

Trends of eutrophication in the Loire River (France)

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The Loire River (France) was known to be sensible to eutrophication at the end of the 1970s, especially in its lower reaches with extreme phytoplankton growth (chlorophyll a concentration up to $250 \mu\text{g L}^{-1}$ in summer). During the 80s and 90s, the Loire estuary was often in state of anoxia in summer, as a result of the biodegradation of large quantities of labile organic matter. In this context, this work aimed at identifying clearly its eutrophication trajectories since the European environmental measures undertook in the early 1990s, and aimed at studying the physical and chemical causes and consequences of phytoplankton blooms.

The long-term water quality time-series carried out by the national authorities allowed to identify the Loire River eutrophication trends since 1980. Since the extreme conditions in the early 1990s, phytoplankton developments in summer were divided 3-fold in the Loire River and in the main tributaries, synchronously with the generalized reduction 2-fold of bioavailable phosphorous. This was mostly attributable to the improvement of P treatment in the upstream waste water treatment plants. Thus, controlling and limiting P point sources greatly limited the magnitude of phytoplankton blooms (from 150 to $60 \mu\text{g Chl. a L}^{-1}$ between 1990 and 2012 in the lower Loire reaches). These trajectories highly changed the spatio-temporal dynamics of nutrients. Organic carbon (C-org) was not measured within the regular survey, however, based on some strong relationships between particulate C-org, suspended solids and pigments concentrations measured recently within a daily scale survey (2012-2014), C-org fluxes of the past could be reasonably assessed and it was estimated that 50% of the total C-org fluxes entering the estuarine zone in summer had autochthonous origins in the 80s and 90s against 20% during the period 2012-2014. Eutrophication has decreased in the freshwater system but keeps affecting the coastal zone, especially because algal species in marine environment are sensible to nitrogen bioavailability while nitrate exports to the Loire estuary keep on increasing (+10% since 1980) despite the 1991 EU Directive on agricultural practices.