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The intelligent information technology for construction waste analysis and management

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ABSTRACT

In modern conditions of increasing the amount of waste generated during construction, demolition, repair or reconstruction of facilities, the problem of analysis and management of this waste is becoming increasingly relevant in solving environmental and economic issues. This problem in Ukraine is complicated by hostilities on its territory, which resulted in a significant number of destroyed or damaged buildings. The scientific article proposes a solution to the problem of analysis and management of construction waste by creating intelligent information technology. The authors propose a conceptual scheme of intelligent information technology, which will provide geospatial information about waste reception centres based on data entered by the end user about the source and type of construction waste. The subject literature on the current state of technologies and methods for construction waste management was analysed, on the basis of which the requirements for intelligent information technology were formed. When describing the components of the conceptual scheme, the nature of the input and output data was analysed, and machine algorithms and technologies that can be used to solve the intelligent task of analysing and managing construction waste were considered. As an option for solving the problem of analysing and managing construction waste, the authors developed the intelligent information system of 4 modules, which implemented the following subtasks: classification of waste collection centres, collection of data on the source of waste and its types, waste classification, determination of the nearest waste collection centres and output of results in the form of an interactive map. The server was written in the Java programming language, using the Spring Framework, as well as Spring Boot and Spring Data JPA. PostgreSQL was chosen as the database management system. The frontend was written using Thymeleaf, as well as HTML, CSS and JavaScript. The fourth module includes a query to OpenStreetMap Tiles to display the map on the user's web page. Further development of the research may involve the use of artificial intelligence technologies or neural networks to analyse images of waste generation facilities, based on which a text file with classes of construction waste can be obtained to generate suggestions to the user on waste management.

Keywords: Intelligent information technology; conceptual scheme; waste management; construction waste; geoinformation technologies

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INTRODUCTION

The problem of construction and demolition (C&D) waste generation is becoming more and more serious due to the growth of the construction industry. Improper handling of construction waste leads to pollution of soil, water resources and atmospheric air, as well as to the loss of valuable materials that can be reused or recycled. In Ukraine, the problem is complicated by outdated disposal technologies, insufficient level of environmental awareness and the lack of a comprehensive construction waste management system. In addition, due to the war in Ukraine, there has been a significant increase in the number of buildings that has been demolishing due to significant damage or has been a subject to reconstruction, and because the problem of balanced and reasonable construction waste management becomes more relevant, in particular in the context of bringing it into line with European norms and rules. In this regard, the development and implementation of intelligent information technologies capable of optimizing C&D waste management processes is an extremely urgent and important task.

Such technologies can be applied in various areas, including:

– waste management on construction sites: to optimize the collection, sorting and transportation of waste;

– recycling and reuse of C&D materials: to identify opportunities for recycling and reuse of various types of waste;

– monitoring and control of waste circulation: to ensure transparency and tracking the movement of waste from the place of generation to the place of disposal or recycling;

– decision-making in the field of waste management: to provide recommendations on the selection of optimal waste management strategies based on data analysis and modelling of various scenarios, as well as optimal routes for their delivery to reduce transportation costs.

The justification for the relevance of creating the intelligent information technology (IT), which will provide proposals for the management of construction waste, is the need to increase the efficiency and environmental friendliness of waste management processes, reduce the negative impact on the environment and promote the transition to a circular economy. Such technology will allow making informed decisions based on the analysis of large amounts of data, considering the specifics of different types of waste and regional characteristics, and ensuring a prompt response to changes in the environmental situation.

ANALYSIS OF LITERARY DATA

The article [1] states that construction and demolition waste is one of the largest sources of waste in the world. In the European Union alone, the annual volume of construction and demolition waste ranges from 310 to almost 700 million tons (approximately 0.63 to 1.42 tons per capita). Despite the availability of established recycling technologies, recycling rates vary significantly, from less than 10 % to over 95 % in different regions. For example, 89 % recycling rates have been achieved in 28 EU countries, but many countries report that most recycled materials are used only for low-grade applications (downcycling). Since 1966, 5,245 scientific articles have been published on construction and demolition waste, with a sharp increase in research activity since the 1990s. In 2022 alone, about 740 articles were published. China leads in the number of publications (over 650 articles), followed by India (about 450 articles), and Spain and the USA have approximately 420 articles each [1].

The construction and operation of buildings accounts for almost 40 % of the depletion of natural resources and 25 % of global waste. This was noted in the article [2], which reviewed the state of the art in material flow analysis research in the context of recycling and disposal of construction and demolition waste. The construction industry accounts for about 20% of workplace fatalities, despite employing only 8.6% of the global workforce. In particular, the data show that in the demolition sector, fatalities in places such as Japan can be six times higher than in studies from the European Union, suggesting underreporting or different safety practices in different regions [3].

From the life cycle analysis of C&D waste management, it can be seen that transportation, sorting and disposal contribute to the environmental impact. Recycling of plastics, metals, aggregates and wood has a positive dynamic for all assessed categories of environmental impact, except for global warming in the case of wood and cardboard [4]. In the article [5], the problems of management of construction and demolition waste due to the generation of large amounts of waste from destruction during military operations and terrorist attacks were considered.

A study on the sources of waste and recommended measures to minimize its generation, as well as the frequency of implementation of relevant measures on construction sites in the UAE was reviewed [6]. The study revealed that the main causes of material waste are lack of awareness; excessive trimming due to poor design; and rework and variation. The most common measures practiced to minimize material losses are: staff training, adequate storage and timely delivery of materials. Waste measurement and segregation are areas that need to be more effectively implemented to achieve material waste minimization goals. Furthermore, contractors' perceptions of the benefits of minimizing material waste showed that this waste is primarily considered a financial problem and its minimization is a cost-cutting activity.

The paper [7] is devoted to the study of demolition waste management strategies in different countries and the role of regulatory authorities in waste management. It also studies the properties of building demolition waste, its hazardous effects and suggests safe methods of recycling/reuse/disposal. Based on the study, a construction and demolition waste management plan has been formulated. For effective construction waste management, it is important that local authorities make the submission and implementation of this plan mandatory. This will go a long way in reducing environmental pollution due to construction and demolition waste. The construction industry in India generates about 10-12 million tons of waste annually. While renewable items such as bricks, wood, metal, paper are recycled in India, concrete and masonry waste (more than 50% of the total waste) is not recycled.

The study [8] examines the increasing amount of construction and demolition waste in Malaysia and its environmental impact. Despite legislation, construction and demolition waste has received significantly less attention than municipal waste. The study uses a life cycle assessment approach to analyse the sustainability and environmental impact of different waste management strategies, including recycling, incineration with energy recovery, and landfilling. After analysing the impact of construction and demolition waste in different regions and the extent of research on the topic, existing methods and models for managing construction and demolition waste were reviewed.

Analysing the impact of construction waste on the environment, the work [9] emphasizes the need for their classification and unification of disposal methods. The proposed solutions are aimed at optimizing the processing and reuse of materials, which will contribute to economic efficiency and reduce environmental burden.

A significant contribution to the study of construction waste transport logistics was made in the article [10], where the authors proposed a model for movement of the C&D waste. It is expected that the implementation of this model will allow achieving not only environmental, but also economic advantages in the field of waste management.

In the study [11], a multi-objective optimization algorithm was developed, with 17 decision variables and three objectives – cost, delay and recovery speed, to optimize the management of construction and demolition waste.

In the work [12], two approaches to construction waste management were considered, and their strengths and weaknesses were analysed. The use of a decision matrix allows assessing the effectiveness of each method and choosing the optimal option for specific conditions.

The study [13] proposes a strategic framework for the effective implementation of smart technologies in construction and demolition waste management. This framework aims to help professionals integrate different technologies, conduct research throughout the life cycle, and bridge the gap between existing and new technologies.

The results of [14] identified 20 barriers for large waste generators and 7 for small waste generators, with 4 common barriers for both groups. These barriers highlight the complexity of waste management and suggest specific policy and strategy needs.

The paper [15] examines the relationship between construction defects and construction and demolition waste generation. Despite numerous studies on both topics separately, their relationship remains poorly understood. The study systematically reviews 59 studies, highlighting key defects, their causes and impact on waste generation.

An analysis of the capabilities of smart bins is presented in [16]. The use of dynamic route optimization algorithms can improve waste collection logistics and ensure timely disposal.

The methods of intellectual analysis of construction waste data remain relevant, the foundations of which can be used to create intelligent information technology. Thus, in [17] the methodology of intellectual analysis of weakly structured multidimensional data of sociological surveys is presented. As studies of the developed information technology for preparing sociological survey data have shown, the most influential on the analysis result are the procedures related to the construction of spaces of primary and secondary features for further clustering and classification.

The classification of construction waste as a means of its effective reuse was considered in details in the work [18]. The authors investigated the technological possibilities of recycling and proposed recommendations for the implementation of innovative methods of utilization.

The work [19] was devoted to a case study, through which empirical data are collected using the ethnographic-action meta-analysis research approach and triangulated with data from the literature, current discussions and other sources. The possibilities of applying Big Data in the context of construction waste management were considered.

In the study [20], the authors developed a robot for automated sorting of construction waste using deep learning. 18 models were tested, which allowed them to identify the most effective algorithms for material recognition and classification.

The use of GIS appears promising in addressing urban environmental issues in the articles [21–24]. The study [22] demonstrated how building information modelling can be used to digitally model the physical characteristics of building projects, planning and management, together with

GIS, which provides tools for better spatial and environmental analysis.

The issue of planning a municipal construction waste management system in Brazil was considered in [23]. The use of GIS allowed optimizing resource allocation and waste processing logistics.

The authors of [24] developed a system that automatically determines the location of demolition waste and optimizes the resources that need to be used for demolition and waste transportation. The system consists of three modules: a GIS module, an optimization module and a decision-making module. The GIS module is designed to quantify the volume of demolition waste in the study area using ArcGIS Pro software. The optimization module determines the near-optimal combination of resources involved in the demolition and transportation process. These resources include work crews, excavators, and trucks. The module performs multi-objective optimization using the non-dominated sorting genetic algorithm NSGA-II. The optimization module considers three objectives in the demolition and transportation processes: time, cost, and energy consumption. Finally, a decision-making module is developed to rank the Pareto-leading solutions.

The paper [25] examines the role of smart technologies in construction and demolition waste management. While municipal solid waste management has successfully integrated digital technologies, construction and demolition waste management lags behind in integration, mainly due to industry conservatism, lack of standardization, and insufficient data. The study systematically reviews 75 academic and technical publications to assess current and potential applications of smart technologies in C&D waste management.

Thus, the analysis of the subject area allowed us to identify the following problems:

– the history of the development of the problem of construction and demolition waste management;

– the state of research on the topic of construction waste management;

– existing methods, models and techniques for monitoring, classification, clustering, analysis and management of construction waste and related objects;

– information systems that can be used for further model construction;

– existing information systems for construction and demolition waste management.

In addition, this analysis allowed us to formulate requirements for intelligent IT:

– definition of functional requirements (waste monitoring, forecasting, route optimization, automated reporting, etc.);

– definition of non-functional requirements (scalability, speed, security, integration with other systems);

– analysis of legal and environmental regulations for construction waste management.

PURPOSE AND GOALS OF THE RESEARCH

The purpose of the article is to develop a conceptual scheme of the intelligent IT for analysis and management of construction waste generated during construction / reconstruction / demolition of objects of various natures, which will provide support to end users regarding the most appropriate handling of construction waste.

To achieve the goal, the following tasks should be solved:

– analysis of data on construction waste that require information processing and approaches to their processing;

– development of a conceptual scheme of the intelligent IT for analysis and management of construction waste;

– implementation of a version of the intelligent applied IT for analysis and management of construction waste.

CONSTRUCTION WASTE DATA ANALYSIS

One of the very first stages of developing intelligent waste management information technology is analysing the input data that the system receives.

One type of input data is the types and volumes of C&D waste. There are different approaches to classification of C&D waste in the literature, some of which discussed more in this section

As shown in the work [18], several types of waste classification can be deduced:

1) by type of construction materials: separation by materials, such as glass, concrete, brick, wood, drywall, etc. These parameters will be most convenient for users to enter, since the type of waste can be specified based on its type most accurately and efficiently, which will simplify further data processing;

2) by standard: division into standard, non-standard and non-recyclable waste. That is, types of materials can be further divided into these groups, which determine the main scenarios for handling the specified materials: reuse, recycling, or landfill;

3) by safety criteria: considering the four existing waste safety classes. Together with the

classification by condition, it allows adding to the result the calculation of hazardous materials that require the care of certified experts for collection, transportation and disposal;

4) by suitability for recycling according to types of technologies: separation of waste by available technologies (technology 1, technology 2, etc.). Considering this classification will help provide the user with more specific information on whether a given type of waste can be recycled in a specific recycling centre based on the availability of the necessary technologies.

Another type of input data is data about the construction site. Unlike waste data, which can be generated dynamically, data about the site usually does not change throughout the entire work. The main type of data about the site is its spatial coordinates. There are many options for filling in this data, such as filling in coordinates through a form, filling in an address, or filling in via an interactive map. Among these methods, an interactive map was chosen, where the user can select the location of the site on the map by clicking. This approach makes it possible to most conveniently fill in the coordinates of the site with the expectation that the user will work with a form to fill in the data, as opposed to manually searching for coordinates or filling in an address, which requires additional search. In the future, the latitude and longitude are determined from the marked marker, which will be used in the analysis in the future.

Additionally, other important data about the building, which is entered by the IT user, includes details such as the type of site, the nature of work being carried out at the site, and other relevant attributes. These data points can be used in further intelligent analysis, helping to optimize waste management processes and improve decision-making.

The last type of input data required for waste management is information on waste reception centres. Unlike facility and waste data, they are added separately and form a single database on centres, which is then used to provide advice.

They contain the following information:

1) coordinates of the centre location (for further processing and recommendation);

2) type of centre (waste recycling point, waste recycling centre, landfill);

3) types of materials accepted at the centre;

4) additional information about the centres, such as address, phone, name, etc.

DEVELOPMENT OF A CONCEPTUAL SCHEME OF IT FOR CONSTRUCTION WASTE ANALYSIS AND MANAGEMENT

So, can be highlighted the following tasks that can be solved by intelligent IT for C&D waste analysis and management:

1) preliminary classification of waste reception centres based on the description of these centres, as well as obtaining their geospatial data;

2) collecting input data on construction waste sources, waste types using a web form;

3) classification of construction waste data obtained from the web form according to the types of classification in the subject literature (expert classification), or by processing waste images using a neural network approach;

4) determination using the Chebyshev metric of the construction waste reception centres closest to the waste source according to the construction waste classes obtained in the previous steps;

5) issuance of the geospatial data obtained in the previous step on construction waste reception centres located closest to the waste source in the form of an interactive map.

The general conceptual scheme of intelligent IT for analysis and management of construction waste is shown in Fig. 1.

Thus, the question arises of collecting information about waste for further grouping and processing. There are several options for collecting this data: using forms to fill in all types of waste, according to the context of the reconstruction object itself; or using artificial intelligence to determine the types and volumes of waste depending on the reconstruction object, an example of which can be seen in [20].

Both approaches have advantages and disadvantages. The advantage of a user survey form is accuracy, but the speed of filling it out can be quite slow. Using artificial intelligence provides a faster data collection speed, while the accuracy of the data depends heavily on the training of the model, with accuracy still inferior to the form.

This work focused on the first type, where the user enters the amount of waste using a survey in a form, although the second type also has its advantages in the context of the problem being solved, which is why it requires further analysis and development.

For the analysis of construction waste generated from construction / reconstruction / demolition sites, it is possible to use neural networks based on data about the facility to generate the amount of possible waste for different waste classes.

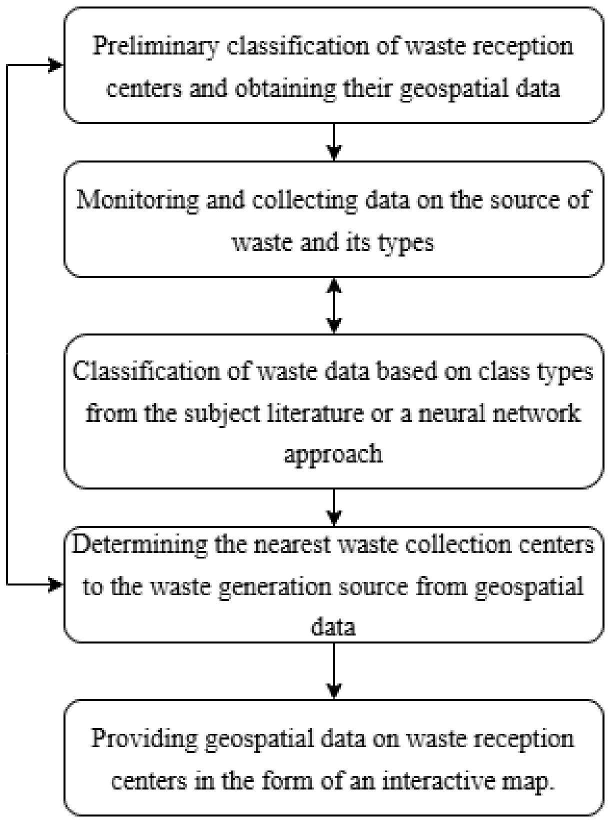

Fig. 1. **The conceptual scheme of the intelligent IT for construction waste analysis and management**
***Source*: compiled by the authors**

However, this direction has many limitations. First, it is necessary to specify much more criteria for waste generation facilities, which will be quite simple to fill in, but these criteria will have a great contribution to predicting the amount of waste. Second, there is a problem in the required amount of data. A neural network requires a large amount of data that needs to be found and processed for further use, which requires further research. Third, the accuracy of the output of the neural network model is quite low, which is why the use of this method may be insufficient to provide an accurate recommendation. In summary, this method has a number of disadvantages, but when working together with the waste classification methods described earlier, it can simplify and improve the analysis result.

The output of the applied intelligent IT are geospatial data about waste collection centres in the form of an interactive map. Proposals are formed on how to handle all classes of waste that the user entered when filling out the web form and to which nearest waste collection centre each class of waste should be transported. In subsequent versions of the IT, the issuance of proposals for transport and the optimal route for transporting waste to waste collection centres using GIS can be implemented.

The task of finding the optimal transportation route is non-trivial in the framework of solving this problem. First, the number of routes may be more than 1 due to the large amount of waste that needs to be transported, as well as due to the variety of waste types that need to be transported to different waste collection centres. Second, as mentioned, there is the task of calculating the workload for each transport. Other tasks can also be set, such as optimization in the conditions that the starting point of the route is not an object where construction / reconstruction / demolition work is carried out, but the starting locations of vehicles.

IMPLEMENTATION OF THE APPLIED IT FOR CONSTRUCTION WASTE ANALYSIS AND MANAGEMENT

An information system for analysing and managing construction and demolition waste was designed and developed (Fig. 2).

The information system that has 4 main modules was developed: three modules were developed by the authors, namely the frontend, server and database; and the fourth module is a query to OpenStreetMap Tiles to display the map on the user's web page.

The server was written in the Java programming language, using the Spring Framework, as well as Spring Boot and Spring Data JPA. PostgreSQL was chosen as the database management system, considering the use of PostGIS for further work. The frontend was written using Thymeleaf, as well as HTML, CSS and JavaScript.

The server interacts with the web application used by the user using the HTTP protocol, where requests are processed by controllers and then by services. The server interacts with the database using Hibernate, a library for Java-database interaction.

The BuildingController class is responsible for storing data about objects, as well as analysing the received data to output a recommendation. The CenterService class is responsible for finding all centres that match the data specified by the user.
In this version of thr applied intelligent IT, to support users in managing construction waste, a list of construction waste collection centres of various types is formed, which are located around the facility and accept at least one of the types of waste specified in the form by the user.

On the first page, the user finds the location of the site where construction work is being carried out on the map (Fig. 3).

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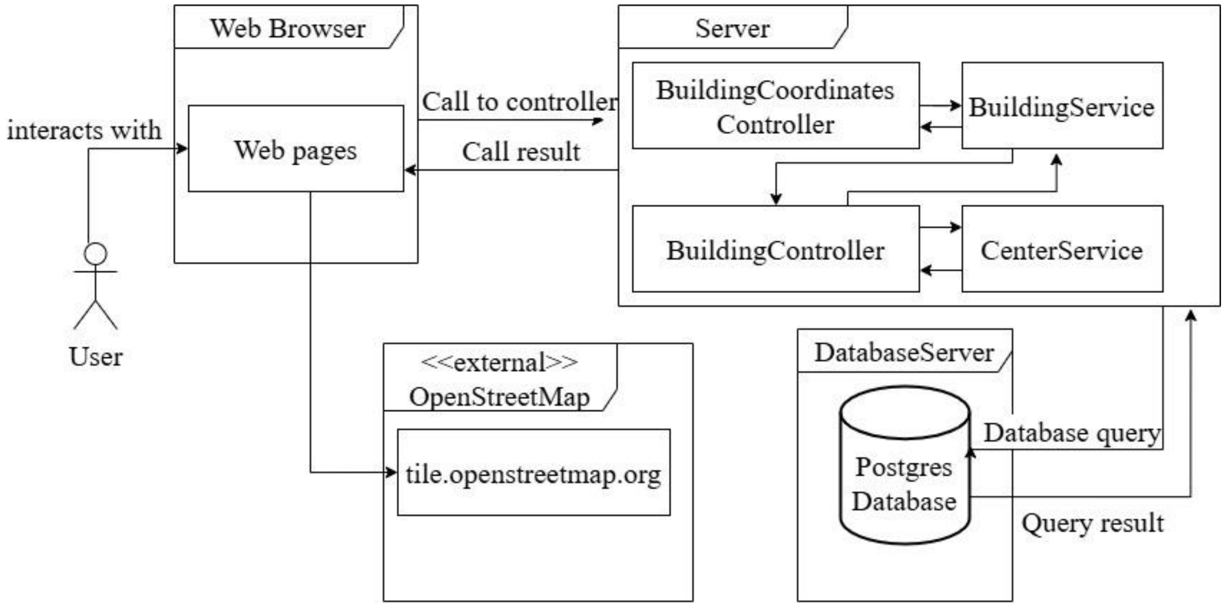


Fig. 2. **The logic scheme of the C&D waste management information system**
***Source*: compiled by the authors**

After that, the user presses the "Next" button at the bottom of the screen and goes to the next page. On the second page, the user needs to fill in data about the site where the work is being carried out. The first question is to select the type of site where construction work is being carried out (Fig. 4). The second question is to select the type of work that leads to waste generation. The selection of the site type and the type of work are implemented in the form of a drop-down list of alternatives for selecting one of them.

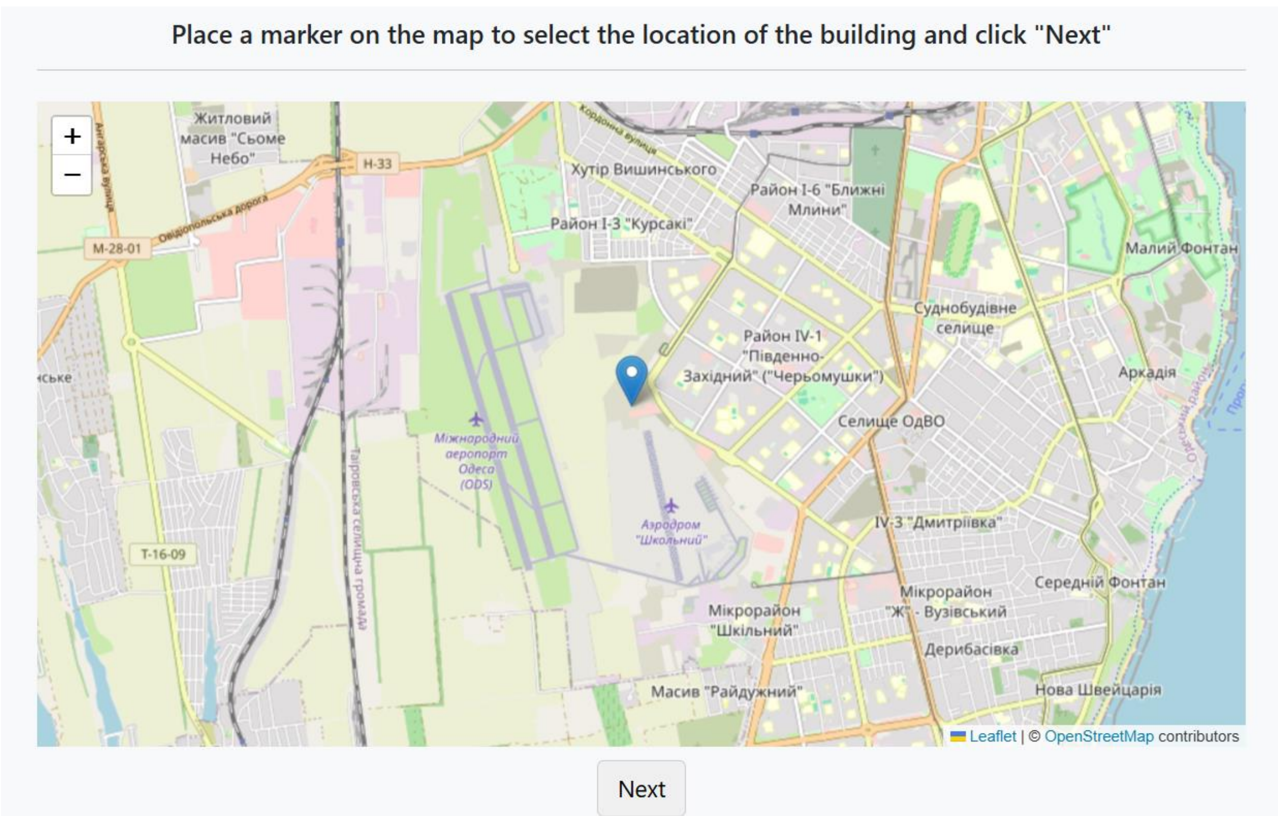


Fig. 3. **The screen form for selecting a construction, reconstruction or demolition site**
***Source*: compiled by the authors**

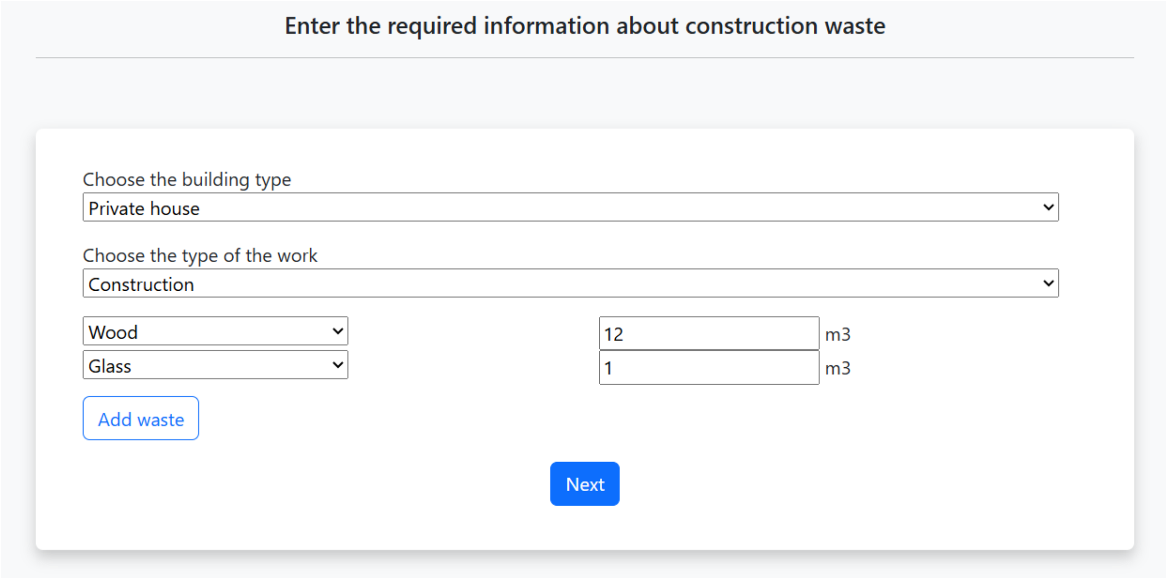


Fig. 4. **The screen form for entering the data about the waste generation site and the data about the generated construction waste**
***Source*: compiled by the authors**

Thus, among the types of construction / reconstruction / demolition objects was offer to choose: apartment, private house, industrial building and infrastructure object. Among the types of work was offered to choose: construction, demolition, repair or "other" in case of carrying out other types of work. Both questions are questions with one answer from the proposed list

Next, the user needs to select the type of waste and specify its volume in cubic meters. The type of waste represents a single-choice selection from a predefined list, ensuring standardization in data entry. The volume of waste, on the other hand, is a mandatory input field where users must manually enter the amount of waste they intend to dispose of. If multiple types of waste need to be recorded, the user can click the "Add waste" button, which will generate a new entry row. For each additional row, the user must specify the type and volume of waste separately, ensuring that all waste types are documented accurately.

Among the types of waste was offered to choose:

– concrete and masonry;
– wood;
– metal;
– drywall;
– asphalt and roofing materials;
– glass;
– plastics;
– doors, windows and plumbing;
– hazardous materials;
– others.

Once all waste data is entered, clicking the "Next" button advances the user to the third page. It shows a table indicating the nearest construction waste collection centres (Figure 5). Depending on the centre displayed and the waste specified when filling out the form, the table displays which waste the centre accepts by checking the appropriate cell in the table.

To optimize waste disposal logistics, the system calculates the maximum allowable distance for each type of waste collection centre relative to the construction site:

– waste collection are included if they are within a 5 km range;

– recycling centres are included if they are within a 10 km range;

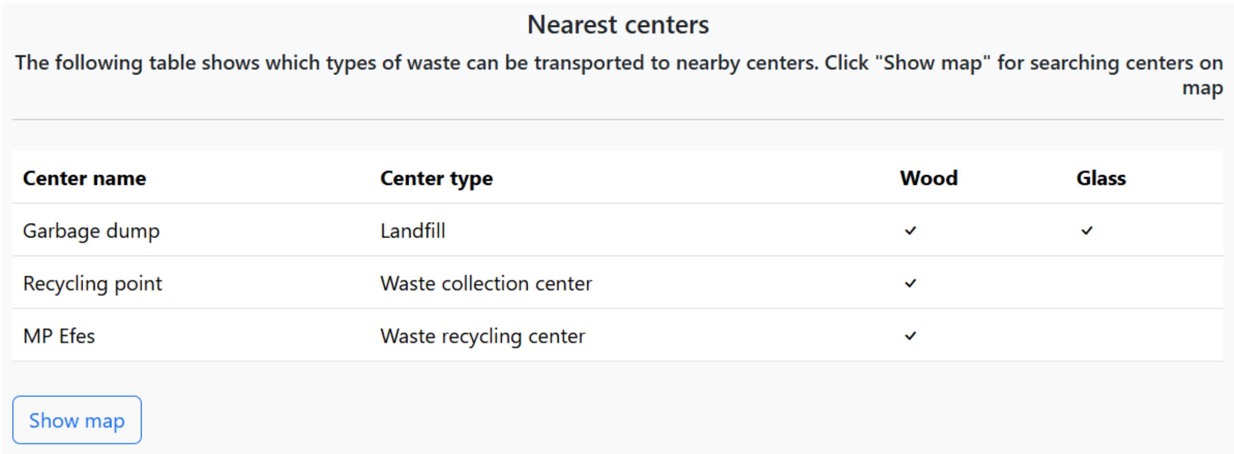
– landfills are included if they are within a 20 km range.

The Chebyshev metric was used to calculate the distance to speed up the calculations, and also because the accuracy of other metrics is not required to solve this task.

After reviewing the table, the user can click "Show map", after which the next page is displayed. Once all waste data is entered, clicking the "Next" button advances the user to the third page. This page displays an interactive map featuring markers that indicate different types of waste collection facilities (Figure 6). Each marker is color-coded for clarity:

– green marker: represents the location of a construction, reconstruction or demolition site;

– blue marker: represents a waste processing (recycling) centre;



Nearest centers

The following table shows which types of waste can be transported to nearby centers. Click "Show map" for searching centers on map

Center name	Center type	Wood	Glass
Garbage dump	Landfill	✓	✓
Recycling point	Waste collection center	✓	
MP Efes	Waste recycling center	✓	

Show map

Fig. 5. **The screen form for a table of waste collection points closest to the waste generation site**
***Source*: compiled by the authors**

– red marker: represents a landfill where waste can be disposed of;

– orange marker: represents a waste collection centre.

A legend explaining the marker colours is available at the bottom of the screen. For added usability, when the user hovers over a waste collection centre marker, a tooltip appears displaying key details about the facility, which includes name of the facility, address, contact phone number and list of accepted waste materials. Additionally, the system ensures that only relevant waste collection centres appear on the map. If a centre does not accept any of the waste types specified in the previous step, it will be excluded from the display, even if it is close to the construction site.

User can return to the table by clicking the “Return to the table” button. The data about the waste collection centres shown in Figures 5 and 6 is demonstrative and was used for testing.

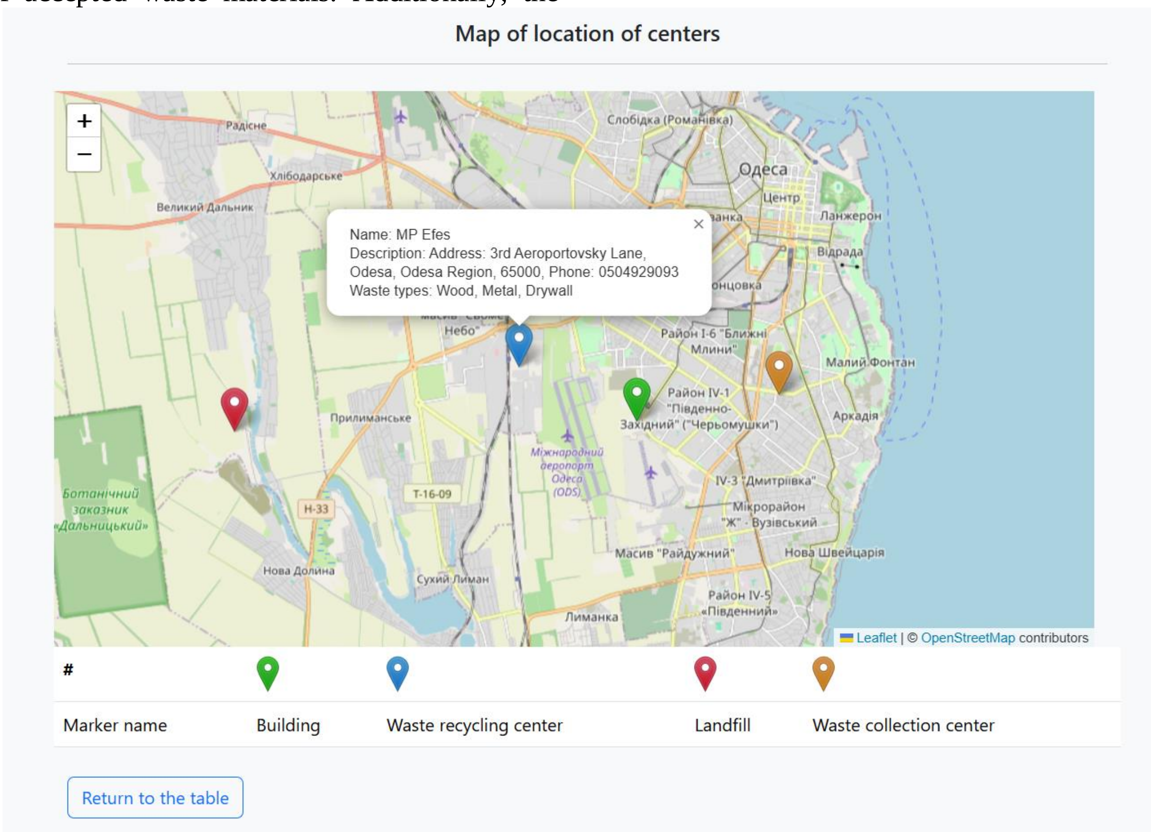


Fig. 6. **The screen form for the geospatial data about waste collection points closest to the waste generation site**
***Source*: compiled by the authors**

CONCLUSIONS

As part of writing the article, to create the conceptual scheme of the intelligent IT for construction waste analysis and management, the state of research in this subject area was analysed and it was found that the problem of construction waste management is becoming increasingly relevant. Various works were considered that investigated this problem from different sides, such as waste classification, the state of waste management in different countries, as well as what information technologies are being researched in this direction.

The conceptual scheme of intelligent IT for analysis and management of construction waste was proposed, consisting of 5 main stages. The input data of the proposed intelligent IT were analysed, including data on construction waste, geospatial data on waste generation sources (reconstruction facilities), as well as waste reception centres. Various algorithms and technologies that can be proposed to solve the problems of construction waste classification, determining the nearest waste reception centres, as well as choosing the optimal waste delivery route were considered.

The authors implemented a version of the intelligent information system for analysing and managing construction waste, consisting of 4 main modules, which solves the following subtasks: classification of waste collection centres, collection of data on the source of waste and its types, waste classification, determination of the nearest waste collection centres and output of results in the form of an interactive map. We see further development of research in the application of artificial intelligence technologies or neural networks to analyse images of waste generation sites to obtain a text file with a list and classes of construction waste, in order to provide proposals for waste management on its basis.

REFERENCES

1. Cudecka-Purina, N., Kuzmina, J., Butkevics, J., Arsirii, O., Ivanov, O. & Atstaja, D. "A Comprehensive review on construction and demolition waste management practices and assessment of this waste flow for future valorization via energy recovery and industrial symbiosis". *Energies*. 2024; 17 (21): 5506, https://www.scopus.com/sourceid/62932. DOI: https://doi.org/10.3390/en17215506.

2. Guo, D. & Huang, L. "The state of the art of material flow analysis research based on construction and demolition waste recycling and disposal". *Buildings*. 2019; 9 (10): 207. https://www.scopus.com/sourceid/26980. DOI: https://doi.org/10.3390/buildings9100207.

3. Cook, E., Velis, C. A. & Black, L. "Construction and demolition waste management: a systematic scoping review of risks to occupational and public health". *Front. Sustain.* 2022; 3: 924926. https://www.scopus.com/sourceid/21101150733. DOI: https://doi.org/10.3389/frsus.2022.924926.

4. Mercante, I. T., Bovea, M. D., Ibáñez-Forés, V. & Arena, A. P. "Life cycle assessment of construction and demolition waste management systems: a Spanish case study". *Int J Life Cycle Assess*. 2012; 17 (2): 232–241. https://www.scopus.com/sourceid/23271. DOI: https://doi.org/10.1007/s11367-011-0350-2.

5. Safranov, T. A., Prykhodko, V. Yu. & Mykhailenko, V. I. "Characteristics of demolition waste management in the regions of Ukraine". *UHJ*. 2024; 33: 88–98. DOI: https://doi.org/10.31481/uhmj.33.2024.07.

6. Al-Hajj, A. & Hamani, K. "Material Waste in the UAE Construction Industry: Main Causes and Minimization Practices". *Architectural Engineering and Design Management*. 2011; 7 (4): 221–235. https://www.scopus.com/sourceid/19600156901. DOI: https://doi.org/10.1080/17452007.2011.594576.

7. Raju, P. & Kameswari, P. "Construction and Demolition Waste Management – A Review". *IJAST*. 2015; 84: 19–46. DOI: https://doi.org/10.14257/ijast.2015.84.03.

8. Mah, C. M. & Fujiwara, T. "The Construction and Demolition Waste Management in Malaysia: The Life Cycle Assessment Analysis". 2018. DOI: https://doi.org/10.13140/RG.2.2.11716.73604.

9. Shuvaiev, A. "Tools for involving construction and demolition waste in the repeated economic cycle in the context of their classification features" (in Ukrainian). *Grail of Science*. 2021. p. 600–605. DOI: https://doi.org/10.36074/grail-of-science.19.11.2021.114.

10. Elshaboury, N. & Marzouk, M. "Optimizing construction and demolition waste transportation for sustainable construction projects". *ECAM*. 2021; 28 (9:) 2411–2425. https://www.scopus.com/sourceid/15249. DOI: https://doi.org/10.1108/ECAM-08-2020-0636.

11. Queheille, E., Taillandier, F. & Saiyouri, N. "Optimization of strategy planning for building deconstruction". *Automation in Construction*. 2019; 98: 236–247. https://www.scopus.com/sourceid/24931. DOI: https://doi.org/10.1016/j.autcon.2018.11.007.

12. Abdelhamid, M. S. "Assessment of different construction and demolition waste management approaches". *HBRC Journal*. 2014; 10 (3): 317–326. https://www.scopus.com/sourceid/21101120602. DOI: https://doi.org/10.1016/j.hbrcj.2014.01.003.

13. Wu, Z., Pei, T., Bao, Z., Ng, S. T., Lu, G. & Chen, K. "Utilizing intelligent technologies in construction and demolition waste management: From a systematic review to an implementation framework." *Front. Eng. Manag*. 2024, https://www.scopus.com/sourceid/21101151249. DOI: https://doi.org/10.1007/s42524-024-0144-4.

14. Faro, I. S. et al. "Barriers to Reverse Logistics of Construction and Demolition Waste". *RGSA*. 2024; 18 (11): e09592, https://www.scopus.com/sourceid/21100268407. DOI: https://doi.org/10.24857/rgsa.v18n11-014.

15. Karunasena, G., Gurmu, A., Shooshtarian, S., Udawatta, N., Ranthika Perera, C. S. & Maqsood, T. "Effect of construction defects on construction and demolition waste management in building construction: a systematic literature review". *Integrated Environmental Assessment and Management*. 2025; 21 (2): 233–244, https://www.scopus.com/sourceid/4400151417. DOI: https://doi.org/10.1093/inteam/vjae026.

16. Alwabli, A., Kostanic, I. & Malky, S. "Dynamic route optimization for waste collection and monitering smart bins using ant colony algorithm". In: *IEEE 2nd International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS)*. Kenitra, Morocco: IEEE. 2020. p. 1–7. DOI: https://doi.org/10.1109/ICECOCS50124.2020.9314571.

17. Arsirii, O. A., Babilunha, O. Y., Manikaeva, O. S. & Rudenko, O. I. "Automation of the preparation process weakly-structured multi-dimensional data of sociological surveys in the Data Mining system". *Herald of Advanced Information Technology*. 2018; 1 (1): 11–20. DOI: https://doi.org/10.15276/hait.01.2018.1.

18. Shuvaev, A. A. "Tools for the Involvement of construction and demolition waste in the repeated production cycle". *STP*. 2023; 4 (104): 48–55. DOI: https://doi.org/10.15802/stp2023/297521.

19. Lu, W., Webster, C., Peng, Y., Chen, X. & Chen, K. "Big data in construction waste management: prospects and challenges". *Detritus*. *In Press*. 2018. 4: 129-139. https://www.scopus.com/sourceid/21101016917. DOI: https://doi.org/10.31025/2611-4135/2018.13737.

20. Demetriou, D., Mavromatidis, P., Robert, P. M., Papadopoulos, H., Petrou, M. F. & Nicolaides, D. "Real-time construction demolition waste detection using state-of-the-art deep learning methods; single–stage vs two-stage detectors". *Waste Management*. 2023; 167: 194–203, https://www.scopus.com/sourceid/26490. DOI: https://doi.org/10.1016/j.wasman.2023.05.039.

21. Arsirii, O. O., Ivanov, O. V. & Smyk, S. Yu. "Risk zones from the filling stations modelling with application of geoinformation technology". *Herald of Advanced Information Technology*. 2021; 4 (1): 84–95. DOI: https://doi.org/10.15276/hait.01.2021.8.

22. Zawada, K., Donderewicz, M., Gertner, A. & Rybak-Niedziółka, K. "The impact of BIM and GIS on the efficiency of implementing construction projects". *Acta. Sci. Pol. Architectura*. 2024; 23: 358–368. DOI: https://doi.org/10.22630/ASPA.2024.23.28.

23. Paz, D. H. F. D., Lafayette, K. P. V. & Sobral, M. D. C. "GIS-based planning system for managing the flow of construction and demolition waste in Brazil". *Waste Manag. & Res*. 2018; 36 (6): 541–549, https://www.scopus.com/sourceid/26492. DOI: https://doi.org/10.1177/0734242X18772096.

24. Marzouk, M., Othman, E. & Metawie, M. "Managing demolition wastes using GIS and optimization techniques". *Cleaner Engineering and Technology*. 2024; 23: 100852, https://www.scopus.com/sourceid/21101059780 DOI: https://doi.org/10.1016/j.clet.2024.100852.

25. Ratnasabapathy, S., Perera, S. & Alashwal, A. “A review of smart technology usage in construction and demolition waste management”. In: *Proceedings of the 8th World Construction Symposium*. Colombo, Sri Lanka. 2019. p. 45–55, https://www.scopus.com/sourceid/21101056430. DOI: https://doi.org/10.31705/WCS.2019.5.

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Інтелектуальна інформаційна технологія аналізу та управління будівельними відходами

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АНОТАЦІЯ

У сучасних умовах збільшення кількості утворених відходів при будівництві, зносі, ремонті чи реконструкції об’єктів, проблема аналізу та управління цими відходами стає все більш актуальною у вирішенні екологічних та економічних питань. Ця проблема в Україні ускладнюється бойовими діями на її території, через які виникла значна кількість зруйнованих чи пошкоджених будівель. У науковій статті запропонований варіант розв’язання проблеми аналізу та управління відходами будівництва за рахунок створення інтелектуальної інформаційної технології. Авторами запропоновано концептуальну схему інтелектуальної інформаційної технології, що буде на основі введених кінцевим користувачем даних про джерело та вид будівельних відходів надавати геопросторові про центри прийому відходів. Було проаналізовано предметну літературу щодо сучасного стану технологій та методів для управління відходами будівництва, на основі яких сформовано вимоги до інтелектуальної інформаційної технології. При описі складових концептуальної схеми були проаналізовані природа вхідних і вихідних даних, а також розглянуті машинні алгоритми і технології, що можуть бути використані для розв’язання інтелектуальної задачі аналізу та управління будівельними відходами. Як варіант розв’язання проблеми аналізу та управління будівельними відходами авторами була розроблена інтелектуальна інформаційна система з 4 модулів, в якій реалізовано наступні підзадачі: класифікація центрів прийому відходів, збір даних про джерело відходів та їх види, класифікація відходів, визначення найближчих центрів прийому відходів та видача результатів у вигляді інтерактивної карти. Сервер було написано на мові програмування Java, використовуючи Spring Framework, а також Spring Boot і Spring Data JPA. В якості системи управління базою даних було обрано PostgreSQL. Фронтенд було написано за допомогою Thymeleaf, а також HTML, CSS та JavaScript. Четвертий модуль включає в себе запит до OpenStreetMap Tiles для відображення мапи на веб-сторінці користувача. Подальший розвиток дослідження може бути пов’язаний із застосуванням технологій штучного інтелекту або нейронних мереж для аналізу зображень об’єктів утворення відходів, на основі чого може бути отриманий текстовий файл з класами будівельних відходів для формування пропозицій користувачу з поводження з відходами.

Ключові слова: інтелектуальна інформаційна технологія; концептуальна схема; поводження з відходами; будівельні відходи; геоінформаційні технології

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