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LOCAL FLORA REPRESENTATIVES OF AREAS HIGHLY POLLUTED WITH HEAVY METALS AS A SUITABLE PLANT MATERIAL FOR NATURALISTIC GARDENS OF THAT REGION

OGRODY NATURALISTYCZNE Z WYKORZYSTANIEM PRZEDSTAWICIELI LOKALNEJ FLORY JAKO TWORZYWA ROŚLINNEGO W ZAGOSPODAROWANIU PODŁOŻY ZANIECZYSZCZONYCH METALAMI CIĘŻKIMI

Key words: plant assortment, calamine flora, industrial land, green areas.
Słowa kluczowe: dobór roślin, flora galmanowa, teren przemysłowy, tereny zieleni.

Celem pracy było opracowanie podstaw planowanego założenia naturalistycznego na podstawie charakterystyki podłoża i w nawiązaniu do podłoża sąsiednich obszarów, porośniętych lokalną roślinnością. Przystosowanie roślin do zanieczyszczeń metalicznych wynikało z podniesionego tła geochemicznego oraz z długowiecznej eksploatacji rud cynkowo-ołowiowych na tym terenie. Gleby badanych stanowisk miały uziarnienie piasków gliniastych lub glin piaszczystych i były średnio zasobne w węgiel organiczny. Stwierdzono przy tym dość szeroki zakres wartości stosunków C:N.
Zawartości przyswajalnych form fosforu i potasu mieściły się w zakresie wartości niskich i średnich, z przewagą wartości niskich. Oznaczona zawartość cynku, ołowiu, kadmu i arsenu była w warstwie 0–20 cm większa niż w warstwie 20–40 cm, co wskazuje na

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wpływ emisji pyłów z zakładów metalurgicznych sąsiadujących z terenem poboru próbek glebowych.
Ocenie walorów dekoracyjnych poddano gatunki roślin zielnych tworzących zbiorowiska na terenach otaczających park stanowiący obiekt prac projektowych. Wybrano gatunki przydatne do tworzenia zieleni urządzonej i zaproponowano tworzenie wyspecjalizowanych szkółek ogrodniczych zajmujących się mnożeniem gatunków lokalnej flory pod odpowiednim nadzorem.

1. INTRODUCTION

Amongst numerous elements of the nature flora is really of great importance, and simultaneously, in the present times of still growing ecological awareness of modern European societies, the strong connection of the garden with its natural environment is gaining more and more significance. During the course of garden art development, the real boom period of so-called landscape gardens, in which plantings were truly inspired with surrounding landscape, dates back to the 18th and 19th centuries. In implemented concepts of those days both native species, and that of the alien origin have often been exploited, provided they were well acclimatized to locally existing conditions [Harwood 2000; Major 2007; Kerrigan 2009]. Nowadays exists plain tendency of making use in such projects exclusively of local species, belonging to the given area flora. In areas polluted with heavy metals designers of landscape, that is naturalistic gardens [Heatherington and Sargeant 2005], can additionally enable fulfilling of remediation function by the properly planned plant material because gradual removing of metallic pollutants from the substrate, or immobilizing in the soil profile, takes place in the course of certain plant growth [Porębska and Ostrowska 1999; Lutts et al. 2004; Saier and Trevors 2010]. Additionally, greenery counteract air erosion, and in this manner contribute to air purifying. In such a case at design works should be used mainly tolerant species, and a number of accessible species straight requiring increased heavy metal content in the soil [Heumann 2002; Krzaklewski and Pietrzykowski 2002; Olko et al. 2008; Kashem et al. 2010].

In areas characterized by elevated content of heavy metals in the substratum, depending on its chemical composition, often the communities of calamine or serpentine flora are formed. In Poland, on the border of the Silesian and the Cracow – Częstochowa Upland, among communities characteristic for this region the stand of calamine flora is distinguished [Jędrzejczyk-Korycińska 2006; Grodzińska et al. 2010, Kapusta et al. 2010]. In the area of upraised level of zinc and lead in the soil to the combination of species belong *Armeria maritima* ssp. *halleri, Biscutella laevigata*, *Cardaminopsis arenosa* subsp. *arenosa*. In the community of this type populations of *Dianthus cartusianorum* and *Silene vulgaris* are also numerously represented. On sunny and warm stands grow several other taxa, which prefer dry, poor or moderate poor habitats, with alkaline or neutral reaction. Communities appearing there on reclaimed surfaces have also interesting, and diversified floristic composition. The number of similar European calamine flora stands located on areas rich in zinc and lead are found in England, Germany, Belgium and in The Netherlands. In some of them occur *Viola calaminaria*, *Thlaspi caerulescens, Minuartia verna,* and some other interesting species. At present the part of objects is being protected [Ernst 1974; Jędrzejczyk et al. 2002].

The objective of the paper was to draw up basis for the intended project of naturalistic garden planned to be created in locally existing park. Specific aims for this undertaking constituted detailed characteristics of considered park bedrock in reference to the bedrock of adjacent areas covered with local flora. Numerous herbaceous plant species well adapted to the climatic conditions prevailing there, and at the same time demonstrating decorative advantages, were selected to examination. Adaptation of plant material to metallic pollutants resulted from the elevated geochemical background of ore-bearing areas, and from activity of the man resulting from long-lived exploitation of ores of zinc and lead in this region. The usefulness of individual species to the application in some kind of green areas were carefully considered.

2. MATERIAL AND METHODS

2.1. Area description

The studied area located on the border of the Silesia and Krakow-Czestochowa Uplands, in the southern-east part of Poland, covers about 5 hectares (N–50º17’ E–19º29’). Medium annual temperature is equal to 7.1 ºC, and an annual sum of rainfalls amounts to 832 mm. The highest sums of rain occur during summer months (May – August) and the lowest have been noted at the beginning of autumn (September – October) and in winter (February). Western winds predominate (SW – NW), with a medium speed 3.0 $m \cdot s^{-1}$ [Kuzio et al. 2005]. The area is in a range of the influence of zinc and lead ores mining, and metallurgical plants associated with their processing. Mining metallurgical plants in years 50.–70. of the last century transmitted annually to the atmosphere over 2 Gt of dusts, of which zinc, lead and cadmium constituted nearly half of the mass. Modernization works conducted in later years, and closing the lead plant, importantly reduced emission into the atmosphere of metallic dusts, nevertheless the environment pollution in this area is still strong [Liszka i Świc 2004]. Four plots were selected, two on area of former mining jobs (plot H and plot W), and two other on area in which mining works were not conducted (plot M and plot P). A bedrock of the plot H, located on above a 100-year old mine waste dump, and of the plot W, situated on the area of small hills built at digging pit shaft from the manual period of extracting ores in the 13th century (so-called „warpie”) is Triassic dolomitic calcareous waste rock with wastes of ores of metals, covered with Pleistocene sand from which *Rendzic Leptosols* [WRB 2007] were derived. Next research sites constitute areas: of currently not utilized meadow (plot M) and of park (plot P), of which soil belonging to *Haplic Cambisols* [IVS Working Group… 2007] were formed of Pleistocene sand. From each research area soil samples were taken from five places in order to receive averaged sample representative for the given site. In park two research positions were allocated (P1 and P2), differing in the solar exposure and the humidity, from each of them 5 individual samples were taken. Samples were taken from two depths 0 – 20 cm and 20 – 40 cm.

2.2. Analyses of selected physical-chemical properties of soils of areas of examinations

In air dried disturbed, sifted through a sieve with 2 mm mesh soil samples following analyses were performed: soil texture by densimetric-sieve method, pH in H_2O and 0.01 mol·dm^{-3} $CaCl_2$ was measured potentiometrically, the content of available forms of potassium, and phosphorous by Egner-Riehm's method and magnesium by Schachtschabel's metod [Lityński et al. 1976], electrical conductivity (EC) by conductometric analysis and the level of total nitrogen, total and inorganic carbon with the use of TOC-TN 1200 Thermo Euroglas apparatus. The level of organic carbon was calculated as a difference between total and inorganic carbon. The analyses of the total content of Zn, Pb, Cd, Fe and As were performed, after digestion of samples in the mixture of nitric and perchloric concentrated acids in ratio 2:1 [Ostrowska et al. 1991] and soluble forms of these metals according to Houba et al. [1994] recommendations using for their extraction a solution of 0,01 mol·dm^{-3} $CaCl_2$ acidified to pH=1,0. The analyses of the elements were performed in solutions with the use of an atomic emission spectrophotometer with inductively coupled argon plasma ICP-AES JY 238 ULTRACE using ICP multi-element standard solution IV (Merck). The accuracy of the analytical methods was verified with the reference to the certified reference material GSS-8 (GBW 07408 – State Bureau of Metrology, Beijing, China). All determinations were carried in 3 replicates and their results adjusted to air dried soil mass.

Statistical analysis of results was carried out with the method of ANOVA variation analysis. To estimate significance of differences between mean values homogenous groups were appointed using the test *a posteriori* of Fisher.

2.3. Estimation of decorative values of plant species and their usefulness to naturalistic gardens

Material for examinations constituted specimens from plant populations belonging to diversified plant communities which represented calamine flora (plot H), meadow community vegetated with unsown wild-plant species (plot M), and partly afforested area overgrown with herbaceous plant species preferring shady and rather moist stands – „warpie" (plot W). The selection of plant species was performed based on floristic and on phenological observations. A special attention was paid to the duration of the vegetative development, the beginning, the height, and the end of blooming. Biometrical measurements were conducted in the course of blooming. Ornamental value of species from plant communities in zone surrounding the park constituting the future object of design works were evaluated. Nomenclature of vascular plants was applied according to recommendations considered in the Critical List of Vascular Plants of Poland [Mirek et al. 2002].

3. RESULTS AND DISCUSSION

Dolomitic calcareous bedrock and fragments of rock appearing in the profile of the soils were a cause of the neutral or alkaline reaction in both examined soil layers. Soil formed in areas, on which mining activity was conducted (H and W plots) had strong loamy sands or sandy loams textures with the content of the skeleton not exceeding 10% in both examined layers. Soils of the meadow (M) and of park (P1 and P2) on account of the lack of dolomitic calcareous waste rock fragments in the profile were characterised by a little bit lighter texture (poor loamy sand) and a lack of the skeleton in both examined layers (Tab. 1). The electrical conductivity ranged within the limits of 0.03 – 0.07 $mS \cdot cm^{-1}$ what testified the lack of salinity of studied soils. Soils of examined plots were medium rich in organic carbon. The content of discussed element was a little bit higher in soils of the old dump (H) and „warpie" (W), that is in soils with heavier texture, appropriately 25.7 and 29.4 $g \cdot kg^{-1}$ in the layer of 0 – 20 cm, than in the soils of the meadow (M) and of both park stands (P1 and P2) (Tab. 1). Relatively small contents of nitrogen were a distinctive feature of soils of discussed sites, when the largest content was indicated in surface horizon of the meadow soil which amounted to 1.72 $g \cdot kg^{-1}$. There were not stated statistically significant differences in the content of this element in surface horizons of soils of the old dump (plot H) and „warpie" (plot W), (appropriately 1.61 and 1.65 $g \cdot kg^{-1}$) and of soils of both sites of the park. Quite wide values of C:N ratios indicate some hampering of the organic matter humification processes.

Contents of available forms of phosphorus and potassium, according to Fertilizer Recommendations worked out by [Materials for drawing… 1989, 1990] workers, were located in low and medium values, with the majority of low. The layer of 0 – 20 cm as a rule contained higher amounts of these elements (87.6 – 124.1 mg P_2O_5 kg^{-1} and 64.2 – 145.0 mg $K_2O \cdot kg^{-1}$) than the layer of 20 – 40 cm (50.5 – 79.0 mg P_2O_5 kg^{-1} and 50.8 – 89.7 mg $K_2O \cdot kg^{-1}$). In terms of the content of phosphorus homogeneous groups were distinguished within surface horizons of sites located on „warpie" and meadow and on both sites in the park. Soils of the sites located in the park were also characterized by a lack of statistically significant differences in terms of the content of available potassium in horizons 0 – 20 cm (Tab. 1). The content of available magnesium in the examined soil was very low in both tested horizons [Materials for drawing… 1989, 1990]. The soil of the old dump and

Table 1. Selected physicochemical properties of soils of studied sites

Tabela 1. Wybrane fizykochemiczne właściwości gleb pochodzących z badanych stanowisk

Site / Properties	Old dump H		„Warpie" W		Meadow S		Manor park P1		Manor park P2	
Depth, cm	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40	0–20	20–40
pH_{H2O}	6,9	6,9	6,9	7,6	6,8	7,0	7,4	7,7	6,9	6,9
EC, mS/cm	0,07	0,07	0,03	0,03	0,05	0,05	0,07	0,07	0,07	0,07
%fraction < 0,02 mm	16	16	22	23	11	11	13	15	13	12
Org. C,g·kg^{-1}	25,7^{g*}±1,2	18,7^{d}±0,6	29,4^{h}±1,0	14,1^{b}±0,9	23,4^{f}±1,3	16,4^{c}±1,4	21,2^{e}±0,6	11,7^{a}±0,6	18,2^{d}±0,6	16,3^{c}±0,6
Tot. N g·kg^{-1}	1,61^{e}±0,03	1,40^{cd}±0,01	1,65^{e}±0,06	1,10^{a}±0,03	1,72^{f}±0,22	1,29^{c}±0,29	1,48^{d}±0,07	1,13^{ab}±0,03	1,32^{cd}±0,06	1,21^{b}±0,05
C/N	15,9	13,4	17,8	12,8	13,6	12,7	14,3	10,4	13,8	13,5
P_2O_5 mg·kg^{-1}	87,6^{c}±15,3	50,5^{a}±10,4	124,1^{f}±0,3	70,9^{b}±1,9	113,4^{ef}±0,8	73,3^{b}±0,3	87,0^{cd}±4,9	59,5^{a}±4,0	97,1^{d}±15,8	79,0^{bc}±13,2
K_2O mg·kg^{-1}	80,9^{d}±8,0	65,4^{bc}±2,9	145,0^{g}±4,6	89,7^{e}±2,4	112,2^{f}±5,8	61,7^{b}±0,6	64,2^{bc}±5,6	50,8^{a}±1,8	65,8^{c}±4,9	59,5^{b}±3,0
MgO mg·kg^{-1}	46,8^{d}±1,0	30,8^{c}±0,2	49,6^{g}±0,0	40,2^{f}±0,7	46,9^{d}±0,1	31,4^{c}±0,6	37,6^{e}±0,4	28,5^{b}±1,3	31,5^{c}±0,3	21,8^{a}±1,2
Zn tot mg·kg^{-1}	7692,5±3,7	5858,7±2,6	9852,7±5,7	5362,0±2,7	7355,4±4,1	4425,8±4,0	3227,0±3,1	1926,4±2,0	2828,8±2,7	1110,2±1,9
Zn sol. mg·kg^{-1}	4305,9±3,7	3451,9±4,2	7835,0±2,5	3240,2±2,7	3040,2±1,8	1670,7±3,7	1313,7±4,7	835,9±1,7	1148,8±5,7	593,4±1,4
Pb tot. mg·kg^{-1}	2074,8±2,6	1726,1±1,9	4873,3±3,9	2548,3±3,8	2466,6±1,7	1694,7±1,4	1814,1±1,8	975,5±0,9	1640,6±2,4	791,6±0,4
Pb sol. mg·kg^{-1}	24,70±0,21	15,01±0,25	60,62±0,34	61,84±0,45	33,39±0,15	21,32±0,19	51,88±0,26	47,20±0,34	64,64±0,29	41,12±0,31
Cd tot. mg·kg^{-1}	48,0±0,21	26,91±0,34	44,66±0,57	40,64±0,56	56,51±0,45	27,52±0,12	26,51±0,23	17,52±0,43	22,59±0,12	18,41±0,24
Cd sol. mg·kg^{-1}	24,57±0,27	25,15±0,24	13,66±0,12	14,05±0,22	28,45±0,21	23,76±0,25	7,39±0,16	3,78±0,09	5,73±0,10	1,87±0,08
Fe tot. mg·kg^{-1}	41176±14	39301±11	27773±12	26642±10	6157,9±6,4	4671,6±4,7	8441,0±1,2	5467,8±2,1	8819,0±5,3	8729,0±2,8
Fe sol. mg·kg^{-1}	3,00±0,20	3,01±0,19	66,55±0,56	80,57±0,78	2,72±0,07	2,58±0,06	2,03±0,07	1,14±0,05	4,19±0,07	1,32±0,05
As tot. mg·kg^{-1}	120,6±0,2	153,2±1,2	99,63±0,35	101,4±0,4	36,83±0,3	39,19±0,28	23,49±0,45	15,63±0,19	25,19±0,25	11,61±0,1
As sol. mg·kg^{-1}	0,12±0,04	0,02±0,0	0,33±0,0	0,25±0,0	0,09±0,0	0,29±0,01	0,37±0,01	0,37±0,01	0,78±0,02	0,29±0,01

Note: a-g*the same letters indicate lack of statistically significant differences between objects at the level = 0.05 (wartości oznaczone jednakowymi literami nie są zróżnicowane statystycznie dla p=0,05).

meadow contained almost identical amounts of discussed element in both tested horizons (Tab. 1). Total content of zinc, lead, cadmium and arsenic in soils of the old mine dump and “warpie” (plots H and W) several times exceeded permissible values for mine and industrial lands determined in the Regulation of the Environment Minister on standards of the quality of the soil and standards qualities of the lands [Regulation... 2002]: 7-fold for zinc, for lead 4.5 – fold, for cadmium 2.5 – fold and for arsenic 1.5 – fold. Also contents of these metals indicated on plots, located in areas which weren’t used for mining i.e.: meadow (M) and of park (P1 and P2) were very high and exceeded much permissible values for the farmlands and wasteland determined in the aforementioned regulation: 10 – fold zinc, 15 – fold lead and 7 – fold cadmium. The content of arsenic was in surface layers of 0 – 20 cm about 1.5 – fold higher than the determined content in the Regulation, while layers of 20 – 40 cm of soils of discussed areas were not polluted with the arsenic. The determined contents of zinc, lead, cadmium and arsenic have always been higher in layers of 0 – 20 cm than in 20 – 40 cm, what points to the strong impact of emission of dusts from metallurgical plants neighbouring the area of the taking out soil samples, augmented by the increased geochemical background associated with natural appearing of deposits of ores containing these elements [Liszka and Świc 2004].

In soils of discussed sites contents of soluble forms of these metals were also indicated applying a solution of 0,01 mol·dm^{-3} $CaCl_2$ acidified to pH = 1. With this solution on average 51.2% of the total content of zinc was extracted, what exceeded the acceptable total content of this metal determined in the Regulation of the Environmental Minister for the soil of industrial lands [2002]. The content of lead extracted with $CaCl_2$ solution was also a little bit higher than acceptable total content of this metal and amounted on average to the 3.6% of its total content. Content of the soluble form of cadmium, constituted 43.2% of its total content on average, and did not exceed the permissible value determined in the Regulation of the Environmental Minister quality of the and standards qualifes the lands for the soil of industrial lands [2002], but considerably exceeded permissible values for the soil of the farmlands and wasteland to which meadow and park soils belong. Contents of arsenic extracted with $CaCl_2$ solution amounted on average to 1% of its total contents, and did not exceed acceptable contents in the above cited Regulation of the Environment Minister concerning the content of this element in the soil of the farmlands and of wastelands [2002].

On examined plots H, M and W, which represented terrain surrounding area of the planned project works (P1 and P2) plant diverse communities were formed. The common feature of these communities was considerable participation of plant species associated with elevated level of heavy metals in bedrock. Table 2 displays species evaluated with respect of ornamental value, assembled considering the colour of flowers or infloresences. The obvious reason of such attitude was brought about by the fact, that it is exactly colour scheme obtained with plant material, which determine general appearance of the garden,

Table 2. Herbaceous plants occurring in studied stands useful in designing

Tabela 2. Rośliny zielne badanych stanowisk przydatne w pracach projektowych

Colour of flowers/ inflorescences	Waste dump – plot H		
	species	propagation	application
White, creamy	*Carlina acaulis*	S	R, N
	Gypsophila fastigiata	S, V	R, B, F
	Scabiosa ochroleuca	S, cuttings	R, F
	Silene nutans	S, cuttings	R, F
	Silene vulgaris	S, cuttings	R, B, F
Yellow	*Allysum montanum*	S, cuttings	R, B, F
	Anthylis vulneraria	S, cuttings	R, N
	Biscutella laevigata	S, V	R, B, F
	Carex caryophyllea	S, V	R, F, N
	Potentilla arenaria	S, cuttings	R, B, F
Red, rosecoloured violet, blue	*Armeria maritima*	S, V	R, B, F
	Dianthus cartusianorum	S, V	R, B, F
Meadow – plot M			
White, creamy	*Achillea millefolium*	S, V	R, B, F
	Anhemis arvensis	S	F, plant pots
	Anthericum ramosum	S, V	F, plant pots, meadow with flowers
	Cardaminopsis arenosa	S, V	R, B, F
	Cerastium arvense	S, V	R, B, F
	Galium album	S, V	R, B, F
	Piminella saxifraga	S, V	F, N
	Melandrrium album	S, V	F, N
Yellow	*Carex caryophyllea*	S, V	R, F, N
	Carex hirta	S, V	R, F, N
	Chamaecytissus ratisbonensis	S, V	R, F, N
	Leontodon hispidus	S, V	R, F, N
	Ranunculus acris	S, V	R, F, N
	Viola tricolor	S	F, N
	Verbascum nigrum	S, V	R, F, N
Red, rosecoloured violet, blue	*Armeria maritima*	S, V	R, B, F
	Centaurea scabiosa	S, V	R, F, N
	Geranium sanguineum	S, V	F, B, N
	Thymus pulegioides	S, V	R, F, N
Warpie – plot W			
White, creamy	*Cardaminopsis arenosa*	S, V	B, R, F, N
	Convararia majalis	S, V	F, N under trees
	Peucedanum orselinum	S, V	R, F, N
	Polygonatum odoratum	S, V	F, N under trees
Yellow	*Cruciata glabra*	S, V	F, N
	Reseda luteola	S, V	R, F, N
	Viola tricolor	S	F, N
Red, rosecoloured violet, blue	*Thymus pulegioides*	S, V	R, F, N

Objaśnienia: S – seed sowing, V – vegetative propagation, R – rock garden, N – naturalistic groups, F – flowerbed, B – border flowers.

and in consequence the psychology of persons staying inside the garden interior. *Achileea millefolium, Anthericum ramosum, Cardaminopsis arenosa, Carlina acaulis, Cerastium arvense, Convallaria majalis, Galium album, Gypsophila fastigiata, Peucedanum orselinum, Polygonatum odoratum, Scabiosa ochroleuca, Silene nutans* or *Silene vulgaris* belong to the species. with white or cream coloured flowers, which can constitute neutral background of the project: They can respectively grow in sunny, or in shady conditions, depending on particular species. In the range of species characterized by yellow, brown and green flowers, it is proposed application of the following: *Alyssum montanum, Anthylis vulneraria, Biscutella laevigata, Carex caryophyllea, Carex hirta, Chamaecytisus ratisbonensis, Cruciata glabra, Helianthemum nummularrium, Leontodon hispidus, Potentilla arenaria, Ranunculus acris, Reseda luteola, Viola tricolor, Verbascum nigrum*. Among the plant species for the sunny garden areas, and blooming in the shadows of pink red, purple and the like, which are useful to the naturalistic composition, should be enumerated: *Armeria maritima, Campanula rotundifolia, Centaurea scabiosa, Dianthus cartusianorum, Gerangium sanguineum, Thymus pulegioides*. Similar requirements of respective plant material is determined by comparable habitats in the area of projected garden. Local populations overgrown the substrates characterized by low trophy value, the similar level of organic matter content, and strongly elevated contents of heavy metals, especially zinc, lead and cadmium. The area of park is corresponding with this bedrock description. The usefulness of above mentioned plant species to green areas management on areas polluted with heavy metals on the border of Silesia and Cracow-Czestochowa Upland is supported by researches conducted by numerous teams at both population and cellular level [Wierzbicka and Panufnik 1998; Jędrzejczyk et al. 2002; Wierzbicka et al. 2004; Olko et al. 2008; Grodzińska et al. 2010]. It is also consistent with results obtained by research groups working in other territories of the Poland [Brej and Fabiszewski 2006; Franiel and Fiałkiewicz 2007], of Europe [Dahmani-Muller et al. 2000; Heumann 2002; Lutts 2004; Arnetoli et al. 2008; Mengoni et al. 2010], and in other regions of the world [Leteinturier et al. 1999; Ginocchio and Baker 2004]. Therefore for each particular region plant assortment should be selected adequate for designed greenery. The accomplish the undertaken task, it is essential to choose properly a suitable plant material demonstrating determined texture, tincture and decorative qualities. It should be underlined, that in this manner we can contribute to the regional biodiversity protection, what is crucial to future remediation and restoration projects [Ginocchio and Baker 2004; Whiting et al. 2004; Batty 2005; Hanus-Fajerska et al. 2010].

In order to enable the utilization of specimens belonging to the local vegetation in the course of garden creating, there is nothing left, but to consider in what manner it is possible to prepare proper number of seedlings, according to the project. To fulfil the requirements it should be established horticultural farms specialized in the seedlings production of the local flora representatives from periodically taken seed samples. Numerous propagation techniques, known in floriculture, enable to obtain efficient multiplication coefficient. It is the kind of approach which gain the acceptance both in European countries and American States. Thus, in polluted areas, where the food production is rather risky, establishing of such horticulture farms is proposed as a way of agricultural activity economically justified, advantageous for environment, and that is why it should be strongly recommended.

4. CONCLUSIONS

From the present study it is concluded that through detailed habitat characterization it is possible to choose appropriate valuable plant material representing features which determine the usefulness to contemporary applications in the naturalistic gardens designs. Simultaneously in areas chemically degraded this attitude can support ecologically safe decontamination of polluted substrate. At the same time, in the region where the food production is risky or forbidden, the production of seedlings from adequate plant material can be economically justified type of agricultural activity.

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