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QUANTITIVE AND QUALITATIVE ANALYSIS OF HOUSEHOLD WASTE – COMPARISON OF OFFICIAL DATA AND RESULTS OF CASE STUDY

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Abstract

Statistical data of household waste management and relevant data found by one year long direct survey at five households were compared. While the composition of residual (mixed) household waste is determined by sieve analysis and manual aftersorting to predetermined groups (and the material composition of waste that passes through a sieve mesh of 8x8 mm openings is not detected by this analysis), during the direct survey in households all the household waste is sorted to predetermined groups. Official information systems report that average total amount of household waste is 301 kg per person and just less than 4 % of it is sorted to usable fractions. The direct survey shows that avarage total amount of household waste is just 164 kg per person and it is possible to sort 63 % of it.

Key words: household waste amount, household waste composition, waste management information systems, waste analysis

INTRODUCTION

In July 2014, the European Commission put forward an initial circular economy package (European Commission, 2014/0397). However, in March 2015 the Commission withdrew the legislative proposal on waste included in

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that package, to make way for ,a more ambitious proposal that will cover the whole of the circular economy.

As part of a new circular economy package, in December 2015 the Commission presented an action plan for the circular economy, as well as four legislative proposals amending the following legal acts:

- Directive 2008/98/EC on waste,
- Directive 1999/31/EC on the landfill of waste,
- Directive 94/62/EC on packaging and packaging waste,
- Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment (European Commision 2016).

Circular economy package was implemented into Waste Management Plan of the Czech Republic which includes targets for the utilization of municipal waste components. Act on Waste (2001) defines the municipal waste as the refuse produced by households and other sources, not containing hazardous substances, which due to its features or composition resembles the household waste. Except for households, the other sources of municipal waste are, e.g. shops, offices, schools, grave yards, municipal green areas, infrastructure facilities. The municipal waste have special features depending on numerous factors such as the type of buildings, coverage of service facilities and other non-residential buildings in the area concerned, technical and sanitary utilities of the building (especially the heating systems).

There are three major driving forces for increasing the recovery of municipal solid waste (MSW). First of all, the landfill directive of the European Union (1999/31/EC) sets the demands for reducing the landfilling of biodegradable waste. In the year 2016, landfilling of biodegradable waste should be no more than 35% of the amount of biodegradable waste generated in the year 1995.

The second major driving force for the recovery of MSW is the objective to reduce greenhouse gas (GHG) emissions and increase the use of renewable fuels in energy production. In the EU, the targets are to reduce the GHG emissions by 20% from the level of 1990 and increase the use of renewable energy to 20% of the total energy use by 2020. The targets have been divided among different sectors of economy.

The third driving force is the need to save natural resources. Reuse and recycling have been determined as the primary means of waste recovery in European waste strategies, but the incineration of waste with energy recovery has also been officially accepted as a means to utilize waste and decrease landfilling (Horttanainen et al., 2013).

Municipal solid waste (MSW) management systems are becoming more complex in many countries as well as in insular communities with the move from landfill-based to resource recovery – based solutions, following the setting

of international and national targets, to divert waste from landfill and to increase recycling and recovery rates. Local authorities need waste compositional information at the local level to plan, organize, develop, implement and observe waste management schemes that will facilitate them to meet their contribution to the National targets (Burnley 2007, Zorpas and Lasaridi 2013).

Accurate and reliable data on waste composition are crucial both for planning and environmental assessment of waste management as well as for improvement of resource recovery in society. To develop the waste system and improve technologies, detailed data for the material characteristics of the waste involved are needed. Characterisation of waste material composition typically consists of three phases: first sampling of the waste itself, then sorting the waste into the desired number of material fractions (e.g. paper, plastic, organics, combustibles, etc.), and finally handling, interpretation and application of the obtained data. The sampling and sorting activities themselves are critical for obtaining appropriate waste composition data. The absence of international standards for solid waste characterisation has led to a variety of sampling and sorting approaches, making a comparison of results between studies challenging (Dahlén and Lagerkvist 2008). Due to the high heterogeneity of solid waste, the influence of local conditions (e.g. source-segregation systems, local sorting guides, collection equipment and systems), and the variability of sampling methodologies generally limits the applicability of waste compositional data in situations outside the original context.

The quality of waste composition data are highly affected by the sampling procedure (Petersen *et al*., 2004). Solid waste sampling may often involve direct sampling, either at the source (e.g. household) (WRAP, 2009) or from a vehicle load (Steel *et al*., 1999).

Vehicle load sampling is often carried out by sampling the waste received at waste transfer stations (Wagland *et al*., 2012), waste treatment facilities, e.g. waste incinerators (Petersen, 2005), and landfill sites (Sharma and McBean, 2009; Chang and Davila, 2008).

There are many methods for conducting municipal waste composition studies. The review of 20 methods for solid waste component analysis based on different methods was presented by Dahlen and Lagerkvist (2008), but a European standard of solid waste component analysis does not exist yet.

In the Czech Republic the composition of residual (mixed) household waste is determined by sieve analysis and manual aftersorting to a predetermined groups. This analytical method is approved and used by the Ministry of Environment of the Czech Republic and is clearly described in Benešová (2009). Three sieves of the mesh with 40x40 mm, 20x20 mm and 8x8 mm openings are used for sieve analysis. The material that passes through sieves of the mesh 40x40 mm and 20x20 mm is sorted to five predefined fractions. The material composition of waste that passes through a sieve mesh of 8x8 mm openings is not detected

by this analysis. The total amount of this waste varies from 14.1 % to 36.9 % of analysed mixed village household waste (Pačesová 2013).

Data obtained by these analysis relevant for village housing development in the Czech Republic are compiled in Table 1.

Specific amount of residual (mixed) household waste and total amount of household waste (including separately sorted fractions and residual municipal (mixed) household waste relevant for village housing developmnet in the Czech Republic are compiled in Table 2.

The amount of impurities in containers for sorted waste components – that are de facto mixed household waste – are detected only sporadically or are not detected at all. Actually, statistical data are not entirely accurate.

Table 1. Residual (mixed) household waste composition (village housing development)

Waste fraction	Years 2001/2002 [1] [%]		Years 2008/2009 [1] [%]		Year 2011 [2] [%]	
Paper	7.6		7.8		8.8	
Plastics	9.0		9.7		10.0	
Glass	8.9		4.9		5.9	
Metals	4.5		2.6		4.1	
Biodegradable waste	6.3		11.7		24.1	
Textile	2.2		2.3		4.4	
Mineral waste	4.0		6.8		5.4	
Hazardous waste	0.5		0.3		0.2	
Combustible waste	6.2		9.4		12.8	
WEEE	-		0.3		0.6	
Residual waste 20-40 mm	5.0	50.8	4.9	44.2	4.6	23,7
Residual waste 8-20 mm	8.9		7.8		5.0	
Residual waste < 8 mm	36.9		31.5		14.1	
TOTAL	100		100		100	

Source: Own elaboration bassed on: [1] Benešová (2009) [2] Pačesová (2013)

Given these facts the long-term monitoring of production and composition of household waste was conducted in selected village households in the Czech Republic. Obtained data found by long-term surveys of household waste composition and the comparison with relevant data of official statistical surveys are presented in this article.

The main aim of this research were the comparison of case study data of household waste composition with relevant data of official statistical surveys and

the comparison of case study data of household waste amount relevant data of official statistical surveys.

Table 2. Specific amount of household waste per person a year in 2008-2009 (village housing development)

	Minimal amount [kg]	**Maximal amount [kg]**	**Average amount [kg]**
Residual (mixed) household waste	132	433	290
Total household waste	144	444	301

Source: Own elaboration bassed on: Benešová (2009)

MATERIALS AND METHODS

The one year long survey of household waste was realized in five households during 2012-2014. Household waste was sorted to relevant fractions and separetely collected and weighted. Common household waste fractions were weigted with precision 1 g at regular one week long intervals. Bulky household waste was weighted with precision 1 kg at the moment of its removing. All the household waste was sorted (and separately collected) into:

1. biodegradable waste,
2. recyclable fractions (eg. plastics, paper, metals, glass, compozite packages, textile, waste electric and electrical equipment (WEEE)),
3. hazardous waste,
4. bulky waste and
5. residual (mixed) municipal waste (including ash from solid fuel heater).

Ad 1) Biodegradable waste mainly consists of kitchen waste and food scraps. The amount of garden biodegradable waste was not measured because all surveyed families process garden waste to compost. This biodegradable waste treatment is considered as waste prevention.

Ad 2) Recyclable fractions were sorted according to the return system operated in the Czech Republic.

Ad 3) Household hazardous waste consists of unused drugs, batteries, detergents and other household chemicals.

Ad 4) Bulky waste consists of old furniture and worn tires.

Ad 5) Residual municipal waste consists of unsorted fractions, vacuum cleaner bugs, hygiene supplies, cat feces etc. Depending on the system of heating, residual municipal waste may contein the ash.

Detailed description of surveyed families is shown in Table3.

Table 3. Description of surveyed households

Household	building	Heating	members	domestic animals
H1	terraced house	gas heater	3 adults	2 cats
H2	terraced house	gas heater	4 adults	No
H3	detached house	solid fuel heater	3 adults	No
H4	detached house	solid fuel + gas heater	5 adults	1 dog
H5	detached house	solid fuel heater	4 adults	1 dog

Source: Own study

After finishing of the survey, the measured values were summarized and then rounded to tenths of kilogram. For the comparison with relevant data it was necessary to determine the amount of household waste fractions related to one person per year (specific amount) and to determine the percentage ratio of sorted household waste fractions.

RESULTS AND DISCUSSION

The values in Table 2 show that the average rate of sorted household waste components was only 3.7 % in 2008-2009.

It is necessary to compare obtained data from different years because it is impossible to obtain relevant data of relevant (analyzed) years. For this reason it is necessary to compare available data related to municipal waste production of each year firstly. In the Czech Republic coexist two information systems of Waste Management. The first one is operated by Czech Statistical Office and the second one is operated by Ministry of the Environment of the Czech Republic. The total amount of municipal waste by both systems is shown in Table 4.

Table 4. Generation of municipal waste in 2009-2014

Year	2009	2010	2011	2012	2013	2014
MSW by CZSO [3] [mil. Mg]	-	-	3,4	3,2	3,2	3,3
MSW by MECR [4] [mil. Mg]	5,3	5,4	5,4	5,2	5,2	5,3

Source: [3] Czech Statistical Office, 2016 [4] Ministry of the Environment of the Czech Republic, 2016

It is evident that the total amount of produced MSW de facto stagnates and thus it can be expected that household waste (as a part of MSW) production stagnates as well so it is possible to compare relevant data of household waste production obtained in different years.

Table 4. Summarized values of household waste fractions per households per year

Waste fraction	H1 [kg]	H2 [kg]	H3 [kg]	H4 [kg]	H5 [kg]	av. H [kg]
Biodegradable waste	104.1	186.7	112.5	404.4	176.7	196.9
Plastics	23.0	38.8	20.6	69.0	30.4	36.4
Paper	48.5	84.6	39.5	58.3	44.4	55.1
Metals	13.7	3.3	4.4	39.6	10.0	14.2
Glass	1.3	29.9	17.6	32.2	31.9	22.6
Beverage cartons	0.7	1.9	7.1	15.2	7.6	6.5
Textile	1.9	0.0	0.0	6.0	4.6	2.5
WEEE	0.0	16.2	2.9	0.0	17.0	7.2
Hazardous waste	0.3	0.7	0.1	4.9	17.0	4.6
Bulky waste	0.0	0.0	0.0	0.0	108.7	21.7
Residual (mixed) waste	107.6	150.6	516.0	162.8	315.1	250.4
TOTAL	301.1	512.7	720.7	792.4	763.4	618.1

Source: Own study

Table 5. Percentage ratio of sorted household waste fractions

Waste fraction	H1 [%]	H2 [%]	H3 [%]	H4 [%]	H5 [%]	av. H [%]
Biodegradable waste	34.6	36.4	15.6	51.0	23.1	32.2
Plastics	7.6	7.6	2.9	8.7	4.0	6.2
Paper	16.1	16.5	5.5	7.4	5.8	10.3
Metals	4.6	0.6	0.6	5.0	1.3	2.4
Glass	0.4	5.8	2.4	4.1	4.2	3.4
Beverage cartons	0.2	0.4	1.0	1.9	1.0	0.9
Textile	0.6	0.0	0.0	0.8	0.6	0.4
WEEE	0.0	3.2	0.4	0.0	2.2	1.2
Hazardous waste	0.9	0.1	0.0	0.6	2.2	0.6
Bulky waste	0.0	0.0	0.0	0.0	14.2	2.8
Residual (mixed) waste	35.7	29.4	71.6	20.5	41.3	39.7
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Source: Own study

Summarized and rounded measured values of household waste fractions produced by pursued households are compiled in Table 4. Percentage ratio of sorted household waste fractions are compiled in Table 5. Specific amounts of household waste fractions related to a person are compiled in Table 6.

With respect to the inaccuracy of the sieve analysis and the small number of observed households it can be said that while percentage ratios of paper, plastics, glass, metals and hazardous waste found by both methods roughly correspond together, the percentage ratios of biodegradable waste, textile and WEEE vary widely. Smaller ratio of biodegradable waste presented by sieve analysis is most probably caused by the sieve methodology itself – the fraction of size under 40 mm represents tens of percent of analyzed samples and it is supposed it consist of biodegradable waste and ash mainly (depending on the type of house heating). Higher amounts of WEEE detected by direct detection in households compared to the sieve analysis may be related to the proper sorting and disposal at the collection centers of this waste. The big difference in the obtained values of textile waste is probably caused by a small number of surveyed households.

Table 6. Specific amounts of household waste fractions related to one person per year

Waste fraction	P1 [kg]	P2 [kg]	P3 [kg]	P4 [kg]	P5 [kg]	av. P [kg]
Biodegradable waste	34.7	46.7	37.5	80.9	44.2	48.9
Plastics	7.7	9.7	6.9	13.8	7.6	9.1
Paper	16.2	21.2	13.2	11.7	11.1	14.6
Metals	4.6	0.8	1.5	7.9	2.5	3.5
Glass	0.4	7.5	5.9	6.4	8.0	5.6
Waste fraction	**P1 [kg]**	**P2 [kg]**	**P3 [kg]**	**P4 [kg]**	**P5 [kg]**	**av. P [kg]**
Beverage cartons	0.2	0.5	2.4	3.0	1.9	1.6
Textile	0.6	0.0	0.0	1.2	1.2	0.6
WEEE	0.0	4.1	1.0	0.0	4.3	1.9
Hazardous waste	0.1	0.2	< 0.1	1.0	4.3	1.1
Bulky waste	0.0	0.0	0.0	0.0	27.2	5.4
Residual (mixed) waste	35.9	37.7	172.0	32.6	78.8	71.4
TOTAL	100.4	128.2	240.2	158.5	190.9	163.6

Source: Own study

The difference of total amounts of household waste is very significant. The average amount of household waste, reported by the official information systems is almost double compared to the average quantity of household waste of the

surveyed households. The system of collecting and transport of household waste is very probably abused by small traders and self-employed persons in order to reduce their own costs of waste removing.

The average amount of residual (mixed) household waste, reported by official information systems is more than four times bigger compared to the average amount of residual (mixed) household waste of surveyed households.

CONCLUSIONS

Comparison of household waste management data (related to village households) reported by official information systems in the Czech Republic and relevant data found by one year long survey at five households shows large differences – the average total amount of household waste by information systems is almost double. For purposes of household waste amount accurate detection and particularly for the fair quantification of household waste treatment costs to municipalities it is strictly necessary to distinguish the household waste from the waste of the same composition but produced by another waste producers.

The composition of residual (mixed) household waste reported by official information systems is almost the same as the composition of total household waste found by direct household survey. The average amount of residual (mixed) household waste, reported by official information systems, is more than four times bigger compared to data of direct household survey. These facts show that it is possible to significantly increase the amount of sorted household waste fractions.

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