



Municipal solid waste management in Minsk

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Municipal solid waste management in Minsk

Current situation, future development and challenges

Karoline Johansson

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Karoline Johansson

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Supervisor: Nina Reistad, senior lecturer at Centre for Environmental and Climate Research (CEC), Lund university.

Assistant supervisor: Martijn van Praagh, Centre for Environmental and Climate Research (CEC), Lund university.

CEC – Centre for Environmental and Climate Research
Lund university
Lund 2020

Abstract

Management of municipal solid waste (MSW) is an urgent issue throughout the world. Urbanization, population increase, and economy growth are all factors which contribute to an increase of MSW generation. The most common treatment method of MSW is through landfilling, which lead to a constant dissipation of resources in terms of material and energy, as well as environmental pollution and emission of greenhouse gases.

A country where more than 80 % of the total amount of MSW is sent to landfills without proper standards, is Belarus. Its capital, Minsk, is a population growing city which struggles with the management of MSW. By performing interviews with important actors within the waste management sector in Minsk, this study investigates the city's current situation of MSW management, possible future development in terms of material and energy recovery as well as barriers for such a development.

The study shows that the low MSW management tariffs per capita in Belarus, together with the low costs of landfilling of MSW, are the main problems regarding the management of MSW in Minsk. Further, unreliable waste statistics, a lack of container sites within the city as well as a lack of awareness and education, also contribute to the ineffective MSW management. To improve the situation, the tariffs of the MSW management should be raised, which would allow further development. It is also essential with the introduction of a landfill tax, which would make other treatment options of MSW more attractive. The main barrier of such an improvement is the political will, since both tariffs and taxes are regulated by the government.

Abbreviations

EPR = extended producer responsibility

DRS = deposit refund system

MHCS = Ministry of Housing and Communal Services

MNREP = Ministry of National Resources and Environmental Protection

MRF = material recovery facility

MSW = municipal solid waste

OSMR = Operator of Secondary Material Resources

RDF = refuse derived fuel

SMR = secondary material resources

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Introduction

Waste generation is an urgent problem throughout the world. Waste is generated by human activity in all economic sectors and approximately 2.01 billion tonnes of waste is generated in the world annually. By 2050, the global waste amount is expected to grow to 3.40 billion tonnes per year, along with the world population expected to more than double. There is a positive correlation between waste generation and population increase, urbanization, economy growth and higher living standards (Kaza et al., 2018).

Depending on the origin, waste is divided into different categories. Industrial waste originates from industries, agricultural waste originates from agricultural activities while municipal solid waste (MSW) comes from households as well as other activities where similar waste is generated, such as schools, companies and hospitals. A large part of MSW consists of product packaging, bottles, food waste and newspapers making it a valuable source of resources in terms of materials and energy (Pichtel, 2005).

Waste management are the activities by which waste is managed, from its origin to its final disposal. MSW is considered the most complex waste stream to manage, since it is composed of such different materials as opposed to more homogenous waste streams such as industrial waste (Madu & Kuei, 2012). Management of MSW imposes economic and social costs on society and differ among different countries and regions (Pichtel, 2005). Many developed countries have implemented policies and measures in line with EU's waste hierarchy (figure 1). High priority is thus given to waste prevention and waste reduction, as well as developing recycling and energy recovery operations. The most common used method for treatment of MSW is however through the disposal on land, called landfilling (Kaza et al., 2018). Landfilling of MSW is the least preferable treatment method according to the waste hierarchy (figure 1), since it inevitably leads to environmental pollution, land degradation, material losses and energy losses.

A country which experience problems regarding the management of MSW, and where the majority of the generated MSW is landfilled, is Belarus and its capital Minsk (World Bank Group, 2018a).



Figure 1. Waste hierarchy according to the in Directive 2008/98/EC on waste (Waste Framework Directive).

Problem statement

Belarus is a country of approximately 10 million inhabitants, generating 4 million tonnes of MSW yearly. Approximately 2 million inhabitants reside in the city of Minsk, where the population constantly is increasing, leading to an increase of MSW generation. Belarus has in recent years taken steps in the right direction involving a national strategy for the management of MSW, awareness campaigns regarding sorting of MSW, a higher number of containers within the city of Minsk and growing recycling practices. Nevertheless, the waste management in Minsk, as well as in the whole of Belarus, is still to a large extent based on landfilling. Approximately 80 % of the total amount of MSW in Minsk is landfilled, resulting in a dissipation of natural resources, land degradation, pollution of soil and water as well as emissions of greenhouse gases to the atmosphere.

Purpose and central questions

The aim of the study was to investigate the current management of MSW in Minsk and analyze what measures can be taken to improve the management of MSW, as well as barriers to do so.

Central questions:

- What problems regarding the MSW management in Minsk can be stated in terms of collection, material recovery and energy recovery?
- What kind of measures can be taken to improve the MSW management in Minsk, regarding collection, material recovery and energy recovery?
- Which are the main barriers of such an improvement?

The study was limited to analyzing the management of MSW in the city of Minsk, therefore excluding Minsk region. The focus of the study was on MSW without any emphasis on different waste fractions. Moreover, the study did not investigate statistics of MSW in Minsk in a profound way, meaning that the quality of statistics was discussed, but the quantitative data was not investigated. Thus, the study was focused on qualitative data rather than quantitative.

An ethical reflection of the study can be found in Appendix I.

Method

In this study, a qualitative method consisting of eight semi-structured interviews was applied.

Qualitative research is primarily exploratory research which is used to obtain an understanding of underlying reasons, opinions and motivations. It is also used to answer questions about experience, meaning and perspective from the standpoint of the respondent. Thus, qualitative research can uncover trends in thought and opinions. These data are, in contrast of quantitative data, not amenable to counting or measuring. Methods for qualitative data collection include group discussions, observations, analysis of texts and documents, in-depth interviews and unstructured or semi-structured interviews, whereas semi-structured interviews often are used to seek views on a focused topic (Bryman, 2016). Since the study aims to describe, explain and investigate a certain issue, a qualitative method in the form of semi-structured interviews was suitable.

A semi-structured interview is a relatively open type of interview and means that the interviewer follows a schedule of different questions that have been prepared before the interview, a so-called interview guide. The questions are usually more general from the beginning but can gradually become more specific, which is a common way of structuring the interview questions as it often makes the interview proceed in a natural way. The questions can also be adapted to the respondent, the environment and the situation and it is also possible for the interviewer to ask follow-up questions. In this way, the interview becomes flexible and rich in content (Bryman, 2016).

The same interview guide was used for all interviews. It can be found in Appendix II.

Selection of respondents

To acquire a trustworthy result, the respondents were selected with focus on obtaining different perspectives on the management of MSW in Minsk. Respondents of the following companies, organizations, institutions, and universities were interviewed:

- **Remondis Minsk:** Remondis Minsk belongs to the Remondis Group, which is one of the world's largest recycling, service and water management companies. Remondis Minsk works to improve the quality of the environment in the capital and the region, to actively introduce separate waste collection and contribute to the reduction of the amount of waste being landfilled (Remondis Minsk, n. d.).
- **Ekologia Goroda:** Ekologia Goroda is a company for waste collection, recycling and waste disposal in Minsk and the Minsk region. The company have a leading position in the market for integrated waste management, as well as the development of environmental documentation (Ekologia Goroda, 2020).
- **TDF Ecotech:** TDF Ecotech is a leading project developer and general engineering contractor operating in the field of environmental technology, waste treatment and alternative renewable energy (TDF Ecotech, 2020).
- **Ecopartnership:** Ecopartnership is an international public organization experienced in waste management. The organization participate in the preparation of studies, development of strategies and concepts at the state level, make recommendations for improving the situation and introducing new approaches. Ecopartnership is a member of the public coordination councils under the Ministry of Natural Resources and Environmental Protection, the Ministry of Housing and Communal Services, the Minsk Regional and Minsk City Committees of Natural Resources and Environmental Protection (Ecopartnership, 2019).
- **Center for Environmental Solutions (CES):** CES is a non-profit and non-governmental organization which promotes principles of sustainable development and the development of international cooperation for environmental protection. It is actively involved in international efforts to protect the environment and human health. CES is carrying out analytical work on ecologically significant questions and is proactive in promoting solutions at the legislative level in Belarus (CES, n. d.)
- **The Operator of Secondary Material Resources (OSMR):** The OSMR is a state institution which coordinates activities regarding the turnover of secondary material resources (SMR). The organization analyzes the effectiveness of handling SMR and maintains a register of companies working with collection, sorting and recycling of waste (OSMR, 2020).
- **School of Business of Belarusian State University:** Vice-Dean of the Faculty of Advanced Studies and Retraining, who is one of the authors of the article Current approaches to waste management in Belarus by Gorbachev and Zenchanka (2019).

- **Plekhanov Russian University of Economics:** Associated professor who is one of the authors of the article Current approaches to waste management in Belarus by Gorbachev and Zenchanka (2019).

Implementation

The respondents were contacted in January and February 2020 and the interviews took place in Minsk during February and March 2020. Table 1 below shows the date and length of the interviews.

Table 1. Respondents with date and length of interviews.

Respondent	Title	Date	Length
Remondis Minsk	General director	2020-02-12	1 h 9 min
Ekologia Goroda	General director	2020-02-13	55 min
Ecopartnership	Chairperson	2020-02-20	1 h 13 min
Universities	Vice-Dean and associated professor	2020-02-27	48 min
CES	General director	2020-02-27	47 min
CES	Project coordinator	2020-02-27	60 min
TDF Ecotech	General director	2020-03-10	1 h 9 min
The OSMR	Head of the department	2020-03-12	48 min

The interviews with the general director of Ekologia Goroda, the general director of TDF Ecotech as well as the respondent of the OSMR were conducted with the support of an interpreter. All interviews were recorded after approval and thereafter transcribed in their entirety. The choice of recording the interviews was made as it means that no relevant information is neglected, in addition it lets the interview proceed in a good way without interruption of having to take notes. However, the respondent may feel hampered by the recording and the situation may be mannered (Bryman, 2016). The transcripts were sent via e-mail to respective respondent. Thus, each respondent was given the opportunity to change or add something.

Data analysis

The qualitative data analysis was based on Hjerm, Lindgren and Nilsson's (2014) and Braun and Clarke's (2006) views on the thematic analysis process. According to Hjerm et al. (2014), the analysis process consists of three phases: coding, thematization and summation. Coding means reduction of data. The purpose of the coding is to reduce the material to its most important parts, while at the same time it is important that no significant part is neglected. After the first coding, a thematization of the material should be done. The thematization process includes a more thorough and detailed coding, where themes are identified based on similarities and differences in the material. It is the thematization that forms the basis of the analysis and largely represents the main areas that emerged in the data collection. The final step is summation, which means that conclusions can be drawn from the coding and thematization processes. These steps are what constitute a well performed thematic study according to Hjerm et al.

These three steps also concretize the six steps that Braun and Clarke (2006) describe as a favorable thematic analysis. According to Braun and Clarke (2006), a proper thematic analysis has taken place when the researcher has: acquainted himself with the collected data, carried out an initial coding of the material, searched for themes, reviewed themes, defined and named themes and compiled the findings in a report. The process used in the study thus follows the steps required to ensure a well-executed thematic analysis. Furthermore, both Hjerm et al. (2014) and Braun and Clarke (2006) emphasize that the qualitative data analysis is an iterative process. This means that the coding that has been performed never should be regarded as permanent, instead the material can advantageously be reworked. Thus, this study has followed an iterative process between the parts of the analysis process.

Reliability and validity

Reliability and validity are concepts used to evaluate the quality of research. The reliability concerns the consistency of a method, meaning the extent to which the results can be reproduced when the research is repeated under the same conditions. Validity measures the accuracy of the result, meaning the extent to which the results really measure what they are supposed to measure. Since results can be reproducible but not necessarily correct, a reliable method is not always valid. A valid method should however always be reliable, since if a test produces accurate results, they should also be reproducible (Kirk & Miller, 1986). The

selection of respondents affects the validity of the study, it is possible that, if other respondents had been interviewed, the result of the study would have turned out different.

In accordance with the scientific theory of qualitative studies, the analysis of data collected is influenced by the interviewer. Depending on the background and the understanding of the interviewer, the material can be analyzed in different ways. This means that what is highlighted in this study would not necessarily be emphasized in the same way by another person with a different background. The reliability is therefore affected by the interviewer and analyzer (Kirk & Miller, 1986).

Furthermore, three of the interviews were conducted through different interpreters. Since the interpreters were not professional interpreters, some difficulties with the translation occurred. Important information may therefore have been lost, misinterpreted or filtered.

Literature search

When searching for literature, the search engines Google, Google Scholar and LubSearch were used. The following words, either alone or in different combinations, were applied: municipal solid waste, MSW, management, strategies, landfills, landfilling, sorting facilities, incineration, recycling, material recovery, energy recovery, incineration, RDF, aerobic digestion, anaerobic digestion, tariffs, taxes, statistics, Belarus, Minsk, Soviet Union. Scientific articles regarding waste management in Belarus published before 2010 were excluded. Additionally, literature has been found through the list of references in already encountered scientific articles, publications and reports.

Background

The background of the study consists of information regarding different treatment methods of MSW, thereafter follows substantial information about Belarus and Minsk.

Treatment methods of MSW

Recycling

Material recovery facilities (MRFs) process recyclable materials which is then sold to manufacturers as raw materials. These facilities play an important role in decreasing the fracturing and production of raw material as well as reducing the amount of MSW sent to landfills. Depending on whether the facility handles mixed MSW or already separated materials, MRFs are generally classified as either clean or dirty. A clean MRF has an inflow of already separated MSW, in form of different recyclable materials, either through a single stream with mixed recyclable materials or multiple streams for different materials. Nonrecyclable or contaminated materials are separated out. More than 90 % of the material entering a clean MRF is processed and prepared for sale (Hosansky, 2014).

A so called dirty MRF has an inflow of mixed MSW, where the recyclable materials are separated by manual and mechanical sorting. The recyclable materials are then processed and prepared for the market, while the nonrecyclable materials are landfilled or sent to another disposal facility. The amount of materials recovered by a dirty MRF can vary from 5 to 45 %. Since the waste stream in a dirty MRF is mixed, the quality of recyclable materials recovered in such a facility is lowered by contamination of broken glass and moist waste (Hosansky, 2014).

Aerobic/anaerobic digestion

The organic component of MSW can be treated by aerobic or anaerobic digestion processes. Aerobic digestion, also called composting, is the decomposition of

organic material by microorganisms in the presence of oxygen. The process creates a nutrient rich fertilizer, while also generating heat, water and carbon dioxide. The heat produced is sufficient to kill harmful bacteria and pathogens as these organisms are not adapted to these environmental conditions. Aerobic digestion is a fast process that requires maintenance as the moisture and temperature need to be monitored closely (Arvanitoyannis et al., 2008).

Anaerobic digestion is the decomposition of organic material by microorganisms in the absence of oxygen. The process produces biogas, consisting of methane and carbon dioxide, which can be used as a fuel and thus decrease the use of fossil fuels. Anaerobic digestion is characterized by strong odors and only a small amount of heat is generated. Because of the lack of heat, the decomposition process takes longer than that of aerobic digestion and does not reach sufficient temperatures to kill pathogens. To overcome these limitations external heat is normally added. Besides the production of biogas, the process generates a nutrient-rich byproduct which, after further treatment, can be used as fertilizer (Arvanitoyannis et al., 2008).

As compared to anaerobic digestion, aerobic digestion has been shown to be the most economically profitable and feasible alternative with moderate environmental impacts, while anaerobic digestion has the lowest environmental impacts of the two (Zulkepli et al., 2017).

Incineration

Confined and controlled burning of MSW, called incineration or combustion, is a strategy that recovers energy from the waste burning process. The energy can either be used for generation of power (electricity), generation of heat or generation of heat and power, referred to as Combined Heat and Power (CHP). The energy generation option depends on the potential to utilize the heat and/or power. The most common energy recovery is generation of power, which in many cases is distributed easily and can be sold through the national grid. For the generation of heat, consumers need to be local or regional to the facility producing the heat and a distribution network is required. If all the available heat cannot be used, the facility will not be able to operate at its maximum efficiency. A CHP facility combines the generation of heat and power, which can increase the efficiency of the facility compared to only generating one of the two. Since the demand of heat and power varies, such a facility can be designed to meet the variation and thus maintain high efficiency (Defra, 2013).

Incineration of MSW results in release of carbon dioxide as well as other emissions to the atmosphere. Some of the residual ash can, after pretreatment, be used as aggregate replacement, otherwise it is sent to a landfill. Residues from flue gas scrubbers, which are necessary to prevent severe pollution of the

atmosphere, are routinely classified as hazardous waste and require safe handling and disposing off (Defra, 2013).

A type of incineration of MSW is refuse derived fuel (RDF), which is a fuel that can be produced from the combustible content of MSW. The non-combustible parts of MSW, such as metals and glass, are removed, while the combustible parts, such as paper, plastics and biodegradable waste, is left to be shredded and compressed into pellets or briquettes. This material can then be used as a substitute for other fuels such as petroleum products, in for example cement plants, coal fired power plants or as reduction agent in steel furnaces (Clarity Environmental, 2020).

Landfilling

There are sanitary landfills as well as open dumps. A sanitary landfill is designed to isolate the waste from the surroundings including reducing the impact of leachate from the waste to groundwater, minimize the presence of oxygen and keep the waste dry. The waste is compacted and buried inside constructed barriers made of natural clay, geomembranes and/or plastic liners. If the landfill obtains the technical requirements and is operated with approved guidelines, it should not pollute the surrounding environment. However, many landfills are old, poorly designed, not well managed and overfull, leading to leachate of hazardous substances, attraction of vermin and wind-blown littering. The leachate can affect human health and the environment through pollution of soil and water. The dispersion of contaminants can be both as solid particles, dissolved in water or in gaseous form. Another issue associated with landfills is the production of methane gas from the decomposition of the biodegradable materials, which is a potent greenhouse gas. If captured, the methane gas can be used to produce heat, electricity or both (Raven et al., 2012).

In addition to sanitary landfills, MSW can also be dumped on land without any technical constructions such as final cover, bottom layering and gas capturing, as well as without any managing and monitoring. This open dumping of MSW pose a great danger to the environment in terms of pollution of soil, groundwater and surface water, methane gas released into the atmosphere, as well as vermin and fires polluting the air with acrid smoke (Raven et al., 2012).

Belarus

Belarus, officially the Republic of Belarus, is a country in Eastern Europe. The country is bordered by Russia to the northeast, Ukraine to the south, Poland to the west, and Lithuania and Latvia to the northwest. There are approximately 9.4 million inhabitants in Belarus, of which more than 2 million inhabitants live in Minsk (table 2), which is the country's capital and most populous city. Minsk is the most economically developed city in Belarus and the population of the city is constantly growing (Official Website of the Republic of Belarus, 2020).

Table 2. Key facts of Belarus (Official Website of the Republic of Belarus, 2020).

Key facts	Belarus
Land area	207,600 km ²
Population	9.408,4 million
Population of Minsk	2.020,6 million
GDP	145.21 BYN billions; 60.45 USD billions Per capita: 16202.20 BYN; 6744.50 USD
Currency	Belarusian ruble (BYN)
Political system	Presidential republic
President	Aleksandr Lukashenko (1994 - present)
Languages	Belarusian and russian

Official MSW statistics

Table 3. Generation, material recovery and landfilling of MSW in Belarus according to the National Statistical Committee of the Republic of Belarus (2019), as well as the average MSW generation, material recovery and landfilling in the EU according to Eurostat (2020). The numbers are in kg tonnes if not otherwise stated.

	2012	2013	2014	2015	2016	2017	2018	EU ø 2018
MSW per capita (kg)	394	389	393	394	399	400	400	489
MSW generated in Belarus	3728	3682	3723	3735	3794	3801	3795	218 million tonnes
MSW generated in Minsk	1007	951	985	985	1008	968	935	-
MSW generated in Minsk of total amount in Belarus	27.0 %	25.8 %	26.5 %	26.4 %	26.6 %	25.5 %	24.6 %	-
SRM recovered in Belarus	373	422	540	583	599	654	714	75 million tonnes
SRM recovered in Minsk	112	127	154	158	169	181	190	-
SRM recovered in Minsk of total amount MSW in Minsk	11.1 %	13.4 %	15.6 %	16.0 %	16.8 %	18.4 %	20.3 %	34.4 %
MSW landfilled in Belarus	3355	3240	3183	3152	3195	3148	3081	57 million tonnes
MSW landfilled in Minsk	895	824	831	827	839	787	745	-
MSW landfilled in Minsk of total amount MSW in Minsk	88.9 %	86.6 %	84.4 %	84.0 %	83.2 %	81.6 %	79.7 %	26.1 %

As can be seen in table 3, 24.6 % of the total amount of MSW generated in Belarus is generated in Minsk, according to the 2018 statistics. Of the total amount of MSW generated in Minsk, 20.3 % was material recovered and 79.7 % was landfilled, which can be compared to EU, where 34.4 % is material recovered and 26.1 % is landfilled.

Statistics on MSW in Belarus are reported by National Statistical Committee of Belarus, using data collected by the Ministry of Housing and Communal Services (MHCS). Additionally, the Ministry of Natural Resources and Environmental Protection (MNREP) also annually publishes data on the generation of MSW (Milios et al., 2014).

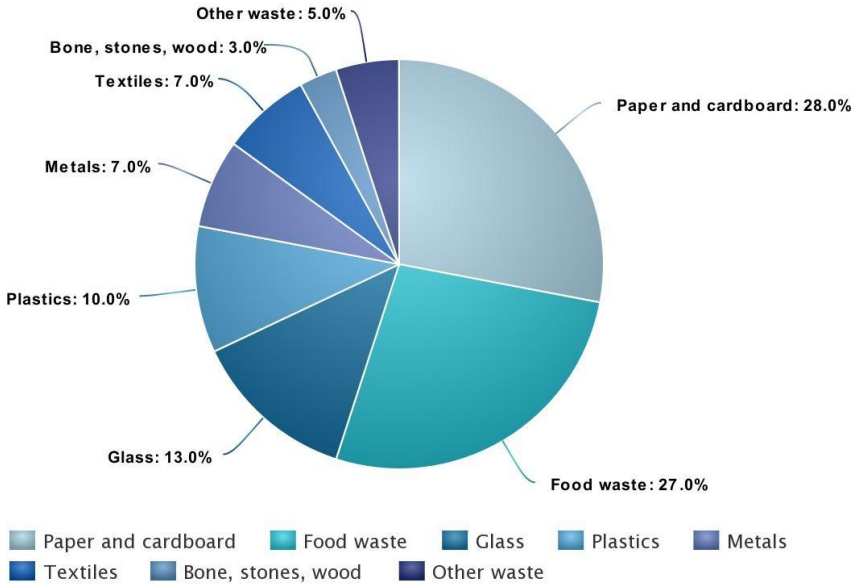


Figure 2. Composition of MSW in Belarus according to Minsk City Executive Committee (2020a).

As is visualized in figure 2, MSW in Belarus mainly consists of food waste (27 %), paper/cardboard (28 %), glass (13 %), plastics (10 %) as well as metals and textiles, which both amount to 7 % each. The rest (8 %) is waste consisting of wood/stones/bones and waste defined as “other waste”.

Legislation

Legislation regarding waste management in Belarus is based on the Constitution of the Republic of Belarus and mainly consists of the Law of the Republic of Belarus on 20 July 2007 № 271-3 “On Waste Management” (hereafter referred to as the Law on Waste Management), which was last amended 2016 (Gorbachev & Zenchanka, 2019). The law provides modern principles of waste management, including minimization of waste generation, the value of recycling as well as reduction of the negative impact of waste on human health and the environment (Law of the Republic of Belarus on 20 July 2007 № 271-3 “On Waste Management”). The law defines MSW as “consumption waste and production waste included in the list of waste related to municipal waste approved by the Ministry of Housing and Communal Services”. Such waste includes waste from human vital activities, for example waste from households, education, sporting, cultural and religious activities, research, waste from trade, social service and transport activities, waste from administrative and economic activities and waste from health care facilities (National Statistical Committee of the Republic of Belarus, 2019). The law contains all aspects of MSW management, including responsibilities of different institutions, planning of waste management schemes, collection, treatment and disposal of waste, different requirements, financial aspects as well as data collection of waste. According to article 25 “Storage and burial of waste”, paragraph 5, burial of secondary material resources is prohibited,

Further, the Law on Waste Management is supported by several Presidential Decrees, among others the 2012 Decree of the President No. 313 “On selected issues related to management of waste from consumption” which introduces the extended producer responsibility (EPR). The EPR system applies to producers and importers of household appliances, tyres, batteries, waste oils, mercury lamps and thermometers, as well as packaging materials made of glass, paper, plastics and composites. The concerned companies can meet their obligation by either applying their own system of waste collection or signing a contract with the Operator of Secondary Material Resources and paying a waste management fee to them (World Bank Group, 2018a; United Nations, 2016).

Institutional framework

As is visualized in figure 3, the MSW management in Minsk is firstly based on the President and the Council of Ministers, as well as the National Assembly which passes laws regarding waste management. Thereafter, Minsk Executive Committee, in accordance with the Ministry of Health, MHCS and MNREP decides about the organization of MSW management in Minsk. Additionally, the

OSMR, established by MHCS, coordinates collection and processing of recyclable materials and is responsible for the implementation of the EPR.

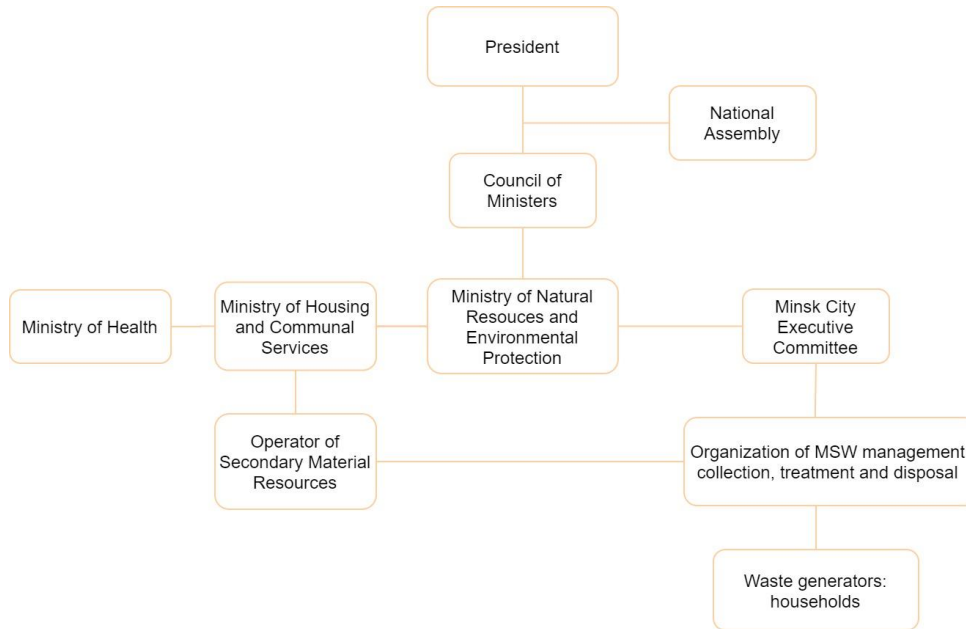


Figure 3. Institutional setup for management of MSW in Minsk.

The following institutions are responsible for the MSW management in Minsk:

- The President of Belarus determines the national policy of waste management, approves national waste management programs as well as the conditions for financial support to legal entities and individual entrepreneurs within the waste sector. The President also establishes the requirements for the management of wastes and defines targets for recycling, as well as defines the list of goods which are subject to the EPR (United Nations, 2016; World Bank Group, 2018a).
- The National Assembly, constituting of the House of Representatives and Council of the Republic, passes laws which regulate MSW management and environmental protection (World Bank Group, 2018a).
- The Council of Ministers is responsible for ensuring the implementation of the national policy and regulates the management of hazardous wastes, in accordance with the President. Further, the

Council of Ministers approves the financial targets concerning revenues and costs of the state-owned Operator of Secondary Material Resources (United Nations, 2016; World Bank Group, 2018a).

- MNREP takes measures to implement the unified state policy on waste management, to ensure the development and execution of plans and projects concerning waste management. Together with territorial authorities, the MNREP constantly works to exercise state oversight over waste management, prevent the burial of secondary material resources, detect unauthorized dump sites, and analyze the availability of properly approved schemes for managing MSW in addition to optimizing district-level waste management schemes (Ministry of National Resources and Environmental Protection, 2020).
- MHCS is responsible for the implementation of the national policy, the development and implementation of state programs as well as plans and activities in the field of waste management. The ministry also approves the list of wastes classified as MSW, carries out coordination of regional programs in the field of waste management, and establish, in coordination with the MNREP, the composition and procedure for the development, coordination and approval of MSW management schemes. Additionally, the ministry coordinates the management of recyclables through the Operator of Secondary Material Resources. This ministry is specifically responsible for MSW and recyclables (World Bank Group, 2018a).
- The OSMR, a state institution established by the MHCS, is, as already mentioned, responsible for organizing collection, treatment and reuse of recyclable materials. They are also responsible for the implementation of the extended producer responsibility principle. This organization receives product fees and distributes payments for collected recyclables and packaging.
- The Ministry of Health is responsible for establishing hygienic norms and standards for waste removal from residential areas (World Bank Group, 2018a).
- At the local level of Minsk, Minsk City Executive Committee is responsible for policy implementation, development of MSW management programs and their implementation, organizing operation of MSW disposal sites, approving fees, developing and approving, in accordance with MNREP, territorial departments, authorized government bodies, and organizations exercising sanitary supervision. Additionally, this committee organizes, together with the OSMR, the management of recyclable materials and inform legal entities about waste management-related issues (World Bank Group, 2018a).

Tariffs and taxes

The tariff for the collection, transport, and disposal of MSW is established per m³ per person, based on national waste norms. Residents living in houses with a functioning waste chute pay 8.2 Belarusian rubles (3.1 euro, exchange rates per 2020-05-26) per m³ of waste, while residents living in houses without a functioning waste chute pay 6,9 Belarusian rubles (2.6 euro, exchange rates per 2020-05-26) per m³ of waste. The tariff is paid to the waste collection companies. (Minsk City Executive Committee, 2020b).

The price of landfilling of MSW in Belarus is 4.87 Belarusian rubles (1.8 euro) per tonne (Appendix 6 to Decree No. 29 of 01.25.2018).

National Strategy

The National Strategy, officially the National Strategy for the Management of Municipal Solid Waste and Secondary Material Resources in the Republic of Belarus for the Period up to 2035, is based on the Constitution of Belarus and the legislation of Belarus, as well as on the documents of long-term strategic planning and the principles and norms of international law (National Strategy, 2017).

The aim of the strategy is to identify directions and measures to minimize the negative impact of MSW on human health and the environment, as well as minimizing the extraction of virgin materials through recycling of secondary material resources, such as glass, paper, metals and plastic. The strategy includes several measures to be implemented for the period of up to 2035. Firstly, the existing MSW management should be improved by better statistical reporting of MSW, enhancement of logistics and separate collection through closing of waste chutes, upgrading of container sites and vehicle fleet, increasing work with awareness campaigns, construction of up-to date landfills as well as closing of landfills, construction of sorting and recycling facilities and changing legislation regarding MSW (National Strategy, 2017).

The strategy also includes the introduction of a deposit-refund-system (RDS) for plastic- and glass bottles as well as aluminum cans. A DRS is based on economic stimulation of consumers to return used packages by introducing a deposit. When buying packaged goods, consumers pay the deposit for the package, and when returning empty packages, consumers get the deposit back (National Strategy, 2017).

Furthermore, the strategy proposes aerobic digestion of MSW as well as production of RDF fuel. The plan is to integrate the production of RDF fuel from mixed MSW into a mechanical and biological MSW processing facility, where the first stage includes a technological operation aimed at separating the biological fraction from the total mass of MSW, the second stage implies the

extraction of SMR suitable for reuse in the process of sorting, and the third stage requires a technological operation for the production of RDF fuel from the remaining part of MSW. According to the strategy, the RDF fuel production should begin in the cities of Mogilev and Grodno based on the existing sorting capacities and the available MSW volumes, as the main consumers (cement plants) are far away from the main sources of raw materials (Minsk and Minsk Region).

Lastly, the strategy involves the construction of an incineration plant in Minsk with a capacity of 500,000 tonnes per year (National Strategy, 2017).

Experience of MSW management in Minsk

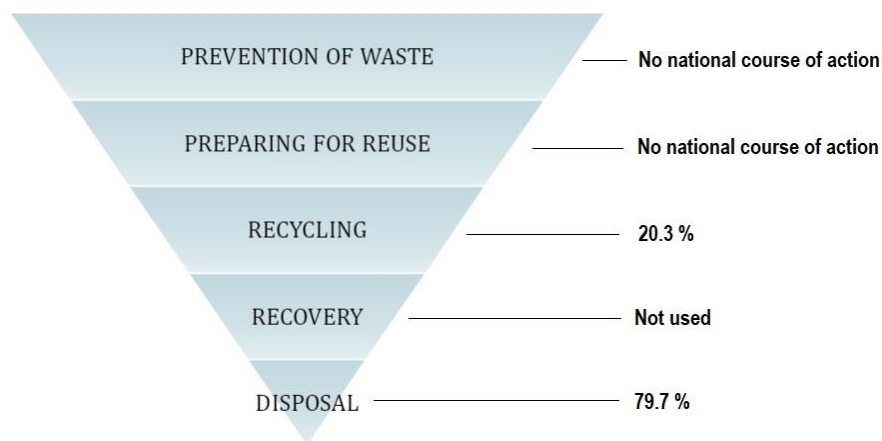


Figure 4. Current management of MSW in Minsk as seen from the perspective of the waste hierarchy.

As can be seen in figure 4, there is no course of action regarding waste prevention in Minsk and no part of the MSW is prepared for reuse, while disposal of MSW (landfilling) is the main treatment method.

Separate collection of MSW in Minsk includes paper, glass, plastics and residual waste. According to a report conducted by CES and Greenpeace (2019), 84 % of the inhabitants of Minsk have access to separate collection of MSW. The recyclable fractions usually have a high percentage of impurities, therefore they are collected together and transported to a sorting plant for further treatment. Most of the residual fraction is directly sent for landfilling, however, a part of this

fraction is sent to mixed-waste sorting lines for the extraction of recyclable materials (World Bank Group, 2018a).

The collection and recycling of ferrous and non-ferrous metals is separated from the management of MSW. These metals are collected through a network of buyout points operated by the state company Belvtormet. The collected metals are either used for production of goods by enterprises subordinated to Belvtormet or being traded on the Belarusian Universal Commodity Exchange (United Nations, 2016).

MSW in Minsk is collected by the unitary enterprise Spetskommunavtotrans, which collect waste from six of the nine districts (amounting to 60 % of the residents), as well as Remondis Minsk, which collect MSW from the remaining three districts (40 % of the residents) (United Nations, 2016). Spetskommunavtotrans is a state-run company while Remondis Minsk is part of the Remondis Group. 49 % of the shares of Remondis Minsk is owned by the city of Minsk and 51 % belongs to the Remondis Group (Gorbachev & Zenchanka, 2019).

The sole operator of landfilling services is the unitary enterprise Ekores. Ekores operates the landfill Trostenetsky (picture 1), which opened in 2007 and is, since 2017, the only operating landfill for MSW in Minsk. The landfill occupies an area of 30.8 ha and was designed for 22 years of service life. It is supposed to be the most well-constructed landfill in Belarus, with bottom sealing of disposal cells and a system for collection of leachates as well as an approved operation plan for the waste disposal (United Nations, 2016). A waste sorting plant with a capacity of 327 tonnes MSW per day was commissioned at the landfill in 2017. In addition to Trostenetsky, Ekores operates two closed landfills for MSW; Trostenets and Severniy (Ramboll, 2017). Gas from both of these landfills are extracted by TDF Ecotech to produce electricity (general director of TDF Ecotech, personal communication, 2020).



Picture 1. On top of the landfill Trostenetsky.

In addition to the separate collection of SMR through containers, there are a type of buying points in Belarus where people can be compensated for depositing their recyclable materials. The buying points are managed by various state organizations and a large part of recyclables are coming from these points. In 2017 the prices were 0.05 USD per kg paper/cardboard, 0.03 USD per kg glass and 0.08 USD per kg plastic (World Bank Group, 2018a).

Results and analysis

This part of the study is divided into three parts: current situation, which consists of two tables demonstrating the problems of the MSW management in Minsk, future development, which consists of one table with suggestions of the respondents on how to improve the management of MSW in Minsk, and lastly a table showing the barriers, according to the respondents, for improving the MSW management in Minsk. All tables are followed by explanatory and analyzing texts along with citations of respondents as well as pictures.

Current situation

Table 4. Problems regarding the current management of MSW in Minsk according to each respondent.

Respondent	Absence of strategic direction	No organizational structure	Hierarchical structure	Landfilling very cheap	Low tariffs of waste management	No open tender	Lack of economic incentives	System of informal waste collection
General director of Ekologia Goroda								
General director of Remondis Minsk								
General director of TDF Ecotech								
General director of CES								
Project coordinator at CES								
Chairperson at Ecopartnership								
Head of the department of OSMR								
Professors								

Structure

Three out of eight respondents described the management of MSW in Minsk as being centralized with a hierarchical top-down structure (table 4). According to the general director of Remondis Minsk, decisions are often considered high up in the hierarchical structure and then brought down. Thus, decisions are often made by people who are too remote and who might not have sufficient knowledge about the issue they are dealing with. The chairperson of Ecopartnership is of the opinion that the ministry of Housing and Communal Services is the most powerful and make all decisions about the development of the waste management sector. Thereafter, the policies that are developed by the ministry are implemented by the authorities in Minsk

“Talking in general, Belarus has a strictly governance system, from top down. All the issues are very often considered over there, and then brought down. Sometimes the decisions are done by people who are not really close to the practice.” (General director of Remondis Minsk)

This is in accordance with the report of World Bank Group (2018a), where one can read that the MSW management in Belarus is centrally controlled.

Moreover, three of the respondents mentioned the lack of organizational structure as an issue (table 4). The general director of CES mentioned that there is no single unit which is responsible for the MSW management, instead it is a fragmented subject between different departments and companies:

“The waste management is somehow like fragmented issue among different authorities within Minsk Executive Committee, there's no single unit which is responsible for the waste management, because some parts fall under the department of communal affairs, some things are under the committee of environmental protection, and statistics is under another, some parts are completely run by companies, for example the issue of waste transportation. There is no one basically who are responsible for PR, communication, advertisement etc.” (General director of CES)

Absence of strategic direction

Three of the respondents think that there is an absence of strategic direction for the MSW management in Minsk (table 4). There is a national strategy for Belarus, but there is no waste management strategy for Minsk specifically, which means that there are no clear measures or targets to follow. This results in an uncertainty regarding plans and development of the waste management sector in Minsk.

“There is no real strategic management or understanding for waste management in Minsk, even now we don't have a Waste Management strategy for Minsk, it has been discussed for maybe 10 years, we do have a national strategy, not only for waste but for secondary resources, on national level, but we don't have one for Minsk.” (General director of CES)

“There are no policy documents for Minsk, no strategic program for waste management in Minsk city [...] there were several efforts to develop a waste program, even some drafts were prepared, but I am not sure they were approved by Minsk authorities, so it is not clear what plans the city have.” (Chairperson of Ecopartnership)

Tariffs

The low tariff that the population pay for the management of MSW was pointed out by all nine respondents as a major issue which hinders the development of the MSW management (table 4).

“The waste collection system is not developed because of the tariffs, they are rather low, landfilling is the most affordable way, the tariff that we pay, if it is not subsidized, in reality the tariff covers only transportation costs from your house to the landfills, that's all. And how can we speak about advanced technologies if there is no willingness to increase the tariff [...]” (Chairperson of Ecopartnership)

“Low costs did not allow to put money into infrastructure” (General Director of Ekologia Goroda)

The average tariff for the waste management is 7 Belarusian rubles (2.6 euro) per 1 m³ of MSW. The tariff of the waste management per capita and year amounts to 7 euro, which can be compared to the MSW management fee in Poland (29 euro per capita and year) and Germany (120 euro per capita and year). It should however be noted that the average monthly wages (after taxes and deductions) in these countries also differ a lot: 310 euro in Belarus, 940 euro in Poland and 1500 euro in Germany (National Strategy, 2017). According to Skryhan et al., the low tariffs are a heritage from the Soviet Union and are based on a normative of waste generation per capita. The tariffs on communal services are considered to be social sensitive components and the increasing of these tariffs is regulated by the national government. The low tariffs do not allow development of the waste

management in terms of recycling or energy recovery (Skryhan et al.). In accordance with Skryhan et al., the World Bank Group (2018a) states that low waste management tariffs hamper investments in the system. Additionally, United Nations (2016) notes that one of the key problems in the current MSW management system include the insufficient level of waste fees which do not cover costs of service provision.

Cost of landfilling

Six out of eight respondents pointed out the price of landfilling as a major issue (table 4), making it the preferable treatment method compared to sorting and recycling.

“Many state companies are trying to reduce costs and trying as much as possible to use landfills, and not to sort, it is cheaper and for the business it is much more valuable, but the thing is the state policy is now like more social, and directed to save money for people, and they are not found of it, so basically it is more easy to put in on landfills and save money that to sort it and to put more money into it.” (General director of Ekologia Goroda)

“The issue is that it is very cheap to put it on landfills, the taxes for the landfilling should be much higher” (General director of Remondis Minsk)

Landfilling of MSW in Belarus cost 2 euro per tonne, which can be compared to the landfilling price in other countries: Poland – 33 euro per tonne, Latvia – 25 euro per tonne, Estonia – 30 euro per tonne, Sweden – 50 euro per tonne and Finland - 70 euro per tonne (Cewep, 2017). All countries in EU which have landfill rates well below the EU average of 28 % have either banned landfilling of organic or mixed MSW, or have implemented a ban in combination with a landfill tax of at least 30 euro per tonne of MSW (European Environment Agency, 2019).

Landfilling of MSW is normally cheaper than treating the waste through sorting, recycling, aerobic/anaerobic digestion, or incineration (GIZ, 2015). The environmental and social costs of landfilling are usually not considered by governments, authorities and waste management companies when comparing the costs of different waste management alternatives. To incorporate the negative external effects of landfilling, a taxation system can be used. The tax should be sufficiently high to make other treatment options more economically viable and thus create an economic incentive to decrease the amount of MSW being sent to landfills (GIZ, 2015). The price of landfilling of MSW in Belarus is very low, allowing this treatment method to exist to such a large extent. If the government would introduce a high tax on landfilling, other treatment options of MSW would

be made more economically profitable. According to Skryhan et al. (2018), an increase of the price of landfilling could be one of the measures for increasing the efficiency of waste management in post-soviet countries. An evaluation of the implementation of the landfill tax in Estonia and Latvia has shown a correlation between tax rate dynamics and a decreasing amount of waste sent to landfills (Klavenieks & Blumberga, 2017). Moreover, countries that are considered to have the most effective waste policy in the EU (Austria, Netherlands, Germany and Denmark, among others) have a landfill tax of more than 80 euro per tonne of MSW (BiPRO, 2012).

No open tender

Open, or public, tender is a contract which is published by a public sector organization to invite companies who can provide services, for example waste management services, that an organization requires with the decision being made on the basis of price and quality of what each company offers (European Union, 2020). Both the general director of Remondis Minsk and the chairperson of Ecopartnership mentioned the absence of an open tendering process as a problem within the waste management sector (table 4). As it is today, there is no competition on the market for such contracts, therefore it is difficult for the private sector to participate in the waste management. According to Filho et al. (2014), participation of the private sector in the field of waste management through an open tendering process is an important mechanism implemented in EU countries' waste management systems.

Lack of economic incentives

Lack of economic incentives for companies working within the waste management sector, or for producers/importers of product packaging, was mentioned by five of the respondents (table 4)

According to the chairperson of Ecopartnership, there is no real interest of the companies that collect the waste to increase the amount of recyclable materials.

“Close to my house there is a container for paper waste, and maybe twenty meters from there, there are another container for paper, a very small one, not so good for paper. For that company it does not matter if there is any paper waste in the container or not. They just put the container there because they got an order to do it, to show that the system is organized but

they are not interested in the volume of recyclable material that they collect.” (Chairperson at Ecopartnership)

This problem was explained by the general director of Remondis Minsk, who said that there is no economic incentive for the collection companies to bring less waste to the landfills. The owner of the landfills, Ekores, is being paid a fixed price in line with the average number of m³ of MSW, and not by weighing the waste in tonnes and calculating the price from the actual amount. The system is in favor of the owner of the landfill since they will get the same amount of money regardless of the amount of MSW.

”So when we bring the waste, they do not measure the amount, they say okay, 5,3 million m³ of MSW according to the norm, they just multiple it with the tariff, so it is like a fixed amount [...] So there is no interest in the system to bring less amount of waste to the landfill, because they are getting this money anyway.” (General director of Remondis Minsk)

Regardless of the amount MSW the collection companies, Remondis Minsk and Spetskommunavtотrans, bring to the landfill, they will pay the same amount of money to Ekores. Thus, there is no incentive to bring less amount of MSW to the landfills for them, which is a significant issue. The MSW should instead be weighed in tonnes, to get the actual amount of it and then base the price on the real amount of MSW and not just the norm. In that case it would create an incentive to decrease the amount of MSW sent to landfills.

According to the respondents of CES, there is no difference in fees for a company who produces/import products of recycled/recyclable materials or non-recycled/non-recyclable materials. Thus, there is no economic stimulant for the companies who choose to use recyclable materials.

“At the moment our producers and importers are not responsible for the life cycle of the products, they only pay a certain fee, from our perspective it is not good that there is no difference in terms of fees depending on recyclability or opportunity to use this material again, you just pay based on weight of the material, it doesn’t matter if it can be recyclable or not, it does not provide a stimulant for those companies who prefer to use recyclable materials.” (General director of CES)

System of informal collection

Four of the respondents mentioned a system of informal collection of recyclable materials (table 4). The buying points of SMR creates an incentive for people to collect recyclable materials out of containers, which decreases the profitability of the companies who own the containers.

“There are some people with low salaries that take the recyclable material out of the containers and goes to these places where they can sell it. Metal, paper and glass, I think. They travel around and extract these materials, which also makes it unprofitable for companies that collect this waste.”
(Professors)

“We also have a system of this, like points for secondary resources, this system is a heritage from the Soviet Union, you can come to this point and sell your glass bottles, plastic, paper or whatever, the quality of the resources coming through this system is much higher, so it is quite effective, but of course for many people, the price for one kg paper or glass is very small, perhaps you would not go for it if you don't have a really strong need” (General director of CES)

There are also many people on the landfills searching for recyclable materials to sell (picture 2), which is a strong social issue since the environment on the landfills is not safe, according to the project coordinator of CES. This is in line with Kumar (2011), who notes that informal waste separation can take place at source in large urban areas, for example in residential areas with high-rise buildings, where the waste pickers sort out the recyclable materials before the collection vehicle arrives. It could also happen during collection, when the collectors sort out the recyclable materials during loading, or at the source of the disposal, meaning on the landfills. According to Kumar (2011), this kind of uncontrolled waste picking can reduce the efficiency of the formal waste collection schemes and can also be dangerous for the people doing it, especially the people who search for recyclable materials on the landfills. However, the respondents of CES both mentioned that the amount as well as the quality of the materials coming through this system is very high, since it has not been mixed with other materials.



Picture 2. Man collecting recyclable materials on top off the landfill Trostenetsky.

Table 5. Problems regarding the current management of MSW in Minsk according to each respondent.

Respondent	No measures on prevention of waste	Low sorting rate	Not enough containers	Overfull containers	Insufficient signs on containers	Lack of information	Waste chutes inside buildings	No separate collection of organic waste	Inadequate waste statistics	No energy recovery
General director of Ekologia Goroda										
General director of Remondis Minsk										
General director of TDF Ecotech										
General director of CES										
Project coordinator at CES										
Chairperson at Ecopartnership										
Head of the department of OSMR										
Professors										

Prevention of waste

Three of the respondents mentioned the absence of measures on prevention of waste as an issue. According to the waste hierarchy, prevention of waste is the top priority of waste management.

“We do not have a policy on for example waste prevention, in the European framework directive the top principle of waste management is prevention, but we do not have any policy regulation, how to actually implement this principle in practice, basically most of governmental efforts are concentrated on collection and recycling, and not on prevention.” (General director of CES)

A waste management system relying primarily on landfilling can benefit more from waste prevention measures than an advanced waste management system with a high degree of material recycling and energy recovery (Gentil et al., 2011). Since the majority of the generated MSW in Belarus and in Minsk is sent to landfills, waste prevention should be given more attention by authorities and decision-makers.

Collection

All respondents mentioned that there is a lack of information regarding MSW management in Minsk (table 5).

According to the respondents of CES and the respondent of Remondis Minsk, there is a misunderstanding regarding the collection of MSW in Minsk. MSW is collected in four different fractions: paper, glass, plastic and residual waste. Since the sorting rate is quite low, the recyclable fractions are usually not clean. The recyclable fractions are therefore being collected by the same truck and brought to a sorting facility. This system creates confusion and misunderstanding by the residents since they are being told to sort their waste in these fractions, just to see that everything is mixed anyway.

“I think one of the most popular question for us, why do we separate waste into different containers and then there is one truck coming and collects everything all together, what is the point then of waste sorting?” (General director of CES)

Another issue is the number of containers within the city. Three out of eight respondents mentioned that there are not enough containers for separate collection

of MSW in the city (table 5), leading to untidy collection points and overfull containers, as can be seen in picture 3 and picture 4. According to the head of the department of the OSMR, there are 5 containers per 1000 people in Minsk, which corresponds to the report by United Nations from 2016, where one can read that there are approximately 200 people per container in Minsk.

“When we talk about Minsk, for 1000 people there is only 5 containers, and in general in Belarus there are only 10 containers for 1000 people. The municipal architecture, there is not enough space for containers, the buildings are so close to another, so we cannot organize special places for separate collection, a lot of containers are overfull.” (Head of the department of the OSMR)

According to CES and Greenpeace (2019), 84 % of the inhabitants in Minsk have access to separate collection of MSW, which seems like a very high number in regard to the number of 5 containers per 1000 people. However, 84 % might not be accurate since it depends on how it is counted. As was mentioned by the general director of Remondis Minsk:

“You can’t rely on these statistics, because if you have a high store building with a thousand residents, and they put one collection point with 4 containers, you can say that they have access to it, but 4 containers are not enough for 1000 people.” (General director of Remondis Minsk)

According to Tonglet, Philips and Read (2004), people's attitude towards recycling and sorting of their waste is mainly influenced by suitable separate collection possibilities and knowledge about recycling, but also by factors such as time, space and other aspects that can make the sorting of waste difficult. Previous experiences of recycling, as well as knowledge of the effects of recycling, are also important for behavior regarding waste sorting. Further, Rousta et al. (2015) has shown that accessibility, especially the distance to the collection point, along with correct information, can significantly increase the waste sorting rate. More containers in the city would make it more convenient for people and would therefore probably increase the sorting rate of MSW.



Picture 3. Collection point in the center of Minsk.



Picture 4. Collection point in the center of Minsk.



Picture 5. Container with the text “отходы бумага”, meaning “paper waste”.

Moreover, the containers often have insufficient signs, making it difficult for people to know which container is right for each fraction, as can be seen especially in picture 4 and picture 7. The container in picture 5 have a text meaning “paper waste” on the front, however, the wholes on top of the container are in the shape and design that is usually used for collection of glass. The same goes for the container to the right in picture 10, where the sign says “отходы пластмасса”, which means plastic waste, but the container have the typical wholes for glass waste.

As can be seen in the pictures (3-7), containers can differ a lot regarding shape, colors, and signs between different districts in the city, which also can play a role in the low sorting rate of MSW. This was mentioned by both of the respondents of CES.

“Different containers, different colors, different shapes, it is difficult for people to understand [...]” (Project Coordinator at CES)

“There are many cases where the points of collection of waste can be completely different, different containers, different colors, different organizing and approaches. [...] When we come to a collection point it really differs from new and old buildings and also between districts in the city.” (General director of CES)



Picture 6. Collection point in a suburban area.



Picture 7. Container for residual waste in the center of the city, with a barely readable sign.

Schloss et al. (2018), explain that people daily interpret different types of color codes that help us to quickly access and understand information, such as the red traffic light symbolizing stop, and the green light symbolizing go. Color coding can be used as visual communication for different waste fractions to facilitate sorting of waste.

Increasing the number of containers, together with improving the appearance of the containers with distinct signs of the specific fraction, most preferably with both text, colors and pictures, would probably increase the sorting rate of MSW in Minsk, especially along with awareness campaigns of the importance of recycling in general as well as information about the management process of MSW in Minsk.

The waste chutes inside the buildings is also an issue according to five of the respondents (table 5). It is more convenient for people to throw all their waste in the waste chute, unsorted, than to take the waste outside and sort it in different containers. According to the National Strategy (2017), waste chutes negatively affect the efficiency of the separate collection system of MSW. According to Rousta et al., the distance to the collection point can affect the willingness to sort MSW. It is reasonable to believe that, if having a few steps to a waste chute, or having to walk 50-100 meters to a collection point, many people would use the waste chute for all their waste.

Furthermore, there is no separate collection of organic waste in Minsk, instead it counts as residual waste and goes to landfills. Since MSW in Minsk consists of up to 27 % of organic material, it is a fraction which, if collected

separately, could significantly reduce the amount of MSW being landfilled. Four of the respondents mentioned the absence of separate collection of organic waste as an issue (table 5).

Education and information

The general director of Ekologia Goroda believes that the main issue regarding the low sorting rate is a lack of willingness among the residents. He emphasized that it is people's way of thinking that is the main problem, and not the equipment and conditions around. He sees that more young people are sorting their waste, while the older generation is more skeptical about sorting.

The respondents of the universities pointed out a lack of awareness and information regarding sorting of MSW. They believe that the problem starts from school with insufficient education in this area.

Waste statistics

Five of the eight respondents think that there are no reliable statistics regarding MSW generation and composition in Minsk (table 5). According to the general director of Remondis Minsk, the issue is that there is no clear understanding on how to measure MSW and there is no obligation to weigh it, resulting in that no one knows the total amount of MSW. Officially, MSW generation in Belarus is 400 kg per capita and year, but according to the calculations that Remondis Minsk have made based on the waste which they collect, the number is around 250 kg per person and year. The issue is that MSW is measured in m³, and then converted into tonnes using a waste density norm. However, as mentioned by the general director of Remondis Minsk, 1 m³ of waste is totally different if the waste is inside a container, compressed inside a truck or in a landfill.

“There are no reliable statistics, the problem is that no one knows the total volume of MSW, we believe it is around 250 kg per person and year in Minsk, officially they say that it is 380-400 kg per person, so if you have this fraction related to this amount, then you have one percentage, if you take the more realistic number of waste then the recyclable ratio is growing. That is why it differs, so it is a problem, but in Minsk there is 250 kg per person and in the villages, it is less than 150 kg per person. We just now how much waste we collect so we have calculated it from that, so for 400 is overstated.” (General Director of Remondis Minsk)

“We do not know the exact amount of MSW, it is a statistical gap, we only have approximate numbers. It is said that we have 350 kg MSW per person and year, but Remondis says less. there is also no information about the morphology of the MSW, the numbers are from the national strategy, but experts say that the numbers are not correct, we need better statistics and research tools.” (Project coordinator at CES)

According to United Nations (2016), there is an uncertainty in the official MSW statistics of Belarus. The law requires reporting of MSW in m³, which are estimations based on vehicle capacity. However, reporting of MSW in tonnes have shown to be more accurate and allow better evaluation of waste management policies. The statistics in tonnes is a combination of direct weighing of MSW as well as a recalculation of m³ to tonnes, using a factor of 0.2 tonnes per m³ (United Nations, 2016). The unreliable waste statistics is also discussed in the report by World Bank Group (2018a), where one can read that the information on waste quantities in Belarus is not accurate since MSW is measured in m³, and then converted into tonnes using a waste density norm. Further, Shershunovich & Tochitskaya (2018), have shown that the Belarusian statistics on waste have issues regarding the methodology, recording and coverage as well as an insufficient degree of international comparability of data.

Moreover, Milios et al. (2014) as well as the World Bank Group (2018a) notes that the MSW reporting system is fragmented and divided across several authorities. It is therefore difficult to assess the reliability of the data and the underlying calculation methodologies used for the different reporting. Harmonization of data reporting by the authorities is required to produce a reliable indicator on MSW generation (Milios et al., 2014). According to both Shershunovich and Tochitskaya (2018), and Kaza et a. (2018), accurate data on the quantity and quality of generated MSW are critical for the development of the waste management system. Accurate waste statistics allows governments to develop proper management methods, allocate budgets in a proper way and implement suitable measures and targets.

Tariffs/taxes/fees

All respondents want to see an increase in the price of waste management per capita (table 6). With higher tariffs, it would be possible to increase the number of containers and optimize the collection, and thereby create better sorting opportunities. It would also be possible to build more sorting plants and recycling facilities, as well as create more awareness campaigns.

“It should be started with the tariffs, having high tariffs you can stimulate, you can put more containers, separately collect them, build a sorting plant only for the recyclables, it is always based on tariffs. A lot of people are already separating, but they will start do it more if they get better conditions, more containers.” (General director of Remondis Minsk)

Decisions regarding tariffs are taken on governmental level. An issue regarding such a raise is however the risk of an increase of illegal disposal of MSW. People may start to dump their waste illegally in non-designated places or burn it themselves. Such behavior leads to social and environmental costs and has been identified as one of the most serious obstacles when introducing a higher waste management tariff (Bartelings et al., 2005).

Moreover, the project coordinator at CES thinks that the tariff should be different depending on if the residents separate their waste or not:

“Different tariffs would be good for example, if you separate your waste you should pay less than if you would mix everything, but in Belarus we only have a slightly lower tariff if there is no waste chute in the building, then you will pay less. I am sure that people would need some economic incentives to separate their waste.” (Project coordinator at CES)

It would however be difficult to implement different tariffs depending on if citizens sort their waste or not, since some kind of control and supervision then would be needed. In houses with one household it might be easy to implement, but in high-store apartment buildings it would be a challenge. Such a supervision system might also not be completely ethical.

Furthermore, six of eight respondents talked about an increase in the price of landfilling of MSW (table 6), to make other treatment methods more attractive. This is in line with the National Strategy (2017) which proposes a special MSW landfill fee. Such a fee would motivate MSW management operators to reduce the amount of MSW sent to landfills. The fee would, according to the National Strategy (2017), become a reliable source of financing for constructing and remediating well-designed landfills. Moreover, a landfill tax would, as aforementioned, make other treatment methods preferable. As can be read in a report regarding MSW management in Poland by the European Environment Agency (2013), the material recovery of MSW significantly increased when a landfill tax of 20 euro per ton was introduced in 2008. The tax is paid by the landfill operator and is, according to the European Environment Agency (2013), the most important initiative that has been taken to divert MSW from landfills.

Collection

Six of eight respondents mentioned the need of more containers for separate collection within the city, which would create better sorting opportunities for the inhabitants (table 6). Moreover, both the general director of Remondis Minsk and the project coordinator at CES argues that MSW should be collected in mainly two fractions, recyclable materials and non-recyclable materials (table 6). The recyclable materials would be taken to a sorting plant, while the non-recyclable waste would go to the landfill. This way of collecting MSW would simplify for the residents and eliminate the misunderstanding of why the fractions of paper, glass and plastics are mixed by the truck that collects the waste.

Four respondents talked about the potential benefits of a deposit-refund system (DRS) for glass bottles, pet bottles and aluminum cans (table 6). By introducing a deposit on the product packaging, which the consumer pays for when buying the product and then get back when returning the empty package, an economic incentive is created. Such systems seek to ensure that valuable or potentially hazardous materials are not disposed of, but instead recovered and recycled. The aim is also to avoid littering and promote the use of recyclable packaging materials. In general, these systems have proved to be highly effective in increasing the collection and recycling rates of the product in question. Several EU countries with an implemented DRS for beverage bottles and cans have reached return rates of at least 80 % and Norway have even reached return rates above 95 % (Balcers et al., 2019). According to Balcers et al. (2019), deposit-refund systems has shown to work very well in countries like Estonia, Latvia and Lithuania, where the economic incentive is an important aspect for the collection system. Before the implementation of a deposit-return system in Estonia, the litter

along roadsides was analyzed. The analysis showed that approximately 80 % of the litter consisted of plastic bottles and aluminum cans. After the introduction of the deposit-return system, the amount of litter along roadsides significantly decreased and an analysis of the composition of the litter showed that the share of beverage containers was below 10 % (Balcers et al., 2019). A deposit-refund system in Belarus would create a stronger economic incentive for people to recycle these packages, as the refund would be higher than the current price of metal, paper and glass at the before mentioned buying points. Such a system is one of the measures in the National Strategy (2017).

Six out of eight respondents mentioned that the waste chutes inside the apartment buildings hinder separate collection of MSW and that they should be closed (table 6). This is in line with the National Strategy (2017), where one can read that waste chutes as a structural element of apartment buildings and as a technical element of the MSW collection system, negatively affect the sorting rate as well as the sanitary conditions of the buildings. Closing of the waste chutes is one of the measures in the National Strategy. To close them, the owner of the building needs to conduct a vote among the residents who live there, and the majority needs to vote in favor of closing them. A legislative act, for example a ban on having waste chutes inside apartment buildings, is also a solution. Both the city of Grodno and the city of Gomel approved such a ban. In Grodno, many residents were dissatisfied when the city authority decided to close the chutes, but over time it worked out well. Along with the closing of the waste chutes in Grodno were also awareness campaigns to promote separate waste collection, as well as a sufficient number of containers within the city (World Bank Group, 2018b). According to the National Strategy (2017), closing of the waste chutes is one of the measures for a successful implementation of separate collection of MSW in the apartment block areas of Minsk. It would alter people's behavior and encourage them to bring their waste to a collection point. Miafodzyeva, Brandt and Olsson (2010), who investigated peoples recycling behavior, found that 34 % of their respondents would agree to close the waste chute in their building and start bringing their waste to a collection point, while 13 % opposed the idea and 53 % did not have a strong opinion. Among the respondents who would agree to close the waste chutes, the most positive groups were schoolchildren and private entrepreneurs, while the majority of the group who had a negative attitude were older than 55 years. Thus, more than 80 % of the respondents in the study of Miafodzyeva et al. (2010) were not against to stop using waste chutes. Closing of the waste chutes would lead to people having to take their waste to a collection point and most probably increase the sorting rate of MSW in Minsk. However, finding placements for new container sites when closing the waste chutes might be a problem due to urban density. This is noted in the report by CES and Greenpeace (2019), as well as by the general director of Remondis Minsk:

“The waste chutes, they are planned to be closed, but it is very difficult in Minsk, because when close them you need to have a place for containers, and in Minsk it is very densely populated, so you have almost no place to put the containers. And the people who have them closed to their apartments, these people will complain.” (General director of Remondis Minsk)

Aerobic/anaerobic digestion

Four of the respondents mentioned separate collection of organic waste as an important future step to develop the waste management in Minsk, either for composting or for biogas production (table 6). Food waste account for 27 % of the MSW in Belarus, making it a fraction which can significantly decrease the amount of MSW being landfilled and thus also decrease the amount of greenhouse gases released to the atmosphere. Separate collection of organic waste is however challenging in several ways. According to the European Commission (2015), organic waste is the most challenging fraction to collect separately, because of smell, need of cleaning of the containers and having a separate trash can in the kitchen. Implementing separate collection of organic waste would need strong educational measures and awareness campaigns to work properly. Another challenge is also finding places for containers for this fractions, however, if the collection would be in only two fractions, dry and wet waste, adding a third container would not mean any extra space compared to as it is today.

“First of all we need to make a possibility to collect organic waste, to produce biogas, and maybe composting. In Minsk biogas from sewage plant, but we also need to do it from organic waste. But it is difficult to add a fifth container for the organic waste, because we have so large buildings with many people and apartments, a lot of people in one small place, it is difficult.” (Project coordinator at CES)

As aforementioned by Zulkepli et al. (2017), aerobic digestion of organic waste According to Zulkepli et al. (2017) As compared to anaerobic digestion, aerobic digestion has been shown to be the most economically profitable and feasible alternative with moderate environmental impacts, while anaerobic digestion has the lowest environmental impacts of the two (Zulkepli et al., 2017).

Energy recovery

Five of the respondents opposed the idea of incineration of MSW. The general director of Ekologia Goroda believes that incineration of MSW not is necessary for Belarus and that separate collection and sorting of MSW is enough. The general director of TDF Ecotech, as well as the chairperson of Ecopartnership, believe that the technology needed to incinerate MSW in an environmentally safe way is too expensive for Belarus and that such a project would lead to emissions of hazardous substances.

“It is not a way for Belarus in my opinion, this plants which burns waste, to build them in an ecological safe way is very expensive, the technology and the equipment is very expensive, to make it clean is expensive. I searched some information about it and rich countries can afford to build these plants but Belarus don’t have the money for it, in our country every kopek¹ counts, they always try to make it cheaper and cheaper. I am afraid if such projects will be released on tender, maybe a Chinese company will win on tender, because they have a cheaper price, and it will not have the technology and safety needed.” (General director of TDF Ecotech)

According to Abbasi (2018), the advantages of energy recovery of MSW through incineration are offset by emissions of carbon dioxide, sulfur dioxides, particulates, heavy metals and other pollutants from the incinerators. It is possible to control these emissions by expensive and rigorous pollution control measures. However, it is not uncommon to find that, especially in developing countries, companies install pollution control systems to get the mandatory license, but then, in order to cut costs, do not operate and maintain these systems properly (Abbasi, 2018). Moreover, the respondents of CES believe that incineration of MSW not only would pollute the air, but also hinder the recycling of MSW, since materials would be burned instead of recycled.

“For me waste incineration is one of the barriers for waste recycling and separate collection in Belarus. To my mind, if we would implement incineration plants, we would burn materials that could have been recycled, because in Belarus the level of recycling is not high, a great amount of resources would be burn. Also, we have no separate collection of organic, all organic waste would go to the incinerator” (Project coordinator at CES)

¹ A kopek is a monetary unit which corresponds to 1/100 of a Belarusian ruble.

“Frankly speaking we are working a lot in order to prevent waste incineration. I mean for the last 10 or more years we have worked in order to prevent it, we think it is a very expensive and very unsustainable way of dealing with waste. [...] the incineration would also pollute the air, the atmosphere.” (General director of CES)

This is in accordance with Abbasi (2018), who notes that once incinerators have been installed, such facilities might decrease the amount of MSW being recycled, since there is a compulsion to utilize the incinerators to their full capacities. This can lead to a situation where more energy is wasted than is produced.

The construction of an incineration plant in Minsk is one of the measures in the National Strategy (2017). According to the National Strategy (2017), such a project has both economic and environmental requisites, since Minsk has heat and electricity consumption infrastructure as well as a high generation of MSW. The plant should have the capacity of 500.000 tonnes MSW per year to attain the best economic and environmental results. The National Strategy (2017) however emphasizes that the reuse of secondary raw materials takes priority above incineration.

Statistics

According to the general director of Remondis Minsk, MSW should be measured by weight and not in m³ as it is today. This would lead to more accurate waste statistics, which would make the development of the MSW management easier. This is also by Gorbatchev and Zenchanka (2019), who think that Belarus should implement the quantitative indicators used in the EU regarding waste management. Further, one can read in the report by United Nations (2016), that the Belarus should make appropriate legislative changes to fully introduce regulation of MSW management in tonnes instead of m³.

Education

Six of the respondents mean that there is a need of better knowledge and awareness of separate collection of MSW and MSW management in general (table 6).

“I think some very strong decisions on the educational level, at schools and universities, they are doing some stuff about batteries and paper collection, which is from soviet times, they collect waste paper and sell it and pay for excursions for the class that collected the largest amount. They spend the

money on the children, they have kind of competitions like this. Second of course, awareness of people who live in these buildings, about sorting the glass and paper and plastic [...]” (Professors)

Guerrero et al. (2013) has showed that when citizens are provided information about the importance of sorting and the benefits of recycling of waste, as well as instructions on how to sort the waste, they are more likely to participate in such activities. Thus, such information and education could strongly affect the efficiency of MSW separation.

Legislation

According to the 2007 Law on waste management article 25, there is a ban on the burial of recyclable materials. A large part of the MSW in Minsk is however landfilled, along with recyclable materials. According to the project coordinator of CES, this is allowed since, if the waste is thrown in the container for residual waste, it is considered to be residual waste even though it contains SMR.

“There are some questions about what is resources and what is waste, the definitions mostly depend on if you throw the waste in containers for recyclable material, then it is resources, but if you throw it in the residual waste, then it is waste.” (Project coordinator at CES)

This issue is also mentioned in the National Strategy (2017), where one can read that the prohibition on landfilling of SMR, as established in the Law on Waste Management, does not define objectives, mechanisms, and terms for implementing this legislative norm. Thus, there is a need of a change in the legislation to make the ban of SMR more effective and increase the amount of SMR being recovered.

Barriers

Table 7. Barriers for development according to each respondent.

Respondent	Lack of political will	No possibility to use the energy from an incineration/RDF plant	Product design	Legislation
General director of Ekologia Goroda				
General director of Remondis Minsk				
General director of TDF Ecotech				
General director of CES				
Project coordinator at CES				
Chairperson at Ecopartnership				
Head of the department of OSMR				
Professors				

Political will

All respondents talked about the political will as a barrier for the development of the MSW management (table 7). Issues regarding tariffs, cost of landfilling and legislation all depend on the government:

“The very low prices of the management of MSW is an issue, we cannot improve this situation, it depends on the government.” (Head of the department of the OSMR)

”The government is unwilling to raise the prices, they prefer to close their eyes and not see the problems, nothing will change in the industry because there are some more existential problems, waste is in the very last place to deal with.” (General director of Remondis Minsk)

Energy recovery

According to the general director of Remondis Minsk, there is no possibility for energy recovery of MSW in Minsk (table 7). The reason is that there are no consumers of RDF fuel on the market, such as cement plants and asphalt plants. This is also noted in the National Strategy, where one can read that RDF fuel production should start in the cities of Mogilev and Grodno instead of Minsk, since the main consumers are far away from Minsk.

Moreover, three of the respondents mentioned that the main barrier of energy recovery of MSW for electricity is that there is no demand of such electricity (table 7), since the nuclear power plant already provides enough electricity. There is also a quota system of how much renewable energy a company can produce:

”If you want to build a plant for renewable energy you need to get a quota from the government, a quota to produce exact amount of electricity from renewable sources. These quotas are very small, and they give very few, about 20 or 30 megawatt per year, so it is very small, too small quota to produce renewable energy for Belarus. About 2-3 % of all electricity produced per year is from renewable energy. The main reason is the nuclear powerplant in Belarus, they want to cut this renewable energy sphere, because all this production and selling of energy is in hand of the government, and they buy the energy from us, a little bit high in price, and they say that they have a lot of energy from the nuclear powerplant and that if they will give more quotas, they don’t know what to do with all this electricity.” (General director of TDF Ecotech)

”As I said there is one very important barrier which is the nuclear power plant, the amount of energy produced from waste resources will be lower, there are some regulations, permissions, limits of power introduced to

municipal lines from such places, it will be limited, because of over production.” (Professors)

“There are three obstacles, first one is what do with ashes after burning, the second one is the impact on the atmosphere, and the third one is that we don’t have any possibility to use the energy, because we have no need from other enterprises, how to use it, because it is a system, we can burn it but we cannot use it.” (Head of the department of the OSMR)

This issue is however not mentioned in the National Strategy (2017), which includes a plan of the building of an incineration plant in Minsk, the plan is based on the good prerequisites in Minsk with electricity and heat consumption infrastructure.

Legislation

Five of eight respondents talked about the waste legislation as a barrier for the development of the MSW management in Minsk (table 7). It is a barrier in many aspects; measurement of MSW in m³, no measures of prevention of waste and SMR considered residual waste when thrown in the residual waste container.

Product design

The respondents of CES highlighted the design of product packaging as a barrier for increasing the sorting rate of MSW. There are no instructions on the products regarding how they should be recycled. Instead, the consumer needs to know this beforehand in order to throw the product in the right container.

“I would say that it is actually a problem with product design and packaging, it is difficult for people to understand what can be recycled and what cannot, in some countries, i have seen it probably in UK, you could see on the product if it can be recycled and how/where. Right now, we only have what kind of material the product is made of but not how you would recycle it. That is definitely one of the obstacles.” (General director of CES)

In for example Sweden the EPR system, which shifts the responsibility for packaging waste from the municipality to the producer, has made the producers to incorporate environmental considerations in the design of their products with the end of life in mind. This has resulted in a large part of recyclable materials in

product packaging as well as recycling instructions on the product (Smart City Sweden, 2020). The EPR system in Belarus has not led to such instructions on the product packaging, the producers can choose to pay a waste management fee to the OSMR and by doing so fulfilling their obligations towards the EPR system. Thus, the EPR system should be changed in a way that further obliges the producers to design their products in a better way regarding recyclability.

Future research

This study has shown that there is an absence of reliable MSW statistics in Minsk and in Belarus as a whole. Accurate waste statistics are a basis for successful waste management. Thus, there is a need for further research regarding MSW generation and morphology in Belarus and how the data collection could be improved. Moreover, research on how to collect MSW in the most effective way for material recovery as well as how to increase sorting of MSW by citizens are important elements to further investigate. Research regarding most cost-effective measures to increase material recovery as well as energy recovery is also essential.

Critical review of the method

The choice of respondents strongly affects the outcome of the study. In this study, eight respondents were interviewed. The spread of the respondents in this study is believed to be sufficient with respondents from different parts of the waste management sector. However, the spread could of course be much broader. Moreover, two of the interviewed respondents in this study work at the same organization, it is therefore not surprising that these respondents have very similar answers and opinions. One of the respondents, the general director of TDF Ecotech, provided more information about the energy sector than the waste management sector. Further, the respondents of the universities are treated as one respondent since both was interviewed at the same time. One of them had limited knowledge in English, which also made it more convenient to interview them at the same time. The intention was to also conduct interviews with representatives from Ekores, Spetskommunavtotrans, the MHCS and the Department of Control over Waste Management within Minsk City Committee of Natural Resources and

Environmental Protection². It was unfortunately not possible to get in contact with any of them. Moreover, there is a possibility that the respondents in this study were not completely objective in their answers. Thus, if a higher number of interviews would have been conducted, the result of the study would have higher reliability as well as if other respondents would have been interviewed, the result of the study could have turned out different. Further, the choice of semi structured interviews as a method affects the result of the study. Structured interviews, or a poll, could have been performed instead and could have possibly led to other results and conclusions.

Furthermore, the study is limited by the fact that the performer of the study does not speak Russian fluently. Three of the interviews (the interview with the general director of Ekologia Goroda, the interview with the general director of TDF Ecotech and the interview with the head of the department of OSMR), were therefore conducted through an interpreter, leading to a possible loss of essential information. Moreover, literature in Russian could only be read in a highly limited way, relevant information for the study may therefore have been excluded.

² Minsk City Committee of Natural Resources and Environmental Protection is a territorial authority of the MNREP.

Conclusions

The main problems regarding the current management of MSW in Minsk is the low waste management tariffs per capita, not allowing any development of the waste management in terms of sorting and recycling facilities, along with the low cost of landfilling of MSW, making landfilling the most affordable treatment option. Additionally, one severe issue is the inadequate statistics of MSW. Another difficulty is the low sorting rate of MSW, which depends on several aspects; insufficient number of containers for separate collection, untidy collection points, unclear and worn signs on containers, waste chutes inside apartment buildings, insufficient information regarding sorting and as well as a lack of information regarding MSW management in general. There is also a lack of economic incentives, for both producers and consumers, regarding recycling of product packaging. Additionally, there is an absence of strategic direction for the future development of the MSW management in Minsk, with no specific measures and targets to follow.

To improve the MSW management in Minsk, this study shows that the introduction of a landfill tax or fee is essential, in order to incorporate the environmental costs of landfilling and to make other treatment methods more attractive. It is also necessary for the government to raise the price of MSW management to finance the development of the waste management and make it more attractive for private companies and investments. It would allow the building of more sorting and recycling plants, a higher number of containers within the city, implementation of separate collection of organic waste as well as awareness campaigns. Further, the implementation of a DRS would create a strong economic incentive for people to recycle their bottles and cans. Since the MSW statistics is measured in m³ and not tonnes, which leads to inaccurate waste statistics, there should be a change in the measurement norm towards weighing all MSW in tonnes. It is also necessary to revise the legislation in a way that makes the ban on burying SMR more effective and not allows recyclable materials being interpreted as residual waste once they are thrown in that container.

Regarding the barriers of improving the MSW management in Minsk, the political will is the main barrier, since tariffs and taxes is regulated by the government.

To gain a deeper understanding of the current situation of Minsk's MSW management, its further development as well as entailed difficulties, more comprehensive research is needed.

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Appendix I

Ethical reflection

Different countries have different economical, geographical, and infrastructural conditions of waste management. Thus, it can be difficult to compare waste management systems between different countries, as well as analyzing how a country's or city's waste management system can be improved, without first making an assessment of such differences. The result of this study is therefore based on information from people close to the practice and well-educated in the waste management area in Minsk.

Interviews included in the work of this thesis was conducted in a way that ensured the respondents the aim of the study, the purpose of their participation and how their contributions were supposed to be used. The recording of the interviews was done after the approval of each respondent. To ensure that the information given in the interviews was right, all respondents were sent the transcription of the interview and were also offered to change or add anything. Additionally, the thesis was sent to all respondents before the publication of it in LUP Student Papers to further guarantee that the information they contributed with was handled and interpreted in a way that they felt comfortable with.

Appendix II

Interview guide

Current situation

- What problems can be stated regarding inefficient management of MSW in Minsk from your point of view?
- What kind of system exists for the measurement of the quantity of the collected waste?
- What kind of system exists for the identification of the composition of the collected waste?
- How much of the MSW in Minsk goes to landfills?
- How much of the MSW is recycled/material recovered?
- Is any of the MSW in Minsk being incinerated to produce energy?
- What is the status of the landfills? Are there many problems with them? Regarding leachate for example
- What is people's general attitude towards sorting their waste?

Development

- Which main gaps in the MSW management can be identified and what kind of steps do you think need to be applied to improve the situation?
- How can the collection be improved?
- How can the amount of material recovered MSW increase?
- How can the amount of energy recovered MSW increase?

- What are the main gaps and what kind of possible changes should be done in the current legislative framework?
- Do you know if there are any allocations planned for the development of the MSW management (such as facilities for energy/material recovery)?

Barriers

- What are main obstacles for increasing the share of sorted MSW?
- What are the main obstacles regarding the development of the collection of MSW?
- What are the main obstacles for increasing the share of recycled MSW? Both in terms of energy recovery and material recovery



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Miljövetenskaplig utbildning
Centrum för miljö- och
klimatforskning
Ekologihuset
223 62 Lund