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ORGANIZATION OF MUNICIPAL SOLID WASTE SORTING: LOCAL ASPECT

Abstract. *The approach to organization of municipal solid waste sorting is developed. It is proposed to introduce a logistics system for the management and handling of solid waste at the local level. The system provides a sequence of logistics operations for planning and organization of waste management.*
Keywords: *municipal solid waste; housing estate; condominium; residential sorting station; recycling*

Introduction

Throughout several years in Ukraine preparation for introduction of the European tendencies for municipal solid waste sorting lasted [1–4]. However, at present the result of it is not satisfactory, as long as most of residential districts in Lviv city have not been supplied with sufficient amount of containers for selective collection of municipal solid waste (MSW). Furthermore, relevant information support of such format for rubbish separation and control over its implementation are absent.

Since 1 January 2018 in Ukraine responsibility for unsorted rubbish has intensified [5]. Now art. 32 with supplemented paragraph of the Law of Ukraine «On Waste» prohibits disposal by burial of unprocessed (untreated) household waste, which obliges Ukrainians to sort all MSW according to material types instead, by separating them to reusable (recyclable), hazardous, and landfilled [5]. According to preliminary experts' predictions as to implementation of regulation on prohibition of unprocessed municipal waste burial, it would not have had capacities to start work from 1 January 2018 on because of infrastructure failure. Thus, today this prognosis can be proved to be true, inasmuch as since early days of this paragraph's (in art.32) effectivity, first successful results as well as active mechanisms of control have not been achieved so far at all. Furthermore, there is no ordinance issued with the list and sequence of operations concerning MSW. Besides, there is lack of rubbish containers for sorting and gap in control over their provision.

Although practice of sorting waste in Ukraine is not new, it is nevertheless not well widespread and far from being immaculate. Basic challenges in thorough and systemic sorting are: insufficient amount of containers for every type of raw material; unorganized location of containers throughout the city and its residential districts; lack of qualitative and quantitative information on MSW, recyclables and its sorting; absence of steps and incentives for encouragement in support of waste

sorting; failure of control over implementation of all these responsibilities. To enhance the situation concerned with sorting MSW in the city, it is necessary to start the work at the local level first, namely at the level of a particular housing estate in a certain city district.

The aim of the work is developing of approaches to MSW sorting at the level of housing estate in a certain city district.

Analysis of recent studies and publications

Issue of MSW management system enhancement at the regional level was covered in the work [6]. In works [7, 8] ways, steps and instruments for achieving enhancement of economic mechanism in MSW management sphere at both state and regional levels were presented. Solutions to be used as models of MSW management in cities of Ukraine were laid down [9–13]. However, all these offers as to enhancement of MSW management system developed at state, regional and municipal levels, are not applicable at housing estate level so far.

Materials and methods of research

Work methods are based on analysis of principles in management of MSW groups. During carrying out the work scheme of mixed-use housing estate was used (MUHE), aimed at outlining rationality of effective handling and management of all MSW.

Presentation of material

In 2010 in Lviv separate collection of household waste was introduced by four fractions: miscellaneous rubbish, glass, paper and plastic. Since then containers with corresponding markings have appeared in Lviv's yards. However, not all city dwellers followed such sorting. There are several reasons that caused it. Those are lack of particular containers, improper waste sorting by residents and low information support concerning MSW sorting system. So, in 2016 new containers were offered for the city – closed ones supplied with a button for opening. New «closed» technology had to limit unpleasant smell emission throughout the city, as well as to complicate access to the rubbish for a waste pickers [10]. And even such change has not resulted in successful sorting waste as long as mistakes that had come with sorting system of 2010 were not corrected.

The problem mentioned is still stalled in the city. The city with its residents requires framing of new organizational conditions based on logistic process of accumulating, sorting and recycling of municipal waste. So, despite lack of specialized factories and systems for recycling all MSW, new approaches to their sorting and management are suggested by us. They are aimed at reducing volume of municipal waste for utilization at landfills.

Principles of collection and sorting all MSW unexceptionally are set as the framework of the approach. Such idea expands logistic circle of their effective management, namely sorting and collection of MSW types which are not recycled in the territory of city, region or state. These sorted wastes will be kept until their further utilization or possibility of their exporting in big volumes for processing. For

their temporary accumulation and proper maintenance conditions, city or district administration will have to provide such area with facility.

However, first of all, it is necessary to introduce logistics system of MSW management at the local level. This system can be carried out with the help of logistic functions which, in turn, fall into processes and operations of MSW handling and management at the level of housing estate (HE).

Logistic process of MSW management is considered as streamlined sequence of planning operations and organization of management concerning MSW movement from its generation to treatment and further control over sites of its reprocessing.

The first stage of logistics process in MSW handling and management for housing estate is establishing economic relations between condominium and companies which deal with accepting recyclables as well as farms concerned with processing organic waste for bio-humus-making. Such firms are more than ten in Lviv to accept recyclables. However, in order to get residents of HE interested in sorting MSW, it is needed to motivate them financially according to the principle, "we sort – we sell – we get money – we maintain the house". This money is designated for expenses of housing estate upkeep (Fig. 1).

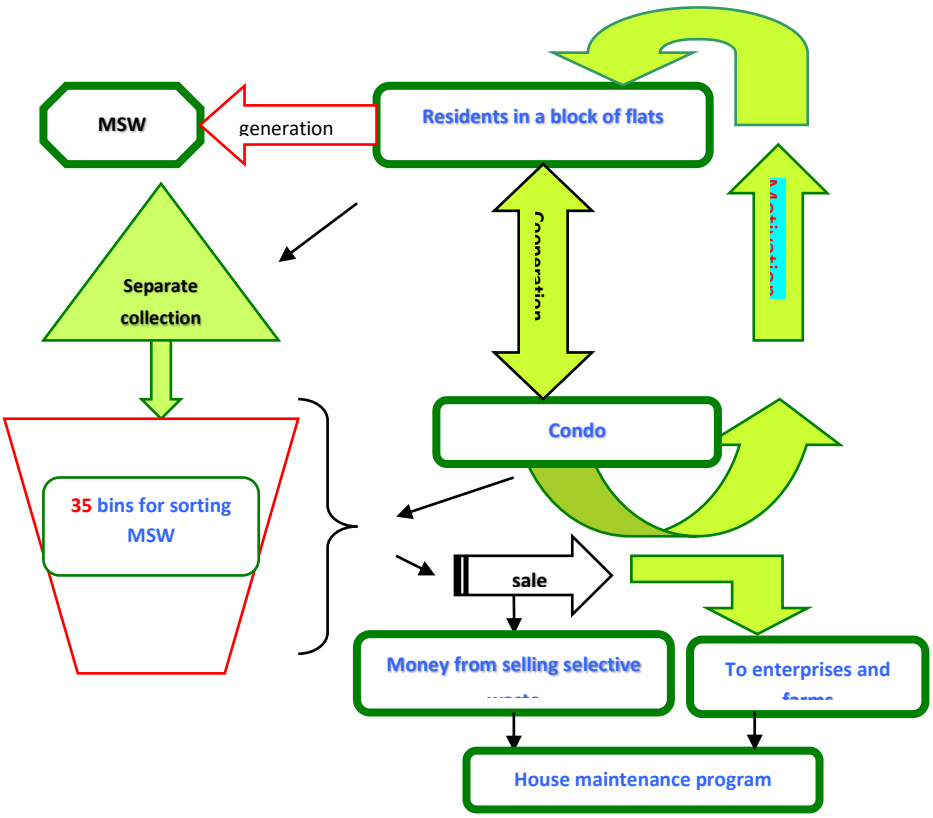

Fig. 1 – Scheme of logistics process for MSW handling and management in a housing estate

For that purpose, it is necessary to conclude agreements with companies dealing with purchase of recyclables.

The second stage is arrangement of a storage facility nearby housing estate for collection, sorting and storage of waste materials. In particular, construction company «Galzhytlobud» started construction works of mixed-use housing estate (MUHE) at address 73, Heroiv UPA str. The building is designed for 394 flats. That MUHE has to meet needs of people of different categories: to offer lodging to hundreds of workers whose offices are located nearby; meet consumer needs of potential dwellers of residential houses and arrange public spaces for leisure activities.

For reaching proper living level in this MUHE, it is also necessary to provide a facility for collection, sorting and temporary storage of separated recyclables. So, site for such facility was suggested within this MUHE (Fig. 2).

The third stage is the very arrangement of the facility adjoining building - residential station for sorting and temporary storage of MSW (Fig. 3).

Crucial moment is the fact that the facility is locked with a key and every dweller of MUHE has it. This enables temporary storage of recyclables until arrival of specialized vehicle from a particular company or a farm. The process mentioned as to MSW handling and management of recyclables within this MUHE is controlled by a person from condominium.

Plastic containers and boxes are placed in this facility. There are several sections in the facility: biowaste, packaging waste, wastepaper, other household stuff (Table).

Fig. 2 – Facility for collection, sorting and temporary storage of MSW on the scheme of MUHE

One of important preconditions for efficient MSW sorting is residents' awareness about the materials they sort. In this case a guide on sorting MSW will help. Information on waste as a potential recycled material, will refer to available sections of MSW sorting in HE, see in the Table below.

Fig. 3 – Facility for collection, sorting and temporary storage of MSW

In section A of facility organic waste for ***compost*** will be collected in containers. Food waste is collected in a paper bag which is thrown into brown bin. Composted waste undergoes further processing into nutrient-rich soils (biohumus).

To food waste items belong as follows: bread, cookies, biscuits, sponge cakes and buns; fruit, egg and vegetable peels; coffee grounds and tea leaves, as well as coffee and tea filters; meat and fish bones, fish and seafood waste; food leftovers; cooked and raw meat, fish, vegetables, fruit, eggs; milk, flour, cereals and pasta; snacks, candies and chocolate; withered flowers, potting plants and soil from repotting, etc.

In container for compost items should be collected such as organic waste from kitchen table: raw and cooked fruit, vegetables and their peels, cereals, eggshell, tea leaves, coffee grounds, plant residues after straining herbal infusions and decoctions; meat and fish waste (in closed composters only), food leftovers. Also to this container it is allowed to throw shredded discarded paper from natural materials (paper, card, package, shredded newspapers, paper tissues, towels, serviettes), garden waste: decayed leaves (last year's), small twigs (branchlets) after trimming and pruning of healthy trees and shrubs, grass clippings mown from lawns, shredded/chopped wood (big branches, roots, rind), annual weeds. No throwing stubs, paper coated with wax or a film, as well as other not biodegradable waste.

Besides, in this section, alongside containers for compost, there are bins placed for waste ***to be incinerated***. Such waste should be packed and put into green bin. Waste will be incinerated for electricity or heat generation. Waste to incinerate comprise: ash (cooled); parch paper; balloons, candles (stubs) and paper table cloths; nappies, sanitary napkins and wash cloths (textile wash cloths (microfibre)); videocassettes, floppy disks and CDs; vacuum cleaner bags (unwoven material); dishtowels, dish brushes and sponges; cigarette stubs, tobacco; wooden and plastic hangers; collection bags with sand from cats litterbox and dogs poop; leather; toothbrush; cotton, cotton wool and plaster; chewing gum; textile and yarn waste; plastic pots; envelopes.

Table – Sections of residential MSW sorting station

Section A Waste to composting	**Section B PW:**	**Section C Wastepaper:**	**Section D Other household stuff**
	1 – from glass (by *colour*): **1a** – clear; **1б** – green; **1в** – amber yellow; (jars and bottles); **2 – from metal:** **2a** – tinplated cans, lids; **2b** – aluminium cans/foil; **2c** – aerosol cans (empty); **3 – from mixed material:** based on paper and cardboard, based on aluminium foil, metalized, etc. (Tetra Pak, Pure Pak, Eco Lean, paper cups, heat sealed packagings etc.); **4 – from plastic** (7) (by markings): **4a** – PETE; **4b** – HDPE; **4c** – PVC; **4d** – LDPE; **4e** – PP; **4f** – PS → PS-E; **4g** – Other/O; (flasks, containers, bottles transparent and coloured nontransparent - white, yellow and black, caps, films, bags); **4h** – recycling code unlabeled plastic; **5 – from foam polystyrene/styrofoam**	**1** – newspapers; **1a** – magazines; **1б** – catalogues; **1в** – advertising leaflets (junk mail); 1g – flyers; **2** – clean and used paper; **3** – copy-books; **4** – books and phonebooks without hard cover; **5** – cardboard without polyethylene film; (cardboard boxes and packing boxes); **6** – paper bags (clean)	**1** – wires; **2** – small electrical appliances; **3** – lighters; **4** – batteries; **5** – lamps; **6** – cullet; **7** – window glass; **8** – disposable razors; **9** – thermometers; **10** – kids toys; **11** – hard cover from books and phonebooks; **12** – sales slips/receipts; **13** – egg cartons; **14** – sticker paper, labels; **15** – shock-proof glass from gadgets (smartphones and tablets); **16** – heat-proof glass (broken heat-proof dishware); **17** – cut-glass ware; **18** – mirror; **19** – wallpaper; **20** – gift wrapping paper; **21** – decorators tape; **22** – photographs; **23** – wrappers from sweets, candies, chocolate bars, pastries, wafers; **24** – drink straws; **25** – ceramics; **26** – cigarettes packs
Section A Waste to incineration			

Section B is designated for sorting ***packaging waste***. In order to send such waste to recycling, they should be cleaned from food residues or dirt and dried, and if necessary (depending on kind of PM) pressured or flattened. Also if required, − to remove lid/cap, label and sort them respectively to recycling.

Collection of glass packaging (bottles and jars from glass), is fulfilled by colours as follows: clear, green and amber yellow. Glass can be recycled into new glass containers infinitely many times. For recycling glass, it needs to be converted into cullet. Production of new glass from recycled glass material reduces energy consuming by 40%. From recycled glass glassware, decorative tile and other wares are produced. During production of 1 ton of glass from cullet, sand usage reduces by 600 kg, limestone by 170 kg, soda ash by 190 kg and feldspar by 70 kg.

Such **metal waste** is sorted as follows: aluminium foil; aluminium molds; aluminium cans (tins); tin-coated steel cans and lids; empty spray containers, etc. Big amount of energy is saved when reprocessing metal. Metal can be recycled infinitely many times without spoiling its quality.

Packaging from **mixed** and multilayered **materials,** which recently acquired widespread usage, in particular, Tetra Pak, Pure Pak, ELM (Ecolean Material) etc. are subjected to mandatory sorting.

It is also worth collecting separately paper cups from coffee, tea or other beverages/drinks, since they contain glue, which does not allow to recycle them inasmuch as adhesives are impossible to remove during transforming paper into pulp. This paper is also lined with plastic or waxy layer which enables hot liquid to be kept within a cup, though it is the one that does not allow to process paper fibres. Laminated paper is required to sort separately from other the mentioned above packagings as well. Such type of mixed material is composed of paper and polyethylene. It is used as heat-sealed packagings for spices, seasonings, dried instant foods as well as medications (pills, disposable syringes, plasters, medicine gloves, etc.). Candies wrappers make up some part of mixed material, so they should be collected separately, too.

In the section for packaging waste, bins to sort various types of plastic (by marking) are placed. On polymeric packaging there is always marking (recycling code) to identify which *type of plastic* it is made from. Plastic packagings fall into 7 kinds of plastics, each has its own numeric symbol which manufacturers put to inform about *type of material*, possibilities of its recycling and to facilitate process of sorting and re-use after recycling. Such items from plastic are sorted as follows: cellophane; rigid plastic packaging – polymeric bottles/flasks, containers, jars, bottles for example, from ketchup, mustard, yoghurt, water, plastic cups for ice-cream, bottles from shampoo, dish soap bottles and detergent/cleaner jugs; foamed polystyrene; plastic lids, caps; soft plastic packagings – miscellaneous films and wrapping made from them, for example, from dairy or meat products; plastic bags, snack packs; plastic plant pots (no soil). In these containers it is not allowed to throw packaging which contain hazardous waste – paint or motor oil, as well as dirty packagings, toys etc. Also in this section alongside containers with the above-mentioned packaging waste, one more container is placed for packaging waste from foamed polystyrene/Styrofoam, namely polyfoam disposable plates.

In section C wastepaper should be sorted. In particular: newspapers; magazines; catalogues; books and notebooks (no polished hard covers); copy-books; office paper for notes, drawing and envelopes; advertising leaflets (junk mail); flyers; other printed products; gift wrapping paper. To be sorted also cardboard: cardboard of various type without polyethylene film coating (cardboard boxes and packing boxes); paper bags and wrapping paper (clean); paper boxes (cartons), for example from loose products [14]. Paper or cardboard filled with food residues or paint as well as paper coated with plastic or glue are not allowed to leave in the container.

In section D all household stuff is collected that has not got appropriate disposal system so far. Those items are not to be hauled to MSW landfills. Such waste is planned to collect, sort and store until the moment of its processing method identification.

The fourth stage involves preparation of MSW in households until being conditioned for selling to recycling enterprises. Such conditions are as follows: sorting of household waste to recycling; rinsing until clean; maximum compressed and flattened recyclable items.

The fifth stage includes separation of waste material in residential MSW sorting station. Each type of waste will have its own separate container. Thus, about 35 bins for sorting MSW will be placed in such station facility (Fig. 4).

Fig. 4 – Storage facility with bins for sorting waste

In many countries, in particular Sweden, Australia, Japan and others effective practice as to using guide on sorting household waste by residents has been introduced already, to provide any helpful information about separate collection of various waste types and their disposal methods. In Great Britain “smart” rubbish bins are set to go on sale. The invention has system of recognition automatically to tell recyclable wastes from the ones to be utilized [11].

With the support of companies «Sankom-Lviv» Ltd, «AVE Lviv» Ltd, «Lvivspetscommuntrans» LME (Lviv municipal utility enterprise), «GreenEra Ukraine» Ltd, it is also worth framing a system for improvement of information support on the proper sorting of different waste types. The system should involve specialized electronic and information terminal.

Conclusions

Tendency of sorting municipal solid waste in Ukraine was analyzed and causes of unsuccessful introduction of MSW separate collection system in Ukraine were established.

To introduce effective MSW sorting system in cities, a new approach was suggested for organization of municipal waste sorting at the local level and stages of logistics process concerning MSW management and handling for housing estates were defined.

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ОРГАНІЗАЦІЯ СОРТУВАННЯ ТВЕРДИХ ПОБУТОВИХ ВІДХОДІВ: ЛОКАЛЬНИЙ АСПЕКТ

Анотація. Розроблено підхід до організації сортування твердих побутових відходів. Запропоновано запровадити логістичну систему поводження та управління з відходами на локальному рівні. Система передбачає послідовність виконання логістичних операцій планування та організації управління рухом відходів.

Ключові слова: тверді побутові відходи; житловий комплекс; об'єднання співвласників багатоквартирного будинку; прибудинкова станція сортування; вторинне перероблення

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