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MONITORING THE STATE OF THE AIR ENVIRONMENT IN THE LVIV REGION

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The article presents the results of monitoring the state of the air environment of Lviv region in 2020. The main sources of pollution are identified and statistical data on emissions of pollutants into the atmosphere are given. The aim of the work is to analyze the state of the environment, natural resources of Lviv region, trends in their changes and environmental measures. Volumes of pollutant emissions from stationary sources of air pollution from enterprises, institutions and organizations of Lviv region were determined by conducting an inventory of stationary sources of pollutant emissions into the air, types and volumes of pollutant emissions into the atmosphere by stationary sources, equipment facilities of the region.

Key words: monitoring; air environment; maximum permissible concentration; pollutants; natural resources; emission sources.

Introduction

Preservation and rational use of natural resources is one of the priorities of state development. The main goals of the development of environmental protection are to increase the level of environmental safety and improve the environmental situation in the region, the development of nature reserves, reproduction and protection of natural resources, improving the level of public environmental awareness. The main priorities and objectives of environmental protection of Lviv region are defined in the Program of socio-economic and cultural development of Lviv region for 2020, Development Strategy of Lviv region until 2020, State Strategy for Regional Development of Ukraine until 2020, Environmental Protection Program for 2016–2020, as well as the draft framework Strategy for Ecological Safety and Adaptation to Climate Change until 2030, developed by the Ministry of Environment of Ukraine.

The Department of Ecology and Natural Resources of the Regional State Administration has created an “Ecological Passport of Lviv Region for 2020”, which contains complete information about the state of the environment, natural resources of Lviv region, trends in their changes and environmental measures (State of the environment in Lviv region. Information and analytical review, 2020).

The materials for the National Report on the State of the Environment were prepared in accordance with the commitments made by Ukraine in 1991 at the World Summit in Rio de Janeiro.

The aim of the work is to analyze the state of the environment, natural resources of Lviv region, trends in their changes and environmental measures.

Materials and methods

The assessment of the state of atmospheric air in the city of Lviv in the first quarter of 2020 was carried out by comparing the average concentrations of pollutants with the corresponding average daily maximum allowable concentrations (MPC) and comparing the maximum single concentrations of priority pollutants with their corresponding maximum MPC. Priority pollutants were those that contributed the most to urban air pollution and were controlled at most stationary air pollution monitoring stations.

The list of priority pollutants is given in Table 1 according to the MPC and hazard class, where the value of the hazard class of the pollutant decreases as its hazard increases (Maximum permissible concentrations (MPC) and approximate safe levels of exposure (SHOES) of pollutants in the air of populated areas, 1997).

Table 1

The value of the MPC of air pollutants

Contaminants	MPC average daily, mg/m ³	Danger class
Dust (suspended solids)	0.15	3
Sulfur dioxide	0.05	3
Carbon monoxide	3.0	4
Nitrogen dioxide	0.04	2
Nitric oxide	0.06	3
Formaldehyde	0.003	2

In the first quarter of 2020, systematic observations of harmful substances in the city's air were conducted by the Laboratory of Atmospheric Air Pollution Monitoring (SAS) of the Lviv Regional Center for Hydrometeorology at four stationary stations (PSZ) with a sampling frequency of four times a day six days a day. Sampling and analysis of atmospheric air samples for the content of pollutants was carried out according to RD 52.04.186-89 Manual on air pollution control, 1989.

7 pollutants were determined, of which the main ones were dust (suspended solids), sulfur dioxide, carbon monoxide and nitrogen dioxide. Specific impurities include: nitric oxide, hydrogen fluoride and formaldehyde. Sample analysis for all these substances is performed by the SZA laboratory. We also determined the pH of precipitation.

In January 2020, the maximum one-time MPC was not exceeded. In terms of average monthly concentrations compared to the average daily MPC this month, the MPC limit exceeds dust, nitrogen dioxide and formaldehyde.

Compared to January 2019, there was an increase in the average monthly concentrations of all pollutants studied.

At maximum concentrations, there was a decrease in carbon monoxide content compared to the same period last year. Dust, sulfur dioxide, nitrogen dioxide, nitrogen oxide, hydrogen fluoride and formaldehyde – increase.

In February 2020, the maximum – one-time MPC was not exceeded. Dust, nitrogen dioxide and formaldehyde exceed the MPC in terms of average monthly concentrations compared to the average daily MPC (State of the environment in Lviv region. Information and analytical review, 2020).

Compared to February 2019, there were no changes in the average monthly dust content. The average monthly content of dust, carbon monoxide, nitrogen dioxide and nitrogen oxide was lower than in February 2019. The content of sulfur dioxide, hydrogen fluoride and formaldehyde increased.

There was a decrease in the maximum one-time content of carbon monoxide, nitrogen dioxide, sulfur dioxide, nitrogen oxide and hydrogen fluoride; increase – on formaldehyde; no changes were observed in dust and carbon monoxide (Regional report on the state of the environment in Lviv region in 2020 (2021)).

In March 2020, the maximum one-time MPC was not exceeded.

Compared to March 2019, there was an increase in average monthly concentrations of dust, sulfur dioxide, formaldehyde, and hydrogen fluoride and carbon monoxide; reduction – nitrogen dioxide, nitric oxide.

There was an increase in the maximum one-time formaldehyde content; reduction – nitric oxide, nitrogen dioxide, dust, carbon monoxide, sulfur dioxide and hydrogen fluoride.

The main sources of pollutants in the air of Lviv are:

- dust – motor transport, woodworking and building materials industry;
- sulfur dioxide – industrial enterprises;
- carbon monoxide – vehicles, heat power companies;
- nitrogen dioxide – heat power companies;
- formaldehyde – motor transport, plywood industry.

Results and discussion

The main air pollutants in Lviv region in 2020 were mining companies (43.8 % of total emissions) and electricity, gas, steam and air conditioning supply companies (40.6 % of total emissions). The Table 2 shows the volumes of pollutant emissions.

Table 2

Volumes of pollutant emissions

	Emissions, thousand tons		
	2020	% until 2019	% to the end
All types of economic activity	76.013	85.5	100.0
Agriculture, forestry and fisheries	1.465	86.7	1.9
Mining and quarrying ¹	33.299	85.3	43.8
Manufacturing industry	2.787	70.8	3.7
Supply of electricity, gas, steam and air conditioning ¹	30.826	91.8	40.6
Water supply, sewerage, waste management	0.318	106.4	0.4
Construction	0.592	52.1	0.8
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.163	87.5	0.2
Transport, warehousing, postal and courier activities	4.867	70.3	6.4
Activities in the field of administrative and support services	0.579	120.4	0.8
Public Administration and Defense; compulsory social insurance	0.554	65.9	0.7
Education	0.240	52.0	0.3
Other economic activities	0.323	116.2	0.4

¹ Emissions are more than 5 thousand tons

The Table 3 shows the emissions of certain pollutants into the atmosphere from stationary emission sources in 2020.

The volume of pollutants released into the atmosphere from stationary sources of emissions of enterprises, institutions and organizations over the past 10 years decreased by 37.200 tons, which is about 33 % less than in 2010.

Of the total amount of pollutants, methane emissions amounted to 35.7 thousand tons, sulfur dioxide – 22.0 thousand tons, nitrogen dioxide – 5.5 thousand tons, carbon monoxide – 3.9 thousand tons. In addition, emissions carbon dioxide amounted to 2968.4 thousand tons.

Table 3

**Emissions of certain pollutants into the atmosphere
from stationary emission sources in 2020**

	Emissions		
	tons	% until 2019	% to the end
Total, including:	76012.6	85.5	100.0
metals and their compounds	27.3	71.6	0.0
substances in the form of solid suspended particles	6448.5	101.9	8.5
nitrogen compounds	5873.66	93.7	7.7
dioxide and other sulfur compounds	22045.4	86.4	29.0
non-methane volatile organic compounds	1999.1	91.1	2.6
carbon monoxide	3910.2	89.4	5.1
methane	35687.1	80.9	47.0
In addition, carbon dioxide, thousand tons	2968.4	87.2	x

Per 1 km² of area there were 3.5 tons of pollutant emissions, per 1 person – 30.3 kg. The Diagram of emissions of pollutants into the atmosphere from stationary sources of pollution in Lviv region shows in Fig. 1.

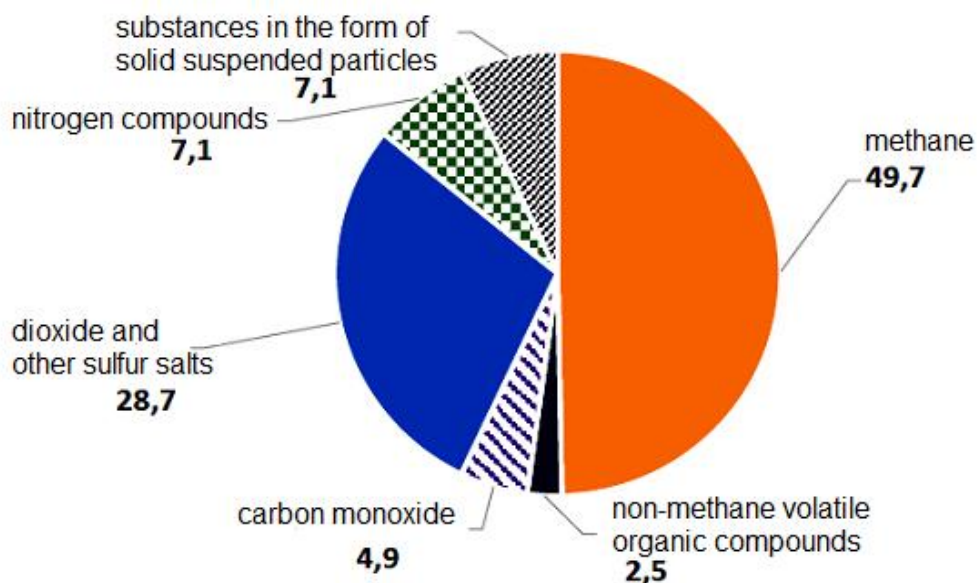


Fig. 1. Diagram of emissions of pollutants into the atmosphere from stationary sources of pollution in Lviv region, tons

Table 4 lists the 10 economic entities of the main stationary sources of air pollution (in comparison with the actual emissions of pollutants into the atmosphere for 2016–2020 in the Lviv region by the largest pollutants).

Table 4

List of the main stationary sources of air pollution

No.	Name of Company	The greatest impact of a stationary source of pollution on the territorial community (TG), the region	Emissions of pollutants, in fact thousand tons				
			2016	2017	2018	2019	2020
1	2	3	4	5	6	7	8
<i>Total, including from vehicles and stationary emission sources</i>			103.106	109.107	106.742	88.865	76.013
1	SE "Dobrotviraska TPP" Public Company "DTEK Zahidenergo"	Dobrotvir local community (LC) Kamyanka-Buzk LC Lviv district	44.898	49.754	43.693	32.214	29.625
2	"Lvivvugillia" State Company	Chervonohrad ITC. LC Chervonohrad district	33.260	36.360	34.383	33.407	28.840
	– "Stepova" mine (No. 10)		12.666	12.746	12.825	12.307	7.555
	– mine "Lisova" (No. 6)		5.622	6.196	6.209	6.106	6.173
	– "Mezhyrychanska" mine (No. 3)		6.637	5.942	5.910	5.921	5.851
	– "Velykomostivska" mine (No. 1)		3.015	4.344	4.332	4.313	4.101
	– "Chervonogradska" mine (No. 2)		2.021	2.873	3.566	3.245	3.651
	– "Vidrodzenna" mine (No. 4)	1.549	1.525	1.541	1.515	1.509	
3	"Lvivgazvydobuvannia" Branch of the GPU (Public Company "Ukrgezvydobuvannia") – all divisions of Lviv region	Stryi LC. Stryi district; Drohobych LC. Medenytsia LC Drohobych district; Komarniv LC Lviv district; Shehyni LC Yavoriv district	4.787	4.486	7.803	6.169	2.807
4	Branch "Gas Storage Operator of Ukraine" (Joint Stock Company "Ukrtransgaz") – all divisions of Lviv region	Stryi LC (Yosypovychi village) Stryj district; Drohobych LC Medenytsia LC Drohobych district; Kamyanka-Buzk LC Lviv district; Sokal LC (Volytsia village) Chervonohrad district; Bibrka LC Lviv district; Mykolayiv LC (Bilche village with Pyatnychany) Stryi district	4.357	4.105	5.573	2.778	2.920
5	State Open Joint Stock Company "Nadiya" mine	Chervonohrad ITC. LC Chervonohrad district	2.081	2.075	1.828	1.445	0.666
6	Public Company "Zhydachiv pulp and paper mill"	Zhydachiv ITC Stryi district	0.000	0.676	1.284	0.842	0.031

Continuation Table 4

1	2	3	4	5	6	7	8
7	MN “Naftoprovid Druzhba” (PJSC “Ukrtransnafta”) – all divisions of Lviv region	Brody ITC Zolochiv district; Koziv LC Stryi district; Hlyniany LC Lviv district; Drohobych ITC Drohobych district	1.096	1.004	0.936	0.968	0.940
8	“Naftogaz Teplo” LC Novyj Rozdil + Novoyavorivsk	Novorozdil ITC. Stryi district; Novoyavoriv ITC Yavoriv district	–	0.990	0.643	0.481	0.290
9	Public Company NPK “Galychyna”	Drohobych ITC Drohobych district	0.177	0.294	0.200	0.277	0.221
10	NVGU “Boryslavnaftogaz” (Public Company “Ukrnafta”)	Boryslav ITC. Boryslav LC Drohobych LC Drohobych district	0.426	0.481	0.497	0.488	0.356

Volumes of pollutant emissions from stationary sources of air pollution from enterprises, institutions and organizations of Lviv region were determined by conducting an inventory of stationary sources of pollutant emissions into the air, types and volumes of pollutant emissions into the atmosphere by stationary sources, equipment facilities of the region.

According to statistical information, the volume of emissions of pollutants into the atmosphere from stationary sources of emissions of enterprises, institutions and organizations of Lviv region in 2020 amounted to 76.0 thousand tons, which is 14.5 % less than in 2019.

Lviv region ranks 6th in terms of emissions of pollutants into the atmosphere from stationary sources and is behind such regions as Vinnytsia, Dnipropetrovsk, Ivano-Frankivsk, Zaporizhia and Kharkiv.

Gross emissions of the region are only 3.4 % of all emissions of Ukraine, emissions of stationary sources per square kilometer average 3.5 tons/km², and per capita is about 30 kg/person.

Volumes of pollutants that entered the air from stationary sources of emissions of enterprises, institutions and organizations in 2020 amounted to 76.0 thousand tons, which is 14.5 % less than in 2019.

Unsatisfactory condition of the atmospheric air of the settlements of Lviv region is due to non-compliance with the technological regime of operation of dust and gas cleaning equipment, non-compliance with measures to reduce emissions to the regulatory level; low rates of introduction of modern technologies of emission treatment; lack of effective treatment of emissions from gaseous impurities.

As in previous years, the main contribution to air pollution is made by the enterprises of energy, coal and extractive industries, as well as enterprises for extraction, transportation and storage of natural gas, namely:

1. OE “Dobrotvirska TPP” (PC “DTEK Zahidenergo”).
2. SE “Lvivugillia” (6 mines engaged in coal mining).
3. SJSC “Nadiya” mine.
4. Branch “Gas Storage Operator of Ukraine” (JSC “Ukrtransgaz”).
5. Branch of GPU “Lvivgazvydobuvannia” (PC “Ukr gazvydobuvannia”).
6. MN “Naftoprovid Druzhba” (PJSC “Ukrtransnafta”).
7. “Boryslavnaftogaz” (PC “Ukrnafta”).
8. “Naftogaz Teplo” LC (Novyj Rozdil heat power plant +Novoyavorivsk heat power plant).
9. PC NPK “Galychyna”.
10. PC “Zhydachiv PPM”.

Pursuant to the Association Agreement between Ukraine and the European Union, the European Atomic Energy Community and their Member States ratified by the Law of Ukraine of 16.09.2014 No. 1678-VII, regarding the implementation of the requirements of Directive No. 2008/50/EU on ambient air quality and cleaner air for Europe and the Directive No. 2004/107/EU on arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in the atmosphere On August 14, 2019 the Resolution of the Cabinet of Ministers of Ukraine of No. 827 “Some issues of state monitoring in the field of air protection”.

To ensure the implementation of the Resolution of the Cabinet of Ministers of Ukraine dated 14.08.2019 No. 827 “Some issues of state monitoring in the field of air protection”, the Department of Ecology and Natural Resources of Lviv Regional State Administration

In order to improve air quality and reduce air emissions, a draft State Monitoring Program in the field of air protection for 2020–2025 is being developed.

Conclusions

1. The most polluted areas of Lviv region are the following:

- Dobrotvir, Dobrotvir LC, Lviv district – the impact of the largest polluter of the region OE “Dobrotvirsk TPP” (PC “DTEK Zakhidenergo”) – 37 % of total emissions of the region;
- Chervonohrad – 15.3 % of the total emissions of the region, Chervonohrad LC, Chervonohrad district – the impact of “Lvivugillia” mines and 41.4 % of the total emissions of the region in Chervonohrad district.
- Stryi – 0.7 % of the total emissions of the region, Stryi LC, Stryi district and 4.6 % of the total emissions of the region in the Stryi district – this is the influence of the Branch “Gas Storage Operator of Ukraine” (JSC “Ukrtransgaz”), GPU Branch “Lvivgazvydobuvannia” (PC “Ukrgazvydobuvannia”), a few industrial enterprises “Lvivska Zaliznytsia” PJSC Ukrainian Railways, Stryi hub station, transit railways and the industrial zone of Stryi, where a significant number of industrial entities are located. Emissions are also accompanied by transport interchanges from the Kyiv – Chop international highway.

2. In the rest of the territory of Lviv region emissions of pollutants are insignificant and do not create a large burden on air pollution.

References

Regional report on the state of the environment in Lviv region in 2020 (2021). URL: <https://deplv.gov.ua/regionalna-dopovid-pro-stan-nps/> (in Ukrainian).

Voznyak, O., Sukholova, I., Yurkevych, Yu., & Dovbush, O. (2018). Thermal modernization of industrial rooms air conditioning system, *Proc. of Lviv Polytechnic National University: Theory and Building Practice*, Vol. 888, 36–42 URL: <https://science.lpnu.ua/sctp/all-volumes-and-issues/volume-888-2018/thermal-modernization-industrial-rooms-air-conditioning> (in Ukrainian).

Law of Ukraine. On Environmental Protection. Resolution of the Verkhovna Rada of Ukraine No. 1268-XII of June 26, 1991, VVR, 1991, No. 41, Article 547 (1991). URL: <https://zakon.rada.gov.ua/laws/show/1264-12#Text> (in Ukrainian).

Jygerey, V. S., Storozhuk, V. M., & Yatsyuk, R. A. (2000). *Fundamentals of ecology and environmental protection*. Lviv: Publishinh house “Afisha”. URL: https://bibliotekakek.at.ua/_ld/0/91_OsnEkologi.pdf (in Ukrainian).

Kapalo, P., Klymenko, H., Zhelykh, V., & Adamski, M. (2020). Investigation of Indoor Air Quality in the Selected Ukraine Classroom – Case Study. *Lecture Notes in Civil Engineering*; 47: 168–173. https://doi.org/10.1007/978-3-030-27011-7_21.

Bogolyubov, V. M. (Eds), Klimenko, M. O., Mokin, V. B., et al. (2018). *Environmental monitoring: textbook*. Kind. 2nd, reworked. and add. Kyiv: NUBiPU. URL: http://dglib.nubip.edu.ua:8080/bitstream/123456789/5823/1/Bogolybov_Monitorung%20dovkslly.pdf (in Ukrainian).

Lavryk, V. I. (Eds), Bogolyubov, V. M., Poletaeva, L. M., Yurasov, S. M., & Ilyina, V. G. (2010). *Modeling and forecasting of the environment*. Kyiv: Academy URL: <https://academia-pc.com.ua/product/212> (in Ukrainian).

Official site of the Ministry of Ecology and Natural Resources of Ukraine (in Ukrainian). <http://menr.gov.ua/>

Shapoval S., Shapoval P., Zhelykh V., Pona O., Spodnyuk N., Gulai B., Savchenko O., & Myroniuk K. (2017). Ecological and energy aspects of using the combined solar collectors for low-energy houses. *Chemistry & chemical technology*; 11(4): 503–508. <https://doi.org/10.23939/chcht11.04.503>.

Kapalo, P., Domnita, F., Bacotiu, C., & Spodyniuk, N. (2018). The impact of carbon dioxide concentration on the human health - Case study, *Journal of Applied Engineering Sciences*, Vol. 8, No. 1, 61–66. ISSN 2284-7197, <https://doi.org/10.2478/jaes-2018-0008>.

Zhelykh V., Yurkevych Yu., Voznyak O., Sukholova I., & Dovbush O. (2021). Enhancing of energetic and economic efficiency of air distribution by swirled-compact air jets. *Production Engineering Archives*; 27(3): 171–175. <https://doi.org/10.30657/pea.2021.27.22>.

Lis, A., & Spodyniuk, N. (2019). The quality of the microclimate in educational buildings subjected to thermal modernization. 11th Conference on Interdisciplinary Problems in Environmental Protection and Engineering EKO-DOK, E3S Web of Conferences 2019; 100(1): 00048. <https://doi.org/10.1051/e3sconf/201910000048>.

Pietrucha T. (2017). Ability to determine the quality of indoor air in classrooms without sensors. E3S Web of Conferences 2017; 17: 00073. <https://doi.org/10.1051/e3sconf/20171700073>.

Kapalo, P., Vilceková, S., Domnita, F., Bacotiu, C., & Voznyak, O. (2017). Determining the Ventilation Rate inside an Apartment House on the Basis of Measured Carbon Dioxide Concentrations – *Case Study, The 10th International Conference on Environmental Engineering*, Vilnius, Lithuania, Selected Papers, 30–35. <https://doi.org/10.3846/enviro.2017.262>.

Lee, Y., & Kim Y. (2022). Analysis of indoor air pollutants and guidelines for space and physical activities in multipurpose activity space of elementary schools. *Energies*, 15(1): 220. <https://doi.org/10.3390/en15010220>.

Kapalo, P., Meciarova, L., Vilcekova, S., Burdova, E., Domnita, F., Bacotiu, & C. Peterfi, K. (2019). Investigation of CO₂ production depending on physical activity of students. *International Journal of Environmental Health Research*. Vol. 29, Is. 1, 31–44. ISSN: 09603123. <https://doi.org/10.1080/09603123.2018.1506570>.

Voznyak, O., Adamski, M., Kapalo, P., Dovbush O., & Sukholova I., (2020). Investigation of the return flow at the air distribution by swirl and flat laying air jets in small-sized premises. *Proc. of Lviv Polytechnic National University: Theory and Building Practice*, Vol. 2, No. 1, 38–45. <https://doi.org/10.23939/jtbp2020.01.038>

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МОНІТОРИНГ СТАНУ ПОВІТРЯНОГО СЕРЕДОВИЩА У ЛЬВІВСЬКІЙ ОБЛАСТІ

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Викладено результати моніторингу стану повітряного середовища Львівської області у 2020 р. Визначено основні джерела забруднень та наведено статистичні дані щодо викидів забруднюючих речовин в атмосферне повітря. Незадовільний стан атмосферного повітря населених пунктів Львівської області зумовлений недотриманням підприємствами технологічного режиму експлуатації пилогазоочисного устаткування, невиконанням у встановлені терміни заходів щодо зниження обсягів викидів до нормативного рівня; низькими темпами впровадження сучасних технологій очищення викидів; відсутністю ефективного очищення викидів підприємств від газоподібних домішок. Як і в попередні роки, основний внесок у забруднення атмосферного повітря роблять підприємства енергетики, вугільної та видобувної промисловості, а також підприємства із видобування, транспортування і зберігання природного газу. Мета роботи – аналіз стану навколишнього природного середовища, природних ресурсів Львівщини, тенденції їх змін та здійснених природоохоронних заходів. Обсяги викидів забруднюючих речовин від стаціонарних джерел забруднення в атмосферне повітря від підприємств, установ та організацій Львівської області визначено на підставі проведення інвентаризації стаціонарних джерел викидів забруднюючих речовин в атмосферне повітря, видів та обсягів викидів забруднюючих речовин в атмосферне повітря стаціонарними джерелами, пилогазоочисного обладнання на підприємствах – суб'єктах господарювання області. З метою покращення якості атмосферного повітря та зменшення викидів у атмосферне повітря розробляється проєкт Програми державного моніторингу в галузі охорони атмосферного повітря на 2020–2025 рр.

Ключові слова: моніторинг; повітряне середовище; граничнодопустима концентрація; забруднюючі речовини; природні ресурси; джерела викидів.