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THE TERRITORIAL DIFFERENTIATION OF THE RECULTIVATED AREA OF OPENCAST BROWN COAL MINE IN THE MOST REGION (CZECHIA) MULTIDIMENSIONAL CLUSTER ANALYSIS

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Introduction

The anthropogenically unaffected areas practically do not exist today. The anthropogenic activity in landscapes is intensifying and expanding. Moreover, reclaimed or otherwise modified areas are often situated next to the damaged or destroyed spaces. They, for example, can be found in places where the mining activity has been terminated. The recultivation of damaged or destroyed areas is an acute problem in Czechia for the Most Region. Brown coal used to be mined in this part of this country. According to the written sources of the 15th century the beginning of mining was not very intensive and of minor importance for the country at that time. The essential increase of coal mining began only in the first half of the 19th century. It was associated with the rise of energy consumption of developing industry. The brown coal (lignite) mining reached its peak in the 20th century, namely, in 1985 (approximately 70 mil. tonnes per year).

The technology of opencast mining brought devastation to the country – the appearance of the so-called moon (lunar) landscape, which can be found in some places at the southern foothills of the Ore Mountains (Podkrušnohorí). Almost all functions of landscape components have been disturbed or even destroyed. For this reason efforts are taken now to restore this territory after minestop – i.e., to readjust it for human living and using. Yet the landscape of recultivated territory has quite different parameters in comparison with the original landscape. The former lowland composed of Tertiary sediments with relative camber of some meters (only someplace the camber used to be ten meters) has converted into a new ground with relative camber of a few hundred meters. Other parts of natural environment have also changed including microclimate. These changes have affected the life and habitat conditions of biota.

In order to make the newly established slopes of the abandoned opencast mine really green it is necessary to verify some suppositions as to the planting greeneries. Whether, for instance, the completely modified hydrological relations can act as a limiting factor for existence and incidence of desirable grasses, shrubberies and trees.

As microclimatic observations are meanwhile rather scanty the adaptation of the newly recovered areas is based only on suggestions. They are derived from general valid rules or empirical observations. On that score the students and teachers of the Department of Geography (Education Faculty of Purkyne University) have assumed microclimatological observations on the slopes of abandoned Strimicka dump and former Most mine. Applied research was oriented to finding out the actual state of habitat conditions for regreening of this dump and extensive recultivation of the former opencast mine.

1. Geographical characteristics of research area

This area is situated about 3 km northeast of Most town between Redhill (365 m) and Sharphill (399 m) in Strimická dump space, which is east of the border of closed lignit opencast mine Most. The dump is outside the Most mine and is composed of piled sand and gravel, loam and clayey sands. It had been used since 1959 till 1973. The thickness of layers scattered on the original ground is between 17 and 48 meters. From the point of view of suitability for recultivation these materials are of very adverse composition, in some parts even phytotoxical. The present ground is represented by an elongated 150 m deep rest pit. It is approximately 3 km long and 2 km wide. The inclination of the upper part of the eastern slope (Strimice dump) is about 30°. The middle part is quite flat but slightly uneven. The lower part is abruptly descending to the mine. The western slope is represented by the former quarry crag (face) (Balej, 2004).

The investigation site is in the area of warm climate T2 (after Quitt, 1972). The Kopisty meteorological station is working in its immediate neighbourhood. This is a professional station of the Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic. Other objects in the surrounding area are: pluviometric stations in Bílina and Litvinov (in Most and Duchcov in the past).

From the point of view of hydrogeography the primary space belonged to the Bilina river basin. Today the area is anthropogenically totally modified and is ultimately different from the original one. The surface of the mine pit is unnaturally drained. The average annual precipitation in the Kopisty station is about 445 mm. It is deep under the republican average (720 mm). It has been steadily reducing in the last ten years. This territory is the driest one in Czechia. The average annual temperature is, on the contrary, getting up and today is 8.76°C. It is about 0.25°C higher than in 1901–1950. The dominant wind directions are NW or SW (windless days account for 29%). The average wind velocity is 2 m/s. The winds are predetermined by the general situation over the republic and by the local relief.

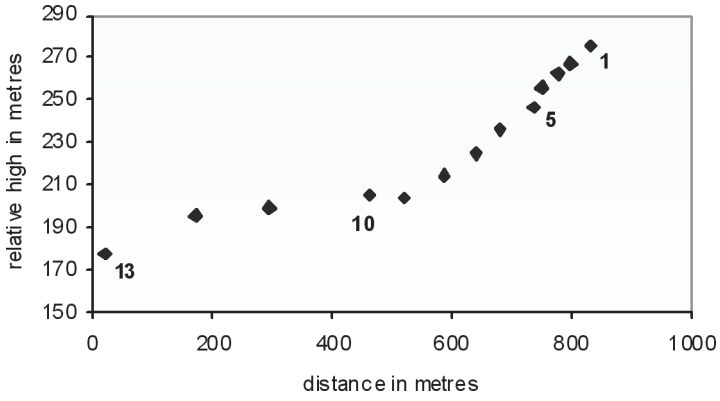

Fig. 1. Position of measuring points on the slope of Strimicka dump. From up to down 1 – start, 2 – slope, 3 – way 1, 4 – way 2, 5 – under slope, 6 – between ways, 7 – birch, 8 – cable, 9 – sleeper, 10 – iron, 11 – reed, 12 – pit edge, 13– pit.

1 pav. *Matavimo taškai Strimicka'os grunto sąvartyne. Nuo viršaus žemyn: 1 – aikštelė, 2 – šlaitas, 3 – 1-mas takas, 4 – 2-as takas, 5 – šlaito papėdė, 6 – tarp takų, 7 – beržai, 8 – trosas, 9 – skersinis, 10 – geležis, 11 – nendrės, 12 – karjero briauna, 13 – karjero dugnas.*

13 observation places were selected for the evaluation for microclimatological situation in the dump slope and rest pit. It was determined by estimated condition of vegetation in %, gradient of slope – by gradient protractor, temperature was measured by digital thermometers also using humidity sensor, wind speed – by anemometer, and wind direction – by small hand flag. Measuring was made each hour from the sun rise to late afternoon on some October days of 2000 under anticyclonic sunshine conditions.

2. Measuring results

The rest pit and the slope of dump over it, thanks to its western orientation, create today their own thermal and wind regime.

Weak inversion of temperature was determined in the morning of the first day of measuring (at night the slope radiated heat and the cool air flew down to the pit). Further in the morning the temperature inversion intensified owing to slope orientation, its height, the height of the Sun over the horizon, and cloudy sky. Later on the pit was warmed up by the Sun and the temperature inversion disintegrated. Not until about 16 o'clock (summertime ST, it is 15 MET, 14 GMT), the temperatures on slope were in balance. After 17 o'clock (ST) it was warmer in the pit than on the high slope edge. Strong dew appeared on this and the following day. Drying of the slope surface set in only at 11 (ST) o'clock. It shifted the value of temperature below that on the previous day. The relative humidity values followed the classical temperature patterns. Certain differences were caused by the quality, vegetation and water capacity (someplace up to water logging) of active surface. In general the relative water content of the slope was low (the maximal value – 40–50%). The wind circulation was influenced by the form relations. The upper edge of the dump slope and the adjoining layer of the atmosphere over the pit corresponded to general wind relations in the region. The situation was documented by the data of Kopisty meteorological station. A different situation could be observed inside the pit. There were two wind circulation systems:

1) The circulation predetermined by the general situation outside the pit;

2) The local wind circulation on the slope, which was a result of temperature and pressure relation. We must accept the form differences on the slope too. Wind relations are more complicated and it is necessary to make additional measurements under various weather conditions. The wind movement in the near-surface layer is likely to be partly influenced by growth. There is a question if this wind movement is not the cause of the strong land drainage limiting the habitat conditions for some kinds of growth. This hypothesis could be proved by more detailed measurements.

3. Interpretation of cluster analysis

All data of measurements was processed by statistical program SPSS.

Results:

1) Cluster of points 9, 10, 11 is logical expression of plateau situation, which is found between slope of the dump and the pit. This area has distinctive vegetation, composed of modest grasses (*Calamagrostis epigeos L*.).

2) Cluster of points 1 and 2 is different from the others. It is up the edge of the slope and the conditions there are quite different from the rest of the dump slope. It is suggested by growth.

3) Cluster of points 5 and 6 is a kind of border between the slope of dump and plateau with continuation to pit.

4) Separate position of point 13 suggested a different situation in the rest pit. Unfortunately there were no technical means to make measurements down to the pit. The assessment results suggested that the habitat conditions for growth on the slope from up edge to the pit bottom on so short a distance (850 m) bore significant differences. It should be taken into account in case of restoration of the whole slope. This pit will be hydrologically restored but not the whole territory. Optimal proof is necessary for restoration to the level of position 7 or 8, with maximal variation point 6.

The assessment of separate incoming characteristics brought rather interesting yet logical results.

1) There exists a direct relation between the water content of the slope and the plant cover;

2) The incline of the slope is in relation with wind velocity;

3) Wind direction is practically in no relation with any other components (it was changing on the slope without evident continuity)

4) Incline of slope and wind speed were in relation. This is a display of breeze circulation.

Besides the cluster analysis it is possible to make other statistical analysis as, for instance, factor analysis. This analysis has shown linkage of growth, incline and humidity. This logical connection is evident in the terrain and supports the cluster analysis assessment.

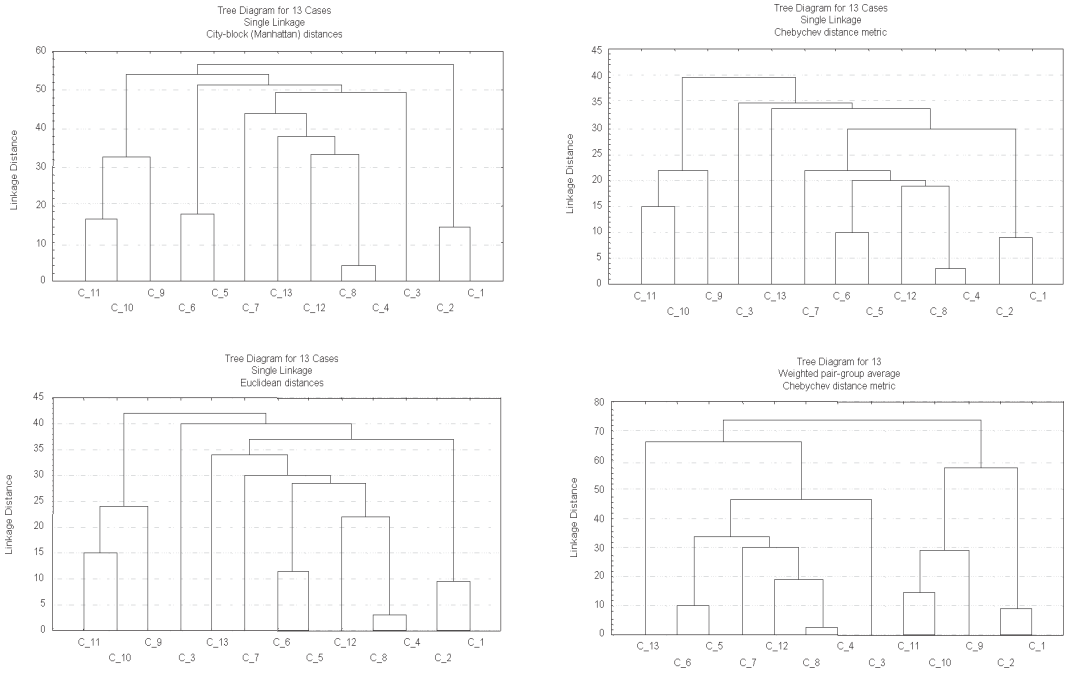

Fig. 2. Some results of cluster analysis.

2 pav. *Kai kurie klasterinės analizės rezultatai.*

Conclusion

Our countryside is under an intensive anthropogenic load, which is not apparent on the first sight. Some information is unavailable. It is possible to use in addition the classic methods of statistical multifactor analysis. This method can reveal some connections in the internal structure. This example documents the possibility of cluster analysis. This method

lies at the basis of dividing the slope of Stųimickį dump by Most in the Northern Czechia using the data of climatic measurements. The boundaries between characteristic belts were established. The first distinguished belt was the upper edge of the slope with climatic situation as in the neighborhood of the opencast mine. It was followed by the middle part with its own climatic situation and the other different part of slope. This result can be practically used for redeeming of this area.

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Čekijos Most regiono rusvųjų anglių kasyklos (karjero) rekultivacijos teritorinė diferenciacija

Santrauka

Šiandien pasaulyje beveik nelikę žmogaus veiklos nepaliestų teritorijų. Tai pasakytina ne tik apie pažeistas, bet ir apie rekultivuotas žemes. Tokia didžiulė teritorija yra netoli Most miesto Šiaurės Čekijoje. Nustojus kasti rusvąsias anglis, šį plotą rekultivuoti, jį pritaikyti kitokiam naudojimui. Dabartinis šio regiono kraštovaizdis iš esmės skiriasi nuo buvusiojo. Rusvosios anglys atviruoju būdu buvo intensyviai kasamos Šiaurės Čekijoje nuo pirmosios XIX a. pusės. Didžiausia žala regiono kraštovaizdžiui padaryta devintajame XX a. dešimtmetyje, kai kasybos našumas buvo didžiausias (1985 m. – 70 mln. t).

Buvusi nuosėdinė lyguma šiandien virtusi 150 m gylio, 3 km ilgio ir 2 km pločio karjeru su grunto saugykla (Strimická) viršuje. Jo šlaitų maksimalus nuolydis neviršija 30º. Klimato atžvilgiu – tai šiltas ir sausas regionas (Kopisty meteorologijos stoties duomenimis, vidutinė temperatūra – 8,76ºC, kritulių kiekis (455 mm) daug mažesnis už respublikos vidurkį (720 mm)). Vyrauja ŠV ir PV krypčių vėjai. Ramių dienų būna 29% per metus. Vidutinis metinis vėjo greitis – >2 m/s. Vėjo kryptį lemia bendra respublikos geografinė padėtis ir vietos reljefas. Anksčiau visa Most kasyklos teritorija priklausė Bilinos baseinui. Šiandien ši teritorija neturi nuotėkio, todėl ateityje virs dideliu dirbtiniu ežeru. Dirvožemiai ir biogeografinė situacija taip pat labai pakitę.

Matavimo rezultatai.

Mikroklimatiniai stebėjimai buvo atlikti 13-oje šlaito taškų (1 pav.) Karjero ir aukščiau esančios grunto saugyklos šlaitas orientuotas į vakarus ir pasižymi savitu terminiu ir vėjo režimu. Rudenį šlaitui būdingos temperatūros inversijos.

Klasterinės analizės (2 pav.) rezultatų interpretacija:

1) 9, 10 ir 11 taškai yra loginė plynaukštės, esančios tarp grunto saugyklos šlaito ir paties karjero, išraiška;

2) 1 ir 2 taškai skiriasi nuo kitų. Jie žymi šlaito viršutinę dalį, kurios specifines sąlygas atspindi augalijos danga;

3) 5 ir 6 taškai žymi ribą tarp grunto saugyklos šlaito ir plynaukštės, kuri pereina į karjerą;

4) ypatinga 13 taško padėtis rodo kitokias sąlygas karjere. Gaila, kad atlikti matavimus pačiame karjere nebuvo techninių galimybių.

Ištirta, kad trumpoje atkarpoje (850 m) nuo šlaito viršaus iki karjero dugno augaviečių sąlygos gerokai skiriasi. Į tai būtina atsižvelgti atkuriant šlaitą. Hidrogeologines sąlygas galima atkurti tik dalyje karjero. Optimaliai tai galima padaryti iki 7 ar 8 taško. Esminiai pokyčiai būdingi 6 taške.

Remiantis darbo rezultatais galima daryti tokias išvadas:

1. Tarp šlaito vandens režimo ir augalijos yra tiesioginis ryšys.
2. Taip pat egzistuoja ryšys tarp šlaito polinkio ir vėjo greičio.
3. Vėjo kryptis faktiškai nuo jokių šlaito veiksnių nepriklauso (ji kinta visame šlaite vienodai, t.y. be akivaizdaus dėsningumo).
4. Tarp šlaito nuolydžio ir vėjo greičio yra ryšys, išryškėja silpna oro cirkuliacija.

Klasterinė analizė gali būti papildyta faktorine statistine analize. Ji suteiktų naujos informacijos apie ryšį tarp šlaito augalijos, nuolydžio ir drėgmės režimo.

Taigi remiantis klimato parametrų klasterinės analizės rezultatais buvo išskirtos būdingos buvusios rusvųjų anglių kasyklos (karjero) šlaito juostos: 1) viršutinė šlaito dalis, kur klimato sąlygos yra tokios pat, kaip ir gretimoje teritorijoje, 2) vidurinioji dalis su specifinėmis klimato sąlygomis ir 3) kita šlaito dalis. Praktikoje tyrimo rezultatais galima remtis keičiant teritorijos paskirtį.