WFD and eutrophication assessment: the role of nitrogen as a driving nutrient in shaping phytoplankton assemblages in 13 Italian water bodies.

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The LIFE - INHABIT Project

The study was carried out in the frame of the Project LIFE – INHABIT, started in April 2010 and completed in June 2013. The project aimed at integrating information on local hydro-morphological features into practical measures to improve the reliability of implementation of WFD River Basin Management Plans (RBMPs) in South Europe. The focus was on rivers and lakes that were scrutinized in two areas in Italy, covering a wide range of environmental features and water body types.

The problem targeted

The enrichment in nitrogen was seen as a possible cause of acidification on aquatic environments, but in recent years the focus has shifted to the role of nitrogen as a limiting factor for algal growth, and thus, as a possible cause of eutrophication, questioning the importance of phosphorus as the only limiting factor of phytoplankton production (Sterner, 2008; Wurtsbaugh & Lewis, 2008). Meta-analysis of experimental data (Elser et al., 2009, 2010) and results of enrichment experiments (Elser et al., 1990) have shown that the limitation by P and N varies between aquatic ecosystems, depending on the level beyond which it is to be expected a significant damage to the state of the water. This level for nitrogen has been identified in 2 mg/l, a value often far exceeded in the waters of lakes and rivers in areas with high impact of nitrogen. It was also highlighted that it is not only the form of nitrate N to monitor and possibly control, but all forms of N, both organic and inorganic, should be monitored as part of the plan of water protection (Sutton et al., 2001).

Methods

Integrated phytoplankton sampling in the eutrophic zone was taken, together with samples for water chemistry, according to stratification (surface, epilimnion, metalimnion, upper and lower hypolimnion), phytoplankton was counted according to inverted microscope technique. The relationships among trophic and environmental variables were explored by Canonical Correspondence Analysis and Redundancy Analysis (CCA, RDA; CANOCO 4.5; ter Braak & Smilauer, 2002). The significance of single variables was tested by Monte Carlo test (499 permutations). Generalized Additive Modelling (GAM) was carried out to test the response of single taxon to environmental variables, selecting the best fitting model from the AIC value. To simplify the data matrix, the 235 taxa were grouped at the level of 23 orders. The first phase of the analysis has allowed the identification of the orders better correlated with nitrogen, allowing then to select some of the algal species belonging to those orders. Further selection was made, eliminating those species not responding, as the sum of all the samples, the value of 10 mm-3 in this way, the number of species in the matrix was reduced to 31.

Conclusions

Considering phytoplankton in general, ammonium seems to be the preferred source of nitrogen by nitrogen-fixing cyanobacteria (Blomqvist et al., 1994; our results confirm cyanobacteria are dominant at the highest levels of ammonia nitrogen.

In the group of lakes studied, an increase of cyanobacteria belonging to Nostocales and Oscillatoriales, following the increasing total nitrogen availability (not only as ammonium), was observed. Since the role of nitrogen-fixing cyanobacteria in promoting an increase in the concentrations of nitrogen, was negligible in many lakes (Lewis & Wurtsbaugh, 2008), it can be inferred that its increase in surface waters, due to human activities, could be responsible for an increased importance of cyanobacteria, even to environments where phosphorus concentrations are moderate (Lespinasse et al., 2013).

The relationship observed between the concentration of ammonium and pennate diatoms, both at the order and species level, seems to confirm what described by Domingues et al. (2011), who observed an inhibitory effect of ammonium on the growth of this diatom group, suggesting a possible toxic effect.

The results of our analysis, further emphasize the need to pay more attention to the contributions of nitrogen, growing steadily in recent decades, at the risk of affecting the increase of nitrate nitrogen on aquatic ecosystems have been limited up to now, thanks to the action of the nitrogen-fixing cyanobacteria (Elser et al., 2009). However, in view of the adoption of actions aimed at reducing the input of increased nitrogen, nutrient load on aquatic ecosystems, a key controlling factor, affecting phytoplankton growth and assemblage structure.