Innovative Methods of Waste Management

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Abstract: Currently, there is a need to develop relevant and effective ways to dispose of industrial waste to minimize environmental damage, develop the economy and improve living standards. The proposed article examines various approaches to waste processing, taking into account the optimal use of resources and reducing the negative impact on nature. The article begins with an overview of existing disposal methods for discarded materials, such as recycling, reuse, and separation of waste into components. Next, examples of disposal projects implemented in various industries are given, with an analysis of their effectiveness and the possibility of scaling these methods. The next part of the report covers various methods of industrial waste disposal, such as recycling, calculation and analysis of rational processing technologies, with the development of a new innovative, hierarchical approach to objectively measuring the environmental impact of various materials and industries on the environment. The potential and limitations of these methods are considered, and possible promising directions are proposed for further research and development of the disposal of environmental pollutants. A hierarchical approach is used to objectively assess disposal methods. The final part of the article summarizes and analyzes the results of the study, as well as formulates recommendations for improving the recycling issues of industrial workings. It is noted that in order to achieve minimal damage to the environment and economy, it is necessary to introduce complex approaches where technological, economic and environmental factors interact.

1 INTRODUCTION

Industrial waste is an urgent problem that is becoming more and more important at present, since the industrialization of society and production processes are at a significantly high level of development and are steadily increasing with a decrease in natural resources and free territories, and at the same time, accordingly, with modern production technologies, waste increases and scales by area. Despite the fact that many industries are making efforts to reduce the volume of garbage, its effective disposal remains one of the unresolved tasks of modern society. Industrial waste has a negative impact on the environment - these toxic substances emitted during the production process penetrate the soil, water and air, thereby causing pollution and destruction of the natural biosphere.

One aspect of reducing environmental pollution is the recycling of material and energy resources. Recycling and use of industrial waste will reduce the volume of these harmful substances and prevent negative impacts on the natural environment. Recycling of plastic, metal and other materials saves natural resources and financial costs.

The purpose of the presented article is a comprehensive analysis of waste processing processes in order to develop optimal solutions. Disposal of industrial waste is essential to the economy. Firstly, it reduces the cost of storage, transportation and disposal of waste. Enterprises that effectively use waste can, firstly, reduce the cost of their processing and make their production more competitive, and secondly, the disposal of industrial waste creates new jobs in this area. This contributes to the economic development of society, improves the social situation, and improves the quality of life in the regions of the country.

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2 METHODS AND MATERIALS

The choice of a rational waste disposal method from existing technologies is proposed to be evaluated using the Thomas Saati hierarchy analysis method [1] in connection with the versatility and simplicity of this method, which can be used to solve various complex problems. Hierarchy Analysis Method (MAI) is a mathematical tool for a systematic approach to making an optimal decision using synthesized calculations in Excel programs. This method is based on the decomposition of the problem with highlighting the main goals and various alternatives, which are subsequently compared with each other to establish significant priorities. The method is based on the following principles: the principle of decomposition, the principle of comparative judgments and the principle of synthesis of priorities. As a result, the relative importance of the studied alternatives for all criteria in the hierarchy is determined and the most effective solutions are developed. Use the table function to create and format tables. Do not use the space bar or multiple tabs to separate columns and please do not use Excel to create tables as this can cause problems when converting your tables into the typesetting program and other formats. Simple, one-column lists should not be treated as tables. Use the displayed list function instead. Save the tables in the same file as text, references, and figure legends. Figure 1 shows an example of the innovative disposal hierarchy discussed in this article. We have selected three criteria for analysis, these are environmental, economic and transport components and their dependence on the considered alternatives to waste processing. MAI algorithm includes the following stages:

1. formation of a hierarchy of goals;
2. prioritization;
3. calculating local priority vectors;
4. checking expert assessments for consistency (calculating the index consistency);
5. calculation of priorities of goals and activities for the hierarchy as a whole based on synthesis local priorities.

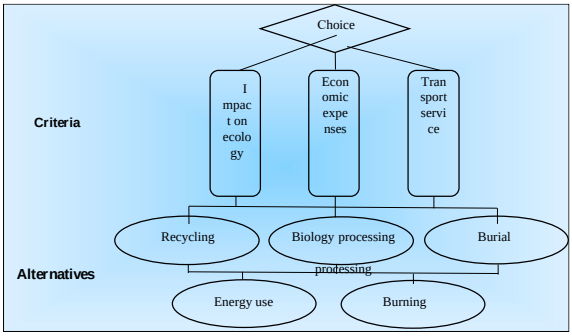

Figure 1. Trajectory of AI Integration in Yakutsk's Architectural Designs (2018-2022).

The valid solution is fixed asset ≤ 0.10. After solving the hierarchy synthesis problem, the homogeneity of the entire hierarchy is evaluated by summing the homogeneity indicators of all levels reduced by weighting to the first hierarchical level.

3 RESULTS AND DISCUSSION

In recent years, new industrial waste disposal technologies have been developed that offer more efficient and environmentally friendly ways to manage waste. This includes processes such as chemical, thermal biological processing [2]. The use of these technologies allows you to increase the percentage of waste disposal and reduce their negative impact on the environment. It also promotes innovation in the industry and the creation of new markets. The initial stage of disposal is the mechanical treatment and processing of industrial waste. It involves the use of various mechanical devices, such as crushers and separators, to separate and process waste. One of the main advantages of the method is its relative simplicity and accessibility. Machining and processing do not require complex equipment or special conditions. There are also some disadvantages. For example, this method is not effective enough for the processing of chemicals or contaminated materials. In addition, this approach can cause increased debris as a result of the processing process. The next method is thermal exposure and processing of industrial waste. The thermal method refers to the use of high temperatures and the conversion of waste into other materials or energy. This method has several advantages [3]. First, it is capable of handling a wide range of waste, including hazardous substances. Secondly, heat treatment allows energy to be generated, which is a significant economic advantage. There are also some disadvantages. For example, this method requires

high energy costs. In addition, the process can lead to the release of harmful substances into the atmosphere, which requires additional measures for neutralization and cleaning. The third method is the chemical processing of industrial waste. Chemical treatment involves the use of various chemical reactions to turn waste into useful products or to render them safe. The main advantage of this method is its ability to process various types of waste, as well as to form valuable products [4]. Chemical treatment can be more complex and require specialized equipment. In addition, it can lead to the formation of hazardous chemical compounds and requires control of the discharge of treated waste. (Table 1).

Table 1: Advantages and disadvantages of industrial workings disposal methods.

Disposal method	Advantages	Shortcomings
Recycling of secondary raw materials	Reducing the consumption of primary resources, reducing the amount of waste, reducing the negative impact on the environment	High equipment and technology costs, limited recyclability of certain materials
Energy use of waste	Improving energy efficiency, reducing energy costs	Potential environmental pollution from misuse or non-compliance with environmental requirements
Biological processing	Natural, low-cost process, waste reduction, production of useful products such as compost or biogas	The need to control and maintain optimal conditions for the biological process, possible restrictions in the processing of certain types of waste
Combustion with subsequent filtration of gases	Energy generation, waste reduction, clean ability	High equipment and operation costs, risks of air pollution in case of improper operation or lack of effective filters
Burial in specialized landfills	No air or water pollution, possibility to use space in landfill for other purposes after reclamation	Long-term environmental impact, potential for groundwater contamination and negative impact on biodiversity

In recent years, there has been an increase in interest in the development and application of new methods for the disposal of industrial waste in order to reduce the negative impact on the environment [5]. Below are several promising areas for the development of industrial waste processing.

1. Development of processing technologies. Modern technologies for processing industrial waste are becoming more efficient, environmentally friendly and resource-saving. Examples are the processes of anaerobic and aerobic decomposition of organic waste, pyrolysis, gasification and chemical processing. The development and implementation of new and improved recycling methods helps to minimize waste and create valuable products from previously useless waste.

2. Secondary resources market expansion. With the development of new waste processing technologies, the possibility of using secondary resources in various industries is increasing. This could include using recycled plastic in packaging production, using secondary metals in the metals industry or using biogas as an energy source. The expansion of the secondary resources market contributes to the sustainability of resource supply and the reduction of primary resource consumption with the preservation of biosphere.

3. Development of the circular economy concept. Circular economics offers a transition from a linear model of production and consumption based on "take-produce-throw-away" to a closed system where waste becomes valuable resources. This includes a macro-level approach to waste management, ensuring it is collected, recycled and reused in production cycles. The development of the concept of a circular economy contributes to the reduction of waste and the sustainable use of resources.

4. Improvement of waste collection and classification system. Optimization of the waste

collection and classification system is an important step in the development of industrial waste disposal. Categorizing waste, proper classification and proper treatment make recycling and reuse easier. The expansion of the collection system and the introduction of advanced technologies in the field of waste management contributes to a significant increase in the volume of recycled waste and the gradual transition to waste-free technologies.

5. Raising awareness, culture and education. An important aspect of the development of industrial waste disposal is to increase the level of education in the field of sustainable waste management and ecology. A broader understanding of waste management challenges and opportunities contributes to the development and implementation of innovative solutions [6-10].

The transition to waste-free production is possible with an integrated approach to the problem, with the widespread development of interconnected technologies, with a combination of a universal ecological culture and the discipline of society.

4 DISCUSSION

An important factor influencing the efficiency of the selected method of industrial waste disposal is the analysis of the characteristics of materials and taking into account their characteristics. The technological requirements of the selected waste treatment method can also significantly affect its effectiveness. Technical parameters such as processing speed, energy consumption, equipment and infrastructure requirements may vary depending on the selected method. Assessment and analysis of these technological requirements will help to choose the most efficient method of industrial waste disposal.

Economic factors play a significant role in assessing the effectiveness of the disposal method. The costs of implementing and operating the method, the possibility of generating income (for example, through the sale of recycled waste or its use in the production process), as well as comparing these costs and possible benefits with other methods, are important factors for making an adaptive decision on the choice of method. Also, when assessing efficiency, it is necessary to take into account the possible economic consequences, such as fines for non-compliance with environmental requirements or loss of image at the enterprise.

To objectively assess the advantages of various waste processing methods, we used the Saati method (MAI) by determining priorities and analyzing the correctness of calculations. We study 4 types of waste processing and their impact on the economic indicators of society - the economy, the environment and the transport component, the latter criterion also has a indirect impact on the environmental and economic indicators of the production process.

First, the criteria are prioritized by evaluating the pairwise comparison matrix. Next, the level of alternatives is determined. Having determined the vector of priorities, we evaluate the correctness of calculations and the reliability of the results through the corresponding indices - the consistency index (IS) and the consistency ratio (OS). The obtained indicators indicate the reliability of the calculated results, they fit into acceptable IE values ≤ 0.10; OS - about 10% or less.

Then we construct matrices of paired comparisons for each level of the hierarchy and obtain priority vectors with the calculation of correspondence indices. Further, all results are synthesized into the final table. Criteria priorities are highlighted in red.

The obtained calculation indicators indicate the priority of methods for processing secondary raw materials (0.34) and further biological processing without a transport component.

5 CONCLUSIONS

This article examined relevant and effective methods of disposal of industrial waste with an objective ranking of relative damage to the environment and economy. Waste disposal has been shown to be not only a necessary step to conserve the environment, but also a potentially profitable process. Research findings have shown that the use of different technologies such as heat treatment, recycling, reuse and recycling can significantly reduce the amount of industrial waste that ends up in landfills and degrades the environment. The above disposal methods lead to a decrease in environmental pollution, conservation of resources and a decrease in the burden on the economy. Moreover, industrial waste can be used as raw materials for the production of new materials or energy. For example, recycling plastic waste can lead to recycled materials that can be used in the production of new plastic products. These measures are regulated by the mechanism of extended producer responsibility (EPR), according to which manufacturers and importers of goods and packaging are obliged to ensure their disposal after use and loss of consumer properties, as well as packaging processing can reduce the base rate of environmental collection by applying a reduction factor, which can

become a significant economic incentive for business. Also, the process of thermal treatment of waste can be used for the production of thermal and electric energy, which is especially important for the cold Arctic territories, which have recently experienced an enhanced anthropogenic press associated with mining operations [11-16]. Within the framework of government decree No. 1224, types of goods that are the object of procurement to meet state and municipal needs that are subject to environmental requirements have been approved. Such requirements allow to increase the demand for products using recyclable materials. Producers of recyclable goods can receive government support through the Industrial Development Fund. It can be counted on by those who use cement and concrete, biofuels, plastic, cardboard and paper products, rubber tiles, and roofing materials as resources. As a result of our calculations, optimal orderly data were obtained on the multi-criteria assessment of various methods of processing industrial waste and their impact on environmental and economic indicators. Thus, the waste disposal hierarchy is ranked on the basis of global priority, and the most preferable method is biological processing - 0.25, then recycling of raw materials, then disposal of waste, etc. These methods are designed for modern technologies and their priority may change with the modernization of waste processing methods.

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