# A SIMPLE *A POSTERIORI* TYPOLOGY OF STANDING FRESHWATERS IN FLANDERS

**Luc Denys**

**Institute of Nature Conservation, Kliniekstraat 25, B-1070 Brussel, Belgium**

## CONTEXT

The European Water Framework Directive requires typologies for all categories of water bodies which are based on characteristics that are relevant to community composition and suited as a framework for reference-based assessment. In support of this, an *a posteriori* typology is presented here for the range of permanent standing freshwaters in Flanders.

## FIVE STEPS TO A TYPOLOGY

### 1. Select variables

The number of variables included in the typology should be limited, yet, they should allow to determine potential community composition in sufficient detail. Therefore, variables with a significant relation to the biological data were identified by a series of CCA's (Table 1). Taking correlations into account, a subset of 17 variables to which a majority of the biota responded (sedimentary and epiphytic diatoms considered jointly) was selected to reflect the most important site characteristics. These variables reflect dimensions, soils, regional characteristics and management, ionic composition as well as nutrient status and metabolic conditions.

Table 1. Variables yielding significant relations with species composition. A. entire dataset, B low pH sites only, C higher pH sites only. Selected variables in bold. Colour intensity indicates relative importance.

| selected variables (p = 0,05) | Diatoms epiphyton A | Diatoms epiphyton B | Diatoms epiphyton C | Diatoms sediment A | Diatoms sediment B | Diatoms sediment C | Rotifers periphyton A | Rotifers periphyton B | Rotifers periphyton C | Invertebrates A | Macrophytes A | Macrophytes B | Macrophytes C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **sand**[1] | | | | | | | | | | | | | |
| loam[1] | | | | | | | | | | | | | |
| clay[1] | | | | | | | | | | | | | |
| peat[1] | | | | | | | | | | | | | |
| **poorly drained soils**[1] | | | | | | | | | | | | | |
| **area** | | | | | | | | | | | | | |
| shore line / area | | | | | | | | | | | | | |
| shoreline development | | | | | | | | | | | | | |
| width | | | | | | | | | | | | | |
| **maximum depth (ordinal class)** | | | | | | | | | | | | | |
| bank slope (ordinal class) | | | | | | | | | | | | | |
| **sodium** | | | | | | | | | | | | | |
| chloride | | | | | | | | | | | | | |
| specific conductivity | | | | | | | | | | | | | |
| **pH** | | | | | | | | | | | | | |
| **aluminum** | | | | | | | | | | | | | |
| **iron** | | | | | | | | | | | | | |
| calcium | | | | | | | | | | | | | |
| sodium | | | | | | | | | | | | | |
| magnesium | | | | | | | | | | | | | |
| sulphate | | | | | | | | | | | | | |
| **silicate** | | | | | | | | | | | | | |
| **dissolved inorganic carbon** | | | | | | | | | | | | | |
| alkalinity | | | | | | | | | | | | | |
| inorganic nitrogen | | | | | | | | | | | | | |
| nitrate nitrogen[2] | | | | | | | | | | | | | |
| nitrite nitrogen | | | | | | | | | | | | | |
| ammonium | | | | | | | | | | | | | |
| Kjeldahl nitrogen | | | | | | | | | | | | | |
| organic nitrogen [2] | | | | | | | | | | | | | |
| **total phosphorus**[2] | | | | | | | | | | | | | |
| **oxygen saturation** | | | | | | | | | | | | | |
| chlorophyl a | | | | | | | | | | | | | |
| **potential gross oxygen production** | | | | | | | | | | | | | |
| potential net oxygen production | | | | | | | | | | | | | |
| biochemical oxygen demand | | | | | | | | | | | | | |
| **chemical oxygen demand** | | | | | | | | | | | | | |
| chemical oxygen demand particulate | | | | | | | | | | | | | |
| chemical oxygen demand dissolved | | | | | | | | | | | | | |
| absorbtion 254 nm | | | | | | | | | | | | | |
| absorbtion 420 nm | | | | | | | | | | | | | |
| absorbtion 420 nm dissolved | | | | | | | | | | | | | |
| absorbtion 440 nm dissolved | | | | | | | | | | | | | |
| phaeophytins | | | | | | | | | | | | | |
| pigment index | | | | | | | | | | | | | |
| cover submerged macrophytes | | | | | | | | | | | | | |
| cover emergent macrophytes | | | | | | | | | | | | | |
| **shore line with scrub and trees** | | | | | | | | | | | | | |
| urbanised[3] | | | | | | | | | | | | | |
| infrastructure[3] | | | | | | | | | | | | | |
| water[3] | | | | | | | | | | | | | |
| grassland[3] | | | | | | | | | | | | | |
| poplar[3] | | | | | | | | | | | | | |
| deciduous[3] | | | | | | | | | | | | | |
| conifer[3] | | | | | | | | | | | | | |
| **heathland**[3] | | | | | | | | | | | | | |
| marsh[3] | | | | | | | | | | | | | |
| **dunes**[3] | | | | | | | | | | | | | |

### 2. Reduce dimensionality

The 17 retained variables may be used to characterise a site *in globo* but are not equally discriminating, nor are they mutually independent. Hence, dimensionality was reduced by means of PCA (Fig. 1). Almost 50 % of their variance was explained by the 3 first principal components (Table 2).

Fig. 1. Correlation plot of selected variables, PCA axes 1 and 2.

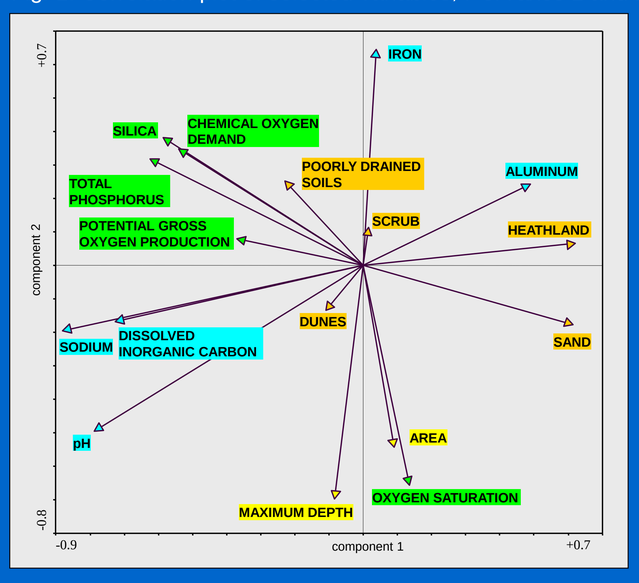
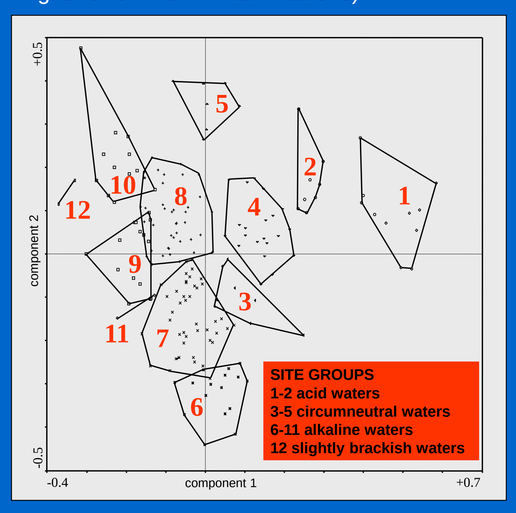



Table 2. PCA characteristics and correlations between selected variables and axes 1 to 3. Variables are colour coded according to general character.

| | axis 1 | axis 2 | axis 3 |
|---|---|---|---|
| **eigenvalue** | 0.25 | 0.15 | 0.10 |
| **cumulative % of variance** | 24.6 | 39.3 | 49.3 |
| ***soil conditions, regional characteristics, management*** | | | |
| **coastal dunes** | -0.11 | -0.13 | **0.63** |
| **heathland** | **0.62** | 0.06 | 0.27 |
| **sand** | **0.61** | -0.18 | 0.44 |
| **poorly drained soils** | -0.23 | 0.25 | **-0.38** |
| **scrub** | 0.02 | 0.11 | **-0.44** |
| ***morphometry*** | | | |
| **area** | 0.09 | **-0.54** | -0.19 |
| **maximum depth** | -0.09 | -0.7 | **-0.27** |
| ***ionic composition*** | | | |
| **dissolved inorganic carbon** | **-0.88** | -0.19 | 0.08 |
| **pH** | **-0.79** | -0.49 | -0.07 |
| **sodium** | **-0.73** | -0.17 | 0.33 |
| **iron** | 0.04 | **0.64** | -0.24 |
| **aluminum** | 0.5 | 0.24 | **0.39** |
| ***nutrient levels, metabolism*** | | | |
| **total phosphorus** | **-0.62** | 0.32 | 0.35 |
| **silica** | **-0.58** | 0.38 | -0.03 |
| **oxygen saturation** | 0.14 | **-0.66** | 0.18 |
| **chemical oxygen demand** | **-0.54** | 0.35 | 0.29 |
| **potential gross oxygen production** | **-0.37** | 0.08 | 0.16 |

Fig. 2. PCA plot of initial site groups (see Fig. 1 for environmental relations).




### 4. Test site groups for characteristic communities

Water types should be characterised by distinct species combinations, as well. This was checked by looking for indicator species, using specificity, constancy and a combined IndVal score (e.g. Table 3), and comparing the distribution of pre-defined assemblages (e.g. Fig. 3). As a result; some of the 'alkaline' groups were combined and only 10 water types remained: two acid ones, three in the circumneutral range, four alkaline ones and a transitional slightly brackish type.

Fig. 3. Occurrence of 18 macro-invertebrate assemblages in the 12 site groups. Brackets indicate groups that were merged, finally.

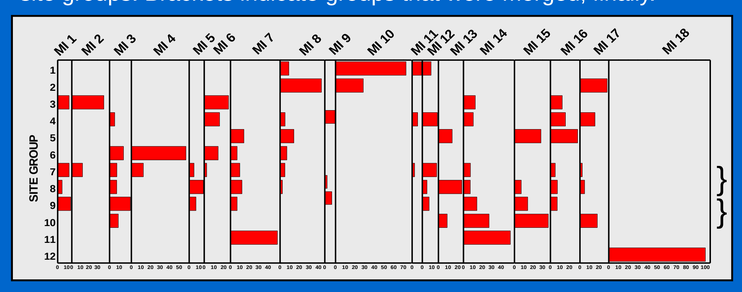



Table 3. IndVal scores for selected invertebrates (p<0.05), calculated for the 10 freshwater site-groups. Brackets indicate groups that were merged.

| | site group | combined IndVal 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALKALINE | *Tiphys latipes* | - | - | - | - | - | - | - | - | - | - | 100 |
| | *Agrypnia pagetana Ipicta* | - | - | - | - | - | - | - | - | - | - | 49 |
| | *Haliplus lineolatus* | - | - | - | - | - | - | - | - | - | - | 98 |
| | *Piona nodata flaminata* | - | - | - | - | - | - | - | - | - | - | 47 |
| | *Piona clavicornis* | - | - | 1 | - | - | - | - | - | - | - | 89 |
| | *Tiphys ornatus* | - | - | - | - | - | - | - | - | - | - | 89 |
| | *Acroloxus lacustris* | - | - | - | - | - | - | 1 | 1 | - | - | 40 |
| | *Piona variabilis* | - | - | 1 | - | 4 | - | - | - | - | - | 70 |
| | *Piona conglobata* | - | - | 4 | - | - | - | - | - | - | - | 35 |
| | *Valvata cristata* | - | - | - | - | - | - | 1 | 6 | - | - | 28 |
| | *Planorbarius corneus* | - | - | 2 | 2 | - | 1 | - | - | - | - | 27 |
| | *Planorbis planorbis* | - | - | 1 | - | - | - | - | 2 | 1 | 3 | 24 |
| | *Gyraulus crista* | - | - | 1 | - | 12 | 1 | 2 | - | - | - | 37 |
| | *Radix ovata* | - | - | 1 | 1 | - | 9 | 4 | 2 | 4 | 4 | 33 |
| | *Piona pusilla* | - | - | 20 | - | - | 7 | 1 | - | - | - | 31 |
| | *Helophorus obscurus* | - | - | - | - | - | - | - | - | - | 18 | - |
| | *Limnesia undulata* | - | - | 5 | - | - | 36 | - | - | - | - | - |
| | *Potamopyrgus antipodarum* | - | - | - | - | - | 46 | 6 | - | - | - | - |
| | *Mystacides longicornis Inigra* | - | - | 8 | - | - | 24 | 7 | 1 | 3 | - | - |
| CIRCUMNEUTRAL | *Arrenurus albator* | - | - | 24 | - | - | - | - | - | - | - | - |
| | *Forelia liliacea* | 1 | - | 32 | - | - | - | - | - | - | - | - |
| | *Caenis horaria* | - | - | 26 | 1 | - | 10 | 11 | 2 | 3 | - | - |
| | *Mideopsis orbicularis* | 1 | - | 26 | - | - | 6 | 2 | - | 2 | - | - |
| | *Mystacides azurea* | - | - | 42 | 1 | - | 1 | - | - | - | - | - |
| | *Piona rotundoides* | - | - | 33 | - | - | 2 | - | - | - | - | - |
| | *Neumania deltoides* | - | - | 24 | 10 | 4 | - | 1 | 3 | - | - | - |
| ACID | *Agabus sturmii* | - | 29 | - | - | - | - | - | - | - | - | - |
| | *Enochrus affinis* | 18 | - | - | - | - | - | - | - | - | - | - |
| | *Helochares punctatus* | 27 | - | - | - | - | - | - | - | - | - | - |
| | *Glaenocorisa propinqua nymph* | 18 | - | - | - | - | - | - | - | - | - | - |
| | *Rhantus exsoletus* | 18 | - | - | - | - | - | - | - | - | - | - |
| | *Oecetis ochracea* | 24 | - | - | - | - | - | - | - | - | - | - |
| | *Argyroneta aquatica* | 45 | 1 | - | 1 | - | - | - | - | - | - | - |
| | *Cymatia bonsdorffi* | 15 | - | - | 1 | - | - | - | - | - | - | - |
| | *Lestes sponsa* | 38 | 7 | - | 2 | 1 | - | - | - | - | - | - |
| | *Sympetrum danae* | 54 | 2 | - | - | - | - | - | - | - | - | - |

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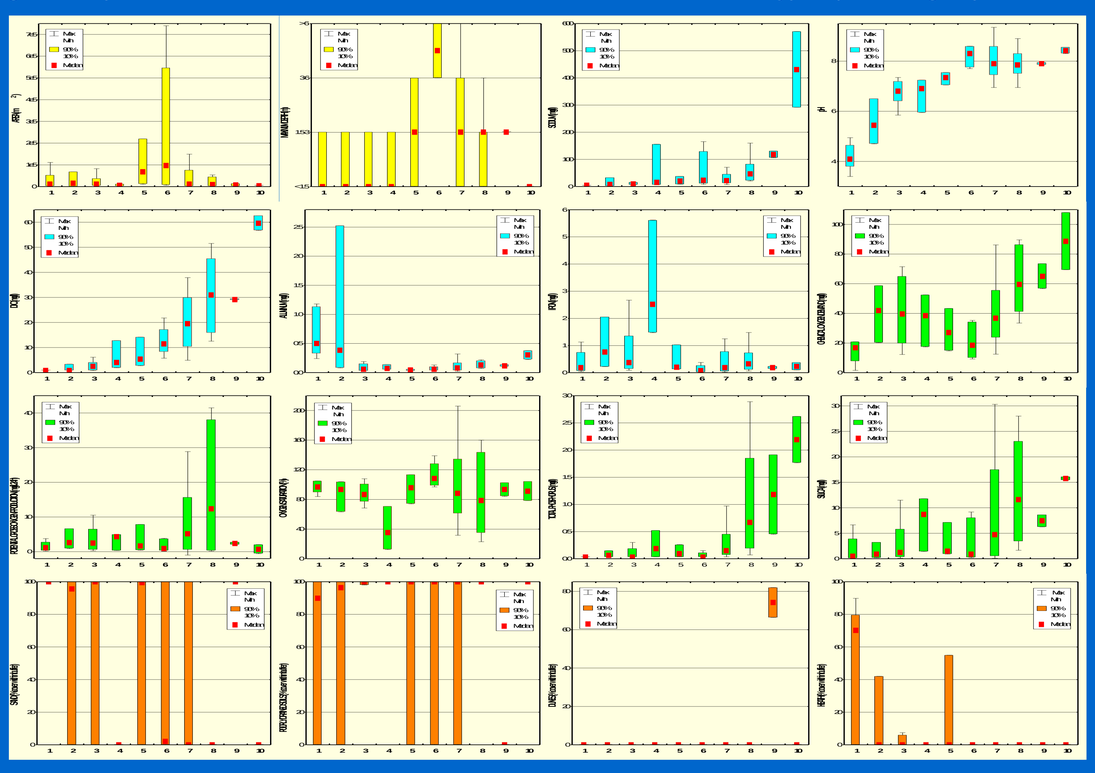
## DATA

In an attempt to address the entire range of variation, 186 standing waters (sand, clay and gravel pits, ponds, reservoirs, oxbow lakes,...) were selected throughout Flanders, taking into account regional distribution, expected variation and a prospection of > 800 sites. Water samples were analysed 3-5 times from spring to autumn and biota were sampled once in summer. Further data were obtained from field observations and GIS resources. More than 70 environmental variables were considered, as well as quantitative data on macro-invertebrate species (excl. chironomids and oligochaetes; Preston scores), macrophytes (hydrophytes and obligate phreatophytes), periphytic rotifers and diatoms in sediments and epiphyton (percentage abundance). Medians are used for multiple measurements.

### 5. Determine characteristics of the water types

The characteristic environmental conditions are determined for the final water ten types (Fig. 4). Although additional water bodies are preferably attributed to a particular type using the selected variables, other variables may be used as well if a distinct relation to the typology can be established. Geograpical and hydrological patterns in the distribution of the types are also examined (Fig. 5).

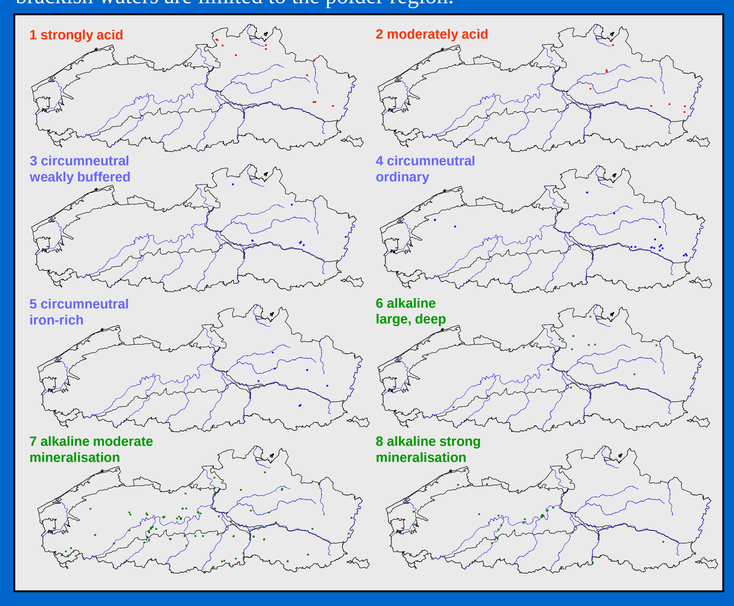
Fig. 4. Box plots for some of the selected variables in relation to the 10 water types (variable groups colour coded).




### 3. Group sites

Sites were classified by minimum variance clustering of their PCA scores (axes 1-3 only). The possible classifications were compared with the PCA ordination of the sites and a prelimary grouping was obtained with minor adjustments. Initially 12 site groups were retained which showed relatively little overlap (Fig. 2). These were used as a basis for further analyses.

Fig. 5. Distribution maps and denomination of the freshwater types 1 to 8, type 9 - dune pools occurs only in the coastal dunes; type 10 - slightly brackish waters are limited to the polder region.




## PROPOSAL FOR A TYPOLOGY

A proposed typology for permanent standing waters, based on the *a posteriori* analyses, is presented in Fig. 6. More strongly brackish, as well as temporary waters need to be added. To make international comparisons possible, the EU requires encorporation of some obligatory descriptors; the scheme shows their relation to the typology. Regional differences in reference conditions or in ecological potencies, require trophic status to be added as an additional level of discrimination. Only for the large, deep alkaline type (pits) and for moderately mineralised alkaline waters, extra types appear to be necessary, however.

Fig. 6. A scheme for a generalised typology of permant, standing freshwaters in Flanders. The 10 types are indicated by coloured boxes. Obligatory descriptors are marked with *.