

UDC 332.1+711:334:338.4:658.8

DOI: <https://doi.org/10.46783/smart-scm/2022-15-2>

JEL Classification: H70, K32, M11, O18, Q20, R13, R58.

**Received:** 10 September 2022

**Hryhorak M.Yu.** Doctor of Economics, Associate Professor, Senior Research Fellow in Institute of Cybernetics of the National Academy of Sciences of Ukraine (Ukraine)

**ORCID** – 0000-0002-5023-8602

**Researcher ID** –

**Scopus author id:** 57208222758

**Zakharchenko O.V.** Doctor of Sciences (Economics), Associate Professor, Professor of the Department of Management and Administration, Rauf Ablyazov East European University (Ukraine)

**ORCID** – 0000-0001-8198-6569

**Researcher ID** –

**Scopus author id:** – 57201253494

**Harmash O.M.** PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine)

**ORCID** – 0000-0003-4324-4411

**Researcher ID** – I-4542-2018

**Scopus author id:** – 57218381499

**Trushkina N.V.** PhD (Economics), Senior Research, Doctoral Student, Research Centre of Industrial Problems of Development of NAS of Ukraine (Ukraine)

**ORCID** – 0000-0002-6741-7738

**Researcher ID** – C-1441-2018

**Scopus author id:** – 57210808778

**Lunov L. Ye.** Postgraduate, Institute of Industrial Economics of the National Academy of Sciences of Ukraine (Ukraine)

**ORCID** –

**Researcher ID** –

**Scopus author id:** –

## **INFRASTRUCTURE PROVISION OF INDUSTRIAL WASTE MANAGEMENT IN THE CONTEXT OF THE STRATEGY FOR RECOVERY OF THE NATIONAL ECONOMY OF UKRAINE**

*Hryhorak Mariia, Zakharchenko Oleh, Harmash Oleh, Trushkina Nataliia, Lunov Lev.  
"Infrastructure provision of industrial waste management in the context of the strategy for recovery of*

*the national economy of Ukraine". The article proposes an integrated approach to evaluating the development of the industrial waste management system on the example of the Kyiv region. This approach is based on the application of a set of indicators that characterize the current state of functioning of this system from the ecological and economic points of view. On the basis of the received results of the conducted diagnostics, barriers, threats, ecological principles of functioning of the regional industrial waste management system were identified.*

*As a result of the study, it was proved that for effective infrastructural support of industrial waste management, it is advisable to implement a comprehensive approach, the essence of which is the integration of the principles of transformation of the industrial waste management system, the implementation of the reverse logistics algorithm, the main components of the organizational and economic mechanism (functions, methods, management tools, information systems, digital, "green" and innovative technologies), financial instruments of green investment for the implementation of the regional industrial waste management strategy.*

*The implementation of the proposed integrated approach will contribute to the adoption of justified innovative decisions on the greening of logistics activities and environmental management; timely solution of problems of management of return flows of production waste using the principles of reverse logistics; minimization of the negative impact on the environment by reducing the volume of waste generation, increasing the volume of processing and reuse of industrial waste; effective implementation of circular economy models, transition to expanding producer responsibility; increasing the level of environmental safety of the region and the country; achieving the goals of sustainable development of the national economy.*

*It has been established that in order to improve the industrial waste management system in the region, it is expedient to: introduce the latest technologies and equipment for collection, sorting, transportation, processing and utilization of waste taking into account advanced European practices; promoting the use of waste recycling as secondary raw materials on the basis of "green" investment; development of a financial mechanism for the application of public-private partnership based on attracting private investments and other non-budgetary sources of financing in the field of industrial waste management; creation of an appropriate cluster structure as an organizational form of partnership in the field of industrial waste management; development and implementation of tools for economic stimulation of industrial waste utilization; implementation of the concept of reverse logistics in the context of the green and circular economy.*

**Keywords:** national economy, natural environment, industrial waste, industrial waste management, regional waste management system, infrastructural support, waste management hierarchy, waste recycling, reverse logistics, ecological principles, green economy, circular economy, sustainable development, transformation, green investment, green technologies, integrated approach, logistics infrastructure, cluster structure, synergistic effect.

**Григорак Марія, Захарченко Олег, Гармаш Олег, Трушкіна Наталія, Лунов Лев.** **«Інфраструктурне забезпечення управління промисловими відходами у контексті стратегії відновлення національної економіки України».** У статті запропоновано інтегрований підхід до оцінювання розвитку системи управління промисловими відходами на прикладі Київської області. Даний підхід базується на застосуванні комплексу показників, які характеризують поточний стан функціонування даної системи з екологічної та економічної точок зору. На підставі одержаних результатів проведеної діагностики виявлено бар'єри, загрози, екологічні засади функціонування регіональної системи управління промисловими відходами.

У результаті дослідження доведено, що для дієвого інфраструктурного забезпечення управління промисловими відходами доцільно впроваджувати комплексний підхід, суть якого полягає в інтеграції принципів трансформації системи управління промисловими відходами, впровадження алгоритму реверсивної логістики, основних складових організаційно-економічного механізму

(функцій, методів, засобів управління, інформаційних систем, цифрових, «зелених» та інноваційних технологій), фінансових інструментів зеленого інвестування для реалізації регіональної стратегії управління промисловими відходами.

Впровадження запропонованого комплексного підходу сприятиме прийняттю обґрунтованих інноваційних рішень з екологізації логістичної діяльності та екологічного менеджменту; своєчасному вирішенню проблем з управління зворотними потоками відходів виробництва із застосуванням принципів реверсивної логістики; мінімізації негативного впливу на довкілля за рахунок скорочення обсягу утворення відходів, збільшення обсягу переробки та повторного використання промислових відходів; дієвому впровадженню моделей циркулярної економіки, переходу до розширення відповідальності виробників; підвищенню рівня екологічної безпеки регіону та країни; досягненню цілей сталого розвитку національної економіки.

Встановлено, що задля вдосконалення системи управління промисловими відходами у регіоні доцільним є: впровадження новітніх технологій і устаткування зі збирання, сортування, транспортування, переробки та утилізації відходів з урахуванням передової європейської практики; сприяння використанню рециклінгу відходів як вторинної сировини на засадах «зеленого» інвестування; розроблення фінансового механізму застосування державно-приватного партнерства на основі залучення приватних інвестицій та інших позабюджетних джерел фінансування у сферу управління промисловими відходами; створення відповідної кластерної структури як організаційної форми партнерства в сфері управління промисловими відходами; розроблення й впровадження інструментів економічного стимулювання утилізації промислових відходів; реалізація концепції реверсивної логістики у контексті зеленої та циркулярної економіки.

**Ключові слова:** національна економіка, навколишнє природне середовище, промислові відходи, управління промисловими відходами, регіональна система управління відходами, інфраструктурне забезпечення, ієрархія управління відходами, рециклінг відходів, реверсивна логістика, екологічні засади, зелена економіка, циркулярна економіка, сталий розвиток, трансформація, зелене інвестування, зелені технології, комплексний підхід, логістична інфраструктура, кластерна структура, синергетичний ефект.

**Григорак Марія, Захарченко Олег, Гармаш Олег, Трушкіна Наталія, Лунов Лев.** **"Инфраструктурное обеспечение управления промышленными отходами в контексте стратегии восстановления национальной экономики Украины".** В статье предложен интегрированный подход к оценке развития системы управления промышленными отходами на примере Киевской области. Данный подход основан на применении комплекса показателей, характеризующих текущее состояние функционирования данной системы с экологической и экономической точек зрения. На основании полученных результатов проведенной диагностики выявлены барьеры, угрозы, экологические основы функционирования региональной системы управления промышленными отходами.

В результате исследования доказано, что для действенного инфраструктурного обеспечения управления промышленными отходами целесообразно внедрять комплексный подход, суть которого заключается в интеграции принципов трансформации системы управления промышленными отходами, внедрении алгоритма реверсивной логистики, основных составляющих организационно-экономического механизма (функций, методов, средств управления, информационных систем, цифровых, зеленых и инновационных технологий), финансовых инструментов зеленого инвестирования для реализации региональной стратегии управления промышленными отходами.

Внедрение предложенного комплексного подхода будет способствовать принятию обоснованных инновационных решений по экологизации логистической деятельности и

*экологическому менеджменту; своевременному решению проблем по управлению обратными потоками отходов производства с применением принципов реверсивной логистики; минимизации негативного влияния на окружающую среду за счет сокращения объема образования отходов, увеличения объема переработки и повторного использования промышленных отходов; действенному внедрению моделей циркулярной экономики, переходу к расширению ответственности производителей; повышению уровня экологической безопасности региона и страны; достижению целей устойчивого развития национальной экономики.*

*Установлено, что для совершенствования системы управления промышленными отходами в регионе целесообразно: внедрение новейших технологий и оборудования для сбора, сортировки, транспортировки, переработки и утилизации отходов с учетом передовой европейской практики; содействие использованию рециклинга отходов в качестве вторичного сырья на основе «зеленого» инвестирования; разработка финансового механизма применения государственно-частного партнерства на основе привлечения частных инвестиций и других внебюджетных источников финансирования в сфере управления промышленными отходами; создание соответствующей кластерной структуры как организационной формы партнерства в области управления промышленными отходами; разработка и внедрение инструментов экономического стимулирования утилизации промышленных отходов; реализация концепции реверсивной логистики в контексте зелёной и циркулярной экономики.*

**Ключевые слова:** национальная экономика, окружающая среда, промышленные отходы, управление промышленными отходами, региональная система управления отходами, инфраструктурное обеспечение, иерархия управления отходами, рециклинг отходов, реверсивная логистика, экологические основы, зеленая экономика, циркулярная экономика, устойчивое развитие, трансформация, зеленое инвестирование технологии, комплексный подход, логистическая инфраструктура, кластерная структура, синергетический эффект.

**Introduction.** In modern conditions, the established regional industrial waste management systems in Ukraine are not effective enough. This is due, first of all, to the imperfection of the institutional support for the implementation of the waste management mechanism (processes of collection, transportation, storage, processing, disposal, removal, disposal and burial), which leads to an increase in the volume of their accumulation; lack of means of waste management; low level of implementation of low-waste technologies and creation of logistics infrastructure and corresponding cluster structures for waste management; insufficient volume of investments in industrial waste recycling; negative consequences of Russian aggression against Ukraine.

At the same time, it should be noted that there is a lack of theoretical and methodological foundations for the formation of regional waste management

systems in Ukraine in the conditions of European integration and decentralization of power, methods of analysis of the process of generation and utilization of industrial waste in regional ecosystems, methodical approaches to determining factors influencing the functioning of the logistic infrastructure of waste recycling and criteria for its improvement creates problems in the formation of scientifically based development of regional industrial waste management plans. All this has a negative impact on the current state of the natural environment and leads to an increase in environmental load, possible environmental risks, and thereby reduces the level of environmental safety in the regions of Ukraine.

Therefore, it is expedient to change the modern paradigm of environmental thinking and environmental policy, search for innovative tools, "green" and logistical solutions, substantiate the theoretical and methodological foundations and develop

scientific and applied proposals, as well as introduce fundamentally new organizational, economic and management approaches and "green" technologies to improve the functioning of the regional industrial waste management system in the context of the concepts of circular economy and balanced sustainable development. Let's consider it on the example of the Kyiv region.

At present, the implementation of an ecologically balanced system of nature management and preservation of natural ecosystems, the development of a regional Concept and Strategy for the management of industrial waste, the introduction of innovative waste recycling technologies, the use of public-private partnership as an effective mechanism for the functioning of logistics infrastructure are recognized as priority tasks for the effective implementation of environmental policy in the Kyiv region. Leveling of environmental risks from the negative impact of logistics activities on the environment, etc. This corresponds to the main provisions of the National Waste Management Strategy in Ukraine until 2030, the State Regional Development Strategy for 2021-2027, the National Waste Management Plan until 2030 within the framework of the implementation of the Framework Directive 2008/98/EU "On Waste", Directive 1999/31/EC "On waste disposal", 2000/53/EC (End-of-life vehicles, ELV) Recycling, 2006/21/EC "On waste management of mining enterprises", 2012/19/EC "On electrical and electronic equipment waste (WEEE)" and the Association Agreement between Ukraine and the European Union.

**Literature and researches review.** The issues of modernization of the industrial waste management system and the corresponding logistics infrastructure are regulated by a number of legislative and normative legal acts (with amendments), among them: the Law of Ukraine "On Protection of the Natural Environment" dated June 25, 1991 No. 1264-XII; Law of Ukraine "On Radioactive Waste Management" dated June 30, 1995 No. 255/95-VR; Law of Ukraine

"On Waste" dated March 5, 1998 No. 187/98-VR; Law of Ukraine "On the Nationwide Targeted Environmental Program for the Management of Radioactive Waste" dated September 17, 2008 No. 516-VI; Law of Ukraine "On Public-Private Partnership" dated July 1, 2010 No. 2404-VI; Law of Ukraine "On Environmental Impact Assessment" dated May 23, 2017 No. 2059-VIII; Decree of the Cabinet of Ministers of Ukraine "On the approval of the National Waste Management Strategy in Ukraine until 2030" dated November 8, 2017 No. 820; Decree of the Cabinet of Ministers of Ukraine "On approval of the National Waste Management Plan until 2030" dated February 20, 2019 No. 117-p; Resolution of the Cabinet of Ministers of Ukraine "On Approval of the State Strategy for Regional Development for 2021-2027" dated August 5, 2020 No. 695; Order of the Ministry of Environmental Protection and Natural Resources of Ukraine "On Approval of Methodological Recommendations for the Development of Regional Waste Management Plans" dated September 10, 2021 No. 586; Regional development strategies for the period until 2027, etc.

The problems of transformation of regional industrial waste management systems using the principles of green economy are of constant interest to scientists and practitioners. As the analysis of literary sources shows, a significant number of scientific works of scientists are devoted to the justification of scientific and methodological approaches to waste recycling and the improvement of regulatory, legal, institutional, organizational, economic, financial and information support for industrial waste management, such as: R. Marshall, K. Farahbakhsh [1]; A. Bartoleto [2]; I. Koblianska [3]; T. Safranov, M. Klymenko et al. [4]; V. Mishchenko, Yu. Makovetska, T. Omelianenko [5]; H.-C. Brauweiler, V. Shkola, O. Markova [6]; T. Halushkina et al. [7]; T. Antonova [8]; N. Pinkevich [9]; R. Timchenko, D. Krishko, Ye. Titunin [10]; O. Kononenko, V. Molodyka [11]; O. Kravchenko et al. [12]; I. Kolodiichuk [13]; V. Yevdokymenko [14]; O.

Minina, N. Shadura-Nykyporets [15]; V. Plokhyy [16]; M. Barinov et al. [17]; M. Melnykova, V. Shkryhun, N. Khazanova [18]; R. Naboka [19]).

In the scientific literature, there are many approaches to considering the environmental component of logistics (Z. Jianwei, Z. Minjie, Z. Liwei [20]; S. Pulawska, W. Starowicz [21]; L. Simão, M. Gonçalves, C. M. T. Rodriguez [22]; M. Moroz, Z. Polkowski [23]; I. Urbanyi-Popiołeka [24]; W. Liu et al. [25]). It should be noted that research by international consulting companies confirms the relevance of green logistics development issues. As a result of research, foreign (S. Luthra, D. Garg, A. Haleem [26]; C. Geiger [27]; F. Barzinpour, P. Taki [28]; C. Pierre, P. Francesco, N. Theo [29]) and domestic (A. Mazaraki, L. Kharsun [30]; T. Kobylinska [31]; Yu. Sahaidak, T. Kharchenko [32]) scientists established that the evolution of the development, establishment, formation and further structuring of green logistics are closely intertwined with logistic principles.

Researchers (D. Rogers, R. Tibben-Lembke [33]; S. Dowlatshahis [34]; S. Srivastava [35]; D. Lee, M. Dong [36]; F. McLeod et al. [37]; M. Starostka-Patyk, V. Popa [38]; A. Mesjasz-Lech [39]) pay considerable attention to the substantiation of the conceptual provisions of the development of reverse logistics in the circular economy system.

In recent years, scientists (J. Coyle et al. [40]; D. Bowersox, D. Closs [41]; Ye. Krykavskyy et al. [42; 43]; O. Bondarenko [44]; A. Hlaskova [45]; O. Karyi, H. Podvalna [46]; O. Sumets, T. Babenkova [47]; I. Blahun, I. Nychyk [48]; N. Smyrnova [49]; I. Sadchykova [50]) have been actively engaged in solving the urgent problems of the formation and functioning of logistics infrastructure in the context of ensuring the sustainable development of the national and regional economy.

Despite the wide range of scientific developments on the chosen topic, further scientific research on the formation of the logistics infrastructure of industrial waste management, taking into account the regional characteristics of the Kyiv region, is

timely and relevant. For quality monitoring of the environment, finding ways to solve the problem of increasing the level of environmental safety, it is advisable to perform an analytical assessment of the current state of development of the industrial waste management system in the Kyiv region. And this problem acquires special importance in the modern conditions of transformation of the regional logistics system and creation of appropriate infrastructure (for example, cluster formations) in the context of the European Green Deal.

**Aim and objectives.** *The purpose of this article* is to study the development trends of the regional industrial waste management system on the example of the Kyiv region; identification of modern problems of formation of proper regional logistics infrastructure; substantiation of the feasibility of applying a comprehensive approach to infrastructural provision of industrial waste management in the context of the strategy of recovery of the national economy of Ukraine.

*The methodological basis of the research* is the provisions of theories of sustainable and regional development, concepts of green and circular economy. Research of modern processes of formation of waste management systems is based on the use of methods: economic-statistical analysis, balance, modeling, analogies and synthesis, system approach, comparisons and observations, classification, structural-logical generalization, etc.

Scientific provisions, conclusions and recommendations are based on fundamental theoretical developments on the formation of waste management systems at the regional level. The basis of the study was the achievements of modern economic science, scientific works of leading domestic and foreign scientists and practitioners in the field of waste recycling, nature management, problems of ensuring sustainable development of territories and finding new ways to achieve it, in particular, through waste management.

*The information base of the research* was: legislative and regulatory acts of Ukraine, Development Strategy of the Kyiv Region for 2021-2027, Regional Waste Management Plan of the Kyiv Region until 2030, official materials of the State Statistics Service of Ukraine and the Main Department of Statistics in the Kyiv Region, Ministry of Environmental Protection and natural resources of Ukraine, the Ministry of Development of Communities and Territories of Ukraine, scientific publications of foreign and domestic scientists.

### **Results, analysis and discussion.**

Statistical analysis shows that the total volume of emissions of pollutants and greenhouse gases into the atmospheric air in the Kyiv region increased by 33.3% during 2000-2020 due to an increase in emissions by mobile sources by 80.9%. However, the volume of emissions of pollutants and greenhouse gases into the atmosphere by stationary sources decreased by 17.7% (Table 1).

Table 1 – Dynamics of emissions of pollutants and greenhouse gases into the atmosphere by stationary and mobile sources

| Years | Total volume,<br><i>thousand tons</i> | Including sources, <i>thousand tons</i> |        |
|-------|---------------------------------------|---|--------|
|       |                                       | stationary                              | mobile |
| 2000  | 167.5                                 | 80.8                                    | 86.7   |
| 2005  | 170.0                                 | 73.0                                    | 97.0   |
| 2006  | 201.9                                 | 108.3                                   | 93.6   |
| 2007  | 251.3                                 | 93.3                                    | 158.0  |
| 2008  | 289.8                                 | 107.4                                   | 182.4  |
| 2009  | 266.7                                 | 101.9                                   | 164.8  |
| 2010  | 269.0                                 | 106.8                                   | 162.2  |
| 2011  | 278.6                                 | 113.6                                   | 165.0  |
| 2012  | 308.0                                 | 129.4                                   | 178.6  |
| 2013  | 277.3                                 | 111.9                                   | 165.4  |
| 2014  | 252.1                                 | 96.2                                    | 155.9  |
| 2015  | 203.6                                 | 78.1                                    | 125.5  |
| 2016  | 210.2                                 | 98.2                                    | 112.0  |
| 2017  | 162.0                                 | 48.2                                    | 113.8  |
| 2018  | 197.0                                 | 81.3                                    | 115.7  |
| 2019  | 214.7                                 | 84.4                                    | 130.3  |
| 2020  | 223.3                                 | 66.5                                    | 156.8  |

Source: compiled according to the data of the Main Department of Statistics in the Kyiv region.

Investigating the development of the regional industrial waste recycling system, it was established that the amount of generated waste decreased by 26.6% in 2020 compared to 2010, and the amount of waste disposed of decreased by 98.6%. It is worth noting that in the Kyiv region there is a trend of significant growth in the ratio between the volumes of generated and disposed of waste. Thus, the

value of this indicator increased in the region for 2010-2020 from 2.3 to 118.3 times. The volume of removed industrial waste to specially designated places or facilities decreased by 2.2%. The volumes of waste accumulated during operation in specially designated places or objects in the region increased by 2.6 times (Table 2).

Table 2 –Indicators of the development of the waste recycling system

| Years | Volumes of waste, thousand tons |          |  |  |
|-------|---------------------------------|----------|--|--|
|       | formed                          | disposed | removed to specially designated places or facilities | accumulated during operation, in specially designated places or objects (waste disposal sites) |
| 2010  | 2932.2                          | 1296.9   | 1715.6   | 37042.0  |
| 2011  | 6626.3                          | 952.4    | 5070.4   | 41489.6  |
| 2012  | 3015.9                          | 571.1    | 1736.8   | 40335.4  |
| 2013  | 2427.8                          | 536.5    | 1578.2   | 41702.5  |
| 2014  | 1272.1                          | 94.4     | 1417.7   | 41502.9  |
| 2015  | 1660.5                          | 127.3    | 1283.6   | 44171.5  |
| 2016  | 1561.3                          | 53.9     | 1393.2   | 45429.3  |
| 2017  | 1265.6                          | 20.2     | 1131.7   | 43140.0  |
| 2018  | 1394.0                          | 33.8     | 1348.4   | 45499.1  |
| 2019  | 1414.6                          | 9.7      | 1535.9   | 46710.8  |
| 2020  | 2153.6                          | 18.2     | 1677.7   | 95588.2  |

Source: compiled on the basis of information materials of the Main Department of Statistics in the Kyiv region; of the "Environment" section of the official website of the State Statistics Service of Ukraine.

According to the analysis of information and analytical materials, the volume of waste generated from the economic activity of enterprises in the Kyiv region increased by 3.4

times during 2017-2020, and their specific weight in the total volume of generated waste increased by 45.5 percentage points (Table 3).

Table 3 – Dynamics of the amount of generated waste by types of economic activity

| Indicators  | Years  |        |        |        |
|---|--------|--------|--------|--------|
|   | 2017   | 2018   | 2019   | 2020   |
| Total volume, <i>thousand tons</i>                                    | 1265.6 | 1394.0 | 1414.3 | 2153.6 |
| Waste from the economic activity of enterprises, <i>thousand tons</i> | 593.1  | 739.4  | 950.7  | 1990.1 |
| Share in the total volume, %  | 46.9   | 53.0   | 67.2   | 92.4   |

Source: compiled on the basis of information materials of the Main Department of Statistics in the Kyiv region; of the "Environment" section of the official website of the State Statistics Service of Ukraine.

It should be noted that the situation with investing in the development of the waste management system in the Kyiv region is significantly deteriorating. This is evidenced by the low share of capital investments for waste management in the entire region. This was especially observed in 2011, 2012, 2014, 2015. Only in 2019 did the situation improve somewhat – the value of this indicator was 65.7%, which is 49.8 percentage points higher compared to 2010. The share of capital

investments for waste management decreased by 11.3% in 2010-2020 or from 15.9 to 4.7% of the total amount of capital investments for environmental protection for all types of environmental protection activities. However, during this period, the specific weight of capital investments for atmospheric air protection and climate change problems increased by 5 percentage points (Table 4).



Table 4 – Dynamics of capital investments by types of environmental protection activities

| Years | The total volume of capital investments (in actual prices), thousand UAH | Including the main types of environmental protection activities |          |                  |          |
|-------|--|---|----------|------------------|----------|
|       |  | protection of atmospheric air and problems of climate change    |          | waste management |          |
|       |  | thousand UAH  | share, % | thousand UAH     | share, % |
| 2010  | 53446.6  | 6622.3  | 12.39    | 8520.2           | 15.94    |
| 2011  | 1398332.6  | 63679.9   | 4.55     | 20979.8          | 1.50     |
| 2012  | 1948849.6  | 18509.3   | 0.95     | 14690.7          | 0.75     |
| 2013  | 1863334.7  | 122331.2  | 6.57     | 56975.1          | 3.06     |
| 2014  | 3789621.1  | 11051.3   | 0.29     | 16568.3          | 0.44     |
| 2015  | 4157510.7  | 1945.7  | 0.05     | 17137.7          | 0.41     |
| 2016  | 8313266.1  | 3005.7  | 0.04     | 1387819.6        | 16.69    |
| 2017  | 4088520.9  | 5800.8  | 0.14     | 1132136.3        | 27.69    |
| 2018  | 1773634.6  | 5384.7  | 0.30     | 148779.1         | 8.39     |
| 2019  | 6945708.4  | 6300.2  | 0.09     | 4560371.1        | 65.66    |
| 2020  | 285410.3   | 49541.8   | 17.36    | 13382.5          | 4.69     |

Source: compiled on the basis of information materials of the Main Department of Statistics in the Kyiv region; of the "Environment" section of the official website of the State Statistics Service of Ukraine.

Statistical analysis shows that the share of current costs for waste management in 2020 was 35.8% of current costs for environmental protection for all types of environmental protection measures, or 10.6 percentage points more compared to 2010. The specific weight of current costs for protection atmospheric air and the problem of climate change decreased during this period by 2.7 percentage points. (Table 5).

Based on the analysis of the approved Development Strategy of the Kyiv region for 2021-2027, it was found that the program document does not pay enough attention to the formation of the regional logistics infrastructure for industrial waste management, which would meet the modern requirements of management. At the same time, the main weaknesses of the Kyiv region include:

- technologically and morally outdated industrial waste management system, insufficient level of their disposal;
- low indicators of the use of industrial waste as secondary raw materials in the context of the circular economy;
- insufficiently effective implementation of measures aimed at preventing the

formation, utilization, disposal and removal of waste;

- lack of a comprehensive approach to managing the recycling of industrial production waste by creating an appropriate logistics infrastructure based on the principles of the green economy.

However, as a result of the research, strengths were also revealed. So, currently active work is being done in the Kyiv region to increase the level of environmental safety. For this purpose, the Regional Waste Management Plan until 2030 (Table 6) is being developed, which provides for the implementation of the waste management system on an innovative basis.

So, as the comparative analysis of strategic documents showed, environmental safety and protection of the natural environment are among the priority areas. At the same time, it should be emphasized that only in the Regional Development Strategy until 2027 are defined waste management tasks, including: support for innovative developments and the introduction of the latest technologies in the field of waste processing and the return of resource-valuable materials to economic circulation; environmental monitoring and informing the

population about the state of the environment; creation and development of eco-networks.

Table 5 – Dynamics of current costs by types of environmental protection activities

| Years | Total current costs (in actual prices),<br>thousand UAH | Including the main types of environmental protection activities |          |                  |          |
|-------|---|---|----------|------------------|----------|
|       |   | protection of atmospheric air and problems of climate change    |          | waste management |          |
|       |   | thousand UAH  | share, % | thousand UAH     | share, % |
| 2010  | 239400.7  | 13517.8   | 5.65     | 60267.9          | 25.17    |
| 2011  | 313066.6  | 15095.3   | 4.82     | 90156.3          | 28.80    |
| 2012  | 357943.1  | 13273.4   | 3.71     | 82502.1          | 23.05    |
| 2013  | 408651.6  | 15446.7   | 3.78     | 107300.2         | 26.26    |
| 2014  | 428268.4  | 13784.2   | 3.22     | 114531.3         | 26.74    |
| 2015  | 489315.8  | 13430.4   | 2.74     | 132640.9         | 27.11    |
| 2016  | 601143.6  | 15290.7   | 2.54     | 167882.2         | 27.93    |
| 2017  | 879681.3  | 15789.8   | 1.79     | 383896.4         | 43.64    |
| 2018  | 766594.9  | 20419.1   | 2.66     | 245918.7         | 32.08    |
| 2019  | 965021.2  | 19589.0   | 2.03     | 309370.0         | 32.06    |
| 2020  | 1122821.1   | 34124.7   | 3.04     | 401815.2         | 35.79    |

Source: compiled on the basis of information materials of the Main Department of Statistics in the Kyiv region; of the "Environment" section of the official website of the State Statistics Service of Ukraine.

Table 6 – List of measures to create waste management infrastructure

| Name of the event and deadlines   | Amounts of financing, million UAH |       | Sources of funding |                 |              |                |
|---|-----------------------------------|-------|--------------------|-----------------|--------------|----------------|
|   | 2025                              | 2030  | State budget       | Regional budget | Local budget | Other sources  |
| Development of project documentation for the construction and reconstruction of waste management facilities (2021-2030) | 55.0                              | 55.0  | -                  | -               | 55.0         | -              |
| Construction of regional waste management facilities (2023-2030)  | 350.0                             | 700.0 | -                  | 50.0<br>50.0    | -            | 300.0<br>650.0 |
| Reclamation of landfills and landfills (2021-2030)  | *                                 | *     |                    |                 |              |                |

Note: \* the amount of funding will be determined in a two-year period after conducting an inventory of landfills and landfills.

Source: compiled on the basis of the project of the Regional Waste Management Plan of the Kyiv Region until 2030.

As a result of the conducted researches [51-60], it was established that for the effective functioning of the logistics infrastructure of industrial waste management (IWM) in the Kyiv region in the context of the paradigms of "green" growth,

circular economy and sustainable development, it is advisable to apply a complex approach (Figure). Its essence consists in the integration of the principles of transformation of the industrial waste management system, the implementation of

the reverse logistics algorithm, the main components of the organizational and economic mechanism (functions, methods, management tools, information systems, digital, "green" and innovative technologies),

financial instruments of green investment for the implementation regional industrial waste management strategy.

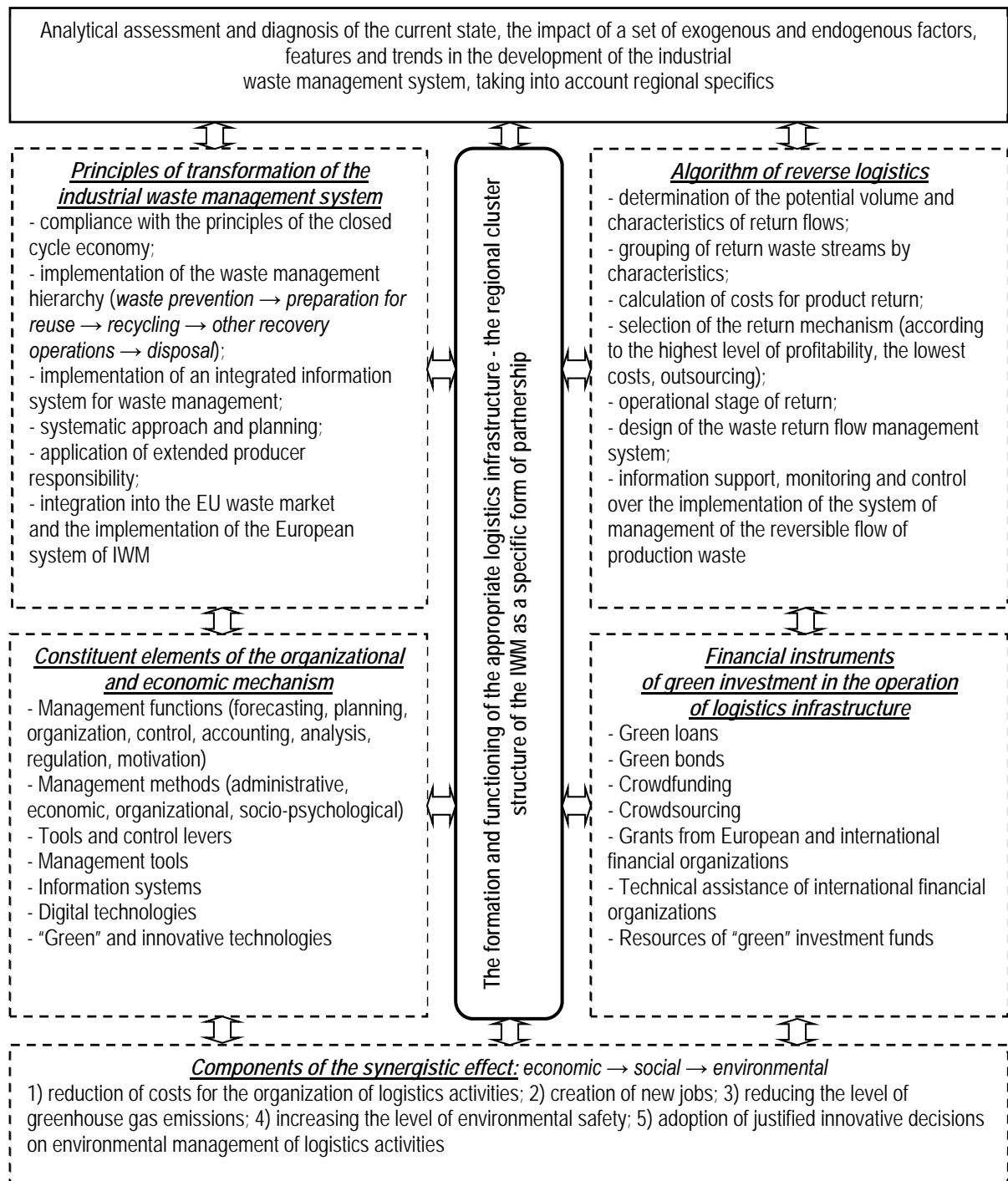


Figure 1 – A complex approach to infrastructural provision of industrial waste management

Source: author's development.

The implementation of the proposed integrated approach will contribute to the adoption of well-founded innovative

decisions on the greening of logistics activities and environmental management; timely solution of problems of management

of return flows of production waste using the principles of reverse logistics; minimization of the negative impact on the environment by increasing the volume of processing and reuse of industrial waste; effective implementation of circular economy models, transition to expanding producer responsibility; increasing the level of environmental security of the region; achieving the goals of sustainable development.

**Conclusions.** Therefore, in modern conditions, waste should be considered as an economic category, which should be based on the fact that waste is an economic object, the management of which depends on regional development.

At present, the regional and local authorities of the Kyiv region need to pay attention to the development of the Comprehensive Waste Management Program and the finalization of the Regional Industrial Waste Management Plan until 2030 with the involvement of various categories of stakeholders.

However, it should be noted that the concepts of "industrial waste" and "production waste" are not clearly defined by the current legislation of Ukraine. In this regard, it would be appropriate to introduce these concepts into national legal documents. This, in turn, would make it easier to distinguish them from other types of waste and would ensure more effective implementation of legislation in the field of industrial waste management, including as a recycling of secondary resources. In addition, the terms "waste management", "waste management hierarchy", "waste recycling", "green investments", "mechanism of "green" financing" should be included in the current legal acts that regulate the issue of waste management. For this purpose, it is expedient to introduce amendments and additions to the Laws of Ukraine "On Waste", "On Protection of the Natural Environment", "On Environmental Impact Assessment", the National Waste Management Strategy in Ukraine until 2030, the National Waste

Management Plan until 2030, the Strategy development of the Kyiv region for 2021-2027, Regional waste management plan in the Kyiv region until 2030.

And also finalize and adopt the draft law "On waste management", in which to define the classification of waste depending on the types of economic activity, the principles and mechanism of implementation of the five-level hierarchy of waste management.

In order to improve the regional industrial waste management system, it is expedient to:

- implementation of the latest technologies and equipment for collection, sorting, transportation, processing and disposal of waste taking into account advanced European practices;
- promoting the use of waste recycling as secondary raw materials on the basis of "green" investment;
- development of a financial mechanism for the application of public-private partnership based on attracting private investments and other non-budgetary sources of financing in the field of industrial waste management;
- development and implementation of tools for economic stimulation of industrial waste utilization;
- implementation of the concept of reverse logistics in the context of the green and circular economy;
- creation of an appropriate cluster structure as an organizational form of partnership in the field of industrial waste management;
- finalization and approval of regional industrial waste management strategies in the context of recovery of the national economy of Ukraine.

*Prospects for further research* in this area are the substantiation and development of conceptual provisions for the formation of a cluster structure of industrial waste management in the regions of Ukraine, taking into account the specifics of their functioning, as well as the justification of a fundamentally new concept of industrial waste management

in the context of the strategy of restoring the national economy of Ukraine.

## References

1. Marshall, R. E., Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management*, 33(4), 988-1003.
2. Bartoleto, A. P. (2015). *Waste prevention policy and behaviour. New approaches to reducing waste generation and its environmental impacts. Routledge studies in waste management and policy.* London, New York: Routledge.
3. Koblinska, I. I. (2011). Upravlinnia promyslovymy vidkhodamy v rehioni na zasadakh lohistyky [Management of industrial waste in the region on the basis of logistics]. *Economic space*, 46, 316-327 (in Ukrainian).
4. Safranov, T. A., Klymenko, M. O. (Eds.) (2012). *Upravlinnia ta povodzhennia z vidkhodamy* [Management and handling of waste]. Odesa: Odesa State Environmental University (in Ukrainian).
5. Mishchenko, V. S., Makovetska, Yu. M., Omelianenko, T. L. (2013). *Instytutsionalnyi rozvytok sfery povodzhennia z vidkhodamy v Ukraini: na shliakhu yevropeiskoi intehratsii* [Institutional development of the field of waste management in Ukraine: on the way to European integration]. Kyiv: State University "Institute of Environmental Economics and Sustainable Development of the National Academy of Sciences of Ukraine" (in Ukrainian).
6. Brauweiler, H.-C., Shkola, V., Markova, O. (2017). Economic and legal mechanisms of waste management in Ukraine. *Marketing and Innovation Management*, 2, 359-368. <http://doi.org/10.21272/mmi.2017.2-33>.
7. Halushkina, T. P. et al. (2017). *Osnovni zasady vprovadzhennia modeli «zelenoi» ekonomiky v Ukraini* [The main principles of the implementation of the "green" economy model in Ukraine]. Kyiv: Institute of Environmental Management and Balanced Nature Management (in Ukrainian).
8. Antonova, T. L. (2017). *Ponyatiye i elementy mekhanizma administrativno-pravovogo regulirovaniya sfery obrashcheniya s otkhodami* [The concept and elements of the mechanism of administrative and legal regulation of the sphere of waste management]. *Legea și viața*, 6, 68-72 (in Russian).
9. Pinkevich, N. S. (2018). The Definition of «Waste» in the Legislation of Ukraine: Legal Collisions. *European Reforms Bulletin*, 3, 34-36.
10. Timchenko, R. O., Krishko, D. A., Titunin, Ye. V. (2018). *Retsyklinh promyslovykh vidkhodiv* [Recycling of industrial waste]. *Urban planning and territorial planning*, 67, 482-487 (in Ukrainian).
11. Kononenko, O., Molodyka, V. (2019). *Typizatsiia rehioniv Ukrainy za mozhlyvostiamy staloho upravlinnia vidkhodamy* [Typification of regions of Ukraine according to the possibilities of sustainable waste management]. *Bulletin of Taras Shevchenko Kyiv National University. Ser.: Geography*, 2(75), 28-34. <http://doi.org/10.17721/1728-2721.2019.75.5> (in Ukrainian).
12. Kravchenko, O. et al. (2019). *Krashchi yevropeiski praktyky upravlinnia vidkhodamy* [Best European waste management practices]. Lviv: Manuscript Company Publishing House (in Ukrainian).

13. Kolodiichuk, I. A. Formuvannia terytorialno zbalansovanykh system upravlinnia vidkhodamy: rehionalnyi vymir [Formation of territorially balanced waste management systems: regional dimension]. Lviv: State University "Institute of Regional Studies named after M.I. Dolishnyi National Academy of Sciences of Ukraine" (in Ukrainian).
14. Yevdokymenko, V. K. (2020). Aktualne doslidzhennia problemy formuvannia rehionalnykh system upravlinnia vidkhodamy [Current study of the problem of formation of regional waste management systems]. *Regional economy*, 2, 167-168 (in Ukrainian).
15. Minina, O., Shadura-Nykyporets, N. (2020). Doslidzhennia rehionalnoi spetsyfiki protsesiv utvorennia i povodzhennia z promyslovymy vidkhodamy [Research of the regional specificity of processes of formation and handling of industrial waste]. *Halytskyi ekonomichnyi visnyk – Galician Economic Bulletin*, 3(64), 32-43. [https://doi.org/10.33108/galicianvisnyk\\_tntu2020.03](https://doi.org/10.33108/galicianvisnyk_tntu2020.03) (in Ukrainian).
16. Plokyi, V. M. (2020). Administratyvno-pravovyi rezhym povodzhennia z tekhnohennymy vidkhodamy: postanovka problemy [Administrative and legal regime of man-made waste management: statement of the problem]. *Jurnalul juridic national: teorie și practică – Journal juridic national: theory and practice*, 1(41), 180-183 (in Ukrainian).
17. Barinov, M. O. et al. (2021). Praktychni aspekty upravlinnia vidkhodamy v Ukraini [Practical aspects of waste management in Ukraine]. Kyiv: Polygraph plus (in Ukrainian).
18. Melnykova, M. V., Shkryhun, V. L., Khazanova, N. M. (2021). Upravlinnia promyslovymy vidkhodamy u misti: instytutsii, investytsii, innovatsii [Industrial waste management in the city: institutions, investments, innovations]. *Economy and Society*, 33, 77-82. <https://doi.org/10.32782/2524-0072/2021-33-77> (in Ukrainian).
19. Naboka, R. Yu. (2021). Porivnialnyi analiz spetsyfiki derzhavnoho rehuliuвання formuvannia ta rozvytku tsyrkuliarnoi ekonomiky v Ukraini ta krainakh YeS [Comparative analysis of the specifics of state regulation of the formation and development of the circular economy in Ukraine and EU countries]. *Bulletin of the National University of Civil Defense of Ukraine. Ser.: State administration*, 1(14), 135-140 (in Ukrainian).
20. Jianwei, Z., Minjie, Z., Liwei, Z. (2011). Research on System Constitution of the Logistics Ecological Environment. *Procedia Engineering*, 15, 375-380. <https://doi.org/10.1016/j.proeng.2011.08.072>.
21. Pulawska, S., Starowicz, W. (2014). Ecological Urban Logistics in the Historical Centers of Cities. *Procedia – Social and Behavioral Sciences*, 151, 282-294. <https://doi.org/10.1016/j.sbspro.2014.10.026>.
22. Simão, L. E., Gonçalves, M. B., Rodriguez, C. M. T. (2016). An approach to assess logistics and ecological supply chain performance using postponement strategies. *Ecological Indicators*, 63, 398-408. <https://doi.org/10.1016/j.ecolind.2015.10.048>.
23. Moroz, M., Polkowski, Z. (2016). The Last Mile Issue and Urban Logistics: Choosing Parcel Machines in the Context of the Ecological Attitudes of the Y Generation Consumers Purchasing Online. *Transportation Research Procedia*, 16, 378-393. <https://doi.org/10.1016/j.trpro.2016.11.036>.
24. Urbanyi-Popiołeka, I. (2019). Cruise industry in the Baltic Sea Region, the challenges for ports in the context of sustainable logistics and ecological aspects. *Transportation Research Procedia*, 39, 544-553. <https://doi.org/10.1016/j.trpro.2019.06.056>.

- 
25. Liu, W., Wei, W., Yan, X., Dong, D., Chen, Z. (2020). Sustainability risk management in a smart logistics ecological chain: An evaluation framework based on social network analysis. *Journal of Cleaner Production*, 276, Article 124189. <https://doi.org/10.1016/j.jclepro.2020.124189>.
  26. Luthra, S., Garg, D., Haleem, A. (2016). The impacts of critical success factors for implementing green supply chain management towards sustainability: an empirical investigation of Indian automobile industry. *Journal of Cleaner Production*, 121, 142-158.
  27. Geiger, C. (2016). ICT in Green Freight Logistics. In: H. Psaraftis (Ed.), *Green Transportation Logistics: The Quest for Win-Win Solutions* (pp. 205-241). Cham, Switzerland: Springer International Publishing.
  28. Barzinpour, F., Taki, P. (2018). A dual-channel network design model in a green supply chain considering pricing and transportation mode choice. *J. Intell. Manuf.*, 29, 1465-1483.
  29. Pierre, C., Francesco, P., Theo, N. (2019). Towards low carbon global supply chains: A multi-trade analysis of CO2 emission reductions in container shipping. *International Journal of Production Economics*, 208, 17-28.
  30. Mazaraki, A. A., Kharsun, L. H. (2018). Rozvytok lohistychnoi systemy Ukrainy: ekolohichni vyklyky [Development of the logistics system of Ukraine: environmental challenges]. *Economy Ukraine – Ekonomika Ukrainy*, 9(682), 3-12 (in Ukrainian).
  31. Kobylenska, T. V. (2019). Svitovyi dosvid statystychnoho otsiniuvannia efektyvnosti zelenoi lohistyky [World experience of statistical evaluation of the efficiency of green logistics]. *Problems of the Economy*, 4, 209-215. <https://doi.org/10.32983/2222-0712-2019-4-209-215> (in Ukrainian).
  32. Sahaidak, Yu. A., Kharchenko, T. B. (2020). Perspektyvy rozvytku zelenoi lohistyky v Ukraini [Prospects for the development of green logistics in Ukraine]. *State and regions. Ser.: Economy and entrepreneurship*, 3(114(2)), 62-67. <https://doi.org/10.32840/1814-1161/2020-3-34> (in Ukrainian).
  33. Rogers, D., Tibben-Lembke, R. (2001). An examination of reverse logistics practices. *Journal of Business Logistics*, 22(2), 129-145.
  34. Dowlatshahis, S. (2005). A strategic framework for the design and implementation of remanufacturing operations in reverse logistics. *International Journal of Production Research*, 43(16), 3455-3480.
  35. Srivastava, S. K. (2008). Network design for reverse logistics. *Omega*, 36(4), 535-548.
  36. Lee, D., Dong, M. (2009). Dynamic network design for reverse logistics operations under uncertainty. *Transportation Research Part E Logistics and Transportatin Review*, 45(1), 61-71.
  37. McLeod, F., Hickford, A., Maynard, S., Cherrett, T., Allen, J. (2010). *Developing innovative and more sustainable approaches to reverse logistics for the collection, recycling and disposal of waste products from urban centers: Literature review and identification of opportunities*. London: University of Southampton, University of Westminster.
  38. Starostka-Patyk, M., Popa, V. (2013). *General Aspects of Reverse logistics. Supply Chain Management Fundamental and Support Elements*, 182-198.
  39. Mesjasz-Lech, A., *Efektywność ekonomiczna i sprawność ekologiczna logistyki zwrotnej*. Częstochowa.
  40. Coyle, J., Bardi, E., Langlay, C. (2002). *Zarządzanie Logistyczne*. Warszawa: PFE.

41. Bowersox, D. J., Closs, D. J. (2017). Logistika: integrirovannaja cep' postavok [Logistic: Integrated Supply Chain]. 2nd ed. Moscow: Olymp-Business (in Russian).
42. Krykavskiy, Ye. V., Chornopyska, N. V. (2009). Lohistychni systemy [Logistics systems]. Lviv: Publishing House of Lviv Polytechnic University (in Ukrainian).
43. Krykavskiy, Ye. V., Pokhylchenko, O. A., Chornopyska, N. V. et al. (2014). Ekonomika lohistyky [Economics of logistics]. Lviv: Lviv Polytechnic Publishing House (in Ukrainian).
44. Bondarenko, O. S. (2015). Obgruntuvannia sutnosti lohistychnoi infrastruktury ta roli v upravlinni finansovymy potokamy pidpriemstv [Justification of the essence of the logistics infrastructure and its role in the management of financial flows of enterprises]. Investments: practice and experience, 8, 51-55 (in Ukrainian).
45. Hlazkova, A. S. (2016). Industrialno-lohistychna infrastruktura yak osnova innovatsiinoi modernizatsii ekonomiky [Industrial and logistics infrastructure as the basis of innovative modernization of the economy]. Market infrastructure, 2, 49-51 (in Ukrainian).
46. Karyi, O. I., Podvalna, H. V. (2017). Lohistychna infrastruktura Ukrainy u svitovykh reitynhakh [Logistics infrastructure of Ukraine in world rankings]. Bulletin of the Lviv Polytechnic National University. Ser.: Problems of economy and management. Lviv: Publishing House of Lviv Polytechnic, 873, 41-49 (in Ukrainian).
47. Sumets, O. M., Babenkova, T. Yu. (2017). Lohistychna infpastpunktupa: teopetychnyi aspekt [Logistic infrastructure: theoretical aspect]. 3rd ed. Kyiv: Hi-Tech Press (in Ukrainian).
48. Blahun, I. S., Nychyk, I. L. (2017). Formuvannia lohistychnoi infrastruktury Zakhidnoho rehionu [Formation of the logistics infrastructure of the Western region]. Black Sea Economic Studies, 18, 215-218 (in Ukrainian).
49. Smyrnova, N. (2019). Sutnist i skladovi infrastruktury lohistychnoi diialnosti v Ukraini [The essence and components of the logistics infrastructure in Ukraine]. Agrarian Bulletin of the Black Sea Region, 94, 109-117. <https://doi.org/10.37000/abbsl.2019.94.16> (in Ukrainian).
50. Sadchykova, I. (2020). Kontseptualni polozhennia obgruntuvannia sutnosti katehorii "infrastruktura" [Conceptual provisions of substantiation of the essence of the category "infrastructure"]. Problems and prospects of economics and management, 4(24), 155-169 (in Ukrainian).
51. Hryhorak, M. Yu. (2017). Intelektualizatsiia rynku lohistychnykh posluh: kontseptsii, metodolohiia, kompetentnist [Intellectualization of the logistics services market: concept, methodology, competence]. Kyiv: Sik Group Ukraine (in Ukrainian).
52. Zaloznova, Yu., Kwilinski, A., Trushkina, N. (2018). Reverse logistics in a system of the circular economy: theoretical aspect. Economic Herald of the Donbas, 4(54), 29-37.
53. Shashyna, M. V., Zakharchenko, O. V., Darushyn, O. V., Buryk, Z. M., Shpinkovska, M. I. (2018). Agroindustrial Complex in the Eastern European Countries in the Context of Sustainable Development. The Journal of Social Sciences Research, 5, 549-562.
54. Hryhorak, M., Karpenko, O., Semeriahina, M. (2020). Formation of the multimodal transportation ecosystem in Ukraine. Intellectualization of logistics and Supply Chain Management, 2, 111-130. <https://doi.org/10.46783/smart-scm/2020-2-9>.
55. Hryhorak, M. Yu., Trushkina, N. V. (2020). Development of the logistics system of the economic region "Polissya" in the context of the green economy: ecological problems and



---

perspectives". *Intellectualization of logistics and Supply Chain Management*, 4, 27-40. <https://doi.org/10.46783/smart-scm/2020-4-3>.

56. Dźwigoł, H., Kwilinski, A., Trushkina, N. (2021). Green Logistics as a Sustainable Development Concept of Logistics Systems in a Circular Economy. *Proceedings of the 37th International Business Information Management Association (IBIMA)*, 1-2 April 2021 (pp. 10862-10874). Cordoba, Spain: IBIMA Publishing.

57. Hryhorak, M., Lyakh, O., Sokolova, O., Chornogor, N., Mykhailichenko, I. (2021). Multimodal freight transportation as a direction of ensuring sustainable development of the transport system of Ukraine. *IOP Conf. Series: Earth and Environmental Science*, 915, Article 012024. <https://doi.org/10.1088/1755-1315/915/1/012024>.

58. Dzwigol, H., Trushkina, N., Kwilinski, A. (2021). The Organizational and Economic Mechanism of Implementing the Concept of Green Logistics. *Virtual Economics*, 4(2), 74-108. [https://doi.org/10.34021/ve.2021.04.02\(3\)](https://doi.org/10.34021/ve.2021.04.02(3)).

59. Trushkina, N., Prokopyshyn, O. (2021). Circular economy as a new way of managing in the conditions of digital transformations. *Green, Blue & Digital Economy Journal*, 2(3), 64-71. <https://doi.org/10.30525/2661-5169/2021-3-10>.

60. Hryhorak, M. Yu., Kostiuhenko, L. V., Harmash, O. M. (2022). Mathematical method of assessing the potential use of logistics infrastructure. *Intellectualization of logistics and Supply Chain Management*, 13, 27-33. <https://doi.org/10.46783/smart-scm/2022-13-3>.