

Mon22-264

Assessment of the state of soil cover pollution in Rivne by heavy metals as a component of GIS ecological monitoring of the city

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SUMMARY

The study deals with the gross heavy metals concentration of Cd, Mn, Cu, Ni, Pb, Zn in the surface sediments of the city of Rivne.

The priority pollutants of the city's soils are presented with such metals as Cu, Mn, Pb, Zn. Their concentration exceeds the background indices for the vast majority of samples

It has been developed the map according to the indicator of total soil pollution Zc.

For 61% of samples, the value of total contamination indicates a dangerous level of contamination, 21% of samples correspond to the category "extremely dangerous".

Such data indicate that the surface sediments of a large part of the city require the implementation of measures to reduce their toxicity and a more detailed study.



Introduction

Within the up-to-date various environmental issues urbanized areas are presented as the significant ones and interpreted as complex multifunctional natural and anthropogenic systems. An important factor of negative impact on the environment is emissions and wastes from industrial utilities and motor vehicles that consist of heavy metals as well.

In order to provide a rationale for the measures aimed at eliminating the negative consequences of anthropogenic interference in natural environment and improving the state of the environment it is necessary to conduct an analysis and assessment of the ecological situation. Therefore, the study of the regularity of the distribution of heavy metals in the soil cover of the city of Rivne is an urgent task to provide residents with an ecologically safe and favorable living environment.

The author states that soil is an indicator of long-term natural processes and its condition is the result of long-term exposure to various sources of pollution. About 90% of heavy metals that have entered the environment are accumulated in the soil (*Myslyva, Onopriienko, 2009*).

Heavy metals are characterized as the pollutants that must be monitored in all environments. They enter the soil mainly from the atmosphere with emissions from industrial enterprises and transport, wastewater, industrial waste, household waste, mineral fertilizers and pesticides (*Sternik, 2017*).

Method and Theory

The author stresses on the one of the main factors of urban systems development and environmental issues emergence presented with economic activity, concentration of industrial production and infrastructure. It is highlighted that the leading branch in the city economy is industry. The industrial potential of the city is characterized by a high level of chemical industry and machine building development (*Klymenkoetal., 2008*).

Within the city location Rivne enterprises are placed more or less densely forming five industrial zones:

- Northern – LLC " Rivnepobutprylad", OJSC "Rivnegaz", SE "Rivnokolormet", CJSC "Rivneboroshno", stations of Lviv railway that serve Rivne manufacture;
- North-Eastern – OJSC "Gazotron", PJSC "Rivnenska fabryka netkanykh materialiv", CJSC "Renome", ATP-15663;
- South-Eastern – KTP "Kommunenergia", CJSC "Rivneenergo", OJSC " Rivnenskyi zavod traktornykh ahrehativ", MU "Rivneelectroautotrans", OJSC "Kamaztransservice";
- South-Western – OJSC " Rivnenskyi zavod budmaterialiv", LLC "Zakhid resources", "Rivneoblvodokanal", PE "Politek", OJSC "Riven", OJSC "Polissiakhlib", PJSC "Agroresurs";
- Central – LLC "Aquaton", OJSC "Rivnenskyi KKhP", OJSC "Ukrtelecom", ATP-15607, Rivne management of the main oil pipeline "Druzhba", LLC "Ecohelp".

The study covers an important stage of land survey as the assessment of the ecological condition of soils that should be based only on reliable information.

The level of soil pollution is assessed by comparing the actual concentration of the element with its MPC, and under the conditions of such standard absence it should be assessed according to the natural background indices. The main calculated indicators of the degree of pollution are **the concentration coefficient K_c and the total pollution index Z_c** (*Pryshepa, 2021*).

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 is actual concentration of the i -th element, mg/kg; C_ϕ is background concentration of the i -th element, mg/kg;

MPC is 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 is 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 the Table 1 (Yakovyshina, 2016; Yatsuk, Balyuk, 2019).

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 of population health indicators in the polluted areas
<i>Permissible</i>	Less than 16	The lowest rate of children's illness and the lowest frequency of detection of functional abnormalities
<i>Moderately dangerous</i>	16 - 32	Increase in the level of general morbidity
<i>Dangerous</i>	32 - 128	Increase in the level of general morbidity, the number of frequently ill children, children with chronic diseases, disorders of the functional state of the cardiovascular system
<i>Extremely dangerous</i>	More than 128	Increase in the general morbidity rate among children, women with reproductive disorders (increase in the number of toxicoses, premature births, stillbirths, etc.)

Examples

The initial materials for a comprehensive assessment of the soil contamination state were presented with the studies dealing with heavy metals concentration in the soils in the city of Rivne of the Central Geophysical Observatory (CGO) of the SES of Ukraine. Soil samples to determine heavy metals concentration were taken in accordance with the requirements for sampling soil contamination (DSTU ISO 10381-1:2004) within long-term monitoring of urban pollution. It has been analyzed 42 soil samples taken in the city of Rivne in 2017.

The main calculated indicators of the degree of pollution are the concentration coefficient K_c and the total pollution index Z_c .

Having calculated the concentration coefficients K_c and using the background indices from the study (Yakovyshina, 2016) it has been concluded that heavy metals concentration in the soil cover of Rivne significantly exceeds their background. Thus, the detected average indices of Mn are 536.8 mg/kg with a background concentration of 91.4 mg/kg, Cu indices are presented with 19.8 mg/kg with a background concentration of 1.18 mg/kg, Ni indices concern with 18.3 mg/kg with a background concentration of 2.71 mg/kg, Pb indices deal with 20.6 mg/kg with a background concentration of 2.8 mg/kg, and Zn indices are 137.7 mg/kg with a background concentration of 3.02 mg/kg.



Analysis of the results allowed to establish the following categories of soil contamination in Rivne with heavy metals: "acceptable", "moderately dangerous", "dangerous" and "extremely dangerous". Thus, in Rivne, most of the sampling sites (69.1%) belong to the "dangerous" category in terms of total contamination. There are points (21 %) that have Z_c indices and correspond to the category "extremely dangerous" as well. Such high indices may be caused by the mechanical composition of soils that can accumulate.

It has been used visualization methods of graduated colors and symbols to map the pollution of urbo-daphotopes with heavy metals. The map of soil contamination distribution (figure 1) shows the areas of heavy metals localization in terms of total contamination.

Developed map demonstrates the "moderately dangerous" category of soil pollution located near the following enterprises: LLC "Vysokovoltnyi Soyuz – RZVA", PJSC "Agroresurs", "permissible" is concentrated near ALC "Rivnokholod". The category of "dangerous" ones is observed close to the enterprises LLC "Rivnenskyi lonokombinat", PJSC "Rivnenska fabryka netkanykh materialiv", LLC "Vyrobnyche pidpriemstvo" Aquaton". The category of "extremely dangerous" ones is concentrated around the railway.

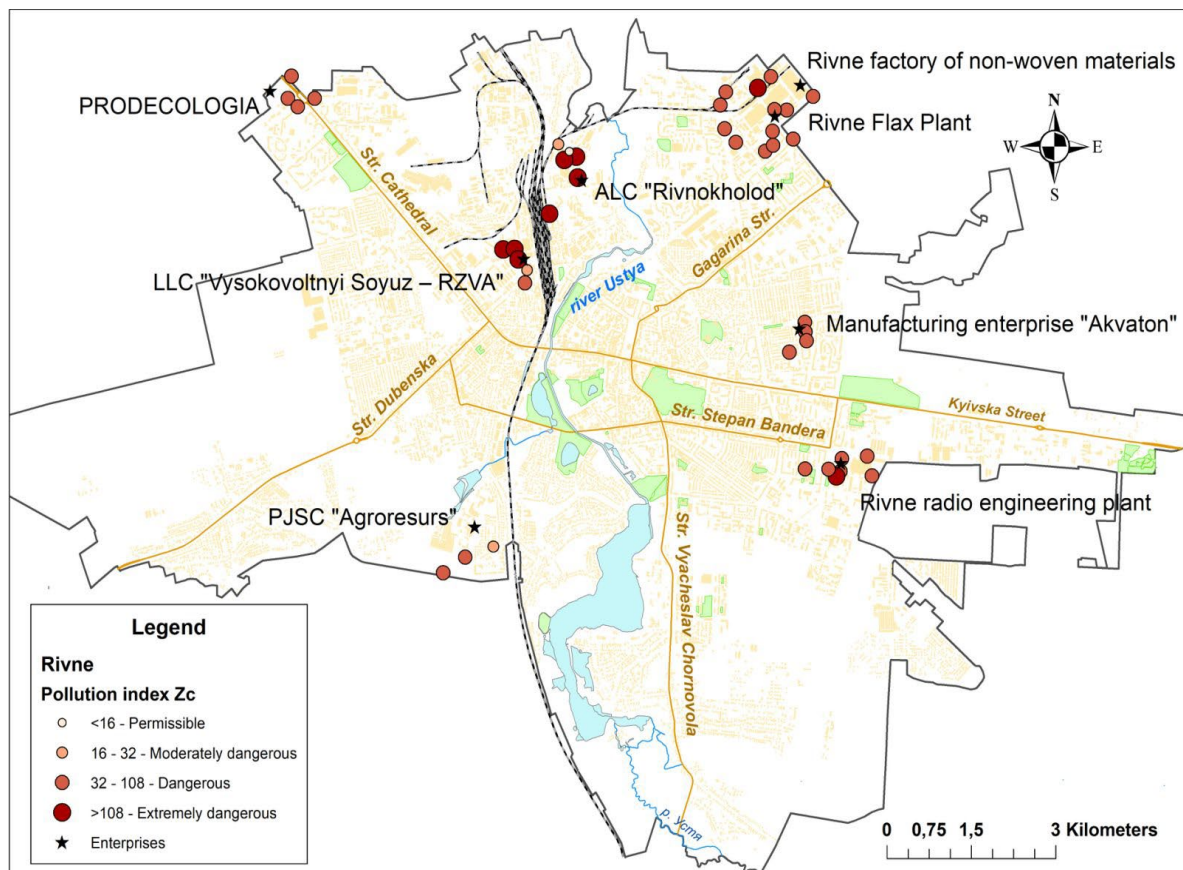


Figure 1 Distribution of soil pollution by total pollution index of heavy metals (developed by the author)

Conclusions

The author outlines the largest polluters of the soil cover presented with LLC "Vysokovoltnyi Soyuz – RZVA", the territory of Lviv railway service within the city of Rivne that is northern industrial zone;



PJSC "Rivnenska fabryka netkanykh materialiv", LLC "Rivnenskyi lonokombinat" located in north-eastern industrial zone; LLC "Vyrobynye pidpriemstvo"Akvaton", OJSC "Radiozavod" placed in south-eastern zone; Scientific and Production Firm "Prodekologiya", ALC "Rivnokholod" and PJSC "Agroresurs".

The paper classifies Rivne city territory according to the total pollution index Z_c . As a result, there are more than a half of the sampling samples (69.1%) classified as "dangerous" ones with average indices of total pollution in Rivne. There are points (21 %) containing Z_c indices and corresponding to the category of "extremely dangerous" ones as well.

It may be assumed that the peculiarities of the soil cover represented by heavy loamy and clayey types contribute to this situation. For a more objective spatial analysis and pollution monitoring it is necessary to increase the number of sampling for uniform coverage of the territory.

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