Ecological Indicators 75 (2017) 73–81

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

On the potential for terrestrial diatom communities and diatom indices to identify anthropic disturbance in soils

Marta Antonelli[a,b,*], Carlos E. Wetzel[a], Luc Ector[a], Adriaan J. Teuling[b], Laurent Pfister[a]

[a] Luxembourg Institute of Science and Technology, Department of Environmental Research and Innovation, 41 rue du Brill, L-4422 Belvaux, Luxembourg
[b] Hydrology and Quantitative Water Management Group, Wageningen University & Research, Wageningen, The Netherlands

ARTICLE INFO

Article history:
Received 29 July 2016
Received in revised form 4 November 2016
Accepted 2 December 2016
Available online 21 December 2016

Keywords:
Bioindicators
Environmental control
Hydrological tracers
Luxembourg (Attert basin)
Soil diatoms
Soil quality

ABSTRACT

A large amount of studies focuses on aquatic diatoms' ecology and their use in the assessment of water quality. Little is known about terrestrial diatoms' ecological behaviour and sensitivity to environmental factors. We hypothesise that terrestrial diatom communities can serve as a proxy of anthropic disturbance levels in terrestrial sites. To test our hypothesis, we apply an aquatic index to soil communities that is to deliver new information on the physiographic controls on soil diatoms. Diatom and soil samples were collected in the Attert River basin in Luxembourg during three seasons, in sites characterised by different combinations of geological, soil (schist, marl and sandstone) and land use (forest, grassland and agriculture) features. We found an effect of seasonality on soil diatom communities, reflected by different species dominance and abundances in samples during the three seasons. Soil pH and land use (which translates in a different amount of total carbon and nitrogen in soil) were identified as the variables having the largest impact in structuring the communities and as among the features with the highest importance in defining the ecological status of the sites (i.e. disturbed farmlands having higher pH and lower carbon and nitrogen content). However, the lack of information about the sensitivity of some of the most abundant terrestrial species in our study area caused some discrepancies between the expected (i.e. forested areas with low anthropic disturbance) and the obtained results, with several forested sites classified as having high anthropic disturbance. These results suggest that soil communities are likely to contain information about soil ecological status and highlight the importance of a better characterisation of terrestrial diatom species for developing a quality index based on soil communities.

1. Introduction

Aquatic diatoms are a biological indicator commonly used for assessing the ecological status of water bodies. Their sensitivity to multiple factors, among which organic and inorganic pollution, pH and salinity, is well documented (Prygiel and Coste, 1993; Kelly et al., 1995; Kwandrans et al., 1998; Gibson et al., 2006; Lobo et al., 2016). In order to estimate degradation levels of water bodies, several diatom-based indices such as the IPS (Specific Pollution Sensitivity Index; Coste in Cemagref, 1982), the TDI (Trophic diatom index; Kelly and Whitton, 1995) and the BDI (Biological diatom index; Lenoir and Coste, 1996) have been developed. These indices are systematically used in biomonitoring programmes related to the European Water Framework Directive (The European Parliament and the Council of the European Union, 2000).

While aquatic diatoms are commonly studied and well ecologically characterised, also because of their use in the calculation of water quality indices (Soininen, 2007), studies on terrestrial diatoms communities (i.e. diatom assemblages which can be found on soil surface) are rather scarce. Studies considering soil algae communities in general, have shown that they are quite responsive to disturbance factors (Bérard et al., 2004; Zancan et al., 2006; Vacht et al., 2014). Similarly, studies focusing on terrestrial diatoms assemblages were conducted in agricultural ecosystems with the aim to test the effect of different factors such as land use, farming and tillage practices on the communities. As a result, Heger et al. (2012) reported a difference in the community structure of terrestrial diatoms in response to different agricultural practices (i.e. organic and conventional farming systems). Stanek-Tarkowska and Noga (2012) found a possible correlation between cultivation and fertilisation systems and variation in organic matter content,

* Corresponding author at: Luxembourg Institute of Science and Technology, Department of Environmental Research and Innovation, 41 rue du Brill, L-4422 Belvaux, Luxembourg.
E-mail addresses: marta.antonelli@list.lu, marta.antonelli88@gmail.com (M. Antonelli), carlos.wetzel@list.lu (C.E. Wetzel), luc.ector@list.lu (L. Ector), ryan.teuling@wur.nl (A.J. Teuling), laurent.pfister@list.lu (L. Pfister).

http://dx.doi.org/10.1016/j.ecolind.2016.12.003

pH and moisture content of soils. These factors are likely to influence the species composition of soil diatom communities (Van Dam et al., 1994; Van de Vijver and Beyens, 1998).

Despite the documented sensitivity of terrestrial diatoms to farming practices, to the best of our knowledge, no diatom index has ever been developed for qualitatively assessing terrestrial sites. The main obstacle to progress is due to the scarce information on terrestrial diatom ecology and to the difficult identification of environmental factors that can directly influence soil diatom communities' composition and species distribution (Stanek-Tarkowska et al., 2015). Here we propose to investigate how gradients in land use, soil type and geology control soil diatom communities. Our hypothesis is that terrestrial diatom communities can be used to define the quality of terrestrial sites. Soil diatom communities are characterised by species living exclusively or almost exclusively in terrestrial environments and by species that can be widely found also in aquatic environment. For this reason, to test our hypothesis we apply a quality index developed for aquatic diatoms (i.e. IPS) to soil diatom communities. Our purpose is to adopt the IPS index as an investigation tool to assess the potential for terrestrial diatoms to provide information on the degree of anthropic influence on the communities prevailing at different terrestrial sites.

We tested our hypothesis in the Attert River basin in Luxembourg (Europe). Our study area is characterised by a large diversity in physiographic settings. In the first section we develop on the study area, sampling protocol and analytical protocols, while the following sections are dedicated to the presentation and discussion of results. The final section of our manuscript provides an outlook on future research lines based on findings from our seminal work.

2. Materials and methods

2.1. Study area

The Attert River basin (245 km^2) is located in the North-West of the Grand Duchy of Luxembourg (49°46′13.0″ N, 5°59′9.2″ E) (Fig. 1). The basin exhibits a wide range of contrasted geological settings, land use and soil types. Schists are the dominating bedrock in the north-western part of the basin, while the 'Buntsandstein' (red sandstone) is characteristic of the north-eastern part. Marls and Luxembourg sandstone dominate in the central and southern parts of the basin, respectively. The soil types mostly map onto bedrock geology, with silty-clay soils having developed on marls, silty-stony soils on schists and red sandstone and sandy-loamy soils on Luxembourg sandstone. Recently formed soils from alluvial deposition are

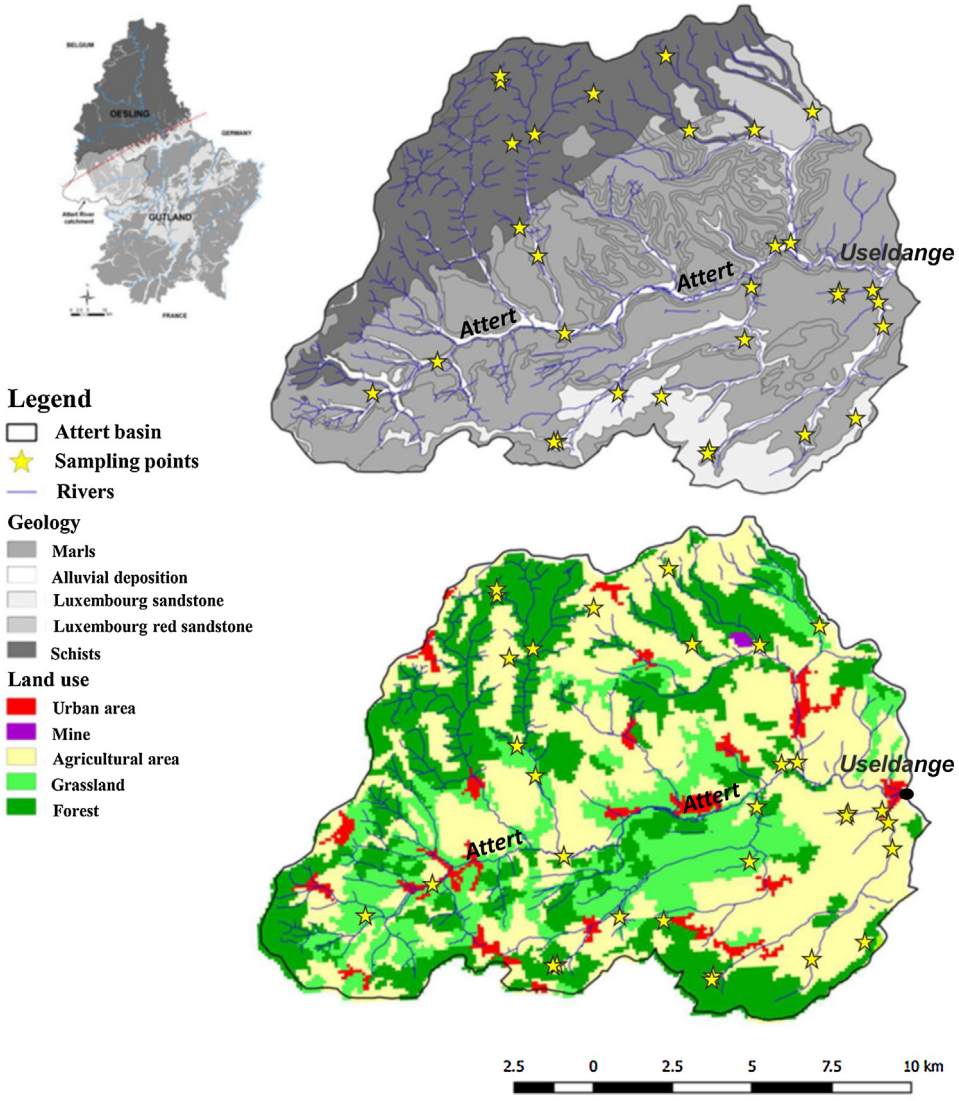

Fig. 1. Physiographic characteristics of the Attert River basin in Luxembourg.