Vol. 11, 2022, 163-170

sciendo

DOI: 10.17512/bozpe.2022.11.19

Construction of optimized energy potential

Budownictwo o zoptymalizowanym potencjale energetycznym

ISSN 2299-8535 e-ISSN 2544-963X

The selection of plantings in the process of reclamation and revitalization of post-war damage to the natural environment in the Donbas area

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Abstract: People modify 56% of the Earth's land. The world trend is changing from rapacious to considered influence such as green construction/production. Nevertheless, the terroristic war of the Russian federation against Ukraine causes the chaotic destruction and snowballing emissions from shell bursts and fires. Reclamation of land should attempt to repair the hugely dangerous influence of this, especially in the temporarily annexed lands of Ukraine. Donbas was one of the most stressed regions due to active mining and other industries, and contained more than 38% of Ukrainian damaged lands. The war deepens the situation. The most natural reconstructive measure is greening. The authors analysed the requirements for greening to gain the maximum benefits. Enduring and effective plant assortments were proposed for the region. For sanitizing the environment, experiments were performed with phytoncide activity using a photographic paper method. It was found and recommend that new phytoncide plants – Japanese quince (*Chaenoméles japónica*) and barberry (*Bérberis*) – were most effective.

Keywords: Donbas, post-war damage, reclamation, revitalization, greening, phytoncide, landscape

Please, quote this article as follows:

Tkachenko T., Mileikovskyi V., Ujma A., Tkachenko O., The selection of plantings in the process of reclamation and revitalization of post-war damage to the natural environment in the Donbas area, Construction of Optimized Energy Potential (CoOEP), Vol. 11, 2022, 163-170, DOI: 10.17512/bozpe.2022.11.19

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Introduction

The destruction of ecosystems as a result of the war with Russia has been called "ecoterrorism" (Bolotina, 2022). The anti-terrorist operation in eastern Ukraine covered approximately 40,000 square km, or almost 7% of the country's territory. Among the main problems that arose here, as a result of military operations, included pollution of the atmosphere, soil and water, and significant changes in ecosystems. A fifth of the forests of southeastern Ukraine have already been destroyed, and it is not known when and at what scale they will be restored (Norenko, 2015). This negatively impacts not only the climate of the region, but also the population's health. The main obstacles obstructing the work of the State Forest Resources Agency in the Donbass is hostilities. Specialists are not able to effectively deal with the consequences of fires due to dangerous working conditions – in many forest plantations, even in the territories liberated from the separatists, there are still stretches of dangerous land and there is a risk of encountering mines. But experts agree that the destruction of the ecology in the east of the country began long before the start of hostilities (Polyanska, 2021).

Today, the modern landscapes of large cities in the Southeast are completely artificial. Cultivated vegetation occupies a significant area. But most of the cultural landscapes are in a neglected state. Weeds and ruderal vegetation have become widespread. The massive spread of ruderal vegetation is the cause of the appearance and development of allergic reactions in the population. Early one-year *Ambrosia artemisifolia*, two-year *Chenopodium album*, *Polygonum aviculare* and perennial *Artemisia austriaca* are particularly dangerous (Sokolov & Trofymenko, 2015) (Figs. 1 and 2).

Therefore, an important measure for the restoration of landscapes in the southeast of Ukraine is the selection of an assortment of ornamental plants that are resistant to climatic features and industrial and anthropogenic load.

The following are the main functions of green spaces:
1) sanitary and hygiene;
2) recreation;
3) architecture and planning;
4) decoration and artistry.

Sanitary and hygienic functions include absorption of carbon dioxide, release of oxygen, noise insulation, ionization, and the absorption of dust and phytoncide. That is, today's plants are a natural biological filter, with the help of which it is possible to significantly improve the quality of air in cities and settlements, benefiting people's health. Mandatory requirements for landscaping systems are uniformity and equability. The main elements of a city's greening system includes parks, gardens, green areas of residential and industrial areas, embankments, boulevards, squares, and protective zones. Green spaces in the city improve the microclimate of the city's territory, creates good conditions for outdoor recreation, and protects the soil, walls of buildings and sidewalks from overheating. This can be achieved by preserving natural green areas in residential areas (Abu Deeb et al., 2021).

Fig. 1. Neglected landscape with ruder vegetation near the Donbas Arena stadium, Donetsk (Premier League, 2020)

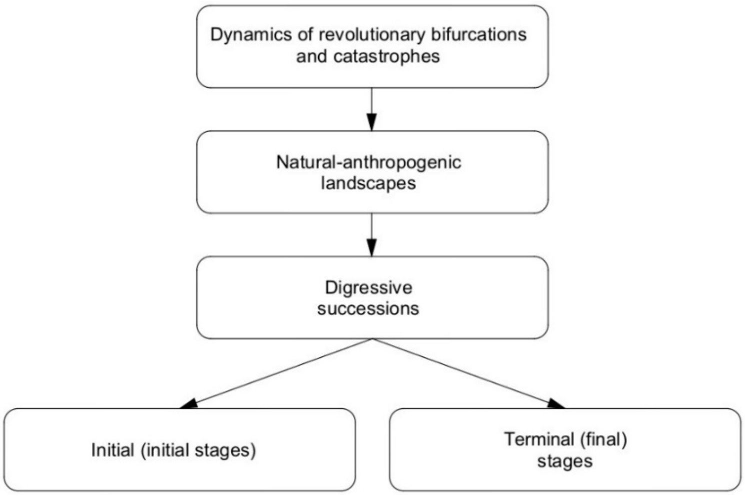

Fig. 2. Schematic of the appearance of digression successions in the natural-anthropogenic landscape (*own research*)

1. Object and research methods

The experiment included 10 types of plants (Table 1), which were planted on a degraded industrial territory with an area of 7000 m^2. The territory was completely cleared of construction and household debris. The relief of the territory was completely leveled. Several tons of soil, sand and peat were brought to the landscaped area. The entire area was filled with new soil up to a layer of 40 cm. Soil analysis on such a large area is diverse, so covering the area with new soil is the most effective way to solve this problem.

Table 1. Characteristics of plant material (*own research*)

View	Life expectancy [year]		Height [m]		Crown diameter [m]	
	average	maximal	average	maximal	average	maximal
Trees						
Acer platanoides L.	100	400	20	30	10	25
Picea pungens Engelm.	100	200	20	25	4	16
Populus alba L.	60	150	2	4	20	35
Quercus borealis F.Michx.	300	1000	25	40	15	30
Thuja occidentalis L.	100	200	12	20	6	8
Bushes						
Bérberis vulgáris L.	30	50	1.0	2	1.0	1.5
Chaenoméles japonica (Thunb.) hort. ex K.Koch	80	100	1	1.5	1	1.5
Juníperus sabína var. cupressifolia Aiton	300	800	5	9	3	4
Pinus mugo Turra.	800	1500	0.5	4.5	20	35
Sambucus racemosa L.	40	60	5	7	1.5	3

Donetsk is characterized by winds, open reliefs and droughts, so for some plants this can become an obstacle to normal existence. Such plants that are not adapted to the climatic conditions are mainly used to give the landscaped territory an aesthetic, and most importantly, exclusive and exotic look. Observation of such plants is carried out constantly, they need special additional care. Therefore, mainly to obtain a good result, plants that are resistant and adapted to the climatic conditions are used in landscaping works. The dustiness and pollution of the Donetsk region requires a careful selection of plants resistant to such conditions. It often happens that plants that are well adapted to industrial and climatic conditions eventually lose the necessary vitality, are affected by pests and lose their decorative qualities. This leads to the decline and death of recreational areas and other urban plantings. Therefore, the range of plants to create a sustainable anthropogenic landscape must be constantly replenished with new species. Selection of plants should be carried out according to the following criteria: resistance to anthropogenic pollution, resistance to high air permeability of the territory, high phytoncide of plants, and good gas absorption capacity.

1.1. Study of adaptive properties of plants

The method of determining frost resistance of plants. Damage to the tissues of axial organs – bark, cambium, wood and heartwood – was performed visually according to the scale on (Table 2). It should be keep in mind that dead, mechanical elements – wood, mechanical bundles in the bark – can be dyed only due to seepage with brown pigment from nearby tissue damage, so the area occupied by them on the section is not taken into account. Damage to the cambium is assessed by the length of the brown areas during the cambial ring (Tumanov, 1967). More fractional accounting of weak injuries (up to 1 point) is explained by the fact that the possibility of regeneration of most tissues is limited to 2-3 points.

Table 2. Scale of frost resistance (Tumanov, 1967)

The degree of damage to the above-ground part of plants [%]	Points
–	0
0-10	0.5
10-20	1
20-40	2
40-60	3
60-80	4
80-100	5

The method of determining phytotoxicity of plants. The method of the ability of phytoncides to be detectedt on the emulsion of photo paper was used. Experiments were conducted at a temperature of 18-20°C. Plant material, which served as a source of volatile fractions of phytoncides, is carefully ground on a grater, weighed in the amount of 20 grams and then placed in an even layer on the bottom of glass vessels with a volume of 200 cm^3. The vessels are covered with thick black paper, in the center of which a pattern is cut out, and the paper is covered with photographic paper with an emulsion layer faced down. In order to avoid the loss of volatile fractions of phytoncides, the paper is tightly pressed with a small load to the vessels, which are then kept for 24 hours in a light-proof chamber. After this time, the effect of phytoncides on the photo paper appears in the form of patterns cut on the paper. In order to determine how long phytoncides can be released, the experiment continues. At the end of the day, the photo paper is removed, developed, and the pulp is covered again with a new sheet. After a day, the paper is removed again and developed. If a cut pattern remains on the photo paper after development, then the experiment continues in the same order. Thus, it is possible to determine the duration of release of phytoncides (further on, DRP).

1.2. Phenological observations

To control establishment, vegetation, flowering, fruiting of plants, damage by pests, phenological (visual) observations were made in the experimental area. Specialists came twice a week and noted the general condition of seedlings of all the types of plants.

Phenological observations of the plants were conducted at different stages of development. The development of plants occurs according to the following scheme: 1. Growth stage: swelling of the buds; the beginning of the growth; active growth; moderate growth; slowing down of growth. 2. Stage of appearance of buds: tying the bud; swelling of the bud; colored bud stage; bud blooming. 3. Flowering stage: the beginning of flowering (5%); middle flowering (50%); mass flowering (90-100%); fading of flowering (< 70%). 4. Binding of fruits: appearance of single ovaries; mass appearance of ovaries; colorization of ovaries. 5. Fruiting: green colorless fruits; ripening and colorization of fruits; abundant fertility.

2. Results and discussion

Prior to wintering, all conifers and some deciduous plants were covered with agrofibre because it is known that conifers do not tolerate frost well in conditions of survival. Also, some woody plant species were covered to prevent the shoots from dying. This number includes *Berberia*, *Chaenoméles japónica*, *Sambucus racemosa*. Other plants tolerate frost well.

In the spring, the degree of damage was determined according to the scale of frost resistance. Coniferous plants survived the winter well, their frost resistance can be estimated at 0.5 points, which corresponds to 0-10% shoot dieback. Deciduous trees are also practically unaffected by frost, frost resistance is estimated at 1 point. Under normal conditions, deciduous trees and shrubs tolerate the cold well, and the damage to the plants is only explained by the fact that they were planted in late autumn and did not have time to take root well enough.

Berberia suffered the worst from frosts. Its degree of damage was 60-80%, which corresponds to 4 points of frost resistance. But the poor endurance of frost is compensated by the good regenerative ability of the shoots. Already in the spring, *Berberia* began to actively recover, and after a month the bushes recovered 100%.

From the literature it is known that almost all conifers have high phytocidal properties, and phytocidal properties are also expressed in the leaves of trees and shrubs (Tkachenko et al., 2019; 2020). In order to verify the reliability of this information and possibly discover new plants with phytoncide activity, some types of coniferous and deciduous plants were collected. In the amount of 20 grams, the crushed plant leaves were placed in a vessel with a volume of 200 ml in an even layer. Each vessel was numbered: 1 – *Chaenoméles japonica*, 2 – *Acer platanoides*, 3 – *Picea pungens*, 4 – *Bérberis vulgáris*, 5 – *Quercus borealis*, 6 – *Sambucus racemosa*, 7 – *Juníperus sabína var. cupressifolia*, 8 – *Thuja occidentalis*, 9 – *Pinus mugo*, 10 – *Populus alba*. The vessels were covered with dense black paper, in the center of which a pattern was cut out, and the paper was covered with photographic paper with the emulsion layer face down. In order to avoid the loss of volatile fractions of phytoncides, the paper was tightly pressed with a small load to the vessels, which were then kept for 24 hours in a light-proof chamber. After this time, the effect of phytoncides on the photo paper appeared in the shape of the patterns cut into the paper. After the first 24 hours, the pattern on the paper was observed on each vessel. The next 24 hours revealed that the phytoncides in vessel 1 had stopped being released. This means that phytoncides in *Chaenoméles japonica* work continuously for 24 hours. It should be noted that as a result of the experiment, *Chaenoméles japonica* was noted as a new phytoncide plant. In vessels 4, 5, 6 and 10 phytoncides were released within 48 hours. *Bérberis vulgáris* (4 vessel) is not mentioned in the known literary sources as a source of phytoncides, but as a result of the experiment, this plant was found to be capable of releasing phytoncides. In vessels 2 and 8 – for 72 hours. In vessel 7, release of phytoncides was observed for 96 hours. In vessels 3 and 9 – for 120 hours. The results of the experiment are summarized in a diagram (Fig. 3).

The results show that conifers have the greatest phytoncide activity (hereinafter FA) (DRP – 96-120 hours). New phytoncide properties were also discovered in *Bérberis vulgáris* and *Chaenoméles japonica*. The contribution of these plants to the optimization of the environment is great. Despite the fact that the DRP of these plants is much less than that of conifers, they are present en masse in plantings (hedges), and therefore, the phytocidal level increases significantly due to the amount.

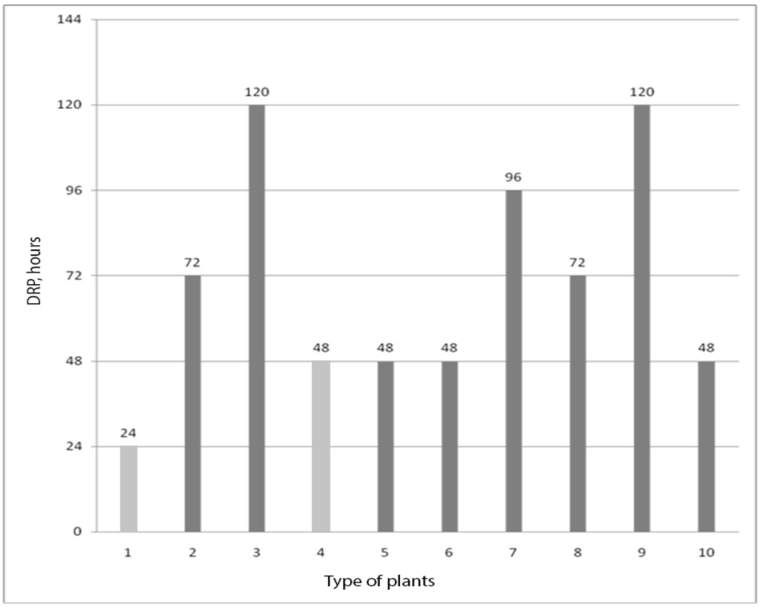

Fig. 3. The results of an experiment to determine the duration of the release of phytoncides by various types of plants: 1 – *Chaenoméles japonica*; 2 – *Acer platanoides*; 3 – *Picea pungens*; 4 – *Bérberis vulgáris* L.; 5 – *Quercus borealis*; 6 – *Sambucus racemosa*; 7 – *Juníperus sabína var. cupressifolia*; 8 – *Thuja occidentalis*; 9 – *Pinus mugo*; 10 – *Populus alba* (*own research*)

Conclusions

On the basis of the conducted research, the following conclusions can be made: The plants have a good frost resistance, adapt well to man-made pollution of the industrial region, have high phytoncide activity, and decorative qualities are not lost during the growth. It should also be noted that as a result of the experiment on the determination of FA, new phytoncide plants were discovered – *Barberry* and *Japanese quince*. *Barberry* is used in landscaping in larger quantities, so knowledge of their phytotoxicity is necessary.

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