

## ANALYSIS OF QUANTITIES OF MUNICIPAL WASTE GENERATED IN THE PODKARPACKIE REGION

### Summary

The paper presents an analysis of changes in the amount of municipal waste produced in individual poviats and communes of the Podkarpackie Region. The work was performed on the basis of own research carried out with the use of data collected from the Regional Data Bank, CSO, 2008 - 2014. The conducted analyses show that most waste is generated in cities with poviat rights where the value of the average waste accumulation is in the range of 200 to 300 kg · (per · year)<sup>-1</sup>. In other poviats, the index value was changing in a very wide range, from 45 to 200 kg · (per · year)<sup>-1</sup>. The analyzed communes of the Podkarpackie Region were also characterized by a large range of changes of the total mixed waste accumulation and household waste per person in a range of 14.5 kg · (person · year)<sup>-1</sup> to 345.3 kg · (person · year)<sup>-1</sup> and 11.3 kg (person · year)<sup>-1</sup> to 221.5 kg · (person · year)<sup>-1</sup>. It was therefore attempted to determine the effects of the administrative and functional type of communes on the size of the examined indicators. The analysis shows that the highest average of total waste accumulation characterized urban communes (253.6 ± 32.8 kg · (person · year)<sup>-1</sup>). The second place was taken by municipalities with urban, tourism and recreation areas (161.5 ± 38 kg · (person · year)<sup>-1</sup>). The lowest value, at the level of 68.6 ± 6 kg · (person · year)<sup>-1</sup>, characterized farming communities, and those with the advantage of agricultural, forests and residential functions. Three specific average values were determined for household waste accumulation ratio, i.e. 169.5 ± 23.7 (urban communes), 96.1 ± 16 kg · (person · year)<sup>-1</sup> (urbanized communes, with multi-functional transition areas and those with tourism and recreation functions) and 53.6 ± 5 kg · (person · year)<sup>-1</sup> for the other communes.

**Key words:** waste accumulation indicator, commune, rate of changes

## ANALIZA ILOŚCI GENEROWANYCH ODPADÓW KOMUNALNYCH NA OBSZARZE WOJEWÓDZTWA PODKARPACKIEGO

### Streszczenie

W pracy przedstawiono analizy zmian ilości produkowanych odpadów komunalnych na obszarach poszczególnych powiatów oraz gmin województwa podkarpackiego. Cel pracy zrealizowano na podstawie badań własnych wykonanych w oparciu o dane pobrane z Banku Danych Regionalnych GUS z lat 2008 – 2014. Z wykonanych analiz wynika, że najwięcej odpadów generowane jest na terenie miast na prawach powiatu, gdzie wartość średnia wskaźników nagromadzenia odpadów zawiera się w przedziale od 200 do 300 kg·rok<sup>-1</sup>. W pozostałych powiatach wartość wskaźnika zmieniała się w bardzo szerokim zakresie od 45 do 200 kg·rok<sup>-1</sup>. Duży zakres zmian wskaźnika nagromadzenia odpadów zmieszanych ogółem oraz z gospodarstw domowych w przeliczeniu na osobę w przedziale od 14,5 kg·(os·rok)<sup>-1</sup> do 345,3 kg·(os·rok)<sup>-1</sup> oraz od 11,3 kg·(os·rok)<sup>-1</sup> do 221,5 kg·(os·rok)<sup>-1</sup> charakteryzował również badane gminy województwa podkarpackiego. Podjęto więc próby mierzące do ustalenia wpływu typu administracyjnego i funkcjonalnego gminy na wielkość badanych wskaźników. Z analiz wynika, że najwyższą średnią wartością wskaźnika nagromadzenia odpadów ogółem charakteryzowały się gminy miejskie (253,6±32,8 kg·(os·rok)<sup>-1</sup>). Drugie miejsce zajęły gminy o obszarach zurbanizowanych, turystycznych i rekreacyjnych (161,5±38 kg·(os·rok)<sup>-1</sup>). Najniższą wartość wskaźnika na poziomie 68,6±6 kg·(os·rok)<sup>-1</sup>, charakteryzowała gminy rolnicze, oraz z przewagą funkcji rolniczej, leśnych i mieszkalnych. Dla wskaźnika nagromadzenia odpadów z gospodarstw domowych wyznaczono trzy charakterystyczne wartości średnie, tj. 169,5±23,7 (gminy miejskie), 96,1±16 kg·(os·rok)<sup>-1</sup> (gminy zurbanizowane, o wielofunkcyjnych obszarach przejściowych oraz o funkcjach turystycznych i rekreacyjnych) oraz 53,6±5 kg·(os·rok)<sup>-1</sup> dla pozostałych gmin.

**Słowa kluczowe:** wskaźnik nagromadzenia odpadów, gmina, tempo zmian

### 1. Introduction

Municipal waste is waste from households, as well as waste not containing hazardous waste from other waste generators which, due to its nature or composition is similar to waste from households [19]. General rules for municipal waste management system in the European Union are set out in the Framework Directive 74/442/EEC on waste. In the field of waste management, the overriding objective is to prevent and minimize waste generation, recovery, disposal and reuse of waste and environmentally safe final disposal of unused waste. The amount of municipal waste generated in a country is dependent on many factors, of

which the main include: the standard of living and the number of population and the size and intensity of consumption of products. The type of waste generated depends on the type of area where the waste is produced, population density, type of development, the presence of public facilities, the presence and size of retail outlets, the type of industry or services and others [6, 10]. In recent years, research and analysis of the factors influencing the amount of waste have been carried out, among others, in the Netherlands [5], Denmark [4], Austria [15], and Poland [9, 10, 11, 13, 18].

Waste monitoring is one of the fundamental aspects of the waste management at all levels of local government.

It is an important tool to support the National Environmental Policy [8, 17, 18]. The most important part of the monitoring is to systematically study the quantitative and qualitative changes in the indicators characterizing waste. The purpose of monitoring is to obtain information on waste and to track trends in their changes, which enables verification of the plans and programs of waste management [16, 12].

Waste management is an area in which there are clear differences between countries, regions, poviats and even communes. They concern mainly the amount and composition of generated waste, and also the degree of deployment and waste recovery [7]. In recent years there has been a dynamic change in the amount of produced waste. Changes in individual units in waste economy are conditioned by many factors: directions of economic development, changes in the quality of life, technical and technological progress [2, 3, 20].

## 2. Aim and scope of the paper

The aim of the paper was to analyze changes in the amount of municipal waste produced in individual counties and communes in the region of Podkarpackie. The study was performed based on the data contained in the Regional Data Bank of the Central Statistical Office [14] in 2008 - 2014. The dynamics of change has been analyzed - increase or decrease in the total mass of accumulated waste in the region as well as in individual communes and poviats - based on the analysis of individual changes in the total municipal waste accumulation and household waste indicator.

## 3. Study area

The Podkarpackie Region is the farthest province to the south - west. It covers an area of 17.84 thousand. km<sup>2</sup>, located at 11th place in the country, and it is inhabited by about 2.13 million people, which gives the region the 9th place in Poland. Podkarpackie Province is one of the cleanest region in Poland. More than 45% of the region is covered by protected areas: the Magura and Bieszczady National Park, 94 nature reserves, 10 natural parks or ecological locations, landscape - nature complexes and natural monuments. This region is very diverse in terms of terrain. The most popular part of the region includes the Sandomierz Basin, the Carpathian foothills, Beskid Niski and Bieszczady. It is the land's varied physiography that makes this area very attractive for tourism, especially in the Bieszczady Mountains.

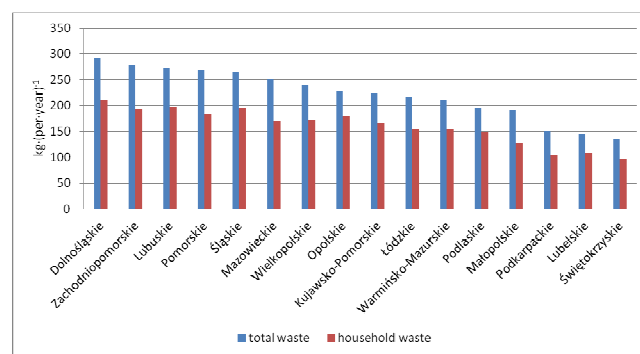
## 4. Materials and methods

### 4.1. The amount of municipal waste collected in Poland

According to the Central Statistical Office, the total amount of collected municipal waste in the analysed time interval ranged from 9.3 million tons in 2008 to 8.2 million

tons in 2014 (Table 1) and thus decrease in the amount of generated waste can be noted. Objective indicators of waste production include a unit indicator of total municipal waste accumulation per capita and a unit indicator of municipal household waste accumulation per capita. The values of these indicators for the whole country are summarized in Table 1. The value of total accumulation varies in individual years, from 212 to 245 kg · (per year)<sup>-1</sup> - the mean value of this indicator is 229 kg · (per year)<sup>-1</sup>. In the case of household waste accumulation indicator, small deviations from the mean value can be seen, which, for the analyzed, period is 163 ± 5 kg · (per year)<sup>-1</sup>.

Figure 1 summarizes the values of total waste accumulation and household waste accumulation per capita by regions. The highest value of the indicators characterizes the regions located in the western Poland (Dolnośląskie, Zachodniopomorskie Regions) in which the value of the total waste accumulation amounted to approx. 280 kg · (per year)<sup>-1</sup> and 200 kg · (person · year)<sup>-1</sup> in the case of households. In contrast, the regions located in the eastern part of the country (Podkarpackie, Lubuskie and Świętokrzyskie) are characterized by the lowest values of these indicators of approx. 150 kg · (per year)<sup>-1</sup> and 100 kg · (per year)<sup>-1</sup>.



Source: own work / Źródło: opracowanie własne

Fig. 1. The mean values of total waste accumulation indicator and household waste accumulation indicator in 2008-2014 by regions

Rys. 1. Wartości średnie wskaźników nagromadzenia odpadów ogółem i z gospodarstw domowych w latach 2008-2014 w podziale na poszczególne województwa

### 4.2. The amount of municipal waste collected in poviats of the Podkarpackie Region

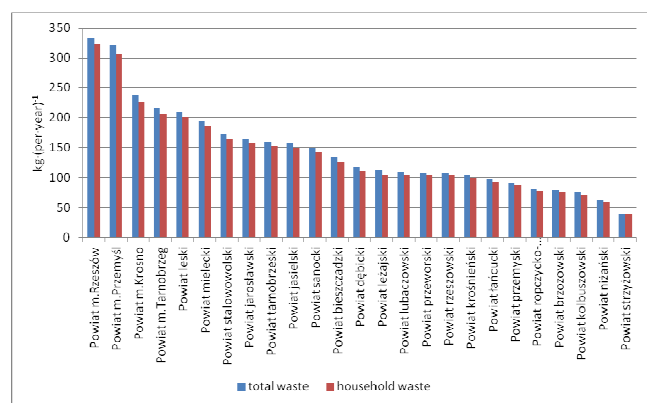
Mean values of municipal waste accumulation indicator and household waste accumulation indicator by poviats (including townships) are shown in Figure 2. Most waste is generated in cities with powiat rights, such as Rzeszów (the region's capital city) and Przemyśl, where the mean value of waste accumulation indicator exceeds 300 kg · (per year)<sup>-1</sup>.

Table 1. The amount of municipal waste collected in Poland  
Tab. 1. Ilość zebranych odpadów komunalnych w Polsce

Specification		Years						
		2008	2009	2010	2011	2012	2013	2014
Total municipal waste	thous. Mg	9353,9	9264,6	9180,1	8843,4	8575,4	8198,7	8281,2
Unit indicator per capita	kg · (per · year) <sup>-1</sup>	245,4	242,8	238,3	229,5	222,5	212,9	215,2
Unit indicator of households per capita	kg · (per · year) <sup>-1</sup>	168,6	166,8	163,4	160,2	158,4	158,7	168,8

Source: own work / Źródło: opracowanie własne

Approx.  $200 \text{ kg} \cdot (\text{per year})^{-1}$  are generated in other cities with powiat rights (Krosno and Tarnobrzeg) and in the district of Lesko which, due to its natural advantages, is a major tourist attraction and therefore many resorts are located there. Thirteen other poviats are characterized by the indicator value in the range of  $100$  to  $200 \text{ kg} \cdot (\text{per year})^{-1}$ . In the Nizański, Kolbuszowa, Brzozów, Ropczyca and Sędziszowice, Przemysł and Łańcut poviats, the average values of waste accumulation is in the range from  $50$  to  $100 \text{ kg} \cdot (\text{per year})^{-1}$ . The least waste (less than  $50 \text{ kg} \cdot (\text{per year})^{-1}$ ) is generated in the Strzyżów powiat.



Source: own work / Źródło: opracowanie własne

Fig. 2. Mean values of total waste accumulation indicator and household waste indicator in 2008-2014 by individual poviats of the Podkarpackie Region.

Rys. 2. Wartości średnie wskaźników nagromadzenia odpadów ogółem i z gospodarstw domowych w latach 2008-2014 w podziale na poszczególne powiaty województwa podkarpackiego

#### 4.3. Changes in the amount of municipal waste produced in different poviats of the Podkarpackie Region

Figure 3 illustrates the pace of changes in the quantities of waste in individual poviats. They are defined as a change in the amount of waste in 2014, as compared to 2008, expressed as a percentage.

The changes are depicted in two groups:

- a group of poviats in which the amount of municipal generated waste is decreasing,
- a group of poviats in which the amount of municipal generated waste is increasing.

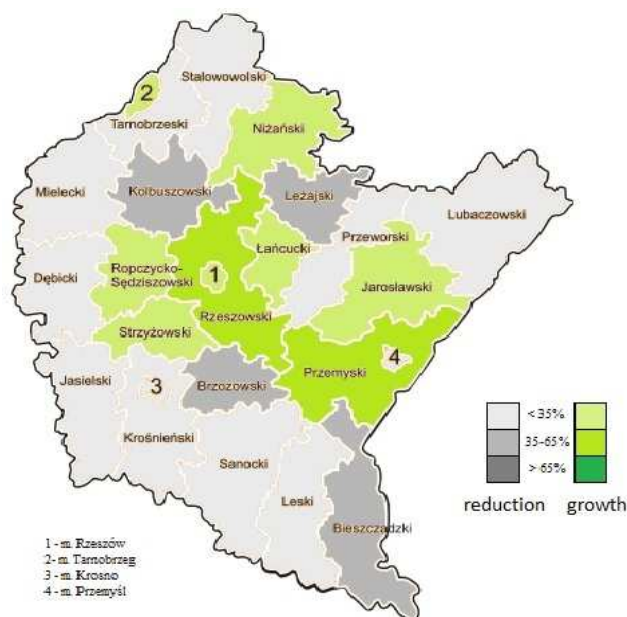
In each group, three levels of the pace of change in the amount of waste were determined:

- level 1 - the pace of changes is small, decrease or increase does not exceed 35%,
- level 2 - average rate of change, decrease or increase between 35 - 65%,
- level 3 - a high rate of change, decrease or increase higher than 65%.

The smallest decrease was recorded in the powiat of Przeworsk and Mielec, where the amount of waste generated in 2014 is 8% lower than in 2008. The largest decrease in the amount of generated waste was observed in the districts of Bieszczady and Leżajsk, for which the decrease amounted to 57% and 48%.

The largest increase was recorded in the powiat of Przemysł where the value of waste generated in 2014 was higher by about 63% than in 2008, and in the powiat of

Rzeszów - an increase by 56%. The smallest increases were recorded in the powiat of Jarosław, the value of waste generated here in 2014, as compared to 2008, increased by 4%.



Source: own work / Źródło: opracowanie własne

Fig. 3. The pace of changes in the quantities of waste generated in the poviats of the Podkarpackie Region in 2008-2014

Rys. 3. Tempo zmian ilości wytwarzanych odpadów w powiatach województwa podkarpackiego w latach 2008-2014

#### 5. Analysis of the variability of the amount of waste generated in different types of communes in the Podkarpackie Region

High variability of the amount of waste generated in 2008-2014 per capita was also observed at the level of individual communes in the Podkarpackie Region. So far, the research made by the authors of the study, did not enable clear identification of the direction and intensity of the observed changes. The probable cause of the changes includes the standard of living and introduced legislative changes related to waste management. In order to better present the situation in a given location, prior to developing the characteristics of the waste stream generated in the surveyed communes, averaged values of individual total waste accumulation indicator and household waste accumulation indicator in 2008-2014 were determined per capita.

In the study, it was observed that the communes of the Podkarpackie Region were characterized by a very large variability in the size of the average individual total mixed waste accumulation indicator and household waste indicator per person. They were, respectively, in the range of  $14.5 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$  to  $345.3 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$  and from  $11.3 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$  to  $221.5 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ . The reason for such a large difference may be the fact that, in the region under analyses, communes are of different administrative types (urban, rural-urban, rural).

Characteristics have been developed for indicators of the size of waste accumulation for each administrative type of communes. The obtained statistical indicators are summarized in Tables 2 and 3.

Table 2. Characteristics of the total mixed waste accumulation indicator for each administrative type of communes  
*Tab. 2. Charakterystyka wskaźnika nagromadzenia odpadów zmieszanych ogółem dla poszczególnych typów administracyjnych gmin*

Administrative type	Value:			Coefficient of variation
	Average	Minimum	Maximum	
	kg·(person·year) <sup>-1</sup>			
1	253,6±32,8	143,9	316,8	20,4
2	76,4±9,3	14,5	345,2	63,9
3	97,2±15,5	17,5	207,6	46,4

where: 1 – urban commune; 2 – rural commune; 3 – urban-rural commune

Source: own work / Źródło: opracowanie własne

Table 3. Characteristics of the indicator of accumulation of mixed waste from households for each administrative type of communes

*Tab. 3. Charakterystyka wskaźnika nagromadzenia odpadów zmieszanych z gospodarstw domowych dla poszczególnych typów administracyjnych gmin*

Administrative type	Value:			Coefficient of variation
	Average	Minimum	Maximum	
	kg·(person·year) <sup>-1</sup>			
1	169,5±23,7	98,9	221,5	22,0
2 and 3	61,6±5,7	11,3	215,9	56,6

where: 1 – urban commune; 2 and 3 – rural commune and the urban-rural commune

Source: own work / Źródło: opracowanie własne

The performed statistical analysis shows that mean values for the amount of total mixed generated waste for the given administrative type of a commune statistically differ significantly at  $p < 0.05$ . However, no statistically significant differences have been recorded for the mean values of household waste accumulation for rural and semi-urban areas. Table 3 shows the so-common characteristics of these two types of municipalities.

The execution of individual characteristics of the quantity of generated waste for each administrative type of the Podkarpackie Region resulted in a decrease of the commune indicators' variability to approx. 20%. The mean value of total mass waste accumulation indicator for the inhabitants of these communes was less than  $254 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ . In rural and semi-urban areas, the mean value of waste accumulation was significantly lower and amounted to  $76.4 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$  and  $94.2 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ . In addition, they were characterized by much greater variability of 50-60%. There were also rural communes where residents produced more mixed waste than in rural communes. The analysis of the household waste accumulation indicator shows that it is also three times higher in rural and semi-urban areas than in urban communes, where it amounted to less than  $170 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ .

As the determined mean values of the indicators under study were characterized by a wide confidence interval, analyses were performed to determine the mean values for the communes, depending on their functional type [1]. The results obtained for the mean values that showed statistically significant differences for different types are summarized in Tables 4 and 5.

Table 4. Characteristics of the total mixed waste accumulation indicator for each functional type of a commune  
*Tab. 4. Charakterystyka wskaźnika nagromadzenia odpadów zmieszanych ogółem dla poszczególnych typów funkcjonalnych gmin*

Administrative type	Value:			Coefficient of variation
	Average	Minimum	Maximum	
	kg·(person·year) <sup>-1</sup>			
1	253,6±32,8	143,9	316,8	20,4
2, 6	161,5±38,1	71,8	345,2	42,6
3	107,0±15,8	56,6	129,5	23,3
4, 5, 7, 8	68,6±6,4	14,5	195,6	51,0

where: 1 – urban, 2 – urbanized, 3 – multifunctional transitional, 4 – overwhelmingly agricultural, 5 – prevalently agricultural, 6 – tourism and recreational function, 7 – forestry function, 8 – mixed functions [1]

The conducted study shows that not all functional type of communes at the significance level of  $p < 0.05$  are statistically significant within differences between the mean values of the total mixed waste accumulation indicator. Similarly, as in the previous analysis, the highest mean total waste accumulation indicator characterized functional urban functional communes. The second place in terms of the amount of generated waste was occupied by communes with urbanized areas, along those with tourist and recreational areas. The mean value of the indicator determined for them was  $161.5 \pm 38 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ . The lowest mean value of total mixed waste produced, at the level of  $68.6 \pm 6 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ , characterized the following four types of communes, i.e. very agricultural, with a predominance of agricultural function, with forest and residential functions.

Table 5. Characteristics of the indicator of accumulation of mixed waste from households for each functional type of communes

*Tab. 5. Charakterystyka wskaźnika nagromadzenia odpadów zmieszanych z gospodarstw domowych dla poszczególnych typów funkcjonalnych gmin*

Administrative type	Value:			Coefficient of variation
	Average	Minimum	Maximum	
	kg·(person·year) <sup>-1</sup>			
1	169,5±23,7	98,9	221,5	22,0
2, 3, 6	96,1±16,0	45,9	215,9	42,2
4, 5, 7, 8	53,6±5,1	11,3	147,0	52,4

where: 1 – urban, 2 – urbanized, 3 – multifunctional transitional, 4 – overwhelmingly agricultural, 5 – prevalently agricultural, 6 – tourism and recreational function, 7 – forestry function, 8 – mixed functions [1]

In the case of the indicator of accumulation of mixed waste from households for each functional type of communes, three characteristic mean values were determined, significantly differing among themselves. The first group consisted of municipalities with urban functional type. In the case of other functional types of communes, only two groups were determined, their mean values were significantly different from each other. In the case of urbanized communes, multi-functional transition areas and those of tourist and recreational functions, the mean value of the indicator of accumulation of mixed waste from households was  $96.1 \pm 16 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ .

In the case of other functional types of communes, the mean value of the analyzed indicator was the lowest and amounted to  $53.6 \pm 5 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ .

## 6. Summary

The study shows that the greatest amount of waste, with a value ranging from 200 to 300  $\text{kg} \cdot (\text{per-year})^{-1}$  in the Podkarpacie Region, is generated in cities with powiat rights and the Lesko powiat which has aroused great interest of tourists (it has many tourist attractions enjoying a lot of attention). In the remaining twenty poviats, the mean value of the total accumulation of household waste contained in the range of 45 to 200  $\text{kg} \cdot (\text{per-year})^{-1}$ .

The evaluation of changes in indicators of waste accumulation in 2008-2014 shows that the largest decrease in the amount of generated waste was observed in the poviats of Bieszczady and Leżajsk, and was, respectively, 57% and 48%. The highest increases were recorded in the powiat of Przemyśl where the value of waste generated in 2014 was about 63% higher than in 2008, and in the powiat of Rzeszów - an increase was recorded at the level of 56%.

The conducted research shows the highest values of the total mixed waste accumulation indicator at the level of  $253.6 \pm 32.8 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$  characterizing urban functional communes. The second place in terms of the amount of generated waste ( $161.5 \pm 38 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ ) was occupied by urbanized areas along with those communes with tourist and recreational functions. The lowest average value of total mixed produced waste, at the level of  $68.6 \pm 6 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ , characterized the following communes: very agricultural, with a predominance of agricultural function, with forest and residential functions.

The analysis of the size of the mixed waste accumulation indicator only for households shows that its highest value can also be expected in urban functional communes. However, in the case of urbanized communes, multi-functional transition areas and of tourist and recreational functions, the mean value was  $96.1 \pm 16 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ . The lowest waste production indicator ( $53.6 \pm 5 \text{ kg} \cdot (\text{person} \cdot \text{year})^{-1}$ ) characterized communes of other functional types.

## 7. References

- [1] Bański J.: Współczesne typologie obszarów wiejskich w Polsce – przegląd podejść metodologicznych. *Przegląd Geograficzny*, 2014, 86(4), 441-470.
- [2] Beigl P.: Prognozowanie zmian ilości i składu odpadów komunalnych. *Mat. VI Międzynarodowego Forum Gospodarki Odpadami*. Poznań – Licheń Stary, 2005.
- [3] Beigl P., Salhafer S., Wasserman G., Maćków I., Sebastian M., Szpadt R.: Prognozowanie zmian ilości i składu odpadów komunalnych, *Mat. VI Międzynarodowego Forum Gospodarki Odpadami „Efficiency of Waste Management”*, Poznań, 2001.
- [4] Christiansen K.M., Fischer C.: Baseline projections of selected waste streams: Development of methodology. European Environmental Agency, Technical Report No. 28, Copenhagen, 1999.
- [5] Hekkert M.P., Joosten L.A.J., Worrell E.: Analysis of the paper and wood flow in the Netherlands. *Resources, Conservation and Recycling*, 2000, 30, 29-48.
- [6] Jalili Ghazi Zade M., Noori R.: Prediction of Municipal Solid Waste Generation by Use of Artificial Neural Network: A case Study of Mashhad, *International Journal of Environmental Research*, 2008, 2, 1, 13-22.
- [7] Jędrzak A., Szpadt R.: Określenie metodyki badań składu sitowego, morfologicznego i chemicznego odpadów komunalnych, opracowanie na zamówienie Ministra Środowiska. Kamieniec Wrocławski – Zielona Góra, 2006.
- [8] Kowalkowski A., Żygadło M.: Planowanie, zarządzanie i ochrona środowiska. Europejski Instytut Kształcenia, Kielce, 1998.
- [9] Malinowski M., Krakowiak-Bal A., Sikora J., Woźniak A.: Ilości generowanych odpadów komunalnych w aspekcie typów gospodarczych gmin województwa małopolskiego. *Infrastruktura i Ekologia Terenów Wiejskich*. Polska Akademia Nauk, Oddział w Krakowie, 2009, 9, 181-191.
- [10] Ministerstwo Ochrony Środowiska. Sprawozdanie z realizacji krajowego planu gospodarki odpadami 2012. [http://www.mos.gov.pl/g2/big/2011\\_11/935528872b22be4e27c786bc41a3c5fc.pdf](http://www.mos.gov.pl/g2/big/2011_11/935528872b22be4e27c786bc41a3c5fc.pdf).
- [11] Nęcka K., Szul T.: Comparison of the Usefulness of Cluster Analysis and Rough Set Theory in Estimating the Rate of Mass Accumulation of Waste in Rural Areas. *TEKA Commission of Motorization and Power Industry in Agriculture*, 2014, 13, 2.
- [12] Nęcka K., Szul T.: Wykorzystanie metod alternatywnych do szacowania wskaźnika masowego nagromadzenia odpadów u odbiorców. *Technika Rolnicza Ogrodnicza Leśna*, 2014, 6, 13-15.
- [13] Pikoń K.: Wolumen generowanych odpadów a wskaźniki makroekonomiczne. *Paliwa z odpadów VII*. Gliwice, Politechnika Śląska, 2009, 245-256.
- [14] *Roczniki statystyczne województwa podkarpackiego 2008-2014*. Główny Urząd Statystyczny. Bank Danych Lokalnych. Warszawa, 2009.
- [15] Salhofer S., Graggaber M.: Erhebung des kommunalen Abfallaufkommens und Untersuchung ausgewählter Sammelsysteme im Bundesland Salzburg. Report. Vienna, 1999.
- [16] Szymański K.: *Gospodarka odpadami – stan i perspektywy*. *Gospodarka Odpadami Komunalnymi*. Komitet Chemii Analitycznej PAN. Koszalin: Wydawnictwo FENIKS, 2006.
- [17] Tałałaj I.A.: Analiza zmian ilości odpadów komunalnych w województwie podlaskim. *Infrastruktura i Ekologia Terenów Wiejskich*, Polska Akademia Nauk, Oddział w Krakowie, 2010, 14, 165-173.
- [18] Tałałaj I.A.: Wpływ wybranych czynników społeczno-ekonomicznych na zmiany ilości odpadów komunalnych w województwie podlaskim. *Inżynieria Ekologiczna*, 2011, 25, 146-156.
- [19] Ustawa z dnia 14 grudnia 2013 r. o odpadach. *Dz.U. z 2013 poz. 21*.
- [20] Żygadło M.: *Strategia gospodarki odpadami komunalnymi*. Poznań: Wydawnictwo Polskiego Zrzeszenia Techników i Inżynierów Sanitarnych, 2001.