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MORPHOLOGICAL VARIABILITY OF THE BROME GRASS: APPLICATION FOR NONSPECIFIC BIOMONITORING OF URBAN ANTHROPOGENIC IMPACT

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Abstract: *We have studied 6 grass species in 100 locations of southeastern Ukraine. We have succeeded to establish almost unity correlation of one specific trait's variability modulus for Anisantha tectorum with official data on emissions of some industrial enterprises. This finding has enabled us to draw ecological maps of the region and city, which generally coincide with the published ones but additionally show some formerly unknown features. A very good correlation between this trait variability module and total pollution emission rate enables estimating the anthropogenic impact in virtually any populated place in the Earth.*

Keywords: variability, morphological traits, brome grass, biomonitoring, anthropogenic impact

INTRODUCTION

Using bioindicators to estimate the environment condition is among most popular approaches last years (Herricks, Schaeffer 1985; Hock, Seifert 2003; Ritz et al. 2009). However bioindicators are very numerous. Besides, most known methods are specific or non-universal. A number of only elementary chemicals detectable using biomonitoring exceeds two hundreds (Paustenbach, Galbraith 2006), and hence the total specific biomonitoring appears as a long-term and expensive campaign, which nevertheless hardly ensures the exhaustive scope of all known and unknown active factors. In this connection, non-specific or partially specific methods such as monitoring air or soil quality gradually become prevailing (Fränzle 2006; Ritz et al. 2009; Styers et al. 2010). Main purpose of this work was to study most widespread grass plants that could be used for non-specific phytomonitoring of the anthropogenic environment.

METHODOLOGY

We have studied 6 grass species in 100 locations of southeastern Ukraine and Donetsk city with different pollution extent from Meotida National Park (the reference point) to waste piles of steelmaking plants and coal mines. A sample size in each location was sufficient to reveal significant difference in every morphological trait. Several morphological traits for each species were quantified.

Collected raw data array included many thousands of numerical values. It was first subjected to complex statistical analysis in order to reveal significant and simultaneously indicative variations and discard non-significant or non-indicative species or traits. First stage of the analysis was based on statistical treatment of whole plants. It included calculation and comparison of morphological divergence coefficient and phenotypic flexibility index for each species in ecologically different locations (ecotopes). Second stage consisted in the variance and factor analysis for individual traits of selected species.

Then data on traits found significant and indicative or, in other words, ecologically sensitive, were juxtaposed where possible with recently published data on the instrumentally measured total pollutant emission (Tretyakov, Averin 2007). The trait showing the highest correlation was selected as a primary one and few other traits as supplemental ones.

Finally the primary trait was used to draw ecological maps of the region and city. To do this, all tested locations were positioned in respective digital maps using true geographical coordinates and characterized by a variability modulus derived from the primary trait normalized by the reference value. Contour plots were created using krigging as a spatial analysis technique.

RESULTS

Preliminary complex statistical analysis had shown that *Iva xantiifolia* is less ecologically sensitive due to lowest divergence coefficient while *Conyza canadensis* and *Gypsophila paulii* are less generally sensitive due to low phenotypic flexibility index. Besides, *Conyza canadensis* as well as *Senecio jacobaea* reveal quite low variability of the morphological traits (see table 1). Further studies were therefore conducted with *Anisantha tectorum* and *Capsella bursa-pastoris* as most significant and ecologically sensitive omnipresent bioindicators.

Correlation between the relative variation coefficient defined as the variability modulus and annual pollutant emission for two most indicative phenotypic traits is graphically presented in fig. 1. Number of data point here is strongly limited by coincidence between published and sampled locations. Nevertheless, it is seen that the primary trait, lower chaff length variance of *Anisantha tectorum*, shows a very good linear dependence with correlation factor about 0.95. Secondary trait, blossom cluster length variance of *Capsella bursa-pastoris*, shows probably non-linear dependence with linear correlation factor about -0.79.

Tab. 1: Summary of sampled plant species and results of statistical analysis

Plant species	Trait Q-ty	Divergence coefficient	Flexibility index	Max. trait variability	Indicator role
Anisantha tectorum (L.) Nevski	11	2.55	0.278	0.480	+
Capsella bursa-pastoris (L.) Medic	12	3.35	-0.228	0.582	+
Conyza canadensis (L.) Cronq.	18	1.97	0.032	0.366	–
Senecio jacobaea L.	17	2.89	-0.637	0.362	–
Iva xantiifolia (Nutt.) Fresen.	11	1.63	0.143	n/a	–
Gypsophila paulii Klokov	11	3.02	-0.034	n/a	–

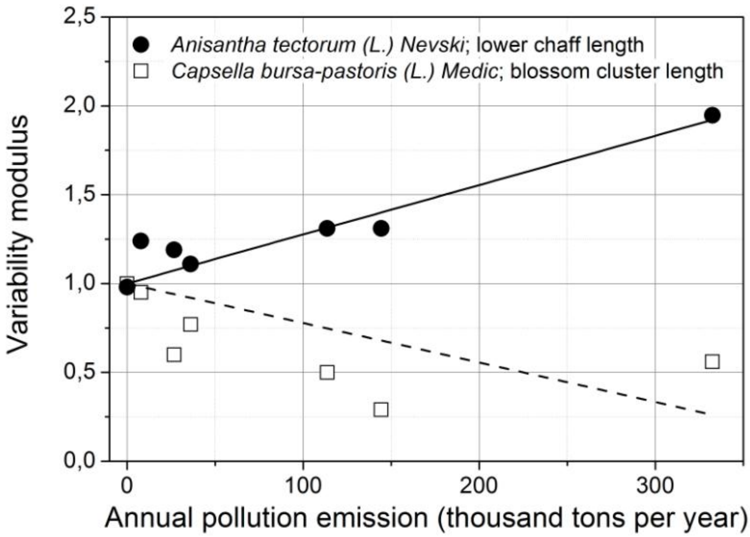

Fig. 1: Summary of sampled plant species and results of statistical analysis

Ecological maps of Donetsk city and Donetsk region were drawn as krigging contour plots on simplified digital geographical maps using the variability modulus for lower chaff length of *Anisantha tectorum* as variable Z. These maps are shown in fig. 2. Those industrial enterprises which are largest environment polluters according to Tretyakov and Averin (2007) were mapped on these plots for comparison. It was empirically found that the most informative pattern is resulted in one-color palette with limited mixing at the number of major levels close to 10 and smoothing parameter about 0.01.

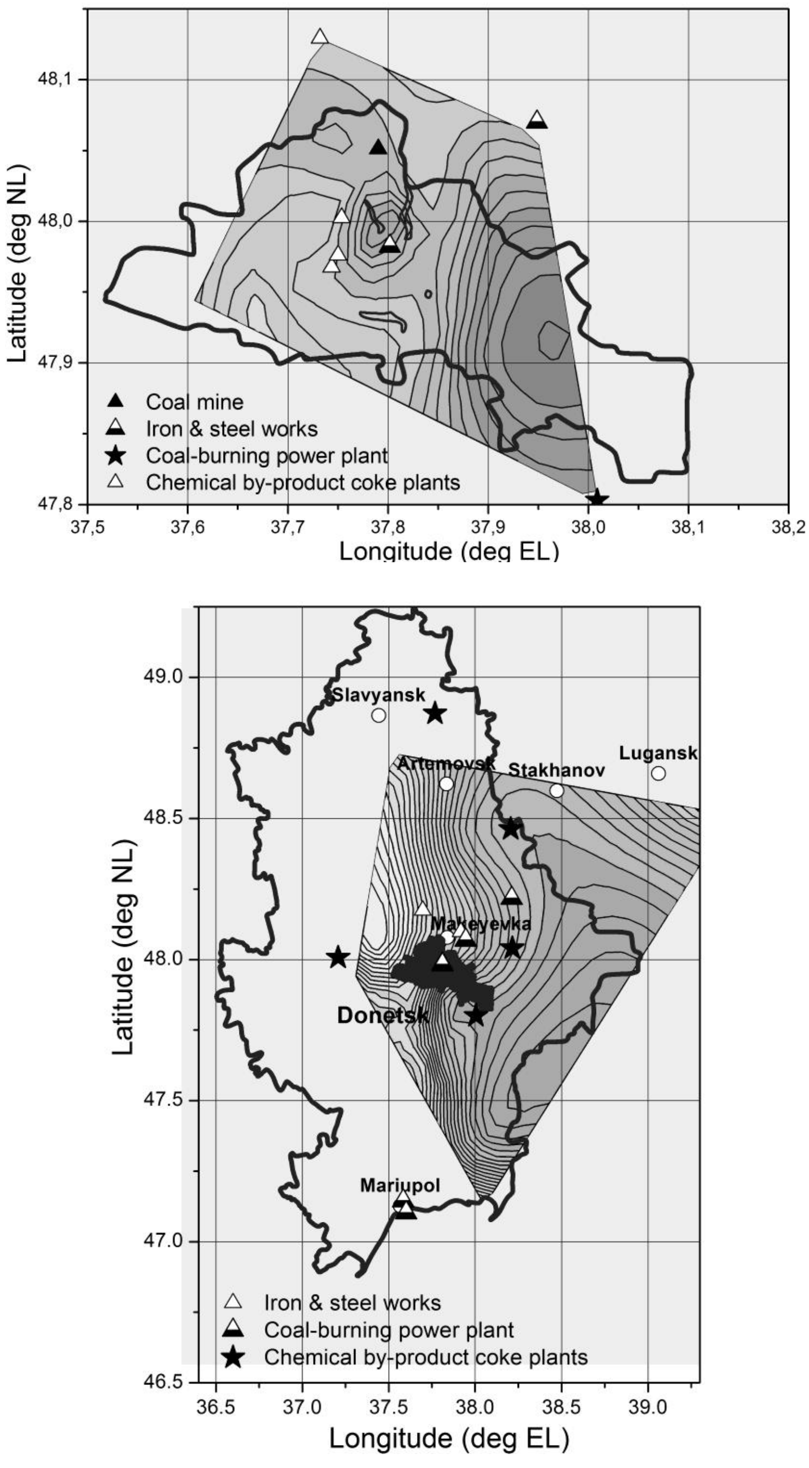

Fig. 2: Ecological maps of Donetsk city (upper plot) and Donetsk region (lower plot)

DISCUSSION

Effective land management, both urban and rural, requires the ecological risk assessment including anthropogenic impact. At present such assessment is made using ecological zoning based on theoretical calculations supplemented by random instrumental analysis. An example of similar approach is air pollution maps for Donetsk city, which can be found at the Donetsk ecological portal (www.doneco.org.ua). They indicate only some excess of air pollutant content in central part of the city obviously related with Donetsk Iron & Steelmaking Works as well as transport.

The present results generally coincide with the published ones but additionally show some formerly unknown features. First, coal mines, reckoned among highest air polluters with methane, quite moderately contribute to the total amount, although a little spot can be found towards northwest from Zasyadko mine. Second, free of large enterprises southeastern districts appear highly polluted as contrasted to northeastern industrial zone. Comparing the urban map with the regional map in fig. 2, one can conclude that this unexpected phenomenon is caused by out-of-town effect of coal-burning power plant. Third, all visible pollution centers are displaced by several kilometers towards northwest from intended polluters due to probably the dominant wind direction. As seen in the regional map, power plants are the main environmental polluters.

It can be assumed that the plants respond generally on sulfur and nitrogen oxides and derivative acid rains as main pollutants. These compounds pollute air as well as soil and water. In view of fast redistribution they hardly could be monitored using random chemical analysis.

CONCLUSION

Proposed method of phytomonitoring per se is simply interpolation of annual pollutant emission in polluter's locations into remote locations based on linear correlation in fig. 1. This method is non-specific, although further studies can establish particulate active agents. The method is low-cost and very simple. Specific details of implementation are patented by authors (Kharkhota et al. 2008). It can be applied in almost any populated place in Earth in any desired scale from whole planet to private allotment in both urban and rural areas. In addition to ecological monitoring of anthropogenic impact, the method can be used to study climate changes, natural ecology, etc.

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