Using diatom taxonomic diversity to assess herbicide contamination in rivers

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1. Introduction

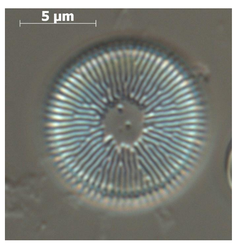
Contamination by micropollutants in freshwater systems has become a major problem, giving rise to toxicological, sanitary and economical concerns.

- In 2010 the French government adopted a plan for a 50% reduction in pesticide use by 2018.
- This study aims to assess the benefit of reducing herbicide use for aquatic organisms.
- Several experiments have established that algae are sensitive to herbicide contamination.
- However *in situ* benthic diatom bio-indication tools do not assess herbicide contamination.

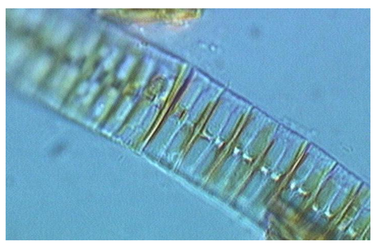
2. Hypotheses

A. Herbicides have an adverse effect on particular ecological guilds

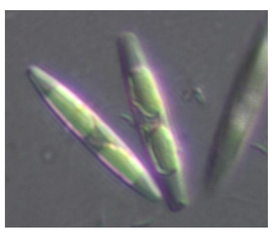
Ecological guilds are groups of taxa co-existing in the same environment but are differentiated by their adaptations to abiotic factors. This study uses the 4 ecological guilds (Berthon *et al.*, 2011, adapted from Passy, 2007).



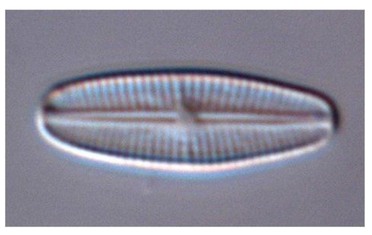
Planktonic guild



High profile guild

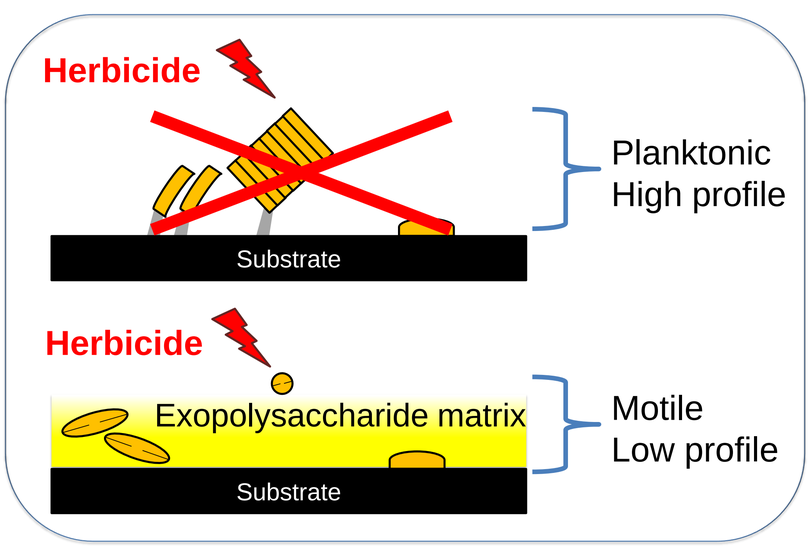


Motile guild



Low profile guild

The motile guild diatoms usually live in thick exopolysaccharide matrices which should provide protection against dissolved herbicides. This was observed in mesocosms studies (Rimet & Bouchez, 2011).

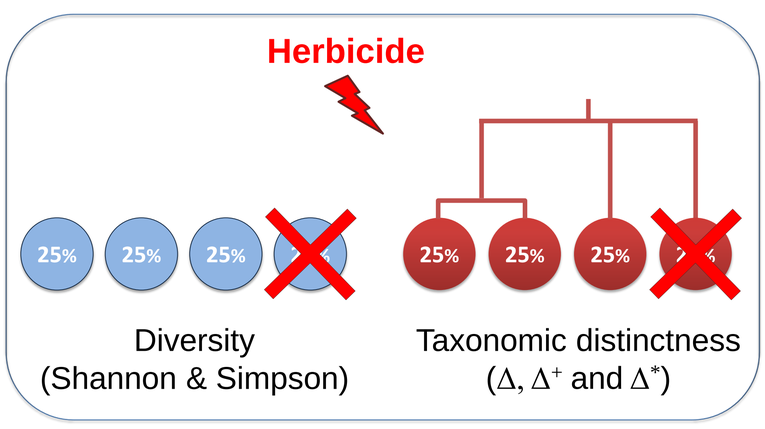


B. Increasing herbicide concentration reduces species diversity and taxonomic distinctness

Morin *et al.* (2009) and Ricciardi *et al.* (2009) observed a decrease in benthic diatoms diversity and taxonomical distinctness when *in situ* herbicide concentration increased.
5 indices were studied:

- 2 diversity indices: Shannon and Simpson
- 3 taxonomic distinctness indices: Δ, Δ^+ and Δ^*

Taxonomic distinctness indices capture not only the distribution of abundances amongst species but also the taxonomic relatedness of the species.



3. Objectives

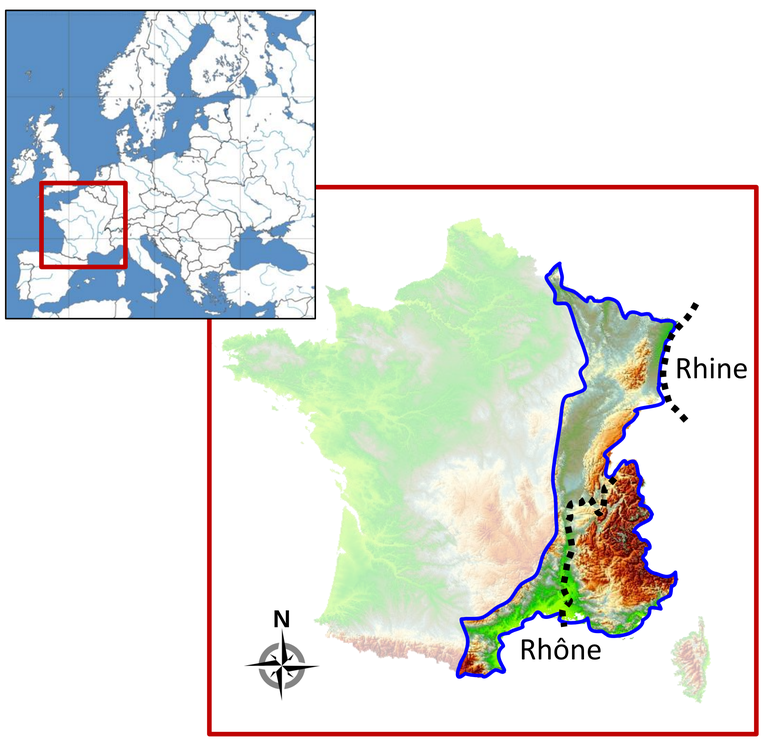
Determine whether benthic diatom-based bio-indicators could be developed to assess *in situ* the impact of herbicide contamination on freshwater ecosystems.

4. Material & Methods

A. Data base

Data were gathered from the Water Framework Directive monitoring of Rhine and Rhône river basins (eastern France):

- Sampling from 2000 to 2008
- 2170 diatom, physicochemistry and typology samples
- Standardized benthic diatom samples: IBD (AFNOR NFT 90 354 ; CEN – EN 13946 & EN 14407)
- 897 corresponding herbicide samples
- Focus on Atrazine which is the herbicide most often quantified in the database
- Atrazine concentration ranges from 0.01 to 0.68µ/L



B. Analysis

Linear, logarithmic and second order polynomial regressions were used to analyze changes in diversity, taxonomic distinctness, ecological guilds abundance and physico-chemical parameters regarding atrazine concentration.

5. Results and discussion

- Strong correlation was found between atrazine concentration, physicochemical parameters, river typology and diversity and taxonomic distinctness indices,.
- Atrazine concentration data originated from multiple laboratories with different quantification limits. This interfered with correlations analysis (fig. 1).
- To remove a typology and nutrient effect on diatom metrics, a particular river size and nutrient level was selected. Under this analysis, atrazine concentration was not related to diversity and taxonomic distinctness indices (table 1.).
- Similarly, no relationships were found between atrazine concentration and ecological guilds (table 1.).

Figure 1. Scattergrams of log transformed atrazine concentration

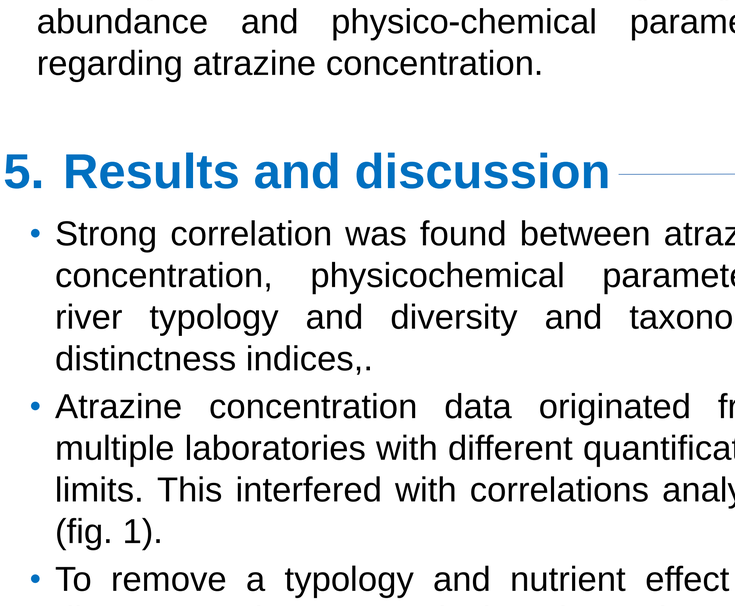


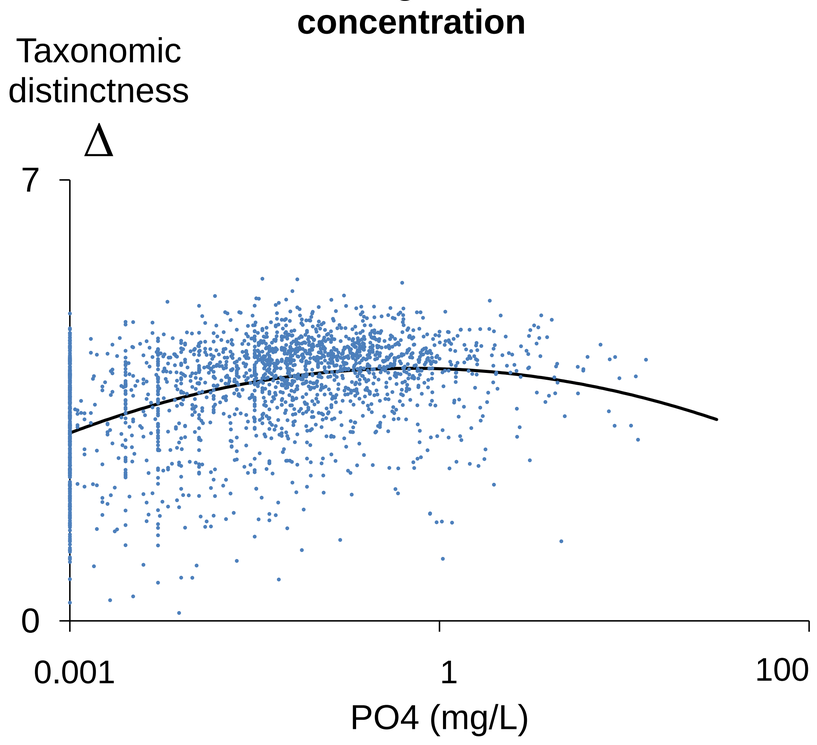
Table 1. Relationships at 4 study scales between atrazine concentration and diversity, ecological guilds and physico-chemical parameters ($\varphi\chi$).

Significant correlations : positive (+) negative (-) none (⦸)
Ecological guilds: planktonic (plk) high profile (high) motile (mot) low profile (low)

	Atrazine / Diversity	Atrazine / Guilds	Atrazine / $\varphi\chi$
All atrazine measurements (quantified and non-quantified)	+ Diversity + Taxonomic distinctness	+ Mot - Low - High + Plk	+ PO4 + Ptot + NO3 + NO2
Atrazine quantified	+ Taxonomic distinctness	- High	+ PO4 + Ptot + NO2
Atrazine quantified Only small size rivers	⦸	⦸	+ PO4 + Ptot
Atrazine quantified Only small size rivers from one ecoregion with low NO3 and PO4	⦸	⦸	⦸

- The strongest relationships were found between diversity and taxonomic distinctness indices and PO4 concentration. Berthon *et al.* (2011) found similar results with ecological guilds.
- Correlation between taxonomic distinctness and nutrients were stronger than between diversity and nutrients.
- Regressions corroborated the assumption that diatom diversity increases when nutrient concentration increases. Diversity reaches a maximum at intermediate levels of nutrients and decreases for high nutrient levels (fig. 2).

Figure 2. Second order polynomial regression between Δ and log transformed PO4 concentration



7. Perspectives

- Results suggest that, at a large geographic scale, the structuring impact of a pesticide is lower than that of nutrients, organic matter and typology. However, a similar study conducted in mesocosms (Rimet & Bouchez 2011) showed a change in ecological guilds induced by herbicide contamination.
- The next step could be testing if herbicides have a greater impact when considering sums of concentrations of molecules with similar action mode.
- Polar Organic Compounds Integrative Samplers (POCIS) might improve the relevance of pesticide measurements as they provide an integrated measurement of hydrophilic chemicals over weeks or months. Such samplers could provide an interesting perspective.

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