



DEVELOPMENT OF AN AUTOMATED SYSTEM FOR THE DECENTRAL FRACTIONING OF MUNICIPAL WASTES

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ABSTRACT. Background: There is a growing problem of the increasing amount of unsorted municipal wastes with the resulting consequences for the environment.

The aim of this study was to present a new solutions of the system for the decentral fractioning of municipal wastes, which enable simplification and improvement of the process together with the reduction of total costs.

Methods: The description of the problem of the increasing amount of unsorted municipal wastes with the resulting consequences for the environment as well as an alternative solution for the decentral fractioning of such wastes was presented. The influence onto the environment as well as the efficiency of the costly mechanical sorting of wastes was queried. The nowadays used principles of sorted and unsorted waste disposal were elucidated and their advantages and disadvantages evaluated.

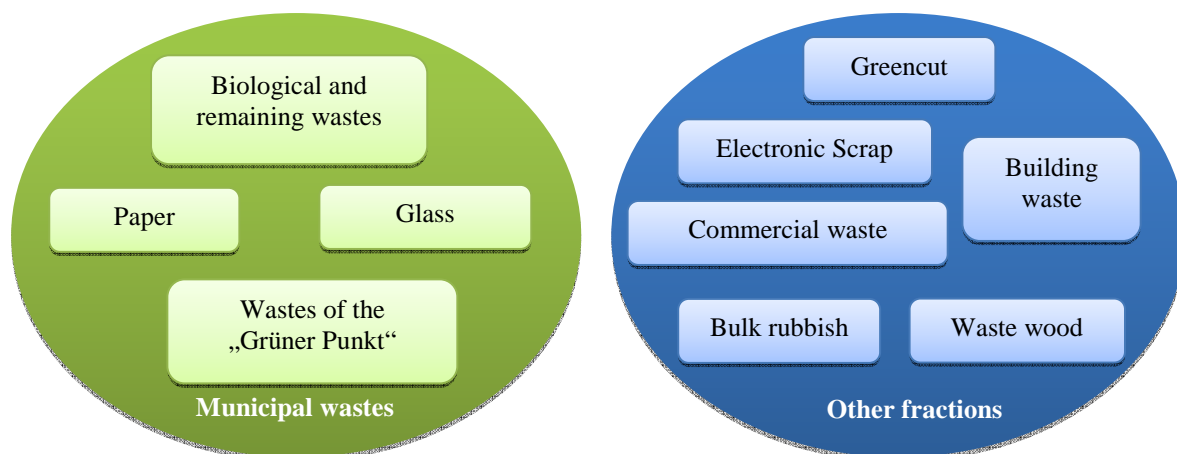
Results and conclusions: Based on this evaluation an innovative and future oriented development of an automated system for the decentral fractioning of municipal wastes was presented. The new developed systems aim at the achievement of an easier, less costly and environment-friendlier process for the disposal of municipal wastes from apartment buildings.

Key words: Municipal waste, decentral fractioning, waste disposal, disposal methodologies, automation, waste sorting.

INTRODUCTION

Before the problems of waste disposal are presented, the main term of municipal waste shall be defined and the different fractions of waste that are differentiated today shall be declared. Municipal waste means all the wastes that accrue in a normal household. These are differentiated into the following fractions: biological- and remaining waste, papers, glasses, plastics and wastes that are summarized in Germany as the "Grüner Punkt" which contain plastics, metal and all other kinds of packaging without papers. Regarding to this, when in the article unsorted municipal waste is mentioned it means the mixing of these fractions. Other wastes like bulk rubbish, commercial wastes, construction waste, waste wood or greencut are not defined as municipal wastes. Picture 1 shows the classification of waste fractions while focusing onto municipal wastes in a graphical manner [Bilitewski, Härdtle, Marek, 2000, Mansoor, Cotton, Westlake 1999, United Nations ... 2010].

Regarding the economics of waste disposal there is a fundamental and crucial difference between unsorted and presorted wastes. Presorted wastes can be recycled a lot more economically since they do not need to be mechanical fractioned and sorted, which leads to a lesser environmental pollution. Unfortunately, most of the inhabitants of apartment buildings are not aware of the economic and environmental burden that unsorted waste produces. To reach a future oriented waste disposal all people must understand that avoidance instead of disposal is the only way to reduce the devastation of the environment through landfills and waste combustion. Only with a reduction of the created wastes, the environment can be spared effectively.



Usual fractions of waste

Fig. 1. Classification of usual fractions of waste
Rys. 1. Klasyfikacja frakcji odpadów

The second important approach is the still not much common idea of "conscious disposal". This term means the proper sorting, but also the disposal of the right amount of municipal wastes. With a compulsory waste fractioning directly at the causer, each person can support an environment-friendly disposal of the produced wastes. By this, the attitude of the waste producing people can be changed to a complete presorted disposal of municipal wastes.

The raising amounts of municipal waste are now and will be in the future one of the mayor problems for mankind. The demanded space for landfills rises because the waste sorting plants are utilized to the capacity cap and through this our planet is more and more polluted by wastes that are difficult to sort and process. To reach the goal of a more environment-friendly waste disposal there has to be made an adjustment to the waste processing concept, so that only presorted wastes will be processed. As a prelude to this change of concept, it is necessary to presort the wastes direct by the causers. For this, a system is needed to improve and simplify the process of waste collecting and to do not even allow a false disposal of different kinds of waste. With such a system, it would be possible to establish a "conscious disposal" without the need for laws and rules to enforce it [United Nations ... 2010, Mulvaney 2011, Cord-Lanwehr 2000].

EXISTING APPROACHES TO A SOLUTION

The main cause for the need to process unsorted wastes lies in the missing obligation for the causers to presort the waste. Regarding to this, the municipal waste is often not sorted due to the ease of disposing them together in just one container. For most people the sorting of the waste, depositing it in different bags and transport these into the different containers are additional efforts they want to avoid. Often people still think that unsorted wastes will be sorted afterwards mechanically or burned altogether and so the presorting is not necessary.

Furthermore recycling is still not as much common as it should be and a lot of people still do not live by the idea of "avoidance instead of disposal". While recycling creates the possibility to reuse wastes in the same or a different manner it is not a magical solution to the disposal of all the wastes produced today. The main disadvantage of recycling is that the main process is very complex and

expensive and produces pollutions due to the release of the exhaust gasses that arise in the process. Anyhow recycling as a method of waste processing is, especially due to the continuous research of new processing technologies, a future oriented solution and does a lot less damage to the environment than thermal processing since the reduction of the waste extent is reached by a much lesser pollution of the air [Cord-Lanwehr 2000, Caldecott, Coggins, McIlveen 2009].

To enable the recycling process the presorting of the waste fractions is of crucial importance. Two different approaches to the presorting process are used today:

- Subsequent sorting of mixed disposed wastes by complex sorting plants,
- Manuel sorting of the fractions by the causer and disposing into different containers.

To compare the two approaches of presorting their advantages and disadvantages are presented in the chart below.

Chart 1. Advantages and Disadvantages of presorted and subsequent sorted waste fractions
Schemat 1. Zalety i wady frakcji odpadów z sortowania wstępnego i zasadniczego

	Advantages	Disadvantages
Presorted waste fractions	<ul style="list-style-type: none"> – No additional sorting by costly sorting plants necessary – Recycling directly possible – Resource saving and environment-friendly disposal process – Conscious Disposal – Future oriented process 	<ul style="list-style-type: none"> – Labour-intensive presorting process for the users – More complex transportation system needed for the disposal companies
Subsequent sorted waste fractions	<ul style="list-style-type: none"> – Easy disposal from the users point of view – Easier transportation system for the disposal companies – High accuracy of the subsequent sorting process 	<ul style="list-style-type: none"> – Intensive subsequent sorting effort – Higher demand for thermal treatment of the unsortable remaining wastes – Inefficient disposal process compared to the disposal of presorted wastes – Higher demand for landfills – Pollution due to the exhausts of the sorting plants

The unsorted waste disposal has advantages for the users due to the lack of need for the presorting but also for the waste disposal companies since they do not need as many trucks to collect the wastes. But because of the overwhelming disadvantages of an unsorted waste disposal this approach will have to be reduced or even completely eliminated in the near future. The part of unrecyclable wastes that can only be treated thermal in unsorted wastes is a lot higher than in presorted wastes. Because of the dense conglomeration between the different kinds of waste, the danger occurs that they cannot be sorted completely and recyclable material is lost and can only be treated thermal anymore.

The presorting of waste by the causer is enabling a direct recycling without the need for expensive and polluting waste treatment plants. Due to this, the recycling process can be less costly and more resources can be regained. Because of this environment-friendly background, the presorting of wastes by the causer has to be viewed as a future oriented treatment process. But this solution has one major disadvantage. If the presorting is not done correctly by the users the recycling process cannot be done or a second inefficient sorting of the waste has to be done. Due to this, the main task at the development of new waste collection systems is to prohibit the false fractioning of wastes by the user.

One more disadvantage is shared by both approaches presorting and subsequent sorting as it is done today. Mostly the wastes are collected in containers outside the buildings so that the trucks of the waste collection companies can reach them more easily. While this is an advantage for the companies,

it inhabits disadvantages for the users, which even lead to a less good presorting behavior. Firstly, the users have to leave the building to dump their waste, which causes inconveniences while it is raining or snowing. Also in the area of the containers, it comes to annoyances due to the smell of the wastes or even vermin. To encounter these problems it would be of a major advantage for a waste collection system to store the wastes inside the houses when the cleanliness can be guaranteed.

ALTERNATIVE APPROACH TO THE PROBLEM - DECENTRALIZED FRACTIONING OF THE MUNICIPAL WASTES

Regarding the above mentioned major problems of today's waste disposal systems a new approach was developed to collect and fraction the wastes decentralized at their production place. With said system, it should be possible to create an easier waste disposal system for the users and by this spread the idea of conscious disposal to the people.

A lot of resources can be saved when the number of processes of mechanical sorting plants can be reduced. The innovative disposal system is based on this idea. The system was developed for the adoption of presorted municipal wastes. The responsibility for the sorting process lies by the causer while the system secures that only correctly sorted waste is disposed. The system works by identifying, weighting and transporting the waste that is placed into special interjection units. The transportation process works without any propulsion, just by gravity the waste is transported from the interjection units, in the several floors of the building, to the cellar where the containers are placed. From here the containers with a pure filling of just one fraction are disposed by the recycling companies. In the following picture, the waste disposal process of the system is described from the user, the technology and the recycling company's point of view.

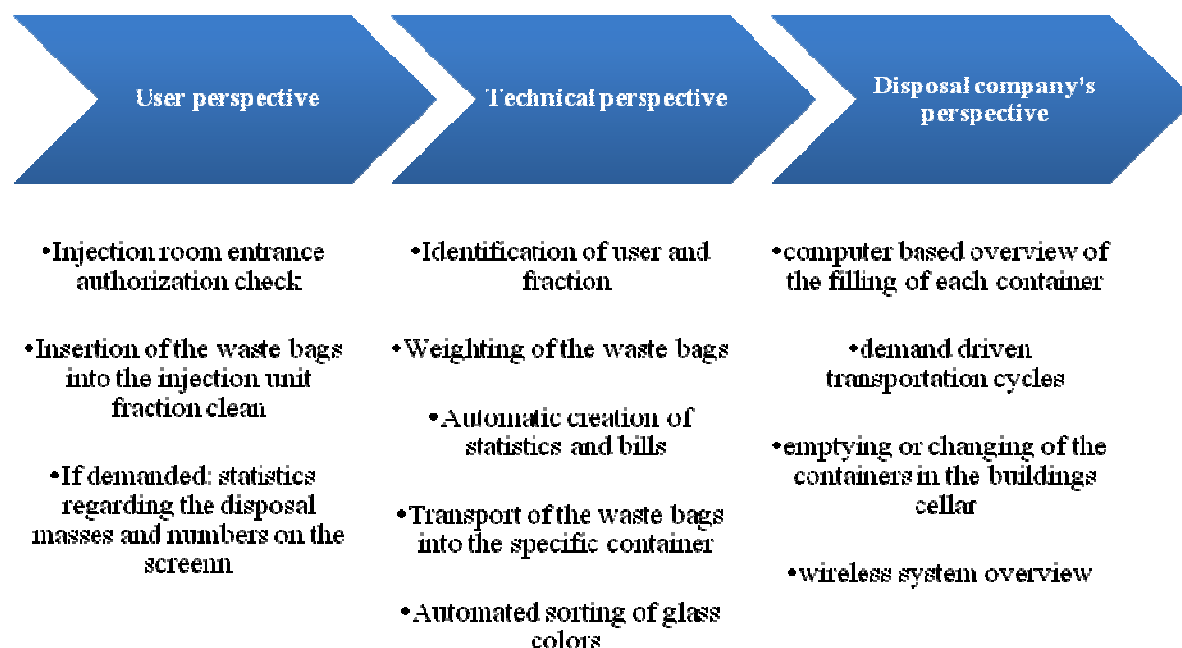


Fig. 2. Presentation of the disposal process from the user, technical and disposal company's perspective

Rys. 2. Proces wywozu z punktu widzenia użytkownika, technicznego i firmy wywożącej odpady

The interjection units are placed on every floor in separated disposal rooms. Entrance to the disposal rooms is given once a person is identified by the chip card that each user is handed for the system. By this, the security of the system and the users is guaranteed and wittingly done damage to the system is prevented. The system is designed to only allow correctly presorted wastes locked within plastic bags to prevent smell, soiling of the area and contamination by vermin. Before the waste can be

introduced into the injection unit, the user again has to identify himself by his chip card. By this the system can refer the dropped waste to the user for later billing. After the identification of the user the waste can be placed into the injection unit. Once the waste is placed into the unit, it is weighted and scanned for accurate presorting. Beside the injection unit is a screen installed on which the user can view the statistics of the waste he just disposed into the system. It is possible to view the weight, kind of fraction, date and time of disposal and mostly important the cost, as well as the cost for the last week or month. By this, the system shall not only provide information but also raise the awareness of the users for the amounts of waste they produce, so that they will come to a more conscious disposal.

After the waste was associated to the user, identified and weighted, it will be transported to the collection containers. The transportation is done by a pipe that leads from the injection units to the containers. Since the containers are placed inside the cellar, there is no need for propulsion but the transport works by gravity. Due to this the waste bags reach a high speed when they are transported downwards. Since the bags can be damaged by the high speed, especially when they reach their destination, the system has a complex device to reduce the kinetic energy of the waste bags. This device is one major part of the system since any damage to the plastic bags would lead to contamination and smell which has to be avoided since the containers are placed inside the houses cellars.

Another waste fraction that is mainly influenced by this problem is glass waste. Without the kinetic reducer unit, the glass would be destroyed at the end of the transportation process and a fractioning of the different glass colors would be impossible. Behind the kinetic reducing unit, a sorting system is placed that transports the waste into the container of its fraction. Here also the glass waste is sorted by the glass color into different containers. Every container contains a sensor that measures how much it is filled already. These sensors are directly connected to the computer system of the disposal companies. By this, it is possible for the disposal companies to plan their truck transports exactly by the filling of the containers and so reduce the transportation costs and the pollution by the trucks.

All the above mentioned necessary identification and sensory processes are calculated in milliseconds so that there are no waiting times for the user in the process of waste disposal. Also the system is directly communicating with the operator so maintenance and repair processes can be done fast and only when needed. By sensors placed inside the system it is capable of identifying the reason of any malfunction and guide the maintenance team directly to the damaged section. So it is not only possible to reduce the reaction time but also to lower the maintenance costs in comparison to a today used system.

BOTTOM LINE

With the use of the newly developed system for a completely automatic decentral fractioning of municipal wastes, it is possible to reduce all the inconveniences involved in today's waste disposal and to ease the process of disposal for the users. Due to the use of an computer controlled system and the implemented sensor technic it is not only possible to guarantee a correct, fraction clean disposal but also a billing system that is fair for the users and enables a complete listing of all disposed wastes of each user. By the use of the presented system, it is possible to automate the waste disposal process and to minimize the costs for the disposition.

But also with such an innovative intelligent system, a healthy environment can only be guaranteed if the users adopt the idea of avoidance instead of disposal on any kind of waste.

SUMMARY

The article is describing the problem of unfractioned and unsorted waste disposal in urban settlements. It describes a research subject with the target to develop a possibility for future sorting of

municipal waste. At first, several examples of today used systems for the fractioning and their advantages and disadvantages are presented. It will be shown, that the most prominent disadvantage of these systems can be found in the lack of an obligation for the users to sort the waste before disposing it and that often the waste will not be sorted because of the laziness of the users. Because of this today used systems have several downsides like: high efforts for the additional waste sorting at high cost sorting facilities, contamination of the environment because of the necessary thermic treatment of no longer separable wastes and the constant overload on the landfills. Accordingly, the article presents alternative solutions, in which, by the usage of automated processes the peripheral waste disposal in urban settlements can be done in the future.

The main principle of this new disposal concept is that the user will have the obligation to presort the waste in the today used fractions like: paper, wastes of the "Grüner Punkt" system, glass and household waste. These wastes will be transported in units using the already established plastic bag system. These bags will be disposed by the users through special insertion modules, which are connected with a pipe system that transports the bags to a central collection station. During the disposal process each bag will be weighted, the fraction of waste will be recorded by a sensor system and the bag will be associated with the appropriate user. By this, the system will be capable to directly collect each waste fraction in a different container and to create an exactly done billing-paper for every user. By this, the system can determine the exact measurement of the filling of the container and will be able to send this information to the service provider for the dispose of the waste containers. Also the system will be connected directly with the service provider for the maintenance of the system to allow a fast reaction if the system is damaged. In the bottom line of the article it will be pointed out that even with the use of such new, intelligent systems for the waste disposal it will be necessary to change our view onto waste management from disposal to avoidance to reach a green and healthy nature for our future.

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OPRACOWANIE ZAUTOMATYZOWANEGO SYSTEMU DO ZDECENTRALIZOWANEGO SORTOWANIA ODPADÓW W OSIEDLACH MIESZKANIOWYCH

STRESZCZENIE. **Wstęp:** Istnieje ciągle zwiększający się problem ilości niesegregowanych odpadów w osiedlach mieszkaniowych wraz z jego konsekwencjami dla środowiska.

Celem tej pracy było przedstawienie propozycji nowego rozwiązania systemu zdecentralizowanego sortowania odpadów komunalnych, które umożliwiają uproszczenie i usprawnienie procesu wraz z obniżką kosztów całkowitych.

Metody: W artykule przedstawiono problematykę zwiększania się ilości niesegregowanych odpadów w osiedlach mieszkaniowych wraz z konsekwencjami dla środowiska jak również przedstawiono alternatywne rozwiązania

zdecentralizowanego usuwania odpadów. Został także poddane dyskusji wpływ na środowisko oraz efektywność kosztownego mechanicznego sortowania odpadów. Zaprezentowano obecnie stosowane zasady wywozu sortowanych i niesortowanych odpadów wraz z oceną ich zalet i wad.

Wyniki i wnioski: W oparciu o tą ocenę zaprezentowano innowacyjne zorientowane na przyszłość rozwiązanie automatycznego systemu zdecentralizowanego segregowania odpadów w osiedlach mieszkaniowych. Nowotworzone systemy są zorientowane na prostszy, tańszy i przyjaźniejszy dla środowiska proces wywozu odpadów komunalnych w osiedlach mieszkaniowych.

Słowa kluczowe: odpady komunalne, zdecentralizowane sortowanie, usuwanie odpadów, metodyka utylizacji, automatyzacja, sortowanie odpadów.

ENTWICKLUNG EINES VOLLAUTOMATISIERTEN SYSTEMS FÜR DEZENTRALE SORTIERUNG VON KOMMUNALEN ABFÄLLEN IN STÄDTISCHEN WOHSIEDLUNGEN

ZUSAMMENFASSUNG. Einleitung: Es besteht ein immer größer werdendes Problem der wachsenden Mengen von Abfällen in städtischen Wohnsiedlungen sowie dessen Konsequenzen für die Umwelt. Das Ziel der Arbeit war es, den Vorschlag eines Systemkonzeptes für dezentrale Sortierung von kommunalen Abfällen, welches Vereinfachung und Vervollkommnung des Sortierungsprozesses sowie Senkung dessen Gesamtkosten ermöglicht, zu unterbreiten.

Methoden: Im vorliegenden Artikel wurden die Problematik der immer wachsenden Mengen nicht segregierten Mülls in städtischen Wohngebieten, dessen Konsequenzen für die Umwelt sowie alternative Lösungen für dezentrale Müllentsorgung dargestellt. Dabei wurden der negative Einfluss auf die Umwelt und die Effektivität der mechanischen Sortierung der kommunalen Abfälle angesprochen, wobei man die heutzutage geltenden Regeln und Prinzipien für die Abfuhr des sortierten und nicht sortierten Mülls samt der Abschätzung der betreffenden Vor- und Nachteile projiziert hat.

Ergebnisse und Fazit: In Anlehnung an diese Beurteilung wurden die auf die Zukunft orientierte Lösung des vollautomatisierten Systems für die dezentrale Sortierung der kommunalen Abfälle in städtischen Wohnsiedlungen präsentiert. Die neuentwickelten Systeme sind auf einfachere, billigere, umweltfreundlichere Abfuhr von kommunalen Abfällen in städtischen Wohngebieten ausgerichtet.

Codewörter: kommunale Abfälle, dezentrale Sortierung, Müllentsorgung, Entsorgungsmethodik, Automatisierung, Sortierung von kommunalen Abfällen.

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