COMPARISON OF ENVIRONMENTAL GOALS AND ECONOMIC EFFICIENCY IN WASTE MANAGEMENT AT MUNICIPAL LEVEL WITHIN REVERSE LOGISTICS

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ABSTRACT

This paper evaluates the economic aspect expressed through the efficiency of municipal waste management expenditures of 17 districts of Bratislava and the ecological point of view through the achievement of objectives of waste management legislation at municipal level as a primary assessment of the potential of municipalities for the possibility of collecting selected waste streams and packaging from the municipal waste stream and achievement of waste management goals for both municipalities and producers through reverse logistics activities (e.g. sorting, material recycling, recovery, etc.).

Key words: *municipal waste management, objectives, efficiency*

1 INTRODUCTION

By introducing extended producer responsibility and urging to engage in the realization of the Circular Economy, the interested groups (including producer of a specified product, traders, municipalities) currently face new obligations in Slovakia. Producer of a specified product means a producer of electrical equipment, batteries and accumulators, packaging, vehicles, pneumatic tires, or producer of non-packaging products that are part of municipal waste, too. Extended producer responsibility means the sum of obligations of producers of specified products laid down in Act about waste or in a specific regulation that apply to these product throughout all stages of their life cycle, aimed at preventing waste from specified products and reinforcing reuse, recycling and other recovery of this waste stream (MoE, 2015, p. 32). Sustainable materials management provides a valuable perspective for encouraging the decoupling of resource consumption from industrial growth (Fiksel, 2006, p.21). Reverse logistics can help to achieve this obligations for producers because it is the process of planning, implementing and controlling the ability to efficiently manage the flow and storage of secondary goods and related information oriented in the exact opposite direction than in a classical understanding of the supply chain, for recovering or appropriately handling the goods, in this case packaging waste (Fleischman at al., 2001 p. 165). Obtaining the end of life products (in this case packaging) from the customers can be classified into two groups: waste stream and market driven. In waste stream, manufacturer has no policy and strategy to control the quality and quantity of the used products; all the returned products are collected and transferred to the material recovery and recycling companies; and the manufacturer can reduce the cost by minimizing the cost of reverse logistic network. In market driven, customers are motivated to return the end of life product by some type of financial incentive. In this way the manufacturer can control the quantity and quality of the returned products (Ghoreishi at al., 2013, p. 131-132).

In this article, we focused on potential of municipality for separation packaging waste to meet regulatory requirements and meet recycling and recovery rates for packaging producer. Activities was evaluated from several points of view. The most important is the economic aspect (efficiency of

selected municipal waste costs) and the ecological aspect (achievement of waste management goals in municipal waste).

2 METHODOLOGY

For the article was selected the waste group 20 municipal wastes (waste from household and similar waste from shops, industry and institutions) and area of capital city Bratislava with its 17 city districts.

In the first step was focusing on choice of suitable cost-output evaluation method. On base of acquired data (costs of waste management, waste quantity, defined territorial units), compared with the outputs of the individual analysis (monetary units at Cost-Benefit Analysis, many output units per cost unit realized at Cost-Effectiveness Analysis or the benefits flowing from the Cost-Utility Analysis project), was selected analysis of cost effectiveness (CEA) according to Boardman and modified according to methodology of Struk and Soukupova (Ochrana, 2004, p. 173), (Struk, Soukupová, 2011, p. 381-382) on basic the formula:

$$\boldsymbol{CEA = \frac{C}{E} \rightarrow min}$$

where,

(C)- annual costs
(E)- outputs expressed in natural units

For the method, Cost-Effectiveness Analysis exists several methods how to evaluate and determine order of alternatives, as following (Soukupová, 2013):

1. by determining the cost per unit of output
2. by the form of decreasing efficiency for the same costs
3. by increasing costs for the same efficiency

For this case, concerns option 3.

Calculation of the values for each reviewed unit (community) was obtained by using the formula:

$$\boldsymbol{CEA_j = \frac{C}{E}}$$ where, j = 1, ..., n.

Analysis consists in assessment two aspects of effectiveness on samples of 17 city districts of capital city Bratislava, as following:

1. expenditure per capita E_1
2. expenditure per tons of municipal waste E_2

In contrast to economic evaluations of efficiency were evaluated also environmental target for municipal wastes. The analysis consisted of methods of comparing the amount of municipal waste generated against municipal waste that was material recycling in line with the target of increasing the preparation for re-use and recycling of waste materials from households and similar to waste from households according directive on waste:

$$\textit{Recycling of municipal waste in \%} = \frac{\textit{Municipal waste recycled} * 100}{\textit{Municipal waste generated}} \quad (1)$$

In the last part, the economic and environmental targets were compared, indicating whether an adequate percentage of waste recovery exists for a given expenditure per tonne of waste.

3 COST-EFFECTIVENESS ANALYSIS IN CITY DISTRICTS OF BRATISLAVA

The 17 city districts of Bratislava generated almost 206.5 thousand a ton of municipal waste in 2016. About 27.5 million € was spent on waste management. This amount should include all the costs of collection, transport, recovery, disposal and other costs associated with waste management - such as rental of containers, investments in technology, etc. The population (the latest available data 2014) was about 419.7 thousand on the territory of monitored districts. Municipal waste generation per capita averaged 500.8 kg of waste,

The efficiency of waste management in individual districts of Bratislava was compared in Tab. 1 Expenditure per capita CEA_{jE1} and Tab. 2 Expenditure per municipal waste tonne of CEA_{jE2}. The analysis was evaluated because of increasing costs for the same efficiency.

3.1 Expenditure per capita

Expenditure per capita an average of all districts was 66.13 €. The value ranged from 65.43 € in the district of Petržalka to 67.33 € in the district of Jarovce.

Municipality	Population	CEA_{jE1}
Petržalka	104 395,00	65,43
Dúbravka	33 011,00	65,60
Podunajské Biskupice	21 528,00	65,68
Devínska Nová Ves	15 974,00	65,68
Karlova Ves	33 056,00	65,70
Ružinov	70 660,00	65,82
Staré Mesto	38 988,00	65,85
Vrakuňa	19 866,00	65,86
Rača	20 531,00	65,86
Vajnory	5 484,00	65,87
Nové Mesto	37 066,00	65,94
Lamač	6 974,00	66,04
Rusovce	3 479,00	66,50
Devín	1 237,00	66,78
Záhorská Bystrica	4 302,00	67,06
Čuňovo	1 248,00	67,25
Jarovce	1 879,00	67,33

Tab. 1 Expenditure per capita in 17 city districts of Bratislava

Expenditure is generally higher than in other parts of Slovakia, which may be because there are more business entities that employ more people in their territories, which then generate more municipal waste that is counted towards the amount of waste in that city.

3.2 Expenditure per municipal waste tonne

The expenditure per municipal waste tonne comparison averaged 138.16 €. The lowest expenditure was in the district of Devín 90,83 €/tonne and highest was in the district of Jarovce 215.28 €/tonne. This calculation is about information how much money was spent in individual districts on one tonne of its waste.

Municipality	Municipal waste amount [t] 2016	CEA_{jE2}
Devín	909,45	90,83
Rusovce	2 230,24	103,73
Záhorská Bystrica	2 775,74	103,93
Staré Mesto	21 358,21	120,21
Podunajské Biskupice	11 611,39	121,77
Ružinov	37 787,62	123,08
Rača	10 899,63	124,06
Nové Mesto	19 150,37	127,63
Devínska Nová Ves	8 180,79	128,24
Vrakuňa	9 132,56	143,26
Petržalka	47 256,03	144,54
Lamač	3 117,66	147,72
Karlova Ves	14 403,85	150,77
Vajnory	2 382,05	151,65
Dúbravka	14 277,89	151,67
Čuňovo	418,92	200,35
Jarovce	587,62	215,28

Tab. 2 Expenditure per municipal waste tonne in 17 city districts of Bratislava in 2016

4 ENVIRONMENTAL WASTE MANAGEMENT TARGET FOR MUNICIPAL WASTE

An analysis of achieving the environmental objectives of waste management for municipal waste consisted in comparing the quantities of municipal waste produced against municipal waste that were materially recycled (included composting and digestion) in urban areas following the directive on waste target of increasing the preparation for reuse and recycling household waste such as paper, metal, plastics and glass to at least 50% by weight. The remainder of the municipal waste was recovered by other means (e.g. energy recovery) or disposed of and stored

In 2016, most of the material waste was recycled in Rusovce district (38.86 %), the least in Ružinov district (9.61%). Both values, as well as the average of 16.78 % of material recovery, are below the waste management targets for municipal waste (50 %).

Municipality	Material recycling / composting and digestion 2016 [t]	Material recycling / composting and digestion 2016 [kg/cap]	Material recycling / composting and digestion 2016 [%]	Difference to target [%]
Ružinov	3 631,45	51,39	9,61	40,39
Devínska Nová Ves	895,00	56,03	10,94	39,06
Staré Mesto	2 475,52	63,49	11,59	38,41
Podunajské Biskupice	1 434,94	66,65	12,36	37,64
Nové Mesto	2 436,54	65,74	12,72	37,28
Dúbravka	1 914,15	57,99	13,41	36,59
Vrakuňa	1 241,39	62,49	13,59	36,41
Záhorská Bystrica	390,42	90,75	14,07	35,93
Karlova Ves	2 040,15	61,72	14,16	35,84
Petržalka	6 739,07	64,55	14,26	35,74
Jarovce	86,15	45,85	14,66	35,34
Lamač	485,01	69,54	15,56	34,44

Rača	1 868,94	91,03	17,15	32,85
Vajnory	461,47	84,15	19,37	30,63
Devín	216,68	175,17	23,83	26,17
Čuňovo	122,33	98,02	29,20	20,80
Rusovce	866,71	249,13	38,86	11,14

Tab. 3 Achieving of Municipal Waste target in 17 city districts of Bratislava in 2016

5 COMPARISON OF ECONOMIC AND ENVIRONMENTAL TARGETS

The goal comparison tells us whether there is an adequate percentage of waste recovery at a given expenditure per tonne of waste.

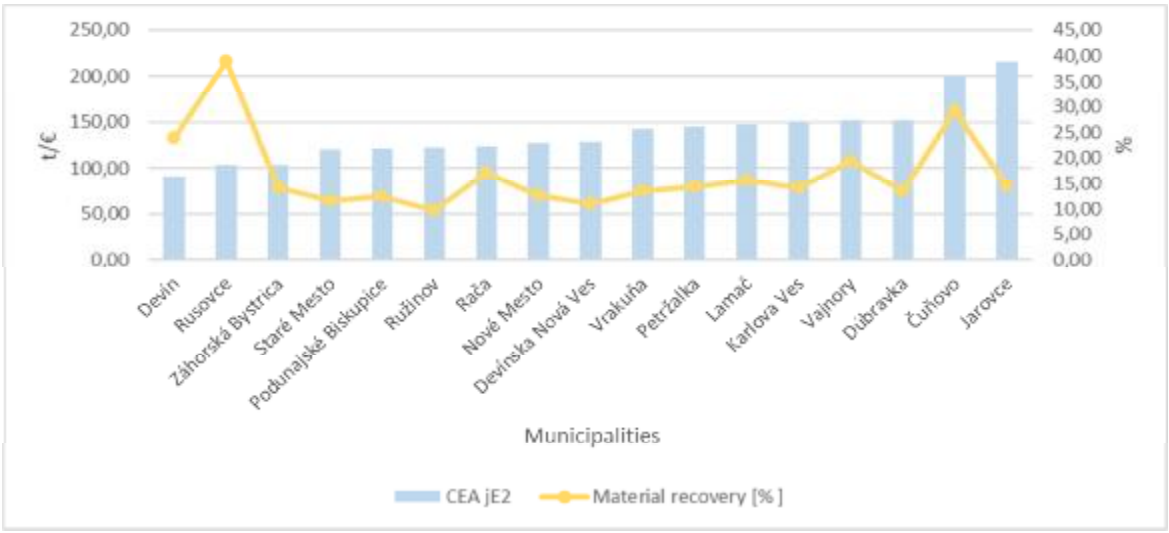

Fig. 1 Comparision of economic and environmental targets in 17 city districts of Bratislava

The picture shows that the expenditure per ton of waste in individual urban districts have a comparable percentage of recovery. Exceptions were Devín and Rusovce districts which percentage of material recovery was higher than expenditures provided on waste management.

6 CONCLUSION

In this paper, we have described and calculated the expenditure per capita and expenditure per municipal waste tonne of 17 districts of Bratislava for municipal waste management. Then we have calculated amount of material recycling (include composting and digestion) in individual districts of Bratislava and compared with recycling target in municipal waste according directive on waste. The calculated values allowed us to compare the cost effectiveness of waste management in individual districts. These values can serve as a tool for producers of packaging, how the municipality effectively manage expenditures allocated to waste management and the separation packaging waste that producers have funded (financing of separation packaging waste). For the future, it would be advisable to extend the scope of monitored municipalities and cities as well as to monitor the trend of these indicators.

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