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INFORMATION TECHNOLOGY FOR ANALYSIS OF WASTE MANAGEMENT OBJECTS INFRASTRUCTURE

The subject *of study in this article is the process of analyzing infrastructure objects for waste management.* ***The current article increases*** *the objectivity of waste management infrastructure objects estimated by developing a model and method of information technology for analyzing several indicators of these objects based on the use of spatially distributed data.* ***Objectives:*** *to analyze the key factors affecting the waste management infrastructure (WMI) to select possible ways to improve the efficiency of its functioning; to develop a model of the WMI objects analyzing process, which determines the structure of information technology for analyzing several indicators of these objects using spatially distributed data; to improve the method of identification and verification of data about WMI objects. The following* ***results*** *were obtained. An approach to the estimation of WMI objects based on set-theoretical and functional modeling of the process of analyzing these objects is proposed. The method for identifying and verifying data about WMI objects has been improved, based on considering them in the form of geographical objects, considering current cartographic and satellite data, which, in contrast to the existing ones, will allow an objective assessment of their compliance with legal and construction standards. For the first time, the structure of information technology for analyzing several indicators of WMI objects is proposed, the use of which in decision support systems will make objective judgments about the existing infrastructure based on spatial data using geoinformation systems.* ***Conclusions.*** *The results of the bibliographic research confirmed that effective monitoring of WMI objects to ensure compliance with legislation in the field of waste management is extremely difficult. This process requires the development of specialized models and methods focused on the use of geoinformation systems for their implementation in decision support systems. Scientific and methodological support of information technology for analyzing several indicators of WMI objects has been developed. Its usage in the tasks of estimating the state of the corresponding objects of the Kharkiv region confirmed that many of them do not meet the existing legal and building requirements, which requires close attention to the problem of waste management and the development of appropriate management decisions.*

Keywords: *model of information flows of the process; the IDEF0 model; a multidimensional database; the method of identification and data verification; satellite imagery; the data flow model.*

Introduction

The concept of sustainable development, formed by the United Nations (UN), has become a guiding principle in the modern world. Sustainable development – development that fosters prosperity and economic opportunities grow increased well-being and environmental protection – offers the most optimal way to improve the lives of people around the world [1]. However, in developing countries, especially in industrial cities with significant population growth, uncontrolled urbanization occurs, which negatively affects the ecosystem as a whole [2]. So, the climate problem remains the main agenda of the largest countries of the world, which is confirmed by the results of the International Summits of world leaders on climate change held in 2021. According to the UN World Meteorological Organization, in 2020 the climate crisis "was constantly intensifying". The temporary reduction in carbon emissions due to isolation in many countries did not have a noticeable effect on atmospheric concentrations of greenhouse gases [3]. The desire to reduce them once again drew attention to the issues of handling household waste, which in the modern world still remain a big problem.

In order to create conditions for raising living standards of the population, it is necessary to systematically analyze the problem of waste management, examining the objects of the existing infrastructure, identifying its shortcomings and developing possible ways for improvement. In this regard, geographic information systems (GIS) open up new opportunities associated with the collection of data on waste management facili-

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ties, their identification, verification for compliance with legislative requirements, etc. Understanding the dynamics of land cover changes and the ability to predict land use is an important source of information for making management decisions [2, 4, 5]. However, this is where the potential of GIS is not fully used: they are not considered as an effective means of helping to make informed decisions in the tasks of waste management in accordance with the requirements of land management, cadaster, environmental protection, etc. There is a need for the development of specialized models and methods, oriented to the use of GIS, for their implementation in decision support systems in the field of waste management [4 - 6].

1. Analysis of publications and problem statement

Considering municipal solid waste (MSW) as waste that is generated in the process of human life and activities (except for waste associated with the production activities of enterprises), Art. 1 of the Law of Ukraine dated 5.03.1998, No. 187/98 VR, MSW management defines how actions aimed at preventing waste generation, collection, transportation, sorting, storage, processing, recycling, disposal, neutralization and burial, including control over these operations and supervision of disposal sites [7]. In this regard, the waste management infrastructure is a complex structure that implements operations for collection, transportation, storage, sorting, processing, utilization and disposal of waste [7 - 9]. To understand the key factors affecting the successful functioning of this structure and the implementation of waste management operations, as well as to identify possible ways to improve its efficiency, we will use the selective method of bibliographic research. The ScienceDirect database (https://www.sciencedirect.com) has been selected as a bibliographic source; the selection of scientific publications was carried out on the basis of the key features "solid waste" and "GIS" for the period from 2011 to 2021.

The analysis of the results of the bibliographic research shows a constant interest in the problem of waste management among scientists from all over the world, who are actively looking for ways to solve it. This problem has become especially urgent since 2019; by 2020 the number of publications on this topic has almost doubled and tends to increase (fig. 1).

The dominant method of waste management is its storage in municipal solid waste and landfills, as the main elements of the waste management infrastructure (WMI). This is the reason that most of the publications (31%) are devoted to solving the problem of improperly disposing of municipal solid waste, justifying the closure of unlicensed landfills, rebuilding old landfills or creating new infrastructure for solid waste management (D. A. Colvero at etc. [5]), etc. In the context of global waste generation, placing landfills in inappropriate places negatively affects the ecosystem as a whole (I. Kamdar at etc. [10]). At the same time, the implementation of the concept of sustainable development leads to the multi-criteria task of a decision making on the formation of WMI that considers environmental, economic and social factors (S. Rahimi at etc. [11]).

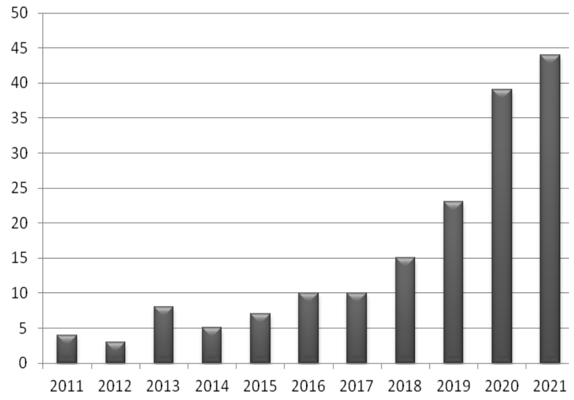

Fig. 1. Bibliographic search results: distribution of publications with key characteristics among more than 900 publications, sorted by relevance

29% of the analyzed works focus on the task of optimizing the collection and transportation of solid waste. However, at present in Ukraine the task of optimizing the waste collection and transportation system is not considered, and its successful solution essentially depends only on the experience of truck drivers involved in garbage removal [12].

Almost every eighth analyzed publication deals with the impact of solid waste on the environment. An ecologically dangerous situation is typical, which increases in the places where landfills are located, causes discontent of the local population, due to the fact that improper use can cause deterioration in the quality of drinking water, atmospheric air, sanitary and hygienic state of agricultural soils [12, 13]. It has been established that the influence of the landfill extends beyond the sanitary protection zone, therefore, it is necessary to improve the system of its monitoring with the obligatory consideration of the impacts on the adjacent territories [10, 11].

A possible solution to the problem of waste management can be the creation of a solid waste management system. An insignificant percentage (5%) of research, which tends to increase, solves the problem of optimizing the location and area for sustainable waste collection, justifies the creation of an effective system for the provision of municipal services, heuristically confirms the reduction of waste collection costs when performing environmental and social requirements (S.M. Darmian, at etc. [14]).

Note that regardless of the aspects of the problem of waste management considered, the results of bibliographic searches confirm the following. Effective monitoring and enforcement of legislation is difficult due to the large size of the geographical areas that need to be monitored, the limited amount of human and financial resources available to environmental and law enforcement agencies, which requires the introduction of new approaches and methods [14 - 16].

Thus, *the purpose* of the article is to increase the objectivity of assessing waste management infrastructure objects by developing model and method of information technology for analyzing several indicators of these objects based on the use of spatially distributed data.

2. Information flow model of WMI object analysis process

In Ukraine, despite some progress in solving the waste problem, the waste management strategy remains unformed. At the same time, according to experts, one should speculate less about the extreme nature of the situation, not to solve problems by an emergency route, but, based on strategic goals and international verified experience, introduce a systematic approach to the analysis of the problem of waste management, to the formation of appropriate infrastructure and the creation of a pragmatic national policy in this area [7, 12].

A widespread way of handling household waste in the world is its removal and disposal at municipal solid waste and landfills. In this regard, Ukraine is no exception, and the situation is further complicated by the fact that this infrastructure for handling solid waste in Ukraine is in a “rudimentary” condition (fig. 2). That is why, more and more often projects being implemented are aimed at identifying and monitoring authorized and spontaneous storage sites for solid waste based on open data [16].

A good example of such projects is the interactive map of the Ministry of Ecology and Natural Resources of Ukraine – geoportal "Ecomapa", the main function of which is to inform users about the situation with waste management. However, the data indicated here contradict other official data, for example, data from the Ministry of Regional Development, Construction, Housing and Utilities, Departments of Ecology and Natural Resources, etc. [7, 12]. Thus, it can be noted that today the identification and analysis of storage sites for solid waste, as objects of WMI, by the available methods is associated not only with large time and financial costs; the results obtained with their help are contradictory.

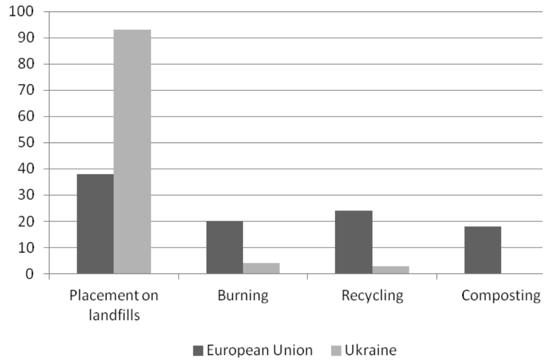

Fig 2. Distribution of solid waste (in%) in the waste management infrastructure in the European Union and Ukraine (according to work [12])

Using the approaches proposed by the authors (for example, in [17 - 19]), we conceptually represent the process of analyzing WMI objects in the form of a model of its information flows:

$$I\_Pr = (V, Z, \varphi, A, O, \psi), \qquad (1)$$

where $V = \{v_1, v_2, v_3, v_4\}$ – a set of input data required for the analysis of WMI objects;

$Z = \{z_1, z_2, \ldots, z_4\}$ – a set of documents regulating the process;

φ – update function;

$A = \{a_1, a_2\}$ – a set of operations that implement the process;

$O = \{o_1, o_2, o_3\}$ – a set of output data of the process under consideration;

ψ – an output function, that generates an output data.

A set V in model (1) constitute the following elements: v_1 – geoportal “Ecomapa” data; v_2 – satellite images of WMI objects; v_3 – data of the Public Cadastral Map; v_4 – basemap.

The internal content of information flows of the process of analyzing WMI it is standardized by a number of documents, which spell out the requirements for these objects, the rules for their placement and operation. Also, given that scientific and methodological support of information technology is being developed, set Z – a set of documents regulating the process, combining elements: z_1 – requirements for the database of waste management infrastructure objects; z_2 – table of decryption sing of objects; z_3 – requirements of the Building Code “Landfills for solid household waste. Basic provisions" (BC B.2.4-2-2005); z_4 – requirements for cartographic models of waste management infrastructure.

A set O in model (1) form: o_1 – database of waste management infrastructure objects; o_2 – results of analyzing several indicators of waste management infrastructure; o_3 – thematic cartographic models of waste management infrastructure.

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For ease and correctness of perception, the model of information flows of the process under consideration let's represent graphically I_Pr. Using the methodology of functional modeling IDEF0, we represent the set-theoretic form of the I_Pr model in the form of a context diagram, the ICOM-codes of which are defined by the sets:

$$V = \{v_1, v_2, v_3, v_4\},\ Z = \{z_1, z_2, \ldots, z_4\}$$

and

$$O = \{o_1, o_2, o_3\}$$ (fig. 3) [17, 18].

Executing the update function - displaying the view [18, 19]:

$$\varphi : V \times Z \to V \quad (2)$$

associated with the refinement of input data depending on the requirements of regulatory documents, i.e. elements of the set V upon arrival of the requirements of the set Z can be changed, updated and corrected within the process (1). For example, from all the data about WMI objects received from the “Ecomapa” geoportal, when implementing the function φ, that information is extracted that is necessary to fill the database in accordance with the requirements of z_1. Satellite images are decrypted in accordance with the table of decryption signs for the objects under consideration z_2, which makes it possible to refine and verify the data of the “Ecomapa” geoportal, etc.

We will form a set of operations of the process I_Pr. It is defined by the elements a_1 – verify data on waste management infrastructure objects; a_2 – evaluate infrastructure objects for compliance with requirements. Then, after executing the function φ to refine the input data, the implementation of the process I_Pr defines the display of the view [19]:

$$\psi : A \times V \to O, \quad (3)$$

which uniquely sets the sequence of operations of the set A and allows you to form the outputs of the process depending on the inputs $V = \{v_1, v_2, v_3, v_4\}$ and operations performed $A = \{a_1, a_2\}$.

To define the type of display (3) in accordance with the rules formed in the work [17], we define the function in a table ψ (Table 1).

In table 1, each row corresponds to one operation a_j (j=1,2), and the column is one valid input element of the set v_n (n=1,2,…,4). The cell at the intersection of a row and a column contains an operation a_j, the execution of which occurs when an element arrives at the input v_n, and the output element o_m (m=1,2,3), which will appear when the operation is performed a_j. For example, upon receipt of an input v_3 to get the output o_2 during operation a_2 output o_1 is required, obtained as a result of the operation a_1 by summarizing input data v_1, v_2 and v_3.

Table 1

Exit Function Tabular View (3)

Operation	Input elements of the set V			
	v_1	v_2	v_3	v_4
a_1	$a_1\|o_1$	$a_1\|o_1$	$a_2\|o_1$	-
a_2	-	-	$a_2\|o_2$	$a_2\|o_3$

For clarity and ease of perception of information flows and process operations I_Pr while observing the severity and formality of the presentation, we will depict table 1 as IDEF0 model (fig. 4) [18, 19]. In it, as a means to perform operations $A = \{a_1, a_2\}$ GIS is considered, and the spatial analysis (or GIS analysis) of multicriteria problems solved with its help contains a set of methods and tools for combining geospatial data with the arguments of decision makers [18].

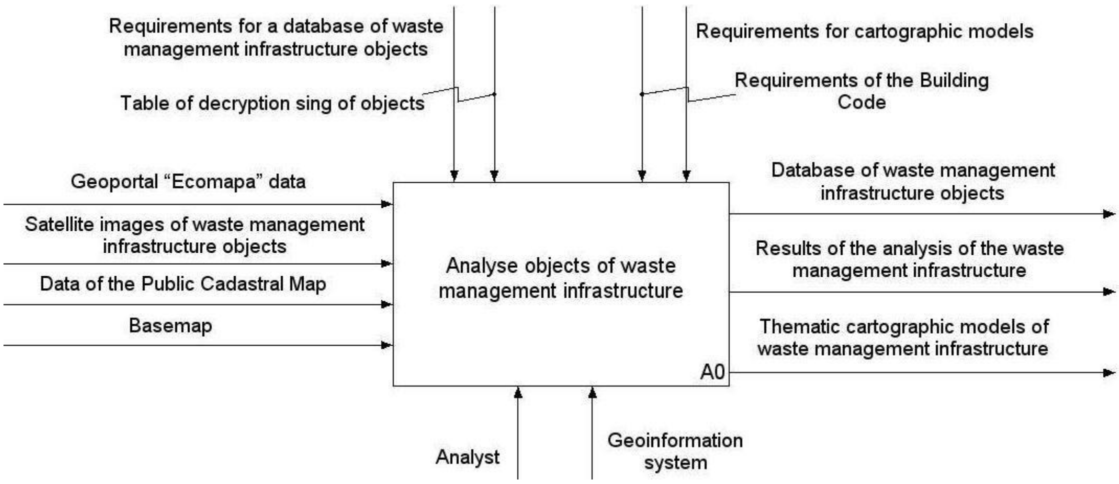

Fig. 3. Graphical representation of the model I_Pr the process of analyzing objects of waste management infrastructure

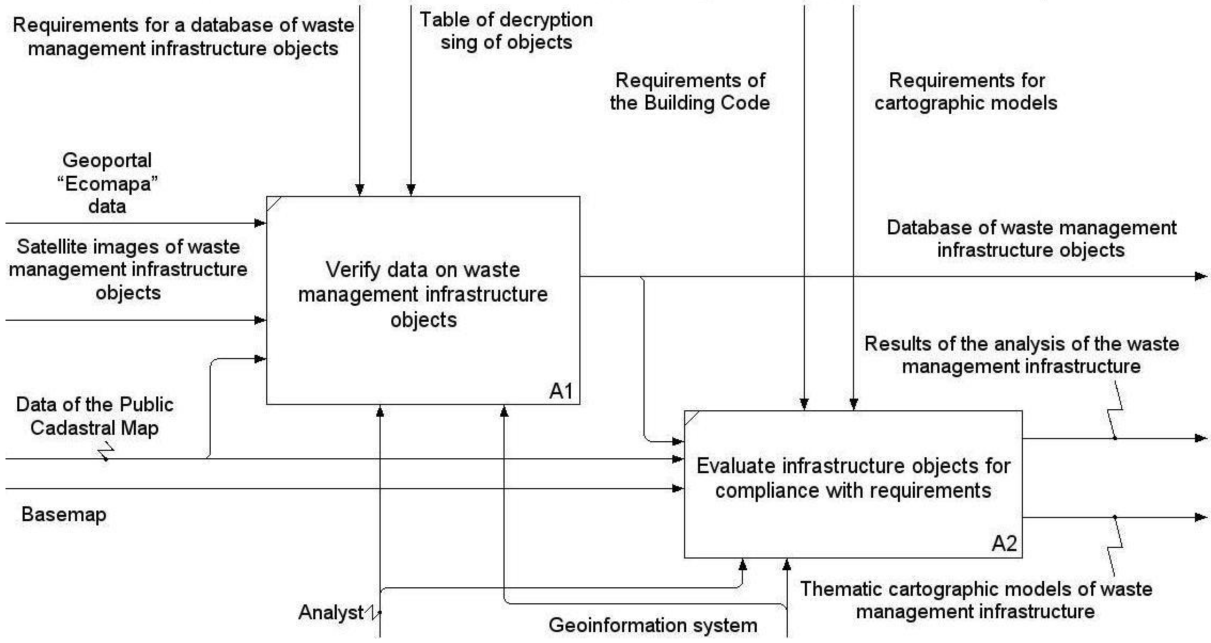

Fig. 4. IDEF0 process model as a structure of information technology for analyzing several indicators of waste management infrastructure objects

Note that the resulting IDEF0 model, in accordance with the requirements of the functional modeling methodology, determines the structure of the information technology of analyzing several indicators of WMI objects.

3. Method for identifying and verifying data about WMI objects

An important stage in the creation of any products based on remote data, digital models of cities and their infrastructure is their verification or quality assessment [2]. So, IDEF0 model as the initial stage of the process defines operation a_1 – WMI objects data verification (fig. 4). In traditional methods, when identifying and defining the characteristics of WMI objects, they are considered as points located in space (on the ground), data about which are taken from land management documentation. In contrast, in the IDEF0 model, WMI objects are considered as geographic objects with their coordinates, area, complex geometric shape, which interact with other geographic objects, spatial data about which are extracted from several sources.

In table 1, the sequence of data receipt at the input of operation a_1 is determined. In accordance with the requirements of the ISO 9000: 2005 standard, the method of their processing and verification to obtain the first output o_1 involves the implementation of the following stages.

Stage 1. In accordance with the requirements of z_1, form a database template (fig. 5), defining its multidimensional structure as the union of the elements of the sets along the planes [20], considering the only inputs v_1, v_2, v_3 operation a_1.

It should be borne in mind that, depending on the goals of the analysis, examining the elements of the set V of the model (1), form a set of indicators for evaluation, supplement and expand the database template, which is provided by the implementation of the update function (2).

Stage 2. Using the data of the geoportal "Ecomapa" (v_1), determine the elements of the multidimensional database in the corresponding plane, which is formed by the union of sets (fig. 5):

$$BD_{Geo} = B \cup C \cup D \cup E \cup F, \qquad (4)$$

where B={b: b – location of the WMI object};

C={c: c – the coordinate of the WMI object along the x-axis};

D={d: d – the coordinate of the WMI object along the y-axis};

E={e: e – WMI object area};

F={f: f – WMI object intended purpose}.

Stage 3. Using the data of satellite images (v_2), in accordance with the requirements of z_2, find the elements of the database sets that are formed by the union (fig. 5):

$$BD_{SI}(t_i) = B'(t_i) \cup G(t_i) \cup C'(t_i) \cup \cup D'(t_i) \cup E_1(t_i) \cup E_2(t_i), \qquad (5)$$

where the set B is transformed into the set $B'(t_i)=\{b'(t_i)$: $b'(t_i)$ – a snapshot of the location of the WMI object at the moment in time $t_i\}$;

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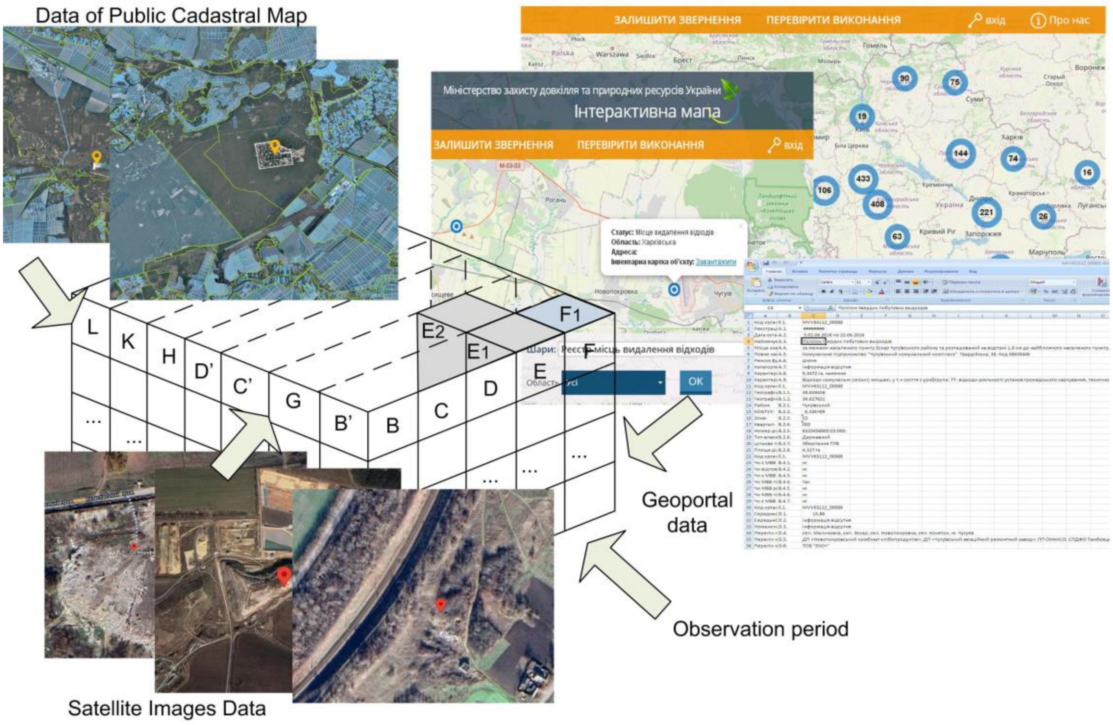

Fig. 5. Three-dimensional representation of the database, considering the time intervals for the identification and analysis of WMI objects from satellite images

$G(t_i)=\{g(t_i)$: $g(t_i)$ – availability of environmental protection means at the WMI object at the moment in time $t_i\}$;

$C'(t_i)=\{c'(t_i)$: $c'(t_i)$ – refined WMI object coordinate along the x-axis at the moment in time $t_i\}$;

$D'(t_i)=\{d'(t_i)$: $d'(t_i)$ – refined WMI object coordinate along the y-axis at the moment in time $t_i\}$;

$E_1(t_i)=\{e_1(t_i)$: $e_1(t_i)$ – the area occupied by waste at the WMI object at the moment in time $t_i\}$;

$E_2(t_i)=\{e_2(t_i)$: $e_2(t_i)$ – total area of the WMI object в at the moment in time $t_i\}$.

It should be noted that the processes of waste management are dynamic: the state of the WMI objects and the MSW stored there, as well as the state of the environment, change. [4, 9]. Therefore, the v_2 data must be updated, considering them with a certain step in time. t_i ($i=\overline{1,N}$). This circumstance leads to the fact that a relational database obtained by combining planes (4) and (5) becomes multidimensional, containing data for a certain observation period.

Stage 4. After clarifying the data on satellite images (v_2), correct the elements of the sets C and D of the database (4) according to the rule, which, for example, for the set C, has the form:

$$C=(C\cap C')\cup(C'\backslash C) . \qquad (6)$$

This refinement occurs once, since it is assumed that the coordinates of the WMI objects do not change over time (or their change is not significant).

Stage 5. Using the data of the Public Cadastre Map (v_3), find the elements of the database sets that are formed by the union:

$$BD_{PCM}(t_i)=H(t_i)\cup K(t_i)\cup L(t_i)\cup F_1(t_i) , \qquad (7)$$

where $H(t_i)=\{h(t_i)$: $h(t_i)$ – the distance from the WMI object to the objects of housing and communal development at the moment in time ti};

$K(t_i)=\{k(t_i)$: $k(t_i)$ – distance from the WMI object to water bodies at the moment in time $t_i\}$;

$L(t_i)=\{l(t_i)$: $l(t_i)$ – distance from the WMI farmland object at a point in time $t_i\}$;

$F_1(t_i)=\{f_1(t_i)$: $f_1(t_i)$ – type of WMI object at the moment in time t_i, $f_1(t_i)\in\{$active, recultivated, status is not defined$\}\}$.

Thus, based on the requirements of the ISO 9000:2005 standard, which determines that the truth of data should be confirmed by practice or not contradict known facts, the initial data v_1 is refined and corrected according to data v_2 (data from satellite images considered as a practice) and v_3 (data Public Cadastral Map that are interpreted as known facts). As a result, the first output o_1 is obtained – a database of WMI objects. Note that the developed model of information flows of the process of analyzing WMI objects and the method of their identification and verification are the main elements of the scientific and methodological support of information technology for multicriteria analysis of WMI objects.

4. Analyzing indicators of WMI objects in the Kharkiv region

Let us consider an example of the application of the developed scientific and methodological support in the tasks of analyzing several indicators of WMI objects of the Kharkiv region for compliance with local building codes. Having highlighted the main structural elements of a multidimensional database, in accordance with stage 2, according to the data of the geoportal "Ecomapa" for the Kharkiv region, they a base BD_{Geo} was formed, which combined information on 74 objects of solid waste storage. In the next step, relying on the data of BD_{Geo}, satellite images of these objects were found by coordinates.

During the formation of the BD_{SI} base elements, images of WMI objects were loaded with the corresponding georeferencing files, the coordinates of the objects and their areal characteristics were refined. Note that at this stage, considering the decryption signs from the set z_1, only 56 objects were found (fig. 6): the coordinates of some objects pointed to agricultural land or residential areas, two objects, according to the geoportal belonging to the Zolochevsky district administration, are located on the territory of the Belgorod region. For undetected WMI objects, the corresponding marks have been entered into the BD_{Geo} database.

1

2

Fig. 6. WMI object detection by satellite imagery:
1 – WMI object is not defined;
2 – WMI object is defined

Also, according to the images for each WMI object, the presence of environmental protection means was determined. (fig. 7).

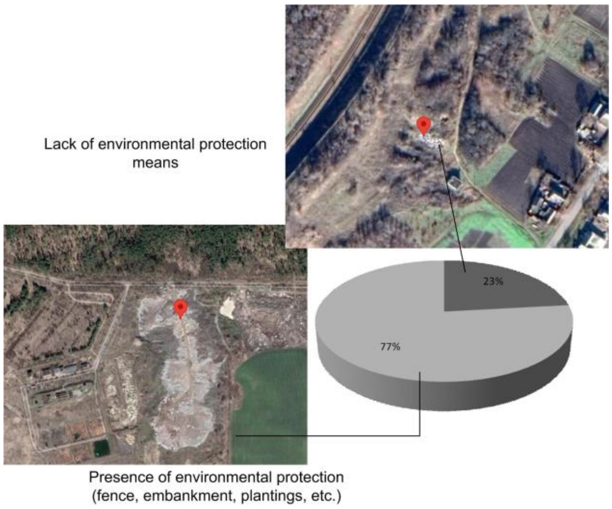

Fig. 7. Determination of environmental protection means at WMI objects from satellite images

At the final stage, using the data of the Public Cadastral Map, the BD_{PCM} database was formed and filled out.

Thus, using the method of identification and verification the WMI objects data for the considered moment in time, a database was formed, which can be expanded and supplemented using actual images of WMI objects and information from other sources. The use of the obtained base in the tasks of analyzing several indicators of WMI objects showed that most of the storage facilities for solid household waste do not comply with local construction standards, in particular:

- almost 80 % of the locations of the analyzed objects do not meet the standards for distances to agricultural land and water bodies;
- slightly more than 40 % do not meet the standards for distances to residential buildings;
- 23 % do not have appropriate environmental protection structures (fig. 7);
- about 70 % of land plots do not have an appropriate designated purpose and should not be used for storing household waste.

The results obtained confirm the need for close attention to the problem of waste management and the development of appropriate management decisions, for example, aimed at engineering equipment of WMI objects in order to reduce their impact on the environment, certification, etc.

Conclusions

The results of the conducted bibliographic search showed that effective monitoring of WMI facilities in order to ensure compliance with legislation in the field of waste management is extremely difficult for a number of reasons [14 - 16]. This requires the development of models and methods that use spatially distributed data and are focused on the use of GIS for their implementation into decision support systems.

Supporting the ideas of works [11, 14] about creating an effective system of waste management, the results of the work are aimed at obtaining objective assessments of the state of WMI objects, based on set-theoretical and functional modeling of the process of analyzing these objects. Unlike work [10], where for formation (improvement) of WMI expert assessments are used, the improvement of the method for identifying and verifying data about WMI objects will allow to objectively assess their compliance with legal and building requirements. This is possible due to the consideration of WMI objects in the form of geographic objects, considering relevant information from not only online portals and government agencies, but also current cartographic and satellite data.

For the first time, the structure of information technology for WMI objects analysis is proposed, which is based on indicators defined by legal and building requirements and allows controlling entire districts and regions. The developed scientific and methodological support allows its implementation in decision support systems to obtain objective conclusions about the existing infrastructure based on spatial data using GIS. It can become an additional tool for promoting the “Smart city” concept, considered in [2], by integrating satellite data to increase the resilience of the environment and society to anthropogenic impact.

Future research directions

Further research should be aimed at solving the issues of processing, interpretation and visualization (especially with the help of thematic mapping) of the obtained data about WMI objects for the analysis of information and the development of appropriate control solutions.

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ АНАЛІЗУ ОБ’ЄКТІВ ІНФРАСТРУКТУРИ ПОВОДЖЕННЯ З ВІДХОДАМИ

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Предметом дослідження в статті є процес аналізу об’єктів інфраструктури поводження з відходами. **Метою** статті є підвищення об’єктивності оцінок об’єктів інфраструктури поводження з відходами шляхом розроблення моделі та метода інформаційної технології аналізу цих об’єктів на основі декількох показників з використанням просторово-розподілених даних. **Завдання:** проаналізувати ключові фактори, які впливають на інфраструктуру поводження з відходами (ІПВ) для вибору можливих напрямків підвищення ефективності її функціонування; розробити модель процесу аналізу об’єктів ІПВ, що визначає структуру інформаційної технології аналізу об’єктів на основі декількох показників з використанням просторово-розподілених даних; удосконалити метод ідентифікації та верифікації даних про об’єкти ІПВ. Отримано такі **результати**. Запропоновано підхід до оцінювання об’єктів ІПВ, який базується на теоретико-множинному та функціональному моделюванні процесу аналізу об’єктів. Удосконалено метод ідентифікації та верифікації даних про об’єкти ІПВ, якій заснована на їх розгляді як географічних об’єктів з урахуванням актуальних картографічних і супутникових даних, що дає змогу об’єктивно оцінювати їх відповідність правовим і будівельним нормам. Уперше запропоновано структуру інформаційної технології аналізу об’єктів ІПВ на основі кількох показників, використання якої в системах підтримки прийняття рішень надасть змогу сформувати об’єктивні висновки про існуючу інфраструктуру, ґрунтуючись на просторових даних з використанням геоінформаційних систем. **Висновки**. Результати бібліографічного пошуку підтверджують, що ефективний моніторинг об'єктів ІПВ для забезпечення дотримання законодавства у сфері поводження з відходами вкрай ускладнено. Це вимагає розроблення спеціалізованих моделей і методів, орієнтованих на використання геоінформаційних систем, для впровадження їх у системи підтримки прийняття рішень. Розроблено науково-методичне забезпечення інформаційної технології аналізу об'єктів ІПВ на основі кількох показників. Його використання у завданнях оцінки відповідних об’єктів Харківської області підтвердило, що багато з них не відповідають правовим і будівельним нормам. Це потребує пильної уваги до проблеми поводження з відходами та вироблення відповідних управлінських рішень.

Ключові слова: модель інформаційних потоків процесу; IDEF0 модель; багатовимірна база даних; метод ідентифікації та верифікації даних; супутникові знімки.

ИНФОРМАЦИОННАЯ ТЕХНОЛОГИЯ АНАЛИЗА ОБЪЕКТОВ ИНФРАСТРУКТУРЫ ОБРАЩЕНИЯ С ОТХОДАМИ

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Предметом изучения в статье является процесс анализа объектов инфраструктуры обращения с отходами (ИОО). **Целью** статьи является повышение объективности оценок объектов ИОО путем разработки модели и метода информационной технологии анализа этих объектов на основе нескольких показателей с использованием пространственно-распределенных данных. **Задачи:** проанализировать ключевые факторы, влияющие на ИОО для выбора возможных направлений повышения эффективности ее функционирования; разработать модель процесса анализа объектов ИОО, определяющую структуру информационной технологии анализа этих объектов на основе нескольких показателей с использованием пространственно-распределенных данных; усовершенствовать метод идентификации и верификации данных про объекты ИОО. Получены следующие **результаты**. Предложен подход к идентификации и оценке объектов ИОО, базирующийся на теоретико-множественном и функциональном моделировании процесса анализа этих объектов. Усовершенствован метод идентификации и верификации данных про объекты ИОО, основанный на рассмотрении их в виде географических объектов с учетом актуальных картографических и спутниковых данных, что в отличии от существующих позволят объективно оценивать соответствие их правовым и строительным нормам. Впервые предложена структура информационной технологии для анализа объектов ИОО на основе нескольких показателей, использование которой в системах поддержки принятия решений позволит сделать объективные выводы о существующей инфраструктуре на основе пространственных данных с использованием геоинформационных систем. **Выводы**. Результаты библиографического поиска подтвердили, что эффективный мониторинг объектов ИОО для обеспечения соблюдения законодательства в сфере обращения с отходами крайне затруднителен. Это требует разработки специализированных моделей и методов, ориентированных на использование геоинформационных систем, для внедрения их в системы поддержки принятия решений. Разработано научно-методическое обеспечение информационной технологии анализа объектов ИОО на основе нескольких показателей. Его использование в задачах оценки состояния соответствующих объектов Харьковской области подтвердило, что многие из них не отвечают существующим правовым и строительным нормам, что требует пристального внимания к проблеме обращения с отходами и выработки соответствующих управленческих решений.

Ключевые слова: модель информационных потоков процесса; IDEF0 модель; многомерная база данных; метод идентификации и верификации данных; спутниковые снимки.

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