The potential of the Phytotoxkit microbiotest for toxicity evaluation of sediments in eutrophic freshwater ecosystems

The study was conducted on sediments collected from the dam reservoir of Turawa (southwestern Poland). Turawa reservoir was built on the Mała Panew river in 1934. For years, it has been subjected to pollution by domestic sewage from surrounding tourist resorts and industrial effluents containing heavy metals. Consequently, in the last decade severe blue-green algal blooms developed during summer seasons, among others.

The objective of the present work was to assess:
- the contamination of sediments in the eutrophic reservoir
- the potential phytotoxic effects of contaminated (fresh/dried) sediments

The study provides an assessment of phytotoxicity using the Phytotoxkit microbiotest and different methods of a sample treatment.

### Materials and methods

Sediment samples were collected from three stations (T1-T3), which were selected to reflect various degrees of contamination.

Physico-chemical analysis included basic properties of sediments (grain-size composition, pH, EC, organic carbon, and potassium content) as well as heavy metals (Cd, Cr, Cu, Ni, Mn, Pb, Zn) content both in dried sediments and pore water. The analyses were performed according to Polish Standards.

Evaluation of sediment phytotoxicity was based on germination and seedling growth of three vascular plants: *Sorghum saccharatum* (monocotyledon), *Lepidium sativum* (dicotyledon) and *Sinapis alba* (brassica). Both end points of the analysis were combined in a germination index (GI), according to the equation: GI = (Gs/Ls) / (Gc/Lc), where Gs and Ls are seed germination (%) and root elongation (mm) for the sample; Gc and Lc the corresponding control values.

Phytotoxicity test was performed as:
1. whole fresh sediments, only after decantation of overlying water
2. solid phases of sediments, after centrifugation and drying
3. liquid phases of sediments (sediment pore water)

### Results of the physico-chemical analysis

Sediment samples differed in their chemical composition. The content of organic carbon, potassium, and heavy metals increased towards the dam (from site T1 to T3).

Though dried sediments were metal-rich, the concentration of heavy metals in sediment pore water was extremely low in all analyzed samples. The same rule applies to the potassium content, which ranged in pore water from 5.53 to 6.41 mg dm⁻³ (common amount in surface waters).

### Results of the phytotoxicity analysis

Sediment samples treated in their chemical composition as fresh or dried, however surprisingly, monocotyledonous and dicotyledonous plants responded adversely to the applied sediments.

### General remarks and conclusions

Differences in sediment characteristics can be very important modifiers of bioavailability/toxicity of contaminants. The results suggest beneficial effects may occur in hazardous areas, such as toxicity of heavy metals, when sediments are nutrient-rich (potassium being a stimulating factor for root growth) and in the neutral pH conditions. In the acidified conditions (sediments with pore water of pH 5.85), heavy metals readily soluble from the sediments were toxic to all plant species.

The three plant species responded differently to contaminated sediments, in both analyzed variants, which may result from their physiological mechanisms for adaptation to stress factors. Thus, the probability that one of the species used in the Phytotoxkit microbiotest will react to environmental pollution, changeable in its toxic nature, is very high.

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### Table: Heavy metals in sediments from Turawa reservoir (mg/kg dry mass)

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Mn</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>60.56</td>
<td>18.32</td>
<td>38.77</td>
<td>326.60</td>
<td>18.37</td>
<td>131.47</td>
<td>1338.0</td>
</tr>
<tr>
<td>T2</td>
<td>168.00</td>
<td>25.95</td>
<td>80.00</td>
<td>540.50</td>
<td>26.00</td>
<td>215.75</td>
<td>2920.6</td>
</tr>
<tr>
<td>T3</td>
<td>279.86</td>
<td>36.75</td>
<td>105.06</td>
<td>940.30</td>
<td>36.61</td>
<td>312.19</td>
<td>4772.0</td>
</tr>
</tbody>
</table>

Heavy metals in pore water (mg/l dm⁻³)

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Mn</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-T3</td>
<td>&lt;0.001</td>
<td>&lt;0.002</td>
<td>&lt;0.004</td>
<td>0.002-0.08</td>
<td>&lt;0.003-0.05</td>
<td>0.004-0.08</td>
<td>0.004-0.087</td>
</tr>
</tbody>
</table>

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### Tables: Granulometric composition of sediments

- **Whole fresh sediments**
- **Solid phases of sediments**
- **Liquid phases of sediments**

### Figures: Maps of sampling locations in Turawa dam reservoir

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### Figures: Germination index (GI) values (% of control) and effects of plant reaction

- **no effect**
- **stimulation**
- **inhibition**

### Figures: Basic physical and chemical properties of sediments in the collected samples

- **Organic carbon content in sediments (%)**
- **Potassium content in sediments (mg/kg dry mass)**

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### Figures: Adverse effects obtained after plant exposure to the whole fresh sediments

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### Figures: Sediment pore water - growth inhibition

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### Figures: Sediment pore water - growth stimulation

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