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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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MODELING THE EFFICIENCY OF WASTE MANAGEMENT

Abstract. The article analyzes modern issues of waste management in Ukraine, in small settlements in particular. Well-known methods and means of forecasting in the field of waste management are considered. A new computer program with mathematical modeling of ecological-economic efficiency, estimation, substantiation of optimization of operating modes and selection of technical maintenance of waste management systems in the development of schemes of sanitary cleaning of small cities is proposed. An example of an automated calculation of profitability indices and ecological safety in the selection of optimal equipment is given. Based on the analysis of the characteristics of the planned operation mode, taking into account the predicted changes in its parameters in order to substantiate the increase of ecological safety of schemes of sanitary cleaning of small settlements by forming the optimal specialized technical equipment was proposed. This reduces the risk of errors in the implementation of practical work and helps increase the efficiency of making independent decisions. The application of theoretical and scientifically practical results of the study will contribute to the implementation of the basic principles and planned special measures. The developed software application can be effectively applied both in industrial and scientific, as well as in the educational process as a simulator of ecological and economic processes in order to consolidate the theoretical basis of professional knowledge of students and postgraduates.

Keywords: modeling, estimation, waste, ecological-economic efficiency, forecast, computer program "Index-E".

Introduction. The critical condition of waste management systems (WMS) is a key factor in the threat to the ecological safety of a modern state.

Experts estimate the total amount of waste accumulated in Ukraine is about 36 billion tons. According to the National Waste Management Strategy [1], in the period of 2017-2030, the volume of waste destined for processing is planned to be increased up to 50% at the base value of this indicator by 2016 at 3%. Among the necessary methods and special measures aimed at solving the problem are the modernization of the material and technical base of economic agents for the reuse of natural resources, recycling and utilization of waste; development of methodological recommendations for WMS for central and local executive authorities, local governments, business entities; development, design and production of specialized equipment.

However, experience shows that the main national program and waste management plans [2, 3], which were used in Ukraine for a long time, are mainly focused on implementation in the regional centers, are not adapted for use in small towns and are too generalizing, not supported by specialized scientific and methodological tools. At the same time, foreign thematic concepts [4, 5] are based on mechanisms of sustainable economic development and require strict compliance with the plan of recommended decisions implementation. These mechanisms are ineffective for use in small settlements (there are around 29 770 in total). There, the WMS is often chaotic or practically absent because of the lack of local monetary resources, targeted state financing and outdated material and technical resources (depreciation of available means of collecting and transporting solid waste (SW) by more than 75%, with 1% renewal of the specialized fleet of garbage trucks from required 12% according to the standards) and the imperfection of methodological foundations for specialized work implementation.

In small settlements, SW is stored in natural formations - beams, ravines, valleys of rivers, forming spontaneous dumps. It leads to pollution of the environment main components by the introduction of highly toxic liquid waste, which absorbs soluble and suspended solids and products of biodegradation to aquifers (pollution of the hydrosphere and lithosphere and gases into the atmosphere). It represents an ecological hazard at the national level and a direct threat to human health and life, indicating the urgent need for the formation of an optimal scientifically grounded material and technical base for the sanitary purification schemes (SPS) implementation.

The analysis of the experience of using normative act DBN B.2.2-6:2013 [6] is a prerequisite for WMS effective operation and development, taking into account the individual needs of the city [7].

Figure 1 – Emergency work for the decommissioning of the SW landfill:
1 - the places for the search of the dead; excavators; 2 - the direction of displacement of the garbage avalanche,
3 - the garbage wall with a height of about 80 m, 4 - the place of combustion of waste, 5 - ponds of liquid waste,
6 - cadets strengthen the dam with sandbags to increase the height and strengthen its walls

An important component of this problem is low effectiveness of scientific and practical decisions taken in the process of implementation of the main stages of SPS development, often due to the subjective imperfection of educational and professional training or the lack of environmental specialists in the field and their lack of practical experience of optimization of specialized systems exploitation. It leads to logistical errors and violations of the technological processes and increase of man-made load (as it is observed on the example of the crisis on SW landfill Hrybovychi in the Lviv region). On Monday, May 30, 2016, about 15:20 there was a garbage fall (fig. 1) on the largest in Ukraine Hrybovychi landfill located near Lviv. Three firefighters of the SES, who were extinguishing the fire the day before, and the employee of the utility company which serviced the landfill, died under the rubble.

Thus, in the absence of an appropriate assessment of the environmental, economic and safety components in the development of WMS, such facilities have increased risks of losses due to elimination of an emergency (such as fire, flooding), search and rescue, emergency repairs.

The substantiation of decisions on designing and independent control over the further operation of special engineering and technical facilities is particularly relevant given the preparation of such sectoral projects as a complex for SW processing with the system of collecting and utilizing landfill gas and generating electricity in Dergachi (Kharkiv region, Ukraine) [8], which is a typical small settlement.

Analysis of research and publications. Sectoral and interdisciplinary aspects of the problem of waste management and the search for solutions to it at various times are widely covered in the writings of such scientists as O.Balatsky, Y.Chien, A.Cook, P.Darulis, S.Engstrum, M.Gomel, B.Gorlitsky, M.Goroh, I.Grabinsky, A.Grechko, M.Krasnyansky, J.Kemm, V. Kravtsev, V.Kuznetsov, E.Kwon, M.Matthews, L.Melnik, O.Parfenyuk, Y. Radov, V.Shmandiy, Y.Stadnitsky, V. Tregobchuk, S.Vysotsky, V. Tan Benilda and others. However, the study of scientific and practical issues concerning the formation of technical equipment for the main stages of handling spent materials, the development of scientific and methodological tools for the development of individual regimes for effective functioning of necessary technological processes at the level of urban planning and the development and small settlements infrastructure modernization is inadequate, outdated and impractical due to conditions of the current economic situation in Ukraine.

At present mathematical tools for economic modeling of various technological processes (including control systems for exhaust materials), and various models of anthropogenic impact assessment on the environment are sufficiently developed. Known developments in WMS can be divided into the following main groups:

- general methodological recommendations - models of optimized WMS in certain settlements or regions (such as the "Development of the Model and Technologies of Logistics of the Communal Waste Transport" project, a scheme for waste management utilization for the center of Nish (Republic of Serbia) [11], specialized software of modeling of SW utilization infrastructure in in Florida (USA) [12], research on the optimal location of receiving and processing set of secondary raw materials [9, 13], the method of ecological and economic forecasting for WMS in major cities of Russia [14], the "temporary typical methodology for determining the economic efficiency of environmental measures and assessing the economic damage to the national economy by environmental pollution" [15] is obsolete, using regulatory factors for the indicators of research facilities and fixed frameworks of their changes taking into account the time factor for comparative analysis and selection of optimal thematic technical solutions without the possibility of modeling all possible dynamics of input data in the process of prolonged exploitation of projected systems);
- specialized methods - systems for estimating and predicting the efficiency of technological processes of handling individual types or fractions of waste. (such as well-known studies on ecological and economic assessment of utilization of rubber-technical waste in secondary raw materials [16], optimization of biofuel production systems [17], prediction of biogas output and temperature of solid household waste landfills based on mathematical modeling [18], formation method of functional and apparatus-circuit chains of energy production systems from sugar factories organic waste [19], the method of ecological and economic substantiation of the creation of waste recycling systems in stationary warehouses of military infrastructure [20]);
- research models - methods and devices simulating the technological physico-chemical processes typical of various waste management stages for their study (such as the installation for the study of air migration of waste chemicals in the simulation of natural ultraviolet radiation) [21] and other.

Several specific environmental, technical, economic and logistical processes of management of basic stages of WMS is performed using such specialized software as "Environmentalist" calculation software series (eg, program "Waste 5.0" - calculation of waste by specific regulations, "calculation hazard class 4.1" - calculation of waste hazard class environment and processing passport hazard waste "That 2.1 vehicle waste"- calculation of the amount of waste in transport enterprises," Waste from wood processing 1.0 "- determining the volume of waste wood [22]); logistics and business applications for computerization process execution in terms of waste management companies developed - «FASTPace», «FleetCom», «1WasteProfile» [23]; «Ecocalc 5.1.0» (program for the calculation of the ecological and economic efficiency of lighting projects, specifying the cost of recycling of waste generated during its use lighting systems [24]) and others.

However, due to complexity, narrow specialization, and depth of profile (economic, technical or environmental) specificity, the majority of known management tools, forecasting and evaluation of WMS require their simultaneous use, adaptation of basic mathematical principles for the design in specific cities and require substantial specialized training of the user. This significantly reduces the potential effectiveness of the implementation of existing methodological tools for the scientific substantiation of the formation of specialized technological systems in the modernization of the infrastructure of small settlements.

Task and goal of the research. The goal is to develop a scientific and methodical tool for modeling and assessing the ecological and economic efficiency of equipment and technological processes of waste management. The novelty of this paper is to propose a new mode for forecasting the efficiency, assessment and justification of the selection of the composition and parameters of technological WMS and their implementation in the form of a computer program.

The subjects of the study are methods, technological processes and specialized technical equipment of WMS. The relevance of the appointment of well-known branch equipment to the technological needs of the projected WMS is established through open sources of information and (or) through the testing of samples of technical equipment (aggregates, technological lines, etc.).

The object is the environmental impact and economic profitability of a technical solution (method, process, device, or system of devices), known in the world of experience, of the state of the art and aimed at working with waste materials (their collection, transportation, sorting, recovery or utilization).

Results. In connection with the considered issues, a computer program for forecasting the efficiency, estimation and substantiation of the selection of WMS "Index-E" [25] has been developed. It is easy to use applied software provision of processes that optimize design objects that increase ecological safety of specialized technical-engineering facilities.

In order to achieve the goal of this work, as the basis for developing an algorithm for the functioning of the automated modeling of the effectiveness of specialized technical equipment with a selecting its optimal composition and mode of long-term operation, the simulation mathematical model for calculating the annual and final indices of ecological and economic efficiency, which includes the following system of mathematical expressions (formula 1):

$$\begin{cases} \mathbf{X1} = (X4 + X5) \cdot h1 \cdot h2^{365д} / h3 \\ X6 = (Ф1 - Ф2) / h2^{1095д} \\ \mathbf{X2} = (X6 + X7) \cdot h1 \cdot h2^{365д.} / h3 \\ \mathbf{X3} = (Z1 + Z2 + Z3 + Z4) \cdot h1 \cdot h2^{365д.} / h3 \\ \mathbf{Y1} = \sum X1 / T \\ \mathbf{Y2} = ((\sum X2 - \sum X3) - \%W) / T \end{cases} \quad (1)$$

where X1 - index of the ecological effect (emission factor of 1 ton of recycled waste in the amount of equipment units per year), (log index - conditional numerical value of the estimated characteristics of the object); X2 - index of economic effect (profit factor per 1 ton of treated waste per year); X3 - index of technical effect (coefficient of expenditure of funds per 1 ton of treated waste per year); X4 - emission of pollutants into the athmosphere from the equipment, (g/year); X5 - discharge of pollutants into the hydrosphere from the equipment, (g/year); X6 - profit from the unit of equipment, (UAH/hour); X7 - total market value of functions (commercial cost of services rendered to order) (UAH/year); h1 - number of operating units of equipment (units); $h2^{365d}$ - number of hours of unit operation in a year (hour/year); $h2^{1095d}$ - number of hours of operation of the equipment unit, in the constant period (3 years), (hour/year); h3 - amount of processed waste by the total number of units of equipment (t/year); F1 - cash flow from the operation of the unit of indexed equipment in a constant period (direct income from the sale of waste products, UAH/year); F2 - cost (or cost when purchasing) unit of equipment, divided by the depreciation rate (UAH/year); Z1 - pay for the personnel required for the operation of the equipment (UAH/year); Z2 - the cost of the area renting occupied by a unit of equipment (based on the average region cost of renting 1 square meter of industrial sites and taking into account the dimensions of the equipment unit), (UAH/year); Z3 - the cost of energy resources that are expended when a unit of equipment is indexed (UAH/year); Z4 - cost of elimination of predicted problems and maintenance of the equipment, in the period of 1 year (per hour of operation of a unit of equipment) (UAH/year); Y1 - the final index of the ecological effect (average value of the influence of equipment on the environment for 1 ton of treated waste in the forecast period); Y2 - the final index of the economic effect (average value of the profit from equipment per year per 1 ton of treated waste in the forecast period), (log index); ΣX1 - sum of annual indexes X1 for the forecast period; ΣX2 - sum of annual indexes X2 for the forecast period; ΣX3 - sum of annual indexes X3 for the forecast period; %W - average percentage of inflation in the region in the forecast period (%); T - duration of the predicted period (number of years).

The analysis of the calculation results of this mathematical expressions system allows us to predict and evaluate the complex ecological and economic effect of long-term exploitation of the alleged technical equipment of the WMS. This reduces the risks and volumes of non-conforming materials exposure to the environment. It also provides a comprehensive scientific substantiation of the economic feasibility of investing in the modernization of the material and technical base of small settlements in the forecast period.

Specialized computer program "Index-E" is developed for personal computers, implemented with Java programming language. It operates in any OS environment, and accelerates and simplifies the calculation implementation for the considered mathematical model. Thanks to the user-friendly interface, the operation of the program does not require complex additional training of the user.

The software application has three main working windows: 1. "start window" (user profile); 2. "calculation unit"; 3. "calculation results".

The Objects block - (specific names of examples of equipment under investigation) is filled up repeatedly for each equipment option. With the addition of names and equipment manufacturers, a list of facilities under the current project (up to 5 facilities per calculation) is formed in the left part of the start window.

To perform an automated calculation it is necessary to formulate tasks for the calculation by entering the initial values of each main indicators and their correction in the years of the forecast period. In the appropriate form, the calculation block of the program allocates the desired object from the list previously set by the user (in the left part of the window) and chooses the name of the indicator and the specific value of each of them (in the right part of the window, figure 2).

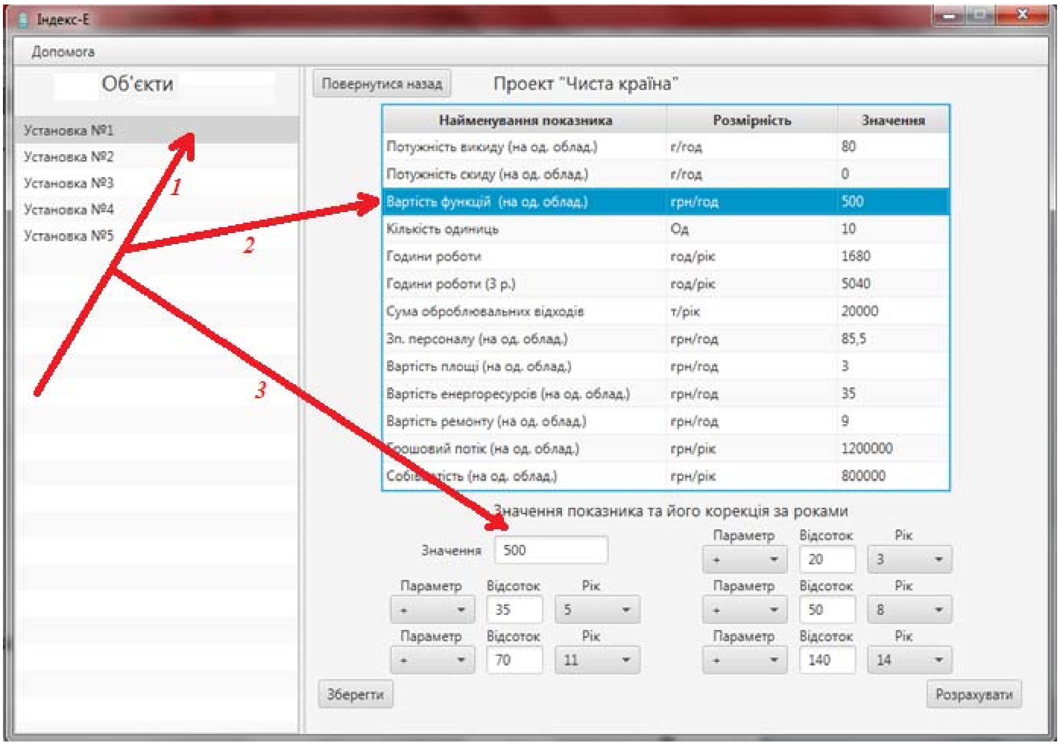


Figure 2 – Window of the calculation block of the program "Index-E" and the order for entering the initial values of indicators

In order to take into account risks and increase the realism of the waste management equipment ecological and economic effect index modeling, the basic indexes of annual indexing are calculated multiple times. It enables modeling the predicted efficiency of technical equipment during a longer period of the operation, taking into account correction, for example, of the values of following indicators.

By adjusting the values of one or more indicators for any year in the projected period for each simulation object (eg, equipment analogs), it is possible to calculate the efficiency indices of the equipment, which are adequate for the modeled operation modes. Taking into account the predicted external ecological, economic, technological and social factors in the early stages of the design of WMS in the process of developing the SPS enables its detailed adaptation to the needs and characteristics of small settlements. The initial values for calculation in the program are entered on the following indicators (table 1).

Table 1 – Signification of indicators of modeling facilities, their corresponding abbreviations and correction, for example, against the background

Indicator	Abbreviation of the indicator	Correction, for example, against the background
X4	Emission power	projected upgrading of equipment
X5	Discharge power	projected upgrading of equipment
h1	Number of units	of the predicted dynamics of waste generation with the production capacity unit of equipment
$h2^{365}$	Hours in a year	of the predicted dynamics of the number of equipment and total amount of treated waste
h3	The amount of processed waste	of projected dynamics of development of the settlement industrial sector
F1	Cash flow (for one unit)	direct income from the sale of waste products, such as alternative fuel from recycled materials
F2	Cost (per unit)	projected upgrading of equipment
Z1	Staff Salary	of the projected dynamics of the minimum wage in the region
Z2	Rent	of the forecast dynamics of the renting cost
Z3	Cost of energy	of projected dynamics of the cost of energy resources in the region

Index-E provides an opportunity to add 1-5 corrections of each indicators' values for all facilities during the period of up to 15 years, which corresponds with the time period for determining the estimated cost of SPS implementation for the DBN B.2.2-6: 2013 [6].

Formation of indicator values correction over the years is carried out together with the introduction of initial values at the bottom of the window: 1) enter the initial value; 2) select the parameter of correction of the entered number (increase "+" or decrease "-", figure 3); 3) specify the percentage of the number of the initial value for which it is planned to increase or decrease the value of a particular year during the period prescribed for the current calculation; 4) select the serial number of the year (figure 4), from which the initial value of the indicator will be automatically replaced by an increase or decrease to the specified percentage by the number. The adjusted value is valid for subsequent years during the forecast period. For the years before the first correction (or in the absence of correction values for a particular indicator), calculation is made using the initial value without its changes.

For example: the initial value of one of the indicators = 10; duration of the projected period = = 15 years; for the value of one of the indicators, the following corrections are given: from the 3rd year "-10%"; from the 6th year "-20"; from the 9th year "-50%"; from the 12th year "+ 20%"; from the 14th year "+ 90%".

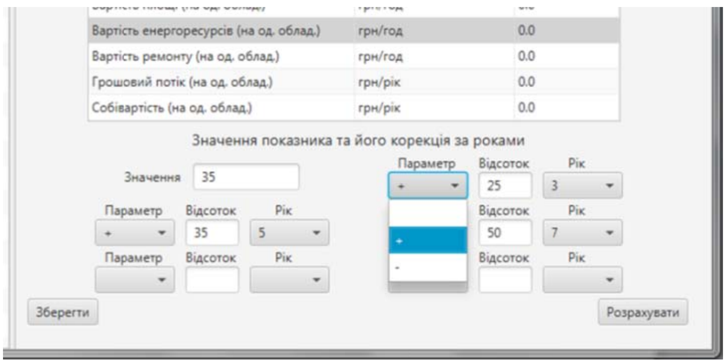


Figure 3 – Choosing the parameter for the correction of the initial value of the indicator

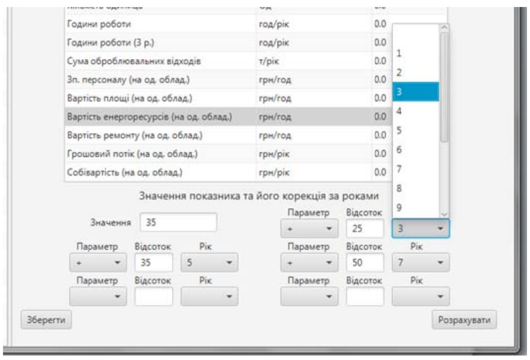
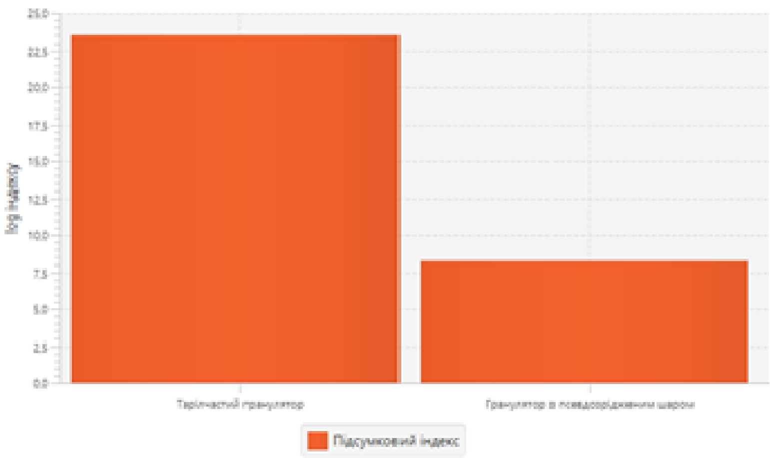


Figure 4 – Choosing the year for the correction of the initial value of the indicator

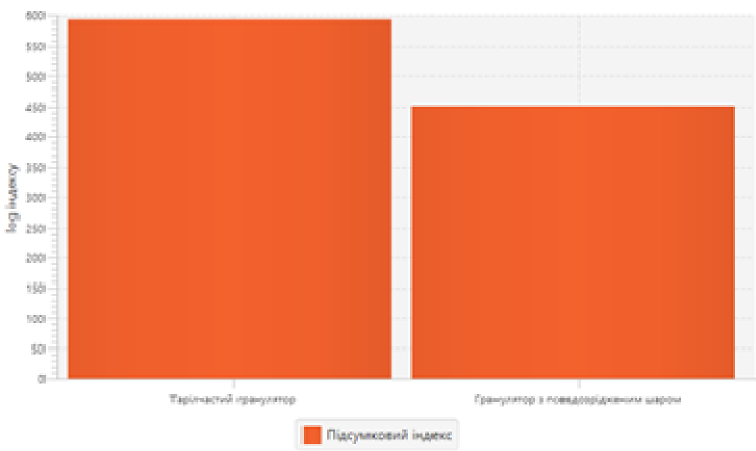
Then the automated calculation of the index of ecological and economic efficiency will have the following dynamics of change: 1st year - "10"; 2nd year - "10"; 3rd year - "9"; 4th year - "9"; 5th year - "9"; 6th year - "8"; 7th year - "8"; 8th year - "8"; 9th year - "5"; 10th year - "5"; 11th year - "5"; 12th year - "12"; 13th year - "12"; 14th year - "19"; 15th year is "19".

It is important to take into account the logical connection of all value corrections by indicators with each other. For example, if the project is planned to modernize or change the initial composition of technological equipment at the 8th year of its operation (supposed scheduled commissioning of additional filters for the treatment of air emissions in accordance with changes in international waste management requirements) and the estimated cost of purchasing an additional unit of equipment is 15% of the initial costs when purchasing a unit of basic equipment, then the correction of the indicator "Cost of the unit equip.", "7 Year -" -100% "; 8th year - "-85%". It is also advisable to make a dependent correction of the value for the "Emission Capacity (per unit)", based on the expected technical characteristics (for example, the next correction of this indicator: the 8th year - "-65%"). The nature of the interaction between value corrections of all calculation variables may vary depending on the technical tasks of design work. This allows coordination of environmental dynamics and technical and economic indicators when modeling possible options for project development.

As a result of the calculation, the Index-E program forms the visualized values of annual and final indices characterizing the investigated technical equipment in the forecast period in the form of diagrams presented in the "Results of calculation" window (figure 5). The generated automatic report of the pro-



A)



B)

Figure 5 – Results of the calculation of the final indices of the ecological - A) and economic - B) effect of the facilities (average values of the coefficients of profit and the impact of equipment on the environment per 1 ton of treated waste)

gram consists of 9-13 pages (depending on the number of specified objects (1 to 5)) and contains the following main blocks:

- user profile of the program and the current project;
- input data for the facilities being investigated;
- results of annual calculation indices of ecological and economic efficiency of facilities (fig. 5);
- evaluation of the results of the final calculation indices of the predicted ecological and economic efficiency of the equipment (table 2).

In order to objectively and reasonably formulate the equipment for WMS, it is expedient to evaluate the results of calculating ecological and economic indices based on the criteria contained in the automatic report (table 2).

Table 2 – Criteria for evaluating the results of the final indices calculating of ecological and economic efficiency of equipment

The value of "Index Y1" (average value of equipment impact on the environment per 1 ton of treated waste)	**Estimation of the index value**
«= 0»	the indexing object is considered environmentally safe for the current project
«> 0» (and the values of the emission (discharges) of pollutants from the unit of equipment do <u>not exceed</u> the established norms of pollutants MPC)	the indexing object is considered to be environmentally safe for the current project
«> 0» (but the values of the emission (discharges) of pollutants from the unit of equipment <u>exceed</u> the established norms of MPC pollutants)	the indexing object is considered conditionally environmentally hazardous for the current project
The value of "Index Y2» (average value of profit per equipment per year per 1 ton of treated waste)	**Estimation of the index value**
«> 0»	the indexing object is considered relatively economically profitable for the project
«< 0» \ «= 0»	the indexing object is considered to be conditionally economically unprofitable for the current project

In addition to evaluating a fixed list of criteria for simulation facilities based on the calculated final indices, their comparative analysis is also expedient. Depending on the difference between the obtained values of the indexes Y1 or Y2 for each equipment option (in the calculation of the project for comparing several equipment analogs), the ratio of environmental safety (or economic profitability (or unprofitability)) of the facilities is determined as a percentage. For example: "Object A is 20% more environmentally friendly (or more economically viable) compared to Object B", which gives object "A" the advantage of being selected from known analogues of specialized equipment for the design of WMS. Scores and analitical conclusion regarding the facilities taken into account may be included in the corresponding summary table for convenient further use.

In order to increase the adequacy of the forecasting results, the evaluation and comparative analysis of the annual index X2 and the final index Y2 for several facilities of the study are carried out taking into account the ratio of the documented performance characteristics of each of the equipment options.

The results of the evaluation of the indexes Y1 and Y2 give the opportunity to group the research facilities by compliance degree categories with the criteria of evaluation, to form several alternatives to the composition of technological lines with different levels of environmental and economic efficiency. The Index-E program contains detailed auxiliary materials on how to calculate the used mathematical model. To visualize the work instructions in the program, the user is provided with a video demonstration of the automated calculation (access mode to the electronic source: https://youtu.be/c2yFIOhe_zY).

The educational and professional training of environmental specialists and improves their skills, promotes the efficiency of the development of the WMS of small settlements. This is a particularly important stage in training specialists that are needed for independent control and evaluation of the ecological and economic efficiency of specialized engineering projects and technical complexes for the collection, transportation, placement, storage, processing or utilization of waste of various genesis.

Conclusions. Thus, the proposed mathematical model and algorithm of ecologically economic evaluation is an effective scientific and methodological tool for substantiating the selection of the technical equipment of WMS. Even with insignificant differences in the documented characteristics of equipment, the method makes it possible to simplify the optimization of the technical basis for the implementation of small settlements SPS and to predict and minimize ecological and economic risks in long-term functioning.

The practical application of the proposed "Index-E" software in the process of developing schemes for sanitary cleaning of small settlements, allows increasing ecological safety of WMS by forecasting, evaluating and analyzing the ecological and economic effectiveness of their technical equipment.

Application of the developed methodical and software complex in the educational process of ecologists professional training as a simulator of ecological and economic processes is aimed at consolidating the theoretical basis of professional knowledge and in carrying out scientific and practical works by students of "Ecology and environment protection". This provides an opportunity to improve the professional skills of the formation, management and modernization of WMS by combining the basic parameters of the specialized technical equipment operation.

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ҚАЛДЫҚТАРДЫ БАСҚАРУ ТИІМДІЛІГІН МОДЕЛДЕУ

Аннотация. Мақалада Украинадағы қалдықтарды басқарудың қазіргі проблемалары, атап айтқанда, кішігірім елді мекендер контекстінде талданады. Қалдықтарды басқару саласындағы белгілі әдістер мен болжау құралдары қарастырылады. Экологиялық және экономикалық тиімділікті математикалық модельдеуді, бағалауды, жұмыс режимдерін оңтайландыруды және қалдықтарды басқару жүйелерін техникалық қолдауды шағын қалалар үшін санитарлық схемаларды дамыту үшін іріктеуді іске асыру үшін жаңа компьютерлік бағдарлама ұсынылады. Оңтайлы жабдықты таңдау үшін кірістілік индекстерінің автоматтандырылған есептеуі және экологиялық қауіпсіздік туралы мысал келтірілген. Кішігірім елді мекендердегі санитария схемаларының экологиялық қауіпсіздігін арттыруды негіздеу мақсатында оның параметрлері бойынша болжамды өзгерістерді ескере отырып, жоспарланған жұмыс режимінің сипаттамаларын талдау негізінде оңтайлы мамандандырылған техникалық құралдарды қалыптастыру әдісі ұсынылды. Бұл практикалық жұмысты жүзеге асыру кезінде қателерді азайтады және тәуелсіз шешімдер қабылдаудың тиімділігін арттыруға көмектеседі. Зерттеудің теориялық және ғылыми-практикалық нәтижелерін қолдану негізгі принциптер мен заңнамалық арнайы шараларды іске асыруға ықпал етеді. Өндірілген бағдарламалық қамтамасыз етуді қолдану өндірістік және ғылыми, сондай-ақ оқу үдерісінде студенттер мен магистранттардың кәсіби білімінің теориялық негіздерін нығайту мақсатында экологиялық және экономикалық процестерді симулятор ретінде тиімді қолдануға болады.

Түйін сөздер: модельдеу, бағалау, қалдықтар, экоэкономикалық тиімділік, болжам, компьютерлік бағдарлама «Index-E».

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МОДЕЛИРОВАНИЕ ЭФФЕКТИВНОСТИ УПРАВЛЕНИЯ ОТХОДАМИ

Аннотация. В статье проанализирована современная проблематика обращения с отходами в Украине, в частности в условиях малых населенных пунктов. Рассмотрены известные методы и средства прогнозирования в сфере управления отходами. Предложена новая компьютерная программа для осуществления математического моделирования эколого-экономической эффективности, оценки, обоснования оптимизации режимов эксплуатации и подбора состава технического обеспечения систем обращения с отходами при разработке схем санитарной очистки малых городов. Приведен пример проведения автоматизированного расчета индексов рентабельности и экологической безопасности об избрании оптимального оборудования. На основе анализа характеристик режима плановой операции с учетом прогнозируемых изменений ее параметров в целях обоснования повышения экологической безопасности схем санитарной очистки малых поселений предложен путь формирования оптимальной специализированной технической оснастки. Это снижает риск ошибок при осуществлении практической работы и помогает повысить эффективность принятия независимых решений. Применение теоретических и научно-практических результатов исследования будет способствовать реализации основных принципов и законодательных специальных мер. Разработанное программное приложение может эффективно применяться как в промышленном, так и в научном, а также в учебном процессе как симулятор экологических и экономических процессов, чтобы укрепить теоретические основы профессиональных знаний студентов и аспирантов.

Ключевые слова: моделирование, оценка, отходы, эколого-экономическая эффективность, прогноз, компьютерная программа «Индекс-Э».

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