

# ***Interactive comment on “Eutrophication mitigation in rivers: 30 years of trends and seasonality changes in biogeochemistry of the Loire River (1980–2012)” by C. Minaudo et al.***

**C. Minaudo et al.**

camille.minaudo@etu.univ-tours.fr

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Authors Comment (AC): We are very grateful for comments provided by Berit Arheimer, referee # 2 of our paper. The very positive evaluation she gave to our work shows the interest of the Biogeosciences community to our paper.

Comments and suggestions she provided are also a great help to improve a little more the manuscript. The following responds to all raised suggestions and comments. You will also find as a Supplement file a marked-up manuscript version highlighting all the changes we made in the manuscript.

Referee Comment (RC): The paper presents 30 years of trends in nutrients and algae

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(pigments) as well as spatial patterns in pressures for the Loire River in France. It's a unique dataset, which clearly shows the correlations in space and time between water status and pressures (Fig. 2 is excellent!).

The topic is of interest for Biogeosciences readers and the paper is very well written, presented and structured. After reviewing the paper, I strongly support its final publication in Biogeosciences.

RC: Some minor suggestions on how to further improve the paper follows. Please, consider to: 1) Insert "spatial patterns" in the title as this is a substantial part of your analysis.(e.g. "Eutrophication mitigation in rivers: 30 years of trends in spatial and seasonal patterns of biogeochemistry in the Loire River (1980-2012)").

AC: We agree adding the spatial characteristic of our study to the title is essential. We adopted the title you suggested.

RC: 2) Indicate significance (bold numbers?) of slope trends in Tables 3-4 and the method for calculating this significance in Section 3.3.

AC: To our knowledge, the "Strength" of trend column in Table 3 already describes the significance of the calculated trends. This is determined based on the squared correlation coefficient between calculated trend and deseasonalized datasets, that is to say the percentage of variance in deseasonalized series explained by the computed trend. Similarly, we present in Table 4 the "Strength" of the seasonal component which represents the percentage of variance in de-trended datasets explained by the computed seasonal component. So, we do not think we should add another parameter in those two Tables, risking to make them unnecessarily too heavy. Nonetheless, we decided to change what we called "Strength" to "Significance", to make sure readers won't miss this point.

RC: 3) Discuss the impact of Climate Change on diffuse nitrogen leaching from arable land in the Discussion section 5.1 as a potential driver to the trends, see Comment

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below.

AC: We do mention the potential effects of Climate Change on diffuse nitrogen leaching from arable land in the Introduction part, citing Bouraoui et al 2002. Nevertheless, it seems to us that it is a good point to add it in the Discussion part as you suggested. As a consequence, we also included the suggested reference (Arheimer et al., 2005) in both sections of the manuscript.

RC: 4) Discuss the potential influence of the constructed dams in the river network and how they may affect the nutrients/algal concentrations on downstream locations.

AC: The main reservoirs are located on the Upper Loire and the upper Allier and the most recent of them were constructed in the early 1980s. We weren't able to see any difference in the time series before and after these constructions as the present study focuses on the period 1980-2012. Phytoplanktonic developments obviously occur in these reservoirs: in fact, Grangent and Villerest dams on the Loire River are known to be eutrophic since the 1980s, with phytoplanktonic cyanobacteria developments both-erling local stakeholders (Aleya et al., 1994; Jugnia et al., 2004).

The only noticeable signs we could observe within this study were on phosphorus concentration and we already pointed out in section 4.2 that particulate retention processes probably occur in these reservoirs, explaining why P concentration are lower downstream. Nitrate is representing most of the total nitrogen, thus there is no noticeable impacts of the reservoirs on NO<sub>3</sub> concentrations. Moreover, Fig. 2 present PO<sub>4</sub> and NO<sub>3</sub> concentration longitudinally for the winter period, thus phytoplankton uptake within these reservoirs can't be questioned here. If it's been shown in other studies that in the reservoirs the phytoplankton assemblage is lake-like, these species don't survive very long in the turbulent and quite turbid river downstream (Abonyi et al., 2011, 2014).

We agree with the reviewer that our paper did not bring all the elements required to decipher the potential impacts of the constructed dams on nutrients and phytoplankton concentration; thus, we decided to add more of them in the Results part (4.1) to clarify

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what we know about it.

RC: 5) Extend the list of European river on page 17300 row 25, by adding a reference to reduced nitrogen concentrations in Swedish rivers (Grimvall et al. 2014, see below).

AC: OK.

RC: 6) Insert reference to another very early model study on changes in nutrient concentration due to climate change among the other references on page 17301 row 6 (Arheimer et al., 2005; see below).

AC: OK.

Comments and Points for Discussion:

RC: i) Page 17314, row 25 and forward: It is interesting that the nitrate is increasing over time from arable land. Could this, in addition to intensified agriculture and lack of implementation of the nitrate directive, also be an effect of higher mineralization of organic matter in the arable soils, due to increased temperature over time? Please, see for instance modelling work on climate change impact on nitrogen leaching by Arheimer et al., 2005.

AC: Please, see above, point # 3.

RC: ii) The importance of constructed dams are mentioned in 'Introduction' and 'Study area and data compilation' but then it is not commented in 'Results' or 'Discussion' sections (what I could notice). If I am right, I think it is worthwhile to mention If OR If Not they could have had any major influence on the trends/changes in biochemistry or lack of such trends (smoothing out the results?).

AC: Please, see above, point # 4.

RC: iii) On drivers: a recent Swedish study of 45 rivers show that downward trends in nitrogen were due to mitigation measures in agriculture during the last decades. Please, find reference below! (Grimvall et al., 2014). Such findings from elsewhere

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than Loire River could be further elaborated on in the Discussion section.

AC: OK, we integrated the suggested reference in our paper, and we added a sentence in the Discussion section 5.1 with findings from elsewhere than the Loire River:

"It has been shown that mitigation measures in agriculture did decrease nitrogen loads in several Swedish rivers (Grimvall et al., 2014) and in the Rhine and Danube Rivers (Hartmann et al., 2007) making a great contrast with many other temperate lowland rivers where nitrate increasing trends are still recorded: the Mississippi (Sprague et al., 2011), Ebro, Po and Rhone Rivers (Ludwig et al., 2009) and also the Thames (Howden et al., 2010). Another potential reason for this increase could be Climate Change: higher mineralization of organic matter in the arable soils is expected and caused by an increased temperature over time (Arheimer et al., 2005) together with higher soil (Bouraoui et al., 2002)."

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/11/C8944/2015/bgd-11-C8944-2015-supplement.pdf>

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Interactive comment on Biogeosciences Discuss., 11, 17299, 2014.

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