WAYS TO IMPROVE THE COLLECTION AND RECYCLING OF SEPARATE WASTE IN THE SELECTED REGION – CASE STUDY

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Abstract

The global shift towards sustainable behaviour is also affecting waste management practices. Recycling is one way to reduce waste. It allows to apply the principles of circular economy by eliminating the single use of different types of materials. The paper deals with waste collection and recycling in a selected region of the Czech Republic and the possibilities of improving these processes. It presents the results of a primary qualitative research conducted in two phases, first in a company engaged in waste collection and sorting, then in a company implementing the recycling process itself. The research involved the collection of primary information through face-to-face interviews according to an interview scenario, which was complemented by observations. The research was aimed at identifying how to implement both the collecting process (in the first phase of the research) and the recycling process (in the second phase of the research), while identifying tools to improve these processes. The revealed tools can be classified into three basic groups, namely tools for the implementation of technical and technological innovations (concentrated mainly on cost savings), improvement of personnel processes (processes related to recruitment and selection of employees, adaptation processes and processes aimed at increasing work-friendliness) and tools enabling the use of optimization methods and models in the management of in-house processes (including the introduction of appropriate information technologies). The research results and their discussion can contribute to improving collecting and recycling not only in the companies where the primary research was conducted, but also in other companies operating in the Czech Republic. They can also be an inspiration for foreign companies, but only after considering the degree of similarity of the conditions under which companies of this type operate.

Introduction

Waste production rates are increasing. It is estimated that 2.24 billion tonnes of solid waste were produced globally in 2020, or approximately 0.79 kg per person per day. At the same time, waste production is expected to increase by 73% from 2020 levels to 3.88 billion tonnes by 2050. Population growth and urbanisation are cited as the main reasons for this increase in waste[1]. It is the difficult-to-accept increase in waste and the concomitant dangers arising from unsustainable waste management, especially in low-income countries, that is leading countries around the world to improve the practices applied in solid waste management[1,2].

Recycling is an important way to stop or even reduce the volume of waste produced. It contributes to the three basic rules of sustainability (reduce, reuse and recycle) and is also key in the transition from a linear to a circular economy[3]. It helps to loop direct flows by contributing to the recovery of virgin resources from used products and their packaging[4]. The ideal outcome of recycling is the gain of material that can be used for the same purpose as the primary resource, e.g. when recycling office paper results in recycled office paper[5]**.** Recycling has a number of environmental benefits. It prevents waste of potentially useful materials, conserves natural resources (such as wood, water and minerals), reduces the amount of waste taken to landfills and incinerators, reduces energy consumption, reduces and prevents air and water pollution, and helps in job creation[3,6].

The above-mentioned environmental benefits of recycling and its ability to contribute to sustainability have led to a great deal of attention being paid to recycling in recent years. In particular, the focus has been on increasing recycling volumes, on ways to improve recycling processes in relation to different types of materials and on reducing the disadvantages of recycling. These consist mainly in the possible economic inefficiency caused by the high investment costs in building a recycling unit[7], the creation of jobs in an unsuitable working environment, and the difficulty in securing quality of products made from recycled materials[8].

As the issue of obtaining quality of products made from recycled materials is closely linked to the quality of waste sorting, attention is also paid to this process. There are two main ways in which solid waste can be sorted, either at the level of households, which are obliged to sort waste into a certain number of categories, or in specialised sorting facilities. Traditionally, sorting at the household level was considered inconvenient because it takes up space and requires time and effort[9]. However, according to research results[9] there are households that prefer a greater extent of domestic waste sorting, even though third-party sorting allows the same goal to be achieved.

The Czech Republic stands out among the EU countries with one of the most efficient and cheapest sorting systems. 73% of the population actively sorts waste, 77% of packaging is sorted[10,11] and the total annual volume of sorted waste is approximately 755.000 tonnes. In terms of materials, mainly paper, plastics, glass, beverage cartons and metals are sorted[11]. While the figures above are certainly very good, it is nevertheless clear that the sorting system in the Czech Republic leaves much to be desired. The biggest space for improvement is in the sorting of bio-waste, batteries, electrical equipment and metals[12].
This paper focuses on the improvement of waste sorting systems in a selected region of the Czech Republic and the possibilities of improving the preparation of sorted waste for recycling and the recycling process itself in the selected company. It presents the results of a primary qualitative research conducted in two successive phases, first in the company providing the collection of sorted waste from the selected region and then in the company implementing the recycling process itself. The presented research results, their discussion and suggestions for improving the processes implemented in both companies can contribute to the improvement of both waste collecting and recycling processes, especially in the Czech Republic. The recommendations for improvement can be used in other countries as well, certainly after considering the degree of similarity of specific conditions. In effect, the results can therefore be used in improving sustainability.

Simulation and/or experiment

The main objective of the qualitative research was to identify ways to improve the processes implemented in the company providing the collection of sorted waste from the selected region as well as in the company implementing the recycling process itself. The research was carried out as a two-phase research.
The first phase of the research took place in a company that collects waste for recycling, fine-sorts it and prepares it for recycling. The sub-objectives of this phase of the research were to identify:

- the company's customers (municipalities),
- the organisation and implementation of waste collection,
- the method and place of sorting of individual materials,
- buyers of sorted materials,
- problems arising during waste collection and sorting.

The second phase of the research took place in the company implementing the actual recycling processes. The sub-objectives of this research phase were to identify:

- materials entering the recycling process,
- the recycling method and the recycling process,
- the output of the recycling process, its properties and its use,
- the problems of the recycling process.

In both phases of the research, primary data were collected using the in-depth interview method combined with observation. The in-depth interview was conducted according to a pre-prepared scenario. Observations were conducted during field trips in both companies to complement the in-depth interviews. The research took place in the spring months of 2022.
The primary data collection was followed by data processing. The method of data processing was content analysis of both the notes and the voice recording of the in-depth interviews.

Discussion and result analysis

Both phases of the research yielded a number of interesting findings and formed the basis for the formulation of recommendations for improving individual activities related to both the collection of materials for recycling and the recycling process itself.
The company specialised in the collection, fine-sorting and preparation of materials for recycling focuses mainly on plastics, paper, glass, beverage cartons and metals. It collects these materials from approximately 25 municipalities located in the selected region. It serves approximately 25.000 inhabitants. In addition to the collection itself, it provides training, consultancy services and the necessary administration. It is a small enterprise. A description of the activities carried out, the main problems associated with the activities and suggestions for improvement are shown in the following table (Table I).

Table I
Description of the individual activities of the collection, fine-sorting and preparation for recycling processes, the problems associated with these activities and suggestions for improvement

Activity	**Description of the activity**	**Problems associated with the activity**	**Suggestions to improve the activity**
Preparing the collection of materials for recycling	Provision of transparent bags for households and individuals doing business in the municipality	-	-
	Collection of sorted materials in transparent bags	Incorrect sorting by some residents	Education
Planning the collection of sorted waste	Manually via "collection cards" (planning respects the requirements of individual municipalities)	Manual planning without the use of software - time loss, elimination of the possibility to optimise transport routes	Introduction of a software tool for: • Collection planning • Waste collection records • Optimization of transport routes • Providing quick information to customers on the volume of sorted materials
Assignment of tasks to collection workers	Collection workers are given collection cards, according to which collection takes place	Shortage of workers, high turnover	Improve staffing activities, in particular: • Recruitment and selection • Training and adaptation Use motivational and incentive tools of human resources management in an extended form
Pick-up of sorted materials.	On the designated day, the transparent bags are placed in front of the houses and collected - the Kerbside collection system is applied	Shortage of workers, high turnover	Improve staffing activities, in particular: • Recruitment and selection • Training and adaptation Use motivational and incentive tools of human resources management in an extended form
Fine-sorting	Manual fine-sorting using a sorting line	Shortage of workers, high turnover	Improve staffing activities, in particular: • Recruitment and selection • Training and adaptation Use motivational and incentive tools of human resources management in an extended form
		The need to sort plastic materials by type of plastic	Shifting, at least partially, the responsibility for more detailed sorting to municipal residents and individuals doing business in the municipality

Activity	Description of the activity	Problems associated with the activity	Suggestions to improve the activity
			Use of motivational and incentive instruments in relation to the municipal population
		High proportion of manual work in a non-ideal working environment	Shifting, at least partially, the responsibility for more detailed sorting to municipal residents and individuals doing business in the municipality
			Use of motivational and incentive instruments in relation to the municipal population
		Staff errors in sorting	Improving the recruitment, selection, training, motivation and stimulation of employees
		Sorting line stops	Increase in the number of sorting lines and cooperation in fault elimination
Preparation of sorted waste for dispatch	Sorted materials are compressed to form transport units.	High proportion of manual work	Cooperation with the customer on transport optimization (application of the P-system for inventory management, connecting collections with other regions)
Transportation of sorted materials to the company carrying out the recycling process.	The activity takes place approximately once a month when the truck is full.	Long storage time for sorted waste	Cooperation with the customer on transport optimization (application of the P-system for inventory management, connecting collections with other regions)
		Variable collection date	Cooperation with the customer on transport optimization (application of the P-system for inventory management, connecting collections with other regions)

The company that carries out the actual recycling processes is engaged in the recycling of plastic waste from municipal sources. It buys input materials from companies engaged in sorting, coming from all over the Czech Republic, but only if specified conditions are met. The output of the recycling process is recycled material, from which it produces its own products. A description of the activities carried out, the main problems associated with the activities and suggestions for improvement are shown in the following table (Table II).

Table II
Description of the individual activities of the recycling process, the problems associated with these activities and suggestions for improvement

Activity	**Description of the activity**	**Problems associated with the activity**	**Suggestions to improve the activity**
Planning the recycling process	Planning is based on customer demand. The aim is to produce the required quantity in the shortest possible time	Existing restrictions consisting in the desire: • to minimize stops of production equipment and • to maximise the use of production capacity	Use of mathematical methods and models in planning (e.g. linear programming)
Material input to the recycling process	The input to the recycling process is plastic in two forms, namely as mixed plastic and plastic film	Occurrence of materials degrading the recycled material	Input material control Sanctions against suppliers for repeated detection of mis-sorting
		Increasing amounts of polyethylene terephthalate in inputs to the recycling process	-
		Lack of inputs if the volume of sorted material is reduced	Motivating and stimulating households to sort
Recycling	Mechanical recycling, uninterrupted operation, production to stock	Energy intensity of the process	Use of roofs on the company premises for the location of a photovoltaic power plant. Technological innovation
		High process cost. Rising operating costs. Upward pressure on product prices	Use of roofs on the company premises for the location of a photovoltaic power plant. Technological innovation
		Permanent shortage of staff Low quality of staff	Higher wages Improving the recruitment, selection, training, motivation and stimulation of employees
Creation of products from recycled material (output from the recycling process)	A wide range of products is produced, especially for gardens and industrial applications. Possibility to customize products according to individual customer requirements	Durability of products limits the need to change products, limits the volume of sales in kind and financial units	Marketing communication in relation to potential customers focused on the presentation of product quality
Product assembly and application consulting	The offer includes the possibility of ordering transport and installation	-	-

Activity	Description of the activity	Problems associated with the activity	Suggestions to improve the activity
Consumer complaints	Product quality complaints are handled (caused mainly by improper handling of products by customers, to a lesser extent by imperfections in the recycling process)	The subject of the complaint may be the twisting of the material caused by the poor quality of the input material and/or its storage in a humid environment	Storage of input material under controlled conditions

Conclusion

Recycling and how it can be improved has been a subject of academic interest and corporate practice for many decades. Typically, this interest has focused on discovering ways to improve the technological process itself, i.e. the way the material used is processed. However, improving recycling also has another dimension, namely improving the management of the process. It is then appropriate to consider not only the recycling itself, but also the sorting of the material that will enter the recycling process. The primary research carried out that there is quite significant scope for improving these processes. By deploying methods and tools suitable for managing different business processes, sorting and recycling processes can also be improved. Primarily, these tools can be divided into three basic groups, namely tools applicable in the field of:

- technical and technological innovation (concentrated mainly on cost savings),
- improvement of personnel processes (both recruitment and selection processes and adaptation processes, as well as processes aimed at increasing work-friendliness); and
- the introduction of appropriate information technologies and the use of optimisation methods and models for the management of in-house processes.

The above tools, or the groups of tools specified above, can be used individually to achieve partial (step-by-step) improvements in these processes, or they can be applied on a larger scale, optimally at the same time if the financial and organisational conditions are favourable. In such a case, a step change improvement in both collecting and recycling processes can be expected not only in the companies where the primary research was conducted, but in companies of this focus in general.

References

1. World Bank: Solid Waste Management. Retrieved January 15, 2023, from https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
2. Azevedo B.D., Scavarda L.F., Caiado R.G.G., Fuss M.: Waste Manage., *120*, 772 (2021).
3. Niaounakis M.: *Recycling of Flexible Plastic Packaging*. Elsevier, Oxford 2020.
4. Kirchherr, J. Resour. Conserv. Recy. *179(4)*, 106033 (2021).
5. Liu M., Tan S., Zhang M., He G., Chen Z., Fu Z., Luan C.: J. Environ. Manage, *255*, 109859 (2020).
6. Ervasti I., Miranda R., Kauranen I.: Waste Manage., *48*, 64 (2016).
7. Costa C.M., Barbosa J.C., Gonçalves R., H. Castro, H., Del Campo F.J., Lanceros-Méndez S.: Energy Storage Materials, *37*, 433 (2021).
8. Keramitsoglou K.M., Tsagarakis K.P.: Resour. Conserv. Recy, *70*, 55 (2013).
9. Czajkowski M., Kądziela T., Hanley N.: Resource and Energy Economics, *36(1)*, 290, (2014).
10. EKO-KOM: Systém sběru a recyklace obalových odpadů. Retrieved December 20, 2022, from https://www.ekokom.cz/
11. EKO-KOM: Systém EKO-KOM. Retrieved February 20, 2023, from https://www.ekokom.cz/
12. Ministry of the Environment of the Czech Republic: Waste management. Retrieved December 20, 2022, from https://www.mzp.cz/cz/odpadove_hospodarstvi