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PROBLEMS OF MUNICIPAL SOLID WASTES IN THE REPUBLIC OF KAZAKHSTAN

Abstract. It has been shown that the proposed method for processing municipal solid wastes by means of application of new technologies, using the process of pyrolysis, will minimize the release of toxic substances into the environment after their preliminary sorting, and with the correct organization of the waste management market.

Key words: ecology, municipal solid wastes, morphological composition, utilization, pyrolysis, processing.

Introduction. According to the statistical data, more than 20 billion tons of production and consumption wastes have accumulated in Kazakhstan. Annually, 5-6 million tons of municipal solid wastes (MSW) are generated in the country. For the eight months of the year 2018 about 3.2 million tons of wastes have been generated, whereof approximately 330 thousand tons, or ~ 10.5%, have been processed and utilized. Last year this indicator made up 9%, and in the year 2016 - 2.6%. For the reduction of wastes and their involvement in recycling, economic levers of incentive should be applied. The Government has approved the Plan for the Formation and Development of the "Metallurgy" Pilot Cluster. It provides for the measures to stimulate the processing and utilization of the production wastes of the metallurgical enterprises for increasing the integrity of processing the raw materials and complying with the ecological requirements for the environmental protection, including the introduction of changes into the existing legislation.

Therefore, the solution to this problem is an important, essential task of today, as a result of which the negative consequences of the activities of the urban infrastructure and society as a whole may be prevented.

In Kazakhstan the situation with the utilization and subsequent processing of municipal solid wastes still remains at the level of the 90s. Recovery of the recyclable materials from the mixed municipal solid wastes is planned for the implementation only in a few cities, and even then, without biodegradable wastes. All this fetid mass is explosive, it pollutes the ground and surface waters, and also affects the climate change; a waste landfill of the world class is so far available only in Astana. Despite the closure of a number of industrial enterprises for economic reasons, the concentration of hazardous substances in the city atmosphere still exceeds several times the permissible standards. Herewith, as it is noted by the experts, the most dangerous substances, i.e. fine solids, carcinogens, heavy metals, are neither measured nor controlled. Although, it is known that a short-term exposure to fine solids increases the morbidity and mortality of the population.

The work [3] pays special attention to the problem of studying the processes of waste formation, transportation, accumulation, management, and consumption, defining the existing shortcomings and developing measures for their elimination. In this connection, it seems to us appropriate to draw attention to one of the approaches to the problem of municipal solid wastes (MSW) - the Concept of Integrated Waste Management (IWM). This approach takes into account the following provisions, confirmed by the global experience:

- firstly, there is no single technology, capable of processing the entire waste stream without harm to humans and the environment;

- secondly, even a suite of technology may bring to the solution of the waste problem only when it is applied together with a set of economic and social instruments [3].

Kazakhstan has an opportunity to receive certain benefits from the development of this market, having in mind both the environmental and economic aspects of the issue. Due to the proper organization of the waste management market, through the application of new technologies, it is possible to minimize a harmful impact on the environment. Herewith, the companies engaged in this sphere, by means of using the advanced technologies, may improve the quality of their own work, which in turn will increase their competitiveness in this market.

"Since the year 2016, the country has introduced a ban on burial of mercury-containing lamps and appliances, scrap metal, spent oils and liquids, batteries, electronic wastes. From January 2019, a ban on burial of plastic, scrap paper, cardboard, paper and glass wastes comes into force. And from January 2021, a ban on burial of construction and food waste will come into force," - said the Minister of Energy of Kazakhstan, Mr. K. Bozumbayev. The high level of environmental pollution in Almaty was noted compared with the world leaders in pollution. The development of health care in order to improve the quality of life of the population indicated the need to support educational and research institutions in the medical field [3-5].

Problems of processing MSW:

- unsorted MSW;
- high humidity;
- low heating value;
- impossibility of compliance with an environmentally safe technology;
- storage on waste landfills;
- composting;
- waste incineration.

There are two main methods for processing MSW:

1. mechanical and biological methods - composting wastes, sorting wastes by recycling enterprises;
2. thermal methods: waste incineration, pyrolysis, waste gasification, combined thermal methods.

It should be noted that incineration is a widespread method for the destruction of MSW, which has been widely used since the end of the 19th century. Unfortunately, the main drawback of this method is the emission of harmful substances into the atmosphere and destruction of valuable organic and other components, contained in MSW.

Upon MSW incineration 28–44% of ash and gaseous products (CO_2, vapors of H_2O, and various impurities) are obtained. Combustion takes place at t = 800 - 900ºC, so aldehydes, phenols, dioxins, furans, heavy metals are present in the gases. This mixture is more dangerous than such military gases as sulfur mustard and sarin.

The solution, which we propose for processing MSW, is pyrolysis.

Pyrolysis is a process, wherein the grinded waste material undergoes thermal decomposition in the absence of air [5-7].

As a result of pyrolysis three main products are formed:

• pyrogas (pyrolysis, pyrolytic gas or synthesis gas) is a mixture of gases, both combustible and non-combustible;

• pyrolysis (pyrolytic) oil and water. Pyrolysis oil has a different composition and can subsequently serve as heating oil or raw material for processing;

• picarbon (solid carbon-containing residue - coal).

Pyrolysis process flow sheet is shown in figure 1.

As is seen from figure 1, in the course of pyrolysis four processes, common to all its types, proceed. By the effect of different temperatures on the wastes, pyrolysis is divided into a low-temperature and high-temperature one. The first one proceeds at the temperature up to 900^{0}C, and the second one - at temperature above 900^{0}C.

The technology of waste treatment during the *low-temperature pyrolysis* consists in heating the raw materials in the mine up to 350-450 ^{0}C in the absence of air, i.e. in the absence of both oxygen and nitrogen.

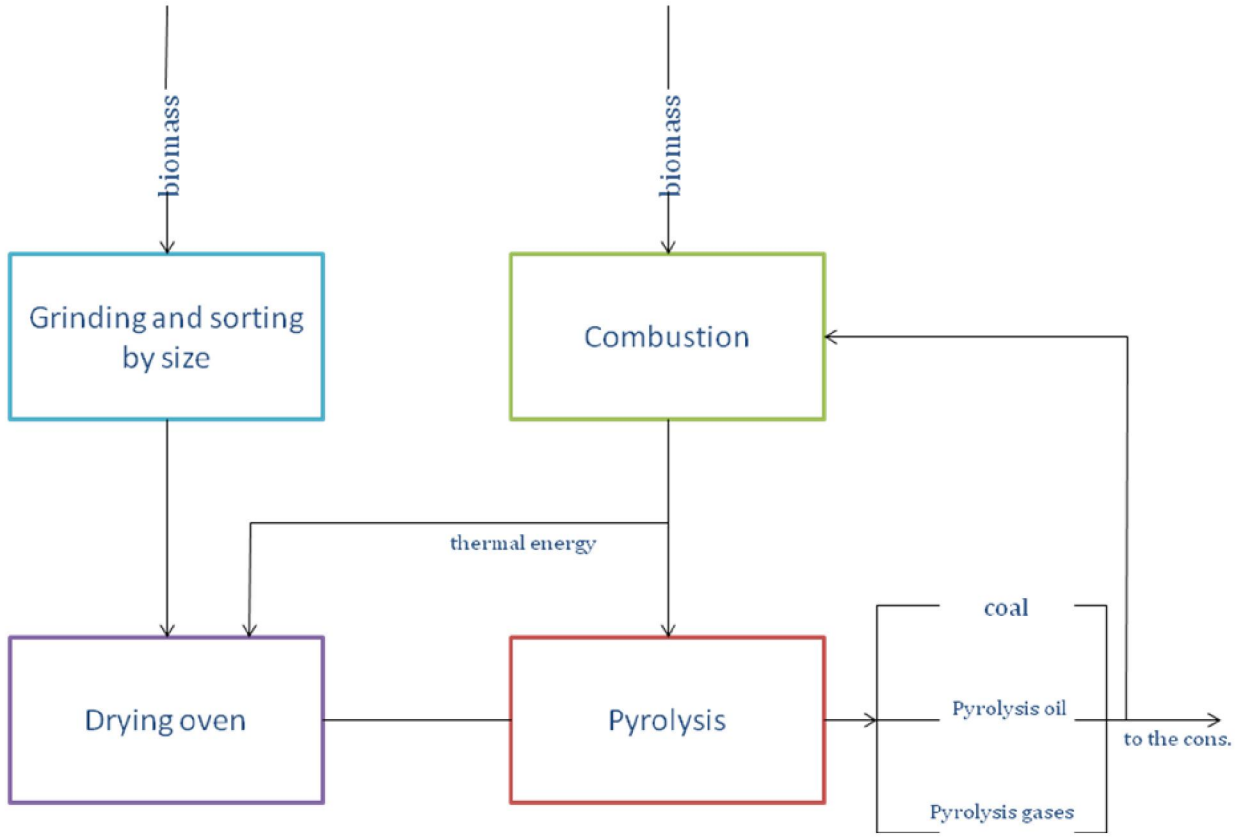

Figure 1 – Pyrolysis process [8]

The process chain of the *high-temperature pyrolysis*, presented in Fig. 3, includes:

1. waste sorting with the removal of large objects, non-ferrous and ferrous scrap metal;
2. grinding and drying of the selected waste;
3. decomposition of dried raw materials with the purpose to generate pyrolytic gas, pyrolytic oil, slags and by-products such as Cl_2, F_2, N_2;
4. elimination of pollutants and lowering of the temperature of the produced gas;
5. use of pyrolytic gas for generating steam, electric or thermal energy. Most often, this gas is used reversibly to initiate pyrolysis;
6. pyrolytic oil after storage is sent as a raw material to the petrochemical industry plants for the production of fuel and lubricants, heating oil substitutes and fuelwood

Of particular note are the positive aspects of the proposed pyrolysis methods:

1. The low-temperature pyrolysis:

- no urgent need to sort hydrocarbon residues (even the completely unsorted wastes provide a yield of pyrolysis gas twice as much as compared only with that of food wastes);
- a possibility of using MSW after their preliminary sorting as a source of raw materials for production;
- *an important feature is the absence of toxic sulfur and nitrogen oxides in the combustion products.*

2. The high-temperature pirolysis:

- a possibility to process the raw materials with a small quantity of combustible materials;
- the resulting gas rises upwards and passes through a layer of wastes, which is fed from above. In this case, the gas does not capture dust particles, which serves as a guarantee of its purity;
- pyrolysis gas is similar to natural gas, and it is expedient to use it to generate thermal energy and to generate electricity in small power plants;
- it is easier to clean pyrolysis gas from unnecessary impurities (if any) due to the low temperature;

- since the process proceeds in the absence of oxygen, pyrolysis gas does not contain hazardous dioxins, generated upon the combustion of hydrocarbons.

Out of various high-temperature methods of MSW treatment the following processes have been tested on a pilot and semi-industrial scale:

1) the process of "semi-carbonization - incineration" of SIEMENS Company, Germany;
2) the process of "pyrolysis-gasification" of NOELL Company, Germany;
3) the process of "pyrolysis-gasification" of "Thermoselect S.A", Italy;
4) the process of incineration at the temperature of 1350-1400°C in a slag melt layer [9-15].

Of the various technologies for waste biotreatment, the most progressive one at present is the technology of biothermal aerobic fermentation of BUHLER Company, Switzerland. The leading companies of the USA, Germany, Italy, and Japan have now switched to the Buhler technology, abandoning the technology of composting in bio-drums (used in all CIS plants) [16, 17].

The products obtained by these methods are in a good marketable state, and can be used not only as fertilizers (which is the practice in Italy, Spain and France), but also as the source raw materials for the production of ethyl alcohol, and as the processed fuel for combustion, etc. [16, 17].

Materials and study methods. For the conduction of the studies an experimental site for MSW deep sorting has been selected and special facilities for the workers' rest (two rooms with a shower and a toilet), a storage facility for the MSW, sorted by type, a storage facility for salvage work tools, equipment and first-aid kits in case of emergency have been built. An overhead crane for lifting and transferring containers with MSW, a press machine for packaging waste paper, 7 Euro bins with a capacity of 1.1m^3, a table for sorting wastes have been installed. A center for recycling glass and paper wastes is provided for.

Study results and discussion. In the modern period of development of young independent Kazakhstan, the topical issues include: ensuring environmental safety, environmental education of the population, accustoming the population to the habit for packaging standards, transportation, storage, and utilization of MSW, strict compliance with the Environmental Code of the Republic of Kazakhstan by the enterprises and population of Kazakhstan.

The main problems of MSW collection and utilization in the megacities include: ensuring the maintenance of sanitary conditions to prevent the emergence and spread of various epidemics, low culture of the population, both at production site and in everyday life, related to the elementary cleanliness, the lack of understanding the harmfulness of MSW accumulation for general health due to the pollution of soil, water and air.

Annually, on average 200-300 kg of MSW (about 1 m^3) are estimated for each city dweller. Besides, every year the wastes increase by 4-6%, which is three times as much as an increase in the birth rate in the country. Soon we will have just nowhere to dump wastes.

Nonetheless, recycling is a very profitable business, especially if approached wisely. For example, MSW are successfully used as recyclable materials. Unfortunately, the current MSW flow sheet does not provide for the use of municipal solid wastes as recyclable materials. Besides, a waste landfill, created in a deep ravine and located 30 km from the city, where the bulk of wastes is stored, 97% of which does not meet the requirements of the environmental and sanitary legislation of the Republic of Kazakhstan, causes great harm to the environment. Harmful substances are carried out by rain and flood waters to the rivers. In summer, the landfill spontaneously ignites and carries all harmful smoke to the city. Reclamation of a landfill is not carried out. Rotting residues of food waste spread stench and poison the air, attracting flies, rats and other animal vectors.

All this leads to the conclusion that the existing technologies for processing of municipal solid wastes cannot offer any decentralized methods of processing on site, and, therefore, the main directions for solving the problem can be reduced only to *the preliminary sorting of wastes with the purpose of their processing and re-using* [18].

Thus, we conclude that it is necessary to apply to strict actions, without hoping for vast spaces and waste incineration. Carrying out separate MSW collection and studying the morphological composition of the wastes have allowed the "Tabigat" Ecological Union to start introducing a new method for the separate MSW collection. A flow sheet of municipal solid wastes has been developed, wherein an intermediate stage is the creation of a waste sorting facility (figure 2).

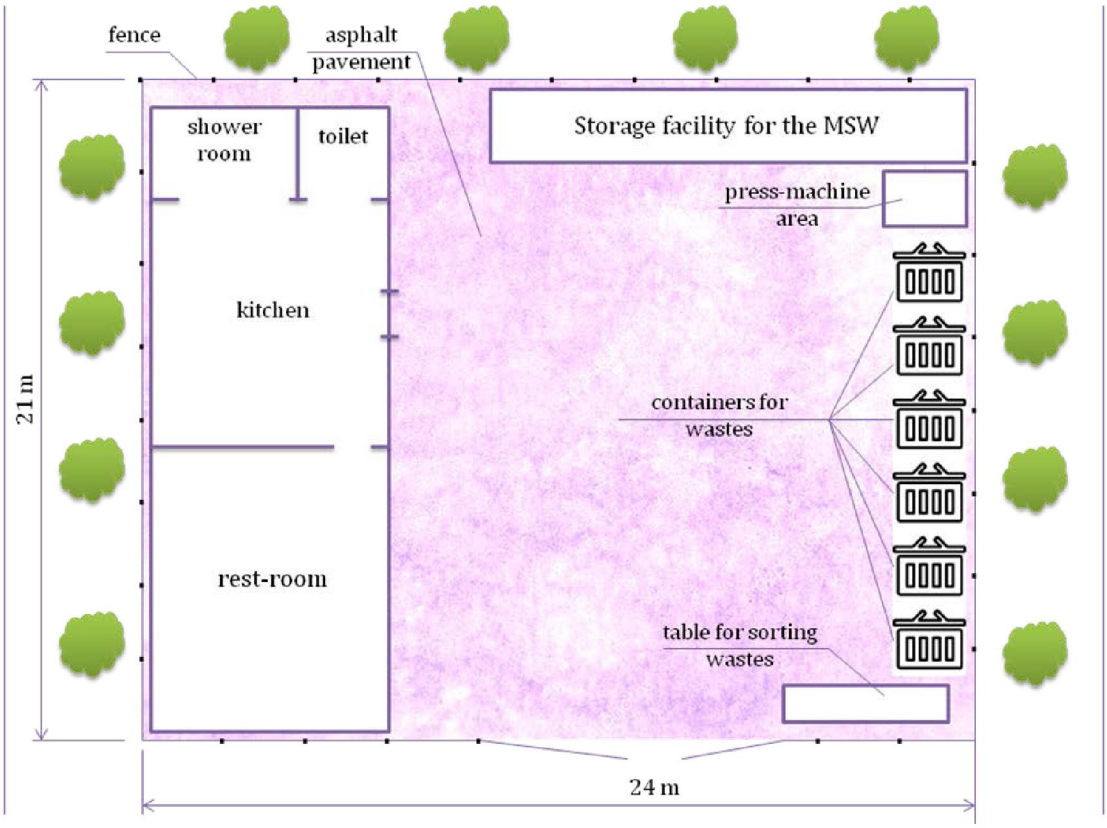

Figure 2 – A waste sorting facility

Due to the mixture of organic and inorganic wastes - paper, polymer wastes, etc., the recyclable materials lose their value, the cost of technologies for their cleaning and washing increases. That is why it is quite rational in the residential compounds to sort the wastes into organic and inorganic fractions. The waste sorting facility separates the inorganic wastes into paper, film, PETF bottles, etc.

Thus, the residents will not need to accumulate several packages for different types of wastes - there will be only two of them. The cost of cleaning the recyclable materials will decrease, and there will be more opportunities to sell it at a bargain price.

The experimental waste sorting facility has been located at the corner of the Satpayev and Rudnev streets. In the process of sorting municipal wastes, their approximate morphological composition has been established, which is shown in the table.

Morphological composition of the wastes

No.	Wastes	%	Specific input kg/cap/day	Specific admission kg/cap/year	Total population in mln. people	Input volume mln. kg/year
1	Paper	0.094	23	34.25	0.2	6.85
2	Food wastes	0.102	25	37.25	0.2	7.45
3	Polyethylene	0.009	2	3.3	0.2	0.66
4	Plastics	0.0099	3	3.6	0.2	0.72
5	Metals	0.0049	1	1.8	0.2	0.36
6	Textile	0.0099	3	3.6	0.2	0.72
7	Glass	0.051	14	18.63	0.2	3.67
8	Fine wastes	0.083	24	30.34	0.2	6.07
9	Plastic foam	0.0049	1	1.8	0.2	0.36
	Total:	**0.3785**	**100**	**138.17**	**0.2**	**27.58**

The data on the volume of wastes are provided on the basis of the performance indicators of the experimental site for 1 month.

The conducted experiment on the separate collection of municipal solid wastes and the study of their morphological composition for 8 years, have confirmed a possibility of collecting MSW in the city by the proposed method with the obtaining of a significant quantity of recyclable materials for their subsequent processing by our ***pyrolysis method***.

The creation of such integrated methods for sorting municipal solid wastes with their subsequent processing by the methods of low-temperature and high-temperature pyrolysis will solve the following existing problems:

- cleaning the city of MSW;
- improvement of the environment situation my means of using the methods of MSW incineration in the absence of air;
- development of industrial processing of the recyclable materials, saving the natural resources (gas, forest, chemicals);
- arrangement of the production of new types of industrial products, based on the use of innovative technologies;
- creation of import-substituting industries (various types of paper products).

Conclusion. Thus, an integrated approach to the utilization of municipal and industrial wastes has been proposed, which consists in using the developed method for preliminary sorting of municipal solid wastes with the subsequent application of the pyrolysis processes.

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ҚАЗАҚСТАН МЕМЛЕКЕТІНДЕГІ ҚАТТЫ ҚАЛДЫҚТАР МӘСЕЛЕСІ

Аннотация. Ұсынылатын әдіс тұрмыстық қатты қалдықтарды өңдеуде жаңа технология негізінде пиролиз үрдісін қолдану қалдықтарды жіктеуден кейінгі қатты заттардың қоршаған ортаға түсуін азайтуға, сонымен қатар тұрмыстық қатты қалдықтарды қайта өңдеуге мүмкіндік беретінін көрсетті.

Түйін сөздер: экология, қатты қалдықтар, морфологиялық құрамы, утилиздеу, пиролиз, қайта өңдеу.

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ПРОБЛЕМЫ ТВЕРДЫХ БЫТОВЫХ ОТХОДОВ В РЕСПУБЛИКЕ КАЗАХСТАН

Аннотация. Показано, что предлагаемый способ переработки твердых бытовых отходов за счет применения новых технологий с использованием процесса пиролиза позволит минимизировать выброс токсичных веществ в окружающую среду после предварительной их сортировки, а также при правильной организации рынка по утилизации твердых бытовых отходов.

Ключевые слова: экология, твердые бытовые отходы, морфологический состав, утилизация, пиролиз, переработка.

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