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TARAXACUM OFFICINALE F. H. WIGG – BIOINDICATOR OF HEAVY METALS CONTAMINATION IN PARK ECOSYSTEMS

TARAXACUM OFFICINALE F. H. WIGG – БІОІНДИКАТОР ЗАБРУДНЕННЯ ПАРКОВИХ ЕКОСИСТЕМ ВАЖКИМИ МЕТАЛАМИ

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The use of *Taraxacum officinale* F.H. Wigg. as a bioindicator for assessing the state of park ecosystems is due to its wide distribution and high sensitivity to environmental pollution factors [1, p. 129113].

The aim of the research was to estimate the impact of recreational load and technogenic pollution on the ecosystems of the Feofaniya Park of Landscape Art Monument (Kyiv, Ukraine) based on a comprehensive analysis of the parameters of spectral reflection characteristics and the content of heavy metals in the leaves, roots of T. officinale and in soils from selected park localitions.

Previously, *T. officinale* was successfully applied for develop an express method for diagnosing and assessing the degree of man-made impact on the ecological state of park areas in Kyiv using the example of three parks: Feofaniya Park, the Park of the Kyiv Polytechnic Institute, and the Mariinsky Park [2, p. 38; 3, p. 116; 4, p. 421; 5, p. 74–82; 6, p. 1; 8, p. 120–141].

This study was carried out in 16 localities of the Feofaniya Park, located at different altitudes above sea level and with different slope angles (Fig. 1). Changes in spectral reflectance indices in *T. officinale* leaves were studied. In each locality, 5 root and soil samples from the root-containing layer (0–5 cm) and 30 leaf samples were taken.

Measurements of the spectral reflectance characteristics of leaves were performed using a field portable spectroradiometer ASD FieldSpec® 3FR (USA) with a working spectral range from 350 to 2500 nm. Data from 10-fold measurements of each leaf were automatically averaged by software, and the result was used to calculate spectral reflectance coefficients – SRC (or R) and vegetation indices.

The content of heavy metals Pb, Cd, Ni, Cr, Co in soil samples, leaves and roots was measured by inductively coupled plasma mass spectrometry on an ICP-MS Element-2 analyzer (Germany).

Localities	Latitude, N	Longitude, E	Altitude above the sea level, m
1	50°20'24.43"	30°28'58.45"	172
2	50°20'25.22"	30°29'04.04"	163
3	50°20'26.20"	30°29'08.75"	155
4	50°20'23.47"	30°29'16.13"	145
5	50°20'21.30"	30°29'24.45"	137
6	50°20'19.75"	30°29'10.25"	130
7	50°20'21.50"	30°29'29.89"	151
8	50°20'17.74"	30°29'18.02"	141
9	50°20'12.81"	30°29'20.38"	139
10	50°20'10.29"	30°29'23.55"	129
11	50°20'07.99"	30°29'28.93"	136
12	50°20'13.57"	30°29'28.67"	133
13	50°20'31.17"	30°29'14.49"	143
14	50°20'35.46"	30°29'35.47"	160
15	50°20'46.01"	30°29'36.26"	185
16	50°20'53.16"	30°29'22.87"	182

Fig. 1. Location and coordinates of *Taraxacum officinale* sampling sites in Feofaniya Park

Among the variety of vegetation spectral indices based on the analysis of literature and own data [7, p. 3–26], the most informative ones were selected:

– *NDVI* = $(R_{800}-R_{670})/(R_{880}+R_{670})$ – *normalized vegetation index;*

– *RVI* = R_{800}/R_{670} – *normal vegetation index;*

– *mSR705* = $(R_{750}-R_{445})/(R_{705}+R_{445})$ – *modified index of the normal Red Edge ratio;*

– *HM contam.* = $(R_{630}/R_{690})/(R_{520}/R_{600})$ – *heavy metal contamination index;*

– *NRDI* = $(R_{780}-R_{740})/(R_{780}+R_{740})$ *Normalized Difference Red Edge index;*

– *GNDVI* = $(R_{740}-R_{560})/(R_{740}+R_{560})$ – *green normalized difference vegetation index;*

– *REP* = $700+40(\frac{R670+R780}{2} - R700)/R740-R700$ – *Red Edge Position index.*

To assess the accumulation activity, we calculated the accumulation coefficients, which are equal to the ratio of the metal content in the leaves (roots) to the content of this metal in the soil – CA*l/s* and CA*r/s*, respectively.

The Pb content in leaves from different locations in the park ranged from 0.379 to 1.597, while in the roots this content was higher and varied from 1.477 to 4.882 mg/kg dry mass. For Pb CA*l/s* was always less than 1, and ranged from 0.054 to 0.182, while the activity of Pb absorption by roots was higher and CA*r/s* ranged from 0.25 to 1.27. The Cd content in leaves ranged from 0.041 to 0.12 mg/kg d.m., CA*l/s* – from 0.765 to 2.239. In roots, the Cd content ranged from 0.053 to 0.205 mg/kg d.m., and CAr/s – from 0.961 to 3.278. The Ni content in the leaves ranged from 0.25 to 5.599 mg/kg d.m., CA*l/s* – 0.039 to 0.909. In the roots this content was significantly higher – from 4.578 to 15.111 mg/kg d.m., CA*r/s* – from 2.104 to 8.520, which indicates a more active accumulation of this element by the root system of *T. officinale* than by the leaves. The Cr content in the leaves ranged from 0.321 to 3.569 mg/kg d.m., and the CA*l/s* ranged from 0.016 to 0.134. In the roots, the Cr content was significantly higher – from 17.329 to 61.988 mg/kg d.m., and the CA*r/s* ranged from 22.27 to 104.54. The content of Co in leaves was in the range from 0.069 to 0.592 mg/kg d.m., and CA*l/s* was in the range from 0.061 to 0.707. The content of Co in roots was also higher than in leaves – from 0.547 to 1.965 mg/kg d.m., and CA*r/s*, respectively, also – from 0.349 to 1.263.

Estimation of the obtained data showed that the highest levels of heavy metals contamination of soils were found in localities 13 (near garage farming) and 12 (near the embankment, between lakes 4 and 5), while the highest metals contamination of roots and leaves were found in localities 12, 6 (near the embankment, between the third and fourth lakes), 1 (near the parking lot at the entrance to the park) and 16 (the roadside near the entrance to the Panteleimon Monastery). This is explained, in the first two cases, by the accumulation due to the transfer of HM through surface runoff from elevated areas of the park to the lower areas near the lakes, in the third and fourth – due to the intensity of vehicle traffic near the monastery and the proximity to the Ring Highway. However, apparently, the accumulation levels of heavy metals in the roots and leaves of *T. officinale* also depend not only on the total concentration of these metals in the soils from the sampling sites, but also on the available, primarily water-soluble fractions. It should also be noted that the spatial distribution of the accumulation of HM in the "leaves – roots – soil" system may be associated with the features of the ravine-beam relief of the Feofaniya Park.

Maps of the spatial distribution of heavy metals were constructed with the *GIS package Golden Software Surfer 19.2.213* using the kriging method and *QGIS 3.16.3*. A map of the distribution of Pb content in soils of Feofaniya Park is presented on Fig. 2. The highest values were found in the locality 13.

The multivariate analysis showed a high level of correlation (0.62–0.90) between the vegetation indices we selected: *NDVI, RVI, mSR705, HM contam., NRDI, GNDVI, REP* and the content of Pb, Cd, Ni, Cr, Co in *T.officinale* leaves.

Fig. 2. Map of the distribution of Pb contamination in soils from *Taraxacum officinale* sampling sites in Feofaniya Park

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