

## PRINCIPLES OF JUSTIFICATION OF REGIONAL PROGRAMMES OF MUNICIPAL SOLID WASTE TREATMENT

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**Abstract.** It is the scientific justification of the regional programme of the municipal solid waste treatment (MSW) with the example of Odessa region which will promote the increase in environmental safety of the population, reduction of the negative impact on the environment by the improvement and modernization of the existing system of MSW treatment with final achievement of a “zero waste” state due to the transfer of the maximum amount of waste into the liquid secondary raw materials, alternative source of energy and environmentally-friendly organic-mineral fertilizer. Such approach differs essentially from the existing developments of regional programmes of MSW treatment and has a scientific - methodical and practical value.

**Key words:** municipal solid waste, waste treatment, regional programme.

### 1. Introduction

In recent years, the solution to the problem of municipal solid waste (MSW) management has become increasingly complex. The reasons for this are the growth of the formation of MSW, structural changes in MSW composition as well as changes in the system of regional and local government and in the legislative sphere of waste treatment in Ukraine. As it is specified in the Law of Ukraine “On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine by 2020”, inefficient MSW treatment is becoming an increasingly acute environmental problem. In recent years the amount of MSW which is not prone to fast decomposition has increased and demands significant areas for placement. The quantity of the overloaded dumps and landfill sites which do not meet standards of ecological safety grows in the regions of Ukraine every year. According to “The National Strategy of Waste Management in Ukraine by 2030” [1] regional plans (programmes) of waste management are developed to

assist the realization of this Strategy not later than two years after its approval. There is a specific situation in each region which needs to be considered at justification of the regional programmes of MSW treatment (RPT), but basic approaches to formation of these programmes will be similar in many ways.

“The Programme of Treatment of Municipal Solid Waste in Odessa Region for 2013–2017” (approved by the decision of the regional council № 823-VI of 04.07.2013.) was focused on “creation of conditions promoting full collection, transportation, utilization and burial of household waste and diminishment of their adverse effect on the natural environment and people’s health as well as expansion and modernization of the operating capacities for MSW collection, processing and utilizing and creation of an effective control system in the sphere of waste treatment”.

The analysis of the current state of MSW treatment system in Odessa region confirms that neither planned problems nor prioritized focus on actions were realized. Actually, this programme was focused on short-term measures, not for the realization of new technological schemes. It was never about the implementation of “pilot” projects which could provide the chance for practical tests and the choice of technologies for the mass implementation. Inconsistencies of this programme were considered in the design of the programme draft on MSW treatment in Odessa region for 2018–2022 (prepared by the USAID “Municipal Power Reform in Ukraine” Project), but this RPT of MSW was not approved by the decision of the regional council. Consistent approach to the development of RPT of MSW does not exist, but separate provisions concerning the formation of the principles of such programmes (with the example of Odessa region) are given by the authors of this article in their works.

The aim of the research is the increase of ecological safety of the population, reduction of the negative

impact on the environment by the improvement and modernization of the existing MSW treatment system with the ultimate achievement of a “zero waste” condition due to transferring the maximum amount of waste into liquid secondary raw materials, alternative source of energy and environmentally-friendly organic-mineral fertilizer..

## **2. Theoretical part**

The problem of the effective MSW treatment remains one of the most essential environmental and social-economic problems in Ukrainian regions. Now the condition of MSW treatment in Ukrainian regions is at the unsatisfactory level. Unfortunately, the dominating way of MSW treatment in all regions is still their removal and burial on landfill sites that demands considerable land resources and exerts considerable impact on the environment. There are very few examples on prevention of MSW formation and utilization of its resource-valuable components. In each region there has been a specific situation which needs to be considered during the justification of MSW treatment regional programmes. As a rule, the majority of these regional programmes are restricted by the determination of MSW formation volumes, inventory of landfill sites condition, calculations of a necessary number of containers and technical means, justification of the expediency of installation of switchyards and new solid waste landfill constructions without definition of their location. Generally, regional programmes of MSW treatment were aimed at increasing the quantity and the area of MSW landfill sites rather than introducing innovative approaches to creating an effective system of MSW management as well as distributing financial resources,

According to the goal of RPT, the solution of the following tasks is defined as follows:

MSW classification and differentiation that will allow to choose the most effective in ecological and socio-economic aspects methods of processing, disposal and removal for each separate stream of MSW components; inventory of the existing landfill sites (“polygons”) and the forecast of the extent of MSW accumulation on the territory of separate regions; assessment of the extent of MSW generation in various parts of the regions; realization of the measures for elimination of unauthorized landfill sites and partial utilization of the MSW, which were saved up on these landfill sites; reclamation of overloaded and closed solid waste landfills; justification of the possibility of creation of new (reserve) modern polygons for partial burial of the MSW which are not subject to processing or utilization; organization of the effective system of collection, transportation, processing and utilization of

MSW components (including dangerous elements); justification of the principles of cluster strategy realization in the sphere of MSW treatment in the regions; justification of the expediency of creation of MSW processing and utilization centres with the use of the best available technologies for the extraction of secondary resources, as well as the disposal and utilization of the environmentally hazardous MSW components; increase in the efficiency of the targeted use of payments by the population and improvement of governmental mechanisms of state regulation of MSW treatment in the market economy; improvement of professional skills of the personnel involved in waste management; Implementation of a set of measures to raise the level of environmental awareness and culture of the general population. Development of the RPT on MSW has to be based on the existing legal framework (legislative documents on MSW treatment, the relevant resolutions of the Ukrainian Cabinet of Ministers and orders of the Ministry of Ecology and Natural Resources of Ukraine, etc.).

## **3. Results and discussion**

Considering that separate MSW collection has covered not more than 13 % of Ukrainian settlements, namely separate collection is implemented for the subtraction of only separate components (waste paper, glass, metal and plastic), it is possible to consider that almost all volume of created waste is placed in specially allotted sites. It is noted that due to the introduction of separate MSW collection, work of 21 waste sorting lines, 1 incineration plant and 3 waste incineration installations in Ukraine in 2014, only 4.2 % of MSW was utilized, 1.7 % of which was burned, and the other was used as secondary raw material. In 2014 in Ukraine there were collected 45 million m<sup>3</sup> of MSW, 65 % of which was removed to places of burial which officially accounted for 6 thousand with a total area of more than 9 thousand hectares. From 48 million m<sup>3</sup> of the MSW formed in Ukraine in 2015 (without the data of the Autonomous Republic of the Crimea, Luhansk region and Sevastopol), only 5.93 % of MSW was processed and utilized, 2.73 % of which was burned, and 3.2 % got to procuring points of secondary raw materials and waste recycling plants [2].

The condition of MSW location is not satisfactory: 16 % of such constructions is overloaded, and 19 % does not meet standards of ecological safety. Besides, there is a need of at least 576 MSW polygons. Under conditions when waste collection and disposal services are provided for 78 % of the population, there appear spontaneous landfill sites, which in 2014 accounted 24 thousand with a total area of 1.5 thousand hectares [3].

For instance, waste treatment status in Odessa region is a subject of the annual regional report on the environmental condition, statistical reviews, special studies, ecological programmes, etc. The description of the state of waste treatment is mainly limited to the data about the quantity and the area of landfill sites, volumes of the waste placed in specially allotted sites (mostly industrial). However, such “standard” array of information about waste placement in specially allotted sites does not allow to fully characterize ecological consequences of the existing situation with waste in Odessa region and determine the resource potential of such waste.

Carrying out the statistical information analysis about waste from different sources of information (as an example of Odessa region), it is possible to define a number of disadvantages which make its practical use more complicated (first of all, it concerns high-quality content of the received results):

1) lack of explanation in reference books about the received statistic figures and the methodologies of their calculation (for instance, the number of the waste formed and placed in one year differs 1500 times; identity of the concepts “waste placed in specially allotted sites and objects” and “waste removed to specially allotted sites and objects”);

2) violation of integrity of information arrays (for example, in some areas of Odessa region there is no information about the amount of generated waste);

3) almost total absence of information about the volumes of waste formation.

For the solution of the task regarding the division of Odessa region into districts by a set of the indicators describing MSW placement based on association of administrative regions in characteristic groups, we used a method of the multidimensional statistical analysis – the cluster analysis. The use of the cluster analysis for division of the territory into districts according to a complex of indicators tied to certain areas is convenient and expedient [4]. The implementation of the algorithm is performed using the application package of Statistica 7.0. A clustering method is k-averages. When processing an array of data, the replacement of missing data with average values was used. The set quantity of clusters is 5. At such quantity of clusters the best results of association in groups take place with significant difference between the received clusters by the indicators which are observed. For example, in Odessa region there are 5 clusters according to the following indicators: quantity of landfill sites; the area occupied by MSW; design area of solid waste polygons, hectare; the design mass of MSW which will be placed on polygons, tons; the share of the area which is occupied with the sites of waste disposal, %; the quantity of landfill sites corresponding to 1 thousand inhabitants; the dynamics

of an average area change of one polygon for the certain period [5].

The obtained data of the cluster analysis can be a basis for justification of the principles of cluster strategy realization in the sphere of MSW treatment in Odessa administrative regions and also have to be used to determine the necessary number of waste-sorting and waste-processing enterprises in the area.

Thus, the problem of the inefficient waste treatment which is typical for Ukrainian regions is relevant and formed MSW are removed in specially allotted places. On average, such objects occupy 0.03 % of the region area, but as it is defined, they are characterized by positive dynamics of the area and quantity changes. A current problem is the need in creation of new places for waste disposal.

For assessment of the scale of MSW accumulation it is necessary to carry out inventory of their landfill sites, first of all, inventory of unauthorized landfill sites. At the same time, it is necessary to record the features of location, the size, possible sources, the dominating components and also existence of ecologically dangerous components of MSW landfill sites. For the overloaded and closed landfill sites it is expedient to offer reclamation activities.

As far as it will hardly be possible to completely abandon landfill burial during a short period of time, it is expedient to prove a possibility to construct new (reserve) polygons with lines of garbage sorting, biochemical processing technologies (receiving biogas and ecologically safe organic-mineral fertilizer).

According to the Department of Ecology and Natural Resources of the Odessa Regional Public Administration there are 608 landfill sites in the area which occupy about 1300 hectares of lands [6]. Most of them are in an unsatisfactory condition and they are operated with violation of the nature protection legislation and sanitary and epidemiologic requirements of safety. For the purpose upgrading of the MSW treatment system it is offered to eliminate numerous landfill sites and construct four modern inter-district MSW polygons within five clusters in Odessa region.

The placement of inter-district polygons has to be based on DBN B.2.4-2-2005 “Polygons of MSW. Design basics.” [7] which contains requirements about where “Polygons of MSW are located”, where “placement of MSW polygons is allowed” and where “placement of MSW polygons is not allowed”. In this regard, it is expedient to analyze physiographic, engineering-geological, hydro-geological, technogenic and socio-economic indexes defining the possibilities of modern MSW polygons placement in certain areas of Ukrainian regions.

MSW and their components classification is a necessary condition for a solution of the problem of management and treatment in Ukrainian regions. Therefore, we offered the newest approaches concerning principles, applied classification aspects of MSW, their components and their treatment [8].

MSW include waste of the residential sector, waste of municipal infrastructure and municipal authorities. The general MSW stream consists of organic waste which easily decays; potential secondary resources (large-size waste and waste of container collection) and dangerous waste [9].

MSW generation and accumulation are the processes taking place within time, therefore, the methodology of MSW management and treatment is based on dynamic approach. The purposeful effect of the project implementation is minimization of MSW accumulation. It is implemented as a result of planning, organization, management and control of the material movement and connected informational and financial flows in the space-time coordinates during all the life cycle of MSW. The MSW components are considered as the differentiated streams of waste: 1) organic waste which decays easily (food waste, park and garden waste, waste of the markets etc.); 2) potential secondary material resources (SMR): large-sized household goods (old furniture, household appliances); waste of container collection (various containers and packaging, waste paper, textiles, metal, glass, leather, rubber etc.); inert mineral large-sized waste (construction debris) 3) dangerous waste (medical waste, mercury lamps, electrical current sources, accumulators).

The principle of MSW flows differentiation which is the basis of the Project of MSW treatment in the region is offered to be realized as follows:

– at the initial stage of MSW life cycle the flow of organic waste which decays easily is separated from the general flow of waste at the time of their generation; the flow is structured depending on the place of generation (type of a house, an object of city infrastructure)

– the flow of potential secondary material resources which is generated as a result of urban population activity and economic activity of infrastructure facilities is divided into components: a) old furniture and household appliances are sent to the specialized organizations for dismantling with the subsequent utilization; b) containers and packaging, waste paper, textiles, metal, glass, leather, rubber are gathered in the mobile containers, marked for each type of SMR and are taken out for further sorting and processing; c) the inert mineral large-sized waste which is formed during carrying out construction and refurbishing works in households and city coordinated objects have to be processed and used in planning works;

– the flow of dangerous waste which is formed in households and city infrastructure facilities is allocated from the general MSW flow by means of organizing address collection of components of the flow.

The managerial principles of MSW flows are developed for Odessa region: the principle of alternative compulsion of economic entities (the organic flow decays easily), the principle of economic feasibility in a chain “a producer of waste” – “a sorter of waste” – “a processor of SMR” (the flow of potential secondary material resources) and the principle of material interest of the parties (the flow of inert mineral large-size waste); principle of conscious safety (the flow of dangerous waste).

The solution of the problem with municipal solid waste treatment within Odessa region is based on an integrated approach.

Creation of environmental protection and safety conditions of local population activity are provided with the help of the system of the organizational and economic actions which are based on the principles of sustainable development and consider specifics of the region development.

Considering significant financial expenses, the first step to differentiate MSW flows can be the obligatory separation of organic waste which can decay easily at the time of its generation as well as a dangerous MSW component.

Organic waste which can decay easily is the secondary raw material for receiving biogas and organic-mineral fertilizer, and, therefore, there is a need in planning biochemical processing of environmentally-friendly organic waste flow during new polygons construction, which will make it possible to receive environmentally-friendly organic-mineral fertilizer and alternative energy source.

It is recommended to install four containers on the container platform. The first container is with the label “Food and Vegetative (park and garden) Waste” for collecting environmentally-friendly organic components of waste which can decay easily, the second one is with the label “Dangerous Waste” for collecting medical waste, mercury lamps, sources of electric current, accumulators, etc., the third one is with the label “Secondary Raw Materials” which is intended for collecting resource valuable components of MSW, which will be sent to the waste sorting enterprise, the fourth one is with the label “Unsorted Waste” which content needs to be sorted at a recycling point.

It is necessary to add to the organic waste flow similar waste from the food industry, vegetable storehouses, catering establishments and markets, the discarded products of supermarkets, etc. for mutual processing. The seasonal formation of fallen leaves and

trees and bushes cut (the second component of this MSW flow) causes the need in organizing the centralized collection and relocation of this substance for composting or anaerobic fermentation on specially equipped platforms or in special equipment (methane tanks). Mutual composting with food waste can serve an alternative version of this type of organic waste treatment in the houses of private sector with backyards.

Construction debris utilization can be provided by the use of this type of waste in road construction or as filler in production of concrete.

Disposal of hazardous waste should be done by industrial means.

Realization of MSW treatment system provides creation of the municipal centre of the secondary material resources (SMR) recycling based on the modular and block principle. It is advisable to include a coordinating administrative group, a SMR structure-store and a transport division in the structure of the centre. A recycling point which is located on the place of one of the block yard container platforms should become the main structural element of the recycling centre. It consists of 5 modules: 1) the module for the separated organic waste which can decay easily; 2) the module for sorting the stabilized potential SMR; 3) the module performing the functions of a collection point for secondary raw materials and taking for money separate fractions of MSW flow, which is sorted by the population; 4) the module for taking and dismantling large-size waste; 5) the module for dangerous household waste fraction collecting [8].

It is necessary to provide logistics service of the points by small mobile economic vehicles. When applying the proposed collection scheme, it is necessary to provide centralized transportation of the collected waste fractions in one type of container and in separate vehicles. As long as the mass of separately collected waste in a recycling point is accumulated, it is transported to the warehouses of the recycling city centres or directly to the waste-sorting / waste-processing enterprises and for industrial disposal.

It is possible to change the situation in the MSW treatment sphere fundamentally by means of cluster approach. The principle of differentiation of MSW flows which is the basis for the concept of MSW management and treatment of city agglomerations [10] is the key when forming a cluster structure of MSW treatment. The cluster in the MSW treatment sphere is multi-spectral and, therefore, there have to be objects of the following types: 1) "core" are the objects around which the cluster groups, they carry out a primary activity and produce final product; 2) "complementary" are the objects which directly provide the functioning of "core" objects; 3) "serving" are the objects the existence of which is

obligatory but whose activity is not directly connected with the "core" objects functioning; 4) "secondary" are the objects whose existence is desirable but is not obligatory for other cluster objects functioning.

We have developed a cluster structure in the MSW treatment sphere for Odessa region [8, 11].

To the first level belong the higher educational institutions on the basis of which research is conducted, technological and logistics chains in the treatment of MSW and their components are developed, the efficiency of the implemented developments is estimated, for instance, the Odessa State Environmental University, Institute of Problems of the Market and Economical and Ecological Research, etc.

The second level of MSW treatment cluster includes recycling points and a recycling city centre, the waste sorting enterprises rendering various services in waste collection, transportation, sorting, that is turning them into the secondary material resources (SMR) and separating dangerous waste. The enterprises which use the received SMR as raw materials for target production and the enterprises carrying out destruction / neutralization of a dangerous flow of the waste extracted from MSW refer to this level of cluster

The material flows created at this level of cluster are involved in the goods production as raw materials and energy resources, which significantly reduces anthropogenic load on the environment and provides economy of the substantiated work and natural resources. The conditions of realization of economic interests of the cluster participants which form its second level are the availability of equipment and technologies for collection, transportation and processing waste, qualified personnel, innovative developments as well as the immutability of market demand for SMR and production made from waste. The second level participants of the cluster in Odessa are LLC "Soyuz", the RC OF "Odeskomuntrans", LLC "Ekorenesans", "Green-port" and others.

The third level of MSW treatment cluster is the infrastructure which is formed by the organizations and institutions providing activity of subjects of managing of the first and the second cluster levels with the administrative, informational, personnel, financial and other resources which are necessary for their functioning, trade enterprises which sell the produced SMR and final product as well as mass media which are necessary in the formation of citizens' ecological consciousness. Local administrations (with housing and communal services), transport institutions with specialized vehicles, trade enterprises, institutions which carry out training and retraining of personnel of the corresponding qualification (the Odessa State Environmental University and the Centre of Post-degree

Formation of the Odessa State Environmental University) and city media should be the participants of this cluster level.

Thus, RPT with MSW need to be realized in 4 directions: 1) the embodiment of MSW treatment system in the city (separation of the organic easily decomposed fraction and dangerous waste, creation of recycling points and centres, etc.); 2) work on the polygon (waste sorting enterprise construction, creation of biochemical processing and then composting and receiving biogas) 3) development of logistics service (transition to small-sized garbage trucks, different cars for the MSW separate components or cars with separate sections without waste suppression); 4) educational work with the population, training, advertising, etc.

## Conclusion

The mass of MSW accumulated on landfill sites and polygons of Odessa region, the current state of MSW treatment system threatens the environment and the citizens' health. Justification of the MSW treatment regional programme (with the example of Odessa region) will promote the increase in environmental safety of the population, reduction of the negative impact on the environment by the improvement and modernization of the existing MSW treatment system with final achievement of a "zero waste" state due to the transfer of the maximum amount of waste into the liquid secondary raw material, alternative fuel and environmentally-friendly organic-mineral fertilizer. The implementation of conceptual and theoretical basis of formation of the optimized MSW treatment system will promote the achievement of sustainable development of the regions.

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