DOI: 10.31319/2709-2879.2023iss2(7).293550pp32-40
UDC 504.3.054

Levchuk Kateryna, PhD in Economics, Associate Professor
Dniprovsky State Technical University, Kamianske
ORCID ID: 0000-0002-4803-5355
e-mail: career_dgtu@ukr.net
Romaniuk Roman, PhD in Tech. Sc., Associate Professor
Dniprovsky State Technical University, Kamianske
ORCID ID: 0000-0001-5176-2249
e-mail: r22roma@i.ua

Левчук К.О., кандидат економічних наук, доцент
Дніпровський державний технічний університет, м. Кам'янське
Романюк Р.Я., кандидат технічних наук, доцент
Дніпровський державний технічний університет, м. Кам'янське

STUDY OF HARMFUL SUBSTANCES EMISSIONS INTO THE AIR ON THE TERRITORY OF UKRAINE AND THE CITY OF KAMIANSKE

ДОСЛІДЖЕННЯ ВИКИДІВ ШКІДЛИВИХ РЕЧОВИН В АТМОСФЕРНЕ ПОВІТРЯ НА ТЕРИТОРІЇ УКРАЇНИ ТА МІСТА КАМ'ЯНСЬКЕ

The article is dedicated to analyzing the structure of Ukraine's industry and its stages of development, as well as the issues of emissions of major harmful substances into the atmospheric air in the cities of Ukraine, particularly in the city of Kamianske. The main branches of Ukraine's industry include: machine building and metalworking, food, light, fuel and energy, chemical and petrochemical, forestry, pulp and paper, and building materials. Positive trends in industrial production development have been observed since 2000. However, the activities of enterprises and organizations in various branches of industry are a significant factor in the release of pollutants into the atmosphere. The main pollutants include: suspended particles, sulfur dioxide, carbon oxide, nitrogen oxide and dioxide, hydrogen sulfide, phenol, soot, fluorine and chlorine hydrogen, ammonia, formaldehyde. Among the most polluted cities in Ukraine are Mariupol, Kamianske, Dnipro, Kryvyi Rih, and Odesa. In the city of Kamianske, the biggest polluters of the atmospheric air are enterprises in the ferrous metallurgy, coke-chemical, and machine-building industries.

***Key words**: harmful emissions, industries, maximum permissible concentration, atmospheric air, gross domestic product.*

Промисловість в кожній країні займає важливе місце, оскільки від неї залежить валовий внутрішній продукт, доходи та добробут населення, внутрішня та зовнішня торгівля, політична та соціальна стабільність всередині держави. Аналіз стану промисловості показує, що в даний час основними проблемами її розвитку є нестійкість, уповільнення темпів зростання, зниження найважливіших показників ефективності виробництва, повільне поліпшення структури промислового виробництва і експорту, досить високий фізичний і моральний знос основних виробничих фондів, високий рівень витрат ресурсів. Разом з тим діяльність підприємств та організацій різних галузей промисловості є визначальним фактором потрапляння в атмосферу забруднюючих речовин. Тому роботи, які направлені на дослідження викидів різних речовин в атмосферне повітря міст України, є визначальними з метою розробки заходів щодо зменшення шкідливого впливу цих речовин на людину та навколишнє середовище та актуальними.

Метою даної роботи є аналіз структури промисловості України та етапів її розвитку, а також дослідження викидів основних шкідливих речовин в атмосферне повітря в містах України, зокрема в м. Кам'янське.

До найбільших за обсягами виробництва галузей промисловості відносяться машинобудування та металообробка, харчова і легка. Починаючи з 2000 р. спостерігалися позитивні тенденції розвитку промислового виробництва, були реалізовані Концепції державної промислової політики, Державної програми розвитку промисловості на 2003–2011 рр. та інші галузеві програми. До основних забруднюючих атмосферне повітря речовин відносяться: завислі речовини, діоксид сірки, оксид вуглецю, оксид та діоксид азоту, сірководень, фенол, сажа, фтористий та хлористий водень, аміак, формальдегід. Серед найбільш забруднених міст України можна виділити наступні: Маріуполь, Кам'янське, Дніпро, Кривий Ріг та Одеса. В м. Кам'янське найбільшими забруднювачами атмосферного повітря є підприємства чорної металургії, коксохімічної галузі та машинобудування. Середньорічний вміст в повітрі концентрацій діоксиду азоту у 1 півріччі 2022 р. перевищував у 2,5 рази гранично допустиму концентрацію, фенолу – у 2,1 рази, а формальдегіду – у 3,6. Несприятлива ситуація спостерігалася і з перевищенням максимального разового вмісту забруднюючих речовин.

Ключові слова: *шкідливі викиди, галузі промисловості, гранично допустима концентрація, атмосферне повітря, валовий внутрішній продукт.*

JEL Classification*: I21; I23*

Problem's Formulation. The industry of any country in the world determines the potential of the national economy, the dynamics of technical production, the extraction and use of natural resources, material and labor resources. Industry plays an important role in every country, as the gross domestic product (GDP), income and welfare of the population, internal and external trade, political and social stability within the state depend on it. It should be noted that the effectiveness of industry is manifested only in those cases when the state creates favorable conditions for entrepreneurial activity and implements state support programs for all its industries.

An analysis of the state of industry shows that the main problems of its development at present are instability, slowing growth rates, a decrease in the most important indicators of production efficiency, slow improvement in the structure of industrial production and exports, a fairly high physical and moral wear and tear of the main production assets, and a high level of resource costs. The main factor that hinders the growth of industrial production and positive structural changes is the low competitiveness of domestic products. This is due primarily to low investment and innovation activity in the industry. Solving these problems requires industrial policy aimed at activating investment and innovation activity, modernizing equipment, introducing new and advanced technologies, increasing production efficiency and competitiveness of national industry based on the transition to an innovative path of development.

At the same time, the activities of enterprises and organizations in various industries are a decisive factor in the release of polluting substances into the atmosphere. Therefore, work aimed at studying the emissions of various substances into the atmospheric air of cities in Ukraine is decisive in order to develop measures to reduce the harmful impact of these substances on humans and the environment, and is relevant.

Analysis of recent research and publications. Many studies are devoted to the problems of harmful emissions into the atmosphere and their impact on human health, for example, research presented in [1-6]. Work [1] addresses the issue of dust pollution during open transportation of bulk materials using conveyors and various handling devices and chutes. Article [2] analyzes the air pollution of Ukrainian cities with harmful substances in 2019 and identifies the main trends in achieving sustainable development goals for cities and communities in Ukraine, including reducing harmful emissions from the country's enterprises. Work [3] is devoted to the use of modern protective helmet designs to ensure the safety of workers during technological processes, protecting them from impacts, dust, gases, mechanical influences, heat, and electric current. Research in [4] assesses the impact of industrial and transportation emissions on the environment of the Dnipropetrovsk region. The impact of polluted air with harmful substances on the health status of the population of Kyiv is described in article [5]. It is noted that with an increase in the concentration of harmful substances in

the air on polluted territories, there was an increase in the incidence of respiratory, cardiovascular, allergic diseases, and so on. Research [6], conducted by the Copernicus Atmosphere Monitoring Service based on satellite images, provides information on air pollution in Ukraine in 2020. The study methodology is described, and the concentrations of harmful substances in the atmosphere in Ukrainian regions are analyzed, as well as the areas with high concentrations of PM2.5 fine particulate matter.

Formulation of the study purpose. The purpose of the work is to analyze the structure of the industry in Ukraine and its stages of development, as well as to investigate emissions of major pollutants into the atmospheric air in the cities of Ukraine, particularly in the city of Kamyanske.

Presenting main material. As noted above, the country's industry is a driving force for the development of science, technology, and other fields. Therefore, let's analyze the structure of Ukraine's industry as of 2019, before the COVID-19 pandemic and the introduction of martial law (Fig. 1).

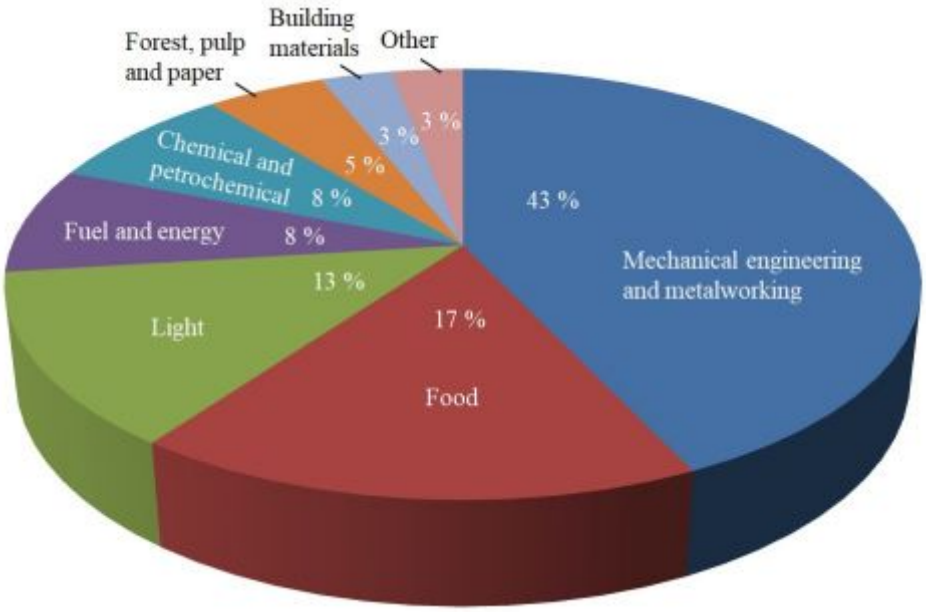

Fig. 1. Structure of the industry in Ukraine as of 2019

As shown in the diagram, the largest industry in terms of production volume in Ukraine is the machine-building and metalworking industry, accounting for 43 % of the total structure of the national industrial sector. The food and light industries also rank among the top three more developed industries. The share of each other industry does not exceed 8 %. It should also be noted that in recent years, the IT industry has been rapidly growing in Ukraine. For example, in 2021, it increased by 36 % with export earnings of $6.8 billion.

Overall, there have been positive development trends in the Ukrainian industrial sector since 2000. In that year, the growth of industrial production was 13 %, and thanks to the implementation of the Concept of State Industrial Policy, the State Program for Industrial Development for 2003–2011, and other sectoral programs, production volumes increased almost four times by 2008. During the crisis period (the second half of 2008–2009), industrial production volumes decreased by 21.9 %. In the post-crisis period (2010–2014), there was again a growth in production by 11 %. The period of industrial development after 2014 has been characterized by instability due to the temporary occupation of territories, the economic blockade of Donbas, the COVID-19 epidemic, and the imposition of martial law. Therefore, to analyze this period, we will use the indicator of gross domestic product (GDP). Fig. 2 shows the dynamics of changes in nominal and real GDP. The chart is built based on the statistics provided on the website [7].

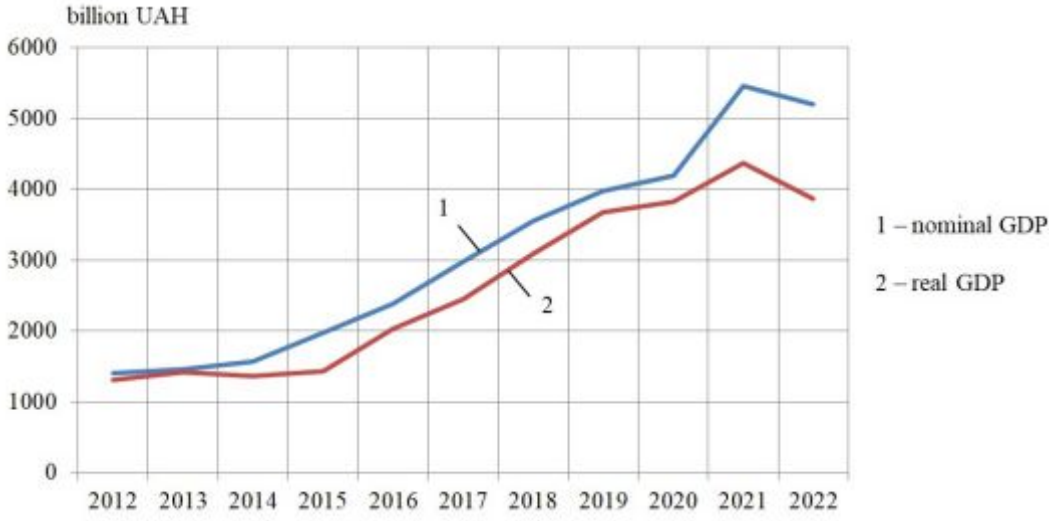

Fig. 2. Dynamics of Ukraine's GDP over the years

It should be noted that nominal (absolute) GDP is determined in current or actual prices of the given year, while real GDP (adjusted for inflation) is determined in prices of the previous year. That is, real GDP takes into account the growth of the gross domestic product in terms of production, rather than prices.

From the graphs, it can be seen that for the period 2012–2021, there was an increase in production both in terms of nominal (3.9 times) and real (3.3 times) indicators.

One of the pressing issues in the development of Ukraine's industry is the general wear and tear of production facilities, low levels of utilization of modern waste processing technologies, air purification, etc., which are the result of significant emissions of harmful substances into the atmospheric air of populated areas.

First, let's analyze the structure and dynamics of harmful emissions in cities in Ukraine. Fig. 3 shows the dynamics of changes in the average annual concentration of major pollutants in the atmospheric air of cities in Ukraine over the years. It should be noted that the number of cities covered by observations ranges from 6 to 39 depending on the type of pollutant. The smallest number of observations is characteristic of soot, and the largest is for suspended particles, sulfur dioxide, and nitrogen.

As the data from the graphs show, during the period from 2020 to the first half of 2022, emissions of major pollutants in cities in Ukraine almost did not change, which is certainly not a positive trend, considering the decrease in industrial production. The situation only improves with the emissions of suspended particles (a 14 % decrease), hydrogen chloride (20 %), and ammonia (50 %). The decrease in emissions of the last two substances is explained by the reduction in the development of the chemical industry. For example, in January–June 2022, the index of industrial production of chemical products decreased compared to the same period in 2021 to 34 %, and rubber and plastic products – to 44 % [8].

Fig. 4 shows the dynamics of changes in AQI over the period from 2020 to the first half of 2022 for the most polluted cities in Ukraine. As is known, starting from the value of AQI = 7.0, this index characterizes high air pollution. This value is marked with a dotted line on this diagram.

Therefore, the five most polluted cities in terms of emissions of major harmful substances are: Mariupol, Kamyanske, Dnipro, Kryvyi Rih, and Odesa. The decrease in AQI values in some cities is due to a reduction in industrial production in those regions.

Let's take a closer look at the structure of emissions of harmful substances in Kamianske. Fig. 5 and 6 show the dynamics of changes for the period from 2020 to the first half of 2022 in terms of the multiples of exceeding the average annual and maximum one-time content of pollutants in the atmospheric air compared to the corresponding maximum permissible concentrations (MPC).

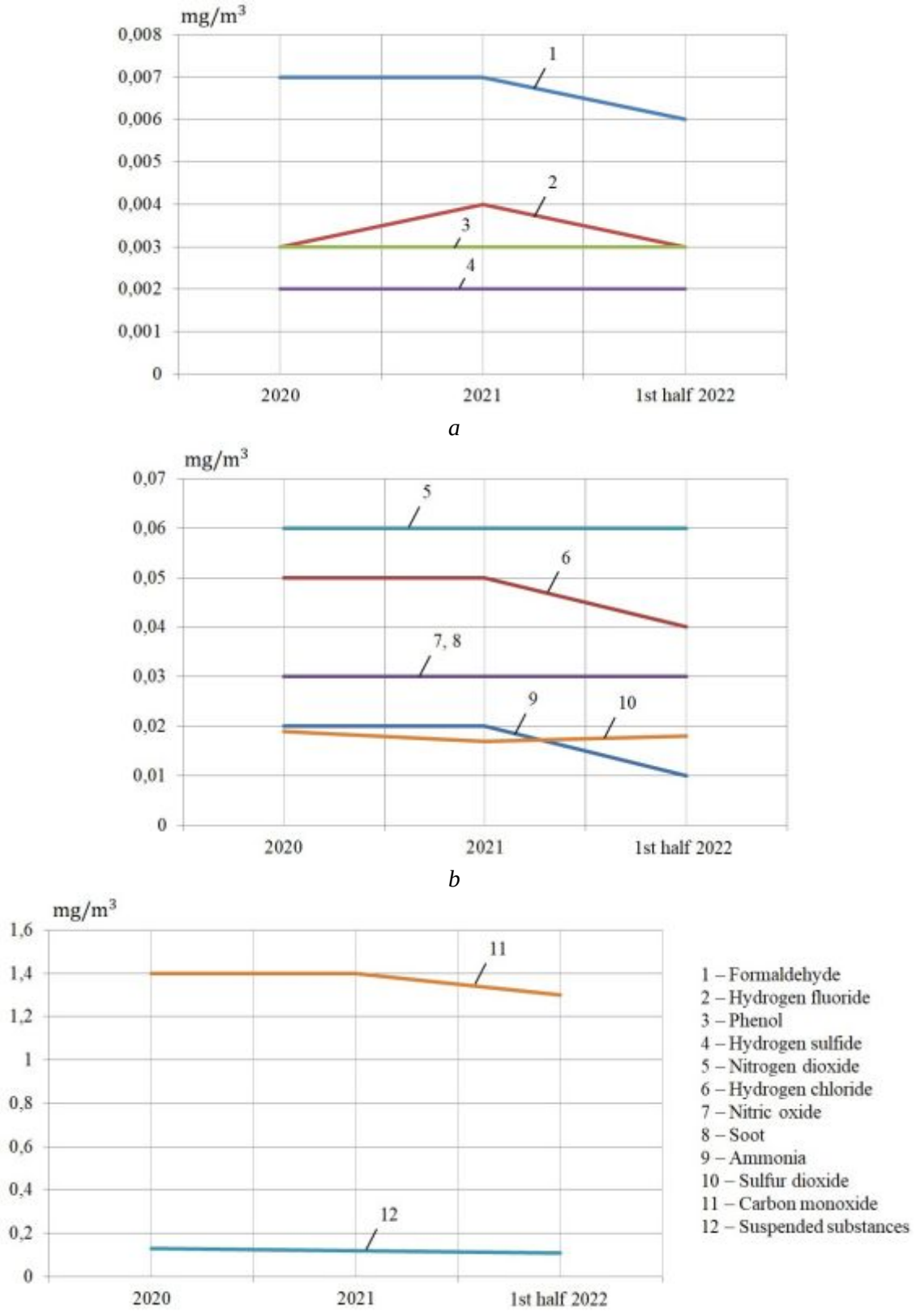

Fig. 3. Dynamics of changes over the years in the average annual content of pollutants in the atmospheric air of cities in Ukraine

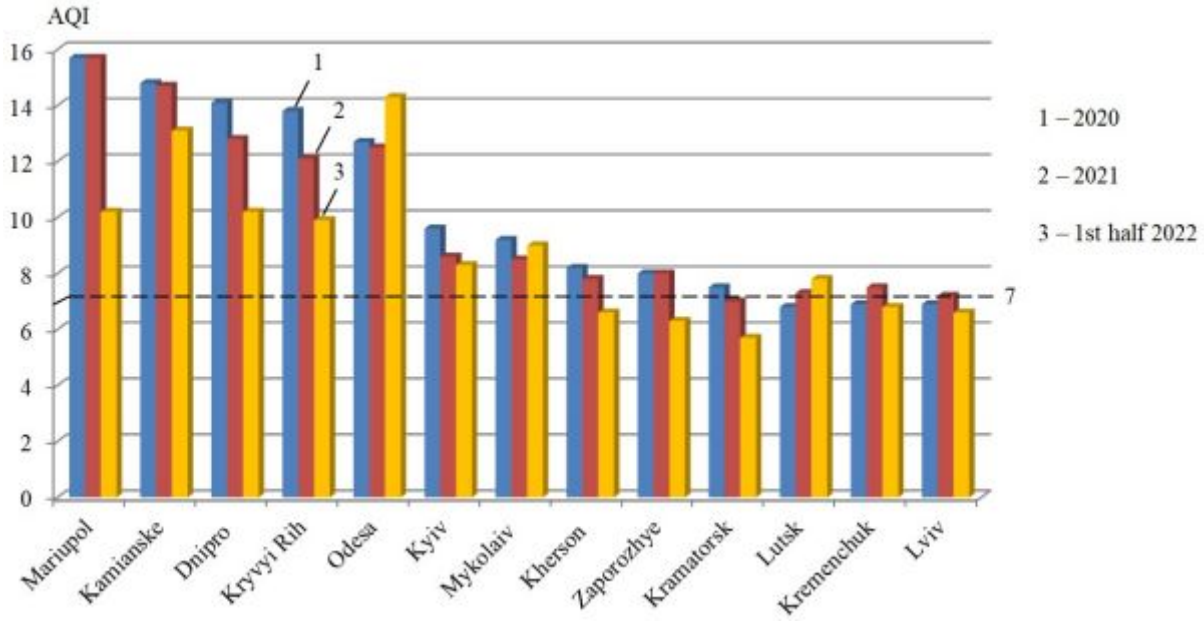

Fig. 4. Dynamics of changes in AQI over the years for cities in Ukraine

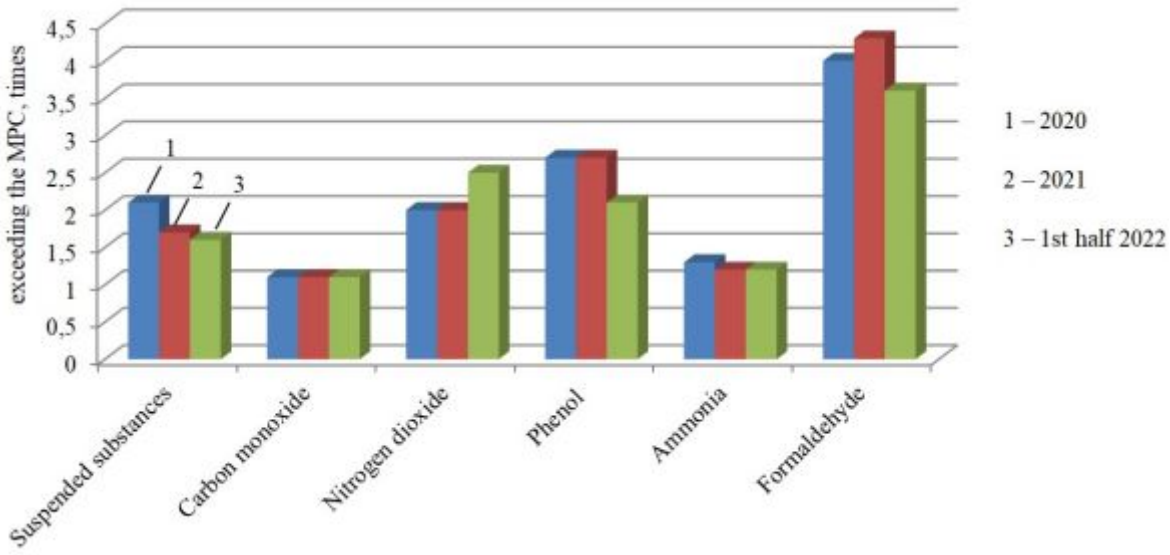

Fig. 5. Multiplicity of exceeding the average annual content of pollutants in the atmospheric air of Kamyanske city in comparison with the corresponding MAC

As can be seen from these diagrams, the main harmful substances in the atmospheric air of the city include suspended particles, carbon monoxide, nitrogen dioxide, phenol, ammonia, and formaldehyde (Fig. 6). It should be noted that the average annual concentration of nitrogen dioxide in the air in the first half of 2022 exceeded the MAC by 2.5 times, phenol by 2.1 times, and formaldehyde by 3.6 times. An unfavorable situation is also observed in exceeding the maximum one-time content of pollutants.

The leading industries in the city of Kamyanske include: black metallurgy, mechanical engineering, power engineering, chemical and coke-chemical industries (Fig. 7).

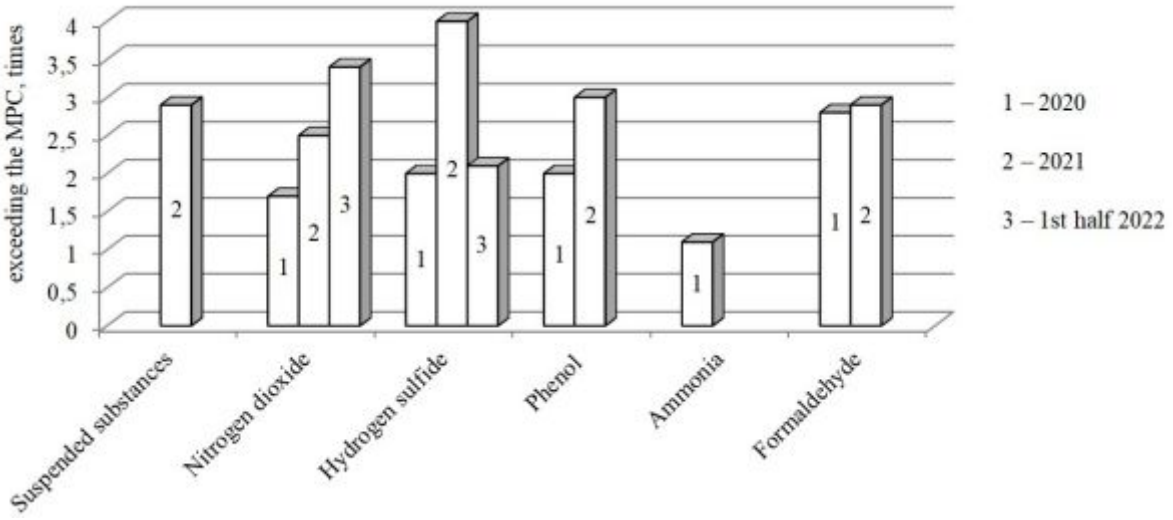

Fig. 6. Multiplicity of exceeding the maximum single content of pollutants in the atmospheric air of Kamyanske city in comparison with the corresponding MAC

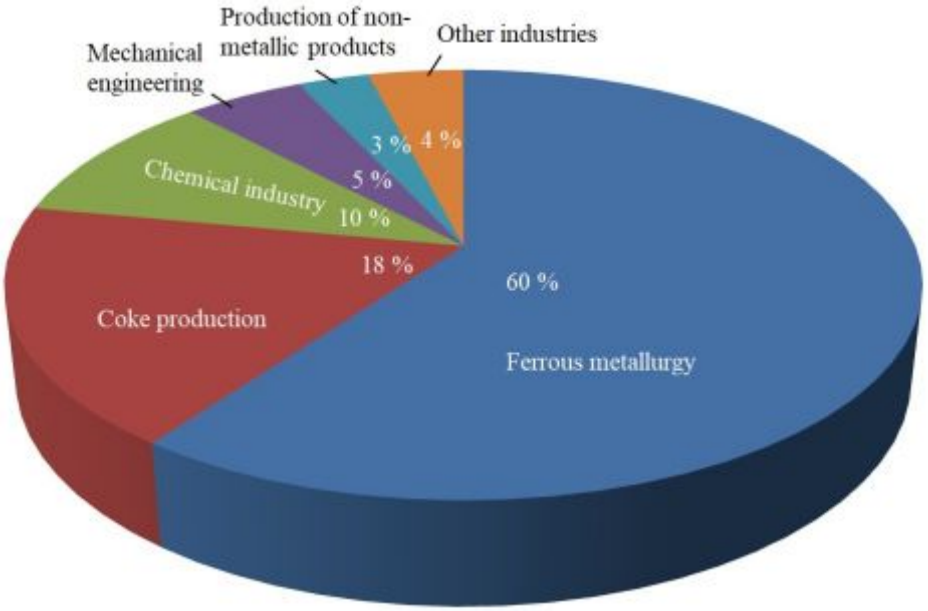

Fig. 7. Leading industries of Kamianske

As can be seen from the diagram, the largest industry in terms of volume of industrial production is ferrous metallurgy, followed by coke production, the chemical industry, and new construction machinery. It is the enterprises of these industries that are the biggest polluters of atmospheric air in the city of Kamianske. These include: PJSC "KAMET-STEEL", PJSC "Dniprovsky Coke Chemical Plant", PJSC "YUZHKOKS", JSC "DNIPROAZOT", LLC PP "ZIP", PJSC "Dniprovagonmash". The percentages of emissions of pollutants from stationary sources into the atmospheric air of these enterprises are shown in fig. 8.

As can be seen from this diagram, the metallurgical plant of PJSC "KAMET-STEEL" is the main polluter of the city's atmospheric air. Its main harmful emissions include: oxides of carbon (approximately 78 %), sulfur, nitrogen, dust of mineral substances and heavy metals. The graphs and charts (Figs. 3–8) are built according to the statistics given on the website [9].

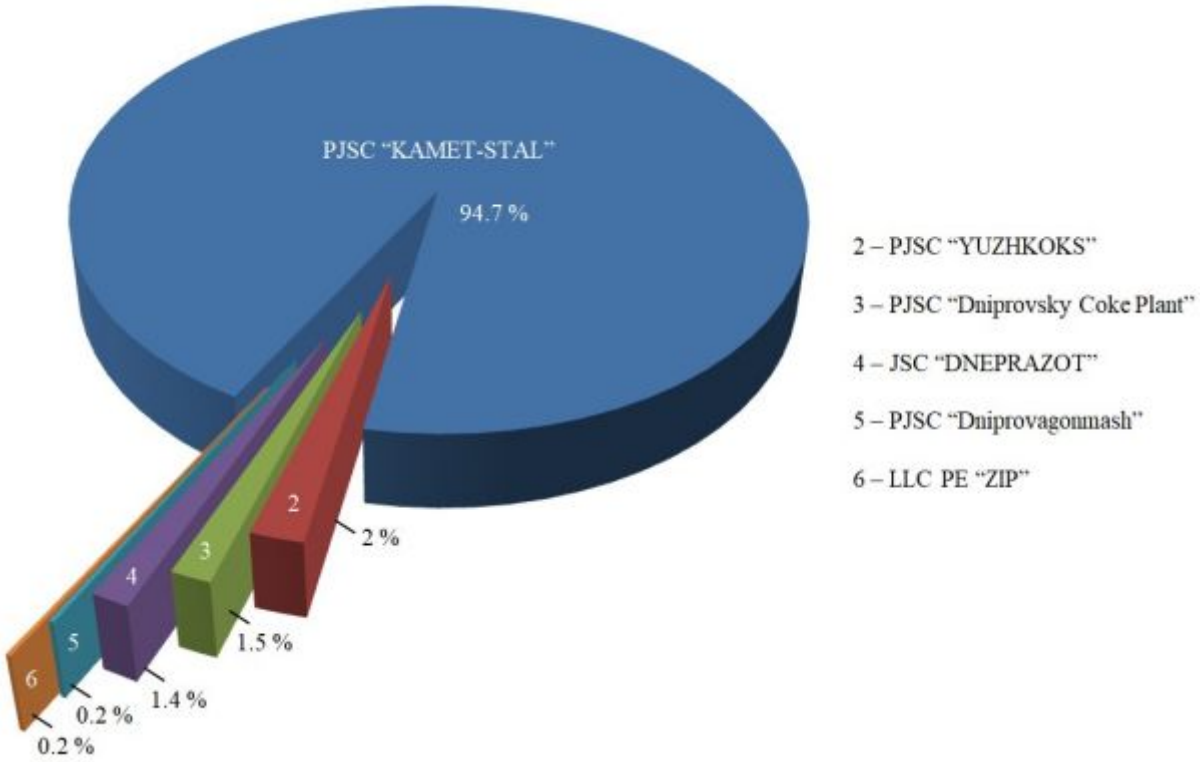

Fig. 8. Percentage shares of emissions of harmful substances from stationary sources of the most polluting enterprises of the city of Kamianske

Conclusions. The structure of Ukrainian industry and the stages of its development are analyzed. Mechanical engineering and metalworking, food and light industries are among the largest industries in terms of production volumes. Since 2000, positive trends in the development of industrial production have been observed, the Concept of State Industrial Policy, the State Industrial Development Program for 2003–2011, and other industry programs have been implemented.

Emissions of harmful substances into the atmospheric air in the cities of Ukraine, especially the city of Kamianske, were studied. The main pollutants include suspended solids, sulfur dioxide, carbon monoxide, nitrogen oxide and dioxide, hydrogen sulfide, phenol, soot, hydrogen fluoride and chloride, ammonia, formaldehyde. Among the most polluted cities of Ukraine, the following can be distinguished: Mariupol, Kamianske, Dnipro, Kryvyi Rih and Odesa. In the city of Kamianske, the biggest polluters of atmospheric air are enterprises of ferrous metallurgy, the coke-chemical industry, and mechanical engineering.

References

[1] Gasylo, Yu.A. & Levchuk, K.O. & Romanjuk, R.Ja. (2018). Matematychne modeljuvannja trasy gidrotransportu za dopomogoju parabolichnyh splajniv [Mathematical modeling of the hydrotransport route using parabolic splines]. *Matematychne modeljuvannja – Mathematical modeling*, 1(38), 55-61 [in Ukrainian].

[2] Levchuk, K. & Romaniuk, R. (2022). Sustainable city development as a key factor of country economic development. *Matematychne modeljuvannja – Mathematical modeling*, 1(46), 131–140.

[3] Hasylo, Yu. & Levchuk, K. & Romaniuk, R. & Strezhekurov, E. & Kriukovska, O. (2021). Analysis of modern designs of heat-protective helmets. *Zbirnyk naukovyh prac' DDTU – Collection of scientific papers of DSTU*, 1(38), 142-148.

[4] Shupranova, L.V. & Khlopova, V.M. & Kharytonov, M.M. (2014). Air pollution assessment in the Dnepropetrovsk industrial megapolice of Ukraine. *Air Pollution Modeling and its Application XXII. Science for Peace and Security Series C: Environmental Security book series*, 101–104.

[5] Stahiv, I.R. (2013). Vplyv zabrudnenogo povitrjanogo seredovyshha na stan zdorov'ja naselennja za 2001–2010 rr [Influence air pollution on health of population from 2001 to 2010]. *Teoretychni ta prykladni aspekty geoinformatyky – Theoretical and applied aspects of geoinformatics*, 10, 126-132 [in Ukrainian].
[6] Воиkovб, S. & Bohovic, R. & Hrnиiar, M. & Murот, M. & Filippovovб, P. & Skalskэ, M. & Soroka, M. (2020). *Air Pollution in Ukraine from space. Study based on the Copernicus Sentinel 5p satellite imagery and quality-controlled air pollution data from the Copernicus Atmosphere Monitoring Service.* Prague-Kyiv: World from Space.
[7] Sait Minfin [Site of Ministry of Finance]. *minfin.com.ua/*. Retrieved from https://minfin.com.ua/ [in Ukrainian].
[8] Kovenja, T.V. (2022). *Analitychna ocinka sytuacii' v himichnij promyslovosti Ukrai'ny v 2022 r. Makroekonomichnyj ta sektoral'nyj zrizy [Analytical assessment of the situation in the chemical industry of Ukraine in 2022 Macro-economic and sectorial sections]*. Cherkasy: SE "Cherkassy NDITECHIM" [in Ukrainian].
[9] Sait Portal vidkrytyh danyh [Site of Open Data Portal]. *data.gov.ua/*. Retrieved from https://data.gov.ua/ [in Ukrainian].

Список використаної літератури

1. Гасило Ю.А., Левчук К.О., Романюк Р.Я. Математичне моделювання траси гідротранспорту за допомогою параболічних сплайнів. *Математичне моделювання*. Камянське, 2018. № 1 (38). С. 55–61.
2. Levchuk K., Romaniuk R. (2022). Sustainable city development as a key factor of country economic development. *Математичне моделювання*. Камянське, 2022. № 1 (46). С. 131–140.
3. Hasylo Yu., Levchuk K., Romaniuk R., Strezhekurov E., Kriukovska O. (2021). Analysis of modern designs of heat-protective helmets. *Збірник наукових праць ДДТУ*. Камянське, 2022. № 1 (38). С. 142–148.
4. Shupranova L.V., Khlopova V.M., Kharytonov M.M. Air pollution assessment in the Dnepropetrovsk industrial megapolice of Ukraine. *Air Pollution Modeling and its Application XXII. Science for Peace and Security Series C: Environmental Security book series.* 2014. P. 101–104.
5. Стахів І.Р. Вплив забрудненого повітряного середовища на стан здоров'я населення за 2001–2010 рр. *Теоретичні та прикладні аспекти геоінформатики : зб. наук. праць*. Київ, 2013. С. 126–132.
6. Воиkovб S., Bohovic R., Hrnиiar M., Murот M., Filippovovб P. & Skalskэ M., Soroka M. Air Pollution in Ukraine from space. Study based on the Copernicus Sentinel 5p satellite imagery and quality-controlled air pollution data from the Copernicus Atmosphere Monitoring Service. Prague–Kyiv : World from Space, 2020. 37 p.
7. Мінфін. URL: https://minfin.com.ua/ (дата звернення: 30.04.2023).
8. Ковеня Т.В. Аналітична оцінка ситуації в хімічній промисловості України в 2022 р. Макроекономічний та секторальний зрізи : аналітична довідка, вип. 5 (станом на 01.07.2022 р.). Черкаси : ДП "Черкаський НДІТЕХІМ", 2022. 29 с.
9. Портал відкритих даних. URL: https://data.gov.ua/ (дата звернення: 30.04.2023).

Надійшла до редколегії 15.09.2023