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Plant communities on oil-contaminated ruderal sites in the Lopejská basin, district Brezno

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Abstract

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The paper deals with three plant communities with mono-dominance of the species *Carex hirta, Melilotus albus* and *Calamagrostis epigejos,* occurring within a territory affected by activity of an oil-processing plant, situated in the geomorphological unit Lopejská kotlina basin, in district Brezno. We describe their species composition, ecological conditions and taxonomic characteristics in relation to soil contents of non-polar extractable substances (NE) in localities loaded by hazardous waste material – acid oil residue. All the examined plant communities are developed under influence of oil substances in soil. In most cases, concentrations of non-polar extractable substances considerably exceed the maximum allowable limit – 500 mg kg^{-1}. In sites with dominance of *Carex hirt*a species, the concentrations of oil substances range from 5,517.6 to 8,090.1 mg kg^{-1}. The plant community with dominance of *Melilotus albus* species is less influenced by waste materials in case of locality Predajná I. Much higher concentrations were found in locality No. 3 inside the oil processing plant area (2,125.5–3,822.5 mg kg^{-1}). The similar results were obtained for the community with dominance of species *Calamagrostis epigejos*. The highest content of oil substances in soil made 6,992.6 mg kg^{-1}. The NE concentrations in soil are so high, that the species *Carex hirta*, *Melilotus albus* and *Calamagrostis epigejos* can be considered as very resistant to pollution by oil substances.

Keywords

oil waste, soil contamination, ruderal phytocoenoses

Introduction

Operation of the oil refinery Petrochema in Dubová village is connected with production of hazardous waste products and contamination of the territory with oil substances. Consequently, there has arisen a natural interest in evaluation of the spreading of the oil substances in soil as well as qualitative and quantitative evaluation of the composition of the existing phytocoenoses.

The discussed oil-processing plant generates hazardous wastes products – acid oil residue, in process of three-step refining of mineral oils with sulphuric acid. In the past, the waste was disposed inside the plant's area (1954–1964) and on two waste dumps outside (1964–1983).

The problem of hazardous waste disposal is high important and asked to be kept on agenda due to dangerous properties of these materials: ecotoxicity, inflammability, corrosiveness, self-igniting, and primarily their lack of ability to meet the constitutional requirements of the modern legislation for the existing damps of hazardous waste (Act No. 223/2001).

The basic requirement on the current waste dumping is to guarantee a perfect landfill sealing with a suitable construction of the sealing system. This is just the requirement not met with old dumps causing contamination of natural environment (Piatrik, 2000).

The soil substrate influenced with oil substances or with waste containing oil substances provides specific sites for vegetation development. Neither direct impact on, nor direct uptake by plant root systems has been recognised unambiguously. It is, however, undisputable that the oil substances absorbed by the surface of the soil particles reduce partially or totally the distribution

of water and nutrients through the soil capillary system to the plant roots and the other organs. As the result, there are affected all physiological processes and the overall vitality of the individual plants. Consequently, deviations from the normal vitality observed in plants of individual populations growing in the locality can serve as the first diagnostic signal of a contamination.

The changes in species diversity of the populations as well as occurrence of synathropic species and retreat of meadow species give us the high valuable information on the spatial distribution of oil carbohydrates over the studied territory. All the changes are associated with several site conditions (geology, soil conditions, hydrology, and naturally, amount of oil substances in soil and their properties).

In this paper we deal with plant communities occuring in localities polluted with waste products containing oil substances, their diversity, cover and species abundance in stands under influence of the oil processing plant in Dubová village. We also present amounts of non-polar extractives in soils.

Material and methods

We performed a several-year botanic and soil-science-oriented research in the area of the oil processing plant Petrochema Dubová, situated in the village of Nemecká, part Dubová, in district Brezno. The two deposits of waste oil substances in the area of village Predajná (4 km NE of the plant) – Predajná I. and Predajná II. consist of excavated depressions filled with liquid to pasty waste material.

The dump Predajná I. (research locality No. 1) is situated 800 m E of Predajná village, on the SE foothills of the hill Hôrka, at 520 m asl. It was established in 1962–1964 with an area of 10,921 m^2 and a capacity of 100,000 m^3. The using of dump was finished in 1974 (Fig. 1).

The dump Predajná II. (research locality No. 2) is situated 200 m W of the dump Predajná I., 520 m asl. It was established in 1973–1974 with an area of 12,000 m^2 and a capacity of 60,000 m^3. This dump was in function up to 1983 (Fig. 2).

Fig. 1. Waste dump Predajná I.

Fig. 2. Waste dump Predajná II.

Fig. 3. Waste dumps in the oil processing plant Petrochema Dubová
×occurrence of community with dominance of *Carex hirta* species, •occurrence of community with dominance of *Melilotus albus* species, °occurrence of community with dominance of *Calamagrostis epigejos* species

The four dumps inside the plant area (research locality No. 3) were constructed in 1954–55 and they served for disposal of acid residue. To the present, two of them, have already been settled out (landfills B and C), the other two (landfills A and D) are still functioning and they are used as temporary disposals for acid residue before the liquidation in the incineration facilities (Fig. 3).

Since 1993, acid residue, the waste by-product in oil processing has not been put on waste dumps. The entire amount of the produced waste with high sulphur content is burnt together with alkaline oil sludge from the waste water treatment plant (Halajová, 1995).

According to Mazúr and Lukniš (1980), the research localities belong to the Fatransko-tatranská region, unit Horehronské podolie and district Lopejská kotlina basin. The parent rock below the waste dumps situated near Predajná village consists of light-grey Triassic Choč Mts dolomites and Reiflin calcites. The plant is situated on Quaternary floodplain clays and gravel clays of contemporary valley floodplains and floodplain cones. The upper layer is, however, consisting of anthropogene sediments similar to clays and gravels with varying content of clayey and sandy constituents, 0.4–2.5 m in thickness (Petríková, 2003). The territory of the Lopejská kotlina basin belongs to the wet valley sub-district with cold winter of the moderately warm climatic district with an average air temperature in July being 14.5–16 °C and an average annual precipitation of 610–900 mm. The temperature in the vegetation period (April–September) is characterized with an isotherm of 16 °C, representing the mean value for 1901–1950 (Collective, 1991). The study area belongs to the phytogeographical district Slovenské stredohorie Mts (Futák, 1966). The autochthonous vegetation cover consists of oak-hornbeam forests belonging to the alliance Carpinion betuli (Michalko et al., 1986).

The floristic and phytocenological research was carried out in vegetation periods 1998–2000. The study was

focused on synanthropic and grassy-herbal stands. The analysis of stands in field as well as processing of the sampled material was provided on the base of the Zürich-Montpellier school (Braun-Blanquet, 1964). Plots for phytocenological relevés were selected on banks of filled land depressions and in close neighbourhood on dump slopes. The area of each plot was 25 m^2. In case of smaller plots we present their area in the relevant phytocenological tables. The quantitative shares of the species were estimated using the combined seven-point scale for abundance and dominance. The permanence of the species in the phytocoenoses is evaluated by means of scale I.–V. The obtained phytocenological relevés were subjected to phytocenological analysis and synthesis. In this step we used an auxiliary method – numerical classification with the program Twinspan (Hennekens, 1996).

Because it was not possible to assign all the identified synathropic plant communities to the codified ones, we always report the dominant species of the community. The classification in higher coeno-taxa will only be possible based on an further appropriate ecological and phytocenological study of phytocoenoses in similar site conditions. The species occurring in the examined herbaceous stands are listed in tables assorted according to their relevance to higher syntaxonomical units, following Jarolímek et al. (1997), or according to their permanent presence in the communities (community with *Carex hirta*).

The names of vascular plants follow Marhold and Hindák (1998), site ecology description is according to Jurko (1990).

The non-polar extractives (NE) contaminating the soil was determined by infrared spectrophotometry, over the frequency range of 3,150–2,750 cm^{-1}. The method is based on extraction of substances (both polar and non-polar) with an organic solvent – 1,1,2 trifluortrichloretan and the subsequent separation of the polar substances by adsorption on silica gel. The testing samples of soils were prepared according to the standardised procedure stated in the "Methodical instructions for sampling and analysis of ground waters and soils polluted with oily and chlorinated carbohydrates" edited by the Ministry of Environment of SR and the Research Institute of Water Management in Bratislava (Collective, 1995). The soil dry matter was determined with an extra portion of the sampled material after drying to a constant weight at a temperature of 105 °C. The soil samples were taken from a depth of 0–20 cm, in autumn 1999.

Results and discussion

The species diversity of plant communities with dominance of ***Carex hirta*** species (Table 1) is very low. There occur only 14 species, five on average per a relevé. The average plant cover is 50%, which means that the stands have relatively low density and height. The dominant species *Carex hirta* has the highest abundance and cover. The two relevés are mono-dominant phytocoenoses with *Carex hirta* species. Permanence of degree IV. and III. has been recognized for *Tanacetum vulgare*, *Lotus corniculatus* and *Oenothera biennis* agg.

In stands of this community are dominant hemicryptophytes, with only a little admixture of terophytes and geophytes. The community is characterised with the species associated with dry to wet soils. So, there are absent species distinctly xerophilous and hydrophilous. Relevant are species with wider ecological amplitude as for water demands. From the viewpoint of soil ecology, the phytocoenosis is characterised with the species that are easy adapted to conditions on mild acid, neutral and mild by alkaline soils. From the species preferring more acid soils, there only occurs *Agrostis capillaris*, from the ones preferring more alkaline soils, *Medicago lupulina*. As for nitrogen content, there are dominant species preferring medium nitrogen amount in soil. In total, we can say that the community consists of species with wide ecological amplitude, easy adaptable to extreme life conditions. The development optimum is reached in June–July.

The species characteristic for higher taxonomical units according to Jarolímek et al. (1997) are not present in our localities, consequently we only identify the community as a stand with one dominant species. Jarolímek et al. (1997) characterised the community as a monodominant, quite dense, low and poor in species, occurring most frequently in sun-exposed and heated sites. Occurrence of most species is random. Identically called association in Austria was reported by Mucina et al. (1993).

Kontrišová and Kontriš (1999) document an occurrence of this community in area of oil resources in the Záhorská nížina lowland. Pyšek (1981) classifies *Carex hirta* as a resistant species tolerating the soil contamination with oil substances.

We present six phytocoenological relevés for the community with *Carex hirta* in the area of plant Petrochema Dubová. Five of them were taken from the plant, the sixth one, with an area of 25 m^2 from the dump Predajná II. at 0.2 m from the border. The occurrence of *Carex hirta* species we also observed directly on the acid residue outside the each of precipitation water. The NE concentration in soil on such sites reached 6,404.6 mg kg^{-1}. As we can see in Table 1, the measured NE values ranged from 5,517.6 to 8,090.1 mg kg^{-1}. The allowable threshold of NE concentration in soil set by the Standard STN 75 7111 is 500 mg kg^{-1} (Jusko, 1997). After exceeding this limit, it is required to begin with a survey and to seek identification of the source of contamination. It is evident that in all cases

the exceeding was enormous. The lowest NE value of 5,5176 mg kg^{-1} was found at the 0.2 m distance from the southern border of dump A in the plant area. This dump serves for temporary disposal of precipitation water from the waste dumps in Predajná. In this site with an area of 5 m^2 and herb cover of 30% we recorded an almost mono-dominant *Carex hirta* community. Apart from the dominant species, only the *Lotus corniculatus* species with abundance of + was found. The highest measured NE value in soil was 8,090.1 mg kg^{-1}. The plant community growing at a 1 m distance from the western border of dump C (at present extinct) on an area of 5 m^2 consisted of seven species with total cover of 50%. The community with *Carex hirta* species occurring east of the dump A (0.5 m from the border), growing on an area of 14 m^2 in soil containing 6,298 mg kg^{-1} oil substances has a cover of even 100%. The cover 100% was also found for community of species *Lotus corniculatus, Equisetum arvense, Tanacetum vulgare, Trifolium pratense, Leontodom autumnalis and Oenothera biennis* agg. Directly at the bottom of dump C, we recorded a mono-dominant plant community with *Carex hirta* species on an area of 5 m^2 with a cover of 15%. The content of oil substances in soil was 7,027.7 mg kg^{-1}. The last relevé with *Carex hirta* was taken at 5 m from the western border of dump C, on an area of 24 m^2 with herb cover of 60% and NE content in soil making 5,855.4 mg kg^{-1}.

The community with dominance of ***Melilotus albus*** species (Table 2) was in our research localities documented by means of seven phytocenological relevés. The stands are gappy, medium dense to dense, opened, with a cover of 70 to 100%. The community consists of 56 species, 16 on average in a relevé. The

Table 1. Plant community with dominance of *Carex hirta* species

Relevé number	1	2	3	4	5	6	
Relevé working number	13	7	11	12	43	55	
Locality*	3	2	3	3	3	3	
Year	1999	1999	1999	1999	1999	1999	Permanence of species
Month	6	6	6	6	7	7	
Day	8	7	8	8	2	13	
Area (m^2)	24	25	5	5	5	14	
Cover E_1 (%)	60	50	50	15	30	100	
Number of species	7	5	7	1	2	7	
NE concentration (mg kg^{-1})	5,855.4	6,404.6	8,090.1	7,027.7	5,517.6	6,298.0	
Slope (°)	0	0	0	0	10	0	
Aspect	–	–	–	–	N	–	
Carex hirta	3	3	3	2	3	5	V.
Tanacetum vulgare	+	r	r	.	.	+	IV.
Oenothera biennis agg.	r	r	.	.	.	r	III.
Lotus corniculatus	.	.	r	.	+	2	III.
Taraxacum officinale agg.	r	.	r	.	.	.	II.
Melilotus officinalis	.	r	r	.	.	.	II.
Trifolium pratense	r	.	.	.	.	+	II.
Calamagrostis epigejos	2	.	.	.	.	.	I.
Agrostis capillaris	1	.	.	.	.	.	I.
Rubus hirtus	.	+	.	.	.	.	I.
Pastinaca sativa	.	.	r	.	.	.	I.
Medicago lupulina	.	.	r	.	.	.	I.
Leontodon autumnalis	.	.	.	.	.	+	I.
Equisetum arvense	.	.	.	.	.	1	I.

*Locality: 2 – dump Predajná II., 3 – plant area

dominant genus is *Melilotus*, which reaches the highest abundance, cover and permanence. There are two species of the genus in the studied area – *Melilotus albus* and *M. officinalis*. These species reach a height up to 1.5 m. Considerably permanent are also the species *Tanacetum vulgare* and *Lotus corniculatus*. The herbal storey has a two-layered structure. The lower layer consists of species *Trifolium repens, T. pratense, Lotus corniculatus, Taraxacum officinal*e agg., *Medicago lupulina, Leontodon autumnalis, L. hispidus* and *Achillea millefolium*. The upper layer comprises biennial hemicryptophytes with dominance of both *Melilotus* species. From grasses are quite abundant *Agrostis capillaris, Arrhenatherum elatius*, *Poa pratensis* agg. and *Festuca rubra*. The development optimum of the community is reached in June–July.

The community occurring in all the three localities very close to the dumps consists mostly of hemicryptophytes, less terophytes and geophytes. Dominant are species with wide ecological amplitude in terms of water demands, absent are both distinctly xerophilous ones (from the second are only present *Tithymalus cyparissias, Scabiosa ochrolueca*) and hydrophilous. The species occurring in this community prefer mildly acid to mildly alkaline soils. From basiphilous species, there are present *Erysimum odoratum, Festuca rupicola, Medicago lupulina, Potentilla heptaphylla and Scabiosa ochroleuca.* As for the soil nitrogen, there are present species associated with soils with medium nitrogen content. From nitrophobic occur – *Festuca rupicola, Pilosella bauhinii, Potentilla heptaphylla, Pseudolysimachion spicatum, Scabiosa ochroleuca* and *Trifolium montanum.*

Comparing this community with the communities described by Jarolímek et al. (1997), we can identify a considerable species affinity and classify their stands to the class Artemisietea vulgaris Lohmeyer et al. in R. Tx. ex von Rochow 1951, order Onopordetalia acanthii Br.-Bl. et R. Tx. ex Klika et Hadač 1944 and alliance Dauco-Melilotion Görs 1966. The relevés from our research localities are poorer in species and have higher proportion of meadow species, primarily from the classes Molinio-Arrhenatheretea and Festuco-Brometea.

Edificator species of this community is *Melilotus albus*, which is according Hartman (1980) a species resistant against oil substances and prone to excessive growth. Manifestations of gigantism were also recorded in our research localities – an excessive height (1–1.5 m) was mainly reached inside the plant area. The *Melilotus officinalis* species was less abundant in our localities than species *Melilotus albus* and did not reach excessive heights.

The soil contents of non-polar extractives in sites with occurrence of the plant community dominated by *Melilotus albus* species are listed in Table 2. For the dump Predajná I. we present 4 phytocenological relevés, three of them occurring at the same transect at different distances from the northern border of the dump. At the distance of 5 m from the dump border we recorded an NE concentration in soil of 903.3 mg kg^{-1}. The stand on plot with an area of 25 m^2 had a cover of 70% and comprised in total 21 taxa. Dense cover was found in case of *Festuca rupicola* and *Lotus corniculatus* species. The other two sites were situated at distances 20 and 25 m from the dump border on northward oriented slopes with inclination of 30º and 25º with oil substances content in soil being 186.4 and 219.9 mg kg^{-1}. These values do not exceed the allowed limit (500 mg kg^{-1}). The herbal stands on plots, each 4 m^2 in area, have the same cover of 90% and the species number 18 and 23, respectively. In stands on both plots we observed higher cover of some grasses such as *Poa pratensis* agg., *Festuca rubra* and *Arrhenatherum elatius*, which indicates more favourable soil conditions of the site. The community with *Melilotus albus* in the locality Predajná I., we even described in close proximity of the dump southern border. The measured concentration of 2,002.3 mg kg^{-1} was considerably above the stated allowed limit. We only recorded 15 taxa of higher plants on the plot 25 m^2 in area in spite of a 100% total cover. Apart from the dominant species *Meliotus albus*, considerable cover was found also in case of the species *Festuca rubra* and *Agrostis stolonifera*.

All the three concentration values of NE found inside the plant area were considerably higher than the set limit. This was probably also reflected in the fact that the number of identified plant species was lower compared to the locality Predajná I. We found the value of NE concentration in soil of 3,352.3 mg kg^{-1}, herbal cover of 70% and species number 14, on the plot with an area of 28 m^2, situated in close proximity of the western border of dump A. The values determined on the southern border of the same dump on the slope with an inclination of 30º at distance of 4 m from the dump border was following: content of NE soil 3,822.5 mg kg^{-1}, the plant community cover 100% and 13 species on an area of 5 m^2. The last spot of the discussed plant community occurs at the SW border of dump C, has an area of 8 m^2, herbal cover of 90% and 11 plant species. The value of oil substances content in soil at distance of 1 m from the dump border was 2,125.5 mg kg^{-1}.

The plant community with dominance of ***Calamagrostis epigejos*** species (Table 3) comprises 63 species, on average 15 per one relevé. The dominant and stand forming species is *Calamagrostis epigejos*, determining the community physiognomy and forming dense stands with dominance of 4 and height of 1–1.5 m. The stand cover ranges from 80 to 100%. The permanence found for species *Calamagrostis epigejos* and *Tanacetum vulgare* was V., for *Achillea millefolium* and *Hypericum perforatum* IV. and for species *Cirsium arvense, Carex hirta, Oenothera biennis* agg., *Agrostis capillaris* and *Lotus corniculatus* III.

Distinctly dominant species in the community are hemicryptophytes, less abundant are terophytes and other life forms. As for soil moisture content, species with wide ecological amplitude are most characteristic for the community. From xerophilous species are present *Anthyllis vulneraria, Securigera varia, Tithymalus cyparissias, Festuca rupicola, Polygala major, Potentilla heptaphylla, Sanguisorba minor, Stachys recta*, from hydrophytes *Lythrum salicaria* and *Thalictrum flavum*. A mildly acidophilous species is only *Agrostis capillaris.* More abundant are species preferring neutral to alkaline site conditions: *Aquilegia vulgaris, Festuca rupicola, Medicago lupulina, Polygala major, Potentilla heptaphylla, Sanguisorba minor, Stachys recta* and *Thalictrum flavum*. The other species do not show preferences in connection with this factor. As for nitrogen content, there occur species preferring soils with medium nitrogen content. Nitrophobic species are: *Securigera varia, Festuca rupicola, Polygala major, Potentilla heptaphylla* and *Pseudolysimachion spicatum*, nitrophilous species are represented by *Eupatorium cannabinum* and *Urtica dioica*.

Table 2. Plant community with dominance of *Melilotus albus* species

Relevé number	1	2	3	4	5	6	7	
Relevé working number	78	15	16	57	145	146	24	
Locality*	1	3	3	3	1	1	1	
Year	1999	1999	1999	1999	2000	2000	1999	Permanence of species
Month	7	6	6	7	6	6	6	
Day	21	8	8	13	6	6	9	
Area (m^2)	25	28	5	8	4	4	25	
Cover E_1 (%)	100	70	100	90	90	90	70	
Number of species	15	14	13	11	18	23	20	
NE concentration (mg kg^{-1})	2,002.3	3,352.3	3,822.5	2,125.5	186.4	219.9	903.3	
Slope (º)	0	30	30	0	30	25	0	
Aspect	–	N	N	–	N	N	–	
Dauco-Melilotion								
Melilotus albus	4	3	4	5	4	4	4	V.
Tanacetum vulgare	1	r	+	+	+	+	+	V.
Melilotus officinalis	+	.	.	+	.	.	+	III.
Picris hieracioides	+	.	.	.	.	.	.	I.
Artemisietea vulgaris								
Artemisia vulgaris	+	r	.	.	+	.	+	III.
Elytrigia repens	.	+	1	.		+	.	III.
Cirsium arvense	.	.	.	+	+	+	.	III.
Arrhenatherion elatioris								
Carum carvi	.	+	+	.	.	.	.	II.
Arrhenatherum elatius	.	.	.	.	2	2	.	II.
Galium mollugo	.	.	.	.	+	r	.	II.
Pastinaca sativa	.	.	.	.	.	r	.	I.
Cynosurion								
Agrostis capillaris	.	2	3	.	.	.	1	III.
Leontodon autumnalis	.	.	.	1	.	.	.	I.
Scabiosa ochroleuca	.	.	.	.	.	.	r	I.
Arrhenatheretalia								
Lotus corniculatus	.	+	+	+	r	r	2	V.
Trifolium repens	+	1	+	.	.	.	.	III.

Table 2. Continued

Taraxacum officinale agg.	.	.	+	.	.	+	+	III.
Daucus carota	+	.	.	.	.	.	.	I.
Dactylis glomerata	.	.	.	.	.	.	+	I.
Molinio-Arrhenatheretea								
Poa pratensis agg.	+	+	2	.	.	1	.	III.
Leontodon hispidus	.	.	.	.	+	+	1	III.
Festuca rubra	3	.	.	.	1	.	.	II.
Lathyrus pratensis	.	.	.	.	+	r	.	II.
Plantago lanceolata	.	r	.	.	.	.	.	I.
Bromion erecti								
Trifolium medium agg.	.	3	.	.	1	1	.	III.
Lathyrus sylvestris					r	+		II.
Trifolium montanum	.	.	.	.			+	I.
Pilosella bauhinii	.	.	.	.			+	I.
Festuco-Brometea and Brometalia								
Medicago lupulina	.	2	+	.	.	.	1	III.
Plantago media	r	.	.	.	.	.	+	II.
Anthyllis vulneraria	.	+	.	.	.	.	.	I.
Senecio jacobaea	.	.	.	r	.	.	.	I.
Silene nutans	.	.	.	.	r	.	.	I.
Hypericum perforatum	.	.	.	.	r	.	.	I.
Securigera varia	.	.	.	.	.	r	.	I.
Tithymalus cyparissias	.	.	.	.	.	+	.	I.
Festuca rupicola	.	.	.	.	.	.	2	I.
Potentilla heptaphylla	.	.	.	.	.	.	r	I.
Pseudolysimachion spicatum	.	.	.	.	.	.	+	I.
Other								
Petasites sp.	3	.	.	.	.	.	.	I.
Rubus caesius	+	.	.	.	.	.	.	I.
Glechoma hederacea	r	.	.	.	.	.	.	I.
Agrostis stolonifera	2	.	.	+		.	.	II.
Tripleurospermum perforatum	.	1	1	.	.	.	.	II.
Carex hirta	.	.	1	1	.	.	.	II.
Hieracium umbellatum	.	.	.	r	.	.	.	I.
Tussilago farfara	.	.	.	.	+	+	.	II.
Astragalus glycyphyllos	.	.	.	.	+	1	.	II.
Equisetum arvense	.	.	.	.	+	1	.	II.
Linaria vulgaris	.	.	.	.	.	r	.	I.
Rumex conglomeratus	.	.	.	.	.	r	.	I.
Erysimum odoratum	.	.	.	.	.	r	r	II.
Calamagrostis epigejos	.	.	.	.	.	.	r	I.

*Locality: 1 – dump Predajná I., 3 – plant area

The community with dominance of *Calamagrostis epigejos* species represents in the studied area evident transition between two classes – Artemisietea vulgaris and Molionio-Arrhenatheretea. There are just abundant species belonging to the second class, order Arrhenatheretalia. Before the construction of the waste dumps, the studied localities had been covered with oat grass – *Arrhenatherum elatius* (L.). The human activities, construction and operation of waste dumps caused disturbance of vegetation, its synatropisation and ruderalisation.

More abundant are species belonging to the class Festuco-Brometea and order Brometalia. These are the species preferring dry, sun-exposed, heated and frequently calcareous sites – alike our research localities (Predajná I. and Predajná II.): *Aquilegia vulgaris, Hypericum perforatum, Lembotropis nigricans, Polygala major, Potentilla heptaphylla, Sanguisorba minor, Stachys recta* and *Trifolium medium* agg.

A phytocoenosis with dominance of *Calamagrostis epigejos* species growing in the Žiarska kotlina basin was characterised by Kontrišová (1980), similar case from Austria was reported by Mucina et al. (1993). Kontrišová and Kontriš (1999) also described a mesotrophic plant community with dominance of *Calamagrostis epigejos* species, occurring in area of oil resources in the Záhorská nížina lowland. The last community prefers moister sites and forms poor-in-species stands in combination with *Deschampsia caespitose* species.

Hartman (1980) and Pyšek (1981) rank *Calamagrostis epigejos* to resistant species with high tolerance against soil pollution with oil substances.

The stands with *Calamagrostis epigejos* community are documented with seven relevés from research localities No. 1 and 3. For the three plots inside the plant area are typical high NE concentrations in soil. Only 8 taxa were found on the plot with an area of 6 m^2 situated at distance of 0.2 m from the eastern border of dump A, where we found NE value of 6,992.6 mg kg^{-1} in soil. Rather higher dominance (2) was found for *Carex hirta* species. Almost the same number of taxa (7) was found on the plot with an area of 12 m^2, herb cover of 80% and NE concentration of 5,732.3 mg kg^{-1} situated at distance of 3 m from the western border of dump C. Higher cover was recorded for the species *Agrostis capillaris* and *Deschampsia caespitosa*, which we consider as resistant against impact of oil substances. On both plots very rarely occur also meadow species from the classes Molinio-Arrhenatheretea and Festuco-Brometea. At distance of seven m from the north-eastern border of dump C, on the plot with an area of 25 m^2 and herb cover of 100%, we identified 17 taxa of higher plants, several meadow species included, and considerable NE content in soil (6,563.1 mg kg^{-1}). On the waste dump Predajná I., we recorded stands with *Calamagrostis epigejos* community almost adjacent to the northern, eastern and western dump borders. The NE concentrations in soil on this site are much lower compared with values found in the plant area. The allowable limit was only exceeded in one case at distance of 0.2 m from the northern dump border on the plot with an area of 25 m^2, where the content of NE in soil was 2,611.2 mg kg^{-1}, cover reached 80% and even 25 plant taxa were present. At the same distance from the eastern dump border, the measured NE value was 292.6 mg kg^{-1}; consequently, the allowable limit was not exceeded. But on the plot with an area of 25 m^2 and cover of 100% we identified only 8 taxa of higher plants. Site factors and physical regularities controlling the transport of oil substances throught the environment evidently influence the situation. The permeability of the bedrock promotes or reduces the distribution distance of NE from the dump. This fact has finally been confirmed with analyses of soil samples taken from the transect at greater distances from the dump. The soil on two plots at the western dump border did not show increased contamination with oil substances. At distances of 0.2 and 2 m from the dump border was the herb cover of 100% and the contents values of NE were 329 and 169.5 mg kg^{-1}, respectively. On the first plot with an area of 4 m^2, we identified 11 herb species, on the second, with an area of 25 m^2 there were growing 27 species, mostly grasses belonging to the classes Molinio-Arrhenatheretea and Festuco-Brometea. On both plots the higher dominance had *Festuca rubra* species.

Conclusions

All the described phytocoenoses are under influence of oil substances present in soil. In most cases, the concentrations of non-polar extractable substances are considerably exceeding the allowable limit – 500 mg kg^{-1}. The stands of the herb community with dominance of *Carex hirta* species have been developed in a very close proximity to the dumps and disposals of oil acid residue. The first are even occurring directly on the waste material, out of the influence of precipitation water. These stands represent initial phases of a starting secondary succession on man-made translocated soils polluted by oil substances. The herb stands are very poor in species and sparse. The phytocoenoses with dominance of *Melilotus albus* species are medium dense to dense, and they reach a height of 1.5 m. We also recorded these plant communities at greater distances from the waste deposits with more abundant occurrence of some grass species. The stands of the community with dominance of *Calamagrostis epigejos* species occur fairly close to the dumps and disposals. The stands are dense and rather high. Namely in case of Predajná I., the stands with *Melilotus albus* and *Calamagrostis epigejos* are typical with higher presence of meadow species, which

Table 3. Plant community with dominance of *Calamagrostis epigejos* species

Relevé number	1	2	3	4	5	6	7	
Relevé working number	54	14	18	60	64	62	80	
Locality*	3	3	1	3	1	1	1	
Year	1999	1999	1999	1999	1999	2000	1999	
Month	7	6	6	7	7	6	7	
Day	13	8	8	13	15	7	21	
Area (m^2)	6	12	25	25	25	4	25	
Cover E_1 (%)	100	80	80	100	100	100	100	
Number of species	8	7	25	17	8	11	27	
NE concentration (mg kg^{-1})	6,992.6	5,732.3	2,611.8	6,563.1	292.6	329	169.5	
Slope (°)								
Aspect								
Calamagrostis epigejos	5	4	4	4	5	5	5	V.
Onopordetalia acanthii								
Linaria vulgaris	.	.	r	.	.	.	+	II.
Artemisietea vulgaris								
Cirsium arvense	.	1	+	.	.	+	.	III.
Artemisia vulgaris	.	.	r	.	.	.	+	II.
Dauco-Melilotion								
Tanacetum vulgare	.	+	1	1	+	+	+	V.
Oenothera biennis agg.	r	+	2	.	.	.	.	III.
Melilotus albus	r	.	.	.	.	.	.	I.
Picris hieracioides	.	.	.	.	r	.	.	I.
Agropyro- Rumicion crispi								
Carex hirta	2	.	1	.	.	.	+	III.
Potentilla anserina	.	.	r	.	.	.	+	II.
Agrostis stolonifera	.	.	.	+	.	.	1	II.
Lysimachia nummularia	.	.	.	.	.	.	1	I.
Odontites vulgaris	.	.	.	.	.	.	+	I.
Arrhenatherion elatioris								
Campanula patula	.	.	.	+	.	.	r	II.
Knautia arvensis	.	.	.	+	.	.	.	I.
Pastinaca sativa	.	.	.	.	.	.	+	I.
Cynosurion								
Agrostis capillaris	.	2	.	1	.	.	1	III.
Polygala major	.	.	r	.	.	.	.	I.
Jacea phrygia	.	.	.	r	.	.	.	I.
Arrhenatheretalia								
Achillea millefolium	.	.	1	2	1	2	1	IV.
Lotus corniculatus	+	.	.	+	.	r	+	III.
Trifolium repens	+	.	.	+	.	.	.	II.
Taraxacum officinale agg.	.	r	.	.	.	.	.	I.
Daucus carota	.	.	.	+	.	.	.	I.
Leucanthemum vulgare	.	.	.	1	.	.	.	I.
Trifolium pratense	.	.	.	.	.	.	+	I.

Permanence of species

Table 3. Continued

Molinio-Arrhenatheretea								
Poa pratensis agg.	+	.	r	.	.	.	.	II.
Leontodon hispidus	.	.	+	.	.	+	.	II.
Festuca rubra	.	.	.	.	.	3	2	II.
Deschampsia caespitosa	.	2	.	.	.	.	.	I.
Phleum pratense	.	.	.	+	.	.	.	I.
Euphrasia rostkoviana	.	.	.	.	.	.	r	I.
Lathyrus pratensis	.	.	.	.	.	.	+	I.
Bromion erecti								
Carlina vulgaris	.	.	r	.	.	.	.	I.
Trifolium medium agg.	.	.	.	+	.	.	.	I.
Pseudolysimachion spicatum	.	.	.	.	+	.	.	I.
Festuco-Brometea a Brometalia								
Hypericum perforatum	.	.	+	1	1	+	+	IV.
Medicago lupulina	r	.	.	.	.	.	+	II.
Tithymalus cyparissias	.	.	r	.	.	.	.	I.
Sanguisorba minor	.	.	+	.	.	.	.	I.
Festuca rupicola	.	.	+	.	.	.	.	I.
Silene nutans	.	.	r	.	.	.	.	I.
Potentilla heptaphylla	.	.	r	.	.	.	.	I.
Pilosella officinarum	.	.	.	1	.	.	.	I.
Arenaria serpyllifolia	.	.	.	.	.	.	+	I.
Securigera varia	.	.	.	.	.	.	+	I.
Anthyllis vulneraria	.	.	.	.	.	.	r	I.
Stachys recta	.	.	.	.	.	.	r	I.
Other								
Aquilegia vulgaris	.	.	+	.	.	.	.	I.
Equisetum arvense	.	.	+	.	.	.	.	I.
Fallopia dumetorum	.	.	r	.	.	.	.	I.
Tussilago farfara	.	.	r	.	.	.	.	I.
Rubus caesius	.	.	r	.	.	.	.	I.
Urtica dioica	.	.	r	.	.	.	.	I.
Eupatorium cannabinum	.	.	.	+	.	.	.	I.
Vicia sepium	.	.	.	.	+	.	.	I.
Armoracia rusticana	.	.	.	.	+	.	.	I.
Lembotropis nigricans	.	.	.	.	.	1	.	I.
Alchemilla xanthochlora	.	.	.	.	.	+	.	I.
Cruciata glabra	.	.	.	.	.	+	.	I.
Fragaria vesca	.	.	.	.	.	.	2	I.
Lythrum salicaria	.	.	.	.	.	.	+	I.
Thalictrum flavum	.	.	.	.	.	.	+	I.

*Locality: 1 – dump Predajná I., 3 – plant area

is probably connected with the former occurrence of phytocoenoses of the alliances Arrhenatherion elatioris, Cynosurion and Bromion erecti in these localities before the construction and operating of waste dumps. Because the contents of NE in soil are very high, we can conclude that the present dominant species *Carex hirta*, *Melilotus albus* and also *Calamagrostis epigejos* are resistant against contamination with oil substances.

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Rastlinné spoločenstvá na ruderálnych stanovištiach ovplyvnených ropnými látkami v Lopejskej kotline v okrese Brezno

Súhrn

V oblasti podniku Petrochema Dubová (Lopejská kotlina, okres Brezno), v okolí skládok gudrónov, sme skúmali tri fytocenózy (spoločenstvo s *Carex hirta*, s *Melilotus albus* a s *Calamagrostis epigejos*), ich výskyt a druhovú, ekologickú a taxonomickú charakteristiku v závislosti od obsahu nepolárnych extrahovateľných látok v pôde. Všetky charakterizované fytocenózy sú ovplyvnené obsahmi ropných látok v pôde. Vo väčšine prípadov koncentrácie nepolárnych extrahovateľnách látok vysoko prekračujú najvyššiu prípustnú koncentráciu – 500 mg kg^{-1}. Porasty spoločenstva s dominanciou *Carex hirta* sa vyvíjajú vo veľmi tesnej blízkosti skládok gudrónov a predstavujú prvé fázy začínajúcej sekundárnej sukcesie na navezených antropogénnych pôdach. Ide o porasty druhovo veľmi chudobné a riedke. Spoločenstvá s dominanciou druhu *Melilotus albus* sú stredne husté až husté a vysoké až 1,5 m. Zaznamenali sme ich aj vo väčšej vzdialenosti od skládok, a to s vyšším zastúpením niektorých druhov tráv. Porasty spoločenstva s dominanciou druhu *Calamagrostis epigejos* sa vyskytujú v pomerne tesnej blízkosti skládok. Ide o porasty dosť husté a pomerne vysoké. Pre spoločenstvá s dominanciou druhov *Melilotus albus* a *Calamagrostis epigejos* je charakteristický vyšší podiel lúčnych druhov, čo pravdepodobne súvisí s výskytom spoločenstiev zväzov Arrhenatherion elatioris, Cynosurion a Bromion erecti na týchto lokalitách pred výstavbou a prevádzkou skládok. Vzhľadom na zistené vysoké koncentrácie NEL v pôde považujeme druhy *Carex hirta, Melilotus albus* i *Calamagrostis epigejos* za druhy odolné voči ropnému znečisteniu.