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## Mapping of heavy metal contamination of soil cover in Rivne as a component of GIS ecological monitoring

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**SUMMARY**

The study analyses the results of laboratory samples of the content of eight heavy metals in gross and mobile forms in the soil cover of Rivne, which were taken at 5 test sites in different districts of the city.

To assess the level of soil contamination, it has been calculated the total contamination indices ( $Z_c$ ) for both forms of heavy metals.

Interpolated surfaces were built to visualise the city's heavy metal contaminated areas.

For the gross form of heavy metals, it was found that most of the sampling sites (52 %) correspond to the "Moderately dangerous" pollution category, and 34 % of the samples correspond to the "Dangerous" category.

For the mobile form of heavy metals, it was found that the vast majority of the territory is within the "Permissible" pollution category – 74 % of samples, 18 % of samples correspond to the "Dangerous" category.

The highest levels of heavy metal contamination in the soil cover of Rivne are at the Northern, the North-Eastern and the South-Western Industrial Zones of the city.



## Introduction

Urban areas, as complex multifunctional urban ecosystems, occupy a special place in terms of various environmental problems. Waste from industrial enterprises and public transport, which causes heavy metal pollution, has a significant negative impact on the environment. Soils are capable of accumulating heavy metals that have been released into the environment and can act as a source of pollution to other environments (*Sakhniuk et al., 2022; Myslyva, Onopriienko, 2009*).

Heavy metals enter the soil as part of various chemicals and tend to accumulate to critical levels, thus negatively affecting the structure and function of urban ecosystems. Therefore, studying the patterns of distribution of heavy metals in the soil cover of Rivne is an urgent task of providing residents with an environmentally safe living environment.

To control man-made soil contamination with heavy metals, the gross form content is determined. However, an increase in the content of the gross form of heavy metals in the soil does not pose a direct threat to the vital activity of organisms, while their mobile form can pose a real danger because it is capable of accumulation. That is why it is necessary to measure the content of the mobile form of heavy metals in the soil if high values of their gross form are detected (*Melnyk et al., 2023*).

## Method and Theory

Economic activity, the concentration of industrial enterprises and infrastructure are the driving force behind the development of urban ecosystems, while also causing environmental problems. Industry plays a crucial role in the city's economy. The city of Rivne is characterized by a significant level of development of the machine-building and chemical industries (*Klymenko et al., 2008*).

Industrial enterprises in Rivne are located within five industrial zones: **Northern, North-Eastern, South-Eastern, South-Western and Central** (*Siaska et al., 2022*).

The level of soil contamination with heavy metals is assessed by comparing the actual concentration of an element with its MPC, and in the absence of such a standard, with the natural background value. The main calculated indicators of the degree of pollution are **the concentration coefficient  $K_c$  and the total pollution index  $Z_c$**  (*Pryshepa, 2021; Sternik, 2017*).

The concentration factor  $K_c$  is calculated by the formula:

$$K_c = \frac{C_i}{C_\phi}, \text{ or } K_c = \frac{C_i}{MPC}, \quad (1)$$

where,  $C_i$  – actual content of the  $i$ -th element, mg/kg;  $C_\phi$  – background content of the  $i$ -th element, mg/kg;

MPC – maximum permissible concentration of a pollutant in soil, mg/kg.

The total pollution index  $Z_c$  is calculated by the formula:

$$Z_c = \sum K_c - (n-1) \quad (2)$$

where,  $n$  – the number of chemical elements.

The degree of pollution is determined by the indicator of total soil pollution  $Z_c$  according to the gradations given in Table 1 (*Sternik, 2017*).



**Table 1** Determination of the degree of technogenic land pollution by the total  $Z_c$  index

Category of soil contamination	The value of $Z_c$	Changes in health indicators of the population in areas of pollution
"Permissible"	Less than 16	There are almost no diseases in children and a small number of manifestations of dysfunctions of systems and organs.
"Moderately dangerous"	16–32	Increase in the number of common diseases among the population.
"Dangerous"	32–128	Increased number of children with chronic diseases and cases of cardiovascular dysfunction.
"Extremely dangerous"	More than 128	High levels of morbidity in children, significant reproductive disorders in women, such as: an increase in the number of premature births, stillbirths.

### Examples

The initial materials for the comprehensive assessment of soil contamination were laboratory data on the concentration coefficients of eight heavy metals in gross and mobile forms, which were calculated by the instrumental and laboratory control department of the State Environmental Inspectorate of the Polissia District. To conduct soil monitoring in Rivne, 5 test sites were selected, with 10 samples at each site. Soil samples were taken in accordance with the sampling requirements for soil contamination (DSTU ISO 10381-1:2004).

To assess the level of soil contamination with heavy metals in gross and mobile forms, total contamination indicators ( $Z_c$ ) were calculated.

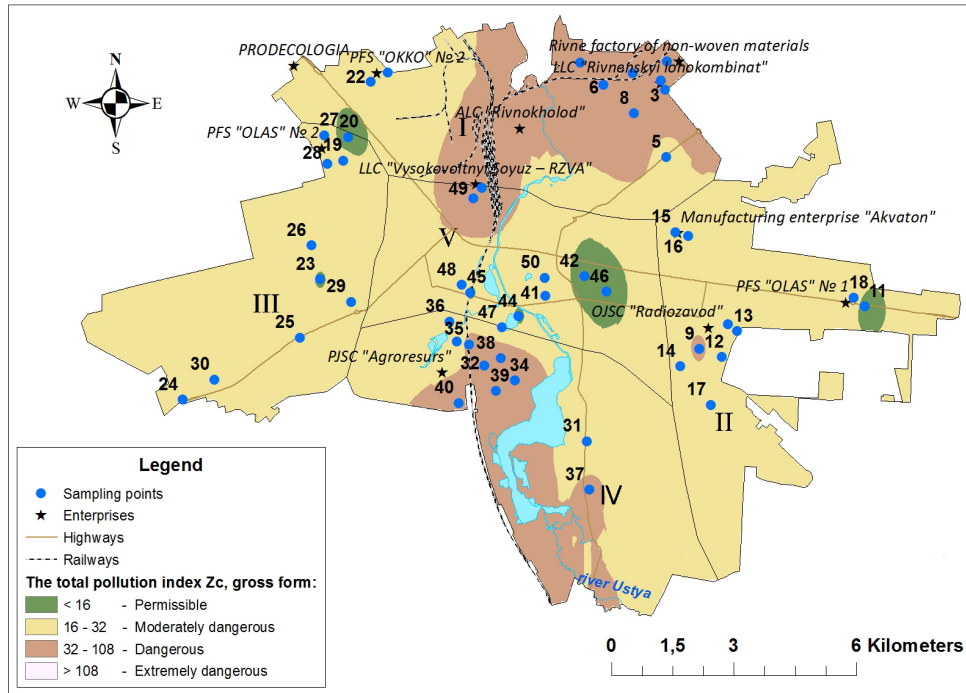
### Results

The analysis of the results made it possible to determine the categories of soil contamination in Rivne with heavy metals, according to Table 1. In the study area, most of the sampling sites (52 %) for gross form of total contamination correspond to the "Moderately dangerous" category; 14 % of samples belong to the "Permissible" category; 34 % of samples have  $Z_c$  indices and correspond to the "Dangerous" category. For the mobile form of heavy metals, it was found that the vast majority of the territory is in the "Permissible" category – 74 % of samples. The rest of the samples are classified as "Moderately dangerous" (8 %) and "Dangerous" (18 %).

One of the interpolation methods used to map the heavy metal contamination of the soil cover in Rivne was **IDW (Inverse Distance Weighted)**.

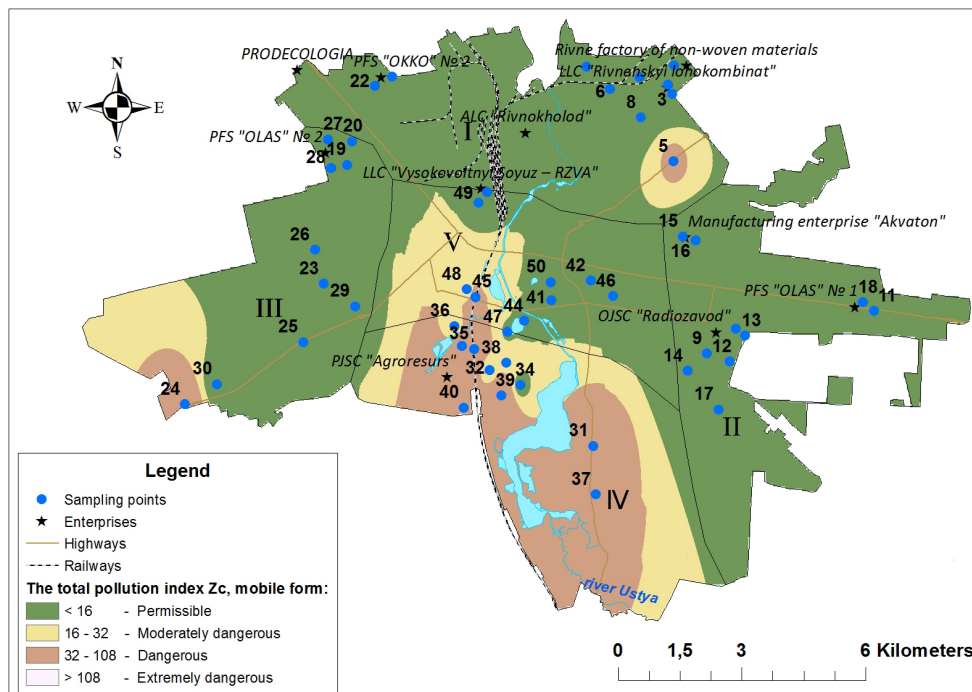
The map (figure 1) shows that the "Moderately dangerous" category of gross form of heavy metal soil contamination is observed in most of the city's territory. The areas of pollution classified as "Dangerous" are concentrated near enterprises (LLC "Rivnenskyi Ionokombinat", PJSC "Rivnenska fabryka netkanykh materialiv", LLC Vyrobynyche pidpryemstvo "Aquaton", LLC "Vysokovoltnyi Soyuz – RZVA", PJSC "Agroresurs", ALC "Rivnokholod", OJSC "Radiozavod") and around the railway.





**Figure 1** Assessment of soil pollution danger by total pollution index of heavy metals, gross form (developed by the author)

The map of mobile form of heavy metal pollution (figure 2) shows most of the territory within the "Permissible" category. In turn, the territories of the city that correspond to the "Moderately dangerous" and "Dangerous" pollution categories are concentrated locally near the main roads and in the southern part of the city, namely around the railway and PJSC "Agroresurs".



**Figure 2** Assessment of soil pollution danger by total pollution index of heavy metals, mobile form (developed by the author)



## Conclusions

The highest levels of heavy metal contamination of the soil cover in Rivne are at the Northern Industrial Zone (LLC "Vysokovoltnyi Soyuz – RZVA", ALC "Rivnokholod" and the territory of Lviv railway service), the North-Eastern Industrial Zone (PJSC "Rivnenska fabryka netkanykh materialiv", LLC "Rivnenskyi lonokombinat", LLC Vyrobynye pidpriemstvo "Akvaton"), and at the South-Western Industrial Zone (PJSC "Agroresurs").

The results obtained allow us to conclude that the vast majority of the soil cover in Rivne is classified as "Moderately dangerous" for the gross form and "Permissible" for the mobile form of heavy metals. As for the "Dangerous" category of soil pollution, it is observed on the territory of large enterprises, such as: PJSC "Rivnenska fabryka netkanykh materialiv", LLC "Rivnenskyi lonokombinat", LLC Vyrobynye pidpriemstvo "Akvaton", LLC "Vysokovoltnyi Soyuz – RZVA", ALC "Rivnokholod", PJSC "Agroresurs" and OJSC "Radiozavod". Soils in this category are also concentrated near main roads and around railways. It can be assumed that such high levels of contamination may also be due to the mechanical composition of the soil, which is capable of accumulating heavy metals.

In order to substantiate measures aimed at eliminating the negative effects of anthropogenic interference in the environment and improving the state of the environment, it is promising to further study the background pollution with heavy metals to compare the obtained indicators in the dynamics in order to achieve safe sustainable development of the urban system of Rivne.

## References

- DSTU ISO 10381-1:2004 (ISO 10381-1:2002, IDT) Soil quality. (2006). Part 2: Sampling.
- Klymenko M. O., Molchak Ya. O., Fesiuk V. O., Zaleskyi I. I. (2008). Rivne: nature, economy and ecological problems. Monograph. Rivne: NUVHP. [in Ukrainian]
- Myslyva T. M., Onoprienko L. O. (2009). Heavy metals in urboedaphotopes and phytocenoses and the territory of Zhytomyr. Visnyk KhNAU. [in Ukrainian]
- Pryshchepa A.M. (2021). Theoretical and methodological bases of assessment of crisis phenomena of the agrosphere in the zone of influence of urban systems. Zhytomyr. [in Ukrainian]
- Sternik V.M. (2017). Biotic activity of urboedaphotopes of the city of Rivne. Candidate's thesis. Rivne. [in Ukrainian].
- Melnyk, V., Malovanyy, M., Lukianchuk, N., & Sternik, V. (2023). The Study of Heavy Metal Impacts on Biotic Processes in the Soils of the Urban Ecosystem of the City of Rivne (Ukraine). *Ecological Engineering & Environmental Technology*, 24(1), 143–153. URL: <https://doi.org/10.12912/27197050/154923>.
- Sakhniuk, S., Tovstonoh, D., Monastyrova, O., Zatserkovnyi, V. (2022). Monitoring of Urban Heat Islands Using Remote Sensing Technologies. In *16th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment, Kyiv, Ukraine*. URL: <https://doi.org/10.3997/2214-4609.2022580055>.
- Siaska, B., Siaska, I., & Tsiupa, I. (2022). Assessment of the State of Soil Cover Pollution in Rivne by Heavy Metals as a Component of GIS Ecological Monitoring of the City. In *16th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment, Kyiv, Ukraine*. URL: <https://doi.org/10.3997/2214-4609.2022580264>.

