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Yegorova T.

Candidate of Geological and Mineralogical Sciences,
Institute of Agroecology and Nature Management NAAS

Ecological and geochemical basis of estimation of agro-landscapes of Ukraine

The purpose. To study causal-investigatory correlations between processes of geochemical migration and ecological state of agro-landscapes, their taxonomic grading and quantitative parametrization.

Methods. Landscape-geochemical zoning of Ukraine and systemic generalization of agro-ecological, agro-geochemical, hydrochemical, bioclimatic, geomorphologic, biogeochemical and mineralogical data.

Results. Taxonomic grading of agro-landscapes is presented which includes systematization of geo-chemical and ecological processes, factors of agro-ecological zoning, their quantitative parameters and criteria of estimation.

Conclusions. Combination of limiting and favorable ecological-geochemical factors of farming agriculture for terrains of regional geochemical landscapes of Ukraine is presented.

Key words: agro-landscape, grading, ecological geo-chemistry, factors of zoning.

Geochemical processes in the biosphere are the subject of research in most applied natural sciences. Each of them focuses mainly on a separate type of geochemical migration or certain chemical elements [4, 6, 14, 15]. Agroecology, studying various environmental factors, pays little attention to the geochemical factors and processes that determine the ecological peculiarities of agrocenosis development. In order to create normal environmental conditions for the development of plants, it is necessary to identify and correct the limiting geochemical factors of their development. Comprehensive identification of such factors is possible by taxonomic classification of agro-landscapes at the local and regional levels. However, at the local level, within a separate crop rotation for land users, these issues are relatively clear, while land evaluation at the regional level is much more complex due to the interaction of a wide range of factors that can correspond to zones of ecological pessimism and optimum. The purpose of the research is to study the causal relationships between processes of geochemical migration and the ecological state of agro-landscapes, their classification by taxonomic categories and informative quantitative parametrization. On these grounds, the landscapes of Ukraine with the optimal and most unfavorable ecological-geochemical features of agriculture are defined. Analysis of recent research and publications. Agro-ecological research in Ukraine is mainly focused on the main problems of ensuring the fertility of lands, which include erosion and salinity of land, loss of humus, lack of nutrients, soil contamination and agricultural products with radionuclides and pesticides [1, 3, 11]. The solving of these problems in separate territories is devoted to scientific developments O.I. Furdicka, O.G. Tararika, V.A. Baranova VP Pattiki, MI Polupana, V.V. Medvedev and others. [1, 11, 12]. Geochemical trends in agro-ecological research in Ukraine are associated with agrochemical monitoring of arable land, which covers the spatial distribution of the main fertility factors of one of the components of a separate functional type of agro-landscapes - arable land [3, 4, 12]. The necessity of complex research of multifactorial geochemical processes in the landscapes of agricultural territories is indicated in the works of OI. Perel'mana, MA Glazovsky, K.I. Lukashova, MK Chertko, VM Hutsuluk, IV Kurayeva, R. Sipos and others. [6, 8, 14, 15]. Studies [6-8]

highlight the impact of natural and man-made processes on the geochemical migration of trace elements on the ecological state of soils and all other components of landscapes - soil forming rocks, surface waters, natural and agricultural vegetation, domestic animals and humans. The presence of such a connection confirms that during the implementation of agroecological research it is necessary to study and evaluate interdependent ecological-geochemical processes. The conducted research is a methodological basis for studying and territorial differentiation of these processes for agro-landscapes in the territory of Ukraine. Materials and methods of research. The analysis of ecological and geochemical processes in agrolandscapes of Ukraine is carried out on the methodological basis of geochemistry of landscapes. Spatial features of the redistribution of natural and man-made substances by the main natural factors (climate, relief, vegetation and soil cover, soil formation and underlying rocks, sediment sediment mineralogy) reflect 25 regional geochemical landscapes, isolated and described by the author earlier [7]. The developed methodology for estimating agro-landscapes in Ukraine contains a taxonomic classification of natural and man-made factors of their formation and corresponding ecological-geochemical processes; development of the system of quantitative parameters and criteria of environmental processes and migration of chemical elements; generalization of the selected parameters (agroecological, technogenic, climatic, agrochemical, agrotechnical, geomorphological, hydrochemical, biogeochemical, metallogenic) for the territories of the geochemical landscapes and their classification into normal, optimal or unfavorable for agriculture. On these bases, for the territories of each of the regional landscapes, extensive complexes of limiting and optimal ecological and geochemical factors of the functioning of agro-landscapes were identified.

The taxonomic classification of agro-landscapes developed by us is based on three basic principles: • the classification of agro-landscapes as the first stage of a large-scale (regional and local) agro-ecological zoning of the territory of Ukraine; • quantitative parametrization of the main natural and technogenic ecological and geochemical processes of the historical functioning of agrolandscapes of Ukraine as the basis of their ecological assessment; • Limiting geochemical factors are considered as regional principles of economic use of the territory of Ukraine. The informative environmental assessment of agro-landscapes should be based on adequately studied quantitative parameters of ecological-geochemical processes, which determine differentiated by each factor of zoning [7, 8]. Such estimation is based on the characteristics of the migration of complex biogeochemical chains of the system sedimentary deposits - soil forming rocks - soils - biocenoses. Research results. The developed classification of taxonomic categories of agro-landscapes contains a description of the leading geochemical and ecological processes of their functioning, parameters and criteria of their quantitative evaluation and qualitative characteristics of landscapes, which are used for zoning of territories (Table 1). Changes in the physico-chemical structure of the natural landscape for economic use, which are the criteria for distinguishing the series of agro-landscapes, can be estimated by the following parameters: excess of areas of ecologically destabilizing lands of gardens and arable land to stabilizing lands of forests and grasslands (EDS) [1]; percent land plots (P); annual total module of man-made waste (MTV) [2, 9]; disturbance of the natural structure of landscapes behind IO Frost; the total indicator of pollution by heavy metals by Yu.E. Sayeth; residual stocks of pesticides and artificial radionuclides in the soil. The water temperature regime of the territories and the chemical properties of natural solutions, which are the criteria for distinguishing types of agro-landscapes, should be evaluated according to the following parameters: the degree of metamorphisation of surface waters by O.E. Belyakova (KIS) [8], hydrothermal coefficient for G.T. Peasant (GTK) [13]. The natural phytopotential of the territories and the natural yield of agrocenoses, which are the criteria for the isolation of families of agricultural landscapes, can be evaluated according to the following parameters: total phytomass and phytocenoses productivity by M.I. Bazilevich (B, P) [6, 8, 14]; the natural yield of cereals, which

highlights the natural fertility of the soil (UF - for winter wheat, UH - for barley steep) [1, 11, 12]. The natural potential of soil fertility, which is a criterion for distinguishing classes of agro-landscapes, should be evaluated according to the following parameters: typomorphic macronutrients of soil solution according to OI Perelman [7, 8]; content of humus for IV Tyurin (Sorg.) [4, 12]; complex index of soil absorption capacity according to T.M. Egorova (CPP) [8]. The intensity of mechanical degradation of soils, which is a criterion for distinguishing the genus of agrolandscapes, can be evaluated by the following parameters: morphostructure, angles of surface tilt (k), depth (h), and dissociation density (l) of the surface of the OI. Spiridonov; landslide (ZZ) and actual losses of the arable layer (VZ) [5]. The maintenance of biogeochemical chains by nutrient (essential) elements, which is a criterion for the isolation of types of agro-landscapes, should be evaluated according to the following parameters: biogeochemical shortage and excess of essential micronutrients in soils under VV. Kovalsky [6, 8]; ore-bearing sedimentary cover according to the types of ore minerals [2, 10]; Clarks of the concentration of essential elements in rocks at VI Vernadsky Ecological and geochemical processes in agrolandscapes of Ukraine were evaluated by 34 of these parameters. This made it possible to determine the territories with the optimal and worst ecology-geochemical features for agriculture, which reflect certain taxa for each of the 6 taxonomic categories. Optimal ecological-geochemical conditions of agriculture at the level of 1-3 factors are on the territory of the 21st regional landscape. Of these, 3 optimal factors are characteristic only of the Trubizh, Auratin and Upper Dinan landscapes occupying the territory of the Forest-steppe of the Right Bank High and Left Bank High and Lowland.

1. Taxonomic categories of agro-landscapes and parameterization of ecological-geochemical processes

Таксономічні категорії агроландшафтів	Типологія геохімічних і екологічних процесів	Якісні фактори агроекологічного районування	Характеристики еколого-геохімічних параметрів природно-техногенних процесів	Критерії просторової диференціації еколого-геохімічних процесів
Ряд	Загальна природно-техногенна міграція і хімічне забруднення	Техногенне навантаження та функціональне зонування земель сільсько-господарського призначення	Антропогенні зміни природних геохімічних процесів певним видом сільськогосподарської діяльності; екологічна рівновага сільгосподарства; техногенне навантаження на компоненти ландшафту	Зміни фізико-хімічної структури природного ландшафту
Тип	Водна фізико-хімічна міграція і водно-температурна забезпеченість	Кліматична та фізико-географічна зональність	Стійкість водних мігрантів і запаси продуктивної вологи	Зміни водно-температурного режиму територій і хімічних властивостей природних розчинів
Родина	Біогенна міграція і природна біопродуктивність	Природні рослинні формації	Маса біологічної речовини, що включена до біогеохімічних циклів	Природний фітопотенціал і природна врожайність агроценозів
Клас	Ґрунтова міграція і гумусо-забезпеченість	Геохімічні класи та комплекси ґрунтів	Агрохімічна деградація ґрунту	Природний потенціал родючості ґрунту
Рід	Механічна міграція та ерозія поверхні	Морфометрія рельєфу	Поширення ерозійних процесів	Інтенсивність механічної деградації ґрунтів
Вид	Літогенна фізико-хімічна міграція і потенційна забезпеченість поживними речовинами	Ґрунтоутворювальні породи і мінералогічні субпровінції осадового чохла	Надлишок і дефіцит поживних елементів у біогеохімічних ланцюгах	Забезпеченість біогеохімічних ланцюгів поживними (есенційними) елементами

The optimal parameters of these landscapes correspond to their type, family and class, that is, to such ecological-geochemical processes: water physical and chemical migration and water-temperature provision; biogenic migration and natural bioproductivity; soil migration and humus availability. At the same time, in other groups of parameters (near, genus and kind of landscapes) they fall into the transition zone between optimum and pessimism. Therefore, the directions of the preservation of fertility and the balanced use of these lands should provide for the reduction of man-caused load, anti-erosion measures and the restoration of natural biogeochemical cycles. The spread of the parameters of the ecological-geochemical factor at the level of the pious region indicates its limiting value for the agriculture of the respective territory (Table 2). The complex of limiting factors indicates significant difficulties in providing economically viable crop yields. Unfavorable ecological and geochemical conditions of agriculture for 1 - 2 limiting factors are available in the territory of 13 regional landscapes.

2. Taxonomic classification of ecological-geochemical factors and parameters of agro-landscapes of Ukraine

Таксономічна категорія агроландшафтів	Класифікаційні еколого-геохімічні фактори функціонування агроландшафтів	Таксони агроландшафтів та їх еколого-геохімічні параметри
Ряд	Природно-техногенна міграція хімічних речовин	ЕДС>1; P>80%; МТВ>100 т/км ² /рік* ЕДС=0,5–1,0; P=80–80%; МТВ=10–100 т/км ² /рік
Тип	Водна фізико-хімічна міграція абіогенних речовин	ЕДС<0,5; P<80%; МТВ<10 т/км ² /рік** КЮ>10; ГТК=0,5–0,8* КЮ=4–8; ГТК=0,6–0,8 КЮ=0,6–4; ГТК=0,8–0,9 КЮ=0,6–4; ГТК=1,0–3,8 КЮ≤0,5; ГТК=1,1–1,8 КЮ≤0,5; ГТК=0,9–1,2**
Родина	Біогенна міграція біофільних хімічних елементів	Б 20; П=8–9; УП 2,2; УЯ 1,6 т/га* Б 20–80; П 8; УП 2,8–3,2; УЯ 1,7–2,3 т/га Б 300–400; П 8–12 т/га; УП 2,7–3,4; УЯ 2,7–3,3 т/га Б 300–370; П 7,5–8; УП 1,8–2,0; УЯ 1,5–1,9 т/га Б 25–370; П 8–13; УП 2,8–3,5; УЯ 2,1–2,5 т/га**
Клас	Водна природно-техногенна фізико-хімічна міграція речовин у ґрунтовому покриві	H ⁺ ; C _{ср.} 0,7–5%; КПЕ=8–26* Ca ²⁺ –Na ⁺ ; C _{ср.} 1,8–5,5%; КПЕ=138–186 H ⁺ –Fe ²⁺ ; C _{ср.} 0,7–2,9%; КПЕ=12–306 H ⁺ –Ca ²⁺ ; C _{ср.} 1,3–3,5%; КПЕ=230–240 Ca ²⁺ ; C _{ср.} 2–5,7%; КПЕ=83–275**
Рід	Поверхнева механічна міграція мінеральних сполук	Височини і гори; k>30', h>20 м, l<0,6 км; ЗЗ>80%; ВЗ>20 т/га* Гори і височини; k>30', h>20 м, l<0,6 км; ЗЗ=1–80%; ВЗ<15 т/га Височини і низовини; k=0,5–1°, h=10–100 м, l<2 км; ЗЗ>80%; ВЗ=15–20 т/га Височини і низовини; k=0,5–1°, h=10–100 м, l<2 км; ЗЗ=1–80%; ВЗ=3–20 т/га Низовини; k<30', h<10 м, l>0,3 км; ЗЗ<1%; ВЗ<3 т/га**
Вид	Екзогенна фізико-хімічна трансформація гірських порід і мінералів	Нестача в ґрунтах Мо, Со в умовах ендегенного розсіювання* Нестача в ґрунтах Мо, Со, Мп в умовах ендегенного розсіювання Нестача або норма в ґрунтах Мо, Со в умовах ендегенної концентрації Надлишок у ґрунтах Zn в умовах ендегенної концентрації Надлишок у ґрунтах Zn в умовах ендегенного розсіювання Норма вмісту в ґрунтах Мо, Со, Мп, Cu, Zn, Sr в умовах ендегенного розсіювання**

* Перший таксон характеризує зону песимуму, ** останній — зону оптимуму еколого-геохімічного фактора.

Of these, two limiting factors are characteristic of the five landscapes - Polissya, Priazov, Tarkhankut, Simferopol and Kerch, common in the Polissya of the Western, Southern and Southern Steps. Such ecological-geochemical parameters correspond to the type and family of agro-landscapes on the territory of the Steppe, class and species - in the territory of Polissya. It characterizes the pious region of such ecological and geochemical processes: water

physical and chemical migration and water-temperature security; biogenic migration and natural bioproductivity; soil migration and humus availability; lithogenic physical and chemical migration and potential nutrient supply.

Conclusions

Ecological-geochemical processes generalize the natural-technogenic redistribution of matter and energy in the zone of active agrarian use. The systematization of physico-chemical, biogenic and mechanical types of migration highlights the target taxonomic classification of agro-landscapes. The ecological evaluation of the processes of geochemical migration was performed on 32 quantitative parameters, including agrochemistry of soils, natural grain yield, biotope productivity of phytocenoses, surface morphometry, sediment mineralogy. Intervals of the vibrations of the investigated parameters are divided into zones of optimum and pozhim. Spatially they meet agrolandscapes with optimal and unfavorable ecological-geochemical conditions and distribution of certain limiting factors of agriculture. For agro-landscapes, where 2 or more limiting factors are concentrated, it is expedient to consider the ecological and economic perspective of their transfer to the category of ecologically stabilizing lands.

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