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ANALYSIS OF CHANGES IN FEES FOR THE COLLECTION AND MANAGEMENT OF MUNICIPAL WASTE AS REGARDS THE EFFICIENCY OF WASTE SEGREGATION

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ABSTRACT: The issue discussed in this paper is related to the correlation between the efficiency of waste segregation and fee rate imposed on residents for generated municipal solid waste, which rate is set and changed by municipal authorities. The main objective of the paper was to analyse the variability of fees for waste collection and management, as well as to analyse changes within this scope during the first several years (from 1 July 2013 to 31 December 2016) since the new waste management system was implemented in Poland. The research area included the municipalities of the 1st Waste Management Region in the Silesian Voivodeship. The mean fee sustained by residents of the examined municipalities for the collection and management of mixed waste was PLN 14.1 per person per month; when residents opted for additional selective waste collection, the fee was PLN 7.3 per person per month. During the examined period, the waste collection fee increased in the majority of the municipalities by 34.0%. One third of the municipalities did not change the rate. In those municipalities where the fee increased, the growth of segregation efficiency was hampered. The mean share of the segregated municipal waste stream in the total stream of collected waste reached 22.6%. No significant correlation was observed between the applied fee rate and efficiency of selective waste collection.

KEY WORDS: municipal solid waste, waste management, waste management fee

Introduction

The act of 13 September 1996 on maintenance of cleanliness and order in municipalities (Journal of Laws 2011 no. 152, item 897, as amended), altered the municipal solid waste management system. "The waste revolution" (resulting from the amendments to the act mentioned above), which came into force on 1 July 2013, had local governments of municipalities assume responsibility for waste generated by their residents. The scope of duties municipalities were entrusted with required outlays on the establishment and operation of the new municipal solid waste management system, including:

- collection, transport, recovery and disposal of municipal solid waste,
- establishment and maintenance of municipal solid waste collection points,
- administration of the system,
- educational campaigns among residents.

Another essential change was related to establishing the method for residents to pay fees for the collection and management of municipal waste. Fees for municipal waste management were not directly associated with the weight of generated waste. They were dependent on the characteristics of households where waste was generated. Dijkgraaf and Gradus (2009), Sakai et al. (2008) and van Beukering et al. (2009) in their articles show the benefit of using fees based on the weight of waste (not for household or per person). These benefits have a financial dimension, but also social and educational. More and more municipalities in Europe are implementing a system "unit-based pricing". Unfortunately, there are still cases of illegal dumping sites in such communes.

There are many debates in the literature regarding whether a change of waste management fee provides enough of an incentive to encourage waste minimization and recycling. Many authors state that a waste management fee for municipal solid waste should be designed to encourage households to reduce the amount of their waste (Welivita et al., 2015).

In 2012 the basic task of the Polish municipality was to calculate the running costs of the system and their distribution among residents. Initially, the policymaker specified neither minimum nor maximum rates of these fees, granting the municipalities complete freedom within this scope. Each municipality, within specific legal limits, shaped its own fee system for municipal solid waste management (Kiepas-Kokot et al., 2015).

In designing a waste management fee, charging method, payment vehicle, features of service package and challenges in implementing should be

considered (Welivita et al., 2015). Charging method can be a flat rate (fixed) or unit rate (quantity-based charge). The flat rate has become popular in many developed and developing countries because of easy handling and constant revenue generation (Töpfer, 2005). However, some developing countries are facing a problem of fees which are not sufficiently covering the cost of waste management. Further, a price correction is also difficult to do due to public and political opposition (O'Connor, 1996). Quantity-based charge method is also known as the "unit pricing" or "pay as you throw" method where households are charged according to the amount of waste or frequency of collection (Chang et al., 2008). The waste amount is measured on the basis of weight, volume (can, bag, tag/sticker) and frequency (Diaz et al., 2005). This method is popular in many countries due to its ability to give a clear price signal hence encouraging households to reduce their waste. Even though it is popular among developed countries such as Denmark, Finland, Sweden, the Netherlands (Dijkgraaf, Gradus, 2004, 2009; van Beukering et al., 2009), and Belgium (Gellynck, Verhelst, 2007), no proof of its application in developing countries was available in the literature.

In Poland, until 2012, it was waste producers themselves (residents) that were responsible for signing contracts with entrepreneurs licensed to collect and transport municipal solid waste. The municipality served only the regulatory and control functions, without affecting the management of waste collected from its residents (Malinowski, 2011). Both in rural and urban areas, the management of waste was improper, as it entailed combustion in household heating systems and dumping waste in locations not intended for this purpose, which would result in the creation of numerous "illegal dumping sites" (Steinhoff-Wrześniowska, 2015; Ciura et al., 2017). The new municipal waste management system began to function on 1 July 2013. The main assumption behind the amendment was to delegate the authority over waste to the municipality where it was generated (Journal of Laws 2011 no. 152, item 897, as amended). At the same time, the European Union and national legislation committed the local municipal government to achieving specific recycling rates for paper, plastic, glass and metals, to preparing construction waste so that it could be reused and recovered by other means, and to reducing the weight of biodegradable municipal waste intended for landfilling (Malinowski, Kopytko, 2014).

The running costs of the new system are covered by fees paid by residents. These fees will soon rise across the country due to increased costs of waste management. Between 2018 and 2020, fees for waste landfilling will double (Journal of Laws 2017, item 723). Such circumstances will translate into higher amounts offered in tenders for the collection and management of waste and, therefore, increased fees for residents. In fact, the latest amend-

ment to the act on maintenance of cleanliness and order in municipalities (Journal of Laws 2011 no. 152, item 897, as amended) necessitates mandatory waste segregation due to the fourfold increase in the waste collection and management fee imposed on residents who will not collect waste selectively. To avoid this drastic rise, one should attempt to increase the weight of selectively collected waste, simultaneously decreasing the weight of mixed municipal waste. This solution will enable one to achieve higher recycling rates for paper, plastic, metal and glass.

Selective municipal waste collection is one method to facilitate meeting EU requirements by the municipality. As of 1 July 2017, the Regulation of the Minister of the Environment on detailed method for the selective collection of certain waste fractions came into force (Journal of Laws 2017, item 19). This regulation specifies the detailed method for the selective collection of certain waste fractions and establishes a uniform segregation system for entire Poland. Pursuant to it, collected waste will be divided into the following fractions: paper, glass, metals and plastics, biodegradable waste and other waste (mixed). The enactment of such regulations in the light of the hitherto most popular waste collection system of two sacks or containers, with the division into segregated and mixed waste, will also cause the cost of its collection and management to change.

The municipality is obliged to specify, by way of resolution, the method for setting the fee rate for municipal waste management (Journal of Laws 2011 no. 152, item 897, as amended). The allowed criteria for setting municipal waste management fees are as follows: number of residents on the property, volume of water used on a specific property or dwelling surface. Revenues from fees imposed on residents must cover all running costs of the system, including not only collection, transport, recovery, disposal of municipal solid waste or establishment and maintenance of selective municipal waste collection points, but also the administration of the system and educational campaigns among residents. In order to encourage residents to consciously handle waste, Municipal Councils very frequently set lower rates for the collection of segregated waste. According to Terek, Piotrowska (2013), the fee for municipal waste collection from people who collected waste selectively as the act was being implemented fell between PLN 2.5 and 15 per person per month. The average value for the whole of our country is PLN 8.5 per person per month. If waste is not collected selectively, the fee increases by 40.0% on average and falls between PLN 7 and 25 per person per month (Terek, Piotrowska, 2013).

The source literature emphasises the key role of ecological education in waste management (Kostecka, 2011). In this context, one can point out the special role that the economic factor plays in shaping pro-ecological attitudes

(Jaźwiński, 2010). The research into what motivates pro-ecological attitudes shows that instrumental (mainly economic and health-related) factors are the most efficient stimuli (Hłobił, 2009). There are research works which indicate that one municipality's decisions could be influenced by those of a neighboring municipality (Zafra-Gómez, Chica-Olmo, 2018). Therefore, of significant importance is to research and analyze spatial interrelations of fee rates for waste collection and management.

Some authors, including Dahlén and Lagerkvist (2010), Dijkgraaf and Gradus (2004) and Sakai et al. (2008), claim that changes in the fee rate or in the method of its setting, often resulting in an increase in the fee rate, lead to reduction of municipal waste generated and to an increase in the share of waste directed to composting or recycling processes, which implements the paradigm of circular economy.

The aim of the paper was to analyse the variability of fees charged for waste collection and management and to analyse changes within this scope between 2013 and 2016 in the municipalities of the 1st Waste Management Region in the Silesian Voivodeship as regards the weight of mixed and segregated waste and efficiency of its selective collection.

Characteristics of the research area

The research was conducted in the 1st Waste Management Region of the Silesian Voivodeship, which includes five counties, namely Częstochowa, Zawiercie, Kłobuck, Lubliniec and Myszków. In 2018, the Municipal Offices from this Waste Management Region were asked to share information necessary to prepare the characteristics of waste management fees incurred by residents of the municipalities and data to prepare the characteristics of waste generated in the research area. Thirty seven municipalities answered. The information for the analysis and statistical interpretation of results was obtained from 34 municipalities and applied to the period from 1 July 2013 to 31 December 2016. Some of the data was also acquired from online public information bulletins. Therefore, the ultimate research area covers 34 municipalities whose location is shown in figure 1.

All of the examined municipalities are provided with waste management services by Częstochowskie Przedsiębiorstwo Komunalne Sp. z o. o. (CzPK), which manages the regional municipal solid waste treatment plant (*Regionalna Instalacja Przetwarzania Odpadów Komunalnych* – RIPOK).

Figure 1. Location of the research area

Source: author's own work.

Research methods

The acquired data, submitted in the form of scanned statements filed by the facilities providing the municipalities with municipal waste collection services, was tallied and verified against the information shared by the Marshal's Office of the Silesian Voivodeship. The analysis of the collected data included:

- calculation of the mean index of municipal solid waste accumulation:

$$W_m = \frac{\left(\frac{M_{2013}}{L_{2013}}\right)+\left(\frac{M_{2014}}{L_{2014}}\right)+\left(\frac{M_{2015}}{L_{2015}}\right)+\left(\frac{M_{2016}}{L_{2016}}\right)}{4} \cdot 1000, \qquad (1)$$

where:

W_m – index of municipal solid waste accumulation [kg per person per year],

M_{2013}, M_{2014}, M_{2015}, M_{2016} – total weight of municipal solid waste collected from residents of the municipality respectively in 2013, 2014, 2015 and 2016 [Mg],

L_{2013}, L_{2014}, L_{2015}, L_{2016} – number of municipality residents respectively in the examined year.

- calculation of the share of segregated municipal waste in the stream of all municipal waste collected from residents of the municipalities in 2013, 2014, 2015 and 2016 based on the formula:

$$U_S = \frac{M_S}{M_S+M_Z} \cdot 100\ [\%], \tag{2}$$

where:
U_s – share of segregated municipal waste in the entire municipal waste stream in a specific year [%],
M_s – weight of segregated municipal waste collected from residents of the municipality in a specific year [Mg],
M_z – weight of mixed municipal waste collected from residents of the municipality in a specific year [Mg].

- specification of the effectiveness of waste segregation by calculating the mean share of segregated waste in the stream of all municipal waste during the research period , calculated as an arithmetic mean of shares for the four years,
- evaluation of the increase/decrease in the share of segregated municipal waste calculated as the ratio of the segregation share in 2016 to the segregation share in 2013:

$$\Delta U = \left(\left(\frac{U_{S\,2016}}{U_{S\,2013}}\right) - 1\right) \cdot 100, \tag{3}$$

where:
ΔU – ratio of the segregation share in 2016 to the segregation share in 2013 [%],
U_{s2016} – share of segregated municipal waste in the entire municipal waste stream in 2016 [%],
U_{s2013} – share of segregated municipal waste in the entire municipal waste stream in 2013 [%].

- based on the known rates for the collection and management of mixed municipal waste and selectively collected waste from residents in 2013 and 2016, we determined the change of these rates in each municipality throughout the four years:

$$Z_{z,s} = \left(\left(\frac{Op_{z,s\,2016}}{Op_{z,s\,2013}}\right) - 1\right) \cdot 100, \tag{4}$$

where:
$U_{Z,S}$ – change in the rate for the collection and management of mixed municipal waste (z) and selectively collected waste (s) [%],
$Op_{Z,S\,2016}$ – rate for the collection and management of mixed municipal waste (z) and selectively collected waste (s) in 2016 [PLN per person per month],
$Op_{Z,S\,2013}$ – rate for the collection and management of mixed municipal waste (z) and selectively collected waste (s) in 2013 [PLN per person per month].

The ratio of the mean rate for the collection and management of selectively collected waste to the mean rate for the collection and management of

mixed municipal waste will allow us to determine whether the municipality encourages its residents to collect waste selectively in financial terms.

For the mean values of analyzed fee rates and above mentioned indexes standard deviation values were calculated and presented in the text.

Results visualization

The results are presented in graphical form. To prepare the presentation, the ArcView GIS 10 was used. Maps were prepared to present the data on waste management in the specific region. To group the municipalities, we applied the Jenks natural breaks classification method, which meets the following assumptions: data of approximate values belong to one class; each class contains a specific number of values; none is an empty set (Jenks, 1967).

Results of the research

Mass accumulation of waste

The mean index of mixed municipal solid waste accumulation for the research area was 236±59 kg per person per year. This value is close to the Polish average, which in 2014 was 214 kg per person per year; however, it was smaller than the value for the Silesian Voivodeship, which in 2014 reached 280 kg per person per year (Ochrona środowiska, 2015). The lowest value of the mass accumulation index was 125 kg per person per year and was recorded in the rural municipality of Niegowa, whereas the highest was recorded in the urban municipality of Zawiercie: 341 kg per person per year.

At present, one of the most important issues related to waste management is not the weight of generated waste but the efficiency of its selective collection and impurity level of this waste (Malinowski et al., 2018). In 2016, the share of selectively collected waste in the entire weight of municipal waste collected in Poland was 25.2% (CSO, 2017). The share of selectively collected waste in the research area between 2013 and 2016 was: 22.6±11.5% (figure 3). Regarding urban and urban/rural municipalities (12 municipalities), this share was closer to the Polish average and reached 24.6%, whereas in rural municipalities – 21.8%. The differences were not statistically significant (Fischer's exact test, $p = 0.05$). In the municipality of Koniecpol, even 59.3% of waste is collected selectively on average yearly. The lowest mean share of segregated waste, only 8.1%, was recorded in the municipality of Niegowa.

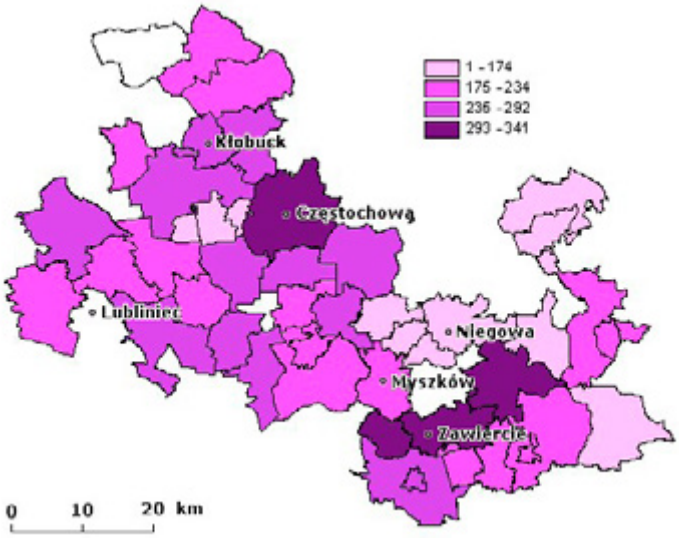

Figure 2. Mean index of mixed municipal solid waste accumulation in the municipalities [kg per person per year]

Source: author's own work.

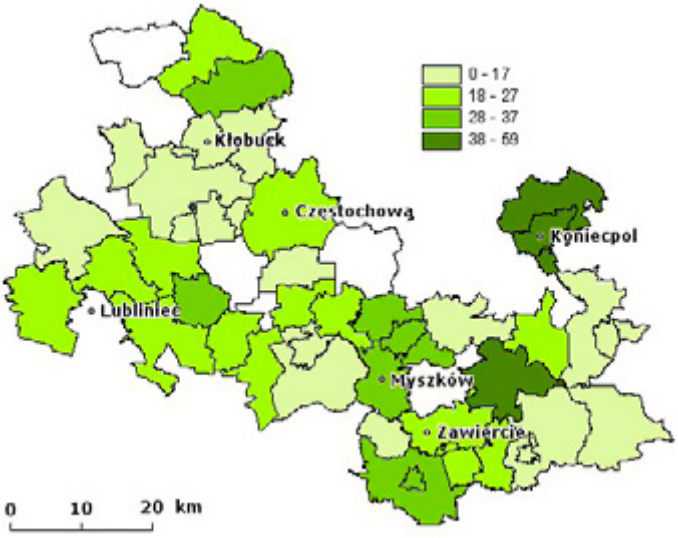

Figure 3. Mean share of selectively collected waste in the total stream of municipal solid waste [%]

Source: author's own work.

From 2013 onwards, the weight of waste collected selectively is observed to have been increasing in Poland. Between 2012 and 2016, there was an approximately threefold growth of the weight of such waste; however, according to Malinowski et al. (2018), its impurity level is approx. 30%.

In nine of all the examined municipalities, the share of segregated waste was observed to decrease by 11.3±7.1% on average, whereas 21 municipalities recorded the increase in the share of "segregation" in the municipal waste stream (figure 4). Such circumstances testify to a good trend among residents of these municipalities and a high level of their ecological consciousness. The mean increase in the share of selectively collected waste during the examined period in these 21 municipalities amounted to 63.9±21.2%. Over 100% growth in the share of selectively collected waste was reported in the municipalities of Panki (118%), Kamienica Polska (100%) and Poraj (102%). The higher increase in the effectiveness of segregation was recorded in rural areas, which is attributable to the fact that these areas are reducing their backlog related to selective waste collection more dynamically. It should also be noted that it is easier for residents of rural areas to collect such waste than for residents of towns or cities. This is related to, for instance, the availability of containers and their location near households. Furthermore, rural dwellers take greater care while segregating waste. As for blocks of flats in urban areas, the responsibility for the segregation of waste is assumed by all dwellers of the entire block, no matter if individuals segregate waste or not.

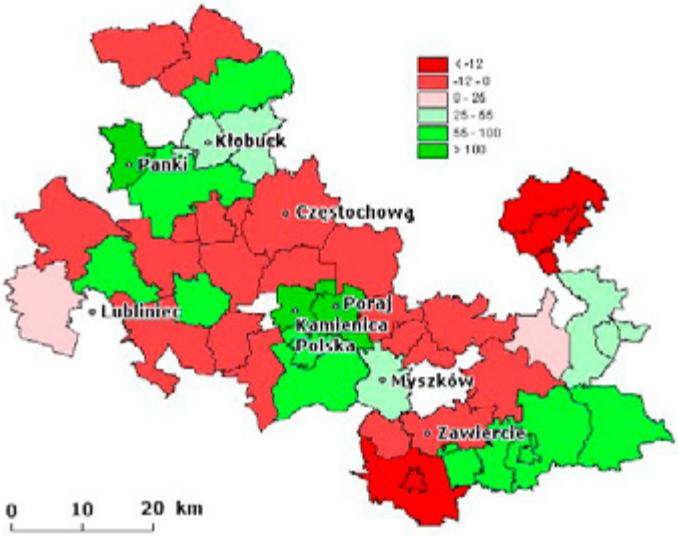

Figure 4. Change in the share of segregated waste in 2016 in relation to segregated waste in 2013 [%]

Source: author's own work.

Fees paid by residents for waste management

Rates of monthly fees for the collection and management of municipal solid waste that the local governments of the majority of the municipalities have established in the research area are charged per person inhabiting the property (figure 5). This method has been used for a long time and is now quite common. With all certainty, its advantage lies in simplicity and low implementation cost (Grzymała et al., 2013).

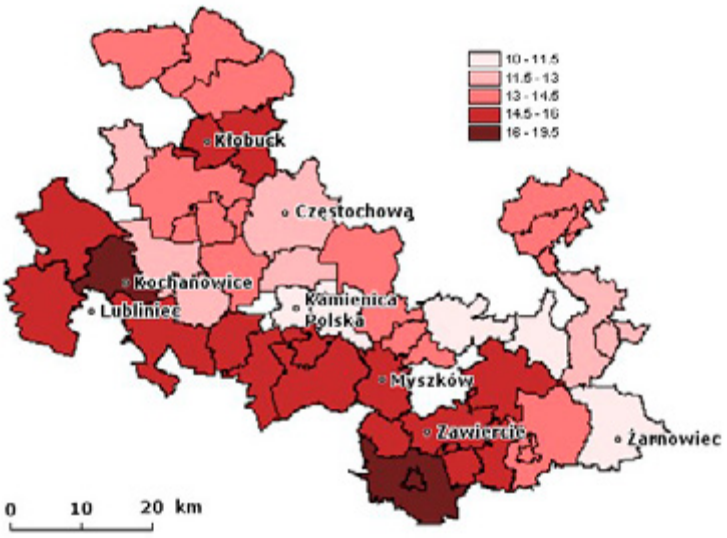

Figure 5. Mean rates for the collection and management of mixed municipal waste imposed on residents [PLN per person per month]

Source: author's own work.

The amount (monthly fee rate) imposed on residents for the collection and management of mixed municipal waste is PLN 10.0 per person in the municipalities of Kamienica Polska and Żarnowiec (the lowest fee rates), whereas in the municipality of Kochanowice – it may be up to PLN 19.5 per person (the highest fee rate). The mean amount for the research area, which is PLN 14.1±1.9 per person per month, was exceeded by 14 municipalities (figure 5). When household waste is also collected selectively, these amounts decrease twice on average (figure 6). Lowest fees for the collection and management of waste from households (which segregate waste) are paid by residents of the municipality of Irządze, PLN 5.5 per person per month, whereas residents of Częstochowa contribute the most to the municipal coffers, that is PLN 10.5 per person per month. The mean monthly fee for the research area was PLN 7.3±1.1 per person.

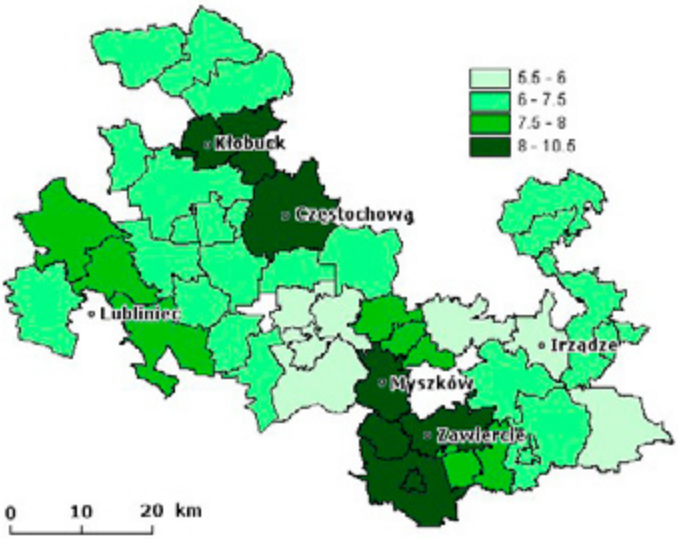

Figure 6. Mean rates for the collection and management of municipal waste also collected selectively [PLN per person per month]

Source: author's own work.

Figure 1 shows mean rates for the collection and management of mixed municipal waste from households which did not opt for collecting waste in colour sacks or containers for segregation. In the southern parts of the region, one may observe significantly higher rates. Furthermore, the towns or cities are characterised by slightly higher rates (PLN 14.5±1.5 per person per month) in comparison to rural areas (PLN 14.0±2.0 per person per month). In the case of households from rural municipalities which opted for waste segregation, the monthly fee for waste collection and management is lower by PLN 1 per person than in urban areas (PLN 8.1 per person in urban areas).

The ratio of the rate for mixed municipal waste collection to the rate for selectively collected waste may be a tool used for promoting waste segregation. When residents committed themselves to segregating municipal waste, the fee for its collection and management was 52.0% lower than in the case of a fee charged when there was no such commitment. The lower cost encourages municipality residents to segregate waste. In the urban municipality of Częstochowa, the fee for waste collected selectively was 84.0% of the amount charged for the collection of mixed municipal waste. Residents of the vast majority of the municipalities pay half as much for the collection of segregated waste than where there is no segregation and mixed municipal waste is collected (figure 7).

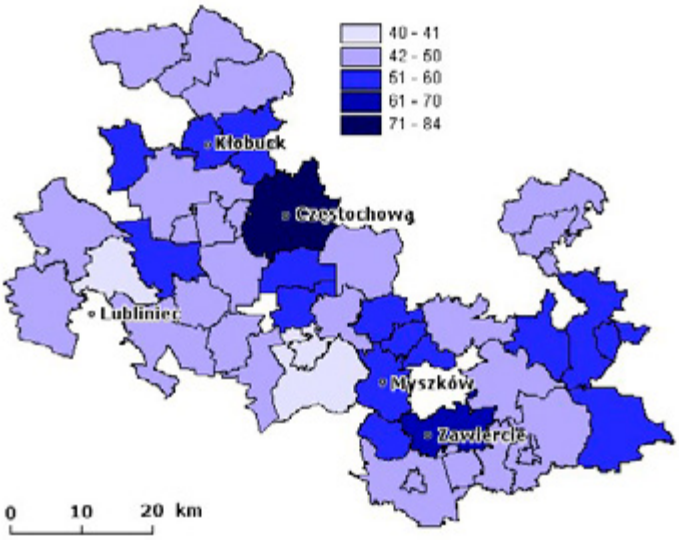

Figure 7. Ratio of the rate for the collection and management of municipal waste collected selectively to the rate for the collection and management of mixed municipal waste [%]

Source: author's own work.

As for the vast majority of the examined municipalities, there was an increase in the fee rate for the collection and management of mixed municipal waste, as well as selectively collected waste (figures 8 and 9). It occurred regardless of legal or economic stimuli. Speaking of both mixed and segregated waste in 2016, this fee was higher by 34.0% on average. The fee for services related to mixed waste decreased in the municipalities of Łazy and Miedźno. The fee was reduced by 5.6% and 8.0%, respectively, in relation to 2013. Fees paid by residents in the case of segregation dropped in the municipalities of Łazy by 5.6%, and Herby by 12.5%. In approximately one third of the municipalities, fees for services related to both mixed and segregated waste had not changed from 2013 (figures 8 and 9).

The spatial variability of fee rates and their fluctuations as regards the management of mixed municipal waste and segregated waste indicate a clear regularity, confirmed by the ratio of the correlation between changing rates for the collection and management of mixed waste and segregated waste, to be exact: 0.81. The calculated average fees for the management of municipal waste bear similarity to the fees estimated by Kiepas-Kokot et al. (2015) for the waste management in regions of the West Pomeranian Voivodeship. The mean fee in these regions for mixed municipal waste man-

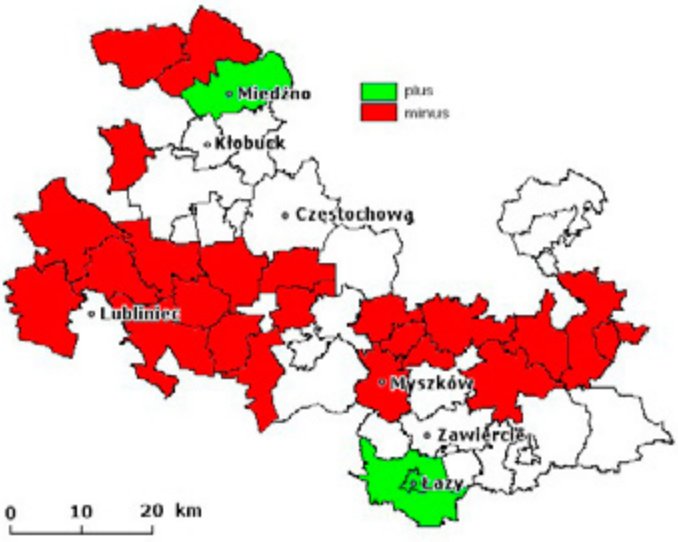

Figure 8. Change in the rate for the collection and management of mixed municipal waste imposed on residents

Source: author's own work.

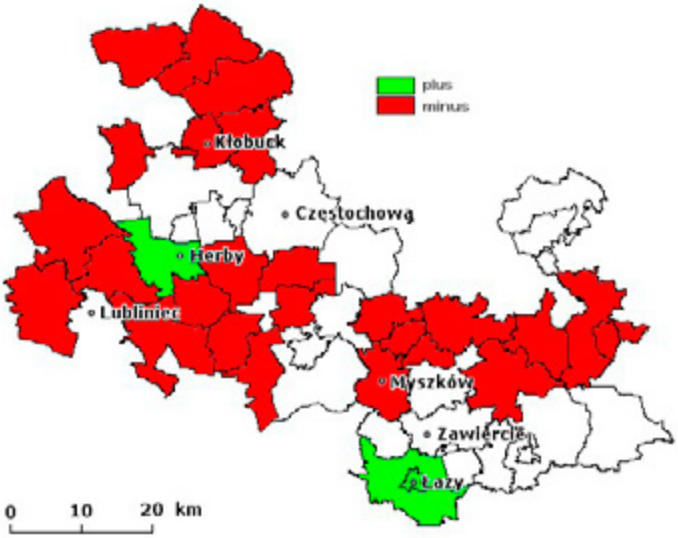

Figure 9. Change in the rate for the collection and management of waste also collected selectively

Source: author's own work.

agement fell between PLN 13.24 and 18.52 per person per month, and for selectively collected waste – between PLN 8.67 and 12.35 per person per month. It is worth noting that the increase in the charge for mixed waste did not always increase the fee for segregated waste. The correlation coefficient for the above dependence is 0.55.

In the municipalities where the fee rate for waste collection increased, the increase of the share of segregated waste in the stream of all collected waste was twice as low when compared to the municipalities where such fees remained unchanged. In the latter municipalities, the share of segregated waste was increasing throughout the analysis. The correlation coefficient between the change of fee rates and the change in the share of selectively collected waste was only -0.27. The municipalities which between 2013 and 2016 had not changed their fee rates were mainly towns or cities and urban/rural municipalities. As can be seen from the above, increasing rates for the collection of waste from households which opted for selective collection of waste impedes the process. This is essential in the light of the prospective increase in fee rates for waste collection and management, which will affect all citizens of Poland.

Apart from the above mentioned work of Kiepas-Kokot et al. (2015) there are no similar research results concerning dependency of fee rates in Polish municipalities and effectiveness of waste management in terms of amounts of waste collected selectively and directed to recycling. Yang and Innes (2007) indicate the importance and need of thorough analysis of the relation between fees imposed on residents and selective waste collection as well as the share of recyclables in the whole MSW stream.

The paper also calculates the correlation between fee rates in the respective years, and weight of collected mixed (R=-0,11) and segregated waste (R=-0,17) as well as efficiency of waste segregation (R=-0,27). Among the compared correlations, no significant one was observed. This indicates that the applied fee rate does not affect the efficiency of waste segregation.

Conclusions

The mean monthly fee imposed on residents of the examined municipalities between 2013 and 2016 for the collection and management of mixed waste in the research area was PLN 14.1 per person; when residents opted for selective waste collection, the rate was twice as low and amounted to PLN 7.3 per person. During the examined period, the waste collection fee increased in the majority of the municipalities by 34.0%. One third of the municipalities did not change the rate. It is important to note that in the

municipalities where the fee rate was increased, the rise applied to both residents who collected only mixed waste and ones who segregated it. Similarly, in the municipalities where the fee was increased, the efficiency of segregation was hampered, which segregation is essential due to the necessity of our meeting UE regulations pertaining to waste recycling.

The mean share of the segregated municipal waste stream in the entire stream of collected waste for the period and region under examination was 22.6%. No significant correlation was observed between the applied fee rate and efficiency of selective waste collection.

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The contribution of the authors

Mateusz **Malinowski** – 40% (conception, literature review, data analysis, interpretation, discussion).

Maria **Łukasiewicz** – 25% (literature review, data analysis).

Stanislaw **Famielec** – 25% (literature review, data analysis, language correction).

Karina **Nowińska** – 10% (data collection, data analysis).

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