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A large river (River Loire, France) survey to compare phytoplankton functional approaches: Do they display river zones in similar ways?

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ABSTRACT

Functional groups of phytoplankton make possible various classifications among taxa and this approach has been receiving a growing scientific interest. We compared three frequently used classifications as possible ecological tools in providing river zones along the large, Continental Atlantic River Loire. The different number of functional groups in each classification was synchronized into six clusters using the Self Organizing Map (SOM) method, which clusters (as river zones where relevant) were then compared in their response to geographical location, hydrological and chemical constraints.

Our findings demonstrated that all the three classifications might serve as a rational tool, but at different level of understanding. Only approaches based on fine functional resolution in benthic and planctonic diatoms, as well as in cyanobacteria were able to provide reliable river zones at both whole river, and at spatio-temporal scales. Functional groups of these approaches followed different regional patterns in geographical, physical and chemical constraints, and were useful ecological indicators of natural river longitudinal processes, as well as of human impacts such as damming or agriculture.

1. Introduction

Upper parts of streams are basically heterotrophic ecosystems where decomposition of allochthonous sources dominates over autotrophic production (Lampert and Sommer, 2007; Üveges and Padisák, 2012). Significant autotrophic primary production is expected to occur only in large rivers (Thorp and Delong, 1994) and it is limited to middle river sections, or to lowland areas of high river orders, presuming favourable conditions for phytoplankton growth (Reynolds and Descy, 1996).

Theoretical concepts have been developed to understand longitudinal patterns of various biotic (Huet, 1959; Vannote et al., 1980) and abiotic (Newbold et al., 1981) parameters along rivers, but longitudinal changes of river phytoplankton composition have been scarcely studied (Lampert and Sommer, 2007). While biological processes might change continuously along rivers (Vannote et al., 1980), the 'Riverine Ecosystem Synthesis Model' (Thorp et al., 2006) presumes the existence of functionally different river zones based on hydro-morphological and geo-morphological differences. Thus, based on these longitudinal distinctions, the model predicts the existence of different river zones reflected by the corresponding composition of biota.

Here, the authors propose the use of phytoplankton functional groups to test their success in determining river zones by compositional changes in potamoplankton along the River Loire. Three functional approaches gained considerable scientific interest in recent years (Salmaso et al., 2012): phytoplankton functional groups—FGs (Reynolds et al., 2002), the morpho-functional classification—MFG (Salmaso and Padisák, 2007), and the morphology-based functional classification—MBFG (Kruk et al., 2010). While the MBFG classification has been proposed as a simple tool for water quality management, FGs have been already used to develop water quality indices for lakes (Padisák et al., 2006) and for rivers (Borics et al., 2007). Most of the recent publications test only one of these classifications, but some comparative analyses already provide results for reservoirs (Hu et al., 2013), floodplain lakes (Izaguirre et al., 2012) and river ecosystems (Stanković et al., 2012).

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Furthermore, the European official demand for ecological monitoring (WFD, 2000) has led to the development of new assessment methods for lake phytoplankton (Reynolds, 2005; Padisák et al., 2006) and for benthic diatoms (Stenger-Kovács et al., 2007; Kelly et al., 2009; Jüttner et al., 2012). However, ecoregional differences still pose a major challenge in their application at large spatial scale (Tison et al., 2005; Beltrami et al., 2012; Várbíró et al., 2012). Even if the WFD requires the monitoring of river phytoplankton and accordingly, new assessment methods have been developed (Borics et al., 2007; Mischke et al., 2011), at the moment, potamoplankton is not included specifically to assess ecological status in rivers.

Former Loire phytoplankton studies were mainly focused on water quality issues, and they were restricted to analyses the influence of upstream dams (Michard et al., 1996; Bonnet and Poulin, 2002; Latour et al., 2004), and of nuclear power plants in the middle Loire (Lair and Reyes-Merchant, 1997; Lair et al., 1999). Longitudinal changes of the phytoplankton, however, were considered only in a few publications. Leitão and Lepretre (1998) described some topographical relationships of potamoplankton composition along 6 stations in the Loire. Recently, Descy et al. (2011) concluded similar functioning of controlling factors on potamoplankton to those found in other large, but more regulated Europen rivers. Furthermore, Abonyi et al. (2012) highlighted that human impacts might be successfully indicated by the $Q_{(r)}$ compositional index (Borics et al., 2007) along the Loire; and that besides natural processes, shifts in FGs are also related to human mediated physical and chemical impacts.

The objective of this article is to compare three phytoplankton functional classifications (MBFG, MFG, FG) as potential ecological, and water quality management tools along the River Loire. The authors use the same dataset presented by Abonyi et al. (2012); and apply the three functional systems independently, with the following specific questions:

(i) How these classifications display river zones, reflected by the correspondent morphological, morpho-functional, and functional composition of potamoplankton?
(ii) Which relationships can be found between these river zones and basic regional differences in geography, climate and hydro-ecoregions along the River Loire?
(iii) How the identified river zones (if relevant) are able to follow the main chemical characteristics in the River Loire?

2. Material and methods

2.1. Study area

The Loire catchment occupies almost 20% of France (117,045 km^2), and is the largest among the Continental Atlantic rivers. The Loire drainage area still involves several exceptional habitats and its flow regime still remains relatively unaffected when compared to other large European rivers (Descy et al., 2011). Along its course, water discharge is mostly influenced by two main tributaries: the River Allier and the River Cher (Fig 1), while in the whole Loire basin three main ecoregions can be

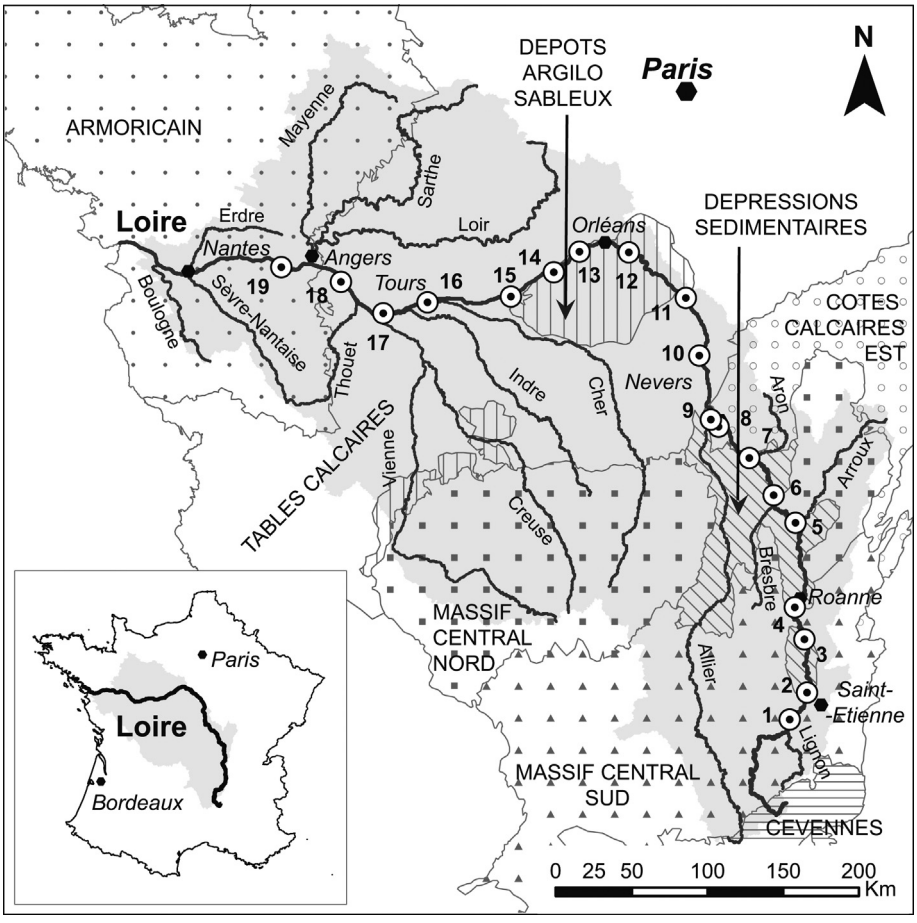

Fig. 1. The River Loire sampling stations, 2009. Besides the Loire catchment (grey area), figure also indicates hydro-ecoregions according to Wasson et al., 2004 along the basin.