Analysis of the amount of textile waste in mixed municipal waste in the Czech Republic between 2016 and 2021

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Summary

The EU strategy for sustainable and circular textiles, published in March 2022, sets out the aim to propose binding targets in preparation for the reuse and recycling of textile waste as a part of the revision of EU legislation on waste planned for 2024. However, to set such specific targets for textile reuse and recycling, including the subsequent scaling up of collection and recycling capacities, it is necessary to know the amount of textile waste currently present in mixed municipal waste (MMW). This article thus summarises the results of the analyses of 64 MMW samples performed in the Czech Republic. The results show that textile waste amounted to 6.16% MMW in 2016–2021. To estimate the total amount of textiles in MMW, the specific data between 2018 and 2020 was used (as these data are unified between the Czech Statistical Office and the Ministry of the Environment). Based on the data for this period, the total textile volume in MMW amounted to approx. 135,989 tons.

Therefore, the article summarises the current challenges for municipal textile waste management following the EU strategy for sustainable and circular textiles published in March 2022 by the European Commission, defines the data gap in the knowledge of the amount of textile waste in MMW in the Czech Republic, and analyses the possible amount of textile waste in MMW. Although the results only represent the Czech Republic, they can be a valuable input for accurate target setting and as a model for similar analyses performed in other EU countries. Specifically, having data describing the current presence of textile in MMW can form an important base for an evidence-based approach to the design and creation of a network of textile waste collection containers and services prior to the 2025 deadline, in order for it to reflect the existing amounts of household waste. The data can also be used to set targets for textile waste collection, recycling and for reductions of the share of textile in MMW. At the same time, the article indicates that the absence of such data is common, and points to the need for further detailed research in this field.

Keywords: *MMW – mixed municipal waste, textile waste, waste analysis, analysis of textile waste samples in MMW, EU Strategy for sustainable textiles, methodology for analysis of textile waste*

Introduction

Textile waste frequently ends up in municipal waste, where it creates countless environmental issues, from the leakage of toxic substances into groundwater and soil through to greenhouse gas emissions contributing to climate change, especially if dumped1. Currently, around 92 million tons of textile waste are generated across the globe per year, out of which approximately 16 million tons originate from EU countries; and with respect to increasing consumption and the low lifetime of products, this scenario estimates its increase up to 148 million tons by 2030 2.

Regarding textile waste from consumers, which is referred to as municipal textile waste (i.e. all textile waste except for that generated during the production process), the European Environment Agency3

estimates that an average European disposes of approximately 11 kg of such waste per year, i.e. around 5.8 million tons in total. Every year in the EU, up to 2.1 million tons of consumer clothing and soft furnishings are collected separately for recycling or selling on global reuse markets, which represents approximately 38% of textiles launched to the EU market; however, it is supposed that the remaining 62% continue to form part of the mixed municipal waste (MMW) without any further use[4]. By recalculating the 2018 data on waste production according to Eurostat and the number of inhabitants according to the CSO, we learn that the Czech Republic was the seventh biggest producer of textile waste in EU, with an average amount of 12.36 kg per person 5. According to other data on waste production in EU countries, the Czech Republic was the country with the second highest production of textiles going to landfill, with an average of 5.8 kg per inhabitant. Population information for each country was obtained from the 2019 World Population Prospects Revision [7].

Recycling textile waste rather than disposing of it through MMW is associated with multiple benefits. From an environmental perspective, an example is that producing a tonne of recycled polyester rather than using primary raw materials could save approximately 80% of toxin release, 60% of energy use and 40% of CO_2 emissions [8], although currently such closed-loop recycling (with clothes being recycled into new clothing) is only used in less for less than 1% of textile waste [9]. From an economic perspective, the value embedded in the textile (such as the labour and raw materials) is lost when the material goes to waste, meaning that the externalities are associated with a market failure. In a study from 2018, Staicu and Pop estimate that over 500 000 000 USD are lost annually due to textile and clothing being underutilised [10].

In response to these issues, more and more emphasis in recent years has been placed on textile waste in the European Union, which has also determined it as one of the priorities in the European Green Deal. In 2020, the European Commission presented the circular Economy Action Plan (an updated version of the original from 2015), which spells out the priority of the EU's move towards closing the material flow of textiles 7. Analyses of material flows, the goal of which is to collect data and conceptualize them into a logical framework and visualisation, are necessary for knowing the possibilities of increasing the degree of circularity in the textile industry. They are one of the basic prerequisites for better monitoring of material flows used within the entire life cycle and for their understanding, for example by key actors involved in policy-making [11]. In its Circular Economy Action Plan, the European Commission also mentions the links to achieving carbon neutrality by reducing the difficulty of extracting primary raw materials, increasing recycling, and extending lifecycles. The action plan imposes new rules on individual member states aimed at achieving the above-mentioned goals. For example, according to Article 11 (1) of the revised Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, published in the Official Journal of the EU on 14 June 2018, member states are obliged to introduce sorted textile collection starting from 1 January 2025 [12]. At the Czech level, this regulation builds on the approval of a new package of waste legislation taken in December 2020. The main goal is to increase the sorting and recycling of waste, to reduce dumping, and to transpose and fulfill the applicable EU legislation and waste targets. It already contains specific proposals for tools, e.g. obligatory separate collection points for textiles from 2025. The Waste Act and other stated legislation were bindingly adopted in 2020 and entered into force on 1 January 2021[13].

In March 2022, the EU confirmed its position with respect to closing the material flow of textiles and supporting recycling in the EU Strategy for sustainable and circular textile. Besides criteria for eco-design, preventing the destruction of unsold goods, or for solving the problem of microplastics, a significant part of the strategy is devoted to the extended responsibility of the manufacturer and to promoting the reuse and recycling of textile waste [14]. The key message within the context of this article is represented by two types of requirements. Firstly, it is the emphasis on preventing waste generation by preparing the separately collected textile waste from households and similar waste for reuse. This step aims to reduce volumes of waste management types that are lower in the waste hierarchy (recycling, energy use, and dumping). The second requirement is represented by the European Union's plan to monitor development in the generation, composition, and processing of textile waste. The Commission also launched a specialised study aimed at proposing binding targets in preparation for the reuse and recycling of textile waste as a part of the revision of EU legislation on waste planned for 2024.

Czech legislation does not currently create any obligation to measure the volume of textile waste, and at the same time, there are no legally established goals for its reduction[20]. In the Czech Republic there are no comprehensive data based on which the required capacity for carrying out collection in compliance with applicable legislation, both at the level of the Czech Republic and the EU, could be predicted. From 2025, basic and already approved targets will include, for example, the introduction of a system for separate collection of textile waste at the municipal level.

To set this system effectively, it is necessary to fill the data gap regarding the volumes and composition of textile waste, since this information is not at the moment officially reported and analysed in the Czech Republic. This work is therefore devoted to measuring the amount of textiles in MMW in order to form a basis of information to enable the setting of targets in the Czech Republic. The focus of the text is textile waste in MMW.

The most extensive research so far on a similar topic in the Czech context has been conducted by Lucie Nencková in her dissertation from 2017, looking at what happens to household textile waste in the Czech Republic. While this was a significant contribution in terms of sketching the potential material flows, the work highlighted the fact that specific data in the form of the amount of textile waste in MMW is currently lacking. The author states that the most common choice (24% of respondents) for handling unnecessary household textiles is a container for mixed municipal waste, several times a year. 21% of respondents hand over textiles in special containers and 18% donate them to relatives. Other ways were, for example, taking it to a cottage or handing it over to a collection yard. A minimum of respondents used these routes (Nencková, 2017). This article therefore aims to fill that gap [16].

The aim of this work is to present data on the content of textiles in MMW, acquired by performing 64 physical analyses of MMW samples carried out in the Czech Republic in 2016–2021. This share is further recalculated to an amount in tons, which can provide better estimates of current textile amounts in MMW. The aim is to provide a clearer picture of the amount of textiles for which it is planned to set clear targets in accordance with the EU Strategy for Sustainable and Circular Textiles, both for reuse and recycling. Today, many studies are based on significant estimates, and problems with the robustness of these estimates may be based on gaps in data availability and reporting on both the input and output sides, which need to be harmonised to achieve effective combined circular economy monitoring [17]. During the research of current MFA studies in the area of textile flows at the EU level, it was confirmed that the most significant problem is the absence of data and non-aligned definitions of individual processes [18].

Experimental part

Data presented in the results of this work have been gathered by performing 64 physical analyses of MMW samples carried out in the Czech Republic in 2016–2021. In total, around 33 tons of MMW were analysed. Sampling was carried out using a non-probability method. These analyses were made based on cooperation between the Institute of the Circular Economy (INCIEN) and municipalities and cities that were interested in a more detailed analysis of MMW. Their aim was to identify the proportion of respective components suitable for further sorting and recycling. These municipalities got involved in these analyses for three reasons. The first was their involvement in test projects for the given methodologies, for example in Prague where the first waste analyses were conducted. The second was their participation in the project Municipalities on the Way to Less Waste, which was set up by the organisations INCIEN and JRK Czech Republic. Its target included a waste analysis, education, and a set of measures for improving the waste management. The third reason for their engagement was an interest in finding out the composition of their own municipal waste, so as to optimise waste management in municipalities.

Over the course of several years, a sample covering all districts in the Czech Republic was created. The municipalities comprised several types of neighbourhood (e.g. flats or family houses) in various sizes. A basic network for the collection of sorted waste was available in all areas. For the purpose of

this work, a summary of these analyses is used as the only, sufficiently extensive research available for the territory of the Czech Republic over such a long time series under the same methodology. Its added value also lies in its temporal and spatial dispersion. Some of the basic assumptions that can affect the analyses' results include the intensity and availability of the textile collection network, the education of the population about textile sorting opportunities, and the social standing of the population, etc.

The goal of the waste analyses was not only to ascertain the contents of the share of textiles, but also to analyse its total composition based on the methodology for sampling and analysing the composition of MMW[19]. 22 subcategories of sampled waste from the MMW catalogue number 20 03 01 were sampled.

The complete list of sampled categories within the original sample. Textiles are just one category:

- Paperboard + cardboard, printed material,
- Beverage cartons,
- transparent film, coloured film, PET white, PET coloured, other plastics, HDP hard plastics,
- electronic waste,
- gastro-waste,
- **textiles, footwear** (in the results of physical analyses counted together in one category),
- wood and chipboard,
- construction waste,
- glass,
- infectious/non-infectious waste,
- metals,
- hazardous waste,
- other non-combustible/mineral waste (soil, ash),
- other municipal waste – unsortable fine part MMW 0–40 mm.

In certain areas, for example, several sub-categories were simplified and unified (e.g. the various categories of plastic waste). However, this unification did not affect the data in this study since the textile sampling was always consistent. When selecting the sampled amount, a sample containing a mixture of MMW from collection containers situated in areas of apartment blocks or single-family homes was always arranged with the collection company. Thus the samples represented various types of housing within municipalities. The selected municipalities were themselves keen to provide the most representative waste sample, as these waste analyses formed the basis for subsequent important investment decisions related to improving their waste collection systems. Whenever possible (availability of their own equipment for collecting individual containers, available equipment operators), all individual collection containers were gathered from as many different parts of the municipality (high- and mid-rise estates, areas of single-family homes, various districts, etc.) to ensure samples were as representative as possible. This sampling methodology was used for approximately two thirds of samples. The remaining analyses were performed by tipping off control samples from a collection vehicle used for collecting waste from the whole municipality or city.

In some cases, the analyses were carried out for apartment buildings and single-family homes separately (due to the interest in defining differences in sorting across different types of housing). The precise weight of the sample was ascertained either by deducting the reading from the weighbridge before and after tipping off the waste sample from collection vehicles or, in the case of vehicles with their own weighing system, based on readings from that scale. A check was performed after adding up the sum of the weights of all individual samples. Sampling was carried out by trained INCIEN workers led by one technical worker who supervised the process to ensure all analyses were identically conducted, which made the measurement method consistent. Sorted components were subsequently stored in plastic bags for better handling and precise weighing on a digital weighbridge with a load capacity up to 100 kg, Type 1732, produced by ISO.

When collecting textiles in MMW, textiles get wet – for example due to their contact with bio-waste and other wet parts of the mixed waste – and so dirt and moisture collect on the textiles, which results in higher sample weights. Thus the moisture content distorts the research results. Therefore, to calculate the real weight, it is necessary to use a moisture coefficient for a wet MMW sample. For this purpose, a search was conducted in the literature for papers working with moisture coefficients in analyses of

MMW. The most similar analysis was carried out in Sweden. Here, different packaging materials were evaluated, as was the amount of moisture captured by the components of MMW when mixed, for example, with biological waste [20]. A similar procedure was used in a study of material flows in Finland [21]. Unfortunately, no coefficient has been determined directly for textiles; therefore, the coefficient for materials having the most similar properties (high absorbability, structure) was used. For the purposes of this research, the coefficient for paperboard mixed with municipal waste containing 20–30% of bio-waste was selected (which correlates with data regarding the bio-waste contents in MMW in the Czech Republic). This coefficient is determined at 0.74 and the resulting data is recalculated using it.

Data from the Czech Statistical Office (CSO) are used for the final recalculation of the percentage share of textiles in MMW. In the past there were inconsistencies and double data collection between the CSO and the Ministry of the Environment (ME), but the data were united in 2021. In the final volume of MMW produced in the Czech Republic, both municipal waste and "waste similar to household waste" (technically speaking commercial waste according to the Act on Waste) are represented. This change, following which both data from household waste and that "similar" to it are included (this official term refers to waste produced by companies), has resulted in compliance with the European Waste Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008). The data were reconciled and recalculated upon agreement back to 2017. To recalculate data on the amount of textiles in MMW, CSO data for MMW under the catalogue number 200301 for 2017–2020 were used. The final recalculation of the percentage share comes from data related to our own MMW analyses for 2016–2021 and from average MMW production in 2017 – 2020 according to CSO data (when finishing this article, data for 2021 were not yet available). When calculating the percentage share of textiles in MMW, the result was rounded to two decimal places.

In the discussion, the results of own textile analyses are also compared with the only other available data on MMW analyses focused on textiles, which were performed by the company EKO-KOM. In the Czech Republic, no other comprehensive research devoted to measuring textile waste in MMW is currently available. Only EKO-KOM's data for a period of two years is available (analyses are probably still being carried out, but the data is not published). EKO-KOM, an authorised packaging company, regularly analyses the composition of MMW produced by Czech households. Waste analyses in the territory of the Czech Republic are carried out periodically every two years. Data is only available for 2016 and 2018. In 2016, 95 samples were analysed, and in 2018, 121 samples, from 16 different locations in total. In recent years, the analyses are repeated at regular quarterly intervals with the aim of capturing seasonal changes in consumer behaviour. However, other data are not yet publicly available. Thus the publicly available data from the EKO-KOM analyses are currently useful, especially for comparing the final results. Their analysis methodology (manual sorting of sub-samples with a separated undersize fraction) is similar to the analysis performed by INCIEN used in this study. A substantial difference, however, is in the way textiles are counted, since EKO-KOM states clothing and soft furnishings only when their quality is good, which amplifies the trend towards sorting for further material use. Soiled or otherwise damaged clothing, unidentifiable scraps, or otherwise degraded textiles are not included [22,23 2324]. The analyses in this study, on the other hand, also contain unusable textiles (which are estimated by the qualified supervisor of the waste analyses to be around 15% of the total textile samples in individual analyses).

Results and discussion

The goal of the research was to ascertain the average share of textile waste in MMW produced in the Czech Republic. The subject of further calculations were the results from 64 analyses. The following table sets out the partial results, recalculations for the share of textiles in each, and the annual averages for the amount of textiles in MMW in percentages.

Table 1: Results of analyses on the share of textile waste in MMW.

Analysis date	Municipality/town name	Analysed amount (in kg)	Textile volume (in kg)	Proportion of textiles in the analysed sample (in %)	
2016	Lhenice	824.5	31	3.76%	
2016	Lhenice	770.85	25.5	3.31%	
2016	Trojanovice	663.75	40.1	6.04%	
2016	Horní Suchá – Finnish lodges	58.3	2.5	4.29%	
2016	Horní Suchá – block of flats	167.9	7.6	4.53%	
2016	Prostřední Bečva	141.5	9	6.36%	
	Average representation of textiles in the sample for 2016				**4.72%**
2017	Životice	427.7	32	7.48%	
2017	Nový Jičín	436.6	26	5.96%	
2017	Únětice	480.9	31.6	6.57%	
2017	ZEVO (Waste-to-Energy Facility) – Municipal District Prague 13	833.82	61.92	7.43%	
2017	ZEVO (Waste-to-Energy Facility) – Municipal District Prague 15	706.8	16.5	2.33%	
2017	ZEVO (Waste-to-Energy Facility) – Municipal District Prague 13	959.9	43.5	4.53%	
2017	ZEVO (Waste-to-Energy Facility) – Municipal District Prague 13	670.98	40.8	6.08%	
2017	Jaroměřice	463.5	21.5	4.64%	
2017	Harrachov	615.4	6.5	1.06%	
	Average representation of textiles in the sample for 2017				**5.12%**
2018	Municipal District Prague 15	619.5	46.35	7.48%	
2018	Municipal District Prague 15	672.3	29.1	4.33%	
2018	Municipal District Prague 13	264.85	17.4	6.57%	
2018	Municipal District Prague 15	562.8	20.7	3.68%	
2018	Municipal District Prague 16	618.7	25.4	4.11%	
2018	Municipal District Prague 15	614	48.1	7.83%	
2018	Straškov - Vodochody	446.4	32.1	7.19%	
2018	Police nad Metují	332.7	39.7	11.93%	
2018	Choceň	304.5	26	8.54%	
2018	Hrušovany	286.9	20.4	7.11%	
	Average representation of textiles in the sample for 2018				**6.88%**
2019	Horní Jířetín	284.45	31.65	11.13%	
2019	Veselá	394.2	15.9	4.03%	
2019	ZEVO (Waste-to-Energy Facility) – Prague Štěrboholy	622.8	36	5.78%	
2019	Příbor	458.24	45.85	10.01%	

2019	Odolena Voda	365.97	21.15	5.78%	
2019	Modřice	374.08	22.8	6.09%	
2019	Družec	463.49	53.06	11.45%	
2019	Brniště	402.8	36.5	9.06%	
2019	Kovářská	370.1	18.2	4.92%	
2019	Velešín – mid- to high-rise housing estate	344.8	39.5	11.46%	
2019	Velešín – single-family homes	329.4	23	6.98%	
2019	Ostřetín	374	36.8	9.84%	
2019	Buštěhrad	394.9	19.8	5.01%	
2019	Zádveřice-Raková	338.6	12.5	3.69%	
2019	Ratiboř	514.1	21.3	4.14%	
2019	Lukov	372.6	14.3	3.84%	
2019	Chýně – mid- to high-rise housing estate	299.5	8.8	2.94%	
2019	Chýně – single-family homes	326.5	23.1	7.08%	
2019	Libchavy	415.3	22.6	5.44%	
2019	ZEVO (Waste-to-Energy Facility) – Prague Štěrboholy	609.5	42.6	6.99%	
2019	ZEVO (Waste-to-Energy Facility) – Prague GASTRO	616.1	27.4	4.45%	
2019	Paskov	401.1	26.8	6.68%	
	Average representation of textiles in the sample for 2019				**6.67%**
2020	Bělá pod Bezdězem	522.35	19.4	3.71%	
2020	Dolní Podluží	514.2	22	4.28%	
2020	Dolní Podluží	496.4	51.4	10.35%	
2020	Letohrad	488.65	54.2	11.09%	
2020	Olešnice	480.1	13.3	2.77%	
2020	Nový Jičín	412.95	37.3	9.03%	
2020	PSAS – GASTRO (30.9.)	593.65	24.75	4.17%	
2020	Veselí nad Lužnicí	381.55	17.7	4.64%	
2020	PSAS – GASTRO (9.12.)	609.2	31.85	5.23%	
	Average representation of textiles in the sample for 2020				**6.14%**
2021	Teplice	355.4	13.6	3.83%	
2021	Kopřivnice – mid- to high-rise housing estate	396.7	18.65	4.70%	
2021	Kopřivnice – single-family homes	407.9	19.2	4.71%	
2021	Bílovec	467.15	32.05	6.86%	
2021	Sedlec-Prčice	460.8	18	3.91%	
2021	Paskov – mid- to high-rise housing estate	300.15	15.95	5.31%	
2021	Paskov – single-family homes	259.35	39.5	15.23%	
2021	Rudolfov	470.55	45.35	9.64%	
2021	Studená	420.5	5.5	1.31%	
	Average representation of textiles in the sample for 2021				**6.16%**

Data from the waste analyses were averaged and the final average share of textile waste in MMW amounted to 6.16% in 2016 – 2021, with a standard deviation of 2.79%. Textile waste in MMW is most often represented in the range of 3.37% to 8.95% (i.e. 6.16% ± 2.79%). Table 2 shows the summarised results of the main statistical indicators for the representation of textile waste in MMW. Most relevant for further work and for estimating and generalising the total amount are the data between 2018 and 2021, as these years represent unified statistics of ME and CSO. However, the calculation for 2016 – 2021 contains more measurements and uses more samples for the average percentage value; that is why both versions are stated.

Table 2: Statistical analysis results

Indicator	**2018 – 2021**	**2016 – 2021**
average (arithmetic)	6.53%	6.16%
median	5.78%	5.78%
weighted average	6.34%	5.92%
standard deviation	2.93%	2.79%

It is necessary to take into account that this generalisation comes from a relatively limited sample created using a non-probability method. Further, it is important to say that fluctuation is a characteristic feature of the proportion of textile waste in MMW. Compared to other waste types, only a small amount is formed continuously. This probably approximates to 1%, which can be seen in the analysis results with the lowest textile share. In cases where there is a larger quantity of textiles, it is often apparent that there is only one source, e.g. a household sorting its wardrobe. Since these activities are frequent and therefore necessary to take into account if we want to accurately estimate the share of textiles in MMW, it cannot be said that these one-time reasons constitute a distortion of the actual results of the analysis. As a result of this characteristic, however, the correlation between the amount of analysed waste and the amount of textiles is low. In practice it means that in some cases the amount of MMW is high, but the sample does not contain waste from 'wardrobe sorting' and thus the amount is low, but sometimes even the small MMW samples contain a high share of textile waste. Owing to the low correlation between the amount of analysed MMW and the amount of the textile waste separated out of it, the weighted average is thus a less relevant indicator.

Which means that in analyses of MMW, deviations in certain samples are apparent. The variance of the measured quantity lies within the range 1.06 – 15.23%. In specific analyses containing deviations, the assumed reasons for such deviations were stated by the leading technical worker supervising the research.

The average amount of MMW produced in the territory of the Czech Republic between 2018 and 2020 according to CSO data is 2,798,126.67 tons. The average share of textile waste for the same period, i.e. 2018 – 2020 according to locations where analyses were made, is 6.56%, which converted to tons is 183,557 t. However, this amount according to the methodological setting of the research is to be recalculated using the selected coefficient 0.74 to deduct moisture [20]. After deducting moisture, the final amount of textile waste represented in MMW is 4.86%, i.e. 135,989 t when converted to tons.

In a basic comparison to check the relevance of the data, an analysis of the available data on the share of textiles in MMW in other European countries was carried out. In Finland, a study from 2016 gives us an average share of textiles in MMW of 5.1 – 6.0% [22]. In a follow-up Finnish study devoted to modelling a comprehensive analysis of material flows based on six sorting studies, it was found that the share of textile, footwear and bags formed 6.3% in MMW[23]. That share was further specified, and according to expert estimation the textile share was only 5% [24]. In Denmark, a similar study from 2018 states a 2.9% textile share in small containers and 7.7% in containers for MMW in recycling centres[25].

The similarity of these values with the values resulting from the analyses stated in this study indicates that the results are in compliance with the textile share in municipal waste in other European countries. However, to use this data to accurately and effectively set systems for handling textile waste, further research regarding the material flows of textiles in the Czech Republic is necessary. This relates to the previously mentioned issue of data uncertainties and differences among existing sources.

Table 3: Conversion of the percentage share of textile waste in MMW to tons

Source: Author's own work

Waste type / production per year (in tons or percentage)	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Aggregated average (for 2018–2020)**
MMW production volume according to CSO data (in tons)	-	-	2,806,203	2,783,234	2,804,943	-	2,798,126.67 t
Textile share in MMW according to INCIEN analyses (wet sample)	4.72%	5.12%	6.88%	6.67%	6.14%	6.16%	6.56%
Textile share in MMW according to INCIEN analyses (dry sample)	3.49%	3.79%	***5.09%***	***4.94%***	***4.54%***	4.56%	4.86%
Total volume (converted to dry sample)			***140,938.739 t***	***137,374.864 t***	***135,955.587 t***		***135,989 t***

Note: Only the years 2018 – 2020 were considered in calculating the final textile amount, i.e. when harmonised data from CSO and ME were available and could therefore be taken as objective. Conversions were also performed using results from this period.

For a comparison with results of these studies, we can look, for example, at information provided by EKO-KOM for 2018 regarding the occurrence of respective groups in tons, converted from the total amount of MMW reported by municipalities. Based on these analyses, the textile waste content in MMW amounted to 2.1%, i.e. 43 thousand tons (+- 37) in a quantity conversion. For data from 2020, it is stated that the textile share in MMW is 1.8% and the material occurrence is converted to 38 (+-51) thousand tons. EKO-KOM also uses similar correction moisture coefficients. In its analyses of MMW from 2018, its moisture estimation is approx. 20% of the weight for paper or plastic. However, for calculating the total amount in tons, EKO-KOM uses the total amount of MMW directly reported by municipalities. This data is not publicly available; therefore, only the data officially available from the ME is used for the purposes of this study. For further work with this data, coordination and unification of the resulting values is necessary.

The EKO-KOM analyses would indicate a lower textile share than our study – the EKO-KOM percentage approaches the lower limit of the final representation from our analyses. However, it is important to recall the difference in methodology that may explain part of this difference. EKO-KOM considers only textiles in good condition, i.e. which can be reused, while analyses performed by INCIEN also incorporated soiled or damaged clothes to ascertain the comprehensive, total representation of textile waste in MMW, which on average constituted 6.16% in 2016 – 2021 (with a standard deviation of 2.79%, i.e. with a share mainly between 3.37% and 8.95%).

For more precise results it is necessary to follow up the research with further analyses, which would make more data available and hence permit more advanced follow-up statistical work. Besides which, a more precise moisture coefficient would support the accuracy of the final result. Research focusing specifically on the amount of this figure for textiles is needed.

Conclusions

The basic assumption for fulfilling the mandatory textile collection measures is knowledge, as precise as possible, of amount of textile waste in MMW, based on which it would be possible to determine binding targets both for the collection of textiles for further use and for collection intended for recycling. The main question of this research was to determine the share of textile waste in MMW. According to physical analyses, it was determined that the total textile share, after deducting the corrective moisture

coefficients of 0.74, is 4.86% on average, which is 135,989 tons for the reference period of 2018 – 2020 (i.e. when harmonised data on the total MMW production in the Czech Republic is available). After deducting the qualified estimate of 15% for further non-usable textiles from the total textile amount in the sample, the resulting amount is 4.13%. When converted to tons, the amount is approximately 115,563 tons of textiles. Although data for only 2018 – 2020 are used for the final calculation, in the results the article's authors publish all the data available for possible follow-up research that would examine another time series. When using data from 2016, the average textile representation in MMW is 6.16%, with a standard deviation of 2.79%, i.e. most frequently in the range of 3.37% to 8.95%.

The output of this article is the specific part of the material flows of textile waste not yet covered by data which currently ends up in mixed municipal waste in the Czech Republic. However, a suitable follow-up step is to conduct a comprehensive study of the material flows of textile waste (i.e. an MFA study), for which this work may be a partial input. An analysis scheme for material flows that aims to effectively visualise the actual flows of materials within the system is also a useful interpretive framework for conceptualising this complex issue. Such analysis would be a significant base for both identifying data gaps and policy discussions regarding setting suitable specific measures (legislative, economic, etc.), which would contribute to the efficient collection, use, and return of materials back into circulation in compliance with new European and national targets in the area of textile waste management. Specifically, the results can be used in the further work of the authors, who are preparing a conceptual framework for the MFA at the level of the Czech Republic and for other research teams, which include, for example, the CEVOOH project (Centre for Environmental Research: Waste and Recycling Management and Environmental Safety). The main goal of the project is to provide the Ministry of the Environment with professional background in the area of waste and recycling management and problematic material flows, including textile waste.

For greater accuracy of results, it would be necessary to extend the research by more locations, use probability sampling methods, and ideally perform measurements repeatedly, which would prevent deviations caused by e.g. random wardrobe sorting in households. However, such data must be reflected in the results since similar cleaning activities in households are carried out frequently, and thus constitute relevant and regular waste content. At the same time, it would be appropriate for such research to distinguish between usable textiles and the textiles that remain which are too damaged or soiled. Usable textiles are considered to be a material suitable for material utilisation at the level of textile reuse, or material recycling (in the same or worse quality); disposal by energy use and landfilling is not considered material utilisation. Reusable or recyclable textiles are considered textiles that are not damaged or significantly soiled (by paint or cleaning products due to their use as a substitute for rags and cloths for household cleaning, etc.). The ratio of damaged or significantly soiled textiles has not been separately sampled on a regular basis in order to provide representative results for all analyses. Nevertheless, based on a qualified estimate of the technical supervisor present at physical analyses, it can be stated that approximately 15% of the textile share in the sample cannot be reused. For further analyses or follow-up research, we recommend also recording this part of textile waste. However, this consideration is included only as an incentive for utilising the results of this research if were to form the basis for creating a textile collection network. The comment is made to highlight that not all textiles are actually reusable and it is important to educate the population so that they are able to identify which textiles to sort for further use and which to dispose of in MMW. Further research also requires a correction coefficient, which in this study was determined based on data for another waste group. But for greater accuracy, it is necessary to measure it specifically for textile waste.

The results of this study can help to scale up suitable financial support (e.g. within support subsidy programmes), which will help to create a sufficient textile collection network and simultaneously show the quantitatively non-negligible amount of materials which can be diverted from mixed waste and reused or recycled. One of the issues related to data collection and setting total capacity is the fact that currently there is no centralised system of textile collection available in the Czech Republic; collection is now provided by various private companies and non-profit organisations/charities. The usual method of collection is via separate textile containers, but part of the collection also takes place through take-back by individual manufacturers. Therefore, it is difficult to accurately estimate current capacities.

Data available from this research can help shape the discussion and create specific support instruments to increase capacities for textile collection, which will be relevant especially in connection with the upcoming changes responding to the newly published EU Strategy for Sustainable and Circular Textiles. Specifically, having data describing the current presence of textile in MMW can form an important base for an evidence-based approach to the design and creation of a network of textile waste collection containers and services prior to the 2025 deadline, in order for it to reflect the existing amounts of household waste. The data can also be used to set targets for textile waste collection, recycling and for reductions of the share of textile in MMW.

The results will thus be important in helping to finalise policy regarding textile collection and other waste components, together with setting specific quantified targets, both on the European and national level. With respect to the high percentage of textiles in waste, it is obvious that it will be necessary to focus attention on establishing an action plan which will include educating the population to motivate collection, gradual capacity increase, testing the functionality of the collection network, and various collection models, including data evaluation, e.g. for partial pilot projects. With respect to the applicable legislation calling on textile collection to be provided from 2025, it is essential to introduce these steps as soon as possible.

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Analýza množství textilního odpadu ve směsném komunálním odpadu v České republice mezi lety 2016 – 2021

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Souhrn

Strategie EU pro udržitelný a cirkulární textil zveřejněná v březnu roku 2022 vytyčila cíl navrhnout závazné cíle pro přípravu k opětovnému použití a recyklaci textilního odpadu jako součást revize právních předpisů EU o odpadech plánovaného na rok 2024. Pro nastavení tak konkrétních cílů opětovného použití a recyklace textilu, včetně následného nadimenzování sběrných a recyklačních kapacit, je však nutné znát množství textilního odpadu dnes zastoupeného ve směsném komunálním odpadu (SKO). Tento článek proto sumarizuje výsledky rozborů 64 vzorků SKO realizovaných v ČR. Výsledky ukazují, že textilní odpad tvořil mezii lety 2016 až 2021 6,16 % SKO. Pro odhad celkového množtsví textilu v SKO pak byla využita konkrétně data mezi lety 2018 a 2020 (jelikož se jedná o data sjednocená mezi Českým statistickým úřadem a Ministerstvem životního prostředí). Dle těchto dat za pro tyto roky celkové množství textilu v SKO pohybovalo okolo 135 989 tun.

Článek tedy shrnuje aktuální výzvy pro nakládání s komunálním textilním odpadem v návaznosti na Strategii pro udržitelný textil v EU vydanou v březnu 2022 Evropskou komisí, definuje datovou mezeru ve znalostech množství textilního odpadu ve směsném komunálním odpadu v ČR a analyzuje potenciální množství textilního odpadu ve směsném komunálním odpadu. Ačkoliv výsledky reprezentují jen Českou republiku, mohou být cenným vstupem pro přesné nastavení cílů a vzorem pro obdobné analýzy realizované na území dalších zemí EU. Konkrétně, údaje popisující současnou přítomnost textilu v SKO mohou být důležitým základem pro přístup založený na důkazech k návrhu a vytvoření sítě sběrných kontejnerů a služeb na textilní odpad před termínem v roce 2025, aby odrážely stávající množství textilního odpadu v SKO. Data lze také použít pro stanovení cílů pro sběr textilního odpadu, recyklaci a pro snižování podílu textilu na SKO. Článek současně ukazuje na běžnou praxi absence těchto dat a poukazuje na nutnost dalšího, podrobného výzkumu v této oblasti.

Klíčová slova: *SKO – směsný komunální odpad, textilní odpad, analýza odpadů, analýza vzorků textilního odpadu v SKO, Strategie EU pro udržitelné textilie, metodika analýzy textilního odpadu*