ANALYZING CERTAIN CHRACTERISTICS OF MUNICIPAL SOLID WASTE GENERATION IN THE PROCESS OF WASTE MANAGEMENT

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Abstract

Based on the regulations of Act XLIII/2000 on Waste Management to implement the strategic objectives and targets in the Act for the prevalence of the basic waste management principles a National Waste Management Plan II will be worked out and then accepted by the Parliament as part of the National Environmental Protection Programme.

On the basis of the national plan the administrative bodies of environmental protection in accordance with the regional settlement and development programmes make a regional waste management project with the inclusion of the regional, local authorities, and other authorities concerned as well as the non governmental organisations for environmental protection.

In our research we analyze the correlation between municipal solid waste per capita and urbanisation level. We have conducted similar calculations in the filed of population density and income. The study was carried out on a micro region level.

Our analysis can help determine the framework conditions and factors that influence waste generation, and therefore should be taken into consideration when designing waste policies.

Key Words: *municipal waste, waste generation, regional differences*

JEL Classification:Q 53

1. INTRODUCTION

From the various waste categories our research focuses on the problems of municipal waste generation. Municipal solid waste is a solid one deriving from the households and a form of waste similar in nature and composition to that of household waste as they can be managed together.

Removal of the link between waste generation and economic activity has a significant role in helping to meet the objective of reduced waste generation. In the 1990's waste generation increased at a greater rate than economic growth. The amount of waste generated in European

countries belonging to the OECD increased by an estimated 10 % between 1990 and 1995, while GDP increased by only 6.5 %.

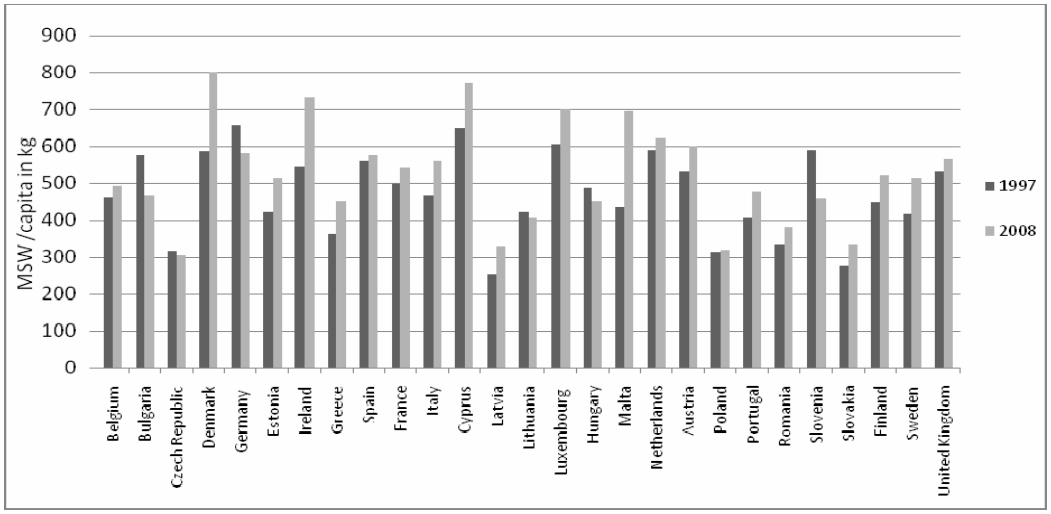
In the European Union de-linking of municipal waste generation from household expenditure was occurring in certain countries from 1984 to 1998. Germany, the Netherlands and Iceland showed successful de-coupling of municipal waste generation from economic activity, while other countries such as Portugal, Greece, France, Spain, Denmark and Sweden made not much progress. Household expenditure, however, is not an optimal parameter for comparison purposes as municipal waste includes commercial waste as well.

Although some de-linking from economic activity occurred in the 1990s for municipal waste, the majority of EEA member countries were away from meeting the EU fifth environmental action programme target of stabilising municipal waste generation per capita at 300 kg per capita by 2000.

The Sixth Environment Action Programme (2002–2012) defines the EU's key environmental objectives. One of the goals is to decouple resource use and waste generation from the rate of the economic growth. The programme also targets a significant reduction in the volumes of waste generated through waste prevention initiatives and a significant reduction in the quantity of waste going to disposal. It further supports reuse and aims to reduce the level of hazard, giving preference to recovery and especially recycling, making waste disposal as safe as possible, and ensuring that waste for disposal is treated as close as possible to its source.

According to the Waste Framework Directive (2008/98/EC), the European Commission will propose measures to support waste prevention activities, e.g. by setting prevention and decoupling objectives for 2020. Also by 2020, at least 50 % of waste materials from households and possibly from other origins must be recycled or prepared for re-use. The minimum target calculated for construction and demolition waste is 70 % by 2020.

Figure-1: Municipal waste generated in the EU 1997-2008



Source: Eurostat

On average the European citizen generated 10 % more waste in 2008 than in 1997. The waste volume grew even faster (11.5 %) in the EU-15 Member States. The aggregated figures show considerable differences among Member States *(Figure 1.)* Whereas the Czech Republic generated less than 300 kilograms of municipal waste per inhabitant, Denmark exceeds 800 kilograms per capita. Some Member States have experienced exceptionally high growth rates over the past years and others have experienced a considerable decrease.

Interestingly, although ten of the EU-12 Member States have enjoyed relatively rapid economic growth over the period, municipal waste generation has fallen or increased by less than 2 % in five of those countries. There are several possible reasons for the decrease: some biowaste may have been reused as animal feed, some combustible waste may have been used as fuel in individual households due to increasing coal prices. Furthermore, the gradual introduction of weighbridges at the landfills has provided more reliable information as previously the amounts of municipal waste were estimated according to the volume, which may have led to an overestimation of the mass. In 18 Member States, however, growth in waste generation was above average, with the highest rate of increase (93 %) occurring in Malta. Member States have difficulties in preventing the generation of municipal waste, mainly because of increased consumption. Nonetheless, according to (Ventour, 2008) there is potential for preventing biowaste from households, especially in wealthier parts of Europe. (Alwast et al. 2008) has analysed the waste generated by selected waste streams in the EU-27 and estimated the potential for recovery. The amount of biodegradable waste generated totalled 87.9 million tonnes. Around 67 % of this waste was from municipal sources and the remaining 33 % was from the food industry and services. Thirty-seven per cent of biodegradable waste was recovered but the picture varied across the EU and the authors concluded that the countries' recovery potential was between 31 % and 98 %.

Waste generation reduction is the ultimate objective of any social policy targeted towards waste flows. When designing waste management policies there are certain factors we should concentrate on. First, population density is likely to positively impact on waste generation. Only economies of scale spurred by urbanisation could invert the trend and reduce collection where density is higher. Household related features may matter at such a level. In fact, we expect that the larger the size of households, the less is waste generated per capita. Nevertheless, even a positive link could be plausible in case collection schemes and waste management at home level (composting) is poorly developed on average. Accordingly, more single households should drive waste generation up. Economic and demographic factors play an important role in the generation and management of municipal waste. An econometric analysis (Mazzanti and Zoboli, 2008) conducted for the EU-25 Member States covering the years 1995–2005 tried to explore the causes of waste generation. First of all, the analysis finds no absolute decoupling of municipal solid waste (MSW) generation and consumption per capita. Contrary to earlier analyses on the subject, however, there is now evidence of a relative decoupling, i.e. MSW generation is growing more slowly than income. The new Member States seem to have expressed a larger relative decoupling. In addition, the analysis concludes that high population density and urbanisation result in more waste generation and that richer and more services-oriented economies produce more municipal waste. However, insufficient coverage of waste collection systems can have a significant impact on the accuracy of data on the amount of waste collected.

The general regulation of waste management in Hungary is nearly identical with the strategy of the European Union, which is not surprising as the harmonisation of the legal system was a prere*q*uisite for the accession. (Baranyai,2008) The amount of municipal solid waste /MSW/

(*Figure 2*.) slightly increased between 2000 and 2007 in Hungary. The reasons lying behind can be the usually unfavourable changes in consumer behaviour patterns and the widening range of municipal waste management services (making it mandatory, the growing number of residences included, extending it to holiday homes). There have been steps to encourage the use of recycled packages and although legal regulations help the sale of refundable products, their production has significantly been decreased.

2. THE RESEARCH

In our research we wanted to examine the connections of various indicators on the micro region level. This analysis can help determine the framework conditions and factors that influence waste generation, management and disposal and therefore must be taken into consideration when designing waste policies. Similar researches have been done by (Baranyai,2008) concerning the South Transdanubia region.

By using the regional statistical database of the Central Statistical Office we have examined if there is a correlation between the amount of waste per inhabitant and the population density per micro-region in Pest county in 2008. By assuming that the volume of municipal solid waste per capita is relatively higher in the city we have been searching a correlation between the amount and the extent of urbanisation of the micro-region, which was determined by proportioning the number of the city-dwellers to that of the micro-region.

We have also had a closer look at the relationship between the volume of municipal solid waste per capita and the personal income tax per capita by considering the thesis according to which consumer patterns change due to higher income and it results in more waste. To verify the above mentioned We have calculated the Spearman rank correlation coefficients (r_s) to analyse the connections above.

Pearson Correlation, Spearman rank correlation, ANOVA, SPSS 13.00 programme package and Microsoft Excel were used to process and evaluate statistical data.

2.1. Results and Discussion

In the first step in our research we have calculated the correlation between the amount of municipal solid waste per capita and urbanisation level. In our calculations the higher percent of urbanisation level means the greater number of towns located in certain micro region. To highlight the correlations, we have used tables like *Table 1*.

Table 1: Calculation of rank correlation between the amount of MSW and urbanisation in Pest county

The rank of micro-regions based on the amount of municipal solid waste per capita kg/person, 2008			The rank based on the extent of urbanisation	The rank of micro-regions based on urbanisation		
1	Budaörs	460.6	4	1	Dunakeszi	75%
2	Dunakeszi	447.6	1	2	Érd	50%
3	Aszód	438.1	10	4	Budaörs	40%
4	Szentendre	381.6	9	4	Gyál	40%
5	Cegléd	374.8	8	4	Monor	40%
6	Gödöllő	374.3	7	6	Ráckeve	35%
7	Ráckeve	364.0	6	7	Gödöllő	33%
8	Vác	352.6	13	8	Cegléd	27%
9	Szob	338.9	14	9	Szentendre	23%
10	Érd	326.2	2	10	Aszód	22%
11	Gyál	324.4	4	11	Dabas	20%
12	Veresegyház	320.3	12	12	Veresegyház	13%
13	Pilisvörösvár	304.7	15	13	Vác	11%
14	Monor	301.3	4	14	Szob	8%
15	Dabas	272.8	11	15	Pilisvörösvár	7%
16	Nagykáta	193.1	16	16	Nagykáta	6%

r_s= 0.444118 , P‹0.1; the correlation is weaker than average and significant on a 10% level

The correlation is not too strong so based on these data urbanisation is not in a strong correlation with the waste generation habits of the inhabitants. The correlations between the other indicators can be seen in *Table 2.*

Table 2: The result of correlations among MSW, personal income tax and density

	Spearman's rho	**Municipal solid waste, kg/person**	**Personal income tax per tax payer, HUF**	**Population density, person/ km2**
Municipal solid waste, kg/person	Correlation Coefficient	1.000	.421	.309
	Sig. (2-tailed)	.	.105	.244
Personal income tax per tax payer, HUF	Correlation Coefficient	.421	1.000	.862(**)
	Sig. (2-tailed)	.105	.	.000
Population density, person/ km2	Correlation Coefficient	.309	.862(**)	1.000
	Sig. (2-tailed)	.244	.000	.

As we can see from the results, there is a significant correlation between the population density per micro-region and the personal income tax per taxpayer (r_s= 0,862, P‹0,01).

The strength of this correlation is of further concern but this is not the subject of the present examination. The correlations between the amount of municipal solid waste per person and the other factors of the table cannot be regarded significant, however as Sig. (2-tailed) exceeds 10% everywhere.

To carry out further examinations we have also included the micro-regions of two counties of the Northern Great Plains, namely Hajdú-Bihar and Szabolcs-Szatmár-Bereg. we have chosen these two counties because regarding their size, they are similar to Pest county, their population density is half that amount and, at the same time, the average ratio of the registered unemployed is three and five times higher than the values of Pest county, respectively. *Table 3.* presents the descriptive statistics of the indicators of the three counties.

Table 3: Calculations regarding the selected counties

Micro-regions		N	SUM	Mean	Std.Deviation	CV %
Pest county	Municipal solid waste, kg/person	16	5576	348,50	67,99	19,51
	Number of commercial outlets	16	16171	1010,69	506,51	50,12
	Personal income tax per taxpayer, HUF	16	6927039	432939,94	140036,09	32,35
	Number of taxpayers per 1000 persons	16	6984	436,50	18,37	4,21
	Population density, person/ km2	16	4135,3	258,46	208,29	80,59
	Area,km2	16	6391	399,44	279,75	70,04
Hajdú-Bihar county	Municipal solid waste, kg/person	9	2385	265,00	61,52	23,22
	Number of commercial outlets	9	8265	918,33	1107,27	120,57
	Personal income tax per taxpayer, HUF	9	2096208	232912,00	71489,87	30,69
	Number of taxpayers per 1000 persons	9	3627	403,00	41,22	10,23
	Population density, person/ km2	9	898,9	99,88	122,40	122,55
	Area,km2	9	6212	690,22	261,97	37,95
Szabolcs-Szatmar-Bereg county	Municipal solid waste, kg/person	12	3755	312,92	94,06	30,06
	Number of commercial outlets	12	9352	779,33	827,46	106,18
	Personal income tax per taxpayer, HUF	12	2641797	220149,75	54609,36	24,81
	Number of taxpayers per 1000 persons	12	4314	359,50	33,00	9,18
	Population density, person/ km2	12	1170,4	97,53	59,15	60,65
	Area,km2	12	5938	494,83	164,33	33,21

From the last column of the table we can see that except the number of taxpayers per 1000 persons in case of all the indicators there is a very high changeability between the micro-regions of all the three counties. The reason for this, in many cases, can be the fact that in the case of certain indicators in a micro-region neighbouring a city are 7-10 times bigger that the other similar indicators of the other micro-regions in the county. The most striking one in the case of both counties of the Northern Great Plains is the number of commercial outlets, where the value of the CV% is above 100%. Another striking indicator is the CV% value of the population density where explanation also lies in the great differences between the data of the Debrecen micro-region with 422 person/m^2 , Polgár with 36.6 person/m^2, Nyíregyháza with 266.2 person/m^2 or Záhony with 134.6 person/m^2 and Vásárosnamény, the most densely populated one with 53 person/m^2.

Table 4. Multiple Comparisons

Dependent Variable	(I) County code of micro-regions	(J) County code of micro-regions	Mean Difference (I-J)	Std. Error	Sig.
Municipal solid waste, kg/person ANOVA result (F=3,49; P‹0,05)	1	2	83,50(*)	31,71202	0,013
		3	35,58	29,06455	0,229
	2	1	-83,50(*)	31,71202	0,013
		3	-47,92	33,56085	0,162
Number of commercial outlets, ANOVA result (F=0,295; P=0,747)	1	2	92,35	328,9247	0,781
		3	231,35	301,4645	0,448
	2	1	-92,35	328,9247	0,781
		3	139	348,1012	0,692
Number of personal income tax per taxpayer, HUF ANOVA result (F=18,78; P‹0,01)	1	2	200027,93(*)	43339,11	0
		3	212790,19(*)	39720,95	0
	2	1	-200027,94(*)	43339,11	0
		3	12762,25	45865,80	0,783
Number of taxpayers per 1000 persons ANOVA result (F=22,56; P‹0,01)	1	2	33,50(*)	12,51	0,011
		3	77,00(*)	11,46	0
	2	1	-33,50(*)	12,51	0,011
		3	43,50(*)	13,24	0,002
Population density, person/ km2 ANOVA result (F=4,88; P‹0,05)	1	2	158,58(*)	64,28	0,019
		3	160,92(*)	58,91	0,010
	2	1	-158,58(*)	64,28	0,019
		3	2,34	68,03	0,973
Area,km2 ANOVA result (F=4,101; P‹0,05)	1	2	-290,78(*)	101,56	0,007
		3	-95,40	93,08	0,313
	2	1	290,78(*)	101,56	0,007
		3	195,39	107,48	0,078

* The mean difference is significant at the .05 level.

In the other part of the examination we have also examined whether the mean data of the micro-regions typical of the counties in case of the variables in the table above differ. ANOVA examination was carried out for each variable separately. Due to the constraints of space, not all the six ANOVA tables and the attached Multiple Comparisons tables can be published now so that is why we have to concentrate only on the important information necessary for drawing conclusions as presented by *Table 4.*

From the first column of the table we can calculate the F quotient of the ANOVA calculation, which is the proportion of BETWEEN GROUPS and the MEAN SQUARE OF WITHIN GROUPS and the significance level of the probability of the F trial. In case of all variables when the value of P is lower than 0.05, the result of the ANOVA examination is significant, which suggests that there is a deviation between the average values of the counties. To decide the concrete mean values, we have chosen the LSD (Least Significant Difference) test among the post-hoc ones.

The table compares the mean values of the certain pairs under the headings of the county codes of I and J micro-regions. The most important information is hidden in the last column marked as (Sig.) which shown the significance level of the t-test done in pairs. Where this value is lower than 0.05, there is a significant difference between the examined two mean values. Micro-regions were coded by counties: 1= Pest, 2= Hajdú-Bihar, 3= Szabolcs-Szatmár county.

The evaluation of the table is easy when knowing the codes.

What is obvious is that based on the average number of commercial outlets in the ANOVA examination there is no significant difference between the certain counties so this variable is not so necessary to be dealt with. In the case of the other variables we can see that the mean values of the micro regions in Pest county are significantly different from the averages of both counties except the municipal solid waste and the area. There is no statistically proven deviation in case of the two indicators mentioned above from the micro region averages of Szabolcs-Szatmár county. A significant difference could only be shown regarding the number of taxpayers per 1000 persons between the mean values of the micro regions of Hajdú-Bihar and Szabolcs-Szatmár counties.

Among the variables examined so far further calculations were carried out with the municipal solid waste kg/person, personal income tax per taxpayer HUF and population density person/m^2. By counting with their absolute value, a correlation was shown among the variables. The Pearson Correlation was used in the calculations, which are presented by *Table 5.*

Table 5. Calculation of correlations in the selected counties

			Municipal solid waste, kg/person	Personal income tax per taxpayer, HUF	Personal income tax per taxpayer, HUF
Pest county	Municipal solid waste, kg/person	Pearson Correlation	1	0,485	0,287
		Sig. (2-tailed)		0,057	0,281
		N	16	16	16
	Personal income tax per taxpayer, HUF	Pearson Correlation	0,485	1	,593(*)
		Sig. (2-tailed)	0,057		0,015
		N	16	16	16
	Population density, person/km2	Pearson Correlation	0,287	0,593(*)	1
		Sig. (2-tailed)	0,281	0,015	
		N	16	16	16
Hajdú-Bihar county	Municipal solid waste, kg/person	Pearson Correlation	1	0,676(*)	0,44
		Sig. (2-tailed)		0,046	0,236
		N	9	9	9
	Personal income tax per taxpayer, HUF	Pearson Correlation	0,676(*)	1	,881(**)
		Sig. (2-tailed)	0,046		0,002
		N	9	9	9
	Population density, person/km2	Pearson Correlation	0,44	0,881(**)	1
		Sig. (2-tailed)	0,236	0,002	
		N	9	9	9
Szabolcs-Szatmár-Bereg county	Municipal solid waste, kg/person	Pearson Correlation	1	0,465	0,279
		Sig. (2-tailed)		0,128	0,379
		N	12	12	12
	Personal income tax per taxpayer, HUF	Pearson Correlation	0,465	1	,854(**)
		Sig. (2-tailed)	0,128		0
		N	12	12	12
	Population density, person/km2	Pearson Correlation	0,279	0,854(**)	1
		Sig. (2-tailed)	0,379	0	
		N	12	12	12

* Correlation is significant at the 0.05) level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)

Based on the data of the table there is a strong correlation in the two counties of the Northern Great Plains between personal income tax per taxpayer HUF and population density person/m^2. (r=

0,854, P‹0,01), (r= 0,881, P‹0,01) In Pest county this correlation is of medium strength (r= 0,59, P‹0,05)and significant. We have found another very strong, significant correlation in the table, which is between municipal solid waste kg/person and personal income tax per taxpayer HUF in Hajdú-Bihar county. (r= 0,676, P‹0,05**)**

3. CONCLUSIONS

We were not able to prove strong statistical correlation between the amount of MSW and the level of income. Likewise, the correlation was not significant between urbanisation and population density. The calculation proves the hypothesis according to which the cities are ranked above their vicinity due to the fact that their functions (suburbs, areas to be supplied) stretch beyond their borders. Thus we can see that those who generate waste in the city are not definitely the city-dwellers who live there. This is further supported by the fact that according to the census in 2001 almost six-tenths of the 417 thousand employees in the county were not employed in their domicile. The importance of commuting is expressed by the fact that regarding the settlements of Pest county 36% of the total number of employees are commuters. Most of them travel between their homes and workplaces in the areas close to the capital city. Among them the regions of Veresegyház and Monor are of great importance where almost seven-tenths of the employees work away from their homes. More than six-tenths of those living in the Pilisvörösvár, Dunakeszi and Aszód micro-regions also commute. The proportion of those employed in their domicile exceeded 50% only in the regions of Cegléd, Dabas, Vác as well as Szob. The micro-regions of a Budaörs, Gödöllő and Pilisvörösvár have the greatest power of attracting workforce where more than 40% of those employed are commuters. The role of commuting to work is the slightest in the regions of Cegléd, Dabas, Nagykáta and Monor where one-third or even fewer number of those employed commute.

The correlations in case of the three counties examined can only partly show the connections expected by formal logic, therefore these factors should not be over emphasized when planning strategies.

We were aware of the shortcomings and deviations due to the artificial boundaries of micro-regional organisations but it is an existing regional level by law to which statistical data are also attached.

Income growth, urbanisation and an expanding service sector may all lead to more MSW generation. Environmentally responsible behaviour by firms and households, the adoption of waste recovery/reuse innovations and waste prevention policies can be among the drivers that can reverse MSW growth in the future.

There is no evidence that more general national waste strategies have had a major effect on MSW generation. Policies more specifically focused on waste prevention seem to be necessary to achieve further waste reductions as economies grow.

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