Journal of Energy Technology

JET Volume 12 (2019) p.p. 27-40
Issue 2, September 2019
Type of article 1.01
www.fe.um.si/en/jet.html

AN ANALYSIS OF THE RESPONSIBILITY FOR ZERO WASTE

ANALIZA ODGOVORNOSTI ZA DRUŽBO BREZ ODPADKOV

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Keywords: municipal solid waste, zero waste, recycling, lightweight packaging waste, waste management, material recovery

Abstract

European Union Directive 2008/98/EC sets the priority hierarchy of the prevention of waste, re-using waste, recycling waste, waste recovery, and waste disposal.

Although every one of us is in daily contact with waste, we do not have the knowledge that can lead us to the sound management of waste from the beginning, before products are identified as waste.

Zero waste is a fundamental concept of the sustainable community of the future. It is a phrase frequently used by politicians seeking to upgrade the municipal solid waste management systems in their communities. In this manner, the responsibility of zero waste is given to the waste management process instead of to householders. Householders then equate waste prevention with recycling and the proper waste management of the collectors, public services, or waste management company. In reality, zero waste starts with each one of us at home. Households should aim to reduce consumption and undertake repairs to extend the life span of products.

Behaviour change can only start with knowledge. In reality, waste prevention does not include recycling. Recycling leads to a combined reduction of waste brought to landfill and raw material extraction.

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The present paper evaluates household waste to clarify the facts. It analyses the composition of three streams: municipal solid waste, separately collected packaging waste, and bulky waste in different regions of Slovenia.

The research defines waste into five different categories. The first category is waste that can and should be avoided. The second category is waste that can be re-used. Further on, the research expands by researching the market of the third category that defines recyclables, which waste can be recycled; the last two categories are the waste that we are fighting with at the end of the waste management process, either to make it to the waste-to-energy process or to comply with landfill restrictions. At the end of the research, we summarize the situation of household waste in 2018.

Our goal is to reduce the quantity of waste, making only waste that can be recycled. If we consider waste prevention to be a fight against waste, we can put our plan in place by taking the first step: getting to know our enemy.

Povzetek

DIrektiva 2008/98/EC nam postavlja prioritetno vrsti v hierarhiji: 1. Izogibanje odpadkov, 2. Ponovna uporaba odpadkov, 3. Recikliranje, 4. Energetska izraba, 5. Odlaganje odpadkov

Čeprav smo vsi v dnevnem kontaktu z odpadki, vsak od nas nekaj odvrže v kanto za smeti, pa nimamo dovolj informacij, spoznanj, vpogleda, da bi obvladovali odpadke preden to postanejo, preden jih zaznamujejmo kot odpadke.

Zero Waste je koncept trajnostne družbe, prihodnosti. To je fraza katero pogosto uporabljajo politični veljaki, ki promovirajo nadgradnjo obdelave komunalnih odpadkov. Ob takšni uporabi fraze, je odgovornost za zero waste prenešena na proces obdelave odpadkov in soodgovrnost ne prevzamejo uporabniki, oziroma povzročitelji komunalnih odpadkov.

Gospodnjistva tako enačijo izogibanje, oziroma ne povzročanje odpadkov z recikliranjem in kvalitetno obdelavo odpadkov, zbiralcev odpadkov, komunalnim dejavnostmi in komunal.

V resnici pa je zero waste začetek proizvodnje odpadkov. V trenutku, ko stvar poimenujemo kot odpadek, jo odvržemo, smo povzročili odpadek in koncepta zero waste več ni. V resnici so gospodinjstev tista ki vplivajo na količino ustvarjenih odpadkov in imajo v svoji prioritetni vrsti popravila in podaljševanje življenjske dobe produktom.

Sprememba obnašanja se lahko prične z izobraževanjem. Preprečevanje nastanka odpadkov ni recikliranje odpadkov. Recikliranje je način kako zmanjšati količino odpadkov, ki končajo na odlagališčih oziroma v sistemu energetske izrabe.

Naš cilj je zmanjšanje količine odpadkov, in dejansko proizvajati le takšne odpadke, katere se lahko reciklira. Če definiramo zmanjševanje odpadkov kot boj proti odpadkom, lahko naredimo prvi pravi korak v smeri spoznavanja našega sovražnika.

1 INTRODUCTION

Households do not take sufficient responsibility for the concept of zero waste. Merely sorting waste is not enough to acknowledge that a zero waste household exists.

We need to move to a position where there is no such thing as waste, merely transformation; this position is called zero waste, *[1]*.

The article is about waste from households. In Slovenia, 476 kg/per capita/year of municipal solid waste was generated in 2016; 67% of separate collection was reported. Slovenia is achieving the targets of Directive 2008/98/EC. In principle, the directive has shown us the common sense we should use when dealing with our daily waste.

However, with no extra boundaries and knowledge and applying to re-use (in households), and proper recycling (in households), we do not reach the directive's original aim.

With improved standards of living, consumption is growing, and households are producing more waste.

A household's consumption patterns affect the quantity and types of waste creation. High-resource-consuming households produce a higher amount of waste than low-resource-consuming households do, *[2]*.

Many industrial and urban activities, including households, generate a considerable amount of solid waste every day all over the world, even if the recycling and energy generation from solid waste is increasing, *[3]*.

Civilization is evolving, and time-saving methods evolve accordingly: convenient shopping; convenient use of plastic bags; convenient food packaging convenient plastic bottles of water bought on the way.

Time control goes hand in hand with evolving standards. Controlling our time and saving our time means the use of modern materials in packaging. Modern materials are now recognized to be those that pollute our planet, so the only way to save our planet is to substitute modern materials with non-modern materials, such as glass and paper.

As Slovenia has a high share of separate collection and is known to be one of the best in the EU, we decided to investigate separately collected packaging material. To clarify, separate collection is an excellent way to establish minimum losses of recyclable materials, but only when recyclables are appropriately collected and separated with care.

2 REVIEW OF REGULATIONS AND CONCEPT OF ZERO WASTE

2. 1 Directive 2008/98/EC

Directive 2008/98/EC of the European Parliament and of the Council states the priority order in waste prevention and management legislation and policy in Paragraph 1 in Article 4 of Chapter 1: (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g., energy recovery and (e) disposal.

For recycling, the directive emphasizes high quality recycling in Paragraph 1 in Article 11 of Chapter 1: Members States shall take measures to promote high-quality recycling and, to this end, shall set-up separate collections of waste where technically, environmentally and

economically practicable and appropriate to meet the necessary quality standards for the relevant recycling sectors.

Nevertheless, Directive 2008/98/EC states in Paragraph 2 that Member States shall take the necessary measures designed to achieve the following targets: (a) by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as the waste streams are similar to waste from households, shall be increased to a minimum of 50% by weight overall.

As different areas of waste origin are reflected in different types of waste composition, so too should expectations and credentials.

By aiming for the goal of Directive 2008/98/EC, set in Paragraph 2, we experience consequences, such as:

(1) Contamination with inappropriate materials – The financial aspects of sorting result in loss; it is not economical to sort material where there is a low share of recyclables.

(2) Contamination of organic matter that affects the personnel employed in sorting facilities. The residual organic matter in pots and trays and some films encourages the growth of microbes in this plastic packaging and the contamination of cellulosic substrates, such as paper and cardboard, which provide favourable conditions for growth, *[4], [5].*

2.2 ZERO WASTE concept

The commonly used definition of the "zero waste" concept was proposed by the Zero Waste International Alliance in 2004, *[6]*, as follows: "Zero waste" is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, in which all discarded materials are designed to become resources for others to use.

As the generation of waste is increasing, it is clear that without a comprehensive and strategic roadmap, the zero waste goals may not be achieved in the desired timeframe, *[7].*

There are seven domains for indicators of zero waste concept integration: (1) Geo-administrative, (2) Socio-cultural, (3) Management, (4) Environmental, (5) Financial/economic, (6) Organization/institutional, (7) Policy/governance, *[2].*

The study of Zero Waste has distinct features. Sustainable consumption practices promote responsible consumption behaviour that ensures zero production of unwanted waste. It is possible to avoid and prevent waste creation of unwanted and excessive waste through sustainable consumption. In addition to sustainable consumption, a systematic transformation of existing inefficient manufacturing systems is also required for eliminating waste creation, *[8].*

In the waste hierarchy, waste avoidance is at the top. However, it is difficult to measure it, because it has a subjective perspective. Avoidable waste should not exist in the waste stream. This material is difficult to define, as we do not know the history of its emergence.

3 METHODS AND ANALYSIS OF SORTING SEPARATELY COLLECTED WASTE

Households aim to minimize waste by separating it properly. The quality of separation plays an extremely high role in waste management. Separation at source is significant for the sorting process in waste management. Mere separation does not cover the zero-waste concept. It is just one of the measures we take to walk the path towards zero waste.
Separation of lightweight packaging waste at source is a process of the preparation of input material for sorting line system, which is merely a production process in waste management.

Financial indicators always play a significant role in every production process. As a waste management facility represents a production process, the input material evaluates the determining factor in the decision of optimizing the waste management process in order to achieve the expected results.

In the case of waste, the design of the production process/waste management depends on households.

3.1 Definition of Lightweight packaging waste (LWP).

Lightweight packaging waste (and variations of it) is separately collected in many European countries that follow the EPR (Extended Producer Responsibility) initiative, first established in Germany in the 1990s, *[9]*.

The model and assessment reported in unpublished data, *[9]* on the process and economic efficiency of German sorting facilities, the development of which has been fundamental in shaping material recovery facilities design around the world but has been granted little scientific attention.

Each country has its defined waste quality, depending on socio-cultural and financial/economic structure. The economics of sorting changes with the waste composition, so the design of sorting lines should change accordingly.

As contamination problems of separately collected packaging waste in Slovenia occur, the comparison with German sorting facilities is explained with the definition of LWP in Germany, which is different from that in Slovenia.

3.2 Problems of sorting lightweight packaging waste (LWP)

The problem is described in *[9]*, where the example of lightweight packaging waste (LWP) sorting in Germany was analysed. The complex nature of LWP waste combined with challenging processing conditions were identified as significant factors explaining the relatively low overall recovery efficiencies achieved in these plants.

The authors of *[9]* indicated that LWP waste in Germany is a material mixture with a high content of plastics (around 50%) consisting of a mix of different packaging polymers, ferrous and non-ferrous metals, a fraction of paper and cardboard packaging, aseptic containers (beverage cartons) and other composite packaging. Mis-sorting or contamination levels vary considerably across collection areas, ranging from 5% to as much as 50% of the collected waste, averaging around 20% for the entire country.

The approximate 2.25 million tons of waste collected each year from households in yellow bins or sacks are sorted in fewer than 100 installations, with almost 90% of the total amount being processed in fewer than 50 plants, *[10].*

The lack of access to economic data gives no real data about processing efficiency and economic feasibility of facilities for central sorting. Nevertheless, material recovery facilities play a pivotal role in today's integrated solid waste management systems, *[11].* Such studies are crucial in economic evaluation and planning of separate collection and recycling programmes *[9], [12], [13], [14].*

The more pressure put on a separate collection system, the more contaminants are found in separately collected packaging. Recyclables traders of materials (i.e., aluminium, PET, PP, LDPE, tetrapak, and paper) expect a high purity of materials; otherwise, the material loses the value. The contaminants also cause losses of recyclables in the process.

As households are not aware of the contamination factor in separately collected packaging waste, this article analyses the present situation of the system in Slovenia.

3.3 Waste management system development

Knowledge of the individual material fractions in waste represents the basis of any waste management system planning and development, *[15]*. This information is also crucial for establishing baselines and for evaluating the effectiveness of environmental policies, *[16]*.

Research, *[9]*,assessed the significance of economies of scale of such plants and tackled operational practices as a means of explaining why there are, frequently, significant discrepancies between expected designed process efficiency and real-life experience with material recovery facilities operation.

The lack of information on the financial perspective of sorting waste sets false expectations for the waste-sorting results.

According to *[9],* studies showed that sorting costs represent 30–50% of the total system cost of packaging waste management. Due to competition, confidentiality data is missing from the global perspective of all factors, for which a scientific approach for the best technological approach could be identified.

In the separate collection system, all materials (metal, non-metal, paper, plastic) are mixed together. The more contaminants materials have, the more losses we incurred when deriving recyclables from the stream.

Simulation of technical and economic performances of materials recovery facilities is a basic requirement for planning new, or evaluating existing, separate waste collection and recycling systems.

As the analysis shows *[9]*, the case of Slovenia is different from that of Germany. The contamination of yellow bins or sacks is much greater, and sorting lines are also built for non-recyclable streams of waste (i.e., mixed communal waste), which is in contradiction of energy efficiency principles.

3.4 Material recovery facilities (MRF)

The structure of material recovery facilities, according to *[9]*, is followed in sequence through the typical facility planning steps:

(1) definition of main plant requirements, waste input characteristics and core process flowchart;

(2) sizing of process installations based on (1);

(3) calculation of capital and operational costs (the cost estimation model); and

(4) estimation of material transfers through the plant and costs/revenues related to plant outputs.

MRFs are industrial plants with significantly different process layouts. Nevertheless, different sections or modules in the plants can be identified to have a standard primary function. Based on this function, five main technical sections were identified and used to structure the facility-sizing exercise and subsequent costing model:

(1) feeding and pre-conditioning;

(2) conditioning – ballistic separation, air separation – physics;

(3) sorting – manual, automatic;

(4) refining – quality control;

(5) product handling – baling, loading operation.

Each section has allocated its associated building needs, unit processes and personnel.

It is crucial to evaluate and combine separate collection and recycling programmes, as well as sorting technology.

The non-recyclable waste stream needs to be acknowledged and well defined, and only then can the hierarchy of Directive 2008/98/EC come into effect.

The non-recyclable stream should not end up in the recyclable stream just to follow Directive 2008/98/EC. As presented in this article, the contaminated recyclable stream is a risk.

4 MATERIALS AND METHODS

The analyses were performed with different methodologies according to the waste stream.

The stream of separately collected packaging waste was performed by the National Laboratory of Health, Environment and Food in Novo mesto, Slovenia. The output stream from the sorting line was thoroughly investigated and weighed. The material was identified as: avoidable waste – does not belong in the stream; recyclables, and waste-to-energy material – residue after sorting. In the stream of separately collected packaging waste, there is no material appropriate for landfills. In the stream of separately collected packaging waste, no material was recognized as re-usable, as the material was contaminated or broken.

The stream of municipal solid waste was analysed in a waste management facility in Krško. The waste was weighed and divided into three groups: recyclables, waste-to-energy material, landfill material.

The stream of bulky waste was also analysed in the waste management facility in Krško. Bulky waste has a large volume in comparison to it weight. In bulky waste, material was found that was able to be marked as re-usable material, as there was no contamination with biodegradable matter.

5 RESULTS AND DISCUSSIONS

5.1 Analysis of separately collected packaging waste in Slovenia

An analysis of separately collected packaging waste has been performed for different regions of Slovenia as presented in Table 1. Avoidable waste is waste that is not supposed to end up in the waste stream of separately collected packaging waste. Thoroughly defined material in this stream is presented in Table 2. In different regions, different shares of waste are found, as the socio-cultural impact reflects the waste composition.

Recyclables represent materials that are acceptable to traders. Shares of recyclables in the stream of separately collected packaging also differ according to the region from which it was collected. The more precise the separate collection in households is, the higher the possibility to sort the recyclables from the waste stream. Furthermore, the last data set differs according to the region, and the numbers show an alarming situation. What is extremely important, and which must be acknowledged, is that contaminated recyclables, dirty recyclables, and recyclables destroyed during the collection process are not recyclables. This material can be used only in waste-to-energy technology.

Table 1: *Mass percentage of material in analysed separately collected packaging waste of different sources in Slovenia*

Separately collected waste source in %	Sežana	Idrija	Ljubljana	Lenart
Avoidable waste	36.1	27.8	29.3	12.8
Re-usable waste	0	0	0	0
Recyclables	12.9	34.6	24.5	31.8
Only waste-to-energy	51	37.6	46.2	55.4
Landfill	0	0	0	0

Ljubljana is the capital of Slovenia. Figure 1 presents the quality of lightweight packaging waste. As can be seen, only 24.5 % of the material are recyclables. Other materials are not usable, contaminated, or missorted.

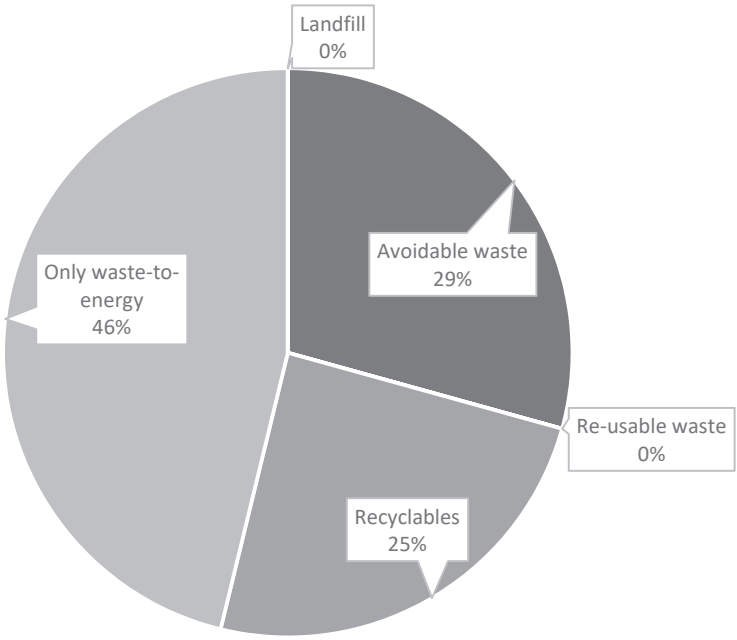

Figure 1: *Quality of LWP in Ljubljana*

In Table 2, the avoidable waste is presented for each source of origin. The percentage of total separately collected packaging waste is shown. Not properly sorted material at source includes electronics, bulky waste, medical materials, biodegradable waste, batteries, as well as textiles, nappies, and footwear. The residue after screening can be used only as in waste to energy process and is not meant to contain recyclables.

Table 2: *Not sorted material is presented as the percentage of total collected LPW from different sources in Slovenia*

Not properly sorted material source %	Sežana	Idrija	Ljubljana	Lenart
Electronics	0.1	0.2	1	0.3
Nappies	1.5	0.9	1.3	0.6
Textile	5.7	4.7	2.1	3
Footwear	2.1	0.9	0.9	0.4
Bulky waste	8.5	7	5.5	5.4
Medical materials	/	0.09	0.1	0.1
Candles	0.1	0.1	0.04	0.04
Batteries	0.1	0.1	0.2	0.03
Biodegradable waste	6.06	3.4	0.9	0.6
C&D waste	1.05	/	/	2.3
Residue after screening: 0–70 mm	/	/	17.3	/
Residue – mixed communal waste	10.9	9.4	/	/
Total	36.11	26.79	29.34	12.77

In Figure 2, the share of waste materials is also represented for Ljubljana. Bulky waste represents 5.5%. For sorting lines, the bulky waste and C&D waste are extremely dangerous from the technical point of view.

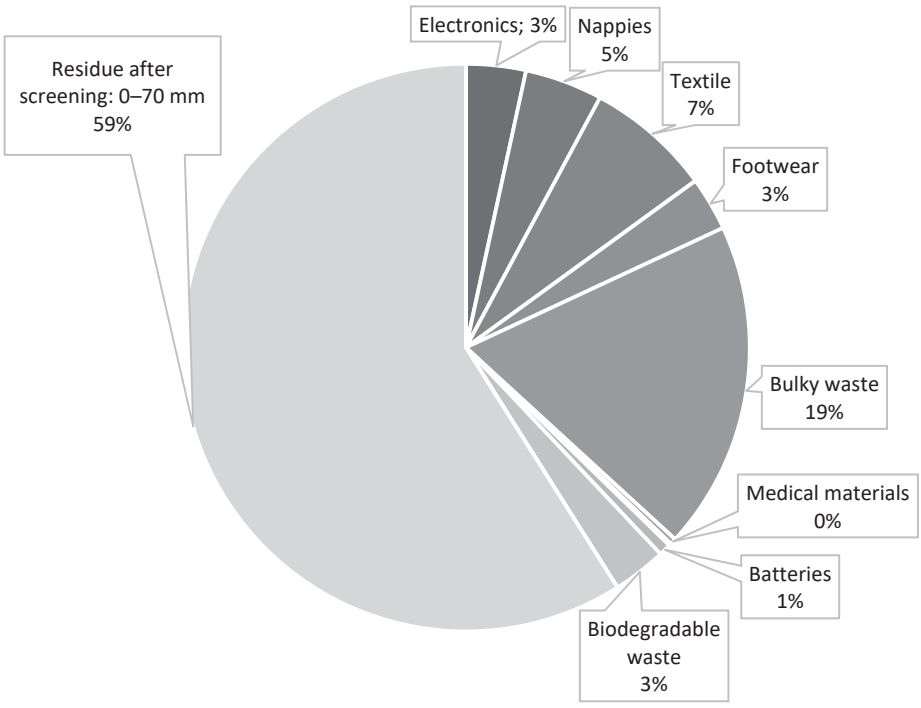

Figure 2: *Definition of avoidable waste from collected LWP in Ljubljana*

The analysis shows that the system of separated collection, without cleaning all the plastic to remove all the biological matter, causes a significantly lower share of valuable recyclables.

Manual or automatic sorting lines have recyclable losses due to machinery congestion caused by contamination.

When we estimate an extremely high separate collection share of household waste, we have high contamination accordingly. Consequently, only 30% of recyclables can be sorted out at sorting lines.

5.2 Analysis of mixed municipal waste

The analysis of mixed municipal waste in Table 3 reflects the separate collection system. As expected, as the share of recyclables is decreasing, so is the share of landfill material, as the law sets parameters that have to be abided by.

Avoidable waste is hard to recognize in the waste stream. The definition of avoidable waste in mixed municipal waste is a subjective matter. There is some share of waste that should be avoided, but this is a matter for different research. Furthermore, re-usable waste is difficult to determine without insight into the condition of the material before the owner defined it as waste. The share of recyclables was analysed during 2017 and recyclables represented only five per cent of waste in mixed municipal waste. It needs to be pointed out that these recyclables are dirty and can be traded only with a lower price.

Table 3: *Mass percentage of material in the analysed mixed municipal waste stream in Krško*

Municipal waste source %	Krško
Avoidable waste	0
Re-usable waste	0
Recyclables	5
Only waste-to-energy	93
Landfill	2

The municipality of Krško lies in eastern Slovenia. Households have been encouraged to separate waste for more than 20 years. According to success of separate selection the share of recyclables in mixed municipal waste is low, as represented in Figure 3.

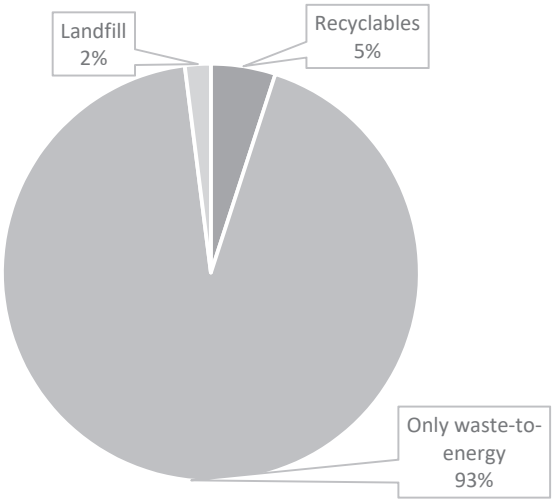

Figure 3: *Share of waste stream in mixed municipal waste collected in Krško*

5.3 Analysis of bulky waste

The analysis of bulky waste was performed through visualization. The bulky waste was checked and weighed when entering the waste management facility. The represented percentage of different sets of material in Table 4 shows the current situation in the Krško region. The recyclables in bulky waste such as metals, PP, and wood can be separated manually. Much of the bulky waste could have been processed through a system of repair and re-use, and some could have been avoided by proper sorting at source, or just proper use and treatment through its lifetime.

Table 4: *Mass percentage of material set in bulky waste in the Krško region*

Bulky waste source %	Krško
Avoidable waste	10
Re-usable waste	20
Recyclables	10
Only waste-to-energy	60
Landfill	0

6 CONCLUSION

Separate collection itself does not ensure recyclables. Also, separate collection itself does not ensure zero waste, as citizens believe.

What citizens can improve is the usage of the right packaging, making every-day decisions not to produce solid waste, clearing their shopping lists of unnecessary items. As long as we live in our modern society, we will generate waste, so zero waste is an ideology we should follow in order to minimize the problems, as we are and will be waste producers and accordingly we need to take responsibility for our actions.

The economy is based on market flow. The stream of material should not be stopped. The material stream should be properly guided. Directions are given but still not regulated within the laws and regulations to have a greater effect on minimising waste.

Zero waste is foremost a challenge for households and not for waste treatment facilities.

At the point at which waste is generated, there is an immediate need for technology to treat the waste properly. To use the best technology or system, to treat the waste according to waste structure, waste valorisation must be provided. Not all technology can be effective or optimal for all types and quantity of waste. Waste treatment needs the best optimization with energy consumption of the process to avoid needless costs for no result.

By following the necessary steps, at the end of the day, in some cases waste treatment causes unnecessary costs, energy consumption, and is environment-unfriendly.

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