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## RISK-ORIENTED MONITORING OF HEAVY METALS IN THE ENVIRONMENT OF THE INDUSTRIAL REGION

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**Objective.** The purpose of our research was to analyze the volumes of industrial atmospheric emissions and discharges from heavy metals (HM) water sources and determine their relationship with the actual concentrations of these compounds in air and drinking water in the industrial city of Dnipro.

**Materials and methods.** It has been conducted an analysis of air pollution and water sources in the city of Dnipro according to the data of the regional state department of statistics, the regional department of water management, the laboratory of the regional center of hydrometeorology.

**Results.** In recent years, in the volume of industrial emissions of HM into the atmospheric air of the city of Dnipro, priority is given to manganese and copper (47.76 and 39.84%, respectively). In addition, lead (68%), cadmium (100%), chromium (62%), copper (88%), nickel (15%) occupy a significant place in the total amount of emissions. Water effluents make a significant contribution to environmental pollution. The most significant contribution is made by iron and zinc (88.2 and 7.5%, respectively). This situation is due to the concentration in the city of a significant number of powerful enterprises, unaccounted for sources and vehicles. In life-sustaining environments, these HM are constantly determined. Their average concentrations mostly do not exceed the corresponding maximum permissible concentrations, but are 2.3-3.5 times higher than the background values. Continuous monitoring of the content of HM indicates a gradual increase of these substances in water by 1.5-32 times and a decrease in atmospheric air by 1.5-24 times due to the dispersion and sedimentation properties of these metals. The obtained data are the basis of the need to strengthen the control of state supervision bodies over the content of HM in the environment of such a powerful industrial city as Dnipro.

**Conclusions.** It has been shown that industrial atmospheric emissions and wastewater from enterprises are powerful sources of HM pollution of the atmospheric air and water basin of the city of Dnipro and the Dnipro river. Their concentrations significantly exceed the background values, which is a significant risk factor for negative impact on the ecosystem and public health. Research results confirm the complex nature of metal migration and point to the need for further monitoring of HM in the environment for the development of scientifically based methods of reducing the content of HM in the external environment to regulatory levels, reviewing their effects on the human body taking into account the combined effect with other factors, establishing new regional regulations.

**Keywords.** Heavy metals, emissions, environment, health risk.

## РИЗИК-ОРІЄНТОВАНИЙ МОНІТОРИНГ ВАЖКИХ МЕТАЛІВ У НАВКОЛИШНЬОМУ СЕРЕДОВИЩІ ПРОМИСЛОВОГО РЕГІОНУ

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**Мета роботи.** Аналіз обсягів промислових атмосферних викидів і скидів у вододжерела важких металів (ВМ) та визначення їх зв'язку з фактичними концентраціями цих сполук у повітрі і питній воді в умовах промислового міста Дніпро.

**Об'єкт і методи дослідження.** Проведено аналіз забруднення атмосферного повітря та вододжерел м. Дніпро за даними обласного державного управління статистики, обласного управління водного господарства, лабораторії обласного центру гідрометеорології.

**Результати дослідження та їх обговорення.** За останні роки в обсязі промислових викидів ВМ у атмосферне повітря м. Дніпро пріоритетними є марганець та мідь (47,76% та 39,84% відповідно). Крім того, вагоме місце у загальній кількості викидів займають свинець (68%), кадмій (100%), хром (62%), мідь (88%), нікель (15%). Значний вклад в забруднення докільця вносять водні стоки. Найбільш вагомий внесок вносять залізо та цинк (88,2% та 7,5% відповідно). Така ситуація обумовлена концентрацією у місті значної кількості потужних підприємств, неврахованих джерел викидів та автотранспорту. У життєзабезпечуючих середовищах ці ВМ визначаються постійно. Їх середні концентрації здебільш не перевищують відповідних гранично допустимих концентрацій, але у 2,3-3,5 разів вищі за фонові величини. Постійний моніторинг вмісту важких металів свідчить про поступове збільшення цих речовин у воді у 1,5-32 рази та зменшення у атмосферному повітрі у 1,5-24 рази за рахунок розсіювання та седиментаційних властивостей цих металів. Отримані дані є основою необхідності посилення контролю органів державного нагляду за вмістом ВМ у докільці такого потужного промислового міста як Дніпро.

**Висновки.** Показано, що промислові атмосферні викиди і стічні води підприємств є потужними джерелами забруднення ВМ атмосферного повітря та водного басейна м. Дніпро та р. Дніпро. Їх концентрації значно перевищують фонові значення, що є вагомим фактором ризику негативного впливу на екосистему та здоров'я населення. Результати досліджень підтверджують складний характер міграції металів та вказують на необхідність подальшого моніторингу ВМ у докільці для розробки науково обґрунтованих методів зниження до нормативних рівнів їх вмісту в зовнішньому середовищі, перегляду їх дії на організм людини з урахуванням поєднаної дії з іншими факторами, встановленню нових регіональних нормативів.

**Ключові слова.** Важкі метали, викиди, докільця, ризик для здоров'я.

Ukraine is a developed country with a strong industrial potential. Annually, up to 4 million tons of pollutants from industrial enterprises and motor vehicles enter the atmospheric air of the country: more than 10 million tons of toxic chemical compounds are released into the atmosphere from industrial sources, 2.5 billion m<sup>3</sup> of contaminated wastewater is released into water sources [1,2,3]. In 43 cities, where 1/3 of the country's population lives, the level of air pollution is much higher than the norm [4].

The experience of monitoring studies of the state of urban areas shows that the ecological state of a territory is associated with the level of industrial development [5]. Emissions from industrial enterprises, transport, and the use of agrochemicals are the main causes of environmental pollution. In this regard, the most obvious example is the Dnipro region, where the largest number of sources of man-made pollution is concentrated. General emissions into the atmosphere from stationary sources in the region reach 537.7 thousand tons/year. Also of concern is the significant

amount of air emissions from stationary and mobile sources per square kilometer in the region, which is 16.8 tons (compared to Lviv – 3.5 tons, Vinnytsia – 3.0 tons, and Kyiv – 2.1 tons). Among all chemical pollutants, HM have a special place in terms of their scale of distribution and biological effects on living organisms. They are widely used in various industries and agriculture, which leads to their constant presence in the environment, accumulation in the human body and negative manifestations at all levels: molecular, cellular, organ, systemic [6,7,8]. According to the world yearbook, the volume of emissions into the atmosphere alone reaches 2000 thousand tons of lead, 840 thousand tons of zinc, 94 thousand tons of chromium, 51 thousand tons of molybdenum, 5 thousand tons of silver, 43 thousand tons of tin, 320 thousand tons manganese, 98 thousand tons of nickel, 11 thousand tons of mercury, 12 thousand tons of selenium, 78 thousand tons of arsenic, 5.5 thousand tons of cadmium, 4.4 thousand tons of cobalt, 11,000 thousand tons of iron, 520 thousand tons of titanium, 7200 thousand tons of aluminum, 260 thousand tons of copper [9]. At the same time, the policy of European countries in the field of environmental protection is aimed at reducing air emissions by introducing a more thorough regional and national regulatory framework, using an improved system to combat industrial pollution and the spread of waste-free technologies [10]. In Ukraine, the reduction in HM emissions and discharges over the last decade is largely due to the general economic crisis in the country and the corresponding decline in industry. Nevertheless, cases of significant HM content in the environment continue to cause concern, especially since the lack of exceeding the normative concentrations of these toxicants is not evidence of the absence of their negative impact on the human body [6]. In Ukraine, as in other European countries, environmental agencies are faced with the task of preventing environmental pollution and deterioration in modern conditions [7,12]. In accordance with the requirements of the modern period of Ukraine's development, international obligations and European principles of environmental policy, it is necessary to activate the introduction of new effective levers of environmental policy.

The purpose of our research was to analyze the volumes of industrial atmospheric emissions and discharges from HM water sources and determine their relationship with the actual concentrations of these compounds in air and drinking water in the industrial city of Dnipro.

The analysis was conducted according to the data of the regional state department of statistics, the regional department of water management, the laboratory of the regional center of hydrometeorology.

The evaluation of the obtained results shows that the volume of industrial emissions of HM in the city of Dnipro on the average for the last years makes  $9,57 \pm 1,2$  tons /year, the larger half among which belongs to manganese – 47,76% and copper – 39,84%. In the structure of the region, the industrial facilities of Dnipro supply 68% of lead, 100% of cadmium, 88% of copper, 62% of chromium, 15% of nickel, 0.4% of manganese to the air basin.

Estimation of HM emissions data shows that the amount of water runoff entering the Dnipro river from the city enterprises on average during the observation period reaches  $183.7 \pm 9.7$  t/year. Among them, iron and zinc have the largest volumes – 88.2% and 7.5%. It should be emphasized that the share of gross emissions of the industrial city in the Dnipro River is 50% of the total in the Dnipropetrovsk region.

Data from hygienic studies of the air of the residential zone of 2 industrial districts of Dnipro and drinking water of Kaidatsky and Lomovsky water mains, which provide water to these areas, indicate the constant presence of HM in life-giving environments. Their average concentrations mostly do not exceed the corresponding maximum allowable concentrations, but 2.3-3.5 times higher than the background values. Analysis of the dynamics of the content of heavy metals over a six-year period indicates a gradual increase in the content of these substances in water by 1.5-32 times (despite on military actions in Ukraine) and, contrary to expectations, a decrease in atmospheric air – by 1.5-24 times.

Correlation analysis of data for most heavy metals did not reveal the relationship between annual emissions and average annual concentrations in the air of industrial areas of Dnipro, which is probably due to the presence of many unaccounted sources of HM, their sedimentation properties

and/or transboundary transport. Analysis of the dynamics of lead content in the air revealed inconsistencies, namely – a decrease in its concentrations in the surface layer of the atmosphere over the past 6 years against the background of increasing industrial emissions. Correlation analysis confirmed the quantitative relationship between these phenomena ( $p < 0.05$ ).

No correlation was found between the volume of most metals polluting wastewater from the enterprises of Dnipro region and their concentrations in drinking water. This is probably due to the rapid deposition of metals, their solubility in water and the location of the water intake, which is much higher downstream of the Dnipro than the place of industrial and domestic effluents.

Thus, the analysis determined that industrial atmospheric emissions and wastewater of enterprises are powerful sources of pollution of air and water basins of the Dnipro city and Dnipro river, which leads to exceeding their background values in the environment and increases the risk of negative impact of these compounds on human health and the ecosystem [13]. This fact is the basis for the need to strengthen the control of state oversight bodies using the updated legal framework and regulatory mechanisms for its operation. Despite the decrease in the content of HM in the air in the dynamics of observations, their concentrations in drinking water increased significantly, and taking into account the lack of correlation between industrial emissions and discharges of HM with their actual content in air and drinking tap water, research confirms complex the nature of metal migration and indicate the need for further research in this area. An integral and most effective [10] form of modern control over HM should be considered environmental and hygienic monitoring, which will help solve three preventive tasks: the development of scientifically sound methods to reduce to regulatory levels of HM in the environment, reviewing most of them with combined action with other factors, the establishment of new hygienic standards, including regional ones.

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O. Antonova – idea of the article, analysis of scientific literature, participation in writing the article;

V. Glavatskaya – collection and processing of material, participation in the writing of the article.

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