UDK 631.4

N. A. Bilova[1], V. N. Yakovenko[1], E. D. Yushchuk[2]

MICROMORPHOLODGY OF ARTIFICIAL EDAPHOTOPES IN FOREST ECOSYSTEMS OF DESTRUCTIVE AREAS OF UKRAINE

[1]O. Gonchar Dnipropetrovsk National University
[2] Krivyi Rih Pedagogical University

In the paper the materials of construction and development of artificial forest edaphotopes, their micromorphological dynamics in Western Donbass technogenesis environment are stated.

Key words: micromorphology, forest edaphotopes, technogenesis, Western Donbass.

Н. А. Белова[1], В. Н. Яковенко[1], Е. Д. Ющук[2]
[1]Днепропетровский национальный университет им. О. Гончара
[2]Криворожский педагогический университет

МИКРОМОРФОЛОГИЯ ИСКУССТВЕННЫХ ЭДАФОТОПОВ В ЛЕСНЫХ ЭКОСИСТЕМАХ ДЕСТРУКТИВНЫХ ТЕРРИТОРИЙ УКРАИНЫ

В статье изложены материалы конструкции и развития искусственных лесных эдафотопов, их микроморфологическая динамика в условиях техногенеза Западного Донбасса.

Ключевые слова: микроморфология, лесные эдафотопы, техногенез, Западный Донбасс.

Н. А. Білова[1], В. М. Яковенко[1], Є. Д. Ющук[2]
[1]Дніпропетровський національний університет ім. О. Гончара
[2]Криворізький педагогічний університет

МІКРОМОРФОЛОГІЯ ШТУЧНИХ ЕДАФОТОПІВ У ЛІСОВИХ ЕКОСИСТЕМАХ ДЕСТРУКТИВНИХ ТЕРИТОРІЙ УКРАЇНИ

У статті викладені матеріали конструкції та розвитку штучних лісових едафотопів, їх мікроморфологічну динаміку в умовах техногенезу Західного Донбасу.

Ключові слова: мікроморфологія, лісові едафотопи, техногенез, Західний Донбас.

In Western Donets Basin under the influence of undermining of coal beds subsidence of valley area of Samara Dniprovska occurs. Consequently underflooding destroys all components of forest biogeocenoses. But it happens step-by-step that gives an opportunity to plan the sequence and rates of subsidence phenomena, to identify the death stages of certain areas of Samara pine forest, to devise the methods and periods of its restoration.

Over the time of 35 years the unit on destructive land recultivation of Complex Expedition of O. Gonchar Dnipropetrovsk National University have been doing monitoring researches of destructive edaphotops, have been taking part in development of projects for design and formation of artificial soils and forest ecosystems in anthropogenic environment of Western Donets Basin.

Undermining of the territory and subsequent subsidence at 5-7 m runs nonuniformly and forms wide diversity of silva. This phenomenon is caused by different circumstances: geological stratigraphy, depth and pace of undermining of coal beds, depth of underground waters, relief, availability of different types of vegetation, etc.

For prevention of depth of natural valley forests on the area of more than 5 hectares it was necessary to develop guidelines and introduce into industry a whole number of nature conservation methods:

- The first method. Making a dam on the territory for delaying the water flowing from the water basin arisen as a result of subsidence of adjacent woods.
- The second method. So as not to allow the penetration of water through the protective dum and save the territory from underflooding and death of woodland, the method of vertical drainage was used. It was realized through laying of

the shaft wells with continual pumpdown of the water and dropping it into the riverbed of Samara.

- The third method is the cases when there is no subsidence, but underflooding occurs because of the overflow, appeared bodies of water and disturbance of processes of floodplain in spring.
- The fourth method. Territories where there is no underflooding, but destruction and death of forest biogeocenoses occurs because of interbiogeocenosis relations. Forest planting perished with underflooding and affections is a source of disease of weakened and aged trees.
- The fifth method. The artificial rise of day at original level (5-7 m) by formation of platforms of mine rocks with subsequent construction of filling on their surface. It ensures regular growth and development of forest plantings.
- The sixth method. Making soil artificial horizons from substrates of potential genetic propinquityof creating soil morphons (horisons).
- The seventh method. Use of creating typology of artificial forest culture biogeocenosis in anthropogenic landscape environment compiling on basis of typological principles of professor Belgard.

For diagnosing and fundamental guidelines along with conventional physicochemical methods micromorpholodgical soil structure analysis was made. One side of the study was ecological micromorpholodgy of standard alluvial genetic types of soil and soils of different degrees of destruction, degradation and death under the influence of subsidence deformations and underflooding. The other side of the study was ecological micromorpholodgy and physicochemical primary and prolonged processes of soil formation, development of methods of design of artificial soils by arrangement of soil horizon and whole soil profile in accordance with the selection of wood and shrub species, defining the principles of typology of artificial forests for revegetation of mine dumps in Ukraine. Special attention was paid to:

- syngenetic processes – primary embryonic soil formation;
- depth and characters of soil profile;
- depth and characters of soil horizons;
- the possibility of ecological and biological processes interprenetrating between individual horizons;
- lack of historical and genetic relations of individual bulk layers, soil (geological) horizons;
- biological compability of horizons;
- biological conditional compability;
- biological incompability;
- absolute biological incompability of constructible horizons;
- the level of ecological concordance of forest culture phytocenosis to habitat;
- absolute ecological concordance of forest culture biogeocenosis to habitat;
- relative concordance;
- absolute discordance of forest phytocenosis to habitat.
- level of forest suitability of established silvicultural conditions.

Monitoring observations for 1975 – 1985 – 1995 – 2010 testify that under the influence of underflooding silvicultural characteristics of soil retrogress, destruction of macro-, meso- and microstructure of soil mass occurs, sodium and potassium penetrate to soil-absorptive complex.

Ecological micromorpholodgy can penetrate into the depth of soil processes up to molecular and crystalline level and define by the instrumentality of polarized and scanned microscopes, computer and video equipment nucleation of chemical compounds which cannot be defined by method of physical-chemical analysis. Any destruction of soil by chemical analysis does not enable to define functioning of certain components in their interaction, interconnection and interdependence. Sample of “mince” made of experimental frog enable to get empirical notion about chemical composition, but not about structure functional organization of organism. Triturated watch put to the most careful gross analysis does not enable to discover the peculiarities of their construction and principle of operation. Ecological micromorpholodgy reveals qualitative and quantitative composition of substratum without destruction of sample's architectonics. It documents not only the levels of structural organization, but also in combination with physicochemical analysis it discovers the secrets and features of soil formation.

Studying the deformed and destructive soils in technogenesis environment in Western Donets Basin, Alexandria and Lviv-Volyn coalfields we managed to get the data which throw light upon the ecological essence of soil formation progressing in substrates (edaphotopes) making by nature or by man.

Among 6 experimental areas let's dwell on the area № 1 (3,2 ha), where the monitoring tests had been conducted for 35 years. Here 16 wood species are tested on the common platform with capacity of 10 – 12 m, filled in the territory of subsidence. The platform serves as a base, on the surface of which the artificial edaphotopes of different thickness, configuration and structure had been constructed.

Variant 1. Floodplain of the river Samara, subsided area and the platform built of mine rocks. The layer of the same rock of 2-meter thickness was specially applied on the platform. The task is to show ecological fitness (unfitness) of mine rock for growing of forest plantations on it.

Typological formula: heavy clay, dryish clay, level of morphological organization (LMO) – 1, half-cleared structure of plantation, initial structure of forest – 10 Robinia.

By 1999 plantation of robinia, common birch, black poplar, Bolle polar are completely degraded.

Micromorphological description of mine rock (2010).

Mine rock is heavy clayey mass on its granulometric composition. It consists of siltstone, mudstone and 16-20 % of organic matter coagulated irreversibly. The organic matter is resinous polymerized chemical compounds.

By the research findings the organic matter of mine rocks is not mineralizable and doesn't become available for plants' nutrition. Mine rocks by their physicochemical, water-air, mechanical properties are unfit for growing plants. They are absolutely impervious, have high density, hardness, viscosity, stickiness. In the time of drying up they are cemented, in the time of moistening they turn into sticky clay without air, as a rule with total moisture capacity. In point of chemical fertility mine rocks are anazotic compounds. They have trace of phosphorus, potassium, calcium, magnesium, sulfur, iron and microelements. Pyrite influences distinctly negatively. Content of pyrite is near 1%, it causes drop of pH to 3,2.

It is paradoxical that mine rock in the leach process has no adverse impact on water bodies. Our experiments have shown that fresh mine rock ejected on the daylight has solid residual 0,2 % at the most. Volume weight of mine rock is 1,6 – 2,2 g/cm3, specific weight – 2,7 – 2,5 g/cm3.

Ratio of Cha/Cfa reaches 10. It indicates that humic humus acids prevail over fulvic acids.

In consideration of ecological micromorpholodgy of mine rocks it could be concluded that for 35 years of functioning of rock, its connection with atmospheric air, oxidation processes, had affected the rock construction, which at the present time is notable for mixed character and heterogeneity of its structure, compared with fresh rock ejected from a mine (fig. 1).

Light-colored sections alternate with brown-colored carbonate-clay sections. As a result of physical and chemical weathering, under the influence of exothermal reactions, against the background of decomposition of primary mine substrates the oxidation process (combustion) of the rock occurred intensively.

After crushing the coal rock (rock of the Concentration Plant) the total surface, the area contacting with atmospheric air and primitive but active biota increase. Here the reactions of hydration, dehydration, hydrolysis, oxidation, dissolution and exchange are the most accepted. Pyrite interacting with oxygen and water undergoes the following changes:

$2Fe\ S_2$ (pyrite) $+ 7O_2 + 2H_2O = 2FeSO_4 + 2SO_4$;

$12FeSO_4 + 6H_2O + 3O_2 = 4Fe_2\ (SO_4)_3 + 4Fe(OH)_3$;

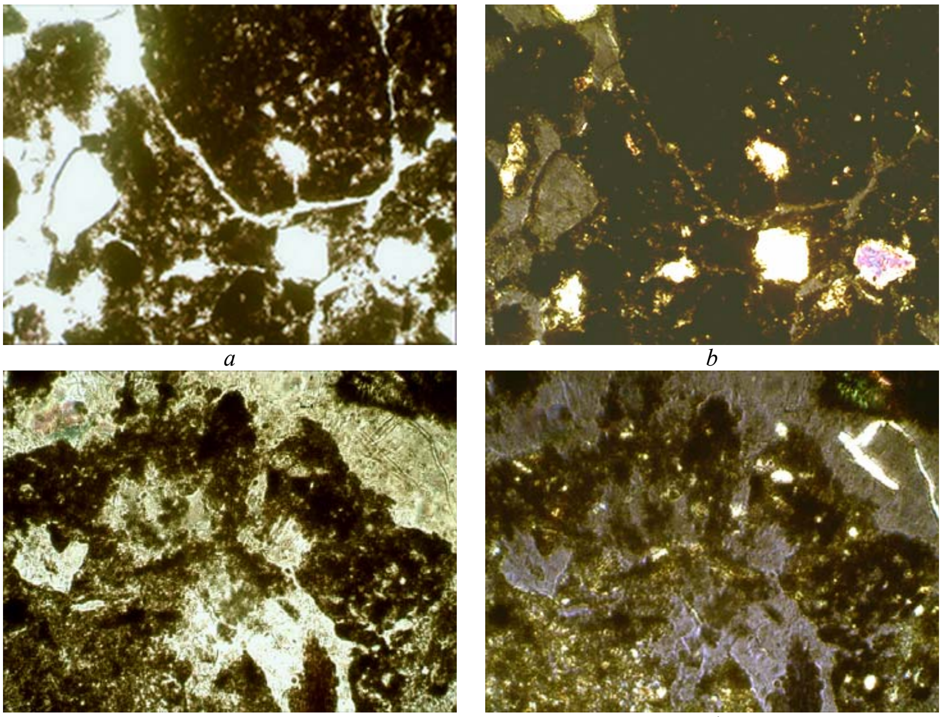
$2Fe(SO_4)_3 + 9H_2O = 2Fe_2O_3 \times 3H_2O$ (limonite) $+ 6H_2SO_4$.

As a result of the reaction the limonite is generated. This mineral in the sections has brown color and is consisted of separate particles capable to absorb the moisture.

Hydration is typical for the reactions attaching water. Red iron ore, ferric oxide – hematite interacting with water generates hydroxide or limonite.

$2Fe_2\ O_3 + 3H_2O = 2Fe_2O_3 \text{ x } 3H_2O$, dehydration is an inverse process progressing under water deficit. Pyrite as iron solphide prevails in the mine dumps where considerable part of iron is represented as its oxide compounds.

On the clear sections after 35 years of their physical, chemical and biological transformation it can be observed that the top layers of rock are different from the underlying. On the fig. 1 the primary distribution of plasma, fine-dispersed material generally consisting of clay are clearly defined.



c *d*

Fig. 1. **Fresh mine rock** (a – Nick. II. x 70; b – Nick. +. x 70);
mine rock after 35 years (c – Nick. II; d – Nick. + x70)

Elementary structure changes along the certain sections sandy-plasma-pulverescent. Structural aggregations are not isolated. Skeleton is of pulverescent size, there are some sandy grains 1,4 mm, 0,5 mm. Large grains of quartz and calcite are thrown about the whole mass. The trace of mica in the form of glowing sticks distributed in clayey mass. Carbonate-clayey plasma is rather saturated, greatly heterogeneous, optically unoriented. Pores are of anomalous form, not intercommunicating. Diameter of some of them is 0,6 mm. There is no new formation.

Variant 2. Description of plantation and ecological micromorpholodgy of soil profile on the second variant of reclamation (in 35 years)

Type of silvicultural conditions – L0-1 (dryish loam). Stratigraphic structure of edaphotope: loess 0 – 50 sm; tertiary sand – 50 – 100 sm; mine rock – 100 – 70 sm.

Type of plantation light structure – half-lighted, light condition – normal, of the second age phase (polewood).

Type of stand – 10 Robinia of 24 years, height 5,5 – 6,5 m, diameter of a trunk – 95 – 120 mm, spread of branches – 350 – 420 mm, density – 0,9.

Typological formula:
L0-1 (0 – 50 cm)
S0-1 (50 – 100 cm)
C2 (100 – 700 cm) LMO – 3
Half-lighted, third age degree.

Macro- and micromorphological structure description of soil profile on the variant 2 in 24 years.

H 0 1 0 – 7 cm Forest litter of robinia leaves, herbal admixture (bedstraw, celandine), seldom - cereals.

H0 2 7,0 – 15 cm dusty mass covering the soil and serving as a mulch against the settlement of steppe herbaceous vegetation.

Hp1 15 – 35 cm Loess-like loam medium-humused at a depth of 0 – 15 cm with grayish tint. Microstructure is friable. Carbonate-clayey material forms aggregates of size 0,02 – 0,5 mm. Grains of mineral skeleton (quartz, feldspars, glauconite, hornblende) occupy 40 – 60 % of section area; they are homogeneous by size, have rounded and half-rounded shape. Crystalline calcite fills plasma and cements loessial aggregates. There are certain large grains of calcite. From 1995 to 1999 pore space had been continuing to form pores-cracks of 1 – 2 mm. In the under study section there are clods and inspissations of round shape, generated by clayey material. Biopores frequently filled by coprolith or coprolithlike remains have been progressing. Upper horizons of soil have acquired grey color through availability of humic matter and considerable quantity of dusty mass of litter (fig. 2).

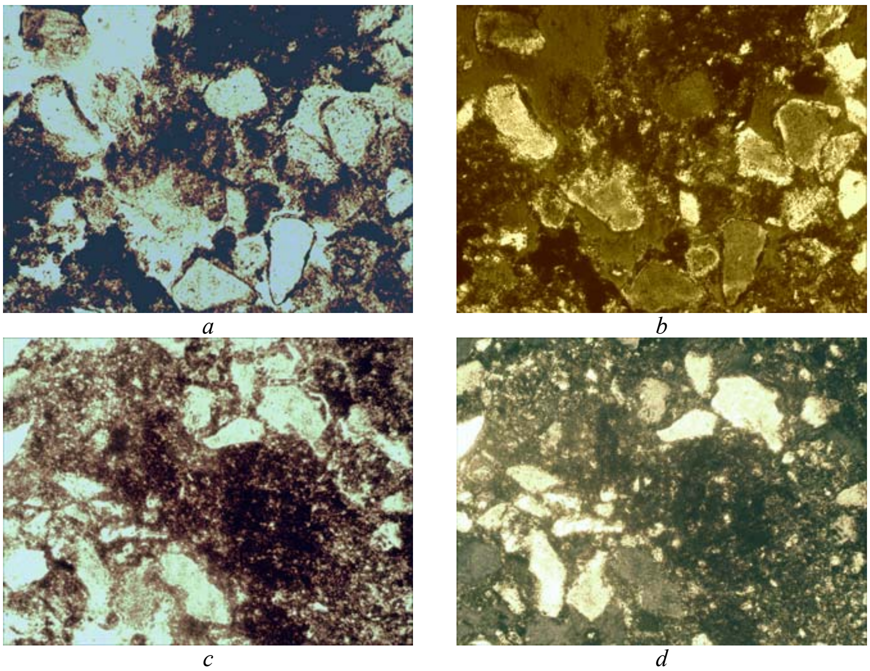


Fig.2. **Fresh loess** (a – Nick.II; b – Nick. +. x 70); **loess after 35 years** (c – Nick. II; d – Nick. +. x70)

Comparing the observations of primary soil formation in initial loessial substrates (1975) and the same rocks in 30 and 34 years it is clear that forest vegetation doesn’t acidate the loessial substrate so that the destruction process of sparingly soluble compounds would be evident. At first quite the contrary the process of humus accumulation, structure formation, arisen humate calcium procure the improvement of silvicultural conditions. On bare loessial edaphotopes of steppe environment the process of humus accumulation occurs more intensive under forest vegetation than on open steppe. Forest accumulate the litter which goes to ruin slowly, undergo the stages of decomposition, mineralization and condensation of humus matters. The condition of humus of this "forest" edaphotopes in comparison with initial not afforested loesses and loess-like loams is at its apogee. In consideration of the opinion of V. V. Dokuchaev to the effect that "loesses are soils", it could be mentioned that falling under the influence of active biological environment they become capable to resuscitate their potentialities rapidly and to acquire the qualities of chernozem type of soil formation.

Variant 3, 4. Planting description and ecological micromorphologdy of soil section on the forth variant of reclamation (in 35 years).

Considered variant is the most favourable, productive and inexpensive.

The type of forest conditions – L0-1 (dryish loam). Here sandy interlayer is not on the bottom of the productive layer, but in the middle, developing receptacle of moisture as a result of condensation processes and free absorption of backup water level of underlying loam. The moistening conditions in this connection could be qualified as atmospheric-ground. The thickness of artificial soils has the following stratigraphy: chernozem – 0 – 50 cm; tertiary sand – 50 – 100 cm; loam – 100 – 150 cm; clay – 150 – 700 cm.

The type of light structure – half-lighted, the type of stand – 10 Robinia, 24 years.

Typological formula:

L0-1 (0 – 50 cm)

S2 (50 – 100 cm)

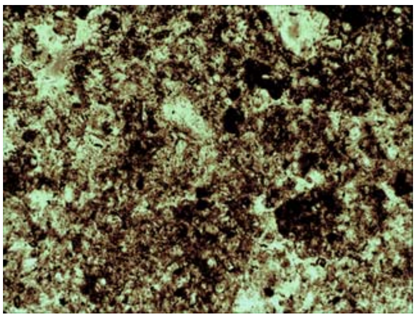
L2 (100 – 150 cm) 10 Robinia

C2 (50 – 700 cm)

Half-lighted third age stage

General density – 0,8 – 0,9. The plantation is characterized by high vitality, richness in fruits, virtually absence of pests. The grass stand is well-developed. Rootstock grasses predominate (Poa compressa, Elytrigia repens), covering – 45 %.

Description of macro- and micromorphological structure of forest improved chernozem on Variant 4 in 35 years (2010) (fig. 3).


a

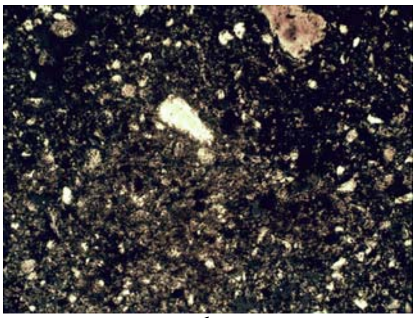

b

Fig. 3. **Development of chernozem layer on experimental areas 3 – 4** (a – Nick.II; b – Nick. +. x 70)

Hor. 0 – 30 cm over a period of time from 1975 to 2010 under the influence of forest vegetation had been acquiring a number of positive qualities. The structural composition has been improved. The quantity of large rounded aggregates has been increased. Pore space occupies 45-55% in upper layers and 25-35% in lower layers. The horizon's coloring is dark-brown, almost black. Mineral skeleton includes feldspars, micas, epidottsoizite minerals. Zircon is found rarely. Throughout the section the active work of burrowing mesofauna is found. In the upper horizons there is a considerable quantity of coprolites of earthworms. The size is 0,2 – 0,6 mm, 1 – 2 mm. Microstructure is friable. Organic matter is dispersed along the full soil mass. Humus is a sort of silt. In certain zonules the incrustation of clay are visible. Vegetable remains in half-decomposed and decomposed condition.

As it has already been said, undermining of coal layer causes slumps of surface area with consequent various serious consequences, underflooding in the first place conditional of ground water outlet on the day surface. Underflooding causes the death of forest plantings, negative transformation of forest fertile soils, with deteriorated water, air, physical-mechanical and physicochemical properties. Mineralization of mine water reaches 9,427 mg/l with rigidity of 48,8 mg-eq. According to Alekin (1946) such water labels as salty, hard, chloride type. In the central floodplain, where forest plantations were filled by water to 1,5 – 2,00 m the chemical composition of water is notable for increased rigidity (51, 6 mg-eq.), strong salinity (solid residue > 10 000 mg/l), labels as chloride class, sodium-potassium group, type of strong mineralized soil. High mineralization of underflooding water causes by outlet of water from a mine, for instance Pavlograd mine where the salt load reaches to 46 g/l. For comparison of salt loads, we would remind you that irrigation water should contain insignificant amount of salt. Water with salt load of 1g/l fits all types of irrigation. Limiting salt content is 1,5 g/l. It is clear that so high mineralization of water in mine dumps area with solid residue about 9427 – 10734 mg/l doesn't create favourable conditions for growing of forest biogeosenoses. Monitoring observations for 1975 – 1985 – 1995 – 1999 – 2010 argues for destruction of macro-, meso- and microstructure of soil mass, penetration of sodium and potassium into soil-absorbing complex. Solid residue increases to 0,75%. Soils change from meadow-forest into strongly saline by the degree of salinization, into chloride-sulphate soils by the type of salinization. To compare the pace and pattern of change of micromorphological features we had advisedly planned the scientific research on the model test areas, located on monitoring ecological geobotanical profiles of Samara Biosphere Station of Complex Expedition of DNU. The level of detrimental effect of mentioned mine high-mineralized water on forest soils is disclosed: mudding of porous space by fine-dispersed mass, formation of homogeneous (clayey) and mixed (sandy-pulverescent-cleyey) incrustations, microzonality foundation, negative transformation of humus form, washing it out of the floor profile, erosion of floor profile horizons, death of pedofauna. Speed of deformation depends on salt load of water environment, genetic type of soil, duration of flooding process. For prevention of forest soils' destruction it is necessary to apply damming, vertical and horizontal drainage, carry out regeneration of soils by forestry and silvicultural methods in the course of their reuse.

REFERENCES

Адерихин П. Г. Влияние лесной растительности на черноземы / П. Г. Адерихин, А. Л. Бельгард, С. В. Зонн, И. А. Крупенников, А. П. Травлеев / Русский чернозем. 100 лет после Докучаева. – М. : Наука, 1983. – С. 117–126.

Белова Н. А. Лес и степные почвы / Н. А. Белова, А. П. Травлеев. – Д. : ДНУ, 1999. – 345 с.

Бельгард А. Л. Степное лесоведение / А. Л. Бельгард. – М. : Лесная промышленность, 1971. – 335 с.

Бяллович Ю. П. Системы биогеоценозов / Ю. П. Бяллович // Биогеоценотические основы теории системы лесов // М. : Наука, 1973. – С. 37-47.

Вавилов Н. И. Закон гомологических рядов в наследственной изменчивости / Н. И. Вавилов // Сельское и лесное хозяйство. – 1921. – № 1–3. – С. 84-99.

Вавилов Н. И. Линеевский вид как система / Н. И. Вавилов // Тр. по прикл. бот., ген., и сел. – 1931. – Т. XXVI, вып. 3. – С. 109-134.

Дарвин Ч. Происхождение видов путем естественного отбора / Ч. Дарвин. – Сочинения. – Т. 3. – М. ; Л. : Изд-во АНСССР, 1939. – 832 с.

Димо Н. А. Почвы Молдавии, задачи изучения и главнейшие особенности / Н. А. Димо. – Кишинев : Картя Молдовеняскэ, 1958. – 24 с.

Зонн С. В. Высокогорные лесные почвы восточного Тибета / С. В. Зонн. – М. : Наука, 1964. – 235 с.

Зонн С. В. Географо-генетические аспекты почвообразования эволюции и охраны почв / С. В. Зонн, А. П. Травлеев. – К. : Наук. думка, 1989. – 220 с.

Мазинг В. В. Что такое структура биогеоценоза / В. В. Мазинг // Проблемы биогеоценологии. – М. : Наука, 1973. – С. 148-156.

Медведев В. В. К вопросу об использовании баз данных в агропочвоведении / В. В. Медведев, Т. Н. Лактионова, И. В. Плиско // Вісник ХДАУ, серія «Грунтознавство, агрохімія, землеробство, лісове господарство». – 2001. – № 3. – С. 79-82.

Новосад К. Б. Еволюція чорноземів типових глибоких південно-східного Лісостепу України під різними фітоценозами / К. Б. Новосад / Вісник ХДАУ : зб. Наук. пр. Харк. держ. аграр. ун-т. – 2000. – № 1. – С. 143-153.

Работнов Т. А. Некоторые вопросы изучения почвы как компонента биогеоценоза / Т. А. Работнов // Вестник МГУ. – 1974. – № 3. – С. 10-18.

Сибирцев Н. М. Почвоведение / Н. М. Сибирцев. – СПб., 1914. – 504 с.

Тимирязев К. А. Чарльз Дарвин и его учение / К. А. Тимирязев. – М. : Типо-литография Т-ва И. Н. Кушнеров и К, 1905. – С. 128-129.

Тихоненко Д. Г. Про класифікацію грунтів України / Д. Г. Тихоненко / Вісник ХДАУ, серія «Грунтознавство, агрохімія, землеробство, лісове господарство». – 2001. – № 3. – С. 33-39.

Уранов А. А. О сопряженности компонентов растительного ценоза / А. А. Уранов // Уч. Записки Моск. госуд. педагог. ин-та, 1931. – С. 59-85.

Шеляг-Сосонко Ю. Р. Концептуальні засади наукового розуміння біорозмаїття / Ю. Р. Шеляг-Сосонко, І. Г. Ємельянов / Конвенція про біологічне розмаїття: громадська обізнаність та участь. – К., 1997. – С. 11-23.

Надійшла до редколегії 25.11.10