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IMPROVEMENT OF THE MUNICIPAL SOLID WASTE DISPOSAL SYSTEM IN UKRAINE, ON THE EXAMPLE OF THE TOWN OF CHORTKIV, TERNOPIL REGION

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Abstract. Today, in Ukraine, there is a problem with solid waste disposal, especially in small towns. The lack of a developed system for the collection and disposal of solid waste, the presence of natural landfills instead of equipped landfills lead to the fact that small towns are abandoned. Therefore, the creation of a new solid waste management policy is an acute problem for these towns and villages. This article is devoted to analysing the global experience of solid waste management and, based on that, formulating recommendations for solid waste management in small towns using Chortkiv as an example.

Keywords: municipal solid waste, utilization, recycling, waste sorting, container sites, landfill site.

1. Introduction

As of 2021, the situation in the collection, processing and disposal of waste in general, including solid waste (MSW), remains problematic in Ukraine and needs to be addressed urgently. In 2019, 441.5 million tons of waste were generated in Ukraine, which is 20.2 % more than in 2018, with 98.7 % (435.6 million tons) of waste generated by economic activities, including 390.6 million tons (88.5 % of the total) – in extractive industries and quarries, and 1.3 % (5.9 million tons) – in households (Papagiannis et al., 2021).

According to official data, the total amount of solid waste collected in Ukraine in 2019 was 52.9 million m^3 or about 10.4 million tons (Morone et al., 2019), which corresponds to a specific volume of solid waste of 140 kg / (man × year). At the same time, the share of Ukraine in solid waste processing and recovery is still very low: in 2019, 49.7 million m3 or 9.8 million tons of solid waste were deposited in landfills and dumps, which corresponds to about 94.2 % of the amount of solid waste collected.

According to official statistics, in 2020, there were 6.073 landfills and dumps in Ukraine, of which 258 facilities were overloaded and 905 facilities did not meet safety standards. In general, the area of landfills and dumpsites in Ukraine amounted to 8,838 hectares, of which the area of landfills and dumpsites that do not meet safety standards is almost 1.7 thousand hectares (Municipal solid waste…, 2015).

The data presented in the report of the International Finance Corporation (World Bank Group) for 2015 are quite consistent with the official data, according to which Ukraine annually generates 11-13 million tons of solid waste, more than 90 % of which is stored in landfills and dumps. The total number of landfills is estimated at 6.700 units, and their total area is 10.000 ha (Municipal solid waste…, 2015).

Every day an average Ukrainian produces about 3 kg of solid waste (hereinafter MSW), which in extreme periods (such as the all-Ukrainian quarantine) increases by 2 or even 3 times. Therefore, this problem is one of the main ones that must be solved immediately. All possible measures must be taken to neutralize its roots and all growing toxic effects. Considering the number of countries in the world that have managed to find a way to

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use waste as raw materials and energy, and thus earn a considerable income, it is high time for Ukraine to find its way to a clean life and an easy income so as not to suffocate in the fumes of the associated waste.

2. Basic theoretical part

To understand exactly what word the new policy should start with, it was decided to do research in a small town of Chortkiv in the Ternopil region. The analysis of the average town, where a large part of the population lives in homesteads (Fig. 1), will allow a more rational approach to the dissemination of the new strategy in cities and villages in particular.

It is worth noting that there is a direct connect between the morphological composition of waste and the place where the inhabitants of the city live. How? Homesteaders produce a large proportion of organic waste regardless of the season, resulting in a gradual decrease in the percentage of this waste in the 'off-season'. Meanwhile, the residents of apartment buildings without gardening work on land depend on products purchased in the store. That is, the share of organic waste is large only in the summer-autumn period, and at other times – falls sharply.

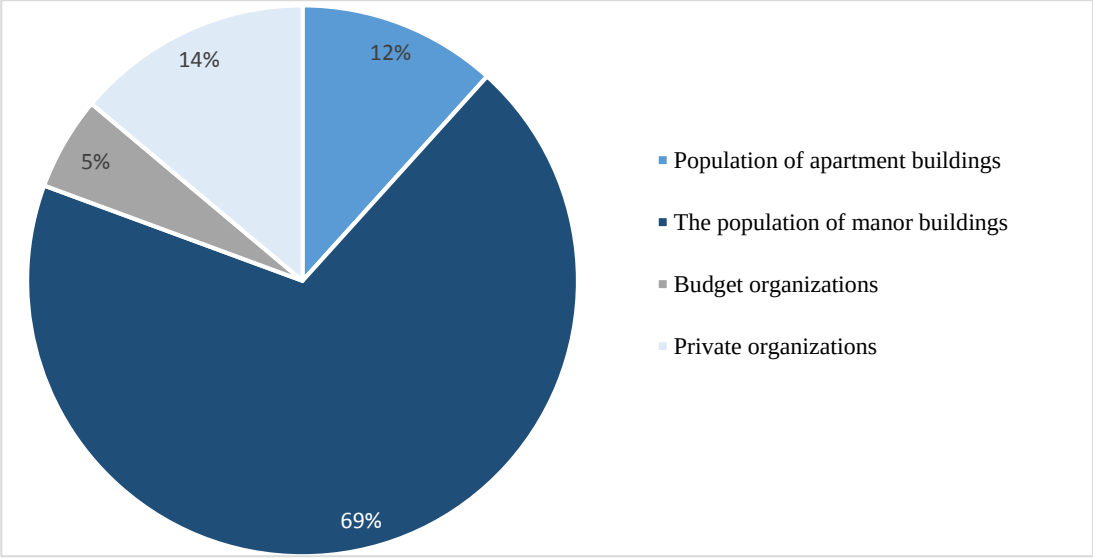

Fig. 1. Annual volumes of MSW formation by categories of generators

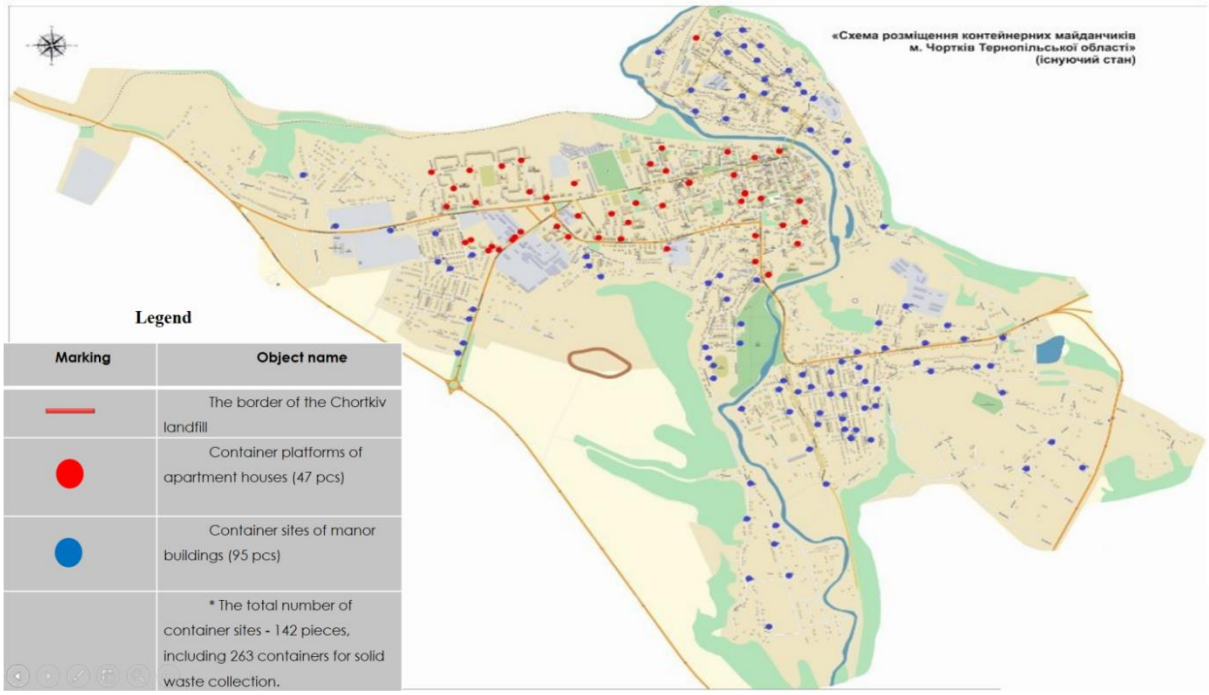

Fig. 2. Layout of container sites in Chortkiv

Thus, taking into account Chortkiv, where 69 % of the population lives in homesteads, which is unusual for the city, it was analyzed that organic waste occupies the largest share in the city's solid waste throughout the year. In physical terms, the amount of household waste in Chortkiv is estimated at 18.0 thousand tons per year, including fractions, in tons per year:

- Food waste – 5667.4;
- Polymers – 3573.7;
- Paper and cardboard – 2400.5;
- Glass and ceramics – 1191.3;
- Wood – 1137.1;
- Textiles – 703.9;
- Bones, skin, rubber – 649.8;
- Non-ferrous metals – 433.2;
- Hazardous waste – 270.7;
- Ferrous metals – 180.5;
- Small construction waste, street garbage, etc. – 1841.0.

Therefore, the number of container sites that are located near the manor building is almost three times higher than the number of container sites that are located near the apartment building (Fig. 2).

Fig. 3. Examples of arrangement of container sites in Chortkiv

The coverage of the population in the solid waste collection system in Ukraine averaged 78 % in 2013, which remained unchanged in 2018. However, only 65 % of the population in the Ternopil region, which needs immediate intervention, is involved in raising the ecological level of the region and the state as a whole. Depreciation of vehicles in 2013 amounted to 60 %, in 2018 – 65 % in Ukraine, and in the Ternopil region, it was 70 %. (On the adoption of the solid waste…, 2004)

Thus, it is clear that not only external blockers (finances, laws) but also internal ones (ecological ignorance of citizens) are in opposition.

3. Analysis of international experience

Abroad, the concept of 'clean living without waste' has long been known. What does it mean? It means learning to use somewhere the waste you produce. Of course, all this should be solved at the state level – the construction of waste recycling plants, the disposal of waste residues, the proper disposal of waste after its removal from settlements. But you also need to start with the smallest link in this chain – the person who produces this waste. Here are some impressive examples of waste disposal and management systems.

India – 'Plastic Streets'. An enchanting technology to replace bitumen – a hydrocarbon used to make asphalt. According to this technology, about 15 % of the specified hydrocarbon can be replaced by plastic waste in road construction. After all, miles of roads have already been built. So the government buys waste from citizens to build roads (Chaudhary et al., 2021).

Copenhagen (Danmark) is an incinerator. The energy from the incineration is used to heat the whole city. The plant can be called a resort because, on the roof, there is a big slide made of plastic garbage, which is used as entertainment for skiing in winter. The plant supplies 97 % of the heat to the households. In 2020, the plan was renovated to convert biomass. Now it operates as 'VIO4'. Today, Copenhagen's energy-efficient heating system is the largest in the world, providing 98 % of the population's needs.

Vienna (Austria) – Incinerator – Thermal Power Plant. Biotechnology is used to break down plastic. This requires a special fungal enzyme that breaks down polymers into simple monomers. The technology is called the 'plastic cycle' by which the waste becomes a raw material for a needy business (Schmidt et al., 2020).

San Francisco (USA) – Single stream solid waste system (with sorting at waste sorting plants and subsequent disposal). According to some conclusions, local authorities were disappointed with the efficiency of waste sorting and decided to bring all waste to a common point of the solid waste disposal system. So it all works

like this: the waste is brought to the plant, where employees first sort what is not recyclable and what can get stuck in the machines during further processing (packaging, cardboard). Next, the paper is separated mechanically. It flies up under the force of vibration, and metal and glass products fall. The next step is the magnet – it attracts metal, sorting it out from the mainstream of solid waste (Sverdrup & Belyazid, 2014). Plastics are detected by a sensor with infrared light, which can classify them into different categories with different densities.

The waste sorted in this technological process is pressed into blocks of 16 categories, which are then sold to China or reused. In this way, a maximum of 10 % unprocessed waste is produced.

Japan is an island of waste. Plasma gasification is used in incineration (burning at a temperature of 1200 ℃), after which a small amount of slag is produced, which is then cleaned and used in construction. The island is built from ash densely pressed into briquettes (bulk method).

Switzerland – Waste sorting plants. Probably the most demanding country in terms of waste sorting is Switzerland. Those who violate sorting regulations must pay a fine for each unsorted package. This has made the country a leader in environmentally friendly solid waste management (in Forbes magazine – one of the cleanest countries). A small portion of the waste that cannot be recycled is incinerated (Sverdrup, Belyazid; 2014).

Great Britain – converts food waste into energy (one of the world leaders in this category). Several hundred plants operate on this principle of processing, which can supply 500 thousand households. The technology of "anaerobic digestion" is the use of bacteria to process and obtain biogas and biofertilizers from the mass of food waste. In a special facility, access to oxygen is blocked, allowing the bacteria to multiply and break down the food waste. The UK government estimates that such a plant can generate an average of 200 kWh of energy from one ton of waste (Sarigiannis et al., 2021).

South Korea – underground garbage trucks. The city of Songdo deserves the title of a 'smart city' or even a 'city of the future. People throw garbage from their homes into a special pneumatic sewer, from where it is directed to sorting mechanisms. South Korea is pioneering the processing of solid waste through the use of plasma gasification technologies (with no formation of resins and residue of toxic waste). In this way, South Korea is using the most environmentally friendly way to dispose of waste while being able to use the energy from the process to benefit its citizens (Ko et al., 2020).

Belgium. A Belgian innovation called Ecolizer allows you to evaluate production or consumption ideas upfront (Peace et al., 2018). You can determine how much waste they may create, whether they pollute the atmosphere or the soil, how many resources are used for transportation, energy supply, waste disposal, etc. The country disposes of 75 % of its waste and turns it into energy, fertilizer, or raw materials for production.

Germany – GCC (for heat/electricity). With its technology, the country incinerates more than 26 million tons of waste. From the slag produced by burning solid waste, the Germans form cinder blocks and use them in road construction. Interestingly, almost 90 % of the recycled secondary raw materials in the country consist of glass containers. Another popular method in Germany is fermentation. It is worth noting that there is also a campaign for schoolchildren to receive half of the delivery of their school supplies (Schmidt et al., 2020). In European countries, with the help of incinerators, 20–25 % of solid waste is burned, in Japan – about 65 %, in the United States – about 15 %. The most active "incinerator" is Germany, with 66 facilities that burn more than 26 million tons of waste annually (2018).

It should be noted that innovative ways of waste disposal today come from ingenious and unusual startup projects such as the idea of an Indian scientist to use plastic in road construction, and the idea of ordinary Ukrainians to make a breakthrough in eco-fashion from waste. A twenty-seven-year-old man invented a technology to process coffee grounds. Thus, the world's first glasses made of coffee grounds were created. The frame is made only of thick organic glue, and the lenses can be made of any kind of glass. The price of such glasses is 85 US dollars (converted into dollars, since the main customers live abroad). So, processing coffee grounds has both environmental and economic benefits, reducing solid waste emissions to landfills and bringing significant profits at a low cost.

4. Results and Discussion

In our opinion, the priority and most promising steps for the introduction of a new life of solid waste and a clean city are:

a) Introduction of a law for mandatory sorting of MSW concerning liability for non-compliance (in the form of fines).

b) Involvement of the media, local government and volunteers to disseminate information on the need to sort MSW.

c) Introduction of separate collection of MSW in the form of coloured containers with markings on container sites.

d) Introduction of hazardous waste collection points, waste paper, glassware waste, metals and medical waste as part of MSW and reusable waste (clothing, furniture, household appliances).

e) Introduction of mobile collection points for hazardous waste, waste paper, glassware waste, metals and medical waste as part of MSW and reusable waste (clothing, furniture, household appliances).

Considering the fact that in Ukraine, more than 90 % of solid waste is disposed of in landfills and unauthorized landfills, although, in fact, waste disposal can be used only in such cases as disposal of combustion residues, non-combustible and non-recyclable waste and highly toxic materials, the following introductions are proposed to improve the technology of solid waste disposal in the town of Chortkiv, relying mainly on reducing the percentage of solid waste removal to landfills:

I. According to the EU Waste Framework Directive (2008/98 / EC), the introduction of separate collection of waste such as metal, glass, paper and plastic, is extremely important to improve the quality of solid waste recycling. Therefore, it is advisable to create 4 or 5 container sites with the obligatory inclusion of brown containers for the collection of organic waste.

II. Considering the large share of food waste, the solution of the following cases seems perspective:

1. Construction of compost pits on the outskirts of the city.

– Individual discharge of sorted organic waste into compost pits. Opportunity to take fertilizers to the needy for free.

– Arrangement of separate containers (at container sites) for collection of sorted organic waste, which will then be taken to the organized construction of compost pits on the outskirts of the city. Introduction of compulsory construction of a compost pit for residents of manor buildings and fines for non-compliance with the terms of the rules.

2. For residents of apartment buildings – the introduction of mandatory sorting of organic waste and their disposal in special containers for organic waste or individual removal of organic waste to compost pits built on the outskirts of the city.

III. In a warm season and the seasons which, according to statistics, are characterized by the largest emission of organic waste – summer-autumn, it is proposed to remove organic waste more often than usual to ensure the sanitary and hygienic condition of container sites. In the warm season, organic matter can spoil faster, thus quickly creating a favourable environment for the reproduction of various bacteria and other living creatures.

To plan a container site, it proposed to use containers with a capacity of 1.1 m^2 made of plastic resistant to UV radiation, biological and chemical influences, without cadmium. But the biggest advantage is that it can be granular. The container complies with DIN 840.

Dimensional characteristics: length – 1.375 m, width – 1.075 m, height – 1.450 m.

According to the formulas, the dimensions of the container site will be:

Fence length:

$$L = 1.75 + N (0.35+ K), \quad (1)$$

Where N is the number of containers on the container site.

K is the overall size of the containers (in this case the length of the container)

L = 1.75 + N (0.35 + K) = 1.75 + 4 (0.35 + 1.375) = = 8. 65 m – for 4 container platforms.

L = 1.75 + N (0.35 + K) = 1.75 + 5 (0.35 + 1. 375) = = 10. 375 m – for 5 container platforms.

Fence width:

$$B = 2K, \quad (2)$$

Where K is the overall size of the containers (in this case the width of the container)

$$B = 2K = 2 \cdot 1.075 = 2.15$$

IV. Rethinking tariffs for processing and disposal, which would ensure operation at the required technical and environmental level and include a certain component for implementing investment projects. In world practice, it is estimated that the average household can allocate from 1 % to 3 % of its resources for solid waste management. In contrast, the people of Chortkiv allocate a maximum of 20 hryvnias from their savings.

V. It is estimated that the financial support for the construction of the waste processing complex, provided by the "National Waste Management Strategy in Ukraine until 2030", and providing it with the necessary equipment should amount to almost 17 million UAH. Currently, the provision of this program in Chortkiv circumscription is 700 000 UAH.

To ensure maximum efficiency and profitability of the waste processing plant, it is proposed:

– to find the nearest companies that will buy waste as cheap raw materials for their products;

– to find ways to present the image of the plant, involving young people who have an idea of their ideal future;

– to use an interesting and original design, with monetary incentives for the most interesting option or for several options that can be combined, as in Austria, where the plant is a resort complex, with a ski slope on the roof);

– to develop a facility for composting organic waste on the territory of the plant.

VI. According to the Waste Framework Directive, it is advisable to implement one of the models of the 'polluter pays' policy (Pparagraph 3.1.2). According to it, solid waste will not be taken to landfills but processed. Thus, it is proposed to arrange the first model of this

policy, namely, create an organization at the expense of a group of producers that will not make a profit, but only manage the disposal of used goods.

VII. The technology of replacement of bitumen-hydrocarbon used for the production of asphalt is proposed. It will enable to solve the problems of bad roads and the disposal of plastic waste. In road construction, it is possible to replace about 15 % of the specified hydrocarbon with plastic waste. The polymers are granulated to form MR6 granules, which melt for a "new asphalt substance" that is more resistant to thermal radiation than the conventional one. But this technology is only used to process such polymers as polyethylene (high and low density), polyethylene phthalate and polyurethane. Also, during melting, there is a high probability of dioxins (Huang, 2019). It should be noted that this method is a breakthrough in the fight against plastic at the moment – reducing its number in water bodies and the environment, in particular, means correcting the effects of past generations, providing comprehensive solutions and actions in the present. This technology is also likely to have an impact on the future as plastic waste can accumulate in the soil. However, it should be noted that at the moment, this is the most appropriate solution to combat large amounts of plastic waste and bad roads in Ukraine.

VIII. It is also proposed to expand the Ukrainian startup for processing coffee grounds, the last stage of which is the manufacture of glasses. Collecting coffee grounds should be organized according to the time of its formation, and the production should be located in the area with the highest concentration of cafes and restaurants.

In the end, it is proposed to extend agitation of the population, to develop startups, with a reward for a profitable idea, to spread interest in a healthy future of society and the possibility of its implementation.

5. Conclusions

In this article, the current state of waste management in small towns is analyzed using the example of the town of Chortkiv. The results show that there is an urgent need to modernize the waste management system in small towns. Therefore, the main global approaches were analyzed, and the most interesting of them were identified. Taking the town of Chortkiv as an example, priority changes for modernization of the waste management system were proposed, which will significantly increase the frequency of waste recycling and reduce the impact on the environment.

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