In the context of global consumption growth, the amount of household waste is increasing, the management of which should be based on the choice of those methods that ensure the growth of its processing and do not increase the financial burden on the population.

This study examines the most common methods of organizing the management of solid domestic waste and the formation of tariffs for its disposal in the Netherlands. The effect of the applied method on the composition of the generated waste and the degree of separation of their components is analyzed. The cost of handling each ton of waste using each of the three most common methods is calculated.

The different influence of the method of payment for household waste management on the volume of mixed waste generation per capita and the volume of waste generation in general has been proven. The largest volumes of mixed waste were generated in those municipalities that introduced an annual fee per inhabitant. The smallest are when using payment by the volume of the garbage bag.

Depending on the method used in determining the payment for household waste management, the financial burden per tenant is calculated. In municipalities that have implemented a fixed fee for waste disposal per inhabitant, the load was 1.04 % of the annual income of the person, and when paying depending on the volume of garbage bags, 4.65 %.

It is established that the existing waste management system in the Netherlands has ensured a high level of organization of separate collection of household waste.

As a result of the study, no direct relationship was found between the method of calculating payment for waste disposal and the generation of mixed waste. It is concluded that the effectiveness of the implementation of the household waste management policy depends on the level of public awareness of the negative consequences of its impact on the environment

Keywords: municipal solid waste, cost of waste management, simple method, complex method

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THE INFLUENCE OF ORGANIZATIONAL AND ECONOMIC METHODS OF HOUSEHOLD WASTE MANAGEMENT ON THE VOLUMES AND STRUCTURE OF ITS FORMATION: THE EXPERIENCE OF THE NETHERLANDS

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1. Introduction

The rate of removal of solid domestic waste from landfill sites and the level of its processing have become one of the main indicators of the development of society and its sustainable development. Climate change and emissions of harmful gases into the atmosphere depend, among other things, on the amount of waste and the way it is handled. Numerous studies were conducted in developed countries by the end of the 20th century in this area. The research focused on the legislation, organization, infrastructure, and economics of solid waste management. One of the main objectives of those studies was to identify the optimal combination of laws, infrastructure, and financing of waste management, without having a negative impact on the quality of life and economic development.

Ukraine, like other countries in Eastern Europe, is obliged to achieve a high level of waste disposal from landfills by minimizing its formation and increasing the rate of recycling. Limited economic resources and tight deadlines to achieve this goal force to turn to the experience of advanced countries that have achieved high rates in the waste management system. The main thing for such countries is to get a clear understanding of the effect of legislation, investment in infrastructure, the way tariffs are formed and the self-awareness of citizens to achieve the desired result.

The Netherlands is an ideal example for the analysis of municipal solid waste management. In the Netherlands, 9.1 million tons of municipal solid waste, or 521 kg per inhabitant, were collected in 2020, an increase of 6.8 % compared to 2019. The increase in the generation of municipal solid waste was mainly due to additional mixed, vegetable, fruit, and garden (VFG) waste. It is worth noting that the volume of self-exporting household waste also increased from 3.1 million tons in 2019 to 3.4 million tons in 2020. The self-exporting waste streams were mainly glass, wood, construction and bulky garden waste [1]. The municipal solid waste treatment infrastructure in the Netherlands consists

mainly of waste incineration technology to produce heat and electricity, as well as the treatment of biowaste to produce compost or biogas. As of January 2019, there were 45 licensed solid waste processing plants in the Netherlands. The main share of installed processing capacities (about 70 %) accounted for waste incineration (69.8 %) [2].

Studying the experience of applying the economic and organizational tools used in the household waste management system in the Netherlands will allow many countries to make their own choice of tools to increase the volume of waste recycling.

2. Literature review and problem statement

The problem of effective management of household waste is one of those problems of mankind whose solution affects the state of the environment. Since the last century, Western Europe and the United States have been actively engaged in scientific and legislative activities in the direction of finding effective tools that affect the increase in the degree of recycling of household waste. The task of finding optimal organizational and economic tools for household waste management is relevant both for European countries and the Far East. Each country solves the problem of organizing waste collection and payment for its management based on the volume of processing of waste generated, the degree of achievement of strategic processing indicators, and incomes of the population. Scientific reports and articles on this problem regularly appeared after 1988, and in 2019 increased to 75 papers, the growth rate for 10 years was 294.74 % [3]. Some studies have scientifically proven the low effectiveness of a differentiated tariff for waste management, taking into consideration the volume, weight, or frequency of waste collection. Scientists substantiate the feasibility of applying a package pricing model depending on the annual income per capita, annual consumption, and the cost of waste disposal. The authors propose the introduction of three tariff packages for waste management for citizens with low, medium, and high income. At the same time, each subsequent package compensates for the uncovered costs of previous packages [4]. Such an approach to household waste management makes the effectiveness of the waste management system dependent on the structure of incomes of the population, and a fixed tariff does not stimulate a decrease in its formation and a decrease in pollution.

Other studies prove that differential tariffs can be successfully applied in large cities and do not lead to a significant increase in the illegal export of waste or the cost of its collection [5]. The researchers claim that paying by weight or per bag led to a 60 % reduction in organic waste production and 50 % in unsorted waste [5]. Scientists have analyzed that the introduction in 1993 in the Dutch municipality of a tariff tied to the amount of waste led to a decrease in their generation by 30 % in the first year. They proved the greatest effectiveness of such a tariff for the separate collection of compostable waste. According to the researchers, the introduction of differentiated tariffs cannot be successful without providing the population with infrastructure and raising citizens' awareness of the separation of solid domestic waste [6, 7].

In the scientific literature, the expediency of applying fixed tariffs is also economically substantiated [7]. An analysis of 125 tariff rates in Spanish cities showed that the application of fixed tariffs did not lead to a deterioration in waste recycling rates. The authors of this analysis believe that differential tariffs are initiated, in large part, for environmental and political reasons than for economic ones. They also proved the effectiveness of using a combination of two tariffs: municipal payments for services and payment for the amount of waste [7]. A study into the trends in the evolution of tariff systems in the Netherlands for the period of 1998–2010 led to the fact that payment for the number of trips to collect waste became the most common. It was also concluded that payment for each abandoned package had a negative impact on the rate of separate collection of recyclables [8]. In municipalities where differentiated tariffs are applied, residents usually comply more with the rules of separate collection, which leads to a decrease in the production of mixed municipal solid waste [9, 10]. A study conducted by Wolde in 2020 in the Netherlands supported the thesis of the need for a differentiated tariff system. It stressed, on the other hand, that the introduction of such a system was caused solely by environmental considerations rather than economic considerations. The study also emphasizes the increase in the requirements of citizens for the quality of service when implementing such a system [11].

Scientific studies into the methods of setting a tariff for the management of solid domestic waste have not solved the problem of choice. The introduction of a differentiated tariff is an expensive system, pursuing mainly environmental goals, and requiring the need to improve the quality of infrastructure and services in its implementation. Despite the transition to differentiated pricing, disputes about its effectiveness continue in Europe. Fixed rates still exist in countries with advanced recycling rates. However, the application of a fixed tariff does little to encourage the separate collection of waste and the reduction of mixed waste. With the introduction of a fixed tariff, the responsibility for the education of a culture of waste management increases.

Our review of the available scientific literature [4–11] showed that the task of choosing economic tools for building an effective waste management system is not solved and requires the need for in-depth study and systematization of the existing evolutionary experience. Recycling volumes directly depend on the amount of recyclable waste. The increase in recycling resources is directly influenced by the choice of the method of setting payment for waste management. European countries demonstrate different volumes and structures of household waste processing, depending on the methods of payment used for its management. Limitations in choosing a method are the way to organize waste sorting, the income of the population, the number of participants in the waste management system. In addition, changing the method of payment for waste management also changes the financial costs of the population. The lack of analytical studies of the relationship between payment methods, the financial burden on the population, the amount of household waste suitable for recycling caused low volumes of recycling. The ideal option for critical analysis and comparison of different approaches and drawing adequate conclusions is the experience of the Netherlands. The example of the Netherlands should help understand the results of the introduction of various pricing systems for household waste management services.

Different combinations of municipal solid waste management practices in one country should provide a comprehensive pattern for testing research results in practice.

3. The aim and objectives of the study

The main objective of this study is to identify the relationship between the applied organizational and economic methods of solid waste management and the amount of its formation. This will allow local authorities, through the choice of one or a combination of methods, to manage both the volume, pace, structure of the formation of solid domestic waste, and its processing.

To accomplish the aim, the following tasks have been set:

– to summarize and systematize the systems and methods for determining tariff rates in the system of solid waste management in the Netherlands;

– to analyze the financial burden on the population, the volume and structure of the formation of solid domestic waste using the dominant methods of payment for the cost of managing it.

4. The study materials and methods

The object of this study is the management of solid domestic waste.

By changing the method of payment, it is possible to influence the structure and volume of sorted waste. However, each method has a different financial burden on the population associated with paying the tariff for household waste management. The choice of an economic tool should be carried out taking into consideration its impact on all related processes and states.

The main data needed for this study were acquired from official public information from Dutch municipalities. The study collected information on fees and tariffs for solid waste disposal from 384 municipalities in all provinces. Updated data in "allecijfers" were used to determine the number of residents in each of these cities and towns, the data represent the situation at the end of 2021. The Statline database was used to extract information on the effectiveness of waste management. The 15 main subcategories of household waste systematized in the Netherlands were analyzed. In order to align the subcategories with other statistical guidelines, they were divided into 8 major groups as follows:

a) recyclables (R) are a mixture of various municipal solid waste, bulky waste, and other household waste. This waste is the least desirable because it is sent to incinerators and turned into ash in the production of energy and heat, a process that is the most expensive and technologically complex of all;

b) biowaste (B) is a VFG and bulky garden waste. This type of waste is easily converted into high-quality compost or used to produce biogas, provided that such waste is collected separately. Separate collection guarantees, on the other hand, high quality, dryness, and cleanliness, which affects the overall rate and cost of solid waste processing;

c) glass (G) includes containers and flat glass, which is easily recycled, so it is desirable that it is collected separately;

d) paper and cardboard (PC) – this material is one of the most recyclable and makes a direct contribution to environmental protection;

e) packaging waste (P) includes waste from all types of plastic packaging. The costs of processing this material are borne by the manufacturer, these costs are added to the price of packaging materials. A separate levy makes sense for the producer of municipal solid waste as it is collected free of charge;

f) metals (M) include metals and metal packaging. Steel is the most recyclable material on earth, using well-defined and reliable technologies. The probability that a product made of steel will be completely recycled an unlimited number of times with separate collection is about 100 %;

g) other plastics (OP) include hard plastics and foam;

h) other recyclables (OR) include textiles, household goods, gas cylinders, and fire extinguishers.

To implement the objectives of this study, official data on the organization of solid waste management and the structure of fees in 384 municipalities of the Netherlands were collected. Based on a detailed analysis of these data, methods for determining tariff rates for solid waste management were categorized in accordance with the mechanism for its calculation. Then, for further comparative analysis, data on the formation of each category of household waste in 278 municipalities were collected. Official statistics on private households and waste were used to derive the average cost of solid waste management for a waste producer in the Netherlands as follows:

a) when analyzing the calculation mechanism, which depends on the number of people living, information was used on the cost of solid waste management per taxpayer. Based on the assumption that B, G, PC, P, OP, M, and OR are collected free of charge, the cost of handling mixed waste per ton of municipal solid waste in general and beyond its types was calculated.

b) when analyzing the cost of solid waste management based on the number of people, volume, and frequency, it was assumed that all waste producers use their own containers. It was also assumed that the containers were put on the site for collection 13 times a year, and the collection of B, G, PC, P, M, OP, and OR is free of charge. The study found that containers of 140 liters for mixed waste are most often used in municipalities, this size was taken as a reference for further calculations. In cases where such a container was not used, the following dimension of the container was considered upwards;

c) in analyzing the payment system based on payment for the area, volume, and frequency of the collection container, a container of 140 liters for mixed waste was taken into consideration.

Organizational aspects of solid waste management in the Netherlands.

The system of collection, processing, and disposal of municipal solid waste is almost the same in all provinces of the Netherlands. By law, Dutch municipalities are required to collect mixed and organic waste from the site, however, the frequency of approaches of collection equipment, and the types and volumes of containers are determined by each municipality independently. Other types of waste are collected from the site, either delivered to common prefabricated or underground containers, or self-delivered to recycling centers in accordance with the municipality's waste collection regulations. The policy of collection, recycling, and disposal of household waste in the Netherlands begins with a distinction between the different types of waste that are not allowed to be mixed. The classification of municipal solid waste is the basis for the construction of subsequent recycling processes. The main categories of municipal solid waste in accordance with the Dutch directives on waste management are:

a) biowaste (B) consists of the VFG waste, including bulky green waste and any other degradable household waste;

b) recyclables (R) are a mixture of different types of waste that cannot serve as secondary raw materials (SR) for traditional mechanical processing processes;

c) paper and cardboard (PC) include all packaging and any other waste made from these materials;

d) packaging waste (P) include bags, bottles, boxes, and any other packaging material made of plastic;

e) other plastics (OP) include hard plastics of all types and expanded polystyrene;

f) metals (M) include any metal products, including those used for packaging;

g) glass (G) includes any glass products used for packaging (glass) or other purposes (flat glass);

h) electronic waste and batteries (EB);

i) small chemical waste (CH) includes waste generated during the repair of houses and gardens;

j) other recyclables (OR) include textiles, furniture, appliances, and any type of household goods that can be reused for the same or a different purpose without the need for special processing processes.

In addition to classification, there are some organizational nuances and regulations governing the process of collection and processing of solid domestic waste, the most important of which are the following:

a) if the solid waste producer uses its own container and/or official garbage bags, the waste must be removed in accordance with the collection schedule, otherwise a fine of 200 euros for each violation [12];

b) there are weight restrictions that are allowed for each size of the container and garbage bag. For example, a container with a volume of 140 liters together with waste cannot exceed 75 kg, a container with a volume of 60 liters, 32 kg [13], a container with a volume of 25 liters, 7 kg [14], a container with a volume of 25 liters, 7 kg, and a container with a volume of 25 liters, 5 kg [15];

c) if the domestic solid waste producer uses a shared dumpster, the volume of the allowable bag is regulated by opening the closure or lid of the container (half or completely). When implementing a weighing system, sensors are installed on a garbage truck. In the case of the introduction of a payment system depending on the frequency of putting waste on the site, a special card is issued for each waste producer, which is used each time to open a common container.

In the aggregate of economic tools that affect the volume and structure of sorted household waste, the system of setting a tariff for waste management is of the greatest importance.

In the Netherlands, there are two main systems of payment for the removal of municipal solid waste: fixed and differentiated, which depend on the volume, frequency of collection, or weight of the waste removed. As of 2021, the Netherlands is implementing six main methodologies for financing payment for the disposal of solid domestic waste:

a) a flat rate is a system in which each house pays a fixed amount annually, regardless of the size of the dwelling, the number of people, and the waste produced;

b) the rate depending on the size of the dwelling is a system in which the annual fee depends on the number of people living;

c) volume-dependent rate is a system in which the municipality offers containers and packages of standard size. Waste producers choose the size of the container for municipal solid waste, and the annual disposal fee is proportional to the selected volume;

d) weight-based is a system in which the waste producer pays for each kilogram of paid waste produced. As a rule, the municipality concerned provides special technical means for billing waste disposal by weight;

e) frequency-based – this is a system in which the waste producer pays each time he takes out a container/bag to collect waste;

f) based on the number of garbage bags – this is a system in which the waste producer pays for each garbage bag that is offered for collection. It is important to note that only official garbage bags are allowed for solid domestic waste.

Before the transition to a system of tariff differentiation, the preferred method for most municipalities was the system of payment for services depending on the size of housing (61 % in 1998). A system based on the weight of municipal solid waste produced was the least applicable. In 2000, only 23.4 % of municipalities used such a system [16]. By 2007, fixed rates and rates dependent on the size of ownership had lost ground to other systems based on frequency and volume, but remained the leading ones. The weight-based system has been recognized in the Netherlands as the most accurate and efficient of all the others. The complexity of the application and the higher cost of implementing such a system seemed to be sufficient reason not to choose it as a priority (less than 1 %) (Fig. 1).

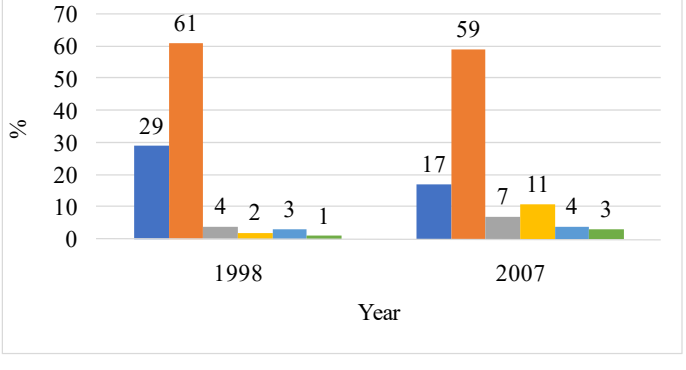

Fig. 1. Changes in shares of household waste management systems between 1998 and 2007

Expert recommendations to increase the number of municipalities applying a differentiated tariff, either by weight or by frequency of solid waste supply in order to reduce the generation of unsorted waste, have not been implemented.

5. Results of studying the influence of economic methods on the organization of solid waste management in the Netherlands

5. 1. Generalization and systematization of methods for determining tariffs in the waste management system in the Netherlands

Analysis of data from 384 municipalities has made it possible to identify 2 main organizational and economic ways of handling solid domestic waste, which are designated as simple and complex. The simple technique is based on a fixed

annual fee depending on the number of people living in the household; the volume of waste produced; the weight of the waste produced; and the number of garbage bags used. Most municipalities use different combinations of these simple systems in one group (a complex technique) to create its own organizational and economic system of solid waste management. All of these complex methods have a combination of a fixed or population-dependent component when the tariff is formed. The simple component is used by municipalities to cover all administrative costs, clean-up of public areas, rehabilitation of contaminated areas and other expenses that cannot be attributed to a specific polluter. Simple methods include the following techniques for determining payment for solid waste management:

1) a fixed annual rate (method code 1);

2) annual rate depending on the number of people (method code 2);

3) annual rate depending on the volume of garbage containers used (method code 3);

4) payment each time the garbage container is displayed depending on its volume (method code 4);

5) payment for the displayed/discarded garbage bag (method code 5);

6) payment for the exposed garbage container (method code 7);

7) payment by weight of the removed garbage (method code 8).

Complex methods:

1) annual rate depending on the number of people and payment for the placed dumpster (method code 27);

2) a fixed annual rate, and an annual rate depending on the volume of garbage containers used (method code 14);

3) a fixed annual rate, and payment for the exposed/discarded garbage bag (method code 15);

4) a fixed annual rate, and payment for the exposed dumpster (method code 17);

5) a fixed annual rate, and payment by weight of garbage removed (method code 18);

6) the annual rate depending on the number of people, and the annual rate depending on the volume of garbage containers used (method code 23);

7) the annual rate depending on the number of people, and payment each time the dumpster is exposed depending on its volume (method code 24);

8) the annual rate depending on the number of people, and payment for the exposed/discarded garbage bag (method code 25);

9) the annual rate depending on the number of people, and payment by weight of garbage (method code 28);

10) payment each time when the dumpster is exposed, depending on its volume, and payment by weight of the garbage removed (method code 48);

11) a fixed annual rate, an annual rate depending on the number of people, and payment each time a dumpster is put up depending on its volume (method code 124);

12) a fixed annual rate, payment each time the dumpster is put up depending on its volume, and payment by weight of the garbage removed (method code 148);

13) a fixed annual rate, payment by weight of the garbage removed, and payment for the exposed/discarded garbage bag (method code 185);

14) the annual rate depending on the number of people, payment by weight of garbage removed, and payment for the exhibited dumpster (method code 287).

The study showed that 83.6 % of the total population uses three main methods of determining the tariff for waste disposal. Payment by the number of inhabitants turned out to be the most common method (161 municipalities, 9,663,198 waste producers). Payment on the basis of a flat tax for the site, volume, and frequency of waste disposal ranked second (113 municipalities, 3,419.574 waste producers). And, finally, payment depending on the number of inhabitants, volume, and frequency of waste disposal closed the top three (30 municipalities, 984.247 waste producers).

5. 2. Analysis of the financial burden, volumes, and structure of waste using dominant methods

A study of the relationship between the implemented payment system and trends in the formation of solid domestic waste has made it possible to investigate the average rate of generation of household waste and the percentage of groups for each payment system in the Netherlands (Tables 1, 2).

Table 1

Quantity and quality of data collection

Code	Number of employing municipalities, units	Number of municipalities with available data, units	Percentage, %	Population, people	Population of municipalities with available data, pers	Percentage, %
1	10	6	60.0	415,016	197,895	47.7
2	161	122	75.8	9,663,198	7,929,252	82.1
3	12	12	100.0	563,166	563,166	100.0
4	5	5	100.0	298,498	298,498	100.0
5	1	1	100.0	177,359	177,359	100.0
7	1	1	100.0	28,901	28,901	100.0
13	2	1	50.0	38,072	38,072	100.0
14	113	89	78.8	3,419,574	2,925,072	85.5
15	8	8	100.0	236,070	236,070	100.0
16	6	4	66.7	264,535	212,619	80.4
18	7	3	42.9	37,267	18,655	50.1
23	1	1	100.0	39,346	39,346	100.0
24	4	4	100.0	79,444	79,444	100.0
25	4	4	100.0	105,070	105,070	100.0
26	1	1	100.0	27,575	27,575	100.0
27	30	24	80.0	984,247	734,127	74.6
28	1	1	100.0	6,899	6,899	100.0
36	1	1	100.0	23,947	23,947	100.0
48	1	0	0.0	50,650	0	0.0
124	3	3	100.0	93,669	93,669	100.0
148	10	6	60.0	270,880	144,593	53.4
185	1	1	100.0	17,171	17,171	100.0
286	1	0	0.0	25,900	0	0.0

Based on the generalized data in Table 3, it is possible to build a balance of household waste generation based on average indicators as follows:

$$MSW_{ps}=0.401B+0.302R+0.06G+$$
$$+0.073P+0.128PC+0.01M+$$
$$+0.04OP+0.021OR,$$

where MSW_{ps} are the annual generation of municipal solid waste per capita in the Netherlands.

Table 2

Rate of household waste generation for each payment system in the Netherlands

Code	Annual waste production (kg/person)	Rate of waste generation by category, %								
		R	B	G	P	PC	M	OP	OR	TR
1	524.03	47.0	29.1	4.7	4.5	10.5	1.6	0.6	2.0	23.9
2	483.85	47.4	29.0	5.0	4.3	10.9	1.4	0.5	1.7	23.8
3	469.26	31.0	38.4	6.3	7.2	13.5	1.1	0.5	2.2	30.7
4	446.28	22.9	44.2	5.9	8.5	14.0	1.0	0.4	3.2	33.0
5	353.10	32.2	30.4	7.5	10.6	13.6	1.5	0.70	3.5	37.5
7	480.80	12.9	53.8	5.4	9.3	14.5	0.0	0.0	4.1	33.3
13	513.90	29.8	44.5	4.9	8.0	10.9	0.4	0.3	1.1	25.7
14	435.89	25.5	42.1	6.1	8.5	14.0	1.0	0.5	2.0	31.9
15	441.89	16.9	52.0	6.8	9.0	12.0	0.5	0.3	2.5	31.1
16	491.05	34.8	40.20	4.9	6.5	11.2	0.9	0.4	1.1	25.0
18	396.30	30.8	34.9	6.5	8.3	15.0	2.2	0.4	1.9	34.3
23	481.80	24.2	45.1	4.9	8.9	11.7	0.1	0.2	4.9	30.8
24	513.33	19.0	50.1	5.8	8.7	13.1	1.1	0.5	1.7	30.9
25	540.05	11.7	59.2	6.0	7.9	12.0	0.8	0.5	1.9	29.1
26	563.00	29.0	44.4	5.5	4.9	12.0	2.0	1.0	1.2	26.6
27	449.18	35.7	35.6	6.0	6.2	12.9	1.5	0.6	1.5	28.7
28	450.60	37.0	37.8	7.9	5.7	10.5	0.6	0.4	0.1	25.1
36	514.00	37.5	36.3	5.9	5.9	11.2	0.6	0.0	2.7	26.2
124	438.50	30.5	39.1	6.3	5.4	15.4	0.9	0.5	1.9	30.4
148	455.85	30.5	40.2	5.4	6.5	13.9	1.1	0.6	1.8	29.3
185	269.90	48.0	15.0	8.9	9.3	16.7	0.0	0.0	2.0	36.9

Based on the equation, it can be concluded that the Dutch waste management system has made significant progress, having managed to collect the absolute majority of biowaste separately. During the study, a high level of organization of the system for collecting clean paper and cardboard was found (12.8 % of the total amount of household waste generated). Mixed waste not suitable for secondary raw materials (R) still accounts for more than 30 % of total municipal solid waste. This situation calls for the development of further organizational and economic actions to increase the resource potential for development.

The highest level of R generation per capita was found in those municipalities that use a combination of a fixed annual fee, weight and payment for a garbage bag (48 % of municipal solid waste generated). In municipalities that have implemented an annual fee based on the number of residents, 47.4 % of household waste generated is R. In those municipalities that apply a simple fixed fee, 47 % of the household waste generated is R (Fig. 3).

Our study has made it possible to draw conclusions about the effectiveness of the impact on the volume of secondary raw materials (TR) and the potential for its recycling of such an economic tool as the method of payment for household waste management. Thus, the application of the payment system for each garbage bag proposed for collection allowed municipalities to recycle up to 37.5 % of the generated solid household waste. The combination of a fixed annual fee, a payment system for a garbage bag and the weight of the waste removed ensured the recycling of 36.9 % of the generated household waste. When applying a fixed annual rate of payment based solely on the weight of the waste removed, 34.3 % of the generated waste was recycled (Fig. 2).

Further research has been expanded to determine the total cost of municipal solid waste management in general and per ton of mixed waste (R) in particular. The data of the study show that in the Netherlands there are three main methods of forming payment for waste management (Table 3).

Table 3

Cost of solid waste management in the Netherlands

Indicator	Method code		
	2	27	14
Average annual payment for single residents, €	241.17	205.57	N/A
Average annual payment for two or more residents, €	152.71	102.79	N/A
Number of single residents	3,744,489	358,974	N/A
Number of two or more inhabitants	5,918,709	567,412	N/A
Percentage of single residents, %	38.75		
Percentage of two or more inhabitants, %	61.25		
Weighted average annual payment per person, €	140.22	157.12	128.22
Number of garbage containers on site per year	N/A	13	13
Weighted average annual payment per person for the placed garbage container on the site per year, €	N/A	53.48	431.88
Weighted average annual payment for municipal solid waste management services per person, €	140.22	170.12	560.09
Weighted total annual payment per ton R per person, €	611.39	1,064.50	5,038.98
Weighted average total annual payment per ton of solid household waste per person, €	289.80	377.90	1,284.94

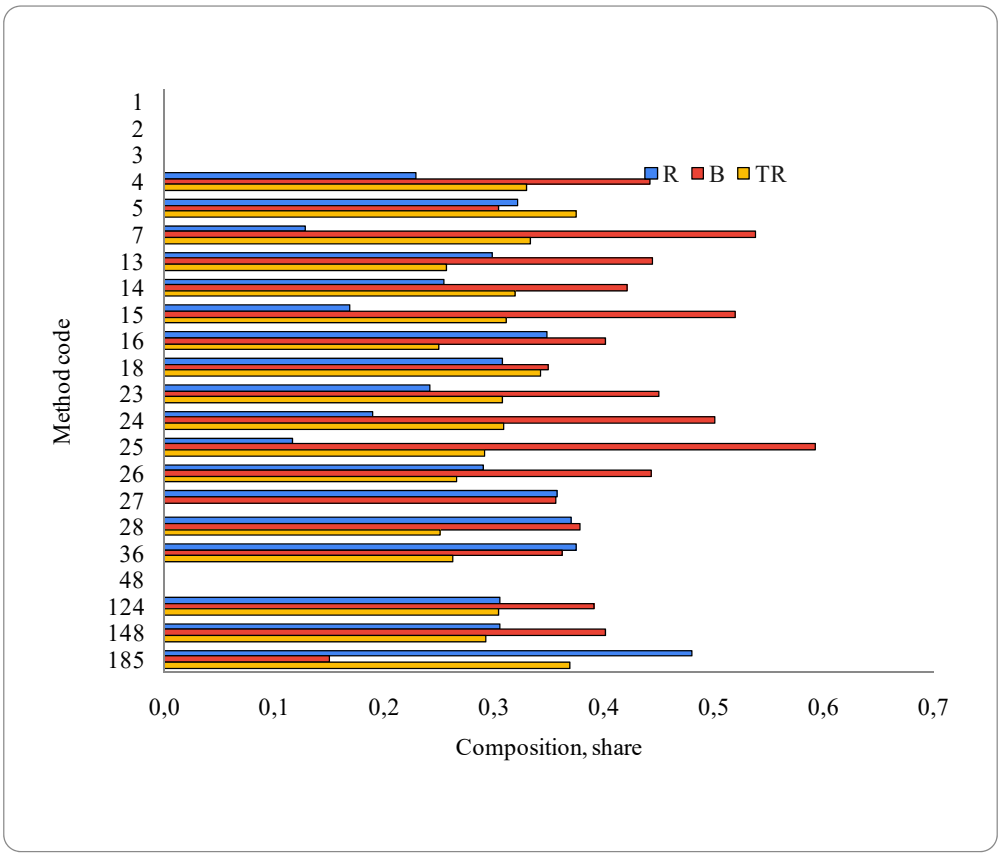

Fig. 2. The composition of solid domestic waste in the implementation of each organizational and economic management system

In those municipalities that implement System 2, the cost of solid waste disposal per person is 1.04 % of the annual revenue of €27,656. Under system number 27, the cost is 1.37 %. If system number 14 is applied, these costs are 4.65 %.

6. Discussion of results of studying the impact of economic methods on the organization of waste management

Our study covers most municipalities in the Netherlands (Table 1). The only criterion used to exclude the municipality was the availability of reliable data, so the bias factor was excluded. The study was able to calculate all existing methods of solid waste management in the Netherlands. It was also possible to consider in detail the scope of each method (Tables 1, 2). It was also possible to analyze the effect of the chosen method on the level of cutting the mixed waste, biowaste, and recyclables (Fig. 1). The effectiveness of the use of different payment methods for solid waste management was determined on the basis of an analysis of waste collection statistics from 16,834,189 inhabitants, which is 95.7 % of the total population. Such a high level of coverage eliminates any concerns associated with the choice of an effective method of payment for the management of solid domestic waste. However, the disparity in the number of municipalities implementing each system imposes limits on the completeness of the economic comparison, limiting it to only three. The lack of better data on the ratio of houses to apartments in each municipality was another problem of the study. The choice of containers of standard volume and the number of times the waste is offered for collection can be challenged, and further research can improve the accuracy of the results obtained. Finally, the large variation in total cost between the three systems may call into question the objectivity of the results obtained.

Municipal solid waste management methods in the Netherlands have developed contrary to the belief that a method tied to the amount of waste generated should dominate. The Netherlands remains in favor of either the fixed annual rate method or a combination of a flat annual rate and a volume fee. The study showed that the variety of methods used did not worsen the overall result of processing, which may be at odds with the statement about the need for total introduction of a particular method.

A comparison of the economic methods of household waste management in the Netherlands revealed three methods for determining the annual rate, which affect the volume and structure of waste generated (depending on the number of people; depending on the number of people and payment for the exposed dumpster; depending on the volume of garbage containers used). Using the experience of the Netherlands in the selection of organizational and economic tools that affect the degree of solid waste treatment will allow municipalities in many countries to use the provided results of the study for implementation in its waste management policies. The results of the study will accelerate the choice of the method that corresponds to its strategic goals and organizational capabilities.

Restrictions in choosing the method of establishing payment for household waste management are the level of income of the population, the organization of the waste collection and sorting system, the intensity and breadth of

informing the population, control over the disposal of waste in landfills.

A promising direction for further research is the modeling of scenarios for changing the waste management system under the influence of economic and organizational tools.

7. Conclusions

1. The method of payment for solid waste management, based on a fixed annual fee, has given way in the last 25 years to a method based on the number of people living. The annual rate depending on the number of residents was applied in 190 municipalities (49.48 %) with a total population of 11,113,873 people. A fixed rate depending on the volume of waste containers used has been implemented in 161 municipalities (41.92 %) with a total population of 9,663,198 people.

A fixed payment, which depends on the number of people living, has the advantage that the annual payment is not tied to the weight, volume, or frequency of waste generation. The fixed fee is controlled by the municipality and is intended to cover not only all organizational costs for the collection and recycling of waste but also to cover the costs of public cleaning, infrastructure, and other expenses. The main direction of reducing the cost of solid waste management when using this method is to reduce costs in the waste management system and reduce the tariff in order to stimulate the positive dynamics of reducing the volume of mixed waste.

2. Available data did not establish a clear correlation between all available methods of payment for household waste management and the amount of residual waste produced by recyclables. However, the study of the relationship between a particular method and the volume of waste generated has made it possible to identify the direct impact of the method on the structure of waste. It was determined that when using the annual rate depending on the number of people, municipalities had high rates of mixed waste generation per capita and the lowest amount of all waste generated. As for the financial burden on the population, the system mentioned was not the most expensive of the three main dominant ones. Using a flat annual rate based on the volume of dumpsters used, the highest waste generation rate, and the lowest per capita R production were obtained. It is also noted that this method is the most expensive.

Waste generation, recycling level, and landfill prevention in the Netherlands are among the best in the world. The experience of the Netherlands is a role model, as even the highest production of R per capita in the Netherlands is still a worthy role model in other European countries. Our study found no clear correlation between financial, organizational, and even demographic factors. This result supports the conclusion that any further significant reduction in the rate of solid waste production will depend mainly on the commitment and awareness of residents.

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