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Ecological successions of phytocenoses in the process of formation of the phytomeliorative cover of landfills

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Ecological successions of phytocenoses in the process of formation of the phytomeliorative cover of landfills

V Popovych, P Bosak, I Dumas, Yu Kopystynskyi and V Pinder
Lviv State University of Life Safety, Lviv, Ukraine, 79007

E-mail: bosakp@meta.ua

Abstract. The vegetation in the landfills within the Western Forest Steppe of Ukraine is characterized by the rich species composition of the grass cover near the bottom and its almost absence at the top (southern slope). The transforming function of adapted plant groups leads to significant reduce of the intensity of denudation processes of technogenic substrates, and initiate soil-forming processes in them. The aim of the work is to establish the peculiarities of successional processes in different types of landfills of the Western Forest Steppe of Ukraine, depending on various technogenic factors. It was found that large landfills have the largest species composition – Lviv – 30 species, Ternopil – 20, Lutsk – 19. Small landfills – Lavrykiv – 10 species, Vereshchytsya – 11 species have the smallest species composition. Succession stages (syngenetic, initial endo-ecogenetic, mature endo-ecogenetic) are described at each investigated landfill, and projective coverage is calculated. It was established that the highest coefficients of Jaccard's floristic similarity are characteristic to the investigated areas of landfills where there is no waste dumping, or it is only in certain areas (the second phase of dumping). The average coefficient of floristic similarity of all investigated landfills is K_j=0.29.

1. Introduction

Overgrowth of landfills within the Western Forest Steppe occurs at the foot and, partly, on the slope surfaces. Small overgrown areas on the surface of landfills are the result of recultivation works (mining and biological stages). However, the recultivation works obviously did not involve a preliminary study of phytocenoses and their selection was not correct, which led to the death of forest crops.

The species composition of the vegetation involved in the natural overgrowth of the Lviv landfill was studied in [1]. Peculiarities of phytomelioration of territories used for municipal landfills are described in. The peculiarities of the formation of phytoremedial surfaces using *Brassica napus* L. crops are revealed, and the phytoremedial treatment facilities of the "bioplateau" type are proposed to use for the treatment of runoff from the territory of the landfill. In our opinion, the very essence of phytomelioration of landfills is not sufficiently revealed in this work, and the species composition of vegetation, participating in the process of self-regrowth, is not investigated. The work [3] provides data on the formation of two-stage dynamics of leachate purification and its biological purification. The work [2] provides data on the formation of two-stage dynamics of leachate purification and its biological purification.

Despite the detrimental effect on the development of phytocenoses, landfills quickly become overgrown with ruderal vegetation after closure (natural phytomelioration processes), so this process must be regulated [3-4]. Landfills, even without filling soil mixtures, turn into soil nutritious for vegetation in the process of decomposition [5-6].

The problem for scientists is leachate, accumulated at the foot of landfills and saturated with a large number of heavy metals and chemical compounds [7-9]. In some landfills, there is an increased radiation background, caused by past dumping of radioactive and hazardous materials [10].

2. Material and methods

2.1 Study area

The aim of the work is to establish the peculiarities of successional processes in different types of landfills of the Western Forest Steppe of Ukraine, depending on various technogenic factors. The objects of research are landfills operating within the Western Forest-Steppe of Ukraine (Western Ukrainian Forest-Steppe District).

In the Western Forest Steppe District, five forestry districts are allocated: 1 – Volyn Upland; 2 – Malopolissya Lowland; 3 – Rostotsko-Opilsky; 4 – Prut-Dniester; 5 – North-Western Podillya [11-12]. It was taking into account these forestry districts, the landfills were selected for further research.

2.2 Data collection on plant diversity, community structure, and topography

Ten landfills operating in ecologically overloaded areas of the Western Forest Steppe were studied – in the cities of Lviv, Ternopil, Lutsk, Chervonohrad, Sokal, Rava-Ruska, Tysmenytsia, the town of Maheriv, the villages of Lavrykiv, and Vereshchytsia. In terms of volume and area, landfills are divided into three types: large – Lviv, Ternopil, Lutsk; middle – Chervonohrad, Sokal, Rava-Ruska, Tysmenitsya, Maheriv; small – Lavrykiv, Vereshchytsya (figure 1).

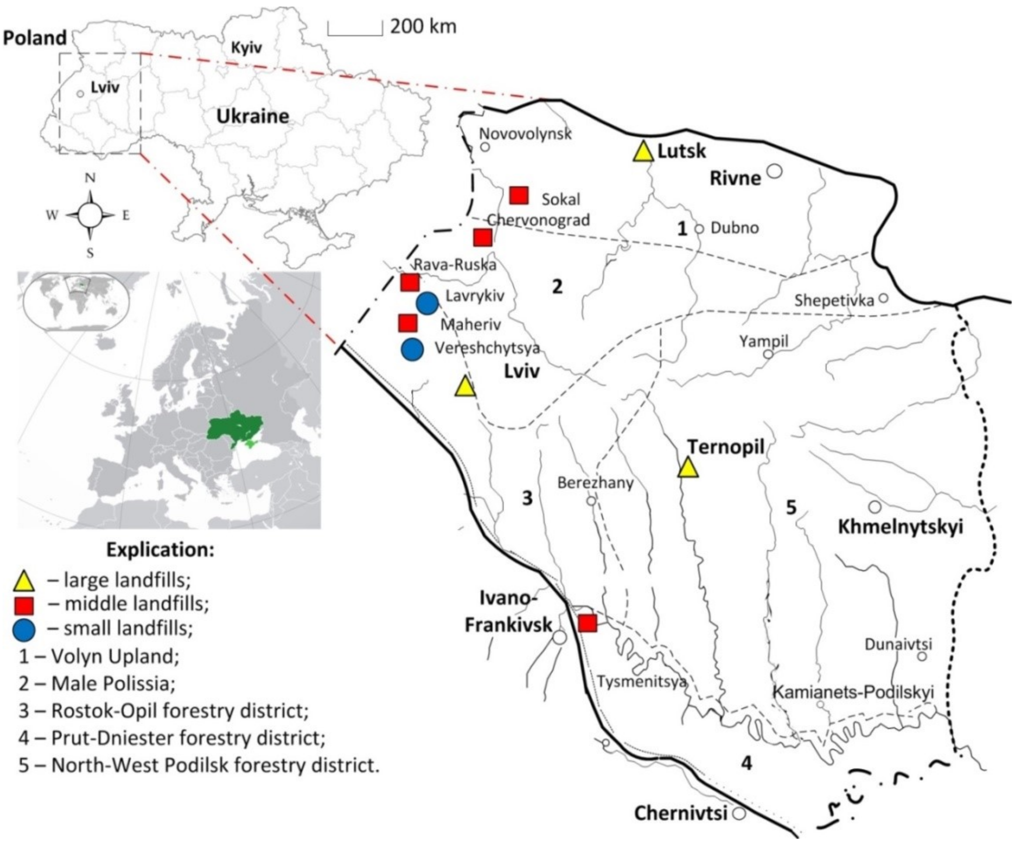

Figure 1. Schematic representation of the location of landfills in the studied area.

The description and analysis of micro-associations was carried out according to the methodology of V. P. Kucheryavyi. In order to investigate the similarity of the flora at the foot and on the surface of the landfill, the Jaccard coefficient of floristic similarity was used [13]:

$$K_j = \frac{c}{a+b-c} \quad (1)$$

where, *a* – the amount of species at the foot of the landfill; *b* – the amount of species on the surface of the landfill; *c* – the amount of common species on the both sites.

3. Results and discussion

During field studies of landfills, significant differences in the species composition of tree stands and grass cover were established depending on the exposure of the slope. Vegetation is characterized by the richness of the species composition of the grass cover at the foot and its almost absence at the top (south side).

3.1 Natural phytomelioration of large landfills

Natural phytomelioration processes on the surface of the **Lviv landfill** proceed slowly. It is characterized by a low species composition compared to the foothills. In the table 1 the species composition of vegetation with high constancy classes, that is, most often found in these phytocenoses, is shown.

Table 1. Successions of the vegetation cover of the Lviv landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 15-25%	Projective cover 35-55%	Projective cover 65-85%
Chenopodium urbicum L., *Plantago major* L., *Arctium lappa* L., *Artemisia vulgaris* L., *Artemisia absinthium* L.	*Chenopodium urbicum* L.+ *Plantago major* L.+*Arctium lappa* L.+*Artemisia vulgaris* L+ *Calamagrostis epigeios* (L.) Roth.+*Eutrigia repens* L.+ *Humulus lupulus* L.	*Chenopodium urbicum* L.+ *Plantago major* L.+*Artemisia vulgaris* L.+ *Calamagrostis epigeios* (L.) Roth.+*Eutrigia repens* L.+ *Humulus lupulus* L.+ *Hippophae rhamnoides* L.+ *Betula pendula* Roth.

Tar basins stored at the Lviv landfill seep into the environment and cause the death of ruderocenoses [14]. At the **Ternopil landfill**, self-ignition processes occur in those places where natural phytoremediation processes are already taking place (figure 2).

Figure 2. Structure of the Ternopil landfill:
1 – zone of stored household waste;
2 – zone of unsuccessful reclamation;
3 – zone of natural phytomelioration processes;
4 – household waste burning zone (photo by V. Popovych).

Among the ruderal species that develop around waste decay processes, the following were found: *Taraxacum officinale* Wigg., *Taraxacum hybernum* Steven., *Chenopodium urbicum* L., *Eutrigia repens* L., *Heracleum sosnowskyi* Manden., *Arctium lappa* L., *Daucus carota* L., *Artemisia vulgaris* L. [15]. In the table 2 the species composition of the succession is shown.

Table 2. Vegetation successions of the Ternopil landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 10-15%	Projective cover 25-45%	Projective cover 55-65%
Chenopodium urbicum L., *Arctium lappa* L., *Artemisia vulgaris* L.	*Chenopodium urbicum* L.+ *Arctium lappa* L.+*Artemisia vulgaris* L+ *Calamagrostis epigeios* (L.) Roth.+*Eutrigia repens* L.+ *Urtica dioica* L.+ *Taraxacum officinale* Wigg.	*Calamagrostis epigeios* (L.) Roth.+*Eutrigia repens* L.+ *Trifolium pratense* Schreb.+ *Fragaria vesca*+ *Betula pendula* Roth.

At the **Lutsk landfill**, the coefficient of floristic commonality (K_j=0.15) indicates a low level of flora similarity [15]. This index is low due to the excellent conditions of vegetation around the landfill and at a certain distance from it. Three stages of successions were identified, the description of which is given in the table 3.

Table 3. Vegetation successions of the Lutsk landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 5-10%	Projective cover 25-35%	Projective cover 45-55%
Chenopodium urbicum L., *Arctium lappa* L., *Plantago major* L., *Taraxacum officinale* Wigg., *Urtica dioica* L.	*Carex pilosa* Scop.+*Trifolium pratense* L.+*Achillea millefolium* L.+ *Robinia pseudoacacia* L.+*Pinus sylvestris* L.	*Achillea millefolium* L.+*Polytrichum commune* L.+*Pinus sylvestris* L.+*Betula pendula* Roth.

During studying the peculiarities of the phytoremedial cover formation at the Lutsk landfill, it was established that there is no vegetation on the surface of the landfill due to the constant uncontrolled processes of garbage dumping. The development of vegetation around the landfill is inhibited by hazardous processes (burning garbage, leachate, biogas), and the natural regeneration of trees occurs at a distance of at least 100 m from the foot of the landfill. The Jacquard flora similarity coefficient for sample plots of the landfill is 0.15 and is low due to the excellent conditions of vegetation growth around the Lutsk landfill and at a certain distance from it. During the floristic descriptions of the studied areas landfill, phytocenoses, that develop singly and are not inherent to the conditions of local growth, were found (*Juglans regia* L., *Aesculus hippocastanum* L.).

3.2 Natural phytomelioration of medium-sized landfills

It was found that the vegetation at the **Chervonohrad landfill** grows mostly on the northern side of the landfill. On the surface of the landfill we found the following ruderal species – *Eutrigia repens* L., *Urtica dioica* L., *Artemisia vulgaris* L., *Taraxacum officinale* Wigg. Jaccard's coefficient of floristic similarity was used to compare the degree of similarity and difference of species. The obtained coefficient of floristic commonality (K_j=0.12) indicates a low level of similarity between the flora of the landfill surface and the foothills.

This situation is caused by the functioning of the landfill itself and the destruction of phytomelioration cover on its surface. Stages of successions at the landfill were identified, the description of which is given in table. 4 [15].

Table 4. Vegetation successions of the Chervonohrad landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 5%	Projective cover 25-35%	Projective cover 55-65%
Urtica dioica L., *Artemisia vulgaris* L., *Taraxacum officinale* Wigg.	*Eutrigia repens* L.+ *Urtica dioica* L.+ *Hippophae rhamnoides* L.+ *Ligustrum vulgare* L.+ *Betula pendula* Roth.	*Eutrigia repens* L.+ *Hippophae rhamnoides* L.+ *Ligustrum vulgare* L.+ *Pinus sylvestris* L.

Natural phytomelioration at the **Sokal landfill** is observed near leachate ponds (eastern exposure of the slope) and on the northern side of the landfill. Among the most widespread ruderal species *Chenopodium urbicum* L., *Plantago major* L., *Artemisia vulgaris* L., *Arctium lappa* L., *Eutrigia repens* L., *Calamagrostis epigeios* (L.) Roth., *Taraxacum officinale* Wigg., *Daucus carota* L., *Urtica dioica* L., *Armoracia rusticana* P.G. Gaertn., B. Mey. & Scherb should be noted. Tree and shrub vegetation on the surface of the landfill is represented by *Ligustrum vulgare* L., *Robinia pseudoacacia* L. Hygrophytes *Alnus glutinosa* (L.) Gaerth, *Populus tremula* L. develop on the banks of filtration reservoirs. A negative phenomenon for the grass cover development is the frequent landslides of the side surfaces of the landfill, as well as the trampling of cenoses by various equipment (bulldozers, garbage trucks).

In order to assess the overgrowth of the landfill and determine the similarity of the flora around the leachate ponds and the surface of the landfill, we used a coefficient. The obtained coefficient of floristic commonality (K_j=0.31) is quite high and indicates the similarity of the flora of the landfill sites and the development of synanthropic vegetation. Three stages of succession were distinguished – syngenetic, initial endoecogenetic and mature endoecogenetic. In the table 5 the successional stages of vegetation are shown.

Table 5. Vegetation successions of the Sokal landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 10-20%	Projective cover 25-40%	Projective cover 55-75%
Chenopodium urbicum L., *Plantago major* L., *Artemisia vulgaris* L., *Arctium lappa* L., *Urtica dioica* L., *Armoracia rusticana* P.G. Gaertn., B. Mey. & Scherb.	*Eutrigia repens* L.+*Calamagrostis epigeios* (L.) Roth.+*Taraxacum officinale* Wigg.+*Daucus carota* L.+ *Ligustrum vulgare* L.+*Robinia pseudoacacia* L.	*Eutrigia repens* L.+ *Ligustrum vulgare* L.+*Robinia pseudoacacia* L.+ *Alnus glutinosa* (L.) Gaerth+*Populus tremula* L.

The **Rava-Ruska landfill** is overgrown with spontaneous vegetation on all exposures of the slopes and the top, except for the eastern slope, where waste is dumped. The densest grass cover is at the foot of the landfill on the northern side. The southern part of the landfill is wedged into a forest massif, where *Pinus sylvestris* L. is the predominant species.

The high coefficient of floristic commonality of the surface of the landfill and the foothills (K_j=0.37) indicates that natural phytomelioraton processes at the landfill occur in accordance with reforestation. The high value of the floristic similarity coefficient attests to the absence of surface leveling of the landfill and, as a result, the destruction of plant cover. The Rava-Ruska landfill is one of those with a high level of projective cover (up to 90% in some places). Three stages of succession were identified, which are shown in the table. 6 [15].

Table 6. Vegetation successions of the Rava-Ruska landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 15-25%	Projective cover 35-45%	Projective cover 75-90%
Plantago major L., *Artemisia vulgaris* L., *Arctium lappa* L., *Urtica dioica* L., *Taraxacum officinale* Wigg., *Persicaria lapathifolia* L.	*Eutrigia repens* L.+*Calamagrostis epigeios* (L.) Roth.+*Taraxacum officinale* Wigg.+ *Plantago major* L.+*Urtica dioica* L.+*Salix caprea* L.+ *Betula pendula* Roth.	*Eutrigia repens* L.+ *Sambucus nigra* L.+*Larix decidua* Mill.+*Betula pendula* Roth.+*Pinus sylvestris* L.

An important positive phenomenon for the phytoremediation processes of the **Maheriv landfill** is the fact that the dumping of waste is carried out very rarely and only from the southern side. Calculated Jaccard's coefficient of floristic similarity (K_j=0.23) for the Maheriv landfill showed that on the surface of the landfill, natural phytomelioration processes are developing by ruderal species.

Common species that were noted are autochthonous and develop only in areas with a significant supply of nutrients and moisture. Successive stages of plant cover, found at the landfill, are listed in the table. 7 [15].

Table 7. Vegetation successions of the Maheriv landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 5-10%	Projective cover 25-35%	Projective cover 45-65%
Chenopodium urbicum L., *Persicaria lapathifolia* L., *Taraxacum officinale* Wigg., *Tussilago farfara* L., *Urtica dioica* L., *Arctium lappa* L., *Armoracia rusticana* P.G. Gaertn., B. Mey. & Scherb	*Eutrigia repens* L.+ *Daucus carota* L.+*Taraxacum officinale* Wigg.+ *Cirsium vulgare* (Savi)+ *Betula pendula* Roth.	*Eutrigia repens* L.+ *Ligustrum vulgare* L.+ *Populus tremula* L.+*Populus alba* L.+*Betula pendula* Roth.+*Pinus sylvestris* L.

The syngenetic stage of succession is represented by ruderal species that do not compete with each other. Among them, *Armoracia rusticana* P.G. Gaertn., B. Mey. & Scherb, which forms communities and provides biomass for microorganisms, should be noted. The initial endoecogenetic succession is represented by a smaller number of ruderal species, though *Betula pendula* Roth. is observed there. Since the landfill is located next to a forest, the mature endoecogenetic succession is represented by *Ligustrum vulgare* L., *Populus tremula* L., *Populus alba* L., *Betula pendula* Roth., *Pinus sylvestris* L., developing at the foot and on the northern side of the landfill.

The **Tysmenytsya landfill** is not operational, but various fur production wastes and household wastes continue to be stored in small quantities. The following representatives of ruderal vegetation have developed directly on the surface of the landfill - *Eutrigia repens* L., *Chenopodium urbicum* L., *Heracleum sosnowskyi* Manden., *Urtica dioica* L., *Artemisia vulgaris* L., *Populus tremula* L., *Salix caprea* L. A somewhat larger species composition is observed on the dams of filtration reservoirs and at the foot of the landfill – *Eutrigia repens* L., *Heracleum sosnowskyi* Manden., *Urtica dioica* L., *Artemisia vulgaris* L., *Daucus carota* L., *Plantago major* L., *Taraxacum officinale* Wigg., *Arctium lappa* L., *Carduus nutans* L., *Prunus cerasifera* Ehrh., *Salix caprea* L., *Populus tremula* L., *Populus alba* L., *Quercus robur* L. Coniferous species were not found. Species – *Carex acuta* L., *Carex aquatilis* Wahlenb., *Phragmites australis* L., *Scirpus lacustris* L. – were found in the reservoirs, despite their significant salinity.

The calculated Jacquard coefficient of floristic similarity (K_j=0.5) for the Tysmenytsya landfill showed a significant similarity of species on the surface of the landfill and in its impact zone. This means that the phytomelioration processes at the landfill proceed in accordance with the reforestation conditions of the region. The restorative function of phytomelioration is noticed. Significant overgrowth of the surface of the landfill makes it possible to distinguish three stages of succession (table 8) [15].

Table 8. Vegetation successions of the Tysmenytsya landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 10-20%	Projective cover 25-40%	Projective cover 55-85%
Chenopodium urbicum L., *Heracleum sosnowskyi* Manden., *Urtica dioica* L., *Artemisia vulgaris* L., *Taraxacum officinale* Wigg.	*Eutrigia repens* L.+*Urtica dioica* L.+*Salix caprea* L.+ *Populus tremula* L.	*Eutrigia repens* L.+ *Prunus cerasifera* Ehrh.+ *Populus tremula* L.+*Populus alba* L.+ *Quercus robur* L.

The overgrowth processes of the Tysmenytsya landfill around waste burning sites take place with *Heracleum sosnowskyi* Manden., *Taraxacum officinale* Wigg., *Arctium lappa* L., *Chenopodium urbicum* L. These are the pioneer species in the syngenetic stage of succession. The initial endoecogenetic succession is represented by only two ruderal species *Eutrigia repens* L. and *Urtica dioica* L. The shrubs *Salix caprea* L. and *Populus tremula* L. appear. The mature endoecogenetic succession has a high projective cover (85%) and is represented by autochthonous species - *Prunus cerasifera* Ehrh. , *Populus tremula* L., *Populus alba* L., *Quercus robur* L.

3.3 Natural phytomelioration of small landfills

The **Lavrykiv landfill** occupies a small area, and the waste that accumulates on it is of a local nature. The calculated Jaccard coefficient of floristic similarity (K_j=0.2) for the Lavrykiv landfill showed that representatives of zonal flora develop near the foothills, and ruderal flora – on the surface. Only 2 common species were noted for both sites, which indicates only the beginning of successional processes on the surface of the landfill. Three stages of succession are distinguished at the landfill and in its impact zone (table 9) [15].

Table 9. Vegetation successions of the Lavrykiv landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 5-10%	Projective cover 20-30%	Projective cover 45-55%
Arctium lappa L. *Tussilago farfara* L., *Taraxacum officinale* Wigg., *Calamagrostis epigeios* (L.) Roth., *Plantago major* L., *Carduus nutans* L.	*Calamagrostis epigeios* (L.) Roth.+ *Taraxacum officinale* Wigg.+ *Fragaria vesca*+*Corylus avellana* L.	*Calamagrostis epigeios* (L.) Roth.+ *Fragaria vesca*+*Corylus avellana* L.+*Salix alba* L.+*Acer negundo* L.

A syngenetic stage of succession takes place on the surface of the landfill with the participation of ruderocenosis. Ruderal species do not compete with each other and their placement in populations is random. The initial endoecogenetic succession is represented by the forest species *Fragaria vesca* and *Corylus avellana* L., which form the litter for the formation of a mature endoecogenetic succession. At the final stage of the succession (at the foot of the landfill), phytocenoses are formed with *Salix alba* L. and *Acer negundo* L.

The surface of the **Vereshchytsya landfill** is covered with ruderal vegetation – *Plantago lanceolata* L., *Taraxacum officinale* Wigg., *Calamagrostis epigeios* (L.) Roth., *Daucus carota* L., *Eutrigia repens* L. Plants arise spontaneously and do not group by location in populations. At the foot of the landfill, along with the listed species, there are representatives of synanthropic vegetation – *Plantago major* L., *Artemisia vulgaris* L., *Trifolium pratense* L., *Urtica dioica* L. Self-seeding of *Prunus cerasifera* Ehrh. and *Betula pendula* Roth. is also observed. At the foothills, there is an aggregation of vegetation and a group distribution of individuals in populations.

The calculated Jacquard coefficient of floristic similarity (K_j=0.45) for the Vereshchytsya landfill showed that similar species develop on the surface and at the foot of the landfill. Three stages of succession are distinguished at the Vereshchytsya landfill and in its impact zone (table 10) [15].

Table 10. Vegetation successions of the Vereshchytsya landfill.

Syngenetic succession	Initial endoecogenetic succession	Mature endoecogenetic succession
Projective cover 10-15%	Projective cover 25-35%	Projective cover 55-65%
Plantago lanceolata L., *Taraxacum officinale* Wigg., *Calamagrostis epigeios* (L.) Roth., *Daucus carota* L., *Eutrigia repens* L.	*Calamagrostis epigeios* (L.) Roth.+ *Eutrigia repens* L.+ *Prunus cerasifera* Ehrh.	*Calamagrostis epigeios* (L.) Roth.+ *Trifolium pratense* L.+ *Betula pendula* Roth.

3.4 Floristic similarity

In order to study the similarity of flora between the studied landfills we calculated Jacquard coefficients of floristic similarity, taking into account the species composition of a separate landfill. In the table 11 shows the initial data for calculating the coefficients of floristic similarity, namely: the total number of species at the landfill, the number of common species between landfills.

Table 11. Combined species of the landfills and their total number.

Common species, quantity	Lviv	Ternopil	Lutsk	Chervonohrad	Sokal	Rava - Ruska	Maheriv	Tysmenitsya	Lavrykiv	Vereshchytsya
Lviv		13	11	7	10	12	11	9	5	9
Ternopil			9	5	8	11	8	10	5	9
Lutsk				5	7	9	10	9	3	6
Chervonohrad					5	6	6	4	1	5
Sokal						8	10	9	4	7
Rava-Ruska							10	7	4	8
Maheriv								9	4	7
Tysmenitsya									3	7
Lavrykiv										3
Vereshchytsya										
Total	**30**	**20**	**19**	**8**	**14**	**17**	**17**	**15**	**10**	**11**

It was found that large landfills have the largest species composition: Lvivske – 30 species, Ternopilske – 20, Lutske – 19. Small landfills have the smallest species composition: Lavrykiv – 10 species, Vereshchytsya – 11 species.

Taking into account the above data and the calculation formula (1), the coefficients of floristic similarity of the landfills of the Western Forest Steppe were established (table 12).

Table 12. Coefficients of Jacquard floristic similarity of the Western Forest Steppe landfills.

K_j	Lviv	Ternopil	Lutsk	Chervonohrad	Sokal	Rava - Ruska	Maheriv	Tysmenitsya	Lavrykiv	Vereshchytsya
Lviv		0,35	0,29	0,22	0,29	0,34	0,30	0,25	0,14	0,28
Ternopil			0,30	0,21	0,30	0,42	0,27	0,40	0,20	0,40
Lutsk				0,22	0,27	0,33	0,38	0,36	0,11	0,25
Chervonohrad					0,29	0,31	0,31	0,21	0,05	0,35
Sokal						0,34	0,47	0,45	0,20	0,38
Rava-Ruska							0,41	0,28	0,17	0,40
Maheriv								0,39	0,17	0,33
Tysmenitsya									0,13	0,36
Lavrykiv										0,16
Vereshchytsya										

The highest coefficient of Jacquard floristic similarity is observed for the Sokal and Magheriv landfills (K_j=0.47). The lowest coefficient of floristic similarity was noted for the Chervonohrad and Lavrykiv landfills (K_j=0.05). Low coefficients of floristic similarity were also noted when comparing Chervonohrad and Lavrykiv with the rest of the landfills. The Chervonohrad landfill coefficients of floristic similarity with the rest of the landfills are within K_j=0.05÷0.35, Lavrykiv – K_j=0.05÷0.20. Such low indicators of the floristic similarity indicate that ruderocoenoses at these landfills are destroyed due to the dumping of solid household waste and the formation of the body of the landfills.

4. Conclusions

Having studied the natural phytomelioration of landfills in the Western Forest Steppe in this way, we discovered that ruderal vegetation, being natural phytomeliorants, develops on the plateau and the surface of the slopes of all landfills. The vegetation of these areas, in most cases, differs from the vegetation of the areas located at the foot of landfills, on dams of filtration reservoirs and in the landfills' impact zone. This is proved by the calculated coefficients of Jaccard's floristic similarity between the studied areas of each individual landfill. It was established that the highest coefficients of Jaccard's floristic similarity are characteristic to the investigated areas of landfills where there is no waste dumping, or it is only in certain areas (the second phase of dumping). Accordingly, at such landfills, the natural phytomelioration cover is not destroyed by garbage trucks and bulldozers, when leveling the plateau and forming slopes. These landfills include: Tysmenytsya (K_j=0.5), Vereshchytsya (K_j=0.45), Lviv (K_j=0.39), Rava-Ruska (K_j=0.37) landfills. At the same time, landfills with low coefficients of Jaccard's floristic similarity were found in the studied areas.

At these landfills, continuous waste dumping processes take place, their plateaus are leveled by construction equipment, grass is trampled and trees and shrubs are cut down. That is, there is a physical impact on vegetation at landfills. These landfills include: Chervonohrad (K_j=0.12), Lutsk (K_j=0.15), Lavrykiv (K_j=0.2). The rest of the landfills in the studied areas have the average volumes of Jaccard's floristic similarity coefficients. However, these coefficients could be higher if exclude the impact on natural phytomelioration processes of such negative factors as the release of filtration water, biogas, and substrate combustion products. Vegetation at these landfills is also affected by the radiation background. These landfills include: Sokal (K_j=0.31), Ternopil (K_j=0.26), and Maheriv (K_j=0.23) landfills. Jaccard's coefficient of floristic similarity between landfills was also calculated. The average value of the coefficient is quite high K_j=0.29 and shows that at landfills in the West Ukrainian Forest Steppe District, natural phytoremediation processes take place with the participation of synanthropic vegetation (ruderal coenoelement).

In terms of practical activities, we believe that to accelerate the formation of environmentally friendly ecosystems, the biological stage of landfill reclamation is carried out with the help of specially selected species of phytoremediation plants and phytomeliorants that can improve the forest and vegetation properties of the soil and form a fertile soil layer. Since 2016, LKP "Green Lviv" has been using such recommendations for landscaping and phytomelioration of the Lviv City Landfill. Within the framework of the project in 2021 "Ecologistics - Improving the Management of Solid Waste Landfills in Lviv Oblast" (Warsaw, Poland) the above-mentioned research and recommendations were also presented. Based on the results obtained, an important scientific and practical problem of identifying environmental hazards caused by landscape-transforming factors of landfills in a technologically loaded region was solved.

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