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# AUTOMATED SYSTEM OF COLLECTING AND SORTING WASTE

*Abstract:* The article describes a model of automated sorting and garbage collection that can be integrated into a smart city system. The structure is divided into several levels: the level of the garbage cans, the city level, the level of the processing plant. The article lists the benefits of using the aforementioned automated system.

*Key words:* «smart» city, processing plant, automation, garbage.

## Formulation of the problem

Nowadays, the problem of environmental degradation on the planet is beginning to occupy one of the most important places. Any solutions to these problems or improvements to existing solutions are now a priority. The largest centers of environmental pollution are large cities, so optimizing urban waste collection and recycling are key stages in designing a "smart" city.

## Analysis of recent research

Advanced technologies for the processing of mixed household waste are: mass burning, mechanical-biological treatment and waste sorting complexes (WSC). WSCs are effective only if waste sorting processes are effectively organized to improve the quality of recycling.

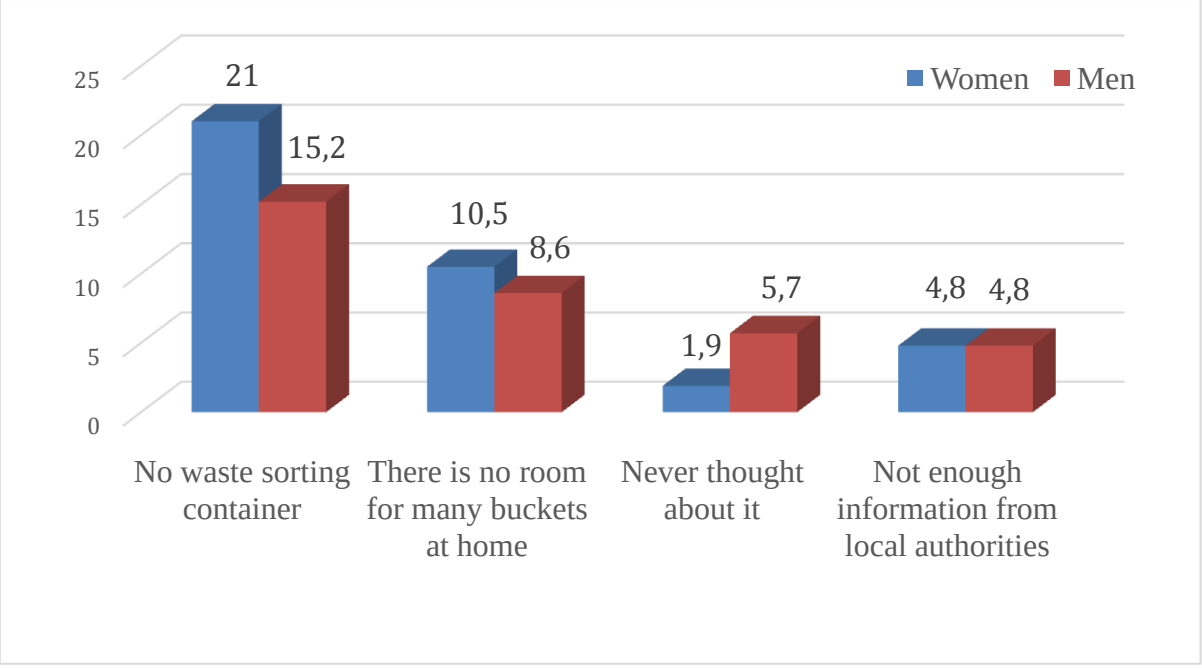


*Figure. 1.* Survey results





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The results of the survey of Kyiv residents show the main obstacles that arise in the implementation of separate collection of household waste (Figure 1).

To prevent negative effects on the natural environment current law establishes a special legal regime of waste management which provides a set of measures and rules of waste management at all stages - from their generation to disposal and burial. This regime is regulated by the laws of Ukraine “About protection of the environment”, “About waste”, “About ensuring the sanitary and epidemiological well-being of the population”, “About radioactive waste management”, “About the use of nuclear energy and radiation safety”, “About scrap metal”, the Code of Ukraine about subsoil and other legal acts.

## Suggested solution

The authors are working on the creation of mixed waste recycling technology, which includes: description of methods and methodologies for collecting and sorting at different levels, automation of the process of accounting for collected garbage and description of recyclables into the market.

After analyzing existing solutions [1, p. 3-4], the process of garbage collection and recycling system within the «smart» city is presented at 3 levels: the level of the garbage bin in each dweller’s apartment, the level of garbage collection containers in the city and the level of the recycling plant.

At the level of the garbage cans, their construction and placement are considered. The container consists of a plastic or metal frame and a special sensor or series of sensors. The sensor is attached to the inside of the top of the container and is a small device that checks the fullness of the container at regular intervals [2, 3]. The sensor recharges automatically when the container is emptied or from a small number of solar panels. The information about the container’s fullness is carried out through network access points located throughout the city, which constitutes network control of the "smart" city [1, p. 5-6]. A container is considered filled when it is full by 80% of its volume or when the last garbage collection was done more than 2 days ago to prevent the odor. When one of the conditions is fulfilled, the sensor sends a signal to the main server, which means moving to the next level - the city level.

City-level is a collection of municipal utilities and software that manages them [1, p. 3; 9]. The software includes a city map, the location of all garbage cans’ sensors and their status (necessity of garbage collection). With this data and information on the location and number of municipal utilities, the program compiles the optimal plan and route for the collection of lorries. There are several criteria for optimizing plans: over

time, over utility costs and minimizing container downtime. The endpoint of this level is the recycling plant, which is the next level of the system.

The plant level is a waste recycling system. Initially, the aforementioned utilities take all the garbage to the landfill, or, in other words, the garbage storage. From it, with the help of conveyor transportation, the garbage gets to the automated sorters. By using the physical properties of certain objects, such as magnetism, you can sort the objects that differ the most. Further, with the help of the developed software and cameras, we can identify the types of garbage based on appearance, to prevent mistakes in the previous stages of sorting. Different types of garbage are moved to different conveyor lines by robotic manipulators. To verify the accuracy of the final sorting, there may be direct human intervention. There is also an option to remove the robotic sorting stage and replace it with a human one. Finally, the sorted garbage is sent to recycling stations where the garbage is used for further use. For example, organic waste is recycled into fertilizer or fuel, paper into packaging paper, etc.

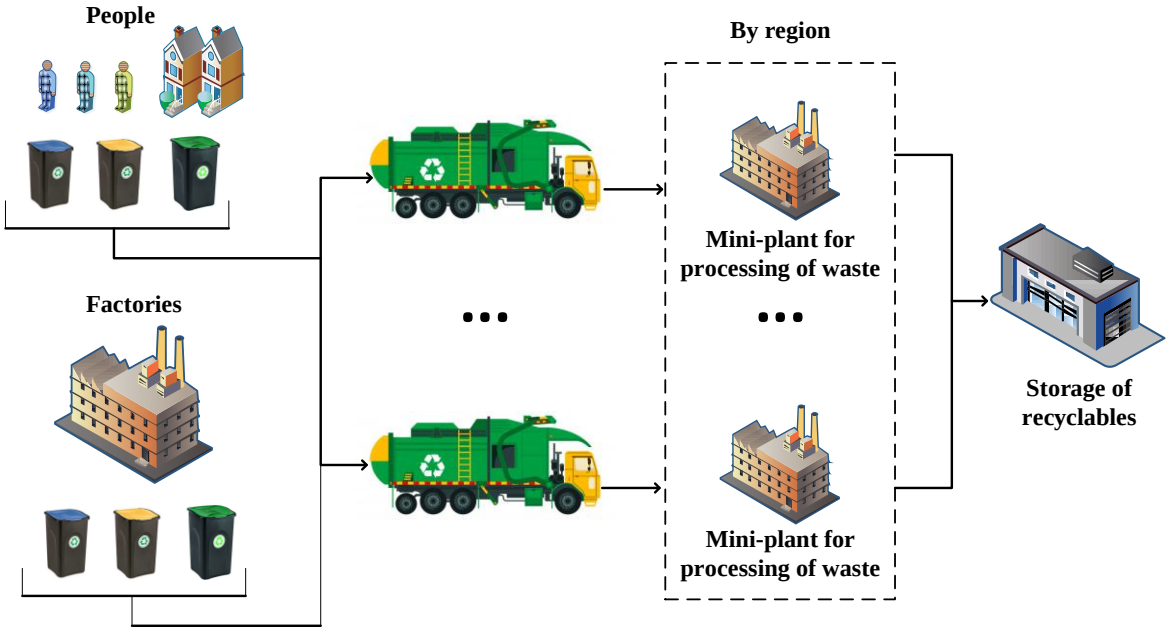


*Figure. 2.* The basic flow diagram of the process of garbage collection and recycling

At each stage of the process (Figure 2), some actions need to be automated and require centralized storage, monitoring, and management of information. The main functions of the software included in the automated system are:

• accounting for the states of the fullness of all city containers, which determines the need for garbage collection;

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• determining the location of all garbage containers on the map with a description of their condition;

• the possibility of assigning containers to a specific area of the city and subsequently distributing them between the various utility companies registered in the city;

• finding the shortest route for a garbage truck to save fuel and reduce harmful emissions;

• dynamic changing of the route when the truck is on the way, if possible;

• collecting statistics to analyze the operation of the system and provide summary information to locals.

## Conclusion

The problem of garbage collection, sorting and recycling constantly arises along with large cities expansion. The aforementioned system is one of the solutions to this drawback. It is very easy to integrate into the "smart" city system and, at the initiative of the governing bodies, the waste collection system can provide its information to all supervisory authorities and each citizen. Besides, the system's output resources are additional means of urban development: fertilizers for urban vegetation development, fuel for the transportation system, packaging for public services, and more.

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