Temporal variability of *Achnanthidium minutissimum* (Kützing) Czarnecki and its relationship to chemical and hydrological features of the Tornastraum, Hungary

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**SUMMARY:** Establishment of indicator values of species used in any kind of environmental quality assessment system has been of essential importance. This need is increased in case of species that are abundant. *Achnanthidium minutissimum* has been, inevitably, one of the most frequently occurring diatom species all over Europe. Some authors list it as r-strategist aquatic weed that indicates disturbed environment. The aim of our study was to analyze the temporal distribution of *A. minutissimum* in relation to physical and chemical parameters and to evaluate the data on basis of the existing diatom indices. In 2004-2005, diatom samples were taken biweekly and water samples for chemical analyses were collected once a month in the Torna-stream, W-Hungary. The diatom assemblages showed marked seasonal distribution, and the relative abundance of the *A. minutissimum* also varied throughout the year. We could find no clear correlation between the relative abundance of the *A. minutissimum* and either the fluctuation of the nitrogen and phosphorus forms or the major ions. Instead, there was significant correlation with Si content of the water which correlated with the seasonal changes of the discharge. The relative abundance of the *A. minutissimum* showed significant positive correlation with three diatom indices (IBD, EPI-D, TDJ): the higher abundance of the species resulted in better water quality. Against the IPS index (which is recommended to apply for ecological status assessment of Hungarian streams) we did not find significant correlation, consequently this index does not use the *A. minutissimum* as a potential indicator species.

Based on the data we conclude that the discharge-dependent Si content of the streamwater and the r-strategy of the species determine the distribution of the *A. minutissimum*; it typically reaches higher dominance after flood periods and therefore indicates natural disturbances. Since flooding is a natural phenomenon existing also in reference state, the species’ abundance can not be used to assess the antropogenic impacts. According to most diatom sampling protocols for WFD qualification, periods after floods should be avoided. In this view we may conclude that high contribution of *A. minutissimum* in any sample may indicate a preceding flood and therefore such samples do not provide a reliable basis for ecological status assessment.

**INTRODUCTION**

Establishment of indicator values of species used in any kind of environmental quality assessment system has been of essential importance. This need has been even more pronounced in case of species that are abundant. *Achnanthidium minutissimum* has been defined as freshwater species (Cholnoky, 1968; Patrick and Reimer, 1966). Inevitably, it is one of the most frequently occurring diatom species all over Europe with broad ecological spectrum (Round, 1991; Krammer and Lange-Bertalot, 1991-2000). The reasons of its wide distribution are manyfold, e.g. light adaptation (Barreto et al., 1998), shade tolerance (Villanueva and Albarino, 1999), strong attachment to stalks of arborescent diatoms (Roemer et al., 1984) in which respect it does not have special demands (Antoine and Benson-Evans, 1986). Some authors list it as r-strategist aquatic weed that indicates either physically, chemically or by biologically disturbed environments (Stevenson and Bahls, 1999). Fore and Grafe (2002) used its disturbance tolerance in their river diatom index. Later Ács et al. (2004) also applied this feature in assessment of ecological status of streams. Another study (http://deq.mt.gov/wqinfo/monitoring/SOP/pdfs/12-1-2-0.pdf) demonstrated its dominance both in polluted and pristine streams and if the relative abundance of this species exceeded the 3% it was excluded from the further analysis. The species is tolerant to metals (Denisseger et
al., 1986; Takamura et al., 1989), however, its abundance is decreasing along increasing salinity gradient (Herbst and Blinn, 1998).

The main aim of this study was to analyse temporal distribution records of *A. minutissimum* in view of the above outlined characterization and in context of the existing diatom indices.

**MATERIAL AND METHODS**

In 2004-2005, diatom samples were taken biweekly from stones and water samples for chemical analyses were collected once a month in the Torna-stream, W-Hungary between September of 2004 and 2005. Torna-stream is a middle altitude stream with calcareous hydrogeochemistry and rough bedrock. It is 51 km long with slight slope (1-3‰); the catchment area of the stream is 498 km².

The water samples were stored in dark and 7°C for the further analyses. Conductivity and pH were measured by laboratory sensors (Radelkis, OK-102/1; MultiLine P3). Ca²⁺, Mg²⁺, K⁺, Na⁺, SO₄²⁻, Si were measured with ICP-OES (Optima 2000 ICP-OES). TP, PO₄³⁻, NO₃⁻, NO₂⁻ and NH₄⁺ were analyzed with spectrophotometry (Marczenko, 1976; Inczédy, 1996; Németh, 1998; Daniel and Pote, 2000). Cl⁻, SO₄²⁻ was determined by titration (Inczédy, 1996; Németh, 1998). Water discharge data were provided by the regional Water Authority.

Diatom samples were preserved in 3-5% formaline. Cold hydrogen-peroxide method was applied to clean the diatom valves that then were mounted in Zrax. Altogether 400 valves were identified and counted in each sample. Diatoms were identified at species level using light microscopy with phase contrast according manuals by Krammer & Lange-Bertalot (1991-2000), Lange Bertalot (1995-2002) and Krammer (2002). The counts were converted to relative abundance.

The diatom indices: TDI, GENRE, CEE, IPS, IBD, EPI-D (Kelly, 1998; Rumeau and Coste, 1988; Descy and Coste, 1991; Coste in Cemagref, 1982; Lenoir and Coste, 1996; Prygel and Coste, 2000; Dell’Uomo, 1996) and the diversity were calculated by the OMNIDIA 4.1 software (Lecointe et al., 1993). The correlation between two parameters followed the Pearson equation (Quinn and Keough, 2004):

\[
r_{y_1,y_2} = \frac{\sum_{i=1}^{n} [(y_{1i} - \bar{y}_1) (y_{2i} - \bar{y}_2)]}{\sqrt{\sum_{i=1}^{n} (y_{1i} - \bar{y}_1)^2} \sqrt{\sum_{i=1}^{n} (y_{2i} - \bar{y}_2)^2}}
\]

**RESULTS**

Altogether 75 species were identified in the 23 samples. Seasonality was the most striking characteristics of the diatom vegetation. In summer and autumn, *Navicula gregaria* Donkin, *Nitzschia palea* Kützing W. Smith, and in spring and summer *Surirella brebissonii* Krammer and Lange-Bertalot and *Fragilaria capucina* Desmazières var. vaucheriae were the most characteristic species of the stream. *Navicula lanceolata* (C. Agardh) Ehrenberg was the only species which was dominant throughout the year.

In the one year study period *Achnanthidium minutissimum* was one of the dominant species with >5% contribution to the total abundance. Its abundance was < 5% only in December and February 2004/2005. In spring and early summer it maintained a moderate, however, constant abundance. In the end of summer it started to increase then reached the highest relative

134
abundance in autumn. The Shannon-diversity changed between 1.2 and 3.93. It peaked in October (3.93 and 3.65). The diatom community was characterized by low diversity in winter then from the beginning of spring the compositional diversity increased (Fig 1a). No significant correlation was found between relative abundance of *A. minutissimum* and Shannon-diversity (Table 1).

![Graph showing relative abundance of *A. minutissimum* and Shannon-diversity](https://via.placeholder.com/150)

**Fig. 1a:** Relative abundance of *A. minutissimum* and Shannon-diversity; 1b: discharge and Si content 1c: changes of six diatom indices in the Torna stream during one year period

Different diatom indices exhibited different range of variation during the one-year study period (Fig. 1c). The IPS and TDI varied in the widest range (12.5 ± 1.64 and 76.8 ± 10.65), changes in the EPI-D was smaller (11.7 ± 0.98). Changes of GENRE, CEE and IBD (12.6 ± 0.75; 11.9 ± 0.8 and 13 ± 0.69, respectively) were moderate. The TDI In general, most indices showed minimum values in summer and the highest index values were found in autumn. Three of the applied indices (IBD, EPI-D and TDI) showed significant correlations with *A. minutissimum* (Table 1).

Discharge of the Torna-stream was quite constant from October to February. The raise in March was attributable to snowmelt. As a consequence of rainfall, discharge increased gradually from May to July then decreased. After high-discharge periods relative abundance of the species decreased gradually, while after the lower discharge the rate of *A. minutissimum* increased sharply. The Si concentration fluctuated quite parallel with *A. minutissimum* and it was the only chemical parameter which showed clear correlation (r = 0.54) with *A. minutissimum*. Similar correlation was observed between the species and the discharge of the stream (r = 0.56). There was no significant direct correlation between discharge and Si, however, if Si was lagged by two weeks the correlation was significantly positive (r = 0.82).

**DISCUSSION**

The relative abundance of the *Achnanthidium minutissimum* showed marked seasonal distribution in the calcareous Torna-stream. Moderate and constant abundance was observed in spring and early summer and it reached the highest relative abundance in autumn. This seasonal pattern was different from that in a Spanish calcareous stream where it reached the maximum in spring (Sabater, 1990). These results might be related to the observation that *A. minutissimum* is stimulated by exposure to UV radiation (Francoeur and Lowe, 1998). The species was also characteristic in other circumneutral streams with high buffering capacity...
(van Dam et al., 1994; Kovács et al., in press) as well as in alkaline boreal streams (Vilbaste, 2001). In contrast, in an acidic mountain stream the species was rare (Kwadrans, 1993). According to Peterson et al. (1998) this species is a typically grazer-resistant taxon which also can result in its the constant presence and dominance.

<table>
<thead>
<tr>
<th>relative abundance of A. minutissimum</th>
<th>significance level</th>
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<tbody>
<tr>
<td>PO${}_4^{3-}$</td>
<td>0.09</td>
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<tr>
<td>TP</td>
<td>0.10</td>
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<tr>
<td>NH$_4^+$-N</td>
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<tr>
<td>NO$_2^+$+NO$_3^-$-N</td>
<td>0.36</td>
</tr>
<tr>
<td>TN</td>
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<tr>
<td>K$^+$</td>
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<tr>
<td>Ca$^{2+}$</td>
<td>0.20</td>
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<tr>
<td>Na$^+$</td>
<td>0.13</td>
</tr>
<tr>
<td>Mg$^{2+}$</td>
<td>0.34</td>
</tr>
<tr>
<td>Si</td>
<td>0.54</td>
</tr>
<tr>
<td>SO$_4^{2-}$</td>
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</tr>
<tr>
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<td>TDI</td>
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<td>Shannon-diversity</td>
<td>0.29</td>
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<td>discharge</td>
<td>0.56</td>
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</table>

Table 1: Correlation and significance level between Achnanthidium minutissimum and physical - chemical parameters and diatom indices

In this study we did not find close correlation between the relative abundance of the A. minutissimum and either the fluctuation of nitrogen and phosphorus forms or the major ions. This observation accords to other studies that supported the species’ occurrence in streams characterized by a wide range of nutrient conditions (Carrick, 2005; Kelly et al., 1995; Verb and Vis, 2000). A. minutissimum correlated significantly with the Si content of the water which followed seasonal changes of the discharge. Groundwater-derived Si seeping results higher Si concentration (Hagerthey and Kerfoot, 2005); however, origin of high Si values needs detailed hydrogeological studies.

The relative abundance of the Achnanthidium minutissimum showed significant positive correlation with three diatom indices (IBD, EPI-D, TDI): the higher abundance of the species resulted in better water quality. Against the IPS index (which is recommended to apply for ecological status assessment of Hungarian streams) we did not find significant correlation, consequently this index does not use the A. minutissimum as a potential indicator species.

Based on the data we conclude that the discharge-dependent Si content of the streamwater combined with the good colonization abilities (r-strategy) of the species are the major factors that influence the temporal distribution of the Achnanthidium minutissimum. It typically reaches higher dominance after flood periods and therefore indicates natural disturbances. Since flooding is a natural phenomenon existing also in reference state, the species’ abundance can not be used to assess the anthropogenic impacts.

According to most diatom sampling protocols for WFD qualification, periods after floods should be avoided. In this view we may conclude that high contribution of A. minutissimum in any sample may indicate a preceding flood and therefore such samples do not provide a reliable basis for ecological status assessment within the WFD.
AKNOWLEDGEMENT

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