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Lithoecotopes and Vegetation on Dumps of the Central Mining and Ore Enrichment Combine (the central zone of Kryvbass)

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Abstract. In the article, characteristics of development of vegetation communities under conditions of mine rock dumps of the Central Mining and Ore Enrichment Combine or their rocky components (lithoecotopes) were determined, namely only lithophilic vegetation.

We classified various lithoecotopes and characterized vegetation communities of varying complexity growing on plateau tops, terraces and slopes, depending on specifics of their constituent rocks and typological features. In accordance with the state of lithoecotopes, including all typological characteristics and the geochemical nature of the rocks, plant lithophilic communities growing on the dumps of the Central Mining and Ore Enrichment Combine, were characterized by significant differences in analytical (floristic and ecomorphic composition, occurrence, layerage, aspect, abundance, cover) and synthetic (similarity, constancy) signs. A detailed survey of the state of plants and their communities within the lithoecotopes has allowed us to establish that their distribution and development have clearly expressed dependence on substrate and relief-exposure, which can be used in phytocenotic and phytocenotic melioration of such technogenic ecotopes. Native overgrowth of all dumps has a shrub-tree forest and grassy pattern in accordance with the typological characteristics and rock composition. In general, taxonomic composition of plant communities growing on the dumps of the Kryvbass central zone is characterised by 153 species belonging to 31 families, of which 66 species are petrophytes, and 18 species are typical only for zone surveyed.

Keywords: lithoecotopes, lithophilic plant communities, typology, taxonomic composition

Літоекотопи та рослинність відвалів Центрального гірничозбагачувального комбінату (центральна зона Кривбасу)

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Анотація. З'ясовано особливості розвитку літофільної рослинності, яка формується на скельних відвалах Центрального гірничозбагачувального комбінату або їх скельних складових (літоекотопах). Проблема досліджень літофільних рослинних угруповань під кутом зору прогнозування їх природного розвитку та оптимізації є актуальною не тільки для Кривбасу, але й для всіх промислових районів відкритого видобутку корисних копалин, в яких на земну поверхню виносяться значні маси твердих розкритих гірських порід. Нами визначені різні літоекотопи та описані рослинні угруповання різної складності на платовидних вершинах, терасах і схилах в залежності від специфіки складаючих їх гірських порід та типологічних особливостей. Рослинні літофільні угруповання відвалів Центрального гірничозбагачувального комбінату у відповідності до стану літоекотопів, включаючи всі типологічні характеристики та геохімічну природу гірських порід, відзначаються значними розбіжностями аналітичних (флористичний і екоморфний склад, трапляння, ярусність, фізіономічність, ряснота, покриття) та синтетичних (схожість, константність) ознак. Деталізоване дослідження стану рослин і їх угруповань в літоекотопах дозволило перекопати, що їх поширення та розвиток мають чітко виражені субстратні та рельєфно-експозиційні залежності, що можливо використовувати у фітоценотичній меліорації техногенних екотопів. Природне заростання всіх відвалів має розріджений чагарниково-деревний і трав'янистий характер відповідно до типологічних характеристик і складу порід. З'ясовано, що зміна рослинних угруповань на залишених без впливу людини літоекотопах носить ендоекзогенний характер. рапляння видів, видова та петрофітна ємкість рослинних угруповань, їх індекси петрофітності в літоекотопах відвалів мають розбіжності в залежності від специфіки умов. В цілому таксономічний склад рослинних угруповань відвалів центральної зони Кривбасу визначається 153 видами, які належать до 31 родини, з яких 66 видів є петрофітами, а 18 видів властиві тільки цій зоні.

Ключові слова: літоекотопи, літофільні угруповання, типологія, таксономічний склад

Introduction. In the current period of significant technogenic disturbances of all biological environments, engineering-technological changes in relief, and destruction of soil and vegetation, research aimed at protection of relief, optimization of landscape for human life and work, justification of phytorecultivation measures, deepening of our understanding of ecological phenomena and processes in the current vegetation layer is of particular relevance.

In open-cast mining areas, large areas are occupied by quarrying and dumping sites that impact negatively on the environment. In the Kryvyi Rih iron ore basin, the area occupied by such sites and other technogenically disturbed lands reaches more than 30,000 hectares, so exploratory and applied studies aimed at optimization of these lands is essential for maintaining biological balance and diversity in the steppe zone of Ukraine.

Among the waste dumps of the Mining and Ore Enrichment Combine there are those which are composed of polygenetic overburden rocks and poor ores, the processing and industrial use of which are not organized, slowed down and currently not yet well researched. The natural overgrowth of such dumps and their phytorecultivation are multifactorially complicated.

The plant communities growing on the rock substrates and their fundamental changes (successions) are lithophilic.

The problem of studies of lithophilic plant communities in respect to prediction of their natural development and optimization is relevant not only for the Kryvbas, but also for all industrial areas of open-cast mining, in which considerable masses of solid overburden rocks are brought on the earth's surface.

Vegetation of the Kryvbas quarries and dumps has been studied for quite a long time on the basis of elucidation and consideration of complex ecotopic differentiation of these dumps, typological and systematic approaches, establishment of taxonomic and ecomorphic complexity of the plant communities (Dobrovolsky, Shanda, Gayeva, 1979, Gittins, 1981).

The concept of this vegetation as a complex succession system and isolation of lithophilic, geophilic, psamophilic plant communities and successions has practically not been developed.

The relevance of the work is determined by the urgent need for optimization of the Kryvorizhzhya landscape by phytorecultivation of the dumps, the use of naturally occurring vegetation on the basis of practical field surveys and the expansion of research in the general theory of vegetation to compensate for the negative changes in vegetation of steppe zone.

The main purpose of this work was to identify the features of lithophilic plant communities and their successions, which occur on the rock dumps of the Central Mining and Ore Enrichment Combine, Kryvbas.

Material and methods of the survey. The survey covered the Petrivsky, Bilshovitskiy, Novobilshovitsky, Kominternovskiy, Novokominternovskiy dumps and waste disposal dumps No. 1 of the Central Mining and Ore Enrichment Combine (Kryvbas Central Zone). The dumps of the Central Mining and Ore Enrichment Combine are made up of different rocks in accordance with the geology of the iron ore deposits in this part of the Kryvbas.

The Petrovsky, Novobilshovitsky, Bilshovitsky, Kominternovskiy dumps form a single solid ridge (strand, lane) along the eastern side of the quarry No. 1 with large terrain and substratum differences within each dump, including their rocky and loose rocks. These dumps to the east are bordered by a successive strip of mines and they are located in the area of collapse of their underground workings, which complicate the terrain, leading to funnel-shaped dips on plateau-like peaks and dump slopes, and landslides on the slopes. Within such a continuous heap or strip, we have identified lithoecotopes that have contrasting characteristics in terms of vegetation overgrowth, cover, density, occurrence rate, formation and development of plant communities (Khlyzina, 2008).

Field surveys, geobotanical description of vegetation, and detailed analysis were carried out according to conventional methods, which are outlined in the basic manuals, recommendations and monographs (Korchagin, 1964; Tarasov, 2012).

During the study period, 130 geobotanical descriptions of 100 m² plots were made. The 100 m² (10 x 10 m) square shaped plots were laid on plateaus and terraces every 100 m. On the slopes, the descriptive plots were oblong (5 x 20 m). We determined occurrence rate, density, plant phytomass, of substrate cover.

Total species capacity of plant families (TSF) in lithophilic plant communities was determined by the formula: $TSF = \text{number of species/number of families}$; total petrophytic capacity of families (PSF) – by the formula $PSF = \text{number of petrophytic species/number of families}$, petrophytic index (PI) of families and plant communities was determined by the formula $IP = \text{number of petrophytic species/total number of species}$.

In our opinion, it is possible to classify the lithoecotopes of quarry and waste dumps according to the leading concepts of O.L. Belgard (Bel'gard, 1950) on the typology of forest and steppe edatopes and the

biogeocenosis detailization scheme of A. P. Travleyev (1973), extending in a certain way the scope of criteria. Among these we distinguished trophicity, moisture capacity, toxicity or vegetative suitability, mechanical composition of substrates, topo- and orographic features of waste dumps, etc., variations and combinations of which allow us to determine the certain types of lithoecotopes and their vegetative suitability.

The terrain of the plateau-like terraces and peaks (planes) may be relatively smooth, flat (a_1), they may also have a large-hilled surface (a_2), or with pronounced micro-terrain of small hillocks (a_3), or wavy (a_4) nature. At the same time, both plateaus and terraces of dumps can be differently oriented: to the south (B_1), to the southeast (B_2), to the southwest (B_3), to the north (B_4), to the northeast (B_5), to the northwest (B_6), to the west (B_7), to the east (B_8), and with the corresponding slopes ($c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8$).

Trophicity (d), moisture capacity (e), toxicity (vegetation suitability) (f) of rock substrates that make up rock dumps or parts thereof can be relatively multilevel, such as low, medium, high, i.e. can be characterized by these levels as $d_1, d_2, d_3, e_1, e_2, e_3, f_1, f_2, f_3$. The dumps or their parts (most often) can be made up of a single type of rock (g_1), or two (g_2) three or more (g_3) types of rock. In size, the rock debris that makes up the dumps can be finely fractional: 1-2 cm (h_1), crushed stone type: 2-5 cm (h_2), middle fragment type: 5-10 cm (h_3), large fragment type: 10-20 cm (h_4), very large fragment type: 20-30 cm (h_5), largest fragment type: 30-50 cm and more (h_6) and differently combined (h_7) for each lithoecotope.

The period of the dumping for the whole dump or its parts is distinguished by the following criteria for litho-ecotopes of dumps of the mining and processing plants: fresh (1-5 years (t_1)), recent (5-10 years (t_2)), medium-old (10-25 years (t_3)), relatively old (25-40 years (t_4)), old (40 years and more (t_5)). On the basis of these criteria it is possible to determine the typological formulas of lithoecotopes on the peaks and terraces, taking into account the compass orientation and the slope exposures. Many such combinations can be uncertain with the complicated combinatorial calculation of their number. With regard to the typology of the slope lithoecotopes, in our opinion, it is still necessary to introduce such a criterion as the slope steepness: from 3° to 30° (i_1), to 45° (i_2), more than 45° (i_3).

Results and interpretation. We should emphasize that in our research we focused our attention only on the vegetation developing on rocky dumps or

their rocky components (lithoecotopes), i.e. only on lithophilic vegetation.

Along the entire continuous line of dumps at the Petrovskiy mine and at the sludge dumps of the Central Mining and Ore Enrichment Combine (the central zone of Kryvbass) we determined various lithoecotopes and described plant communities of various complexities on plateau-like tops, terraces and slopes. The general cover of lithoecotopes depends on specifics of rocks they are formed of as well as on their typological peculiarities.

Lithophilic plant communities of the dumps at the Central Mining and Ore Enrichment Combine, according to the status of lithoecotopes including all typological characteristics (Belgard, 1950) and geochemical nature of rocks (Paran'ko, Khlyzina, 2005) are characterized through significant differences in their analytic features (floristic and ecomorphic composition, occurrence, layering, physiognomic aspect, abundance, cover) and synthetic features (similarity, constancy).

In lithoecotopes 1, 2, 3, 4 of the upper and middle parts of the northeastern, eastern and southeastern slopes of the Petrovskiy and Bilshovytskiy dumping sites (typological formulas $a_1i_2c_5d_1e_1f_3g_1h_3t_5$, $a_4i_2c_8d_1e_1f_3g_1h_3t_5$, $a_4i_2c_2d_1f_3g_2h_3t_5$, $a_4i_2c_8d_1f_3g_2h_3t_5$) composed of quartz-chlorite-sericite shales and quartz-sericite-biotite shales and unoxidized quartzites of average size, where continuous movements of slopes are typical, ecological niches during a prolonged period of time are occupied by *Zygophyllum fabago*, which is not a petrophyte, as well as by *Gypsophyla perfoliata*, rarely and separately occupying only the very upper extremities of slopes and by *Crambe tatarica*, which is marked as a petrophyte in the flora of Ukraine. We observed the state of *Crambe-Zygophyllum* microcommunities with rare distribution in the layer of lithoecotopes during the period 2017-2018. Shale substrates of this type are unfavourable for plants and that is why lithoecotopes located on them are devoid of vegetation during a prolonged period of time, especially when fragments are of a greater size (h_4, h_5, h_6, h_7). This is typical for lower lithoecotopes bordering the mentioned ones. In lithoecotopes which include such or other shales with ore-free quartzites, natural overgrowth is also slowed down and starts in a fragmentary or diffused manner within 20-30 years. Vegetation here is of shrubby-tree-grass type with development of zoochoric and separate anemochorous types of shrubs and trees and anemochorous grasses which is typical for all rocky dumps. It is typical that these can be brought from far away as well as from neighbouring layers of the same dumps covered with soft soil (loess loams, red-brown clays etc.). This soft

soil has much better trophic characteristics and higher suitability for vegetation in comparison with rocks. In case of wind erosion these soft soils are powerful sources of satiation of rock surfaces (especially those composed of small (up to 2 cm) and crushed stone type (2-5 cm) fractions) with the so called fine earth, which fills up substrates of natural rock decay (lithic soil), modifies or partially neutralizes their toxicity, reinforces natural weathering and decay.

The south slope of the Petrovskiy dump is almost completely composed of rocks but at the same time it is differentiated consisting of macroecotopes and microecotopes along its entire length with respective fragments of natural overgrowth (microcommunities and general surface cover of from 8 to 36% according to the L.G. Ramenskiy grid).

On the Petrovskiy dumping site as well as the entire line of dumps bordering the Petrovskiy mine (not far from the quarries) as well as at the sludge dumps of the Central Mining and Ore Enrichment Combine and at dumps of other ore mining and processing plants, on plateau-like tops, terraces and slopes, and in many cases on waterresistant layers covered with rock substrates, fragmentary microcommunities of various forms (insular patchy ones, elongated ones) are formed; these are microcommunities of *Phragmites australis*, *Calamagrostis epigeios*, sometimes of *Tussilago farfara* with admixtures of *Polygonum persicaria*, *Tanacetum vulgare* and in rare occasions even with admixtures of *Bidens tripartita*. It should be noted that only on the Petrovskiy dumping site, on the lower parts of the south slope (these parts often consist of large-sized fractions)

process farmsteads of resettled families were covered with spoil (these families had cultivated horseradish and hop (either accidentally or intentionally). Such fragmented groups of plants are variously distributed on slopes as well as on surfaces of plateau and terraces with various spatial orientation (often along the entire slope). And this gives an opportunity to predict their hydrochorous origin in cases of water running down the slope.

At the south slope of the Petrovskiy dumping site in lithoecotopes of rocks similar in their composition (quartz - sericite - biotite shales and quartz-chlorite shales and unoxidized quartites) with size of fractions (h_3-h_4), i.e. from 5 to 20 cm we found fragmentary microcommunities of various forms – patchy round ones (3.5 m x 3 m) and elongated ones (1 m x 3-5 m) and broken, sparse strip-like – common reed (*Phragmites australis*). And this fact proved that water resistant layers of various forms were embedded close to the surface. At the same time it was determined that: 1) plants growing in the center of the microcommunity (Table 1) were higher than those growing in the periphery; 2) the plants of the patchy round microcommunities (growing in the center as well as in the periphery) were taller than those of the elongated microcommunities; 3) plants in the broken-rarefied strip-like fragments were smaller than in two previous fragments.

It is natural that under harsh conditions height variability of plants (V) is significantly greater. This fact confirms the difference in humidification of substrate lower layers and indicated manifestation

Table 1. Peculiarities of *Phragmites australis* Growth on the South Slope of the Petrovskiy Dumping Site of the Central Mining and Ore Enrichment Combine

No	Variants of ecological positions of plants	Height of plants		V, %%
		cm	%	
1.	Spotty round microcommunity (3 x 3 m ²) center periphery	192.36 ± 1.44 163.0 ± 3.34	100.00 75.49	9.30 21.03
2.	Long, dense, wide (1m) microcommunity center periphery	124.32 ± 4.36 92.42 ± 1.37	64.46 97.82	16.42 26.41
3.	Broken-scattered strip-like microcommunity stippled location	53.42 ± 4.12	27.68	32.13

did we manage to find isolated specimens of *Armoracia rusticana*, *Humulus lupulus* and *Cannabis ruderalis*; and this can be explained by the fact that the process of dumping was going on gradually and in the course of this

of batch effect (community effect) in the case of the common reed. At the same time, it is important to note that the batch effect discovered in trees by G.F. Morozov and described by S.I. Chernobryvenko,

V.I. Shanda in cultivated grass plants and by Y.V. Titov in miscellaneous herbs can be also manifested in lithoecotopes. We should denote points not taken into account by previous researchers: the batch effect depends on configuration, diameter or width of the area covered by this or that group of plants.

Environment-forming functions of plant communities (groups) are also manifested in differences of plant development in the center and in the periphery of the group (imitation of the so called edge effect in forestry). This is especially important for lithoecotopes in the case of hydrological and thermal extremes and in general it is important for phytoremediation when groups of shrubs are planted or grasses are sown in large fragments for future formation of their optimal density. Really, the central plants of a round-spotty fragment are almost 25% taller than plants in the periphery of this fragment, 33% higher than central plants of an elongated microcommunity; and they are also much taller than dotted-scattered plants of an elongated rarefied spot of plants. A typical point here is that coefficients of variation in cases of all possible differences of characteristics and polymorphism of populations of wild plants reflect the real picture of increased variability of height in the relatively complex conditions of peripheral and rarefied grass stands growing on rocky shale-quartzite substrate of the south slope of the Petrovskiy dumping site.

Detailed study of the state of plants and their groups in lithoecotopes made it possible to prove that their dissemination and development have clearly expressed substrate and relief-exposure dependencies, which can be used in phytochemical and phytocoenic melioration of these technogenic ecotopes (Malenko, 1999). It should be also noted that sources of dissemination of *Phragmites australis* on the slopes of the Petrovskiy dumping site may include separate centers of the reed along the banks of the Saksagan River (located not far away), near open water pipes and water drains from the ore mining and processing plant, on neighbouring dumps and the plateau-like surface of the same dump. In the case of fine ground (fragmented) relief of the plateau-like top of the dump in the hollows, sheltered areas between piles of rock fragments on a sufficiently solid rolled, pressed surface, nanocomunities and microcommunities of the common reed are formed (their length is 1 meter and more) and on slopes small patchy and elongated communities of various configuration and spatial orientation are formed (especially along the slope) and this fact gives an opportunity to suggest that they are possibly of hydrochorous origin (Diduh, 2012).

By the example of *Phragmites australis* and especially *Melica transsilvanica* we came to the conclusion about the possible spread of their microcommunities as initials especially on slopes on the basis of anemochory and hydrochory. At the same time, the predominant south-east and east winds disseminate communities of *Melica transsilvanica* from east to west or northwest in the majority of cases on slopes of the dumps bordering quarries as well as on the dump No1 of the pre-sludge area. This phenomenon of plant community expansion should be classified as spatial spreading. It may be presented in various types and forms and first of all by means of spacial assimilation. When a plant community present on a rocky slope (regardless of the substrate and size of fragments) is spread from the top downward, this type of spatial spreading is descending or falling; and when spreading takes place from the foot towards the middle, this type of spreading is ascending, with various forms (spray-like, fan-like, tree-like, continuously spotted, torn spotted, comb-like or linear or arc-shaped) on plateau-like tops and terraces as well as on slopes.

In the *Melica-Phragmites-Artemisia* community of the south slope of the Petrovskiy dumping site (in condition of descending spatial spreading in the complex quartz-chlorite-sericite-biotite-shale lithoecotope with admixtures of unoxidized quartzites of old dumping) (typological formula $a_4i_2c_1d_1e_1f_3g_2h_2-t_4$) with single representatives of *Populus deltoides*, *Populus nigra* and *Ulmus laevis*, the general level of cover of the slope surface is 28%. The fragmentary elongated location of *Phragmites australis* has a stream-dissected descending nature; *Melica transsilvanica* can be found in relatively dispersed groups, *Artemisia absinthium*, *Artemisia austriaca*, *Crambe tataria*, are less dispersed; *Erigeron canadensis*, *Centaurea diffusa*, *Linaria genistifolia*, *Senecio vulgaris*, *Silene ucrainica* are found in areas of stony substrate.

Natural overgrowth of all dumps includes shrubs, trees (woody plants) and grasses according to typological characteristics and composition of the ground.

In a separated (by means of a downward hollow including large and large-sized fractions and deprived of vegetation) lithoecotope of the south slope of the Petrovskiy dumping site (typological formula $a_4i_2c_1d_1e_1f_2g_2h_3t_4$) on quartz-sericite-biotite shales and ore-free quartzites a *Melica-Crambe* community has formed, covering up to 26 – 28 % of the substrate. At the same time, *Melica transsilvanica* in the upper and middle part of the slope is disseminated in an insular

way with displacement of fragments across the slope in a westward direction; and *Crambe tatarica* is present as solitary representatives; in addition to that *Erigeron canadensis*, *Silene ucrainica*, *Linaria genistifolia* are also present and *Phragmites australis*, *Centaurea diffusa* are located near the top. The upper part of the slope is better covered with plants, the middle part is less vegetated and the bottom part (consisting of large-sized fractions) is deprived of any vegetation. This scheme is typical for rocks of the entire line (for quarry-bordering dumps, for sludge-dumps of the Central Mining and Ore Enrichment Combine as well as for dumps of the Southern Ore Mining and Processing Plant and Novokryvorizkyi Ore Mining and Processing Plant), where periods of completed dumping equal to 30–50 years do not really influence overgrowth of rocks consisting of big and large-sized fractions.

The Artemisia-Melica community in the upper part of the southern slope of the Petrovskiy dumping site on the mixture of quartz-amphibole-chlorite shales and quartz-chlorite-sercite shales and unoxidized quartzites (lithocotope typological formula $a_4i_1c_1d_1e_1f_3g_3h_3t_4$) is an illustrative example of descending spatial spreading but it is limited by the zone of large-sized fragments (h_5) and the large lump zone (h_6) from the middle area of the slope. General cover of the substrate is 23%, the maximal density of plants – is 9 specimens per 1 m², types of plant location include a demarcated group type and dotted-scattered type with the same composition of microcommunities. The grass stand includes *Artemisia absinthium*, *Artemisia vulgaris*, *Achillea submillefolium*, *Crepis tectorum*, *Centaurea diffusa*, *Echium vulgare*, *Erigeron canadensis*, *Elaeagnus argentea*, *Grindelia squarrosa*, *Gypsophilla perfoliata*, *Hippophae rhamnoides*, *Hieracium pilosella*, *Kochia scoparia*, *Lactuca tatarica*, *Melica transsilvanica*, *Melilotus albus*, *Poa angustifolia*, *Populus deltoides*, *Populus nigra*, *Rosa dumalis*, *Senecio jacobaea*, *Silene ucrainica* and *Ulmus laevis*.

On the plateau-like tops of quarry-bordering dumps of the Central Mining and Ore Enrichment Combine with a typically large-hilled surface (a_2), with various times of dumping (soft spoil and rocks) a very rarefied vegetation is naturally formed (shrubs and trees) as a result of anemochory and zoochory with density from 5 to 25 specimens per 400 m² with large distances between them. The main species are *Populus nigra*, *Ulmus laevis*, *Rosa dumalis*, *Elaeagnus argentea*, *Hippophae rhamnoides*, *Armeniaca vulgaris*. In addition to this, the same plant species are sometimes artificially replanted as a result of research

projects carried out by various institutions (Kryvyi Rih State Pedagogical University) as well as as a result of activities performed by amateur naturalists and phytorecultivation works performed by the Mining and Ore Enrichment Combine or by mines located nearby. In many cases, the lithocotopes of plateau-like tops of some dumps belonging to the quarry-bordering line are characterized by fine fragment microrelief of hilly type. On the Petrovskiy dumping site in the lithocotope with its substrate basis formed by quartz-sericite-amphibole shales, chlorite-sericite-biotite shales and unoxidized quartzites consisting of medium sized (h_3) and large (h_4) fragments (typological formula $a_3b_2d_1e_1f_1g_3h_3-h_4t_5$) a Koeleria-Artemisia plant community is in the process of its development with general covering of the substrate surface equal to 28% and with significant differences in density of plants (from 5 to 20 specimens per 1 m². In nano-cavities (less than 1 meter) and micro cavities (over 1 meter) as well as in cavities between heaps of dumped rocks (as well as outside these cavities) the following plants can be found: *Phragmites australis*, *Polygonum aviculare*, *Poa angustifolia*, *Poa compressa*, *Anisantra tectorum*, *Calamagrostis epigeios*, *Alyssum murale*, *Barbarea vulgare*, *Lactuca tatarica*, *Crepis tectorum*, on heaps the following plants are present: *Berteroa incana*, *Erigeron canadensis*, *Artemisia absinthium*, *Artemisia austriaca*, *Melica transsilvanica*, *Melilotus albus*, *Kochia scoparia*, *Grindelia squarrosa*, some specimens of *Ambrosia artemisifolia*, *Cyclachaena xanthifolia* were also detected. This indicates that the process of filling these cavities with fine earth from neighbouring hills of the same dump defines the initial stage (weed stage) of covering soft spoil with vegetation on the dumps of the Kryvbass.

In the lithocotope of the plateau-like top of the Petrovskiy dumping site (typological formula $a_3b_3d_1e_1f_1g_3h_4-5-t_4$) on a similar shale-quartzite substrate, microrelief is formed not only of big and large fragments (which are heaped) but also of great lumps up to 1.5 meter in diameter and larger. And this creates a more favourable nano- and microclimate in cavities between hillocks where the Melica-Artemisia community is modified by means of admixtures of separate plants, including such species as *Rumex confertus*, *Tussilago farfara*, *Tanacetum vulgare*, in the presence of *Melica transsilvanica*, *Artemisia vulgaris*, *Artemisia austriaca*, *Crambe tatarica*, *Erigeron canadensis*, *Centaurea diffusa*, *Atriplex tatarica*, *Kochia scoparia*, *Potentilla argentea*, *Grindelia squarrosa*, *Polygonum aviculare*, *Crepis tectorum* and *Asplenium muraria*. In the similar lithocotope of the Novo-Bilshovytskiy dumping

site (typological formula $a_{3,4}d_1e_1f_3g_3h_4-t_5$) *Melica*-*Artemisia* rarefied communities are formed which provide 32% cover of the substrate, and include such species as *Populus nigra*, *Pragmites australis* in microcavities and sometimes (in heaps of large lump dumps and between these heaps with diffused uneven grass stand) such species as *Melica transsilvanica*, *Achillea nobilis*, *Senecio jacobaea*, *Poa compressa* and isolated specimens of *Festuca sulcata*, *Melilotus albus*, *Consolida arvensis*, *Bidens tripartita*, *Plantago media*, *Erodium cicutarium*, *Artemisia austriaca*, *Erigeron canadensis*, *Centaurea diffusa* are also present. So, in the extreme conditions of small-hilled relief and substrates with fragments of various sizes, lithophilic communities with mixed species of various hygromorphic peculiarities (according to Belgard) are formed as well as species of other ecological valences. This is due to the mixed nature of the composition of the types of rocks and soft spoil these dumps are formed of. This phenomenon is typical for all dumps of the Kryvbass except for several small parts of dumps with oxidized ferruginous quartzites, which are poor ores.

In the lithoecotope of the Bilshovytskiy dumping site (typological formula $a_{1,2}c_8d_1e_1f_3g_3h_3-t_4$) on quartz-chlorite-sercite shales, quartz-sercite-biotite shales and ore-free quartzite substrate in the middle area of the slope there is a *Melica* community which has a descending elongated fragmentary form with inset fragments of *Crambe tatarica*, *Gypsophilla perfoliata*. The general cover of the surface is 21%, location of *Melica transsilvanica* is descending, broken linear and diffused (uneven). Linear dotted sections include no more than 4-6 plants per 1 m². There are some scattered plants of *Artemisia absinthium*, *Artemisia austriaca*, *Diplotaxis muralis*, *Linaria genistifolia*, *Erigeron canadensis*, *Silene ucrainica*. Species composition is poor.

The Koeleria- miscellaneous herbs plant community in the south-western slope of the Bilshovytskiy dumping site on mixed shale-quartzite substrate (typological formula $a_{1,2}c_2d_1e_1f_3g_3h_7-t_5$) has a broken-fragmentary-patchy horizontal structure with indefinite spatial spreading within the described period. In the area of up to 400 m² 8 species of shrubs and trees were found, including such species as *Elaeagnus argentea*, *Populus deltoides*, *Armeniaca vulgaris*, *Rosa canina*. The grass stand consists of *Melica transsilvanica*, *Poa compressa*, *Artemisia austriaca*, *Artemisia absinthium*, *Achillea submillefolium*, *Grindelia squarrosa*, *Centaurea diffusa*, *Stachys recta*, *Potentilla argentea*, *Daucus carota*, *Gypsophilla perfoliata*, *Anisantha tectorum*,

Scabiosa ochroleuca, *Consolida regalis*, *Taraxacum officinale*, *Melilotus albus*, *Bromopsis inermis*, *Kochia scoparia*, *Salvia nemorosa*, *Barkhausia rhoeadifolia*, *Euphorbia sequieriana*, *Linaria genistifolia* and *Salvia nemorosa*.

In the lithoecotope of the eastern slope of the Bilshovytskiy dumping site composed of quartz-cercite-biotite shales and ore-free quartzites (typological formula $a_{1,1}c_8d_1e_1f_{1-3}g_2h_3-t_4$), the upper part is occupied by a *Melica*-miscellaneous herbs community with sparse presence of bushy trees (*Populus deltoides*). The general level of plant cover is 76%, providing diffused relatively even dissemination of a cenopopulation of *Melica transsilvanica* and presence of such weed plants as *Ambrosia artemisifolia*, *Cyclachaena xanthifolia*, *Erigeron canadensis*, *Carduus acanthoides*, *Lepidium ruderales*, *Lepidium perfoliatum*, *Berteroa incana*, *Diplotaxis muralis*, *Chenopodium album* and *Atriplex tatarica*, which is an indicator of inclusion of the so called aluminium earth to the stony surface of the slope as the result of water erosion and wind erosion from the surface of this dump and other dumps formed by soft ground (loess soils and clays). In addition to this, great volumes of dust are also produced in the result of explosive technological processes in the quarries. Colonization of this lithoecotope by such plants as *Melica transsilvanica* proves that on shale-poor-ore-quartzite substrates the process of initial overgrowth is proceeding very slowly and penetration of plants is blocked as the result of the extreme conditions of these dumps. *Melica transsilvanica*, as a species has sufficient potential ecological opportunities for holding its positions and expanding its initial centers (fields) on various shale-quartzite substrates. Natural overgrowth of these hard rock substrates is proceeding beyond the stages of weedy short-lived creeping (rhizome) stem grasses as occurs with black earth. Out of 9 species of *Melica* detected in Ukraine, 3 species are evident petrophytes and *Melica monticola* Prokud is able to grow on shaly crushed stone as well as on stony deposits of various rocks, though at the same time it is an endemic in the Crimea. So, the presence of *Melica transsilvanica* on shale-quartzite substrates proves its wide ecological valence. Being non-dense-bushy species *Melica* are able to form dense sods in favourable conditions of various soils but on the hard rocky dumps of ore mining and processing plants, we noticed only dotted and dot-grouped location of *Melica transsilvanica* cenopopulations. In the described plant community with unexpressed spatial spreading, essential plants include such species as *Poa angustifolia*, *Festuca valesiaca*, *Euphorbia*

seguieriana, *Euphorbia virgultosa*, *Consolida orientalis*, *Plantago lanceolata*, *Medicago romanica*, *Medicago lupulina*, *Artemisia absinthium*, *Artemisia austriaca*, *Bromopsis inermis*, *Petrorhagia saxifraga*, *Asplenium ruta-muraria*, *Melilotus albus*, *Scabiosa ochroleuca*, *Allyssum murale*, *Consolida regalis*, *Rumex crispus*, *Linaria vulgaris*, *Senecio jacobaea*, *Diploaxis muralis*, *Galium ruthenicum* and *Daucus carota*.

On the western slope of the Bilshovytskiy dumping site two lithoecotopes were detected on quartz-cercite-biotite-ore free-quartzite substrate with various peculiarities of relief and fragments. In the upper part in conditions of pectinate spatial spreading with broken fragments and microhollows (typological formula $a_4i_2c_7d_1e_1f_3g_2h_2-t_3$) a Melica-miscellaneous herbs community was formed covering 35-40% of the substrate and presenting a diffuse-dotted and group location of plants with density of 8-12 specimens per 1 m². The grass stand consists of *Melica transsilvanica*, подекуди *Koeleria cristata*, *Poa compressa*, *Artemisia austriaca*, *Artemisia absinthium*, *Polygonum aviculare*, *Consolida regalis*, *Melilotus albus*, *Anisantha tectorum*, *Erigeron canadensis*, *Kochia prostrata*, *Euphorbia seguieriana*, *Achillea submillefolium*, *Cichorium intybus*, *Lactuca tatarica*, *Crepis tectorum*, *Diploaxis muralis*, *Berteroa incana*, *Potentilla argentea*, *Artemisia vulgaris*, *Bromus squarrosus*, *Centaurea diffusa*, *Gypsophilla perfoliata*, *Lappula squarrosa*, *Polygonum aviculare*, *Linaria genistifolia*, *Silene ucrainica*.

In the lithoecotope of the plateau-like top of the Bilshovytskiy dumping site (typological formula $a_3b_2d_2e_2f_3g_3h_7-t_4$) composed of unoxidized quartzites, biotite-chlorite shales, quartz-cercite-biotite shales with oxidized quartzites with fractions of various sizes from crushed stone fragments (h_2) to large-sized fractions (h_3) over a prolonged period (within 40 years) a Koeleria-miscellaneous herbs community was formed with general surface cover of up to 85% with various density of the grass stand depending on the size of fractions and peculiarities of the pit-and-mound surface. Projective cover was 35-45%, air-dry mass of plants per 1 m² was from 250 to 320 g, density was 3-5 species per 1 m² with grass stand density of up to 110 plants. The grass stand consists of *Poa angustifolia*, *Poa compressa*, *Poa stepposa*, *Koeleria cristata*, *Melica transsilvanica*, *Artemisia absinthium*, *Artemisia austriaca*, *Centaurea diffusa*, *Centaurea orientalis*, *Anthemis subtinctoria*, *Echium vulgare*, *Coronilla varia*, *Lotus corniculatus*, *Medicago romanica*, *Verbascum austriacum*, *Falcaria vulgaris*, *Astragalus austriacus*, *Lappula squarrosa*,

Inula ensifolia, *Picris hieracioides*, *Seseli campestre*, *Tripolium vulgare*, *Achillea submillefolium*, *Senecio jacobaea*, *Silene supina*, *Goniolimon besseranum*, *Phlomis pungens*, *Hieracium pilosella*, *Nepeta parviflora*, *Teucrium chamaedrys*, *Cichorium intybus*, *Crepis tectorum*, *Ceratocephala festiculata*, *Scabiosa ochroleuca*, *Consolida regalis*, *Euphorbia seguieriana*, *Galium ruthenicum*, *Dianthus carbonatus*, also *Erigeron canadensis*, *Grindelia squarrosa*, *Melilotus albus*, *Potentilla argentea*, *Tanacetum vulgare*, *Diploaxis muralis*, *Berteroa incana*, *Stachys recta*, *Polygonum aviculare*, *Kochia scoparia* and *Gypsophilla perfoliata*. The presence of such pioneer (for crushed stone shale-quartzite substrates) plants as *Erigeron canadensis*, *Melilotus albus*, *Polygonum aviculare*, *Gypsophilla perfoliata*, *Kochia scoparia*, *Centaurea diffusa*, *Melica transsilvanica* testifies the uneven mosaic and slowed process of overgrowth on hard rock dumps. Shrubby and woody plants are represented here by such solitary (on the plateau as well as on terraces and slopes) species as *Populus deltoides*, *Elaeagnus argentea*, *Rosa dumalis*, *Armeniaca vulgaris* and *Crataegus sanguinea*.

On the plateau-like surface of the Kominternivskiy dumping site composed of the same substrates but with greater admixtures of oxidized quartzites and a long period of dumping (up to 80 years) (typological formula $a_1b_2d_3e_3f_3g_3h_1-t_5$) providing an even and puddled surface, the Koeleria-fescue-miscellaneous herbs community has a greater species diversity and density of plants of up to 350 specimens per 1 m², plenitude – up to 37 species per 1 m², projective cover up to 90-95%, with-dry phytomass from 1,230 to 1,750 g per 1 m². The grass stand includes the following species: *Poa angustifolia*, *Poa compressa*, *Poa stepposa*, *Koeleria cristata*, *Festuca valesiaca*, and sometimes one can find some individual specimens of *Stipa capillata*, *Stipa lessingiana*, *Melica transsilvanica*, with scattered growth of *Centaurea orientalis*, *Dianthus carbonatus*, *Galium ruthenicum*, *Lotus corniculatus*, *Senecio jacobaea*, *Phlomis pungens*, *Consolida regalis*, *Nepeta parviflora*, *Hieracium pilosella*, *Cichorium intybus*, *Teucrium chamaedrys*, *Silene supina*, *Scabiosa ochroleuca*, *Achillea submillefolium*, *Euphorbia seguieriana*, *Eryngium campestre*, *Astragalus austriacus*, *Falcaria vulgaris*, *Medicago romanica*, *Anthemis subtinctoria*, *Artemisia absinthium*, *Artemisia austriaca*, *Asplenium ruta-muraria*, *Echium vulgare*, *Grindelia squarrosa*, *Tripolium vulgare*, *Inula ensifolia*, *Lactuca saligna*, *Lactuca tatarica*, *Cephalaria uralensis*, *Crinitaria villosa*, *Asyneuma canascens*, *Veronica austriaca*,

Marrubium praecox, *Silene latifolia*, *Herniaria bessi*, *Erysimum canascens*, *Carduus acanthoides*, *Crambe tataria*, *Potentilla argentea*, *Diplotaxis muralis*, *Linaria genistifolia*, *Plantago lanceolata*, *Plantago stepposa*, *Medicago lupulina*, *Trifolium borysthenicum*, *Minuartia leiosperma*, *Petrorhagia saxifraga*, *Silaum alpestre*, *Erodium cicutarium*, *Dodartia orientalis*, *Ulmus laevis*, *Armeniaca vulgaris*, *Verdascum lychnitis*, *Thymus dimorphus* and *Helichrysum arenarium*.

On the Kominternivskiy dumping site the *Koeleria-fescue*-miscellaneous herbs community is formed on the small fractional substrate of oxidized and unoxidized quartzites (partially quartz-biotite and quartz-amphibole shales) of old dumping (lithocotope typological formula $a_1b_4c_4d_3e_3f_1g_3h_1t_5$). It is characterized by high density of plants (100 and more specimens per 1 m²), 98% of substrate cover is represented by rich species diversity including species of feather grass (*Stipa*) and air dry phytomass of 150–210 g per 1 m². The high abundance of the Poaceae family indicates the zonal (typical for steppes) nature of indigenous vegetation restoration in specific conditions of the small-fragment (sometimes consisting of crushed stone) substrate of rocks where oxidized quartzites with small but sufficient trophic characteristics prevail in comparison with other types of rocks with available admixtures of fine grained soil brought here with dust from tillable lands and open surfaces of the entire quarry dump area. Small-fragment and crushed stone substrates are covered with vegetation faster than other substrates especially against the background of sufficient trophic characteristics and water capacity of rocks. This overgrowth takes place with a certain succession of phases and stages; according to our observations it is uneven and due to this fact for a prolonged period of time non-tussock grasses may cohabit in the lithophilic communities with species of the first stages of overgrowth typical for crushed stone substrates including fractions of various sizes; these first-stage species include: *Erigeron canadensis*, *Polygonum aviculare*, *Grindelia squarrosa*, *Senecio jacobaea*, *Melilotus albus*, *Melilotus officinalis*, *Crambe tataria*, *Berteroa incana*, *Kochia scoparia*, *Gypsophilla perfoliata*. In this *Koeleria-fescue*-miscellaneous herbs community, a significant density is typical for the following species *Poa compressa*, *Poa angustifolia*, *Festuca valesiaca*, *Anisantha tectorum*, *Koeleria cristata*, *Stipa capillata*, *Stipa lessingsana*, *Agropyron pectinatum*, *Bromopsis inermis*, and fragmentarily *Melica transsylvanica*. Singular representatives of the following species can be individually found *Cichorium intybus*, *Achillea submillefolium*, *Achillea nobilis*,

Artemisia absinthium, *Artemisia austriaca*, *Diplotaxis muralis*, *Stachys recta*, *Salvia nemorosa*, *Echium vulgare*, *Potentilla argentea*, *Silene ucrainica*, *Linaria genistifolia*, *Verbascum lychnitis*, *Euphorbia seguieriana*, *Scabiosa ochroleuca*, *Coronilla varia*, *Lotus corniculatus*, *Plantago lanceolata*, *Medicago romanica*, *Medicago lupulina*, *Consolida regalis*, *Euphorbia virgultosa*, *Astragalus onobrychis*, *Silene latifolia*, *Seseli campestre*, *Hyssopus officinalis*, *Verbascum austriacum*, *Chondrilla juncea*, *Hieracium echinoides*, *Scorzonera taurica*, *Rumex crispus*, *Erysimum diffusum*, *Linum perenne*, *Eryngium campestre*, *Minuartia leiosperma*, *Petrorhagia saxifraga*, *Dianthus lanceolatus*, *Teucrium chamaedrys*, *Thesium arvense*, *Holosteum subglutinatum*, *Silaum alpestre*, *Ceratocephala testiculata*, *Consolida paniculata*, *Reseda lutea*, *Centaurea diffusa*, *Centaurea solstitialis*, *Anthemis subtinctoria*, *Lycopsis orientalis*, *Thymus dimorphus*, *Goniolimon besseranum*, *Helichrysum arenarium*, *Phlomis pungens*, *Nepeta parviflora*. Shrubby and woody species include: *Populus deltoides*, *Populus nigra*, *Ulmus caprinifolia*, *Rosa canina*, *Elaeagnus argentea*, *Acer negundo* and *Morus alba*.

All lithophilic communities of plants presented in quarry-bordering dumps are characterized by their high specimen capacity and petrophyte capacity, these capacities and indexes of petrophytic properties are also characteristic of the main families of flowering plants (Table 2).

In general, it should be noted that in the quarry-bordering line of dumps lithophilic plant communities include 141 species of flowering plants representing 29 plant families including 60 petrophytes (Table 3). Descending rows (spectra) of plant communities are presented as follows: I. According to the number of species, *Asteraceae* (34) – *Poaceae* (15) – *Caryophyllaceae* (10) – *Brassicaceae* (9) – *Fabaceae* (9) – *Lamiaceae* (8) – *Scrophulariaceae* (5) – *Apiaceae* (5) – *Rosaceae* (5) – *Chenopodiaceae* (4) – *Ranunculaceae* (4); II. According to the number of petrophytes, *Asteraceae* (11) – *Poaceae* (10) – *Caryophyllaceae* (8) – *Lamiaceae* (6) – *Brassicaceae* (5) – *Fabaceae* (3); III. According to the coefficient of petrophytic properties, (%): *Caryophyllaceae* (80.00) – *Lamiaceae* (75.00) – *Poaceae* (66.66) – *Brassicaceae* (55.55) – *Asteraceae* (32.35) – *Fabaceae* (33.33).

According to the same scheme (as for frequency of species, taxonomic capacity and petrophytic capacity within families, species, petrophytic indexes) lithophilic communities of plants in the quarry-bordering line as well as in other zones are

Table 2. Petrophytic Features of Flowering Plant Families of Lithophilic Groups on Quarry-bordering Dumps

No	Families	The total number of species	Incl. petrophytes	Index of petrophytic properties, %
1.	Aspleniaceae	1	1	100.00
2.	Campanulaceae	1	1	100.00
3.	Geraniaceae	1	1	100.00
4.	Limoniaceae	1	1	100.00
5.	Resedaceae	1	1	100.00
6.	Rubiaceae	1	1	100.00
7.	Santalaceae	1	1	100.00
8.	Euphorbiaceae	2	1	50.00
9.	Lamiaceae	8	6	75.00
10.	Plantaginaceae	3	2	66.67
11.	Caryophyllaceae	10	8	80.00
12.	Brassicaceae	9	5	55.56
13.	Poaceae	15	10	66.67
14.	Scrophulariaceae	5	1	20.00
15.	Asteraceae	34	11	32.35
16.	Boraginaceae	3	1	33.33
17.	Fabaceae	9	3	33.33
18.	Ulmaceae	2	1	50.00
19.	Apiaceae	5	1	20.00
20.	Dipsacaceae	2	1	50.00
21.	Rosaceae	5	1	20.00
22.	Chenopodiaceae	4	1	25.00
23.	Aceraceae	1	-	0
24.	Elaeagnaceae	2	-	0
25.	Linaceae	1	-	0
26.	Moraceae	1	-	0
27.	Polygonaceae	3	-	0
28.	Ranunculaceae	4	-	0
29.	Salicaceae	2	-	0
Total:		141	60	42.55

distinguished.

Comparison of petrophytic capacities of flowering plant families of lithophilic communities present on the quarry-bordering dumps shows that the highest petrophytic index is typical for the community with the highest species capacity and petrophytic capacity, but this is not a regular pattern and there are some communities in which these indexes are high with low species capacity. The most numerous representatives of all communities include the following species: *Asteraceae*, *Brassicaceae*, *Caryophyllaceae*, *Chenopodiaceae*, *Euphorbiaceae*, *Fabaceae*, *Poaceae*, *Polygonaceae*, *Scrophulariaceae*.

The plateau-like top of the first sludge dump with laid rails (for continuous dumping of overburden rocks) and technological excavator and bulldozer works (related to piling rocks, leveling surfaces of the plateau-like tops and terraces) may be viewed as a demonstration and research field for creating a detailed picture of natural overgrowth in various phases and stages of lithophilic successions (Shanda, Voroshylova, 2015). At the same time changes in plant communities

on lithoecotopes left without human influence are of endo- and exogenous nature because the excess external pressure overlaps internal coenotic processes. As a result of such integration against the background of this or that substrate, fluctuation as well as successions are naturally realized. In order to illustrate the process of changes typical for plant communities on small-fragment and crushed stone substrates we selected several ecotopes.

On the northwestern terrace of this sludge dumping site in the small-fragmented and crushed stony lithoecotope with sufficient puddled and relatively even surface of the substrate formed of oxidized and unoxidized ferruginous quartzites with admixtures of quartz-sericite-biotite shales (typological formula $a_1b_6c_1d_3e_3fg_3h_1t_4$), surface cover is 70 – 85% and density of plants is up to 60 specimens per 1 m². Here a *Koeleria*-miscellaneous herbs community has developed. During a certain period of time (1973–1980) this terrace was on the border of the warehouse of ferruginous quartzites. It is significant that on areas of 100 m² up to 30 and even more species of the following plants (local spotty sections) can be

found (of course on water retaining lower layers): *Calamagrostis epigeios* (up to 14 specimens per 1 m²), *Polygonum persicaria*, *Tussilago farfara*, *Trifolium repens*, *Polygonum alpinum*, and in some places small groups of *Phragmites australis* and *Melica transsilvanica*. This community (due to incomplete covering of the substrate surface) is characterized by composition of plants belonging to various phases and stages of natural succession; and so the following species can be found: *Erigeron canadensis*, *Achillea nobilis*, *Ambrosia artemisifolia*, *Grindelia squarrosa*, *Taraxacum officinale*, *Centaurea diffusa*, *Melilotus albus*, *Polygonum aviculare*, *Kochia scoparia*, *Crepis tectorum*, *Lactuca saligna*, *Lactuca tatarica*, *Tragopogon major*. The predominant part of the grass stand is represented by *Poa angustifolia*, *Poa compressa* and *Festuca valesiana* with high density of the haulm stand (up to 150 specimens per 1 m²), *Bromopsis inermis*, *Anisantha tectorum*, *Lotus ucrainicus*, *Scabiosa ochroleuca*, *Medicago romanica*, *Coronilla varia*, *Potentilla argentea*, *Silene ucrainica*, *Linaria genistifolia*, *Artemisia absinthium*, *Artemisia austriaca*, *Nepeta parviflora*, *Solidago virgaurea*, *Goniolimon besseranum*, *Herniaria besseri*, *Teucrium chamaedrys*, *Hieracium echioides* and *Viola ambigua*.

In the lithocotope of the south-western slope of the same dump composed of sericite-biotite shales and unoxidized quartzites (typological formula $a_{1,2}c_1d_1e_1f_3g_2h_4t_4$) a fragmentary *Melica-Artemisia* community has been formed in conditions of descending spatial spreading; this community includes intervals between separate fragments of up to 1 meter and larger, grass stand density is not high (from 3 to 5 specimens per 1 m²), cover of the substrate is 32%, plants grow in intervals between fragments.

Melica transsilvanica plants are located with non-uniform density and location of *Artemisia absinthium* is unevenly dotted and these plants are supplemented with separate plants of *Achillea submillefolium*, *Crepis tectorum*, *Erigeron canadensis*, *Gypsophilla perfoliata*, *Kochia scoparia*, *Centaurea diffusa*, *Senecio jacobaea* and *Grindelia squarrosa*. This fact corresponds to the ecological capacities of lithocotopes with a similar substrate basis, sizes of fragments and location on the body of the dump.

In the first lithocotope of the south-western part of the plateau-like top of sludge dump 1 (typological formula $a_{1,3}b_3c_3d_2e_2f_2g_3h_3t_4$) composed of ore-free and poor-ore quartzites, quartz-sericite-chlorit-biotite shales with insignificant admixtures of oxidized ferruginous quartzites, shrubby and

woody vegetation is represented by separate plants of *Populus deltoides*, *Elaeagnus argentea*, *Hippophae rhamnoides*. Overall vegetation cover is 82%, density is 12-32 plants per 1m². The grass stand of the *Koeleria*-miscellaneous herbs community is represented by *Poa angustifolia*, *Poa compressa*, *Festuca valesiaca*, *Melica transsilvanica*, *Cichorium intubus*, *Artemisia austriaca*, *Artemisia absinthium*, *Koeleria cristata*, *Anisanta tectorum*, *Melilotus albus*, *Lotus corniculatus*, *Scabiosa ochroleuca*, *Plantago lanceolata*, *Centaurea diffusa*, *Euphorbia seguieriana*, *Melilotus officinalis*, *Linaria genistifolia*, *Daucus carota*, *Potentilla argentea*, *Stachys recta*, *Silaum besseri*, *Barkhausia rhoeadifolia*, *Reseda lutea*, *Dodartia orientalis*, *Erodium cicutarium*, *Petrorrhagia saxifraga*, *Polycnemum majus*, *Seseli campestre*, *Silene supina*, *Silene ucrainica*, *Anthemis subtinctoria*, *Dianthus pseudoarmeria*, *Diploaxis muralis*, *Lactuca saligna* and *Thesium arvense*.

In the second lithocotope (typological formula $a_{1,3}c_1d_1e_1f_2g_2h_4t_4$) a sparse fragmentary *Melica-Crambe* community was formed (with descending spatial spreading). *Melica transsilvanica*, *Crambe tatarica* are supplemented by separate plants of such species as *Melilotus albus*, *Erigeron canadensis*, *Gypsophilla perfoliata*, *Atriplex tatarica*, *Senecio jacobaea*, *Artemisia absinthium*, *Armeniaca vulgaris*, в нижній частині схилу *Rumex crispus*, *Grindelia squarrosa*, *Lactuca tatarica*, *Dodartia orientalis*, *Erodium cicutarium*, *Eryngium campestre*, *Diploaxis muralis*, *Kochia scoparia*, *Kochia vulgare*, *Salsola iberica*, *Silene latifolia*, *Centaurea diffusa*, *Potentilla argentea* and *Silaum alpestre*.

In the lithocotope of the second terrace of the first sludge dumping site of the Central Mining and Ore Enrichment Combine (typological formula $a_{1,5}b_5c_5d_3e_3f_3g_3h_2-t_4$) a *Koeleria-fescue*-miscellaneous herbs community has a mosaic structure against the background of local big (20-30) and large lump (30-50) elements of mixed rocks with prevailing poor-ore quartzites and unoxidized quartzites with admixtures of oxidized quartzites and quartz-sericite-biotite shales. Density of plants varies from 20-30 to 60-80 specimens, air-dry phytomass is from 192 to 483 g per 1 m². Total surface cover is 78%. The grass stand is composed of various ecological groups (in terms of their hygromorphic peculiarities, trophic peculiarities and coenomorphous peculiarities). There are some local small mosaic occurrences of *Melica transsilvanica*, as well as *Calamagrostis epigeios*, *Phragmites australis*, *Polygonum alpinum* and *Tussilago farfara*, which is possibly related to the availability of water resistant layers under the

Table 3. Petrophytic Properties of Lithophilic Plant Communities on Sludge Dumps of the Central Mining and Ore Enrichment Combine in Kryvbass

No	Families	The total number of species	Incl. petrophytes	Index of petrophytic properties, %
1.	Aceraceae	1	-	0
2.	Apiaceae	5	1	20.00
3.	Asteraceae	30	8	26.67
4.	Boraginaceae	3	1	33.33
5.	Brassicaceae	5	4	80.00
6.	Caryophyllaceae	11	8	72.73
7.	Chenopodiaceae	4	1	25.00
8.	Dipsacaceae	1	-	0
9.	Euphorbiaceae	2	1	50.00
10.	Elaeagnaceae	2	-	0
11.	Fabaceae	9	2	22.22
12.	Geraniaceae	1	1	100.00
13.	Lamiaceae	5	5	100.00
14.	Limoniaceae	1	1	100.00
15.	Onagraceae	1	1	100.00
16.	Poaceae	9	4	44.44
17.	Plantaginaceae	1	1	100.00
18.	Polygonaceae	5	1	20.00
19.	Ranunculaceae	3	-	0
20.	Resedaceae	1	1	100.00
21.	Rosaceae	5	1	20.00
22.	Salicaceae	2	-	0
23.	Santalaceae	1	1	100.00
24.	Scrophulariaceae	5	1	20.00
25.	Ulmaceae	2	1	50.00
26.	Violaceae	1	1	100.00
Total:		116	46	39.65

finely fragmented and crushed stone surface of the lithocotope substrate as a mixture of rocks. The fund of flowering plants is represented by the following species: *Poa compressa*, *Poa angustifolia*, *Festuca valesiaca*, *Anisantha tectorum*, *Artemisia absinthium*, *Artemisia austriaca*, *Barkhausia rhoeadifolia*, *Euphorbia seguieriana*, *Koeleria cristata*, *Diplotaxis muralis*, *Centaurea diffusa*, *Centaurea orientalis*, *Lactuca saligna*, *Melilotus albus*, *Linaria genistifolia*, *Lotus corniculatus*, *Petrorhagia saxifraga*, *Potentilla argentea*, *Plantago lanceolata*, *Medicago romanica*, *Scabiosa ochroleuca*, *Silaum besseri*, *Silene supina*, *Achillea submillefolium*, *Stachys recta*, *Berteroa incana*, *Grindelia squarrosa*, *Senecio jacobaea*, *Kochia scoparia*, *Gypsophilla perfoliata*, *Crepis tectorum*, *Cichorium intybus*, *Astragalus austriacus*, *Hieracium pilosella*, *Bidens tripartita*, *Erigeron canadensis*, *Polygonum aviculare*, *Echium vulgare*, *Consolida regalis*, *Minuartia leiosperma*, *Veronica austriaca*, *Herniaria besseri*, *Alyssum murale*, *Erysimum diffusum*, *Solidago virgaurea*, *Aster amellus*, *Taraxacum officinale*, *Anthemis subtinctoria*, *Thesium arvense*. Shrubby and woody species include: *Rosa canina*, *Elaeagnus argentea*, *Populus deltoides*, *Populus nigra*, *Ulmus laevis* and *Armeniaca vulgaris*.

In the lithocotope of the south slope of the same terrace (typological formula $a_1b_2c_2d_3e_3f_1g_2h_3-t_4$) the substrate is mainly composed of unoxidized and oxidized quartzites with a smaller admixture of shales. The same *Koeleria-fescue*-miscellaneous herbs community is characterized by greater cover (85%) of the substrate, greater density of plants (90-120 specimens) and an air-dry phytomass (up to 620 g) per 1m². Availability of small fragments of big-fragment substrate reduces the mosaic structure of the community but also defines a combination of plant species at various phases and stages of natural overgrowth which is typical for all lithocotopes with heterogeneous surface structure (those of terraces as well as those of slopes). The characteristic trees and shrubs includes the following species ; *Rosa canina*, *Elaeagnus argentea*, *Populus deltoides*, *Populus nigra* and *Acer negundo*. Species composition of the grass stand is sufficiently diverse and similar to that of the previous community, excluding such hygromorphic species as *Phragmites australis*, *Calamagrostis epigeios*, *Bidens tripartita* and *Tussilago farfara*. Species of the Poaceae family create a relatively even cover of the entire lithocotope area. This is the case with *Poa compressa*, *Poa angustifolia*, *Festuca valesiaca*, *Koeleria cristata*

and *Anisantha tectorum*, but *Melica transsilvanica* is located in separate fragments with a certain relationship to the eastern and north-eastern winds; the grass stand also includes separate locations of *Medicago romanica*, *Coronilla varia*, *Artemisia austriaca*, *Thymus dimorphus*, *Helichrysum arenarium*, *Lotus corniculatus*, *Xeranthemum annuum*, *Trifolium borysthenticum* and *Teucrium chamaedrys*. The following species can be relatively sparsely found in the grass stand ; *Artemisia absinthium*, *Achillea submillefolium*, *Aster amellus*, *Centaurea diffusa*, *Centaurea orientalis*, *Cichorium intybus*, *Diplotaxis muralis*, *Crepis tectorum*, *Daucus carota*, *Erigeron canadensis*, *Gypsophilla perfoliata*, *Grindelia squarrosa*, *Kochia scoparia*, *Lappula squarrosa*, *Linaria genistifolia*, *Plantago lanceolata*, *Polygonum aviculare*, *Rumex confertus*, *Verbascum lychnitis*, *Taraxacum officinale*, *Carduus acanthoides*, *Ceratocephala testiculata*, *Consolida paniculata*, *Echium vulgare*, *Scabiosa ochroleuca*, *Silaum alpestre*, *Silene latifolia*, *Chondrilla juncea*, *Euphorbia virgultosa*, *Erysimum diffusum*, *Hieracium echinoides*, *Dianthus lanceolatus*, *Melilotus officinalis*, *Minuartia leiosperma*, *Lycopsis orientalis*, *Holosteum subglutinatum*, *Nepeta parviflora*, *Phlomis pungens*, *Scorzonera taurica*, *Senecio jacobaea*, *Stachys recta*, *Silene ucrainica*, *Seseli campestre*, *Verbascum austriacum* and *Thesium arvense*. These two lithoecotopes of the first Sludge Dump at the Central Mining and Ore Enrichment Combine are close to the stage of steppification (steppe formation) and natural overgrowth of disturbed grounds.

Within the south-eastern part of the first terrace on the first sludge dumping site (dumped by means of railway transport), where surface leveling and compression was performed during the period of dumping there are sufficiently fresh (1-5 years) and recent (5-10 years) lithoecotopes formed of various types of rocks typical for quarries of the Central Mining and Ore Enrichment Combine. In lithoecotope 1 (typological formula $a_1b_2c_3d_2e_2fg_3h_2t_1$), with its substrate basis formed of quartz-biotite shales, biotite-chlorite shales, unoxidized and oxidized quartzites a sparse pioneer *Erigeron-Kochia-Polygonum* community was formed with general density from 6 to 12 specimens per 1 m². The grass stand includes the following species ; *Erigeron canadensis*, *Kochia scoparia*, *Polygonum aviculare*, in some places *Gypsophilla perfoliata*, *Diplotaxis muralis*, *Centaurea diffusa*, *Silene ucrainica*, *Melilotus albus* are found. This poor (in species composition) community is a starting (pioneer) one based on slowed colonization of the crushed stone substrate; and when passing to the lithoecotope 2 of older dumping (typological formula $a_1b_2c_3d_2e_2fg_3h_3t_2$) density of grass stand (*Erigeron canadensis*, *Kochia scoparia*, *Polygonum aviculare*,

Melilotus albus) is increased (up to 20 specimens per 1 m²) creating a continuous carpet covering of the substrate with admixtures of *Silene latifolia*, *Silene ucrainica*, *Linaria genistifolia*, *Achillea submillefolium*, *Artemisia absinthium*, *Gypsophilla perfoliata*, *Diplotaxis muralis*, *Lactuca saligna*, *Linaria genistifolia*, *Melica transsilvanica*, *Crambe tatarica*, *Grindelia squarrosa*, *Centaurea diffusa*. Development of *Melilotus albus* is characteristic of rocky dumps and similar lithoecotopes, which was pointed out by V.R. Williams, who considered this species to be typical in the process of vegetation restoration on crushed stone substrates and determined this developmental phase of the first weed stage as a characteristic one (Melilotus phase). During respective periods of time this was taken into account by I.A. Dobrovolskiy, V.I. Shanda, N.V. Gayeva (Dobrovolsky, Shanda, Gayeva, 1979), who studied overgrowth of substrates composed of various types of rocks. At the same time, it should be noted that in these two lithoecotopes we have a comparative developmental picture of the first stage of natural overgrowth on rocky dumps which was not observed in the previous ecotopes. *Melilotus albus* (as was determined by many authors is characterized by high contents of alkaloid coumarine and that is why its rarefication and change of the species composition of the *Melilotus*-miscellaneous herbs community may have some features of *Melilotus* weariness (similar to *Trifolium* weariness of soils) and the succession has allelopathic causality. This hypothesis has not been sufficiently checked but it is quite probably due to small contents of colloidal compounds in crushed stone substrates.

On the southern slope of the first sludge dumping site where the surface is composed of the mixture (conglomerate) of quartz-sericite-biotite shales, biotite-chlorite shales and poor-ore quartzites including fragments of various sizes (from fine fractions to large-sized fractions) (typological formula $a_1c_1i_2d_1e_1f_3g_3h_7t_3$) an unevenly distributed, sparse, patchy *Melica* community was formed with density of plants 5-6 plants per 1 m² and providing 10-12% cover of the substrate surface in conditions of complete absence of plant mass remnants. This community can be viewed as an example of independent and simple immigration and spreading of *Melica transsilvanica* as a pioneer species and non-dense bushy herb and development of an almost single-species lithophilic community without previous intermediate stages and phases. *Melica transsilvanica* is able to independently take and hold ecological positions in harsh conditions of lowered trophic characteristics, hygrophylous characteristics and thermal extremes (overheating) during the vegetation period. In this

community only separate specimens of *Crambe tatarica* were detected.

In the lithoecotope 3 (which is located close to the above-mentioned lithoecotope) against the background of a similar conglomerate of rocks (but with smaller fractions) (typological formula $a_1c_1i_2d_1e_1f_3g_3h_3t_3$) a fragmentary dissected Artemisia-Melica-miscellaneous herbs community was developed with general cover of 26% of the surface (descending spatial spreading). The main species are *Melica transsilvanica*, *Artemisia absinthium*, also *Erigeron canadensis*, *Polygonum aviculare*, *Senecio jacobaea*, *Achillea submillefolium*, *Kochia scoparia*, *Silene ucrainica*, *Crepis tectorum*, *Dianthus deltoides*, *Linaria genistifolia*, *Berteroa incana*, *Ambrosia artemisifolia*, *Atriplex tatarica* and *Grindelia squarrosa*. Presence of these species is conditioned by locally band-like (along the slope) washing of fine grained soil away from the surface of the plateau-like top.

Within the second sludge dumping site there is a hollow up to 60 meters long where lithoecotopes of its eastern and western slopes vary in size of fractions and respective conditions of plant community development.

In the lithoecotope of the eastern slope (its substrate basis includes the same shales and quartzites) (typological formula $a_1c_8i_2d_1e_1f_3g_3h_4t_4$), in the upper part there is a Melica-miscellaneous herbs community with isolated *Ulmus caprinifolia* trees and *Rosa dumalis* shrubs. The grass stand is sparse (5-6 plants per 1 m²). The main species: *Melica transsilvanica*, *Artemisia absinthium*, *Gypsophilla perfoliata*, *Crambe tatarica*.

On the western slope with separate trees of *Populus nigra*, (lithoecotope typological formula $a_1c_7i_3d_2e_2f_2g_2h_3t_4$), the substrate is composed in a similar way but with significant admixtures of oxidized quartzites. A fragmentary- band-like Melica-Koeleria-miscellaneous community has formed with bands in some places reaching the foot of the dump. The following species are present in the grass stand ; *Melica transsilvanica*, *Poa compressa*, *Poa angustifolia*, *Crambe tatarica*, *Erigeron canadensis*, *Kochia scoparia*, *Polygonum aviculare*, *Centaurea diffusa*, *Crepis tectorum*, *Senecio jacobaea*, *Diplotaxis muralis*, *Silene supina*, *Linaria genistifolia*, *Melilotus albus*, *Lactuca saligna* and *Euphorbia seguieriana*.

On the northeastern slope of the second sludge dump (in the lithoecotope with the technological formula $a_1c_5i_3d_1e_1f_2g_3h_7t_4$) with the substrate basis including quartz-sericite-biotite shales and unoxidized/partially oxidized quartzites a Melica-miscellaneous herbs community (dissected-elongated-patchy) was formed with cover of 25% and density of herbaceous plants from 5 to 20 specimens

per 1 m² and some separate specimens of *Rosa canina*, *Populus deltoides*, *Armeniaca vulgaris*. The grass stand is represented by mixed and isolated groups of *Melica transsilvanica*, *Phragmites australis*, *Kochia scoparia*, *Polygonum aviculare*, *Centaurea diffusa*, *Artemisia absinthium*, *Artemisia austriaca*, *Erigeron canadensis*, *Grindelia squarrosa*, *Atriplex tatarica*, *Melilotus albus*, мисцяму *Achillea nobilis*, *Diplotaxis muralis*, *Silene latifolia*, *Rumex confertus*, *Senecio jacobaea* and *Crepis tectorum*, while a single specimen of *Oenothera biennis* was registered.

Within the sludge dumping sites of the Central Mining and Ore Enrichment Combine on fresh (up to 5 years) and recent (up to 10 years) flat pressed (by bulldozers and scrapers in the process of moving hard rocks) and relatively even surfaces in conditions of homogeneous substrates (shale-unoxidized-quartzite ones or with admixture of oxidized quartzites or their combinations) uniform Kochia-Erigeron-Polygonum plant communities of carpet type are formed with diffusely uneven spreading and composition of plants belonging to the following cenopopulations: *Kochia scoparia*, *Erigeron canadensis*, *Polygonum aviculare* with small admixtures of *Gypsophilla perfoliata*, *Grindelia squarrosa*, *Silene ucrainica*, *Linaria genistifolia*, which are later substituted (within 5-10 years) by Melilotus-Artemisia-Achillea communities i.e. by the Melilotus phase of restoration of the steppe indigenous vegetation which is typical for hard rocky (crushed stone) substrates in the steppe area with further gradual disappearance of Melilotus from the grass stand and appearance of Koeleria plants and miscellaneous herbs.

Presence of species, species capacity and petrophytic capacity of plant communities, their indexes of petrophytic properties in lithoecotopes of sludge dumps may vary depending on specific conditions.

In the line of sludge dumps (in lithophilic plant communities) 116 species were determined belonging to 26 families including 46 petrophyte species (Table 4). Descending rows (spectra) of plant community families are presented as follows: I. According to the number of species ; *Asteraceae* (30) – *Caryophyllaceae* (11) – *Poaceae* (9) – *Fabaceae* (9) – *Apiaceae* (5) – *Brassicaceae* (5) – *Lamiaceae* (5) – *Polygonaceae* (5) – *Rosaceae* (5) – *Scrophulariaceae* (5) – *Chenopodiaceae* (4). II. According to the number of petrophytes ; *Asteraceae* (8) – *Caryophyllaceae* (8) – *Lamiaceae* (5) – *Brassicaceae* (4) – *Poaceae* (4). III. According to the coefficient of petrophytic properties (%%) ; – *Lamiaceae* (100,00) – *Brassicaceae* (80,00) – *Caryophyllaceae* (72,72) – *Poaceae* (44,44) – *Asteraceae* (26,66).

Table 4. Species Capacity and Petrophytic Capacity of Plant Families in the Central Zone

No	Families	The total number of species	Incl. petrophytes	Coefficient of petrophytic properties, %
1.	<i>Aceraceae</i>	1	-	0
2.	<i>Apiaceae</i>	6	1	16.67
3.	<i>Aspleniaceae</i>	1	1	100.00
4.	<i>Asteraceae</i>	38	12	31.58
5.	<i>Boraginaceae</i>	3	1	33.33
6.	<i>Brassicaceae</i>	9	5	55.56
7.	<i>Campanulaceae</i>	1	1	100.00
8.	<i>Caryophyllaceae</i>	12	9	75.00
9.	<i>Chenopodiaceae</i>	6	2	33.33
10.	<i>Dipsacaceae</i>	2	1	50.00
11.	<i>Elaeagnaceae</i>	2	-	0
12.	<i>Euphorbiaceae</i>	2	1	50.00
13.	<i>Fabaceae</i>	11	3	27.27
14.	<i>Geraniaceae</i>	1	1	100.00
15.	<i>Lamiaceae</i>	8	6	75.00
16.	<i>Limoniaceae</i>	1	1	100.00
17.	<i>Linaceae</i>	1	-	0
18.	<i>Moraceae</i>	1	-	0
19.	<i>Onagraceae</i>	1	1	100.00
20.	<i>Plantaginaceae</i>	3	2	66.67
21.	<i>Poaceae</i>	15	10	66.67
22.	<i>Polygonaceae</i>	5	1	20.00
23.	<i>Ranunculaceae</i>	4	-	0
24.	<i>Resedaceae</i>	1	1	100.00
25.	<i>Rosaceae</i>	6	1	16.67
26.	<i>Rubiaceae</i>	1	1	100.00
27.	<i>Salicaceae</i>	2	-	0
28.	<i>Santalaceae</i>	1	1	100.00
29.	<i>Scrophulariaceae</i>	5	1	20.00
30.	<i>Ulmaceae</i>	2	1	50.00
31.	<i>Violaceae</i>	1	1	100.00
	Total:	153	66	43.14

Average coefficient of petrophytic properties in plant families is 39.65 %.

Plant communities of sludge dump lithocotopes are characterized by a greater variability of species capacities and petrophytic capacities and in these lithocotopes the following families present the

greatest species diversity: *Brassicaceae*, *Caryophyllaceae*, *Chenopodiaceae*, *Fabaceae*, *Poaceae*, *Polygonaceae* and *Scrophulariaceae*.

So, the species composition of the lithophilic communities present on the sludge dumping sites of the Central Mining and Ore Enrichment Combine

Table 5. Petrophyte Species Typical only for the Central Zone of the Kryvbass

No	Species	Families
1.	<i>Alyssum murale</i>	<i>Brassicaceae</i>
2.	<i>Asplenium ruta-muraria</i>	<i>Aspleniaceae</i>
3.	<i>Asyneuma canescens</i>	<i>Campanulaceae</i>
4.	<i>Centaurea solstitialis</i>	<i>Asteraceae</i>
5.	<i>Dianthus carbonatus</i>	<i>Caryophyllaceae</i>
6.	<i>Dianthus pseudoarmeria</i>	<i>Caryophyllaceae</i>
7.	<i>Festuca sulcata</i>	<i>Poaceae</i>
8.	<i>Galium ruthenicum</i>	<i>Rubiaceae</i>
9.	<i>Goniolimon besseranum</i>	<i>Limoniaceae</i>
10.	<i>Marrubium praecox</i>	<i>Lamiaceae</i>
11.	<i>Nepeta parviflora</i>	<i>Lamiaceae</i>
12.	<i>Phlomis pungens</i>	<i>Lamiaceae</i>
13.	<i>Poa stepposa</i>	<i>Poaceae</i>
14.	<i>Polycnemum majus</i>	<i>Chenopodiaceae</i>
15.	<i>Polygonum alpinum</i>	<i>Polygonaceae</i>
16.	<i>Scorzonera taurica</i>	<i>Asteraceae</i>
17.	<i>Silene supina</i>	<i>Caryophyllaceae</i>
18.	<i>Viola ambigua</i>	<i>Violaceae</i>

demonstrates high substrate dependence and temporal dependence.

In general the taxonomic composition of plant communities on dumps of the Kryvbass central zone includes 153 species belonging to 31 families (Table 4), among them 66 species are petrophytes and 18 species are typical only for this zone (Table 5).

These plant communities are presented in descending order as follows: I. According to the number of species; *Asteraceae* (38) – *Poaceae*

complexity growing on plateau tops, terraces and slopes, depending on specifics of their constituent rocks and typological features. In accordance with the state of the lithoecotopes, including all typological characteristics and the geochemical nature of rocks, plant lithophilic communities growing on the dumps of the Central Mining and Ore Enrichment Combine were characterized by significant differences in analytical (floristic and ecomorphic composition, occurrence, layerage, aspect, abundance, coverage)

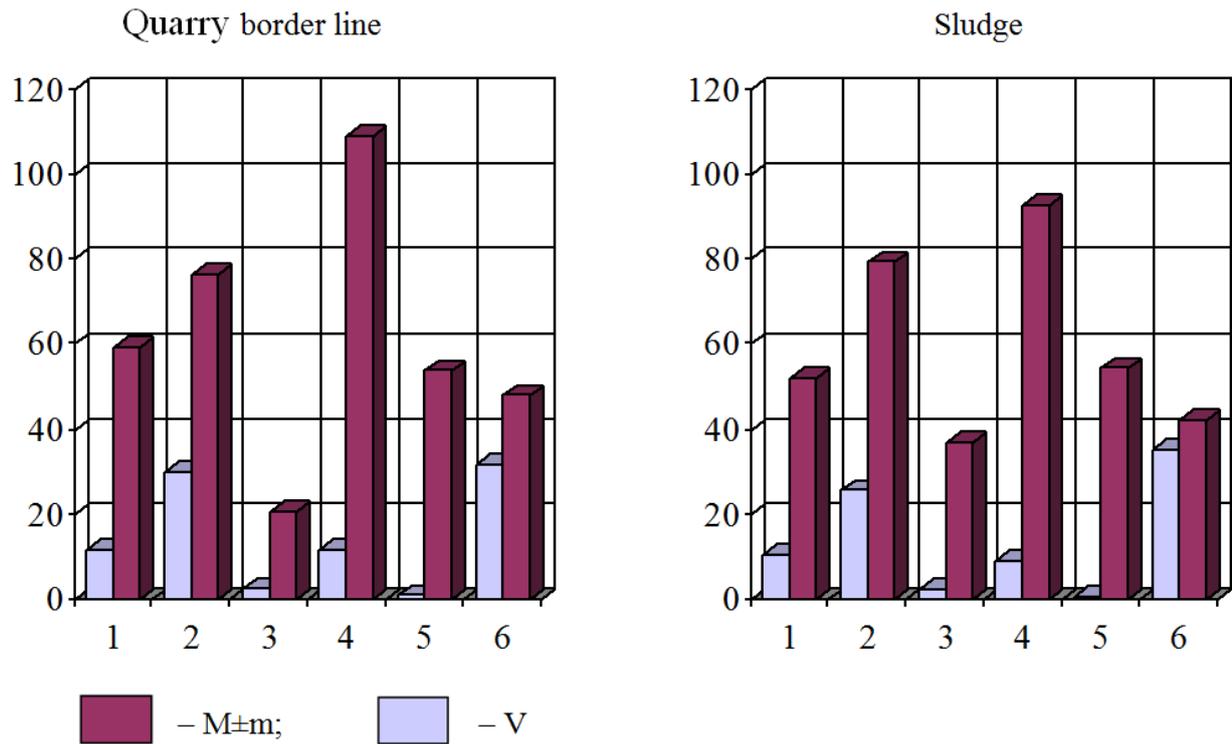


Fig.1. Consolidated indexes of generalized characteristics of lithophilic family communities:

1 – families; 2 – species; 3 – average species capacity of families; 4 – petrophytes; 5 – average petrophytic capacity of families; 6 – index of petrophytic properties of communities

(15) – *Caryophyllaceae* (12) – *Fabaceae* (11) – *Brassicaceae* (9) – *Lamiaceae* (8) – *Apiaceae* (6) – *Chenopodiaceae* (6) – *Rosaceae* (6) – *Polygonaceae* (5) – *Scrophulariaceae* (5) – *Plantaginaceae* (3); II. According to the number of petrophytes; *Asteraceae* (12) – *Poaceae* (10) – *Caryophyllaceae* (9) – *Lamiaceae* (6) – *Brassicaceae* (5) – *Fabaceae* (3) – *Plantaginaceae* (2). III. According to the coefficient of petrophytic properties (%); *Caryophyllaceae* (75.00) – *Lamiaceae* (75.00) – *Poaceae* (66.66) – *Plantaginaceae* (66.66) – *Brassicaceae* (55.55) – *Asteraceae* (31.58) – *Fabaceae* (27.27). Average index of petrophytic properties is 43.14%.

Conclusion. We classified various lithoecotopes and characterized vegetation communities of varying

and synthetic (similarity, constancy) values. A detailed survey of the state of the plants and their communities within the lithoecotopes has allowed us to establish that their distribution and development have clearly expressed dependence on substrate and relief-exposure, which can be used in phytocenotic and phytocenotic melioration of such technogenic ecotopes. Native overgrowth of all dumps has a shrub-tree forest and grassy pattern in accordance with the typological characteristics and rock composition. In general, the taxonomic composition of the plant communities growing on the dumps of the Kryvbass central zone is determined by 153 species belonging to 31 families, of which 66 species are petrophytes, and 18 species are typical only for the zone surveyed.

References

- Bel'gard, A. L., 1950. Lesnaja rastitel'nost' jugo-vostoka USSR [Forest vegetation of southeast of the Ukrainian SSR]. Forest industry, Kiev (in Russian), 254 p.
- Chorna, V.I., Voroshylova, N.V., Loza, I.M. 2018. The ways to increase productivity and improve biogeochemical structure of anthropogenically affected soils Association agreement: from partnership to cooperation (collective monograph). Hamilton, Canada. 217-221
- Diduh, Y. P., 2012. Osnovy bioindykacii' [Basics of bioindication]. Naukova Dumka, Kyiv (in Ukrainian).
- Dobrovolsky, I.A, Shanda, V.I., Gayeva, N.V., 1979. Syngenes behavior and direction in technogenic ecotopes of Kryvbas. Ukr. Botan. Journ. Vol. 36, 6, 524-527.
- Gittins R. Towards the analysis of vegetation succession. – Vegetation succession. Vegetetio. 1981. Vol.46-47, 37–59.
- Khlyzina, N.V., 2008. Sukcesijni systemy na substratah girskyh porid kar'jerno-vidvalnych urochisch Kryvbasu. [The succession systems on the substrates of the rocks of the Krivbass mining and drainage tract]. Gruntoznavstvo, 9 (1-2), 79-85 (in Ukrainian)
- Korchagin AA Species (floristic) composition of plant communities and methods of its study. Field geobotany. M. : Nauka, 1964. Vol. 3, 39–62.
- Malenko, Y.V., 1999. Ecomorphic composition of plant communities on Kryvbas tailing dumps. Ecology and Noospherology. Vol. 6, 1-2, 128-136.
- Mosyakin, S.L., 1999. Fedoronchuk, M.M. Vascular plants of Ukraine. A nomenclature checklist. Ed. S. L. Mosyakin. Kyiv, M. G. Kholodny Institute of Botany, XXIV + 346 pp.
- Opredelitel' vysshih rastenij Ukrainy [Identification guide to higher plants of Ukraine] (1987). Kyiv (in Russian).
- Paran'ko, I.S., Khlyzina, N.V., 2005. Geohimichnyj kontekst typologii' litoekotopiv ta i'h fitoindykacija [Geochemical context of the typology of lithoecotopes and their phytoindication]. Gruntoznavstvo, 6(1-2), 67-75 (in Ukrainian)
- Tarasov, V.V., 2012. Flora Dnipropetrovs'koi' ta Zaporiz'koi' oblastej [Flora of Dnipropetrovsk and Zaporizhia regions]. 2nd edition, Lira, Dnipropetrovsk, 1-296 (in Ukrainian).
- Shanda, V. I., Voroshylova, N. V., 2015. Methodology and theory of biogeocenology. Ecology and Noospherology, 26(1-2), 15–24. doi:10.15421/031502