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Use of Plant Species as Pioneers of Colonization in Degraded or Polluted Lands in Romania

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Abstract: The use of certain plant species as pioneers in the colonization of degraded or polluted lands in Romania has great potential. These resilient species play a crucial role in restoring ecological balance and promoting sustainable development. *Salix alba* has proven effective in stabilizing the soil, preventing the erosion of the soil and the banks of flowing waters and improving water quality. Its extensive root system helps absorb excess nutrients and contaminants from the soil, thus reducing pollution levels. Another valuable pioneer plant is *Robinia pseudoacacia*, which has a high tolerance to harsh environmental conditions and can thrive in polluted areas. Its nitrogen-fixing properties contribute to enriching the soil, making it suitable for the growth of other plant species, it has economic value as a melliferous species and provides habitat for various invertebrate or vertebrate species, thus supporting biodiversity. In the case of heavily degraded areas, it can be advantageous to use pioneer herbaceous plants such as *Festuca arundinacea*, *Agropyron repens* or leguminous plants. These herbaceous species have deep root systems that help stabilize the soil, prevent erosion, and increase soil fertility. Moreover, they can tolerate unfavorable soil conditions, i.e., polluted, compacted soil, soil with little humus, and harsher, drier microclimates. The concept of using pioneer plant species for land rehabilitation and restoration can be a cheaper method for ecological reconstruction. By selecting and implementing the use of these plant species, we can gradually recover degraded lands, restore biodiversity, and create sustainable ecosystems. However, the success of such initiatives depends on long-term interdisciplinary planning, monitoring, and management to ensure the desired results, sometimes taking decades to reach stable, self-sustaining ecosystems. Through their resilience and ecological benefits, these plants contribute to the revitalization of ecosystems and to the promotion of

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environmental sustainability, to the economic recovery of lands that would otherwise be useless and would continue to be a source of pollution.

Kewords: pioneer plants; polluted soils; degraded lands; ecological reconstruction

1. Introduction

Romania has at least 500,000 hectares of degraded land (www.wall-street.ro). From the statistical data of the National Agency for Environmental Protection (ANPM), it appears that in Romania in 2022 there were approximately 1489 sites potentially contaminated by the oil industry, 38 sites contaminated because of activities in the metallurgical industry, 80 sites affected by the chemical industry (other than petrochemical) and other 729 sites contaminated by other industrial activities such as those in the energy, textile, cement, glass, animal husbandry, etc. industries (www.anpm.ro), to which are also added the surfaces polluted by the mining industry, which has been in decline for some time. Contaminated lands must be ecologically rehabilitated either by economic agents (based on the "polluter pays" principle) or by the Romanian state, if the owners no longer exist. It is difficult to estimate how much it costs to rehabilitate a hectare of land and the ANPM reports do not discuss this aspect. Anyway, the calculations are very difficult to make, the situations being very heterogeneous, varying the pollutant, the type of soil, the geographical location, the severity of degradation/contamination, etc. However, it is clear to everyone that these costs are not small at all and that any more economical solution is advantageous. It allows larger areas of land to be rehabilitated with the same money.

2. Cheaper Solutions by Using Pioneer Plant Species in Colonization

Unfortunately, in Romania, funds for the environment are limited. On the approximately 500,000 degraded or polluted hectares, in many cases, the situation is serious; the bank of seeds and organic matter in the soil was reduced or even completely destroyed in the case of heavily polluted or degraded lands, which lost their amount of humus. Many other degraded lands no longer have the capacity to retain water in the soil (van den Putten *et al*., 2013). In such cases, the group of autochthonous species can no longer recolonize the degraded areas and other plant species, much less sensitive and with a high capacity for regeneration and survival, are needed to establish and regenerate a vegetal carpet. Obviously, structurally, this one will not have the same composition as the original one, from the point of view of the new taxa installed. In the long run, a transition scheme toward the original vegetation can be put in place, but this is only possible if the abiotic factors that characterize the respective soils can again be compatible with the requirements that the old plant taxa had for the environment. However homogeneous it may seem, to an uninitiated observer, degraded lands are not uniform; the habitats that would be created would have a microdiversity, soil characteristics, topography, exposure to light and wind, and vary even over small distances; species suitable for planting must be selected for these microenvironments (Asher, 2023). Although a particular species may grow well in a particular climate that does not tell you if it will grow in a particular location—the soil may be too wet, contain too much clay, or receive too little sunlight. But the most important thing that must be considered is the fact that the final goal is to create a new self-sustainable ecosystem in such geographical areas with polluted or degraded lands. Self-sustainability does not appear immediately, but after a certain time. To establish sutosustainability, the ecologically rehabilitated ecosystem must reach maturity. This presupposes extremely detailed studies and the realization of various mechanical works, chemical purification of the soil, and drains to collect any polluted water, etc. The implementation of the vegetal carpet with taxa ecologically compatible with the building conditions in the field is a decisive stage in this action, and the success of the entire rehabilitation action depends on it; moreover, it is then important that this vegetation be maintained (Malschi, 2014). This stage in the ecological rehabilitation is cheaper than the previous stage, which involves mechanical works, and the expenses are about 50 times lower, but the biological recultivation is decisive, due to the fact that a failure in this stage would lead to the failure of the whole process of rehabilitation (Malschi, 2014).

The duration of such rehabilitation is at least a few years because the gradual establishment of a soil with at least minimal fertility takes a long time, then the planting and development of vegetation, even grassy, requires several years again. The formation of a soil structure compatible with the self-sustainability of the future ecosystem is therefore a long process and for this reason it is important to minimize the costs. This can be done primarily by avoiding the failure of the vegetation installation. This requires a great rigor between the minimal capacities of the degraded soil to maintain plant life and very resistant plant taxa adapted as best as possible to the edaphic conditions in the area of interest and also to the climatic conditions. In the case of herbaceous plants, not only wild species can be used but also certain unpretentious culture species, such as grasses or legumes, which have the property of contributing to a faster fixation of nitrogen in the soil in formation, in a more symbiosis chosen with bacteria, such as those of the genus Rhizobium (Petre, 2013). However, one method to detect which are the most adapted and resistant plant species to the particular conditions in the field is to observe and identify the pioneer species that appear first, without human intervention. They can then be helped to multiply and thrive at extremely low cost. The interest is to create an ecosystem with the greatest resilience on the respective land in the shortest possible time. The fact that they already appear spontaneously means that they are very well adapted, compared to any other species that humans could introduce and which would be more pretentious and fragile. The costs would be higher in this last option, and the probability of success of ecological rehabilitation is lower. What is essential for the minimization of long-term costs and for the success of ecological rehabilitation operations is a very good understanding of the feedbacks in the plant-soil relationship, of the mechanisms that work in this relationship and that improve our ability to accurately predict studies the consequences of these interactions for plant community composition and productivity under a variety of conditions (Putten, 2013).

Among the grass, shrub and tree species, unpretentious and which often appear on all categories of degraded land, we note: *Robinia pseudacacia* L., *Salix alba* L., *Hippophaë rhamnoides* L., *Elaeagnus argentea* Pursh, *Fraxinus exelsior* L., *Ligustrum vulgare* L., *Cotinus coggygria* Scop., *Verbascum nigrum* L., *Rosa canina* L., *Lotus corniculatus* L., *Grindelia squarrosa* (Pursh.), *Echium vulgare* L., *Ailanthus altissima* (Mill.) Swingle, etc.

Among the perennial leguminous plant species that would be compatible with degraded lands, Oros (2002) lists: *Amorpha fruticosa* L., *Centrosema pubescens* Benth., *Phaseolus vulgaris* L., *Desmodium uncinatum* (Jacq.) DC., *Lathyrus sylvestris* L., *Lespedeza bicolor* Turcz., *Lespedeza cuneate* (Dum.Cours.) G.Don, *Lespedeza japonica* L.H.Bailey, *Lotus corniculatus* L., *Lupinus perrenis* L., *Medicago sativa* L., *Melilotus albus* Medik., *Melilotus officinalis* (L.) Pall., *Stylosanthes humilis* Kunth, *Trifolium pretense* L., *Trifolium hybridum* L., *Trifolium repens* L., *Ulex europeanus* L.. It is obvious that this list is not exhaustive.

The use of perennial plants is cheaper because it does not require annual replanting, which has certain costs.

Another important criterion, apart from the perenniality of the species, is their selection according to their germination capacity, i.e., the ability of a plant species to form new shoots after the destruction of most of its above-ground biomass, using reserves from underground parts (Cornelissen et et al., 2003); a high germination capacity would allow the survival of the vegetation, if its outer parts were partially destroyed. This would again lead to lower costs regarding the installation of the vegetal carpet.

In fact, the biodiversity in terms of pioneer flora in the colonization of degraded areas is much higher. For example, Certan (2020) mentions that in a former limestone quarry, the taxonomic spectrum is much wider, with 125 species from 108 genera identified, grouped into 42 families of vascular plants. This shows the great adaptability of many plant species, their ability to find an ecological niche even in degraded areas. The methods and technologies used in the colonization of polluted or degraded land are diverse and can be adapted according to the specific characteristics of the land and the proposed objectives. We list below the most important methods:

Direct planting: This method involves direct planting of plants in polluted or degraded land. The plants can be propagated by seeds (this is the cheapest method) or they can be purchased already grown to speed up the colonization process (this is a much more expensive option; the planted material is much more expensive, as well as the labor). This method is used especially in lands where the soil is not very polluted and still has some characteristics suitable for plant development, a minimum of humus.

Phytoremediation; this method involves the use of plants to protect polluted or degraded land from harmful environmental factors. The plant species involved in this process must meet a series of characteristics such as rapid growth, branched root system, high biomass production, and the ability to tolerate and accumulate large amounts of heavy metals (Minuț et al., 2021). Plants can be grown in affected areas, creating a protective layer that reduces soil exposure to pollution or erosion. This method can be used especially in areas with chemical pollution (as there are many in Romania) or in areas affected by erosion.

Shade planting: This method involves planting tall trees or plants that provide shade to degraded land. Shading can help reduce soil temperature and maintain an adequate level of moisture with less evaporation, which can support the establishment and growth of other plant species and other edafon soil organisms that will facilitate the formation of humus and accelerate the development of the vegetal carpet.

Ecological farming (ecological agriculture) promotes biodiversity and does not contaminate the environment with chemical inputs or genetically modified plant species and varieties (www.greenpeace.org; www.sciencedirect.com). This method involves the use of plants grown for agricultural purposes in the process of colonization and ecological reconstruction. Cultivated plants can be used to restore soil fertility, for food production or for use in other ecological industries, or to generate raw materials such as for example the pharmaceutical industry, the food industry, the ecological cosmetics industry.

3. Conclusions

The use of different species of plants (but especially perennial ones) in the colonization of polluted or degraded lands brings many benefits and the process of ecological reconstruction is of great importance, in terms of efficiency, with relatively low costs, compared to the result obtained.

Plants can be used for phytoremediation of polluted land, i.e., to reduce or remove toxic substances from soil or water. Certain plants can accumulate and metabolize pollutants, turning them into less harmful substances or even essential nutrients for the life of plants and other organisms. The problem that needs to be solved is to find solutions to treat and process the plant material that accumulates the pollutants. Plants have the ability to drive soil recovery, improve soil quality by fixing carbon and releasing organic matter into the soil. Through their roots and interaction with soil microorganisms, plants can help restore soil structure and fertility, providing a favorable environment for the development of other organisms. Also, another beneficial effect of installing the vegetal carpet is the reduction of mechanical erosion and, subsequently, even stopping the soil erosion process.

The use of indigenous plants in the process of colonization and ecological reconstruction, species with a high resistance to external harmful agents and adverse conditions, can contribute to the conservation of biodiversity. Indigenous plants are adapted to the specific conditions of the respective lands and can be essential for the restoration of native ecosystems and the complex interactions between plants and animals. What is most important is the fact that the involvement of these types of colonizing species in the process of ecological rehabilitation of land leads to lower costs and greater efficiency and increased resilience of ecosystems.

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