# GEO-ECOLOGICAL RESEARCHES IN BUKOVINA

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**Key words :** Anthrosols, geochemical landscape, Clark concentration, pollution intensity.

**Abstract.** The analysis of urban soils in North-Bukovina using the methodology of landscape geochemistry permitted us to establish methodological procedures for ecological assessment of a given land. The analysis of geochemical coefficients and indices (element concentration coefficient - Kc, Clark concentration - Kk, concise pollution index - Zc, pollution intensity index - Pj) is frequently used.

## Introduction

As we well know, due to intense technological pollution of the natural environment, soils of industrial cities often become object of ecological estimation. This phenomenon is due to industry development, sprawl of urban space, improvement of agricultural technology, etc. The novelty of this trend in science demands paying special attention to the elaboration of its theoretical principles and its methodology (Dinu, 1979). Such is a methodology for landscape geochemistry (Gutzuleac, 1994).

The extent of soil pollution in the urban environment must be estimated taking into consideration background analogues, considering the background and radial landscape geochemical structure. Besides, it is necessary to study the extent of their ecological danger, which is the main task of applied geochemistry. The principles of ecological geochemical analysis of soils and of other landscape components are still poorly taken into consideration in literature (Gutzuleac a. Brandus, 1996).

In this paper, we summarize the results of the author's investigation on the territory of Bukovina, since 1980. The problem the author has tried to solve concerns the development of a methodology for ecological analysis and the estimation of natural components and soils in particular, the analysis and the

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estimation of the ecological situation, and the solutions to various problems of rational use of environment.

For estimation of the ecological state and quality of soils, more than 1000 soil samples have been subject to physical and chemical methods of laboratory analysis, statistical processing being applied. Chemical analysis of soil samples included macro and microelements of ecological interest. Indices of the state of health of the population living in the territory under study have been also used as well as indicators of ecological risk.

Based on the results of this investigation, methods have been prepared for estimation of the geochemical loading on soils of urban territories and a methodology for determining the degree of risk of soils pollution by chemical elements.

**1.Geochemical analysis of the landscape**

In connection with the increasing technogenic pollution of soils, industrial cities become more and more frequently objects of ecological assessment. The actual state of this scientific concern requires preparation of its methodological basis. Such a methodology is offered by landscape geochemistry. The concrete methods of this science and its terminology have an important role. In cities, as well as in natural landscapes, it is necessary to investigate water and air migration, and biological flow of atoms. At the same time, it should be taken into account the fact that cities are constituted of different landscape (and geochemical) systems - residential, industrial, recreational, etc. - that have specific functional roles.

The geochemical analysis of Anthrosols should be made taking into consideration three aspects: study of chemical element migration and of energetic and informative characteristics of these processes.

The analysis of balance degree regarding the urban landscape has a particular importance. Cities are very unbalanced systems, much more unbalanced than natural landscapes. The urban landscape has much free energy. Feedback is characteristic for urban systems, but the positive one exceeds the negative one. It permanently determines the development rhythm of soils towards an unsuitable (environmental pollution) direction. A problem of the urban soils optimization consists in amplifying the negative feedback that leads to their self-organisation. When we study the geochemistry of cities, it is necessary to use the Le-Satelle's principle, the centralisation principle (determination of structural centre of urban landscape, key of problems controlling the processes).

When geochemical methods are used to investigate urban soils, it is important to know that the technogenic flow of substances is dispersed, accumulated and transformed by means of natural components.

To establish connections between the above mentioned processes, it is necessary to analyse the chemical composition not only of soils, but also of bottom sediments, snow layers and vegetation, as well as the natural factors of landscape pollution and self-cleaning.

Tab. 1 - Mobility of biochemically active elements to the alkalino-acid and redox conditions of technogenesis in soils according

| Conditions | | | Mobility[1] | |
|---|---|---|---|---|
| Alkalinity-acidity | Oxidation-reduction | Very low | Moderate | Intense |
| Acid | Oxidation | - | Pb,Ag,Se | Co,Mn |
| | | Mn,Mo | Co,Ni,Cu,V | Cu,Zn |
| Acid | Reduction | As,Se | Pb,Cd | |
| | | Mo,V | Ni,Co,Cu,Zn,Cr | |
| Slightly acid and neutral | Oxidation | Pb | Cd | As,Se |
| | | | Mo,Cu,Co,Ni,Cr | Zn,V |
| Slightly acid and | | Pb | Cd,As,Se | |
| Neutral | | Mo | V,Cu,Zn,Co,Ni,Cr | |
| Alkaline | Oxidation | Pb Co | - | As,Se |
| | | | Cd,Cu,Zn | V,Cr,M |

*Numerator - very toxic elements; denominator - less toxic elements

The assessment regarding the pollution degree of urban environmental components should be made taking into account the basic landscape-geochemical lateral and radial basic structure. In addition, the spatial structure of pollution and the differentiation of territory according to ecological risks should be studied, as it is one of the fundamental problems of applied geochemistry.

The natural and anthropic factors play an important role in the formation of the ecological state (pollution and self-cleaning). Among climatic factors, two groups are pointed out:

- those determining the metabolism intensity of technogenesis' products (sum of solar radiation, ultraviolet, thermal and ozone regimes of atmosphere);

• those determining the intensity of movement and accumulation of technogenesis' products (mean annual wind speed, number of calm days, misty days, precipitations).

Climatic maps of the studied city are prepared according to each index and a synthetic map of climatic factors is also prepared.

Among the main geological and morphological factors, some have to be pointed out: the soil erosion degree and the slope aspect that determine the intensity and the character of the distribution of technogenesis' products in the soil; the level of the ground water table and its protection degree by impermeable horizons, the particle size distribution of parent materials and their mineralogy and chemical properties, etc.

An important factor determining landscape stability concerning pedo-geochemical pollution is the soil capacity to play a buffer role. The movement of active pollutants is determined by the soil absorption capacity, depending on the particle size distribution and on the humus content, and by alkaline-acid and redox conditions (tab. 1).

**2.Procedures for evaluation of geochemical effects**

Among the methodological procedures used to assess the geochemical weight on soils, the analysis of geochemical coefficients and indices is frequently applied (Metodicheskie, 1982; Lacatusu and. Ghelase, 1992). These are: the concentration coefficient or the anomaly coefficient of chemical elements (Kc), the concentration/Clark (Kk), and the summation pollution index (Zc). When the sum of anthropic weight (influence) exceeds the possibility, acute ecological situations occur.

The concentration coefficient is the ratio between the real quantity of substance in the natural component and its background quantity. The concentration Clark is the same real quantity compared to its Clark in the lithosphere. Zc is the sum of concentration coefficients of chemical elements, the number of elements that are summed depending on their ecological value, on analytical results etc. (about 15 elements, especially heavy metals, are frequently summed). The formulas used to calculate the concentration degree and the soil pollution intensity degree, as well as other natural components, are presented below.

The concentration coefficient (Kc) of a chemical element (i), as compared to its natural background, is:

$$K_{Ci}=C_i/C_f \qquad (1)$$

where: Ci - element concentration in soils of the landscape; Cf - its natural background (concentration);

The concentration Clark (Kk) of an element (i) is:

$$K_{Ki}=C_i/K_i \qquad (2)$$

where: Ki - the Clark, that is the mean quantity of the element in the terrestrial crust (percent of mass).

The summation soil pollution index (Zc) is:

$Z_{Ci}$=Sum of $K_{Ci}$-(n-l) (3)

where: n - number of chemical elements (the elements having Kci>l are totalised; j -landscape component.

The summation index of concentration Clarks (Zkj) of elements in the natural component is:

$Z_{Ki}$= Sum of $K_{Ki}$-(n-l) (4)

**3. Determination of pollution risk**

Determination of the degree of soil pollution risk with chemical substances. From the hygienic viewpoint, the risk of landscape pollution is determined by the level of possible negative influences of this pollution on the environment (whose components have a direct contact - air, water, soils, food products) and man, respectively. The basic criterion for the hygienic assessment of pollution risk is the maximum allowable limit (MAL) of chemical substances in the landscape components. The influence of pollution on human health is determined by using the coefficient of chemical element risk (Kpi). This is determined by the ratio between the quantity of substance in the landscape component which is analysed, and the maximum allowable limit:

$K_{pi}$ =$C_i$/MAL (5)

The summation pollution risk index is determined by the sum of the Kp indices:

To assess the ecological state, the pollution intensity index (Pj) is also used. It is determined by the formula:

Pj= Sum of $K_{Ci}$-M. (6)

where: Kci - concentration coefficient of the chemical element (i); M - the toxic value of the chemical element (according to the risk class V)

| | |
|---|---|
| Class I: | >4.1 |
| Class II: | 2.6-4.0 |
| Class III: | 0.5-2.5 |
| Class IV: | <0.5 |

The use of the above presented formula allows us to take into account the ecological importance of soils and of other landscape components, the synergetic action of the chemical elements that condition people life and

Tab. 2 - Accumulation of chemical elements in the soils of the area's landscapes, influenced by some industrial enterprises and other pollution sources

| Pollution source | Production type | Concentration coefficient (Kc) | |
|---|---|---|---|
| | | 2-10 | >10 |
| Industry, for construction of machines and processing metals | Enterprises for processing metals | Ni, Cr, Hg, Sn, Cu | Pb,Zn |
| | Manufacture of equipment for electromechanical industry. Manufacture of fertiliser. Fertilisers Fertilisers storage battery with lead. | St, Zn, Pb, Bi | Ni,Cd |
| | | | St,Zn |
| Industrial waste water | | Cu | Pb,Zn |

Tab. 3 - Ordination of chemical substances entering the soil from emissions, leakage according to pollution level

| Class | i I Risk degree | Chemical substance |
|---|---|---|
| I | IVery risky | As, Cd, Hg, Pb, Se, Zn, F, benzopyrine |
| II | i Risky | B, Co, Ni, Mo, Cu, St, Cr |
| III | [Moderately risky | B, V, W, Mn, Sr, acetophenon |

health. For instance, the landscape complexes in the central zone of the Cernautzi city (Pj = 70) are threatened by a high risk, that confirms conclusions referring to the ecological pressure and to the necessity to adopt some measures for improving the soils of the respective urban territories.

The analysis of geochemical indices distribution, according to the above mentioned parameters (that are obtained after analysing the natural components), reveals the spatial structure image regarding the pollution of soils in the urban territories (air, soils, water included) that constitutes the highest risk for human health. The selection of chemical factors used to assess the pollution risk of landscapes is made taking into account:

1. specificity of pollution sources determining the complex of polluting chemical elements (Tables 2);

2. priority of pollutants according to the risk level and to the maximum allowable limit (MAL) of chemical substances (Table 3);

3. environmental alkaline-acid conditions according to the water pH (strongly acid- 4, slightly acid - 4.6 - 5, neutral and slightly acid - 6.5 - 8.5, strongly alkaline >8.5);

obstacle character of landscape component that influences the movement of chemical elements. The less characteristic the obstacle properties of landscape are, the higher is the pollution risk, this affecting especially landscapes with an acid pH, lower soil humus content and a lighter texture. The character of land use (localities, agricultural land areas, recreational areas, etc.) has to be taken into account, as well.

When it is not possible to take into account all the chemical elements polluting the landscape, the assessment is made according to the most toxic elements, that is, taking into consideration the elements included in the most dangerous class.

**Conclusions**

The ecological situation of Anthroposols has been estimated using geochemical factors, e.g., the summation soil pollution index (Zc) and the pollution intensity index (Pj). The landscape as a whole has been estimated with the help of the integral indicator of ecological danger (In). The anomalous integral indicator of ecological danger of soils which has been found (In=50) may be considered entirely as critical (threshold), beyond which certain biological reactions of the organism are observed. Monitoration of soils' quality (and of landscapes as a whole) is one of the main conditions for an integral management of Anthroposols.

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