

Scuola Dottorale in Biologia – ciclo XXII

Sezione Biodiversità ed Analisi degli Ecosistemi

The Ph.D. Project of Research:

MACROFITE COME BIOINDICATORI: ANALISI ECOLOGICA LUNGO IL BACINO DEL FIUME TEVERE E VALUTAZIONE DEGLI INDICI MACROFITICI

MACROPHYTES AS BIOINDICATORS:

ECOLOGICAL ANALYSES ALONG THE BASIN OF THE TIBER RIVER AND EVALUATION OF THE MACROPHYTIC INDICES

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RIASSUNTO

Per la corretta valutazione e caratterizzazione di un ecosistema fluviale si ritiene oggi fondamentale utilizzare un approccio di tipo integrato tra metodologie chimico-fisiche e biologiche.

La recente emanazione a livello europeo della Water Frame Directive (2000/60/CE) impone un innovativo aggiornamento delle metodiche analitiche e di classificazione dei corpi idrici.

La WFD, infatti, attribuisce un'importanza prioritaria agli organismi viventi ritenendo che questi costituiscano gli indicatori più validi per definire lo stato ecologico delle acque superficiali e per valutare realmente lo stato di salute di un corpo idrico. Nell'ambito dell'attuazione della WFD diventa, quindi, prioritaria la messa a punto di nuovi descrittori biologici dei diversi livelli trofici dell'ecosistema. Infatti l'applicazione della WFD prevede l'analisi non solo delle comunità di macroinvertebrati bentonici, già inclusi nella precedente normativa nazionale (152/99), ma anche di quelle diatomiche, ittiche e macrofitiche.

Da queste premesse nasce il presente progetto di ricerca riguardante in particolare lo studio ecologico della componente macrofitica che, comprensiva di fanerogame erbacee, macroalghe, briofite e pteridofite rinvenibili sia all'interno che in prossimità di corpi idrici, risulta sicuramente la meno indagata a livello nazionale.

L'area oggetto di studio è il bacino del fiume Tevere, il secondo bacino idrografico per estensione in Italia ed identificato dalle istituzioni governative come bacino pilota per studi di tipo ecologici (Bagnini *et al.*, 2005). Lungo il fiume Tevere e i suoi principali affluenti sono state selezionate, ai fini del campionamento macrofitico, 61 stazioni con caratteristiche morfologiche ed idrologiche differenti, per poter avere una maggiore eterogeneità di situazioni ecologiche.

Ai fini delle elaborazioni e delle analisi floristiche ed ecologiche, oltre ai dati raccolti, sono stati considerati alcuni rilievi floristico-vegetazionali disponibili in letteratura (Caneva *et al.*, 2005; Ceschin *et al.*, 2008; Ceschin *et al.*, 2009) inerenti ad alcuni corsi d'acqua del bacino oggetto di studio.

I rilievi floristici sono stati affiancati da analisi chimico-fisiche delle acque; nello specifico per ogni stazione sono state misurate la temperatura, il pH, la conducibilità, la salinità e la concentrazione di ossigeno disciolto.

Attraverso analisi spettrofotometriche si sono registrate, inoltre, le concentrazioni di fosfati, nitrati e ione ammonio, utili per valutare il grado di eutrofizzazione dei corsi d'acqua in esame. Sono stati inoltre analizzati attraverso un'osservazione diretta altri parametri ambientali come la torbidità, la velocità della corrente e la granulometria del substrato.

La raccolta dei dati macrofitici assieme a quelli abiotici sopra menzionati è stata la base di partenza per poter intraprendere indagini più specificatamente ecologiche.

I dati sono stati ordinati in una matrice ed elaborati secondo procedure di analisi statistica multivariata utilizzando metodi quali classificazione e ordinamento. Per alcune indagini di tipo esclusivamente ecologico è stato utilizzato anche l'approccio della teoria dei fuzzy set. Queste indagini hanno permesso di definire la nicchia ecologica delle specie macrofitiche e i loro ranges di compatibilità e di ottimizzazione in relazione ai gradienti dei fattori ambientali considerati. Sono state, quindi, elaborate curve di risposta ecologica per ogni specie relative a ciascuna delle variabili prese in esame. Le curve e i risultati ottenuti dalla classificazione e ordinamento dei dati hanno permesso di individuare quali specie possono essere utilizzate come indicatori biologici dello stato qualitativo delle acque. Queste specie possono essere considerate dei bioindicatori a tale scopo, in quanto risultano associate ad una ristretta gamma di valori dei fattori abiotici analizzati. E' stato possibile osservare, pertanto, in acque fluenti, fresche, ossigenate, meso-oligotrofiche e in genere poco inquinate, la presenza caratteristica di specie come le alghe Lemanea fluviatilis, Nostoc punctiforme e Chamaesiphon conferviculus, le briofite Cratoneuron filicinum, Fissidens viridulus, Plagionium undulatum, Cinclidotus aquaticus, Plathypnidium riparioides e Pellia endiviifolia e infine le fanerogame Hippuris vulgaris, Elodea canadensis, Groelandia densa, Berula erecta f. fluitans, Mentha aquatica f. fluitans, Lemna trisulca e Ranunculus tricophyllus. Nei tratti fluviali, invece, caratterizzati da acque lente, poco ossigenate, eutrofiche ed inquinate si trovano in modo peculiare specie come le alghe Enteromorpha flexuosa, Stigeoclonium sp., Oscillatoria amphibia e le fanerogame Persicaria amphibia, Schoenoplectus lacustris, Eleocharis palustris, Potamogeton natans, Spirodela polyrhiza e Potamogeton pectinatus. Si evidenzia, in quest'ultima tipologia di acque, l'assenza totale di briofite sottolineando la sensibilità che questo gruppo tassonomico nel suo insieme mostra nei confronti di condizioni generali di inquinamento.

Infine, sono stati testati sul set di dati raccolti alcuni dei principali indici macrofitici (MTR, GIS e IBMR), elaborati in ambito centro europeo, al fine di valutarne l'adeguatezza e applicabilità ai corsi d'acqua del bacino in oggetto rientranti in un contesto più propriamente mediterraneo.

Dai risultati emerge che questi indici, seppur mostrando una buona strutturazione metodologica, non riescono ad interpretare la vera condizione qualitativa dello stato trofico delle stazioni in oggetto; tali indici, infatti, non arrivano a discriminare in modo sensibile situazioni qualitativamente differenti. Appaiono, quindi, evidenti alcuni limiti di applicabilità di questi indici a contesti differenti da quelli di elaborazione, non solo per la scarsità

di specie in comune, come nel caso dell'indice MTR, ma anche per problematiche di tipo tassonomico; si fa presente, infatti, che talvolta questi indici considerano bioindicatori solo a livello di genere, mentre come sottolineano anche i risultati emersi in questa indagine, è spesso necessario arrivare al rango di specie a causa delle diverse risposte che, a volte, possono esistere tra specie del medesimo genere.

Inoltre confrontando le risposte autoecologiche ottenute nel presente studio con i coefficienti specie-specifici di sensibilità attribuiti dai diversi indici macrofitici alle specie in comune, si nota che l'informazione autoecologica non è talvolta coincidente, per alcune specie, come ad esempio *Ranunculus trichophyllus* e *Myriophyllum spicatum*, elemento questo che sottolinea l'importanza di un adattamento di tali coefficienti per le specie in ambito mediterraneo.

In ultimo, analizzando le liste dei bioindicatori relative agli indici macrofitici, è stato possibile evidenziare che queste riportano anche alcune entità che, in questo studio, si sono rivelate ad ampia ecologia e quindi non idonee a tale scopo.

I risultati ottenuti hanno permesso di ampliare le conoscenze floristiche relative alla componente macrofitica presente nell'area di studio. In particolare, oltre alle fanerogame, sono stati indagati con particolare attenzione i gruppi tassonomici relativi alle alghe, ai cianobatteri e alle briofite acquatiche di cui risultano, in ambito nazionale, solo poche e frammentarie informazioni.

Infine, i risultati ottenuti, hanno permesso di analizzare le relazioni esistenti tra le specie macrofitiche e i principali fattori ambientali, oltre che a creare un modello ecologico che possiede una sua congruità e che testimonia l'importanza dell'uso dei bioindicatori per la stima della qualità delle acque e del grado di alterazione ambientale nel suo complesso.

I risultati del presente progetto di ricerca rappresentano la base per future ricerche che avranno come obiettivo la formulazione di un indice macrofitico più idoneo per il contesto italiano ed in particolare per il settore mediterraneo contribuendo in questo all'implementazione delle linee guida di biomonitoraggio per la Water Frame Directive.

EXECUTIVE SUMMARY

For the correct evaluation and characterisation of a river ecosystem it is considered essential nowadays to adopt an integrated approach that takes into account physical, chemical and biological methods.

The recent adoption at the European level of the Water Frame Directive (2000/60/EC) requires an innovative update of the analytical and classification methods for water bodies.

The WFD in fact, gives top priority importance to living organisms as it sees these as the most valid indicators to define the ecological status of surface waters and to truly assess the health of a watercourse. In the context of the implementation of the WFD it therefore becomes a priority to develop new biological indicators of the different trophic levels of the ecosystem. In fact the implementation of the WFD involves examining not only the communities of benthic macroinvertebrates, that are already included in previous regulation (152/99), but also the diatom, fish and macrophyte communities.

These are the premises that underlie the present research project, that pertains in particular to the ecological study of the macrophytic component found both within and in proximity of water bodies, which includes herbaceous phanerogams, macroalgae, bryophytes and pteridophytes, and which is the least explored at national level .

The area under study is the basin of the River Tiber, the second basin in Italy by extent and identified by governmental institutions as a basin for pilot ecological studies (Bagnini *et al.*, 2005). For the purpose of the macrophyte survey, 61 sampling stations were selected along the River Tiber and its major tributaries, which had different hydrological and morphological characteristics, in order to have a greater diversity of ecological circumstances.

For the purposes of the elaborations and for the floristic and ecological analysis, in addition to the collected data, reference was made to certain floristic and vegetation surveys available in the literature and linked to some of the watercourses in the river basin under study (Caneva *et al.*, 2005; Ceschin *et al.*, 2008; Ceschin *et al.*, 2009).

The floristic survey was supported by chemical and physical analysis of the waters, which measured for each station the temperature, pH, conductivity, salinity and dissolved oxygen concentration.

Furthermore, the concentrations of phosphates, nitrates and ammonium were measured with spectrophotometric analysis, useful for assessing the degree of eutrophication of waterways under consideration. Whilst through direct observation other environmental parameters were analysed, including turbidity, current velocity and particle size of the substrate.

The collection of macrophytic data together with the abiotic data mentioned above was the starting point to carry out the ecological investigations.

The data was arranged in an array and processed according to procedures of multivariate statistical analysis using methods such as classification and sorting. For some analysis of an exclusively ecological nature, a fuzzy set theory approach was also applied. These investigations allowed to define the ecological niche of macrophytic species and their ranges of compatibility and optimisation in relation to gradients of the environmental factors considered. Ecological response curves were then elaborate for each species to each of the variables taken into consideration. The response curves and the results obtained from the classification and sorting of data made it possible to identify which species may be used as biological indicators of the qualitative state of the waters. These species can be considered as bioindicators for this purpose because they are associated with a narrow range of values for the abiotic factors analysed. It has been possible to observe therefore, in cool, oxygenated, meso-oligotrophic, flowing waters, with generally little pollution, the presence of distinctive species such as the algae Lemanea fluviatilis, Nostoc punctiforme and Chamaesiphon conferviculus, the bryophytes Cratoneuron filicinum, Fissidens viridulus, Plagionium undulatum, Cinclidotus aquaticus, Plathypnidium riparioides and Pellia endiviifolia, and finally the

phanerogams Hippuris vulgaris, Elodea canadensis, Groelandia densa, Berula erecta f. fluitans, Mentha aquatica f. fluitans, Lemna trisulca and Ranunculus trichophyllus. In the stretches of water characterized instead by slow currents, poor oxygenation, eutrophication and pollution, there are distinctive species such as the algae Enteromorpha flexuosa, Stigeoclonium sp., Oscillatoria amphibia and the phanerogams Persicaria amphibia, Schoenoplectus lacustris, Eleocharis palustris, Potamogeton natans, Spirodela polyrhiza and Potamogeton pectinatus. We highlight for the latter type of waters, the total absence of bryophytes, emphasizing the sensitivity that this taxonomic group as a whole shows towards general conditions of pollution.

Finally, certain of the principal macrophytic indices elaborated in a central European context (MTR, GIS and IBMR) were tested on the data set collected in order to assess their suitability and applicability to the watercourses of the basin under consideration and falling within a more strictly Mediterranean context.

The results show that these indices, although exhibiting a good methodological framework, fail to interpret the true qualitative condition of the trophic state at the stations in question; indeed these indices do not

discriminate in appreciable manner qualitatively different situations. There appear to be therefore, some obvious limits of applicability of these indices to contexts that are different from those where they were developed, not only because of the scarcity of species in common, as in the case of the MTR index, but also for taxonomical issues; we highlight in fact that sometimes these indices consider bioindicators only at the genus level, but as has also been outlined in this study, it is often necessary to reach the rank of the species due to different responses that can sometimes exist between species of the same genus. Furthermore by comparing the autoecological responses obtained in this study with the species specific coefficients of sensitivity conferred by the various macrophytic indices to the species in common, we note that the autoecological information does not always coincide, as for species such as *Ranunculus trichophyllus* and *Myriophyllum spicatum*; an element which emphasises the importance of adapting these coefficients to species in the Mediterranean context.

Lastly, by analysing the lists of bioindicators linked to the macrophytic indices, it has also been possible to highlight that these lists also report entities that in this study have displayed wide ecological amplitude, and therefore are not suitable for this purpose.

The results obtained have allowed to increase the floristic knowledge relating to the macrophytic component present in the area of study. In particular, apart from the phanerogams, other taxonomic groups were investigated with particular attention: the algae, cyanobacteria and aquatic bryophytes groups, for which there is, nationally, only modest and fragmentary information.

Finally, the information obtained made it possible to analyse the relationships between the macrophytic species and the main environmental factors, as well as to create an ecological model that has its own congruity and demonstrates the importance of the use of bioindicators in assessing the quality of the waters and the degree of environmental alteration as a whole. The results of this research project are the basis for future research that will have as its objective the formulation of a macrophytic index that is more suitable to the Italian context and in particular for the Mediterranean region, thus contributing to the implementation of the guidelines for biomonitoring under the Water Frame Directive 2000/60/EC.



1. INTRODUCTION

For a correct analysis and ecological characterization of a river ecosystem, it is deemed essential nowadays to use an integrated approach between physical, chemical and biological methods; and specifically, in regards to biological methods, between the diverse methods that utilise the information relating to species and biotic communities at different trophic levels (Bielli *et al.*, 1999; Minciardi and Rossi, 2001).

This is the direction taken by the Water Frame Directive 2000/60/EC, which requires an innovative update of the analytical and classification methods used for inland water bodies. In the WFD top priority importance is given to living organisms, which are considered more valid indicators in defining the ecological status of surface waters and to truly assess the health of the water body. Biological assessment has a number of distinct advantages over conventional abiotic chemical monitoring. It gives a better indication of the bioavailability of pollutants and their likely ecological effect. Furthermore, biological assessment is less dependent upon the time and place of sampling. Organisms respond to continuous pollution and also to pulses of pollution and may be considered to present a time, and to a lesser extent, space integrated record of the water quality at a particular site (Hellawell, 1986; Wright, 1995). Additionally, the assessment of pollution through the use of organisms may monitor a wider range and lower concentration (through bioaccumulation) of substances than can feasibly be measured in water and/or sediment samples (Whitton and Kelly, 1995). Conversely, biological methods may respond only to substances that produce a detectable effect on the test organism(s). Biological monitoring is therefore most usefully employed when a range of organisms are monitored, each for specific purposes, and in combination with traditional abiotic chemical assessment of water and/or sediment (Nixon et al., 1996).

The implementation of the WFD requires in fact, the analysis of not only the benthic macroinvertebrate communities already considered in the previous national legislation (Decreto leg. 152/99), to which bioindicator methods refer to and which have now been standardized better to define the ecological status of water bodies (Ghetti and Bonazzi, 1981; Ghetti, 1997), but testing also the diatom, macrophyte and aquatic vertebrate communities.

1.1 MACROPHYTES AS BIOINDICATORS

With the term macrophytes reference is made to a group that is defined in terms of structure and consisting of plant species that have in common macroscopic dimensions and the fact of being found both near and within surface water bodies. They include herbaceous phanerogams, pteridophytes, bryophytes and macroscopic algae, which form macroscopically visible agglomerations (Holmes and Whitton, 1977; Caffrey, 1987; Haury *et al.*, 1996; Haslam, 1997; Bielli *et al.*, 1999).

In regard to phanerogams, aquatic environments have a highly specialized flora, which in the case of Italy comprises about a hundred species with herbaceous habit.

Among the herbaceous phanerogams a distinction can be made between:

- hydrophytes: are plants that live in water. Can be distinguished and defined as pleustophytes species that do not present a root system and are freely floating (*Lemna sp.*, *Spirodela sp.*), and rizophytes species with a totally or partially submerged root system (*Myriophyllum sp.*, *Elodea sp.*, *Potamogeton sp.*).
- elophytes: are species with a robust root system that is anchored to the saturated, muddy substrate, while the upper portion (especially the flowering structure) is always above water. They are found along rivers, especially where the transition zone between the riverbed and riverbank is gradual (eg. Phragmites sp., Typha sp.).
- geophytes: are terrestrial plants that are not strictly aquatic but include certain species that can colonize the wet areas, generally keeping to the bank habitat (*Glyceria sp.*, *Phalaris arundinacea*, *Carex sp.* and *Cyperus sp.*).

In relation to the bryophytes and pteridophytes, there are only few species that live within the aquatic environment. Mosses and marchantiophytes (liverworts) are found mostly anchored to rocks and pebbles that are partially or fully immersed in the flowing waters.

Lastly, the aquatic microflora is characterized by the presence of filamentous cyanobacteria and macroalgae that occur as floating masses or anchored to phanerogams or to the substrate; the latter type is found mainly at stations characterised by high velocity currents.

In the literature and especially at the national level, information relating to algae, cyanobacteria and bryophytes found in the watercourses and relating to their role as bioindicators, are rather scarce and fragmentary.

In contrast, at the European level, several studies (Holmes, 1983; Hellawell, 1989; Borsant and Premazzi, 1992; Chambers and Prepas, 1994; Carbiener *et al.*, 1995; Kelly and Whitton, 1995; Barrat Segretain, 1996; Haslam,

1997; Lewis and Wang, 1997) have highlighted the importance of macrophytic species as bioindicators for assessing the quality of flowing surface waters, pointing to the following characteristics:

- marked sensitivity to certain types of pollutants such as biocides and organic pollution, which appear to be underestimated by macrobenthic indicators (Botineau and Ghestem, 1995; Robach *et al.*, 1996; Minciardi *et al.*, 2003);
- limited mobility;
- length of the life cycle (annual or over many years) that allows an assessment of the cumulative effects of various stress factors that occur over time.

However, attention should be paid to the fact that plant species, because they are intimately tied to the environment in which they are found, are influenced not only by pollution of organic origin, but also by all the other ecological factors that justify their presence in a particular site.

Each plant species has a window of tolerance in relation to each ecological factor within which it can perform its vital functions. The amplitude of this window varies from species to species and is referred to as the ecological amplitude. Plants that are more demanding and have more restrictive tolerance are said to have narrow ecological amplitude, and are the ones that can give the most useful contribution as bioindicators.

Described below are certain ecological factors (mainly abiotic), that influence the distribution and development of macrophytes:

- light: determines the photosynthetic rate in macrophytes, so much so that shade arising from the riparian vegetation and from the floating surface macrophytes has considerable influence on the development of the submerged species (Haury *et al.*, 2000). On the contrary, strong irradiation can cause substantial development of epiphytic filamentous algae. These may in turn affect the growth of the macrophytes on which they grow by restricting their photosynthetic functions (Wade *et al.*, 2002).
- temperature: influences phenology, but also the population dynamics of the biotitic component of the ecosystem on a seasonal basis (Haury *et al.*, 2000).
- hydraulic regime: is characterized by current velocity and discharge
 that are linked to the slope and morphology of the watercourse. The
 hydraulic regime selects species that can resist the current with
 anchoring systems. According to some authors, above the threshold of
 1 m/s, a negative correlation can be shown between the increased speed

of the current and the total plant biomass, explicable in terms of the problems in anchoring down even for root plants. Other authors argue that a moderate current speed can stimulate the growth of macrophytes as it increases the availability of oxygen, while below a certain threshold the proliferation of epiphytic algae may inhibit plant growth (Peltre *et al.*, 1998). Bryophytes prefer turbulent waters and fast currents; indeed in the high stretches of watercourses and thanks to strong rhizoid, aquatic mosses are the dominant plant species.

- depth: influences photosynthesis and there is a direct dependency on water clarity. With total transparency vegetation can grow at depth (Haury *et al.*, 2000).
- substrate: the type of substrate can affect the composition of the macrophytic populations; for example bryophytes need stable substrates to anchor to, while elophytes require loose substrates. The stability of the substrate is the factor that most affects the growth of macrophytes (Haury *et al.*, 2000), and is a function of particle size and current velocity.
- Physic-chemical parameters: mineralization and water trophic dynamics determine the presence and development of species. In particular the trophic level, in relation to the nutrient content (nitrogen and phosphorus), is crucial in defining the distribution and development of macrophytes. Thus it is no coincidence that most of the macrophytic indices rely on using the different taxa as indicators of a different level of sensitivity or tolerance to the trophic level of the waters.

Among the parameters that characterize the chemistry of water, alkalinity appears to influence macrophytes (Riis *et al.*, 2001).

For the purpose of trophic exchanges, submerged and floating hydrophytes are strictly dependent on the water in which they are immersed, as the root system operates essentially as anchoring structures to the substrate; geophytes and elophytes however, are less dependent on the water for the trophic exchanges and are affected by the chemistry of the sediment.

In addition to the ecological factors described above, anthropogenic disturbance can also greatly affect the occurrence and development of macrophytes, by directly or indirectly altering the ecological factors that control their distribution.

Anthropogenic disturbance factors can be summarized thus:

- hydraulic interventions: often have as objective the control of watercourses; such structures can severely reduce the size of the watercourse bed, increasing current velocity and leading to the disappearance of lentic environments, favourable to the settlement and development of macrophytes.
- water pollution: carries a profound impact on aquatic ecosystems, as such the different causes should be analyzed separately:

 eutrophication: is an alteration of the trophic system due to a strong increase in organic matter, especially nitrogen and phosphorus. Often watercourses are the recipients of sewage treatment plants or non-purified effluents, as well as wastewaters;
 - pollution from pesticides: that are often used in irrigation canals and in small semi-artificial watercourses to control the hygrophilous bank vegetation;
 - pollution from metals and synthetic compounds: the presence of trace metals and synthetic compounds results in the loss of diversity and the gradual disappearance of sensitive monolithic species, while other species (eg. some mosses) proliferate and are often used as bioaccumulators.
- diffusion of exotic species: occurs mainly along riparian environments
 where the potential vegetation is highly disturbed by anthropogenic
 disturbances. Invasive alien species, often pioneer species that are not
 very demanding in terms of ecology, will quickly spread there, thus
 contributing to the loss of naturalness in the banks.
- mowing: is a practice frequently used in the management and maintenance that is carried out to facilitate the flow of water. Mowing may encourage the proliferation of those species resistant to cutting, such as *Sparganium erectum* and *Elodea canadensis*, which become more frequent while the less tolerant eventually disappear.

1.2 DESCRIPTION OF THE MAIN BIOLOGICAL INDICES APPLIED TO MACROPHYTES

Starting in the '70s and exploiting the bioindicator properties of macrophytes, several macrophytic indices have been developed in Central Europe to evaluate the state of ecological integrity of surface watercourses (Caffrey, 1987; Haury and Peltre, 1993; Tremp and Kohler, 1995; Haury *et al.*, 1996; Haslam, 1997; Hill, 1997).

Within the European scientific literature it is possible to find several, variously structured macrophytic indices.

A first type of index is based on the presence/absence and abundance of a limited number of indicator species suitably selected and collected in "sensitivity groups".

The Macrophyte Index Scheme (MIS) (Caffrey, 1987) is the only indicator belonging to this type that has been used in Italy (Turin and Wegler, 1991). The index considers the presence/absence of 29 indicator taxa, divided into 4 "sensitivity groups" according to a decreasing gradient of sensitivity. Depending on the abundance ratio of the taxa found and using a conversion table, it is possible to assign each station to one of 5 "quality" classes as defined in the methodology. The limitation of this index is the small number of indicator taxa identified which are exclusively aquatic species (Azzollini *et al.*, 2003).

The second type of indices instead take into account numerous indicator taxa, each of which is assigned a specific numeric ratio of sensitivity to pollution resulting from increased organic matter, and because of this are defined as score indices. These include:

- Plant Score per Taxon \rightarrow (England Harding, 1981)
- Trophyx Index → (England Newbold and Holmes, 1987)
- Mean Trophic Rank (MTR) → (England Newman *et al.*, 1997)
- Trophic Index of Macrophytes (TIM)→(Germany Schneider and Melzer, 2003)
- GIS (Groupement d'Intéret Scientifique) → (France Haury *et al.*, 1996)
- Indice Biologique Macrophytique en Rivière IBMR → (France AFNOR, 2003)

As part of this research, in order to assess the quality of running water bodies through the analysis of the macrophytic component, indices were tested - namely the MTR (Newman *et al.*, 1997), the GIS (Haury *et al.*, 1996) and the IBMR (AFNOR, 2003; Haury *et al.*, 2006) - which were elaborated for the waterways of Central Europe, and their applicability to rivers falling within a more strictly Mediterranean context was analysed.

1.3 RESEARCH AND OBJECTIVES

The main objective of this research is to define for the Tiber river basin, that was identified by governmental institutions as a pilot river basin for ecological studies (Bagnini *et al.*, 2005), a cognitive framework for the effective use of the macrophytic component as bioindicator of the quality of surface running waters.

The use of macrophytic species as biological indicators should not disregard knowledge of their ecological behaviour, which should be rooted in the geographic context of the area where it is applied. Without this knowledge, the information given by the various European indices in assessing the quality of water courses may be unreliable or even misleading.

Therefore, in relation to the main objective and in order to contribute to studies testing and validating certain macrophytic indices, the following was attempted:

- ➤ deepen the taxonomic and ecological knowledge of aquatic macrophytes within a national context, and in particular of those less studied groups such as algae and bryophytes;
- analyse the correlations between the macrophytic component and the physicochemical parameters of the waters and the role of macrophytes as bioindicators of water quality through the description of the ecological response curves of species to the physicochemical parameters considered;
- ➤ define and describe the macrophytic species that are most sensitive and therefore more suitable for bioindication and biomonitoring;
- analyse and test certain macrophytic indices, described at European level, in order to assess the degree of applicability and reliability in describing the state of the water quality of the river systems in peninsular Italy.

The results will be used to evaluate the role of macrophytic species as bioindicators of water quality of the river system and will contribute to the implementation of the guidelines for biomonitoring under the Water Frame Directive 2000/60/EC.

2. MATERIALS AND METHODS

2.1 STUDY AREA

2.1.1 Framework of the basin of the Tiber River

The investigated area is the Tiber River basin that has a total area of around 17500 km², occupies much of the central Apennines and covers mainly two regions, Lazio and Umbria, where almost 90% of the entire river basin territory is found (Fig.2.1). Within these regions are important urban centres, like Rome, Perugia, Terni and Rieti. The remainder of the river basin territory lies in the Emilia Romagna, Tuscany, Marche and Abruzzo regions.

In terms of its morphology the limits of the river Tiber basin are determined by two watershed lines, one on the eastern side and the other on the western side. The eastern line separates the basin from the water courses on the Adriatic side, developing mainly along the Apennine ridge for a distance of about 474 km, largely at high altitude. The western line extends along the anti-Apennines, on the alignment formed by volcanic hills between the Colli Albani and Monte Amiata and the Alpi di Poti, the Alpi di Catenaia and the Alpi di Serra, for a distance of approximately 403 km and at lower altitudes.

The territory is characterized in a strong way, by the presence of the Tiber valley, which runs from north to south.

From a hydrographical point of view the catchment basin consists of a main river, approximately 400 km long represented by the River Tiber, with its source on Monte Fumaiolo and its mouth at Fiumicino, south of Rome and the main tributaries with their related branches belonging to the secondary hydrographic network.

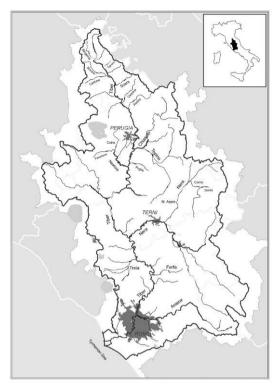


Fig.2.1: Tiber River basin

From a hydro-morphogical point of view the basin can be divided in three principal sectors. First an upper sector related to the mountainous zone, which has generally steep slopes, torrential character and a rocky substrate. Second a middle sector, falling within the Umbria region, in which the main river and its tributaries are characterized by pebbly and gravely lithologies and variable slopes that determine an alternation between, on the one hand, shallow tracts with faster flows and turbulent motion, and on the other, deep waters tracts with middle laminar flow. And thirdly, a lower sector which has instead a lentic character, a typical fluvial regime and calcareous sandymuddy substrates. This last sector falls almost entirely within the region of Lazio.

The prevailing lithotype is a calcareous one. As far as the bioclimate is concerned, it is temperate in the upper and middle sectors, while it is transitional Mediterranean in the lower one (Biondi and Baldoni, 1994).

The plant landscape of the basin presents a good level of conservation in the mountainous and sub-mountainous zones, while the valley floors and the plains have, with some exceptions, lost most of their original fluvial ecosystem characteristics, due particularly to urbanization and agricultural activities. This land use, evident above all in the central to downstream sections of most of the basin's rivers, is the principal cause of the general water eutrophication and mineralization (Casini and Giussani, 2006).

2.1.2 Site descriptions

As there already existed in the literature macrofitic data relating to stations in the lower basin of the River Tiber (Caneva *et al.*, 2005, Ceshin and Salerno 2008, Ceschin *et al.*, 2009, Ceschin at al. in press, Bisceglie at al. in press.), for the present study, the river basin sampling stations that were selected corresponded to the middle and upper sectors, so as to extend knowledge and describe in a qualitative and quantitative manner the macrofitic component. Thus, besides the approximately 70 stations extrapolated from the field-specific literature, a further 61 sampling sites were set up in the Tiber and its tributaries in order to have an ecological-environmental gradient from the areas further upstream to those further downstream. The sites were sampled between 2006 and 2009 in the summer and autumn seasons.

Furthermore, different types of water courses, rivers and streams, were examined, with different hydrological and morphological characteristics, in order to have a greater ecological heterogeneity.

The choice of sampling stations was made on the basis of the following criteria:

- homogeneity and representativeness of the stretch of water in relation to the environment (natural banks, tree or shrub vegetation, etc.);
- presence of geo-morphological and hydrodynamic characteristics in the water course that favoured the development and growth of aquatic vegetation;
- presence of a quatic macrophytes (including algae and bryophytes) with coverage no less than 5%;
- presence of supra-aquatic macrophytes even if not necessary;
- ease of access to the stations, also in view of the need to extract water samples for chemical and physical investigations.

In relation to what has been outlined above the following stations were selected (Tab. 2.1):

Tab 2.1: Sampling sites selected for this study for basin River Tiber; 2005/2006 literature data, 2006/2009 I sampled stations.

Sampling sites	2005/2006	2006/2009
Tiber River	48	13
Aniene River	12	15
Chiascio River		1
Clitunno River		3
Corno River		2
Farfa River	7	
Nera River		5
Nestore River		2
Sordo River		1
Timia River		1
Topino River		2
Treia River	4	
Argentina stream		1
Assino stream		1
Caina stream		1
Campiano stream		1
Carpina steam		1
Cerfone stream		3
Fersinone stream		1
Puglia stream		1
Seano stream		1
Singerna stream		1
Soara stream		1
Sovara stream		1
Stianta/Tignana stream		1
Vigi stream		1

Each of the stations mentioned in this work was given an alphanumeric code, in which the capital letters indicate the name of the river or stream where the station is found, while the numbers indicate the position in the sequence of surveys carried out along a water course, starting from the watercourse stations further upstream and working towards those further downstream. For longer rivers, such as the Tiber, the Nera, the Treia and the

Aniene, further lowercase letters were added to the code to identify the river section where the station was located (u: upper, m: middle, 1: lower and mou: mouth) (attached 1).

2.1.3 Brief description of the sampling stations in the basin of the River Tiber (2006-2009)

Below is a brief description of the sampling stations on the River Tiber and of the water courses of the primary and secondary network. Rivers and streams will be described starting from those located further upstream in the basin and progressing to those further downstream (Fig. 2.2). A photograph image is reported for each site.

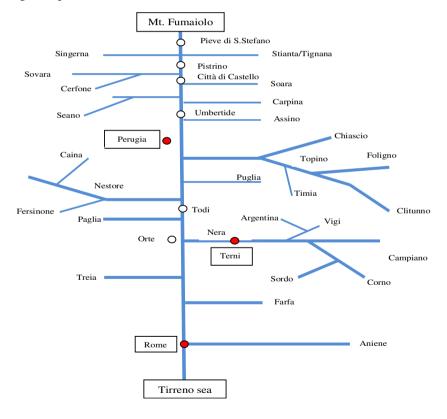


Fig.2.2: Tiber River basin scheme

River Tiber

- The Tu_1 station corresponds to the source of the Tiber on Mount Fumaiolo (Emilia Romagna region). The water gushes from the rock at about 1303 m above sea level, forming a small stream. The substrate is formed by rocks and boulders that are colonized predominantly by aquatic bryophytes, such as *Cratoneuron filicinum*, *Fontinalis antipyretica* e *Platyhypnidium riparioides*.





- Tu₂ station is situated upstream of Pieve di S. Stefano (AR) in the locality of Molin del Becco. The riverbed is approximately 6 m wide. The water is clear and the substrate consists of gravel and silt. What can be mainly observed in the water are filamentous algae such as *Cladophora glomerata*, *Auduinella hermannii* and *Nostoc punctiforme* but we find few shore species including *Typha latifolia* end *Equisetum arvense*.



Tu₂

- Tu₃ station is located near the town of Pieve di S. Stefano (AR), in Tuscany, about 403 m above sea level. As this is a relatively anthropized area, the riverbanks are characterized by artificial embankments formed by high walls. In this stretch of the Tiber the riverbed is about 4 m wide and the water runs clear and cool on a substrate of rocks and pebbles. Especially evident in the water, is the presence of filamentous algae such as *Cladophora glomerata, Oedogonium* sp. e *Microspora* sp. In the parts of the riverbed that are only reached by water periodically, there is the presence of certain species of phanerogams, such as *Nasturtium officinale, Veronica anagallis-aquatica, Juncus articulatus, Alisma plantago-aquatica* e *Mentha aquatica*.
- Tu_4 is found in the locality of Formole, downstream of Pieve di S. Stefano. The riverbed is wider and reaches about 15 m. In this section the water has a good degree of clarity and flows slowly. The substrate consists primarily of gravel and silt. The riverside area is characterized by arboreal and shrub species typical of the riparian environment, such as *Salix alba*, *S. eleagnos*, *S. purpurea* and *S. triandra*. In the waters, species such as *Cladophora glomerata*, *Microcystis flos-aque*, *Spirogyra sp.*, *Vaucheria geminata* (algae) and *Alisma plantago-aquatica*, *Nastirtium officinale*, *Juncus articulatus* and *Agrostis stolonifera* (phanerogams), can be found.





 Tu_3 Tu_4

- Tu₅ station is located in the vicinity of S. Sepolcro (AR), 291m above sea level. The surrounding area is characterized by scrub woodland and by uncultivated areas along the right bank. The riverbed is approximately 6 m wide. The water is clear and the current runs with average speed and laminar flow. In the water there are visible masses of filamentous algae, comprising mainly *Vaucheria geminata*, *Spirogyra* sp., *Oedogonium* sp., *Cladophora glomerata*, as well as phanerogams, such as *Nasturtium officinale*, *Veronica anagallis-aquatica*, *Mentha aquatica*, *Lytrum salicaria*, *Eupatorium cannabinum* and *Carex pendula*.



Tu₅

- Tu₆ station is located at 333 m above sea level, along the road towards the locality of Pistrino (Umbria region). The sampling site is located upstream of the bridge that leads to the village. The riverbed is about 16 m wide, the water is very clear and the substrate consists mainly of gravel and silt. The riparian zone is characterised by a strip of woodland *Populus nigra*, *Salix purpurea*, *S. alba*, and *Robinia pseudoacacia*. In the waters phanerogams are abundant, such as *Zanichellia palustris*, *Veronica anagallis-aquatica*, *Nasturtium officinale* and *Potamogeton crispus*.



Tu

- Tm₇ station is located downstream of the bridge that leads to Pistrino. The riverbed is about 12 m wide and is surrounded by scrub and riparian woodland, including *Populus nigra*, *P. alba*, *Salix alba*, *S. purpurea* and *Alnus glutinosa*. The water is clear and the current runs with average speed and laminar flow. The substrate has a good heterogeneity, consisting of boulders, pebbles, gravel and silt. In this section algal cover is abundant and the dominant species are *Cladophora glomerata* and some species of the genus *Spirogyra*. Also of note is the presence of phanerogams such as *Lemna gibba*, *Veronica anagallis-aquatica*, *Nasturtium officinale* and *Mentha aquatica*.



 Tm_7

- Tm₈ station is located downstream of Pistrino. The riverbed is about 12 m wide, the water is clear and the current flows slowly. The artificial riverbanks are formed by large boulders. There are visible masses of filamentous algae in the water, mainly *Vaucheria geminate*, *Cladophora glomerata*, *Spirogyra* sp. and *Oedogonium* sp. There are also phanerogams, such as *Lemna minor*, *L. gibba*, *Nasturtium officinale* and *Potamogeton crispus*.



Tms

- Tm₉ station is located near the town of Città di Castello in the Umbria region, 280 m above sea level. The water is clear and the current is characterized by average speed and a flow that becomes locally turbulent in the presence of small rapids. In the water there is abundance of filamentous algae such as *Vaucheria geminata*, *Cladophora glomerata*, and *Oedogonium* sp., as well as phanerogams such as *Potamogeton nodosus*, *P. crispus*, *Lemna gibba*, *Veronica anagallis-aquatica* and *Sparganium erectum*.

 Tm_9

- Tm₁₀ station is located within the town of Umbertide, 775 m above sea level, and is subject to diverse types of anthropogenic disturbances associated with the mechanical mowing of the riverbank vegetation, to the proximity to roads and housing and to the artificialisation of the banks; furthermore this stretch of river is used as venue for fishing competitions. Here the riverbed is about 20 m wide and the waters are partly cloudy. The substrate consists of pebbles, sand and silt. In the water we find the presence of *Nasturtium officinale*, *Veronica anagallis-aquatica* and *Potamogeton nodosus*.



 Tm_{10}

- Tm₁₁ station is located near Ponte Pattoli (PG). The riverbed is about 30 m wide and is framed by rows of trees, including *Salix alba* and *Populus nigra*. The water is cloudy and the current runs very slow. Few macrophytes are present, among these *Cladophora glomerata*, *Spirogyra* sp., *Oedogonium* sp., *Phormidium* sp., and *Potamogeton nodosus*.



 Tm_1

- Tm₁₂ station is located near Pontecuti, 113 m above sea level. The riverbed is approximately 30 m wide. The water is very cloudy and the current runs very slow. In the waters there is a predominance of filamentous algae masses, comprising *Vaucheria geminata* and *Spirogyra* sp., cyanobacteria such as *Oscillatoria* sp. and *Phormidium* sp., as well as some phanerogams such as *Potamogeton nodosus*, *P. crispus* and *P. pectinatus*.



 Tm_{1}

- Tm₁₃ is located in the locality of Baucche near Orte (Lazio region), 54 m above sea level. The riverbed is 40 m wide. The macrophytes present include *Potamogeton natans*, *P. nodosus*, *P. pectinatus*, *Callitriche stagnalis*, *Sparganium erectum*, *Mentha aquatica*, *Lytrum salicaria*, *Ceratophyllum demersum*, *Apium nodiflorum* and *Berula erecta*.



Tm₁₂

Singerna stream

The SING station is situated in the locality of Ontaneto in the province of Arezzo. The Singerna stream is one of the tributaries on the right bank of the River Tiber. The station is surrounded by riparian vegetation, trees and shrub, including Salix eleagnos, S. purpurea, S. alba and Populus nigra. The streambed is about 10 m wide, the waters are clear and the current flows with average speed and with laminar flow that is turbulent in places. The substrate is formed mainly of boulders and pebbles. The banks of the stream are artificial and formed of loose material, that entails the absence of a proper macrophytic band. The waters hold taxa such as Cladophora glomerata, Nostoc punctiforme, Mentha aquatica, Veronica anagallisaquatica and Epilobium hirsutum.



SING

Tignana-Stianta stream

The Tignana stream is a tributary of the River Tiber on the left bank. The STI station is situated in the locality of Aboca (AR). It features a riverbed about 4 m wide, with clear waters and a turbulent current that flows with average speed. The site has poor macrophytic coverage. Taxa that are present include *Cladophora glomerata*, *Spirogyra* sp., *Platyhypnidium riparioides*, *Stachys palustris* and *Iris pseudacorus*.



STI

Sovara stream

The Sovara stream is a tributary on the right bank of the River Tiber and crosses the locality of Pistrino. The SOV station features a riverbed about 4 m wide, with clear waters and a current that flows with turbulent average speed. The substrate consists mainly of pebbles and silt.

The water holds taxa such as *Cladophora glomerata*, *Vaucheria geminata*, *Oedogonium* sp., *Oscillatoria limnetica*, *O. subbrevis*, *Phormidium retzii*, *Potamogeton crispus*, *Veronica anagallis-aquatica*, *Berula erecta* and *Nasturtium officinale*.



SOV

Cerfone stream

This is a tributary of the Sovara stream for which three sampling stations were selected:

- CFR_1 station is situated in the locality of Monterchi. The riverbed is approximately 6 m wide. The current has average laminar flow and the water is clear. The substrate consists of silt. In the water Myriophyllum spicatum is present.
- CFR₂ station is located near CFR₁ but further downstream. Here the substrate changes and consists mainly of boulders and pebbles. In the water there is the presence of *Lemanea fluviatilis*, *Vaucheria geminata*, *Hygroamblystegium fluviatile*, *Veronica anagallis-aquatica* and *Sparganium erectum*.
- CFR_3 station is located within the town of Monterchi. The riverbed is 5 m wide, the substrate consists of silt, the current has average laminar flow and the water is partially clear. There is the presence of species such as *Potamogeton crispus*, *Sparganium erectum*, *Berura erecta*, *Apium nodiflorum*.





Soara stream

The Soara stream is a tributary on the left bank of the River Tiber. The SOA station is located south of the town of Città di Castello, about 939 m above sea level. The riverbed is about 5 m wide, the water is clear and the water current flows slowly. The substrate consists of pebbles. In the water there is the presence of filamentous algae masses formed by various species of *Chara* sp., *Vaucheria geminata*, *Zygnema* sp., *Spirogyra* sp., and phanerogams such as *Potamogeton crispus*, *Myriophyllum spicatum*, *Veronica anagallis-aquatica* and *Ceratophyllum demersum*.



SOA

Seano stream

This is a secondary tributary of the River Tiber flowing into the waters of the Nestore stream. The SEA station is located near the village of Calzolaro (PG). The riverbed is about 4m wide and is characterized by clear, slow flowing waters. The substrate consists of gravel and silt. In the water there are taxa such as *Chara* sp. *Vaucheria geminata*, *Ulothrix zonata*, *Zygnema* sp., *Zanichellia palustris*, *Veronica anagallis-aquatica*, *Nasturtium officinale*, *Typha latifolia* and *Alisma plantago-aquatica*.



SEA

Carpina stream

This is a tributary on the left bank of the River Tiber. The CAR station is situated close to the locality of S. Maria di Sette (PG). The riverbed is about 3 m wide, with clear, slow flowing water. The substrate consists of gravel and silt; along the right bank large boulders can be seen. Macrophytic coverage is poor and consists of species such as *Vaucheria geminata*, *Oscillatoria subbrevis*, *Cladophora glomarata*, *Platyhypnidium riparioides*, *Potamogeton nodosus* and *Veronica anagallis-acquatica*.

Assino stream

The ASS station is situated in the locality of Pian d'Assino, south of the town of Umbertide. The stream is a tributary on the left bank of the River Tiber. The riverbed is about 7 m wide and is characterized by a substrate formed mainly of pebbles and silt. The water is clear, and the water current runs with laminar flow and is slow in certain stretches, average in others. In the water the presence of filamentous algae is visible, such as *Chara* sp., *Vaucheria geminata*, *Spirogyra* sp., *Oscillatoria tenuis*, *Oedogonium* sp., *Cladophora glomerata*, and phanerogams such as *Zanichellia palustris*, *Veronica anagallis-aquatica*, *Mentha aquatica*, *Juncus articulatus*.





Caina stream

This is a tributary of the River Nestor. The CAI station is situated close to the locality of Pieve Caina. The riverbed is 5 m wide with a substrate that consists of boulders and silt. The water is cloudy ant the current flows slowly. In the water there is the presence of a large amounts of filamentous algae, such as *Cladophora glomerata*, *Oedogonium* sp., *Potamogeton nodosus* and *Veronica anagallis-aquatica*.



CAI

River Chiascio

The Chiascio is a tributary of the River Tiber and the CHS station is situated in the locality of Passaggio di Bettona (PG), 592 m above sea level, just before the confluence with the River Topino. The water is cloudy ant the current flows very slowly. The substrate is characterized by gravel, sand and silt. The water holds species such as *Potamogeton nodosus*, *Myriophyllum spicatum*, *Lemna minor* and *L. gibba*.



CHS

River Topino

The River Topino has its source on the slopes of Mount Pennino (1571 m) near Bagnara, in the municipality of Nocera Umbra, 649 m above sea level. It joins the River Chiascio in the locality of Passaggio di Bettona, and then flows into the River Tiber. Along this river two sampling stations were selected:

- TOP_1 station is further upstream and is near the locality of Capo d'Acqua (PG). The riverbed is 6 m wide, the water is clear and the current has average speed and laminar flow. There is considerable algal coverage characterized by taxa such as *Vaucheria geminata* and *Spirogyra* sp. - TOP_2 is situated just before the confluence with the River Chiascio near Torandrea, 617 m above sea level. The riverbed is 15 m wide and the cloudy waters flow slowly. The substrate consists of gravel and silt. In the water there is the presence of *Cladophora glomerata*, *Myriophyllum spicatum*, *Potamogeton pectinatus*, *P. nodosus* and *Lemna minor*.



Timia stream

This is a tributary of the River Topino. The TIM station is situated close to the locality of Bevagna, 691 m above sea level. The riverbed is 10 m wide and the water is partly cloudy and flows with the average-slow speed. Of note is the presence of *Potamogeton nodosus* and *P. pectinatus*.



TIM

River Clitunno

The River Clitunno has its source in the locality of Fonti del Clitunno in the municipality of Campello sul Clitunno, from a karstic resurgence. For this river three sampling stations were selected:

- CLT₁ is located in correspondence of the resurgence, 741 m above sea level and within the historical park. The station is characterized by very clear waters and dense populations of phanerogamic macrophytes, such as *Hippuris vulgaris* and *Groelandia densa*. The riverbanks are surrounded by dense vegetation that is enriched by exotic species placed there as adornment for the park.
- CLT_2 is situated near the locality of Case Vecchie, 203 m above sea level. The riverbed is about 6m wide and the substrate consists of gravel, pebbles and sand. In the water an abundant coverage of macrophytes is noticeable, such as *Callitriche stagnalis*, *Ranunculus trichophyllus*, *Myriophyllum spicatum*, *Berula erecta*, *Apium nodiflorum*.
- CLT₃ is situated near the village of Chiesa Tonda, 226m above sea level. The riverbed is about 10m wide and the heterogeneous substrate consists of gravel, pebbles, sand and silt. The water is clear and the current runs with average speed and laminar flow. Of note is the abundant coverage of macrophytes in the riverbed, that include *Nasturtium officinale*, *Callitriche*

stagnalis, Potamogeton crispus, Zanichellia palustris, Berula erecta and Hippuris vulgaris.









CLT₂ CLT₃

Puglia stream

This is a tributary on the left bank of the River Tiber. The PUG station is situated near the locality of Collepepe (PG). The riverbed is about 5 m wide and there are few macrophytes in the water, such as *Zanichellia palustris*, *Apium nodiflorum* and *Potamogeton pectinatus*.



PHC

River Nestore

This is a tributary on the right bank of the River Tiber for which two sampling stations were selected:

- NES₁ station is characterized by a riverbed about 10 m wide where the water flows very slowly and is very cloudy. Taxa which are present include *Cladophora glomerata*, *Oedogonium* sp., *Nasturtium officinale*, *Potamogeton nodosus*.
- NES₂ station is located upstream of the locality of Marsciano, 578 m above sea level. The riverbed is about 20 m wide, the water is partly cloudy and the current runs with average speed and turbulent flow. The site is characterized by a certain anthropic disturbance brought by the nearby roads and housing. The substrate consists mainly of boulders, pebbles and sand, mechanically reworked by man; of note also are artificial platforms at the bottom of the river. In the water there is considerable presence of filamentous algae, including *Cladophora glomerata*, *Melosira varians* and *Zygnema* sp., while less abundant are the phanerogams, that include *Zanichellia palustris*, *Veronica anagallis-aquatica*, *Mentha aquatica*, *Juncus articulatus*.





NES₁ NES₂

Fersinone stream

This is a tributary of the River Nestor. The FRS station is located just before the confluence with the River Nestor, about 510 m above sea level. The river is about 10 m wide and is characterized by partially clear waters, sometimes affected by the discharges of cattle sewage. The substrate consists of boulders, pebbles and sand. Macrophytic coverage is characterized by clusters of filamentous algae such as *Cladophora glomerata*, *Oscillatoria limosa*, *Spirogyra* sp. and *Zygnema* sp., and few phanerogams such as *Potamogeton nodosus*, *Mentha aquatica*.



FRS

River Nera

This is a tributary on the left bank of the River Tiber for which five sampling stations were selected:

- N_1 station is situated just upstream of the locality of Borgo Cerreto, 342 m above sea level. The riverbed is 8m wide and the substrate consists mainly of boulders and pebbles. The water is clear and the current runs with average speed and laminar flow. In the water *Ranunculus trichophyllus*, *Apium nodiflorum* and *Veronica anagallis-aquatica*.
- N_2 station is situated near the locality of Terria, 246 m above sea level. The riverbed is about 10 m wide and the substrate consists of gravel and sand. The water is clear and the current runs with average speed and turbulent flow. In the water there is the presence of species such as *Potamogeton crispus*, *Callitriche staganalis*, *Berula erecta*, *Lemna trisulca* and *Ranunculus trichophyllus*.
- N_3 station is situated near the locality of Castel del Lago, 203 m above sea level. The station is characterized by riparian scrub vegetation, including *Salix alba, Populus nigra*, and *Alnus glutinosa*. The substrate consists of pebbles. The water is clear and the current flows at high velocity. In the water species present include *Cladophora glomerata*, *Fontinalis antipyretica*, *Platyhypnidium riparioides*, *Lemna trisulca*, *Callitriche stagnalis*.
- N_4 station is situated in the locality of Narni Scalo, 55 m above sea level. The station is characterized by the proximity of roads, housing and allotments close to the bank. The water is partially clear. The substrate consists primarily of pebbles, sand and silt. Macrophytic coverage is abundant with species such as *Myriophyllum spicatum*, *Callitriche stagnalis*, *Potamogeton pectinatus*, *Lemna minor*, *Zanichellia palustris*.
- N_5 station is situated close to the dam of S. Liberato. The substrate consists of sand and silt and the water is fairly clear and flows very slowly. Taxa found include *Spirogyra* sp., *Oscillatoria* sp., *Phormidium valderianum*, *Oedogonium* sp., *Nostoc punctiforme*, *Callitriche stagnalis*, *Zanichellia palustris*, *Elodea canadensis*, *Sparganium erectum*.



Campiano stream

This is a tributary on the left bank of the River Nera. The streambed is about 4 m wide. The water is clear and the current runs with average speed and turbulent flow. Abundant coverage of phanerogams is found in the water comprising primarily *Ranunculus trichophyllus*. The riparian zone is characterized by the presence of *Salix alba*, *S. purpurea*, *Populus alba* and *Sambucus nigra*.

Argentina stream

This is a tributary on the right bank of the River Nera. The ARG station is situated in the locality of Postignano-Seccano upstream of the confluence with the Vigi stream. The streambed is about 2m wide. The water is clear with a fast current and turbulent flow. The substrate consists mainly of boulders, pebbles and gravel. In the water there is abundant macrophytic coverage characterized by Fontinalis antipyretica, Nasturtium officinale, Apium nodiflorum, Epilobium hirsutum, Eupatorium cannabinum and Berula erecta.





CMP ARG

Vigi stream

This is a tributary of the Argentina stream. The VIG station is situated close to the locality of Cerreto di Spoleto. The stream bed is 4 m wide. The water is clear and the current runs with average speed and turbulent flow. The substrate consists of boulders, pebbles and, to a lesser extent, gravel. In the water there is the presence of filamentous algae such as *Cladophora glomerata*, *Oscillatoria subbrevis*, *Vaucheria geminata* of bryophytes such as *Platyhypnidium riparioides*, *Palustriella commutata* and of phanerogams such as *Apium nodiflorum*, *Nasturtium officinale*, *Veronica beccabunga*.



River Sordo

This is a tributary of the River Corno. The SRD station is located near the town of Norcia, about 570 m above sea level. The riverbed is about 3 m wide and entirely covered with aquatic vegetation such as *Ranunculus trichophyllus*, *Veronoca anagallis-aquatica*, *Berula erecta*, *Nasturtium officinale*.



SRE

River Corno

This is a tributary on the left bank of the River Nera for which two sampling stations were selected:

- CRN₁ station is situated in the locality of Rocca Porena near the small town of Cascia. The riverbed is 4 m wide. The water is clear and the current runs with average speed and laminar flow that is turbulent in places. The substrate consists mainly of pebbles, boulders and gravel. There is the presence of species such as *Cladophora glomerata*, *Oscillatoria amoena*, *O. subbrevis*, *Ulothrix zonata*, *Vaucheria geminata*, *Platyhypnidium riparioides*, *Veronica anagallis-aquatica* and *Nasturtium officinale*.
- CRN_2 station is situated in the locality of Serravalle, just upstream of the confluence with the River Sordo. There is the presence of species such as *Vaucheria geminata*, *Fontinalis antipyretica*, *Apium nodiflorum* and *Zanichellia palustris*.





CRN₁ CRN₂

River Aniene

Tributary on the left bank of the River Tiber in which it flows within the city of Rome. Along this river thirteen sampling stations I were selected for this study in the 2006/2009:

- ANu₁ station is situated in the locality of Filettino, 914 m above sea level. The riverbed is about 4m wide. The water is clear and the current runs with average speed and turbulent flow. The substrate consists of boulders, gravel and sand. In the water different taxa are found, algae such as *Cladophora glomerata*, *Ulothrix zonata*, *Spirogyra* sp. bryophytes such as *Hygroamblystegium tenax*, *Platyhypnidium riparioides*, *Plagiomnium undulatum*, *Lunularia cruciata*, *Pellia endiviifolia*, and phanerogams such as *Veronica beccabunga* and *Nasturtium officinale*.
- ANu₂ station is located further downstream on the main road to Filettino, 733 m above sea level. The riverbed is 4 m wide and the substrate consists

of boulders, gravel and sand. In the water there are Cladophora glomerata, Vaucheria geminata, Oedogonium sp., Platyhypnidium riparioides, Hygroamblystegium fluviatile, Conocephalum conicum, Marcantia polymorpha and Veronica beccabunga.

- ANu₃ station is near the locality of Trevi, 634 m above sea level. The riverbed is about 6m wide and the substrate consists mainly of pebbles, gravel and sand. In the water abundant algal masses are found, formed by *Oscillatoria* sp., *Cladophora glomerata*, *Vaucheria geminata* and bryophytes such as *Fontinalis antipyretica*, *Cinclidotus fontinaloides* and *Conocephalum conicum*.
- ANu₄ station is located upstream of Subiaco, 510 m above sea level. The riverbed is about 10 m wide. The water is clear and the current runs with average speed and turbulent flow. The substrate comprises mostly of boulders and pebbles. In the water there are abundant filamentous algae masses and bryophytes such as *Oscillatoria* sp., *Vaucheria geminata*, *Ulothrix zonata*, *Nostoc punctiforme*, *Conocephalum conicum*, *Lunularia cruciata* and *Cinclidotus fontinaloides*.
- ANu_5 station is located in Subiaco, close to the former paper mill and 373 m above sea level. The riverbed is 15 m wide and the clear waters flow slowly. The bottom of the riverbed is characterized by the presence of cement platforms on which a substrate of pebbles and gravel has been mainly accumulating. In the water there is a dense algal cover characterised by *Vaucheria geminata*, *Mougeotia* sp., *Spirogyra* sp., *Oscillatoria* sp.
- ANu₇* station is located downstream of the small town of Subiaco, where the Ponte S. Francesco bridge is situated, 372 m above sea level. The riverbed is 15 m wide, the water is clear and the substrate consists of pebbles and sand. Also at this station there is the presence of artificial platforms at the bottom of the riverbed. In the water, 80% of the macrophytic cover comprises of algae such as *Vaucheria geminata* and *Oscillatoria* sp.
- ANm_{10}^* station is situated in the locality of Anticoli Corrado, 323 m above sea level. The riverbed is 15 m wide and the substrate is made of loose material consisting of pebbles, gravel and sand. In the water there is the presence of *Vaucheria germinata*, *Oscillatoria* sp., *Callitriche staganalis*, *Apium nodiflorum*, *Veronica anagallis-aquatica* and *Ranunculus trichophyllus*.
- ANm₁₃* station is situated near the locality of Vicovaro S. Sepolcro, 270 m above sea level. The riverbed is 5m wide and the substrate comprises

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The numbers of stations are not consequential. The missing numbers refer to sampling stations, taken from literature data and not described in this paragraph.

pebbles, gravel and sand. In the water algal cover is very abundant and the species found include *Vaucheria geminata*, *Ulothrix zonata* and *Cladophora glomerata*.

- ANm_{15}^{*} station is located near Castel Madama power station, 253 m above sea level. The riverbed is 10 m wide and the substrate consists mainly of gravel and sand. The water is clear and the current run with average speed and laminar flow. In the water there are found *Ranunculus trichophyllus*, *Veronica anagallis-aquatica*, *V. beccabunga*, *Apium nodiflorum*.
- ANm₁₇* is also located near the Castel Madama power station, on the opposite side of the river of the previous station. In the water there are found *Elodea Canadensis*, *Potamogeton crispus*, *P. nodosus*, *Callitriche stagnalis*, *Sparganium erectum* and *Iris pseudacorus*.
- ANl_{19}^* station is located in Tivoli, 205 m above sea level. The water is partly cloudy and flows very slowly. The substrate consists primarily of silt. In the water, a continuous carpet cover of *Elodea canadesis* is noticeable.
- ANl₂₁* station is situated in the locality of Villanova di Guidonia, 45 m above sea level. The riverbed is about 10 m wide. The water is partly cloudy and flows slowly. The substrate consists mainly of sand and silt. There are species such as *Vaucheria geminata*, *Ulothrix* sp., *Zanichellia palustris*, *Veronica anagallis-aquatica* and *Callitriche stagnalis*.
- ANl₂₃ station is situated in the locality of Lunghezza, 27 m above sea level. The riverbed is about 13 m wide and the substrate consists primarily of silt. In the water there is widespread presence of *Potamogeton pectinatus*.
- ANl_{24} station is located within the city of Rome, near the Grande Raccordo Anulare ring road. The riverbed has an average width of 20 m. The substrate comprises primarily of silt and the current has average speed and laminar flow. The area is degraded; however, the hydrological conditions seem to favour in the water the presence of macrophytic vegetation. Of note among the dominant species present is *Potamogeton pectinatus*.
- ANI₂₅ station is located at the confluence of the Aniene river with the River Tiber. The water course is set within steep artificial embankments, densely covered by *Arundo donax*. Here the river has an average width of 20 m. The water is cloudy and the current runs with laminar flow. The substrate consists primarily of silt. Along the banks all kinds of waste are visible (discarded batteries, scrap metal, etc) testifying to the considerable environmental degradation that exists along this stretch of river found within the urban area of Rome. In the water there is the presence of *Enteromorpha flexuosa*, *Cladophora glomerata* and *Potamogeton pectinatus*.







 $ANu_{3} \hspace{3.5cm} ANu_{4} \\$





 ANu_5 ANu_7





 $ANm_{10} \hspace{3.5cm} ANm_{13} \\$





 $ANm_{15} \hspace{3.5cm} ANm_{17} \\$





ANI₁₉ ANI₂₁





 ANl_{23} ANl_{24}



ANI₂₅

2.2 FLORISTIC SAMPLINGS

The macrophytes were sampled during the main vegetation period that lasts, in general, from June to October.

Most of the sampling sites belong to the monitoring network of the Environmental Protection Agencies of the Umbria, Tuscany and Lazio regions.

The survey was carried out in 50 m long sections with uniform morphology condition, substrate characteristics, flowing velocity and vegetation patterns.

A qualitative and quantitative inventory of macrophytes was carried out including filamentous algae, bryophytes and vascular plants.

As for the algae group, the samplings concerned mainly the floating masses of filamentous algae and the epilithic and epiphytic macro-patinas. In regards to the bacillariophyceae group, epiphytic species were considered. No specific method was used for sampling diatoms, therefore the data component concerning this undervalues the actual occurrence of diatom species in the watercourse basins. Different sampling procedures in relation to the specific algal component were analysed. For floating algae a direct collection method was carried out, while for the samples of benthic algae the procedure involved scraping the samples from macrophytes, pebbles and rocks.

At each station, a qualitative and quantitative inventory of the algal taxa was carried out. In regards to the quantitative data of the macroscopic aggregation, the percentage cover of the species in river was evaluated on 5m² stretches according to the Braun-Blanquet's scale (Braun-Blanquet, 1964). The taxa which were ranked higher than 25% were considered dominant.

Samples were fixed in 4% formaldehyde and analysed under optical microscopes (Leica DM RB) equipped with a computer image analysis device (Leica, IM1000).

For the taxonomical determination, main monographs were followed (Bourrelly, 1966, 1968, 1970; Reichardt, 1984; Ettl and Gärtner, 1995; John *et al.*, 2002). Most entities were determined to the species level. Some however, owing to the absence of reproductive structures, were determined to the genus level.

The specimens of bryophytes that could not be determined in the field were dried and, accompanied with information on location, environment and collection date, were taxonomically determined according to the key produced by Cortini Pedrotti (2001, 2005) and Aleffi *et al.* (2008).

For the determination and nomenclature of vascular plants, reference was

made to the specific literature (Pignatti, 1982, Conti et al., 2005).

For each of the stations sampled a survey was carried out of the aquatic species, including the riverbank species that have their root system in the water and that may be periodically submerged (AA.VV., 2007). Furthermore, as these procedures rely solely on the analysis of species that live in close contact with the water, the shrub and arboreal vegetation found along the riverbanks was described in a generic manner and only for the purposes of the contextualization and description of the area.

Thus for each individual survey station the general characteristics were described (latitude and longitude, altitude, aspect, slope, substrate, area surveyed) trying also to clarify, for the benefit of the aquatic nature of the surveys, the hydro-geomorphological characteristics of the stretch of the watercourse analysed (morphology, condition of the riverbed, water transparency, current velocity, substrate, chemical and physical parameters of the waters, anthropic disturbances, etc.).

The appendix (2) includes the template form specifically developed as part of this study for the sampling of macrophytes and used in the field for the floristic surveys and the collection of habitat and hydrological data. For each species found in the sampling sites a coverage value was associated. The present study adopted the abundance-dominance scale proposed by Braun Blanquet (1964):

- r : rare species with few individuals and negligible coverage
- +: species coverage that is less than 1%
- 1: species coverage that is in the range 1-5%
- 2: species coverage that is in the range 5-25%
- 3: species coverage that is in the range 25-50%
- 4: species coverage that is in the range 50-75%
- 5: species coverage that is in the range 75-100%

2.3 ANALYSIS OF CHEMICAL AND PHYSICAL PARAMETERS

The distribution and development of aquatic vegetation, as reported in the literature (Butcher, 1933; Meriaux, 1982; Wiegleb, 1984; Riis *et al.*, 2001; Barendregt and Bio, 2003; Abou-Hamdan *et al.*, 2005), depends on certain factors that include the mineralization of the water (conductivity and hardness), the trophic state (phosphates and nitrates) as well as hydromorphological and sedimentological parameters.

Therefore, the distribution of macrophytes found in the study area was analysed in terms of certain physical, chemical and hydro-morphological parameters considered important in the development of aquatic species. In regards to the chemical and physical properties of the watercourses, these were measured *in situ* using a multi-probe analyser (WTW Analyzer) for conductivity, pH value, dissolved oxygen and water temperature.

Spectrophotometric analysis was used to assess the concentration of phosphate (PO_4^{3-}) , ammonium (NH_4^+) and nitrate (NO_3^-) , elements considered amongst the main factors responsible for the organic pollution of water courses.

Data on phosphate, ammonium and nitrate concentration, were compared to official figures issued by local water authorities (ARPA Lazio, 2005-2007; ARPA Umbria, 2005-2007; ARPAT, 2005-2007).

Moreover, other parameters were analysed, such as turbidity, current speed and particle size of the substrate.

Hydromorphological and hydrogeological data were acquired directly in the field in the following manner:

- the current speed was estimated visually according to qualitative assessment scale (very slow, slow, average and laminar, average and turbulent, high and turbulent, very high and turbulent);
- the particle size of the substrate was evaluated based on the presence of rocks, boulders, pebbles, gravel, sand and silt;
- brightness was measured indirectly according to the tree coverage of the surrounding riparian environment;
- turbidity was estimated according to a scale based on the degree of transparency of water (total, partial, null).

The data relating to the chemical and physical parameters is attached (3) to this document.

This collected data is the starting point for the ecological survey, which is the object of the research project.

2.4 STATISTICAL ANALYSIS

To carry out the statistical analysis an array was constructed comprising both the field survey data and survey data taken from the literature and relevant to the study area (Ceschin and Salerno, 2008; Ceschin *et al.*, 2009). The overall dataset was organized in a matrix comprising 132 sites and 339 species, based on the coverage value of the species (attached 4).

To describe the behaviour of species within the ecological space, principal component analysis (PCA) and the Biplot method (Gabriel, 1971) was applied to the species centroid matrix, i.e. the average behaviour compared to the ecological factors in question (temperature, pH, dissolved oxygen concentration, conductivity, ammonium salt concentration, nitrates and phosphates, current speed and water turbidity). For this analysis the multivariate statistical analysis program Ginkgo (De Cáceres *et al.*, 2003) was used.

To define the ecological niche of the different species found, and to assess the degree of correlation and response (as bio-indicators) to the gradients of the main parameters considered, specific statistical analysis techniques were adopted based on fuzzy set theory (Zadeh, 1965, 1978) as proposed by Andreucci *et al.* (2000) and Biondi, Feoli, Zuccarello (2004), so as to describe the ecological response curves of species to the ecological parameters considered.

According to this method, the species are described as a fuzzy set, which present a specific degree of belonging to the whole range of the ecological factors considered. The membership function (expressed as degree of belonging) can vary in a continuous manner from 0 to 1, in opposition to the classic logic. The more the value gets close to 1, the more the species is connected and compatible to a particular status of the environmental variable. The more it gets close to 0, the more its presence is excluded. The degree of belonging, then, expresses the possibility that a species is present in environmental situations characterized by a defined reference value of the factor.

The curve, which results from the interpolation of the degrees of belonging along the whole range of the ecological factors considered, describes the ecological response of the species; it could be interpreted as an environmental compatibility curve (Andreucci *et al.*, 2000; Biondi *et al.*, 2004). The peak of the curve represents the environmental state most suitable for the presence of the species (which can be associated to the optimum concept), while the range, which shows a greater degree of belonging to a specific threshold value suitably chosen, indicates the interval in which at any rate it is plausible to find the species (range of tolerance). For this kind of analysis a specific software was developed (Zuccarello, unpublished).

Finally, using the Ginkgo program (De Cáceres *et al.*, 2003), a cluster analysis was carried out of the individual ecological factor for each group considered (algae, cyanobacteria, briophyte, phanerogams) based on values (degrees of connection) resulting from the response curves formed on the basis of the behaviour of the species for each ecological factor considered. A cluster analysis of the data with a complete linkage algorithm (Anderberg, 1973) on the similarity ratio between relevés (Westhoff and Van der Maarel, 1978) was also carried out.

2.5 APPLICATION OF MACROPHYTIC INDICES (MTR, GIS, IBMR)

In the present study a further pilot study was also carried out, looking at the use of certain macrophytic indices formulated at European level. Among all the water courses investigated in this study, the Tiber and Aniene rivers were chosen for this pilot as there exists extensive research and abundant data that describes in detail the ecological characteristics and the increasing anthropogenic disturbance gradient that occurs from the source to the mouth of the rivers. Among the different macrophytic indices found in the literature (Caffrey, 1987; Haury and Peltre, 1993; Tremp and Kohler, 1995; Haury et al., 1996; Haslam, 1997; Hill, 1997) the MTR, GIS and the IBMR indices were selected as these present a standard methodology based on a coefficient of sensitivity ascribed to each specie in relation to the trophic state. These indices consider a large number of taxa, many of which are present in the Italian territory. Furthermore the GIS and IBMR indices expand the list of taxa including not only the sensitivity coefficient for strictly aquatic species, but also that for supra-aquatic species. Finally the IBMR index reports for each species the coefficient of ecological amplitude.

The macrophytic indices were therefore applied to the data according to the procedures and methods described by the authors and reported in attached (5). It was thus possible to calculate the values of the macrophytic indices applied to the respective sampling stations.

3. RESULTS

3.1 GENERAL FLORISTIC

The flora surveyed consists of a total of 328 taxa. In annex (4), there is the complete list of organisms found in the study, including species, subspecies and varieties.

The species sampled can be distinguished in 5 distinct taxonomic groups: algae, cyanobacteria, bryophytes, pteridophytes and phanerogams. Species belonging to this last group can be further distinguished between strictly aquatic species (A) and riverbank species (R), i.e. water bank macrophytes that have their root system in water for 85% of the year.

The largest group is that of the phanerogams, with 156 of species; 34 are strictly aquatic species (A), while the riverbank species are 122 (R). To this group follow algae and cyanobacteria with 149 entities, bryophytes with 23, and lastly pteridophytes, represented by a single species. The Fig. 3.1 shows the percentage composition of the different taxonomic groups.

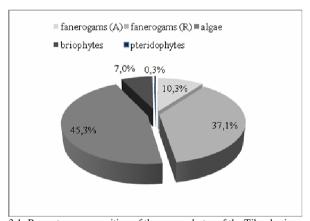


Fig. 3.1: Percentage composition of the macrophytes of the Tiber basin.

In regards to the distribution of species in the watercourse of the basin, it can be noted that some are widely dispersed.

Among these in particular are certain filamentous algae like *Cladophora glomerata* (Chlorophyta), that with a frequency of 70% proves to be the species most abundant and widely distributed in the majority of the rivers investigated. Very widespread are also Xantofita, *Vaucheria geminata* and other Chlorophytes, such as *Microspora amoena* and genera such as

Oedogonium and Spirogyra. Also epilithic and epiphytic species appear widespread within the floating algal masses and macro-patinas even if they are not significant in terms of biomass; they include *Phormidium valderianum*, Closterium ehrebergii, several species of the genus Oscillatoria and Melosira varians, Cocconeis pediculus and Gomphonema olivaceum (Fig. 3.2).

Particularly abundant are also certain riverbank phanerogams, such as *Lycopus europaeus* (64,4%), *Lythrum salicaria* (59,1%), *Scrophularia auriculata* (49,2%), *Mentha aquatica* (43,2%) (Fig. 3.3) and some riverbank species, including *Potamogeton nodosus* (44%), *Myriophyllum spicatum* (36,4%), *Potamogeton pectinatus* (35,6%) (Fig. 3.4).

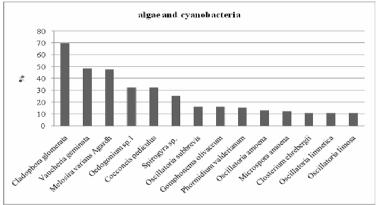


Fig. 3.2: More common species of algae and cyanobacteria in the watercourses of the Tiber basin

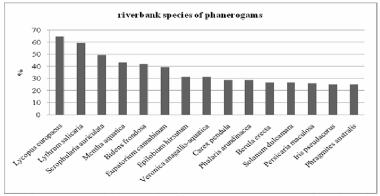


Fig.3.3: More common riverbank species of fanerogams in the watercourses of the Tiber basin

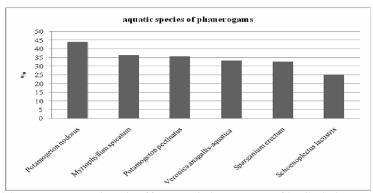


Fig. 3.4: More common aquatic species of fanerogams in the watercourses of the Tiber basin

Other species have a more limited distribution and are quite rare at the basin scale. Of note among these is the bryophyte group that, with the exception of *Fontinalis antipyretica*, is represented by poorly distributed species, which are often exclusive to certain watercourses. For example *Cinclidotus aquaticus*, *Fissidens viridulus*, *Orthotrichum stramineum*, *Plagionium affine* and *P. undulatum* were only detected in the upper stretches of the River Aniene; just as *Dialytrichia mucronata* was only found in the upper stretches of the River Nera. Even liverworts like *Aneura pinguis*, *Pellia endiviifolia*, *Lunularia cruciata* and *Conocephalum conicum* appear to be poorly distributed and were detected only in the River Aniene.

Also among the algae and cyanobacteria groups some taxa have a more limited distribution and are only found in a few watercourses of the basin. In particular over 20 taxa are present exclusively in the River Tiber, including some species of Chlorophyceae, Monoraphidium contortum, Pediastrum simplex, P. tetras, Chaetophora elegans, Klebsormidium flaccidum and various species of the Closterium (C. kuetzingii var praelongum, C. brevius) and Cosmarium (C. bioculatum, C. laeve, C. meneghinii, C. punctulatum). The species Monoraphidium arcuatum, Cosmarium granatum var. boryanum and Pediastrum cornutum were recorded only in the River Nestore; Hantzschia amphioxys and Phacus sp. in the River Treia; Chrococcus turgidus in the River Nera, and finally Oscillatoria sp., Closteriopsis acicularis, Cosmarium humile, Scenedesmus obstusus e S. serratus in the River Aniene. Some species appear to be exclusive to certain fluvial stretches. In particular, the cyanobacterium Chamaesiphon incrustans and red algae such as Lemanea fluviatilis and Audouinella hermannii were only detected in the upper stretches of certain watercourses, characterised by cool, well oxygenated waters with low

eutrophication. The species *Closterium ehrebergii*, *Pediastrum integrum* and *Scenedesmus falcatum* are only present in the middle stretches of watercourses, whereas *Entheromorpha flexuosa*, *Stigeoclonium tenue* and several species of the genus *Oscillatoria* are found only in the lower stretches of some rivers, like the Tiber and the Aniene, characterised by polluted, hypertrophic waters.

The only pteridophyte found, *Azolla filiculoides*, appears to be exclusive to the lower stretches of the River Tiber.

Even among the phanerogams, there are species that were found only in certain watercourses of the study area, such as *Elodea canadensis* in the River Aniene, *Groelandia densa* and *Hippuris vulgaris* in the River Clitunno, and species that characterise particular stretch of the watercourses, such as *Persicaria amphibia* and *Spirodela polyrhiza*, found in lower and final stretches of the River Tiber.

As for floral abundance there are significant variations along the longitudinal axis of the waterways in the basin.

In general in fact, diversity is higher in the middle stretches, while it tends to decrease in lower ones. This is particularly evident along the rivers Tiber and Aniene that are, among the watercourses of the basin, those that have been most investigated (Tab. 3.1).

Tiber river	n. stations	n. taxa	n.taxa/ n.stations
upper section	5	69	13,80
middle section	7	125	17,86
lower section	44	170	3,86
mouth section	4	58	14,50

It should be noted however, that there is a slight increase in floral abundance in the final stretches at the mouth of the River Tiber. This stretch is characterized by the presence of certain species that are better adapted to environments with the high conductivity due to the ingression of brackish water.

For the River Aniene there is a significant decrease in diversity proceeding towards the confluence (Tab.3.2).

Aniene river	n. stations	n. taxa	n.taxa/ n.stations
upper section	9	92	10,22
middle section	9	84	9,33
lower section	9	66	7,33

Along the longitudinal axis it is also possible to detect differences in the distribution of the diverse taxonomic groups in relation to the different stretches of the river: upper, middle, lower and mouth.

In particular in the River Tiber it is evident how algae, cyanobacteria, aquatic and riverbank phanerogams exhibit greater floristic richness in the middle and lower stretches, while bryophytes do so in the upper sections. (Fig. 3.5).

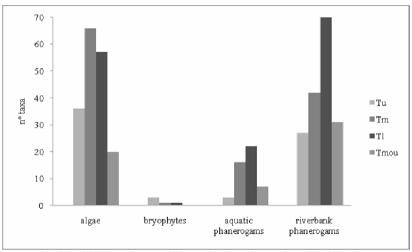


Fig. 3.5: Distribution of taxonomical groups in the various sections of the Tiber river.

In regards to the Aniene, there is a decrease of algal and bryophyte species towards the river mouth, an opposite trend to the phanerogams for which an increase was recorded; bank phanerogams instead show an increase in diversity along the middle stretches (Fig. 3.6).

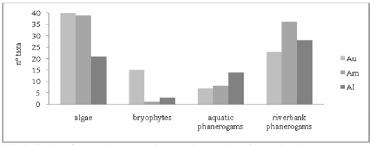


Fig. 3.6: Distribution of taxonomical groups in the various sections of the Aniene river

In this study the cyanobacteria, bryophyte and algal taxonomic groups were investigated with particular attention, in particular because at the national level there is scant and fragmentary information in the context of inland waterways.

In order to apply the information, certain floristic results for these taxonomic groups are reported in detail below.

3.1.1 Algae and Cyanobacteria

As already mentioned above, for algae and cyanobacteria a total of 149 taxa were detected, including species, subspecies and entities determined at the genus level (Attached 6). The entities found belong to six phyla: Cyanophyta, Chlorophyta, Rhodophyta, Xanthophyta, Euglenophyta and Bacillariophyta. The phylum most represented in qualitative terms is that of the Chlorophyta with 56 taxa (9 orders), followed by Bacillariophyta with 54 taxa (5 orders) and Cyanophyta with 29 taxa (4 orders). Figure 3.7, shows the relative percentages of the various groups.

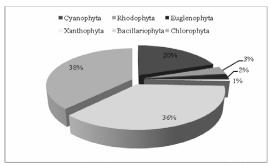


Fig. 3.7: Percentage composition of the algae and cyanobacteria of the Tiber basin.

There are significant variations in the algal floristic richness along the longitudinal axis of the basin watercourses. In general in fact and consistent with what has emerged previously, diversity is greater in the upper to middle stretches, whilst it decrease significantly in the lower sections. This is particularly evident along the rivers Tiber and Aniene (Tab. 3.3).

Tiber river	n. stations	n. taxa	n.taxa/ n.stations
upper section	6	40	6,67
middle section	7	66	9,43
lower section	44	57	1,30
mouth section	4	20	5,00

Aniene river	n. stations	n. taxa	n.taxa/ n.stations
upper section	9	47	5,22
middle section	9	39	4,33
lower section	9	21	2,33

Even the distribution of the various phyla along the rivers presents some variations according to the different stretches of the river (Fig. 3.8 and Fig. 3.9)

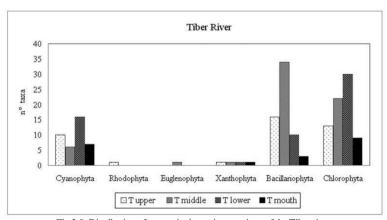


Fig.3.8: Distribution of groups in the various sections of the Tiber river.

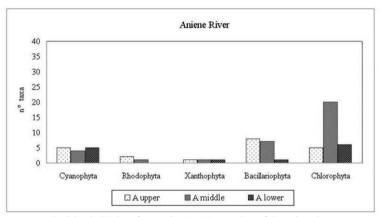


Fig. 3.9: Distribution of groups in the various sections of the Aniene river.

In particular, Rhodophytes can only be found in the middle and upper sections of both rivers, while Cyanophytes are distributed throughout, although still showing an increase towards the lower stretches of the Tiber. Chlorophytes generally have a wide distribution even though they are more prevalent in the middle and lower stretches. Lastly, Bacillariophyta show a marked decrease in the lower, final sections. For Xantophyta and Euglenophyta there are no significant variations in number along the river length.

3.1.2 Bryophytes

Bryophytes together with the Pteridophytes are taxonomic groups that are least represented and distributed in the watercourses investigated (Fig. 3.1). The 23 species of bryophytes surveyed can be distinguished between 16 mosses and 7 liverworts. Fig. 3.10, illustrates the relative percentages.

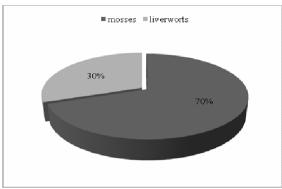


Fig. 3.10: Percentage composition of the bryophytes in the Tiber basin.

Bryophytes are distributed more in the upper sections of watercourses where they find more ideal conditions to their development (Tab. 3.4). The table below shows the average number of species found in the different sections of the rivers Tiber and Aniene.

Tab. 3.4: Floristic bryophytes richness in the various sections of the rivers Tiber and Aniene

Tiber river	n. stations	n. taxa	n.taxa/ n.stations
upper sector	6	3	0,50
middle sector	7	1	0,14
lower sector	44	1	0,02
mouth sector	4	0	0,00

Aniene river	n. stations	n. taxa	n.taxa/ n.stations
upper sector	9	15	1,67
middle sector	9	1	0,11
lower sector	9	3	0,33

3.2 ECOLOGICAL BEHAVIOUR OF THE MACROPHYTE SPECIES

Each plant species is characterized by its own ecological niche, defined by environmental parameters that determine its structure, composition and development in a given environment. As part of this research, the following environmental parameters were considered to describe the ecological behaviour of the sampled macrophytes: temperature, pH, dissolved oxygen concentration, conductivity, concentration of ammonium salts, concentration of nitrates and phosphates, current velocity and turbidity of the water.

The paragraphs that follow consider both the overall ecological behaviour of the different taxonomic groups that were investigated (algae, cyanobacteria, bryophytes and phanerogams) and the behaviour of the individual species in relation to each parameter.

3.2.1 Ecological characteristics of the taxonomic groups

To get an overall picture of the behaviour of the taxonomic groups in relation to the ecological factors considered, Principal Component Analysis (PCA) was applied to the dataset. This analysis allows for the reduction of a relatively large number of variables into a number of latent variables. This is achieved through a linear transformation that projects the original variables into a new Cartesian system in which the new variables, called "principal components", are arranged in descending order of variance: thus the variable with greater variance is projected onto the first axis, the second on second axis and so on. The reduction in complexity is achieved by limiting the analysis only to the main new variables produced (in terms of variance).

For the present study, PCA was applied to data based upon the centroids of the species, i.e. on their average behaviour in the ecological space taken as a whole.

PCA identifies the first two axes that explain about 3/4 of the variance (the first axis about 51%). Following the biplot method it is then possible to obtain the scatter diagram (Fig. 3.11). In the diagram, the red vectors represent the projections of the original variables in the new ecological space of the PCA. They start at the origin of the two axes and their direction in the plane indicates the increase of the variable represented. Fig. shows the positions and trends of the variables in the plane described by the first two principal components.

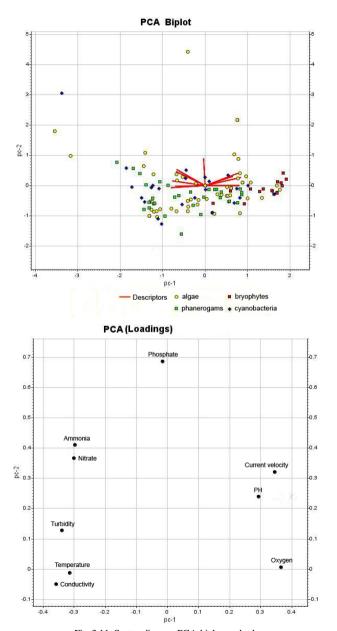


Fig. 3.11: Scatter diagram PCA biplot method.

The different taxonomic groups are distributed on the two 1, 2 axes. The 1 axis is positively correlated to the speed of the current, pH and oxygen concentration, and is negatively correlated to conductivity, temperature, turbidity and the concentration of nitrate and ammonium. The 2 axis appears to describe a gradient of increasing eutrophication. Along this axis in fact, it is possible to detect the increase in the concentration of phosphates.

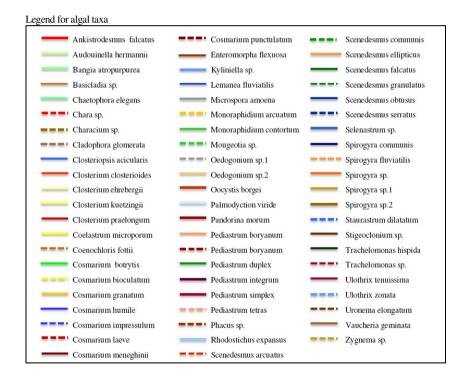
From the general analysis of data, which evaluates the overall ecological behaviour of the individual taxonomic groups in relation to the parameters considered, it is possible to state that the various groups are distributed in the new ecological space differently. In particular the algae, cyanobacteria and phanerogams show a widespread distribution throughout the ecological space; in contrast, bryophytes are confined to the right side portion of the plane, which presumably describes conditions of high current velocity, good oxygenation of the water and a decrease in temperature, turbidity and conductivity. This space seems to describe a good quality level of water.

3.2.2 Ecological characteristics of individual species

This section looks at the environmental behaviour that species show to each environmental factor, analysed through the elaboration of response curves and dendrograms.

Algae

Below are reported the response curves of algal taxa to each chemicalphysical parameter. These curves show graphically the ecological response of the single taxon to the variable considered (Legend algae).



temperature

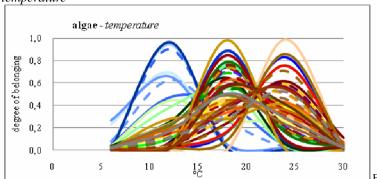


Fig. 3.12

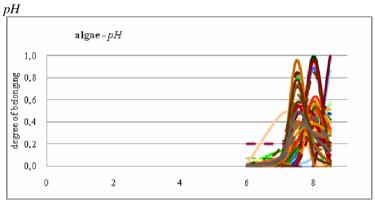


Fig. 3.13

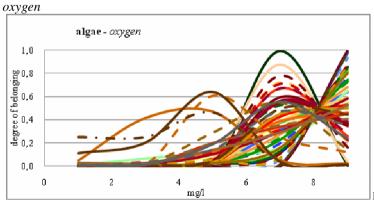


Fig. 3.14

conductivity

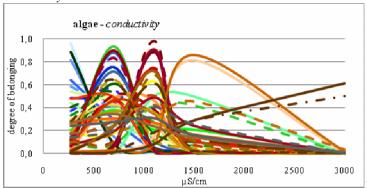


Fig. 3.15

ammonia

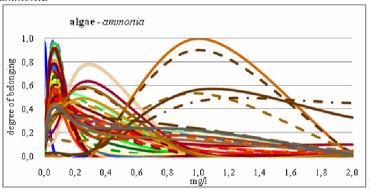


Fig. 3.16

nitrate

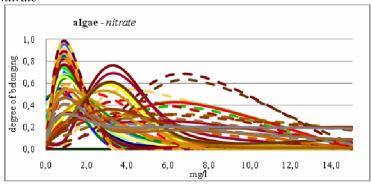


Fig. 3.17

phosphate

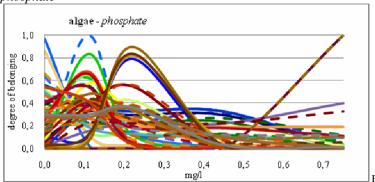


Fig. 3.18

current velocity

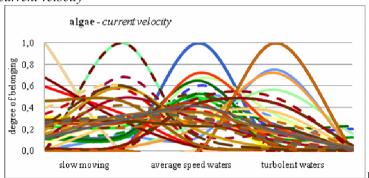


Fig. 3.19

turbidity

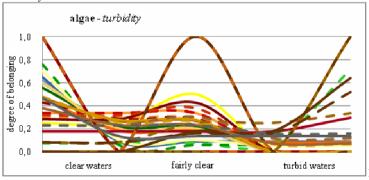


Fig. 3.20

In the graph relative to the response curves of algal species to temperature, three values are evident in which the organisms examined express their optimum, i.e. the optimal temperature conditions where it is more likely to report their presence. The first value corresponds to about 11°C (cool waters) and is characterized by a set of curves relating mainly to species of Rhodophyta such as Audouinella hermannii, Kyliniella sp., and among the Chlorophyta, to species of the genus Selenastrum sp., and species of Staurastrum dilatatum, Ulothrix zonata, and Palmodyction viride. The second value is around 19°C (warm waters), were Euglenophytes are found, including *Phacus* sp. and *Trachelomonas hispida*, as well as Xantophytes, including Vaucheria geminata, and Chlorophytes, including the genera Scenedesmus (S. serratus, S. ellipticus, S. granatus), Basicladia sp., Mougeotia sp. and other species such as Microspora amoena, Ulothrix tenuissima, Spirogyra communis, Closterium closterioides, Cosmarium impressulum. The third group of curves is represented by an optimum that lies around 24°C (warm water) and is characterised by Chlorophytes with numerous species of the genera Spirogyra, Oedogonium, Pediastrum (P. borianum and P. simplex), and genera of Zygnema sp. and Characium sp. as well as species including Uronema elongatum, and the Rhodophyta Lemanea fluviatilis.

For pH values it is possible to distinguish mainly between two *optimum* levels in which the majority of the taxa examined are found: 7.5 and 8. These are values typical of waters in limestone regions where alkalinity is low. Species of *Kyliniella* sp., *Cosmarium granatum*, *Monoraphidium arcuatum*, *Pediastrum borianum* and *P. integrum*, are characteristic however, of higher pH values (8.5).

The curves are in general relatively high and narrow, signifying that the range of tolerance to this environmental factor is quite low.

In regards to the O₂ parameter, the algal group is particularly heterogeneous. Most species have their *optimum* at high concentrations (> 9 mg/l) where waters are well oxygenated. Among these are found numerous red algae such as *Lemanea fluviatilis, Kyliniella* sp., *Bangia atropurpurea*, and green algae with some species of the genus *Cosmarium* (*C. granatum*, *C. humile*, *C. bioculatum*), *Pediastrum* (*P. boryanum*, *P. integrum*, *P. duplex*), *Mougeotia* sp., *Zygnema* sp., and species such as *Spirogyra communis and Ulothrix zonata*. Other species are instead distributed in waters that are sufficiently oxygenated (*optimum* 7 mg/l), such as *Cosmarium laeve* and *C. punctulatum*, and species of the genus *Oedogonium*. Finally, some Chorophytes such as *Enteromorpha flexuosa*

and the genus *Stigeoclonium sp.* present wide, flattened curves where the highest value recorded is about 4 mg/l, that is, in very poorly oxygenated waters.

Conductivity is described by a rather wide range of values that go from low (200 < C < 300 mS/cm) to very high (> 3000 mS/cm), the latter typical of conditions of excessive mineralization found in highly polluted waters or due to the ingression of brackish waters. For low conductivity values few species are detected including *Kyliniella* sp (Rhodophyta) and *Ulothrix zonata* (Chlorophyta). While for average to high values the species detected include *Spirogyra communis, Scenedesmus falcatus, Pediastrum integrum, Monoraphidium contortum, Cosmarium impressulum, Zygnema* sp. The majority of the species sampled are distributed around two values: 700 and $1000 \mu S/cm$, while *Entheromorha flexuosa* can live in environments where the conductivity has values even greater than $3000 \mu S/cm$.

Most of the taxa examined are distributed around relatively low concentrations of ammonium ion. *Lemanea fluviatilis* is a species that has the narrowest range for this parameter, and are found in environments where the concentrations are almost nil. Unlike some species of the genus *Oedogonium sp.* that are characterized by average values (0.3 mg/l) that suggest the presence of pollution. Furthermore, the graph also shows that for higher concentrations that probably correspond to more polluted conditions, species that include *Entheromorpha flexuosa*, are characterized by wider curves.

The graph describing the ecological response of species to the concentration of nitrates is characterized by high, narrow curves for low concentrations, which become wider and lower as the nitrate concentration increases. It presents three maxima values: 0.9, 3 and 7.5. The latter value is characteristic of qualitatively poor water due to high organic pollution, where it is possible to find species such as *Cosmarium punctulatum*, *Ankistrodesmus falcatus*, *Chaetophora elegans* and *Mougeotia* sp.

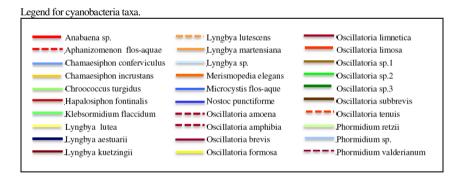
The curves of algal taxa relating to phosphate are extremely heterogeneous. Species such as *Bangia atroporpurea*, *Closteriopsis acicularis*, *Coenochloris fottii*, *Oedogonium* sp., *Ulothrix zonata* and *Spirogyra* sp. show strong sensitivity and are found only at low concentrations. Species like *Entheromorpha flexuosa*, *Stigeoclonium* sp., *Basicladia* sp. and *Lemanea fluviatilis* tolerate instead higher concentrations. Three species,

Cosmarium granatum, Monoraphidium contortum and Pediastrum boryanum, are found at very high concentrations (0.75 mg/l), typical of poor quality waters due to organic pollution.

The organisms examined respond to the changes in current velocity in an extremely diverse manner. There are species that live in environments characterized by slow moving waters, such as *Ankistodesmus falcatus*, *Cosmarium meneghinii*, *Monoraphidium contortum*, *Uronema elongatum*, *Mougeotia* sp., *Chaetophora elegans*, while others are found in turbulent waters, such as *Cosmarium granatum*, *Monorapidium arcuatum*, *Lemanea fluviatilis*.

Clear waters are characterised by taxa such as Audouinella hermannii, Bangia atropurpurea, Kyliniella sp., Lemanea fluviatilis, Closterium closterioides, C. herebergii, C. praelongum, and various species of Scenedesmus, while in cloudy waters the species detected include Ankistodesmus falcatus, Monoraphidium contortum, Mougeotia sp. and Stigeoclonium sp.

Cyanobacteria



temperature

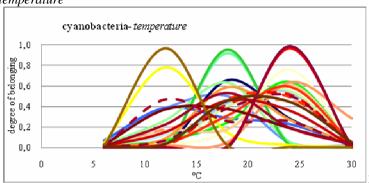


Fig. 3.21

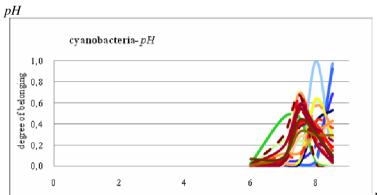


Fig. 3.22

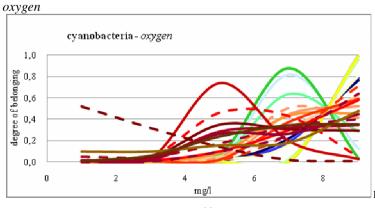


Fig. 3.23

conductivity

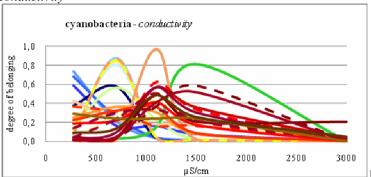


Fig. 3.24

ammonia

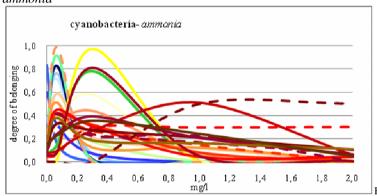


Fig. 3.25

nitrate

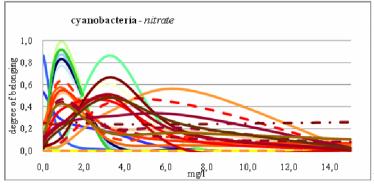
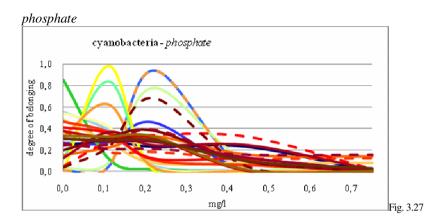


Fig. 3.26



current velocity

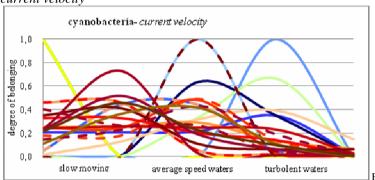


Fig. 3.28

turbidity

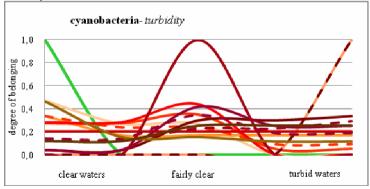


Fig. 3.29

With regards to temperature, three main groups of curves are identified with optimum levels at about 11°, 18° and 24°C. Some species of the genus Lyngbya sp. and Phormidium sp. are found in cooler waters, while Lyngbya lutescens and L. lutea are typical of environments characterized by warmer temperatures. Lastly, many species of the genus Oscillatoria sp. (O. formosa and O. amphibia) are found in warm waters. Some species such as Oscillatoria tenuis, O. amoena, Phormidium retzii and Chamaesiphon incrustans present fairly wide curves that evidence their generalist behaviour towards the parameter considered.

In Fig.3.22 the value relating to the curves at which the *optimum* for many species is found is pH = 7.5; these include *Lyngbya lutea*, *L. martensiana*, *Oscillatoria amphibia*, *O. brevis* and *Aphanizomenon flos-aquae*. Whilst species of *Lyngbya lutescens*, *Oscillatoria formosa*, *O. tenuis* and some species of the genus *Phormidium* sp., find their *optimum* at pH = 8. *Chamaesiphon conferviculus*, *Microcystis flos-aque* and *Nostoc punctiforme* are exclusive to waters with high pH values.

In regards to the O_2 parameter, the cyanobacteria group is quite heterogeneous. *Oscillatoria amphibia* is present in environments characterized by very low concentrations of oxygen. Some species of the genus *Oscillatoria* sp., *Lyngbya* sp., and species such as *Klebsormidium flaccidum*, have their *optimum* in environments that are quite oxygenated. While most of the species found are typical of well-oxygenated and supersaturated waters.

In Fig. 3.24 it is possible to see how most of the curves, and consequently the species, present maximum values at high concentrations of conductivity. Few species such *Chamaesiphon conferviculus*, *Microcystis flos-aque* and *Nostoc punctiforme* prefer environments characterized by low conductivity.

As for ammonium, at low concentrations many species display high, narrow curves, such as *Lyngbya lutescens*, *L. aestuarii*, *Klebsormidium flaccidum*, *Chamaesiphon incrustans* and *Microcystis flos-aque*. On the other hand, of note is the presence of certain species that are indifferent to this parameter because they present a wide distribution, or can tolerate better higher concentrations of ammonium; these include *Hapalosiphon fontinalis*, *Oscillatoria amphibia* and *Aphanizomenon flos-aquae*.

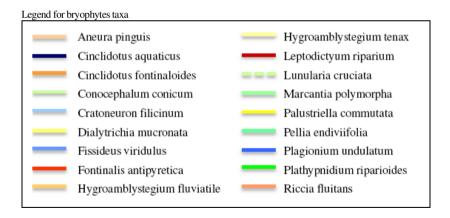
Curves relating to phosphates appear in a distributed manner mainly for average to low concentrations. Aphanizomenon flos-aquae, Oscillatoria

brevis, O. amoena, O tenuis and Merismopedia elegans show a wide distribution, while species such as Lyngbya lutescens, Phormidium retzii and Oscillatoria amphibia, are found in environments characterised by average to high concentrations of phosphates.

Most of the species were found in environments characterised by slow or average currents, whilst the species found in turbulent waters were few, and among these *Chamaesiphon conferviculus* and *Phormidium retzii*.

Clear waters are characterized by species such *Chamaesiphon* conferviculus, *Chroococcus turgidus*, *Lyngbya aestuarii*, *Microcystis flosaque*, *Nostoc punctiforme*, *Phormidium retzii* and various species of the genus *Oscillatoria* sp., whilst in turbid waters species found include *Oscillatoria amphibia* e *Lyngbya martensiana*.

Bryophytes



temperature

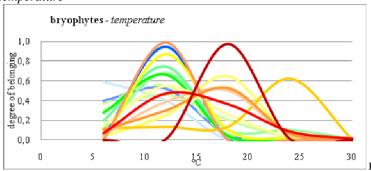


Fig. 3.30

рΗ

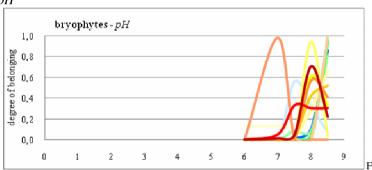


Fig. 3.31

oxygen

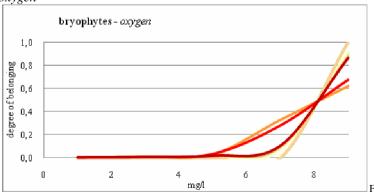


Fig. 3.32

conductivity

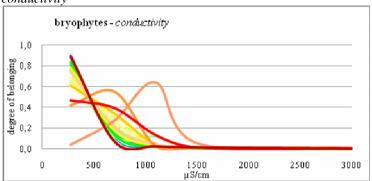


Fig.: 3.33

ammonia

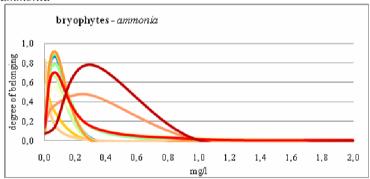


Fig. 3.34

nitrate

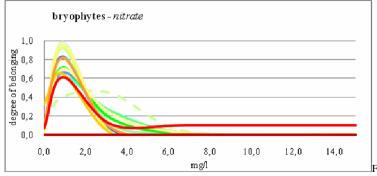
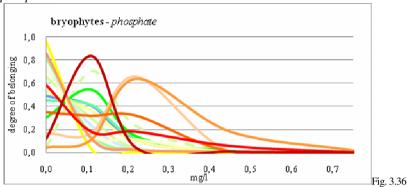


Fig. 3.35

phosphate



current velocity

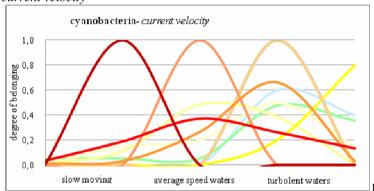


Fig. 3.37

turbidity

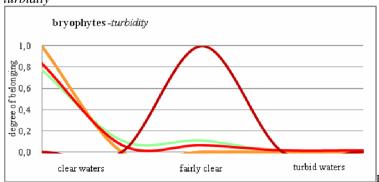


Fig. 3.38

Most of the bryophytes species examined were found in cool waters. Few species, including Hydro*amblystegium fluviatile*, *Dialytrichia mucronata* and *Leptodictyum riparium*, show a preference for warmer waters.

The graph of the response curves in relation to pH (Fig. 3.31), shows that most species are distributed in environments characterized by waters that are rather alkaline. Only *Riccia fluitans* tends towards neutral or slightly acidic waters.

Fig. 3.32 shows that all the bryophyte species are distributed in waters that are well oxygenated. *Cinclidotus fontinaloides* and *Fontinalis antipyretica* are the only species among those sampled that are found in environments characterized by low concentrations of dissolved oxygen.

All species of bryophytes examined are found in waters in which the level of conductivity is low, with the exception of *Riccia fluitans* that has its *optimum* in waters with high conductivity.

For the majority of species, the response curves to the variations in ammonium concentration are high and narrow around the lower values. Only *Leptodictyum riparium* and *Riccia fluitans* can be detected in environments where the ammonium ion has higher concentrations.

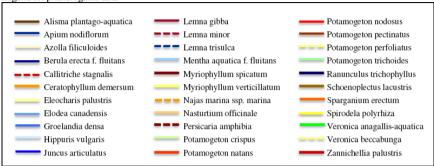
In Fig. 3.35 it is possible to notice that all the species of bryophytes are found in environments characterized by low concentrations of nitrates.

As for to phosphate, the different taxa show a distribution that is relatively heterogeneous (Fig. 3.36). For species such as *Riccia fluitans* and *Hydroamblystegium fluviatile* it is possible to note how the maxima of the curve relate to average to high concentrations.

The majority of bryophytes were found in clear, fast flowing waters. Only *Leptodictyum riparium* is typical of slower flowing waters whilst and of more turbid waters.

Phanerogams





temperature

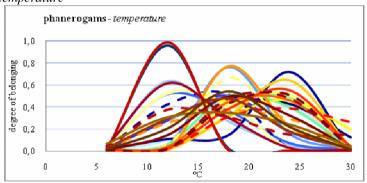


Fig. 3.39



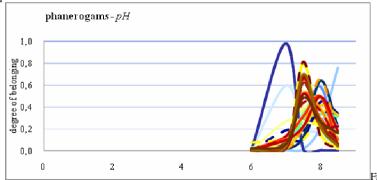


Fig. 3.40

oxygen

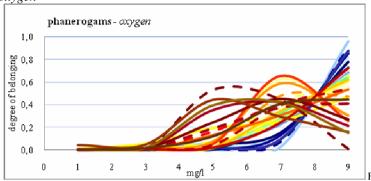


Fig. 3.41

conductivity

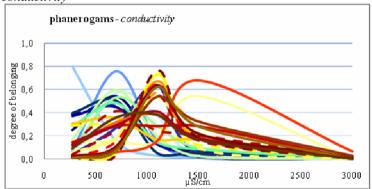


Fig. 3.42

ammonia

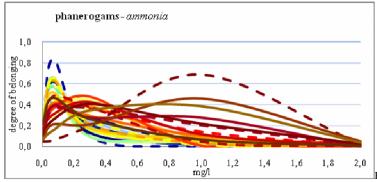


Fig. 3.43

nitrate

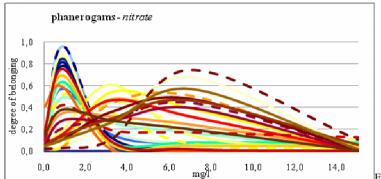


Fig. 3.44

phosphate

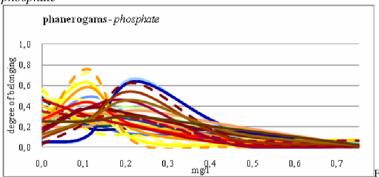


Fig. 3.45

current velocity

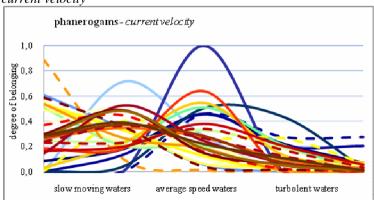


Fig. 3.46

turbidity

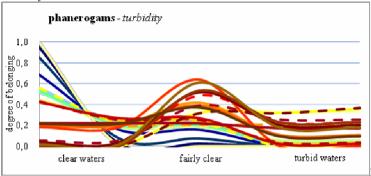


Fig. 3.47

In relation to temperature, there are three different groups of autoecological response curves Fig. 3.39. In cool waters there is of note the presence of *Hippuris vulgaris*, *Ranunculus trichophyllus*, *Groelandia densa*, while in warmer waters there is the presence of *Myriophyllum verticillatum*, *Potamogeton natans*, *Persicaria amphibia* and *Eleocharis palustris*. Other species have wide, flat curves and are distributed over large temperature ranges, and include *Veronica beccabunga* and *Zannichellia palustris*.

Most of the species investigated has a pH *optimum* value ranging between 7.5 and 8. Few species show a preference for neutral waters, among these are *Hippuris vulgaris*, *Groelandia densa* and *Juncus articulatus*.

In regards to the O₂ parameter, the curves shown in Fig. 3.41 describe a general distribution of macrophytic phanerogams around the average to high concentrations. Of note instead, is for some species such as *Potamogeton pectinatus*, *Persicaria amphibia* and *Schoenoplectus lacustris*, an ecological *optimum* at low concentrations.

Most species are found in conditions of average to high conductivity. Few species are characteristic of environments with low conductivity such as cui *Mentha aquatica* f. *fluitans* and *Nasturtium officinale*. While significant appears to be the number of species that can be found in environments characterized by high levels of conductivity, such as *Potamogeton natans*, *P. pectinatus*, *Eleocharis palustris*, *Azolla filiculoides*, *Myriophyllum spicatum*, *Potamogeton nodosus*, *Schoenoplectus lacustris* and *Spirodela polyrhiza*.

In relation to the variations in concentration of ammonium ions, in Fig. 3.43 it is possible to observe fairly heterogeneous curves. For low concentrations we find curves that are quite narrow and high, and correspond to species such *Lemna trisulca*, *Spirodela polyrhiza*, *Berula erecta* f. *fluitans*, *Hippuris vulgaris*, *Elodea canadensis* and *Potamogeton trichoides*, that are particularly sensitive to this parameter. Species that have an ecological *optimum* at high concentration values, such as *Persicaria amphibia*, *Potamogeton pectinatus* and *Schoenoplectus lacustris*, show curves that are quite wide.

Species are distributed in a heterogeneous manner in regards to the concentration of phosphates recorded in the waterways investigated. Some species such as *Veronica beccabunga*, *Zanichellia palustris*, *Ranunculus trichophyllus*, *Lemna trisulca*, *Elodea canadensis*, *Eleocaris palustris* and *Berula erecta* prefer waters with low concentrations, while others appear to exhibit good tolerance to high concentrations of the nutrient, such as *Groelandia densa*, *Hippuris vulgaris*, *Lemna gibba*, *Persicaria amphibia* and *Potamogeton pectinatus*.

The curves show how the majority of species found are characteristic of slow moving waters, with the exception of *Potamogeton natans*, *Groelandia densa*, *Hippuris vulgaris* e *Ranunculus trichophyllus* that instead prefer waters with a moderate current.

Clear waters are characterized by species such as *Eleocharis palustris, Groelandia densa, Hippuris vulgaris, Lemna trisulca, Ranunculus trichophyllus*. As can be seen in Fig. none of the species studied has its ecological *optimum* in turbid waters. However species such as *Azolla filiculoides, Persicaria amphibia* and *Spirodela polyrhiza* can live even in these waters.

3.2.3 Cluster analysis results

Through cluster analysis it was possible to identify different groups for the various taxa considered. Each group consists of taxa that are characteristic of the particular conditions of the ecological factor considered. These groups have been highlighted with different colours. In particular, passing from blue to green, to yellow, to orange and finally to red, different conditions are reported of the various parameters, which are attributed to a progressive deterioration of the quality status of the waters.

In general for different systematic groups are found in relation to each ecological factor considered, different groups of species to be related to conditions of the factor considered. It highlights the peculiar data on bryophyta presenting, on the other hand systematic groups, for each of the factors considered, a reduced number of clusters, that shows a well-defined ecology of the all systematic group and ecology related to environmental conditions are not particularly different.

temperature:

blue: species linked to T ranging between $6^{\circ}-12^{\circ}C \rightarrow \text{cool waters}$ yellow: species characterized by T ranging around 12-18°C \rightarrow average warm waters

light orange: species characterized by T equal to $18^{\circ}C \rightarrow$ warm waters dark orange: species linked to T >18 °C \rightarrow warm water

red: species characterized by T ranging around 24°-30°C → hot water

pH:

blue: species linked to values of pH = $7 \rightarrow$ neutral waters

yellow: species linked to values of pH = $7.5 \rightarrow$ slightly alkaline waters

orange: species linked to values of pH = $8 \rightarrow$ alkaline water red: species linked to values of pH = $8.5 \rightarrow$ alkaline water

oxygen:

blue: species characterized by concentrations greater than 9 mg/l \rightarrow very well oxygenated waters

light blue: species characterized by concentrations above 7 mg/l \rightarrow well oxygenated waters

green: species characterized by concentrations around 7 mg/l \rightarrow oxygenated waters

orange: species characterized by concentrations equal to 5 mg/l \rightarrow low oxygenated waters

red: species characterized by concentrations lower than 5 mg/l \rightarrow very low oxygenated waters

conductivity:

blue: species characterized by values of conductivity equal to 273 μ S/cm \rightarrow waters with low mineralization

green: species characterized by values of conductivity < 700 μ S/cm \Rightarrow waters with average to high mineralization

yellow: species characterized by values of conductivity equal to 700 μS/cm → waters with average to high mineralization orange: species characterized by values of conductivity equal to 1100 μ S/cm \rightarrow waters with high mineralization

red: species characterized by values of conductivity > 1500 mS /cm \rightarrow waters with excessive mineralization

ammonia:

blue: species characterized by concentration values $< 0.065 \text{ mg/l} \rightarrow \text{waters}$ with low concentrations

yellow: species characterized by concentration values ranging between 0.065 and 0.3 mg/l \rightarrow waters with average to low concentrations

orange: species characterized by concentration values equal to $0.3 \text{ mg/l} \rightarrow$ waters with average concentrations

red: species characterized by concentration values $> 1 \text{mg/l} \rightarrow \text{waters}$ with high concentrations

nitrate:

blue: species characterized by concentration values $< 0.9 \text{ mg/l} \rightarrow \text{waters}$ with low concentrations

light blue: species characterized by concentration values equal to 0.9 mg/l → waters with low concentrations

light orange: species characterized by concentration values equal to 3.25 mg/l \rightarrow waters with average to high concentrations

dark orange: species characterized concentration values ranging between 7.05 mg/l and 3.25 mg/l \rightarrow waters with average to high concentrations

red: species characterized by concentration values > 7.05 mg /l \rightarrow waters with high concentrations

phosphate:

blue: species characterized by concentration values $< 0.11 \Rightarrow$ waters with low concentrations

yellow: species characterized by concentration values ranging between 0.22 to 0.45 mg/l \rightarrow waters with average to high concentrations

red: species characterized by concentration values equal to $0.75 \text{ mg/l} \rightarrow$ waters with high concentrations

current velocity:

blue: turbulent waters

yellow: average speed waters red: slow moving waters

turbidity:

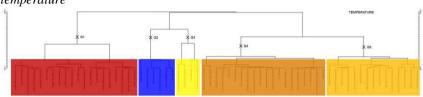
blue: clear waters

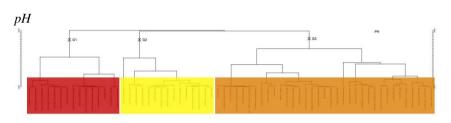
yellow: slightly cloudy waters

red: turbid waters

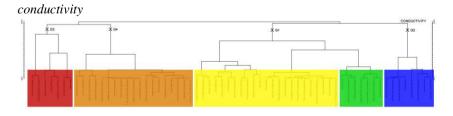
Algae

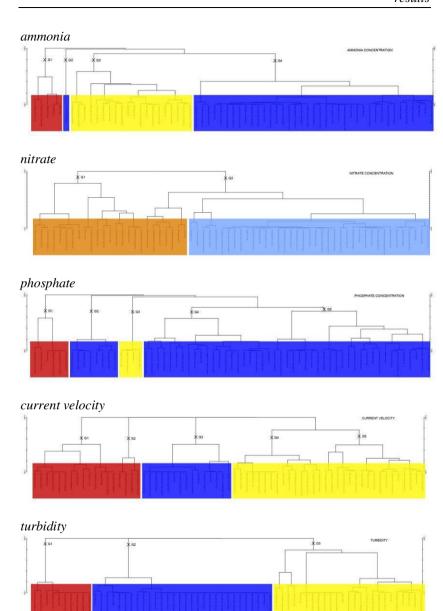






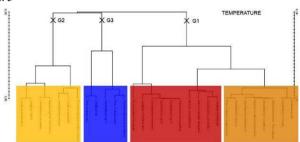




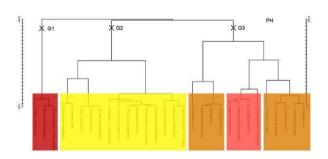


Cyanobacteria

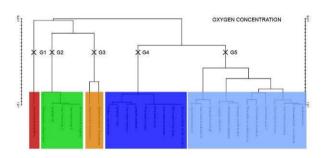
temperature



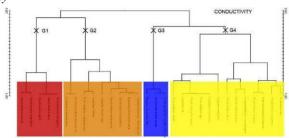
рΗ



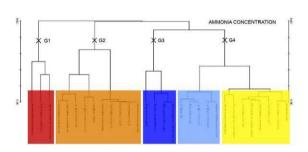
oxygen



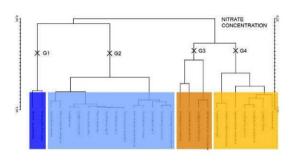
conductivity



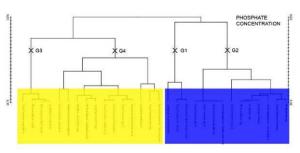
ammonia



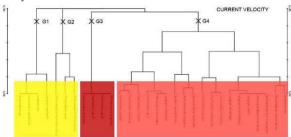
nitrate



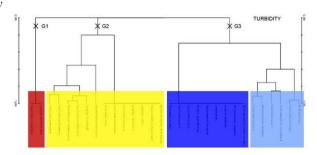
phosphate



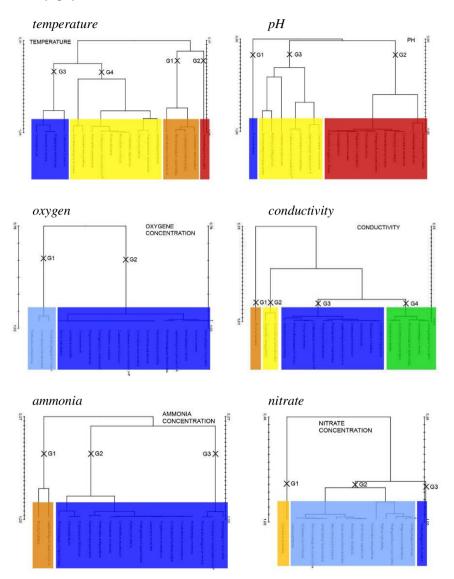
current velocity



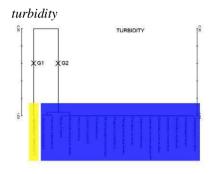
turbidity



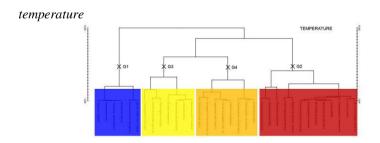
Bryophytes



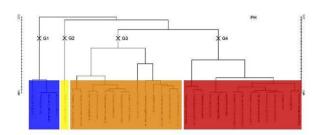
phosphate current velocity PHOSPHATE CONCENTRATION SG1 XG2 XG3 XG4 SG2 XG3 XG4 SG3 XG4 XG2 SG3 XG4 SG3 XG



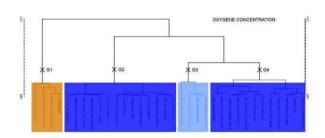
Phanerogams



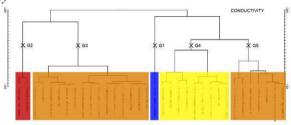




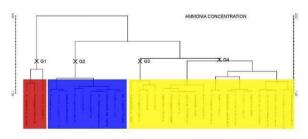
oxygen



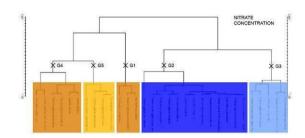
conductivity



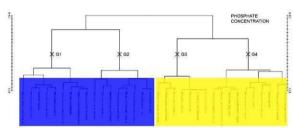
ammonia



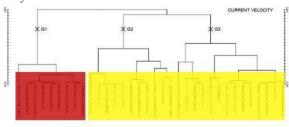
nitrate



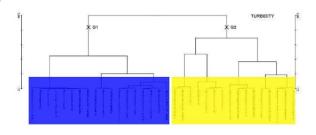
phosphate



current velocity



turbidity



3.3 ANALYSIS OF THE MACROPHYTIC INDICES

As noted earlier, at the national level there is limited information relating to the assessment of water quality through the analysis and study of macrophytes. In particular knowledge contributions for certain taxonomic groups such as algae, cyanobacteria and bryophytes appears scant and fragmentary.

The majority of the information relates to lists of macrophytic indices developed at European level, that report the species considered as bioindicators and their sensitivity to (generally) the trophic level of the waters. A comparison was carried out between the set of sampled macrophytic species and the bioindicator species reported in these indices, highlighting as shown in Tab. 3.5, only those taxa that are not reported in the literature as bioindicators, or where they are, it is only at the genus level. The table represents therefore a small knowledge tool for less investigated groups.

Tab. 3.5: Taxa not reported in the literature as bioindicators or they are reported at the level of genus.

	not reported in the literature	reported at the level of genus in the literature
algae		
Vaucheria geminata		X
Audouinella hermannii		X
Chaetophora elegans		X
Cladophora glomerata		X
Enteromorpha flexuosa		X
Microspora amoena		X
Spirogyra communis		X
Spirogyra fluviatilis		X
Ulothrix tenuissima		X
Ulothrix zonata		X
Anabaena sp.	X	
Lyngbya aestuarii		X
Lyngbya lutea		X
Lyngbya kuetzingii		X
Lyngbya lutescens		X
Lyngbya martensiana		X
Nostoc punctiforme		X
Oscillatoria amoena		X
Oscillatoria amphibia		X
Oscillatoria brevis		X

Oscillatoria formosa		x
Oscillatoria limnetica		x
Oscillatoria limosa		x
Oscillatoria subbrevis		x
Oscillatoria tenuis		x
Phormidium retzii	x	
Phormidium valderianum		x
bryophytes		
Dialytrichia mucronatus x		
Orthotrichum stramineum x		
Plagionium affine x		
Plagionium undulatum	X	

Some of the major Central European macrophytic indexes (MTR, GIS and IBMR) were tested on the data sets collected for the Tiber and Aniene rivers to assess the suitability and applicability in different geographical contexts to that where they were formulated.

For each sampling station the respective values for the MTR, GIS and IBMR indices were calculated (Tab. 3.6). For the GIS index there is a further distinction between values calculated for only the aquatic population (A) and those calculated for the aquatic and riverbank population (A+R).

It is evident that information of this kind would allow, if the methods under consideration are revealed applicable even to Mediterranean rivers, to assess and record in a biological context the water quality and the level of organic pollution. To facilitate reading and interpretation of results, individual values are highlighted with colours conventionally used to indicate the reference classes in water quality monitoring.

Tab. 3.6: Indices MTR, GIS A and A+R, IBMR tested on the sampling for the Tiber and Aniene rivers.

Tiber river	MTR	GIS A	GIS A+R	IBMR
Tu ₁	50	6,0	6,0	15,2
Tu_2	10	3,2	4,1	9,6
Tu_3	27	4,0	4,3	10,0
Tu_4	13	3,1	3,9	8,5
Tu_5	29	3,1	3,5	9,7
Tu_6	29	3,4	3,9	9,1
Tm_7	27	3,3	3,5	7,6
Tm_8	24	3,1	3,3	7,2
Tm_9	25	3,4	3,5	8,2
Tm_{10}	39	4,0	4,4	7,8
Tm_{11}	20	2,9	4,3	8,2
Tm_{12}	20	2,6	3,0	8,0
Tm_{13}	29	3,9	4,2	8,0
Tl_{14}	14	2,7	3,8	8,9

Tl_{15}	30	3,2	4,0	8,6
Tl_{16}	27	3,1	4,6	9,3
$T1_{17}$	30	3,7	4,7	9,8
Tl_{18}	25	3,9	4,4	9,8
Tl_{19}	21	3,2	3,9	9,4
Tl_{20}	22	2,9	4,4	8,1
Tl_{21}	30	2,7	4,4	8,2
Tl_{22}	25	2,9	4,0	7,6
Tl_{23}	29	3,1	4,1	9,2
Tl_{24}	30	3,3	4,4	8,8
Tl_{25}	30	2,3	4,4	7,9
Tl_{26}	32	2,8	4,5	9,1
Tl_{27}	30	2,7	4,4	8,5
Tl_{28}	24	2,4	3,8	7,3
Tl_{29}	29	2,8	4,0	8,5
$T1_{30}$	24	3,0	3,0	7,8
Tl_{31}	21	3,0	3,0	6,9
Tl ₃₂	20	2,3	3,9	7,7
Tl_{33}	30	2,8	4,4	7,6
Tl ₃₄	19	3,2	4,5	8,2
Tl ₃₅	15	2,1	3,8	6,7
Tl ₃₆	19	2,8	3,4	6,8
Tl ₃₇	10	2,3	3,5	7,3
Tl ₃₈	20	2,5	3,8	7,6
Tl ₃₉	16	2,8	3,6	7,3
Tl_{40}	24	3,1	3,9	7,7
Tl_{41}	23	2,7	3,6	7,6
Tl_{42}	23	3,1	3,5	8,8
Tl_{43}	21	2,3	3,5	6,3
Tl_{44}	20	2,8	3,0	5,8
Tl_{45}	22	2,9	3,5	7,5
Tl_{46}	_ 22 _	2,9	3,8	8,0
Tl ₄₇	21	2,8	3,0	6,4
Tl_{48}	17	2,4	3,4	5,6
Tl_{49}	21	2,7	3,7	6,9
$T1_{50}$	24	2,8	3,2	6,4
Tl_{51}	24	3,1	3,1	6,7
Tl_{52}	20	2,6	2,6	5,7
T1 ₅₃	21	2,8	2,8	5,9
T1 ₅₄	10	1,7	2,5	7,1
Tl ₅₅	16	1,9	3,3	5,6
Tl ₅₆	18	2,7	2,2	7,8
Tl ₅₇	23	2,9	3,6	5,5
Tmou ₅₈	18	3,0	3,7	7,4
Tmou ₅₉	13	2,6	3,3	7,5
Tmou ₆₀	10	3,0	3,2	6,7
Tmou ₆₁	12	2,1	3,2	6,4
			-,-	

Aniene river	MTR	GIS A	GIS A+R	IBMR
ANu_1	31,7	3,4	3,3	11,2
ANu_2	20,7	4,5	4,3	10,1
ANu_3	26,7	3,9	4,2	10,0
ANu_4	26,7	4,9	4,0	11,2
ANu_5	27,5	3,1	3,9	10,9
ANu_6	25,0	3,4	3,7	9,1
ANu_7	13,0	2,6	3,4	11,0
ANu_8	32,9	3,7	3,8	9,4
ANu ₉	41,1	4,5	4,6	9,2
ANm_{10}	39,3	4,3	4,6	11,3
ANm_{11}	45,5	4,5	4,8	10,9
ANm_{12}	35,0	4,6	5,3	10,7
ANm_{13}	10,0	2,5	2,5	8,4
ANm_{14}	10,0	3,9	4,5	9,6
ANm_{15}	33,2	3,6	3,6	10,1
ANm_{16}	31,0	4,4	4,6	8,5
ANm_{17}	31,8	4,0	4,1	7,7
ANm_{18}	33,7	4,0	4,1	10,0
ANl_{19}	10,0	3,0	3,7	9,0
ANl_{20}	31,7	4,1	4,3	9,3
ANl_{21}	35,1	4,2	4,3	10,1
ANl_{22}	43,1	4,7	4,9	10,7
ANI ₂₃	_ 20,0	2,5	3,6	8,2
AN124	10,0	1,0	2,3	4,8
ANl_{25}	10,0	1,9	2,8	5,4
ANl_{26}	10,0	1,4	2,0	2,4
ANI ₂₇	10,0	1,5	2,3	5,6

3.3.1 MTR

The application of the MTR index to the floristic data allows to obtain, for each station, a value which should then allow an assessment of the trophic quality of the water at the local level (orthophosphate and ammoniacal nitrogen content). It appears clear from the analysis of the data presented in Table 3.6 that the majority of stations, both for the higher stretches and the middle to lower stretches, are strongly subject to eutrophication. The values highlighted in yellow would indicate the strong likelihood that the stations considered are at risk of becoming eutrophic.

3.3.2 GIS

From the general analysis of data it emerges clearly that the values of the GIS index, with no difference between the different methods of calculation, fall mainly in Class IV – considered indicative of poor water quality – and to a lesser extent in classes III and V. There appears to be no case with good or excellent water quality conditions, which would underline an overall condition of average to high pollution for all the river stretches investigated.

It is highlighted furthermore, that for the certain stations, GIS indices calculated considering only the aquatic population have lower values than those calculated including the riverbank populations, and this generally leads to express less favourable conclusions and lower ratings in terms of quality classes. With regards to the Tiber and considering a more analytical assessment of the data, it emerges that in progressing from the relatively less disturbed areas further upstream towards the urban areas or the mouth of the river, there is a steady decrease in the GIS index values that is also reflected with variations of classes. Similarly for Aniene the urban stretches show the lowest values, showing conditions that are particularly compromised in qualitative terms.

3.3.3 IBMR

Even the values that emerge from the analysis with the IBMR index clearly describe a compromised water quality status; ranging from an average trophic level (yellow) to a trophic level that is very high (red). For the River Tiber it is not possible to distinguish a gradient of increasing pollution when moving from the source to mouth, even if the lower and terminal stretches are characterised by a high trophic level. For the River Aniene there are certain stations, especially along the higher and middle stretches of the river, that are characterised by higher values that show an average trophic level, while for the lower and terminal stretches, which coincide with the urban section, the values increase describing a poor qualitative state.

4. DISCUSSION

4.1 FLORISTIC ASPECTS

Based on what emerges from the results we highlight that beyond the phanerogam component, algae and cyanobacteria represent, with 45%, important elements in the composition of the macro-physical flora in the watercourses of the Tiber river basin. Many of the stations sampled in fact, are characterized by the conspicuous presence of macroalgae, especially in the upper and middle stretches of the watercourses investigated.

Even the bryophyte group, although represented by a small overall percentage (7%), plays an important role especially for the upper river stretches. These sections, in particular at the source of the river, are characterized by the presence of bryophytes, which in some cases, along with algae and cyanobacteria, are the only macro-physical floristic organisms recorded.

The flora recorded presents a taxonomic richness that differs distinctively along the different river stretches examined. In particular, the results indicate that this diversity, in general, reaches its highest values in the middle stretches, where there is in general greater micro-environmental variability. In the upper stretches there is instead relatively lower diversity, due not so much to pollution or anthropogenic disturbances, but to the presence of natural factors associated with the hydrological and hydromorphological characteristics, that are selective and limiting to the growth of macrophytes. In particular, the presence along these stretches of fast flowing and turbulent waters, of a predominantly rocky substrate and of elevated shading of the watercourse, do not allow the optimal ecological conditions for the development of the macro-physical flora and especially phanerogams.

When the forms of disturbance are anthropogenic, there is both a reduction in diversity and an alteration of the floristic composition; phenomena that are more evident the more the disturbance is frequent and intense, both in terms of artificialisation and of water pollution. Indeed, in many of the lower stretches and at the mouth of the rivers investigated, where human impact is stronger, the lowest levels of floristic richness were recorded and a greater diffusion of organisms with wide ecological amplitude, cosmopolitan distribution and/or sinanthropic behaviour were found.

In particular, as is evident from the results for the rivers Tiber and Aniene, the lower stretches, which cross the city of Rome, have a reduced floristic richness; this can be explained both for the reasons mentioned above and by the general uniformity of the environmental conditions found in these

stretches of the rivers. It should be noted though, that along the stretches close to the mouth of the River Tiber, an increase in floristic richness was found, probably due to the influence of brackish and salty water coming from the sea, which allows the development of new and peculiar species. The results of the specific floristic analysis for the taxonomic groups of algae, cyanobacteria and bryophytes, confirm what has been shown previously, with the only exception of the upper stretches of the River Aniene. In fact, the organisms found in this section of the river have a higher taxonomic diversity.

4.2 ECOLOGICAL EVALUATIONS

The analysis of the flora, from an ecological perspective, revealed the presence on the one hand of organisms with wide ecological amplitude, and on the other of organisms that are more sensitive to the variety of environmental conditions encountered along the different watercourses investigated. Among the species with wide ecological amplitude we report for the algal group, Cladophora glomerata, Closterium ehrenbergii, Vaucheria geminata, for cyanobacteria Oscillatoria limosa and Phormidium valderianum, and for the phanerogams Alisma plantago-aquatica, Lemna minor, Veronoca anagallis-aquatica and Sparganium erectum, which were found in river stretches with different characteristics and levels of pollution. Other species show a narrower ecological range, and are found only under certain environmental conditions. In particular, we identify typically rheophilic organisms, that prefer cool, oxygenated, clear, oligo(meso)trophic waters, including the cyanobacterium Chamaesiphon incrustans, the algae Bangia atropurpurea, Lemanea fluviatilis, Audouinella hermannii, Closterium closterioides, the bryophytes Cinclidotus aquaticus, Fissidens viridulus, Orthotrichum stramineum, Plagionium affine, P. undulatum, Aneura pinguis, Pellia endiviifolia, Lunularia cruciata e Conocephalum conicum, and among the phanerogams Elodea canadensis, Groelandia densa, Hippuris vulgaris, Persicaria anphibia and Spirodela polirhiza. We highlight however, that for some of these species and in particular for the red algae Bangia atropurpurea, there are divergent opinions in the literature especially in relation to its degree of sensitivity to eutrophication. Indeed, while some authors describe this species as typical of unpolluted (or only slightly polluted) oligotrophic/mesotrophic waters (Sladeček, 1973; Simic, 2002; AFNOR, 2003; Gutowski et al., 2004; Tardella et al., 2008), others report it as a eutrophic species (Eloranta and Kwandrans, 1996) or classify it as euryvalent in relation to the concentrations of organic matter (Sabater et al., 1989). Even for Lemanea fluviatilis, although there are

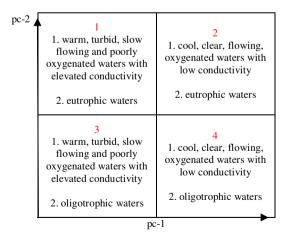
previous investigations that confirm the findings in this study (Dell'Uomo, 1970, 1981; Sheath and Hambrook, 1988; Haury *et al.*, 1996; Rott *et al.*, 1999; AFNOR, 2003; Gutowski *et al.*, 2004), there are some authors that report an unclear ecological preference (John *et al.*, 2002; Eloranta and Kwandrans, 2004).

Unlike the species mentioned above, others grow preferentially in slow flowing, warm, eutrophic waters with low oxygen content, such as those generally found in the middle, lower and terminal stretches of most of the watercourses of the Tiber basin. Among these organisms we report certain green algae such as Ankistrodesmus falcatus, Pediastrum boryanum, Ulothrix tenuissima and species of the genus Mougeotia sp., as well as diverse cyanobacteria such as Microcystis flos-aquae and some species of the genera Aphanizomenon and Oscillatoria. In the latter case, we highlight the finding of Oscillatoria subbrevis and O. limnetica, organisms that, like most of their kind, are linked to polluted waters, rich in organic matter. Among the phanerogams we can point out Potamogeton nodosus, P. pectinatus. Schoenoplectus lacustris. Myriophyllum Ceratophyllum demersum and Lemna minor. In particular, the data collected for Potamogeton pectinatus is consistent with the literature (Peltre et al., 1993; Trémolières et al., 1994) where it is reported several times as a species that, among those of the genus Potamogeton, tolerates best conditions with high organic pollution. It is stressed furthermore, that for some authors Potamogeton pectinatus can grow even in turbid waters, adapting to conditions of limited availability of light. Indeed P. pectinatus, when it is found in such environments extends its photosynthetic stalks to the surface. Even Myriophyllum spicatum shows the same ecological adaptation to the limited availability of light, which allows it to live even in environments characterised by turbid water.

Finally we note the only findings among the algae of *Stigeoclonium tenue* and *Entheromorpha flexuosa* in the confluence zone of the river mouth, which the chemical and physical analysis reports as the most polluted and eutrophicated river stretches of those examined. This finding confirms what already reported in the literature (Cambra and Aboal, 1992; Rosemond and Brawley, 1996; John *et al.*, 2002; Gutowski *et al.*, 2004; Jurisic, 2004), in regards to the tolerance of these species to hypertrophic and highly polluted conditions.

4.2.1 Autoecological analysis

The analysis of the principal components has revealed the relationships these components and certain environmental (temperature, pH, oxygen concentration, ammonia, nitrates and phosphates, conductivity, current velocity and turbidity). Thus it was possible to interpret the principal components as gradients of the variables, for which the species and the taxonomic groups in general are sorted and described, based on their location in the data space. According to the results obtained, the first and second axes describe and subdivide the space into four areas (Fig. 4.1 e 4.2). The first axis can be interpreted as a gradient related to increasing current, degree of oxygenation, temperature and conductivity of the water. The second axis however, can be correlated to a gradient of increasing eutrophication. In these areas are distributed the taxonomic groups examined. In particular, bryophytes are confined to area 4, which on the basis of the considerations above, describes hydrological and chemiophysical conditions associated with good quality waters, and generally found in streams and in the middle to high stretches of the watercourses. Therefore we can state that the bryophyte group, at the genus level, can be considered an indicator of good water quality. In contrast, for the taxonomic groups of algae, cyanobacteria and phanerogam, which are distributed in a heterogeneous manner in the space defined by the principal components, it is not possible to predict, at group level, what the ecological and qualitative indication could be.



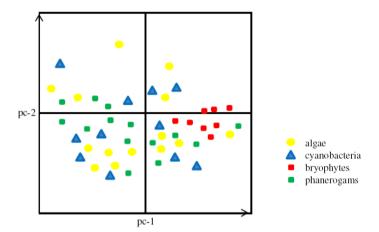


Fig. 4.1 e 4.2: Description and interpretation of the space generated by the first two principal components subdivided into four areas.

With the results obtained from the response curves it has been possible to highlight the ecological behaviour of species in relation to the individual factors considered, pointing out not only the species that show a behaviour that is restricted by these parameters, but also those that are indifferent. With cluster analysis it has instead been possible to group the species based on their similarity in regards to each ecological factor, allowing the identification of groups of species that respond in a similar manner to the particular range of the parameter considered.

From the assessment of the results obtained from the species response curves to the different ecological factors and their grouping by cluster analysis, it was possible to select among all the macrophysical species surveyed those that can best be used as bioindicators of the quality status of the waters. Below are reported the bioindicator taxa selected. Furthermore, also certain species were selected that contrary to those reported as bioindicators, show a wide distribution and, more importantly, a wide ecological amplitude in relation to the various environmental factors considered. The role of these "generalist" species is important especially in the implementation phase of the macrophytic indices, as detailed below.

4.2.2 Bioindicator taxa of good water quality status

These taxa are typical of oligotrophic waters, which are generally not very polluted and characterised by high concentrations of oxygen, high current velocity and low conductivity (Tab. 4.1).

For each taxonomic group we report the respective bioindicator species selected. For the algae and bryophytes groups, we report many species in this regard. It should be noted however, that the algae and cyanobacteria table also includes certain microalgae, as these were found in the macroalgae samples collected in the field; these microalgae cannot be considered for the purposes of the Water Frame Directive, as they are not included among the plant organisms to be analysed. In relation to the bryophyte group however, we underlined what has emerged also through the analysis of the principal components – that indeed the majority of the species sampled turn out to be good biological indicators of qualitatively good waters.

Tab. 4.1: Bioindicator species of good water quality, with the symbol * we indicate the microalgae

Good quality			
Alghe	Cyanobacteria	Bryophytes	Phanerogams
Palmodyction viride*	Chamaesiphon conferviculus*	Cratoneuron filicinum	Hippuris vulgaris Mentha aquatica f.
Kyliniella sp.*	Lyngbya sp.	Fissidens viridulus	fluitans
	Microcystis flos-aque*	Plagionium undulatum	Apium nodiflorum
Closteriopsis acicularis* Staurastrum	Nostoc punctiforme	Cinclidotus aquaticus	Elodea canadensis
dilatatum*	Phormidium sp.	Pellia endiviifolia	Groelandia densa
	Lyngbya aestuarii	DI 1	Juncus articulatus
Cosmarium impressulum*	Phormidium retzii	Plathypnidium riparioides Hygroamblystegium	Lemna trisulca Ranunculus
Lemanea fluviatilis		tenax	tricophyllus Berula erecta f.
Scenedesmus obtusus* Scenedesmus		Dialytrichia mucronata	fluitans
serratus*		Palustriella commutata	
Selenastrum sp*.			
Spirogyra communis		Higroamblystegium fluvio	atile
		Aneura pinguis	
		Riccia fluitans	
		-	

Algae





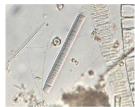


Kyliniella sp.



Spirogyra communis

Cyanobacteria



Phormidium sp.



Nostoc punctiforme



Chamaesiphon conferviculus

Bryophytes



Cratoneuron filicinum



Plagionium undulatum



Pellia endiviifolia

Phanerogams



Groelandia densa



Lemna trisulca



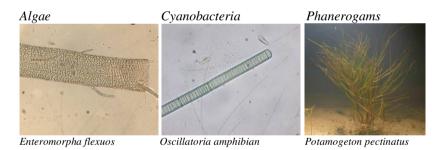
Mentha aquatica f. fluitans

4.2.3 Bioindicator taxa of poor water quality status

The taxa listed below appear distinctive of eutrophic waters, characterized by pollution mainly of organic origin, with warm temperatures, low concentrations of oxygen and slow flowing currents.

Tab. 4.2: Bioindicator species of poor water quality, with the symbol * we indicate the microalgae

Poor quality			
Algae	Cyanobacteria	Bryophytes	Fanerogams
Enteromorpha flexuosa Basicladia sp.* Stigeoclonium sp.* Characium sp.* Closterium kuetzingii*	Oscillatoria amphibia	-	Persicaria amphibia Schoenoplectus lacustris Eleocharis palustris Potamogeton natans Potamogeton pectinatus
Cosmarium bioculatum* Cosmarium granatum* Cosmarium meneghinii* Cosmarium punculatum* Monoraphidium arcuatum* Monoraphidium contortum* Oedogonium sp.			Spirodela polyrhiza



In the table 4.2 there are also reported certain microalgae.

Attention is brought to the small number of taxa that describes this quality status. It is actually the direct result of the high concentration of pollutants that leads in general to a reduction in floral abundance.

Attention is also brought to the fact that the bryophyte group has no species that can live and grow in these waters. The cyanobacteria group is represented by a single species, that is actually nevertheless, a valid bioindicator for these waters.

4.2.4 Species with wide ecological amplitude

Below are listed the taxa of the different groups investigated that show wide ecological amplitude in relation to the environmental factors considered.

Tab.4.3 Species with wide ecological amplitude, with the symbol * we indicate the microalgae

Species	with	wide
ecologic	al an	nplitude

Algae	Cyanobacteria	Bryophytes	Phanerogams
Cladophora glomerata	Oscillatoria subbrevis	Fontinalis antipyretica	Alisma plantago-aquatica
Vaucheria geminata	Oscillatoria amoena		Callitriche stagnalis
Microspora amoena	Chamaesiphon incrustan*		Lemna minor
	Oscillatoria limosa		Sparganium erectum
Oocystis borgei	Phormidium valderianum		Nasturtium officinale
Spirogyra fluviatilis	Merismopedia elegans*		Veronica beccabunga
	Oscillatoria limnetica		Zannichellia palustris
	Oscillatoria tenuis		





Cladophora glomerata



Vaucheria geminata



Spirogyra fluviatilis

Cyanobacteria



Oscillatoria subbrevis



Merismopedia elegans

Bryophytes

Fontinalis antipyretica

Phanerogams







Alisma plantago-aquatica

Lemna minor

Zannichellia palustris

Species with wide ecological amplitude are able to adapt to different environmental conditions and are very common, particularly in the area being surveyed and especially where conditions of greater disturbance and instability do not allow the growth of the more sensitive species. They must therefore not be confused with the real bioindicators species that characterize these environments. For example in the literature, the entire family of *Lemnaceae* are cited as typical of waters with high trophic levels (Portielje and Roijackers, 1995), and are also referred to by the macrophytic indices as bioindicators characterised by different values of sensitivity to the different trophic levels; while from our results, *Lemna minor* would appear to be species with wide ecological amplitude.

4.3 EVALUATION OF THE MACROPHYTIC INDICES

The results obtained from the application of the selected macrophytic indices to the data set are not exhaustive in describing the real quality state of the watercourses investigated. Below are reported some comments relating to the methodologies of the indices tested.

4.3.1 MTR

There is a not good match between the results that emerge from the application of the MTR index to river stretches investigated and the data relative to water quality that was obtained from the chemical and physical analysis. The MTR index appears therefore not particularly applicable to the stations considered. There are several limitations encountered in the methodology. First, it should be made clear that the MTR index was formulated for a specific purpose. It was developed in fact to meet the demands of the Urban Waste Water Treatment Directive, as a tool to verify the impact originating mainly from organic discharges on the macrophytic community. This index therefore, may be less suitable for more general biomonitoring purposes, which also want to assess the impact of diffuse sources of pollution. The MTR index is however more rigorous in its structure and formulation than previously developed indices such as the Macrophyte Index Scheme (Caffrey, 1987). It is based in fact, on a fairly large number of indicator species: 129; and also the method of calculation appear more rigorous, starting from semi-quantitative data.

Specifically it should be noted, that in the list of bioindicators reported in the methodology (attached 5), many of the species mentioned are not very common in the Italian territory. It also emerges from the comparison between the organisms sampled and those listed for the index that the taxa in common appear to be relatively few. In particular the algal group is described by 8 taxa, of which 5 are in common, but among these are the genera Cladophora sp. and Vaucheria sp. that according to the findings of this survey show wide ecological amplitude and therefore cannot be considered good biological indicators. In regards to the bryophyte group, among the liverworts, of the seven species listed for the index, only one, Pellia endiviifolia, was found among the species sampled. This species is reported in the list with a sensitivity value of 6. Looking at the data obtained in this study, this value appears to underestimate the actual information content of the specie in relation to water quality, as it is found in waters that are certainly good in terms of quality. Also with regards to the group of mosses few species (4) are in common with the MTR index list that counts

23 species. With regard to the phanerogams, of 91 entities listed, only 30 were in common. Even for this group there are some species such as *Lemna minor*, *Alisma plantago-aquatica*, *Sparganium erectum* and *Zanichellia palustris* that within the environmental context of this study appear to have wide ecological amplitude and as such should not be included in the reference list of bioindicators.

Finally, the conversion of the values obtained from the application of the index remains doubtful when compared to the final information on the quality of the waters. The final value in fact is not used to classify the site by conferring a specific class rank; instead a rather general indication is expressed on the quality status of the stretch of water considered.

4.3.2 GIS

In general, even the GIS method appears to be a macrophysical indexing tool that is not optimal for environmental bioindication. The result obtained from the application of the index to the data set was not exhaustive in describing the real qualitative and trophic state of the stations investigated. Above all, it appeared unreliable for those stations that in terms of the physical and chemical analysis were not very polluted.

There are several limitations to the applicability of this methodology. Firstly, the GIS index does not appear to be applicable for stations characterized by low macrophytic coverage. In this regard, several researchers (Minciardi et al., 2003) have indicated a minimum threshold of total macrophytic cover of at 5% for the applicability of the method, considering that failure to reach at least this value made it reasonable to assume that colonization by macrophytes was influenced by limiting factors (including hydrological and hydromorphological factors) that were so great as to render negligible the influence of other factors such as pollution. Secondly, the number of bioindicator taxa in relation to the actual taxa found and their relative percentage of coverage in relation to the total macrophytic cover should also be considered (Minciardi et al., 2003). In regards to the bioindicator taxa, we refer to the list (attached 5) drafted by the authors of the GIS index for the monitoring of rivers in France, with counts over 200 species, most of which are common to those found in the watercourses investigated. In the list however, some taxa, particularly in relation to algal organisms such as Entheromorpha flexuosa, Lemanea fluviatilis and Spirogyra communis, are considered only at the genus level. These organisms, if evaluated at the specific level, can give more detailed information for the evaluation of the ecological integrity and quality of the

river system, at least in the Mediterranean context as that of the present study.

Also, some species found seem to express, in the areas investigated, bioindicator information that is different from that expressed by the coefficients of sensitivity to the trophic level of pollution that the authors of the indices ascribe to each bioindicator species. For example, the specie *Ranunculus trichophyllus*, which in this study has been described as a bioindicator of good water quality, is reported in the GIS methodology, as associated to a value of Cs_i of 4. Just as the bryophytes *Lunularia cruciata* and *Marcanta polimorpha*, that are described in this study as bioindicator species of good quality waters are reported in the GIS methodology with a Cs_i of 6, levelling their information content. The index in fact was calibrated in a more continental context, which tends to differ from the local realities and more generally from the Italian watercourses of the Mediterranean region.

4.3.3 IBMR

Among the indices described, the IBMR is the one that appears more complete and reliable. The methodology is analogous to that of the previous indices, i.e. the *in situ* observation of the macrophytic populations, the subsequent identification of taxa and the estimation of their percentage coverage. However, the IBMR index makes reference to a more numerous list of bioindicator plant species (240) and entails the allocation to each organism of a wider coefficient of sensitivity to pollution of organic origin (1-20). Moreover, for each taxa an ecological amplitude coefficient is also indicated (1-3), useful to assess the actual ecological amplitude of the species and evaluate effectively the bioindicator information.

However, from the application of this index to the sampling stations, it is stressed that the results do not always appear as consistent to the actual trophic situation described for the study area. Even for the IBMR index, the results show a quality status of the waters that is in general rather compromised. The index does not appear able to appreciate and describe the stations where the quality and trophic state of waters are good.

Hence also for this index we report certain methodological limitations.

The index list reports, especially for the algal group, entities at the genus level. As has been repeatedly highlighted in this study, the failure to identify taxa to the specific level may cause a substantial loss of ecological information. Furthermore, it should be noted that certain taxa reported in the list correspond to organisms that were found in the present investigation to

be species with wide ecological behaviour and as such cannot assume the role of bioindicators (Tab. 4.4).

Tab. 4.4: List of species of the IBMR index which show wide ecology

IBMR	Cs_i
algae	
Cladophora glomerata	6
Microspora sp.	12
Oedogonium sp.	6
Oscillatoria sp.	11
Phormidium sp.	13
Spirogyra sp.	10
Vaucheria sp.	4
bryophytes	
Fontinalis antipyretica	10
phanerogams	
Alisma plantago aquatica	8
Lenma minor	10
Nasturtium officinale	11
Sparganium erectum	10
Veronica beccabunga	10
Zanichellia palustris	5

Based on these considerations, a test was carried out consisting in a simulated calculation of the IBMR index for the stations of the River Aniene, given by way of example, making changes with respect to the basic methodology. Specifically, for the purpose of indexing the data, the species with wide ecological amplitude were not considered among those to be used as bioindicators, as their inclusion in the calculation as per the original method may very well distort the results and hence the concluding information that is derived.

Tab. 4.5: Results for the stations of the river Aniene for the modified IBMR index

station	ANu_1	ANu_2	ANu_3	ANu_4	ANu_5	ANu_6	ANu ₇	ANu_8	ANu ₉
IBMR	11,2	10,1	10	11,2	10,9	9,1	11	9,4	9,2
station	ANm ₁₀	ANm ₁₁	ANm ₁₂	ANm ₁₃	ANm ₁₄	ANm ₁₅	ANm ₁₆	ANm ₁₇	ANm ₁₈
IBMR	11,3	10,9	10,7	8,4	9,6	10,1	8,5	7,7	10
station	ANI ₁₉	ANI ₂₀	ANI ₂₁	ANI ₂₂	ANI ₂₃	ANI ₂₄	ANI ₂₅	ANI ₂₆	ANI ₂₇
IBMR	9	9,3	10,1	10,7	8,2	4,8	5,4	2,4	5,6

As it can be noticed in Table 4.5 there is a slight increase in final values of the IBMR index that in terms of bioindication means expressing an overall improvement in the water quality of River Aniene. In fact, some stations that with the original calculation of the index previously fell in a poor quality class now are now describe by an average trophic level that is closer to the assessments made on the basis of physical and chemical data. Hence, this kind of elaboration highlights the importance of a careful assessment of which species should be considered as effective biological indicators.

5. CONCLUSIONS

The results obtained within this research project have made it possible, firstly, to broaden the floristic knowledge in relation to the macrophytic component present in the study area. Indeed, in addition to the phanerogams the other taxonomic groups investigated in detail were algae, cyanobacteria and aquatic bryophytes; groups for which there is little and fragmentary information available, especially at the national level. Furthermore, this investigation provides a first contribution to the overall study of the diversity, distribution and ecology of macrophytic species found in the main watercourses of the River Tiber catchment area, which is among the major watersheds in Italy and identified by governmental institutions as one of the pilot river basins for ecological studies. The data presented demonstrates a rich floristic asset, particularly in terms of algal and cyanobacteria species, emphasizing how these aquatic components, as well as the phanerogams, play a key role in these environments. Even from an ecological perspective the macrophytic flora appears well diversified, reflecting the gradients and the variety of the hydrological and chemio-physical conditions found in the various watercourses investigated. By analysing the relationships between the macrophytic species and the main environmental factors that regulate their presence and distribution, it was possible to delineate precisely the ecology of the individual species related to the different taxonomic groups considered. The autoecological study allowed the identification of species with wide ecological amplitude and non-differential behaviour to the variations in environmental parameters, as well as the identification of species distinctive of particular ecological conditions, which as such, may be flagged as potential bioindicators of the trophic state and overall water quality. Species such Lemanea fluviatilis, Nostoc punctiforme, Hippuris vulgaris, Elodea canadensis and Groelandia densa, were found to be indicative of oligotrophic waters and in general with conditions of low pollution. while Entheromorpha flexuosa, Oscillatoria Schoenoplectus lacustris, Potamogeton pectinatus and Spirodela polyrhiza are characteristic of warm, hypertrophic waters with high conductivity.

Finally, on the set of data collected certain macrophytic indices developed at European level were tested to assess their applicability and reliability in describing the qualitative state of the waters in the river systems of peninsular Italy.

The results show that these indices, although presenting a sound methodological framework, fail to interpret the true qualitative conditions of

the trophic state of the stations in question; these indices in fact, fail to discriminate in appreciable manner qualitatively different situations.

Therefore, there appear to be evident limits in the applicability of these indices to different contexts from those where they were elaborated, and not just because of the scarcity of species in common, as in the case of MTR index, but also for issues of taxonomy; indeed, sometimes these indices consider bioindicators only at the genus level, while as the findings of this study also point out, it is often necessary to reach the rank of the species, due to different responses that can sometimes exist between species of the same genus. For example, species of the genus Potamogeton show different responses to the nutrient content found in waterways: from very sensitive species such as *Potamogeton coloratus*, to which the IBMR index ascribes the highest sensitivity index value, to species that are extremely tolerant such as *Potamogeton pectinatus*, which is instead described with one of the lowest values. Moreover, analysing the lists of bioindicator organisms related to the macrophytic indices, it was possible to point out that these lists include organisms that were found in this study to be species with wide ecological amplitude and which therefore are not suitable for this purpose. Lastly, comparing the autoecological responses obtained in this study with

the coefficients of sensitivity conferred by the various macrophytic indices to the species in common, it can be noted that for certain species the autoecological information does not sometimes coincide, an element which emphasizes the importance of adapting these coefficients to species in a Mediterranean context.

The models cannot therefore be applied "sic et simpliciter" to contexts too different from those in which the indicators were formulated.

There emerges hence the necessity to propose alternative indices that can be valid for the Mediterranean environment, which have, that is, a value calibrated for the landscape concerned.

The results obtained in this study, particularly those concerning the ecological behaviour of macrophytic species and in assessing their role as bioindicators of the water quality of the river system, are the basis for future research that will have as its objective the formulation of a macrophytic index that is more suitable to the Italian context and in particular for the Mediterranean region, thus contributing to the implementation of the guidelines for biomonitoring under the Water Frame Directive 2000/60/EC.

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1. ALPHANUMERIC CODE OF THE WATERCOURSES OF THE TIBER BACIN

Each of the stations mentioned in this work was given an alphanumeric code, in which the capital letters indicate the name of the river or stream where the station is found, while the numbers indicate the position in the sequence of surveys carried out along a water course, starting from the watercourse stations further upstream and working towards those further downstream.

With the symbol * we indicate the stations extrapolated from the field-specific literature

River	Code	Location
Tiber	Tu_1	Source
Tiber	Tu_2	Molin del Becco (Pieve S.Stefano)
Tiber	Tu ₃	Pieve di S.Stefano
Tiber	Tu ₄	Formole (Pieve di S.Stefano)
Tiber	Tu ₅	S. Sepolcro
Tiber	Tu_6	regional border (Pistrino)
Tiber	Tm ₇	Pistrino
Tiber	Tm_8	Pistrino
Tiber	Tm_9	Città di Castello
Tiber	Tm_{10}	Umbertide
Tiber	Tm_{11}	Ponte Pattoli
Tiber	Tm_{12}	Pontecuti (Todi)
Tiber	Tm_{13}	Baucche (Orte)
Tiber	Tl ₁₄	Ponte felice*
Tiber	Tl ₁₅	Ponte felice*
Tiber	Tl ₁₆	Stimigliano scalo*
Tiber	Tl ₁₇	Ponzano Romano*
Tiber	Tl ₁₈	Ponzano Romano*
Tiber	Tl ₁₉	Filacciano*
Tiber	Tl ₂₀	Filacciano*
Tiber	Tl ₂₁	Ponte acquedotto del Peschiera*
Tiber	Tl ₂₂	Poggio Mirteto scalo*
Tiber	Tl ₂₃	Poggio Mirteto scalo*
Tiber	Tl ₂₄	Torrita Tiberina*
Tiber	Tl ₂₅	Torrita Tiberina*
Tiber	Tl ₂₆	Nazzano*
Tiber	Tl ₂₇	Nazzano*
Tiber	Tl ₂₈	Nazzano*
Tiber	Tl ₂₉	Nazzano*
Tiber	Tl ₃₀	Casale Meana*
Tiber	Tl ₃₁	Casale Meana*
Tiber	Tl ₃₂	Casale Meana (diga Nazzano)*
Tiber	Tl ₃₃	Casale Meana (diga Nazzano)*
Tiber	Tl ₃₄	Passo Corese*
Tiber	Tl ₃₅	Passo Corese*
Tiber	Tl ₃₆	Ponte del Grillo*
Tiber	Tl ₃₇	Monte Rotondo*
Tiber	Tl ₃₈	Settebagni*
Tiber	Tl ₃₉	Labaro*
Tiber	Tl ₄₀	Labaro*
Tiber	Tl ₄₀	Roma- Milvio bridge*
Tiber		
11001	Tl_{42}	Roma- Milvio bridge*

Tiber	Tl ₄₃	Roma- Duca D'Aosta bridge*
		E .
Tiber	Tl ₄₄	Roma- Risorgimento bridge*
Tiber	Tl ₄₅	Roma- Risorgimento bridge*
Tiber	Tl ₄₆	Roma- Matteotti bridge*
Tiber	Tl ₄₇	Roma- Margherita bridge*
Tiber	Tl_{48}	Roma- Cavour bridge*
Tiber	Tl ₄₉	Roma- Umberto I bridge*
Tiber	Tl_{50}	Roma- Castel S.Angelo bridge*
Tiber	Tl_{51}	Roma- Mazzini bridge*
Tiber	Tl ₅₂	Roma- Sisto bridge*
Tiber	Tl ₅₃	Roma- Tiberina Island*
Tiber	Tl_{54}	Roma- Sublicio bridge*
Tiber	Tl ₅₅	Roma- dell'Industria bridge*
Tiber	Tl ₅₆	Roma- Marconi bridge*
Tiber	Tl ₅₇	Roma- Marconi bridge*
Tiber	Tmou ₅₈	Tor di valle*
Tiber	Tmou ₅₉	Centro Giano-State Natural Reserve Litorale Romano*
Tiber	Tmou ₆₀	Centro Giano-State Natural Reserve Litorale Romano*
Tiber	Tmou ₆₁	Tor Boacciana *

River /Stream	Code	Location
Singerna	SING	Ontaneto
Tignana/Stianta	STI	Aboca
Sovara	SOV	Pistrino
Cerfone	$CERF_1$	Monterchi
Cerfone	CERF ₂	Monterchi
Cerfone	CERF ₃	Monterchi
Soara	SOA	Città di Castello
Seano	SEA	Calzolaro
Carpina	CAR	S. Maria di Sette
Assino	ASS	Pian D'Assino
Chiascio	CHS	Passaggio di Bettona
Topino	TOP_1	Capo d'Acqua
Topino	TOP_2	Torandrea
Timia	TIM	Bevagna
Clitunno	CLT_1	source
Clitunno	CLT_2	Trevi
Clitunno	CLT ₃	Trevi
Puglia	PUG	Colle Pepe
Caina	CAI	Pieve Caina
Nestore	NES_1	Monte Petriolo
Nestore	NES_2	Marsciano
Fersinone	FRS	Marsciano
Argentina	ARG	Postignano-Seccano
Vigi	VIG	Cerreto di Spoleto
Campiano	CMP	Visso
Sordo	SRD	Norcia
Corno	CRN_1	Rocca Porena (Cascia)
Corno	CRN_2	Serravalle

River	Code	Location
Aniene	ANu ₁	Filettino
Aniene	ANu_2	Filettino
Aniene	ANu_3	Trevi
Aniene	ANu_4	Subiaco hatchery fish
Aniene	ANu ₅	Subiaco
Aniene	ANu_6	Subiaco*
Aniene	ANu_7	Subiaco S. Francesco bridge
Aniene	ANu_8	Subiaco*
Aniene	ANu_9	Subiaco S. Francesco bridge*
Aniene	ANm_{10}	Anticoli Corrado
Aniene	ANm_{11}	Anticoli Corrado*
Aniene	ANm_{12}	Mandela Scalo*
Aniene	ANm_{13}	Vicovaro (S. Sepolcro)
Aniene	ANm_{14}	Vicovaro (S. Sepolcro)*
Aniene	ANm_{15}	Castel Madama
Aniene	ANm_{16}	Castel Madama*
Aniene	ANm_{17}	Castel Madama
Aniene	ANm_{18}	Castel Madama*
Aniene	AN1 ₁₉	Tivoli
Aniene	ANl_{20}	Tivoli*
Aniene	ANl_{21}	Villanova di Guidonia
Aniene	$AN1_{22}$	Villanova di Guidonia*
Aniene	$AN1_{23}$	Lunghezza
Aniene	ANl_{24}	Roma Tor Cervara
Aniene	ANI ₂₅	Roma "Nature Reserve Valle dell' Aniene
Aniene	$AN1_{26}$	Roma "Nature Reserve Valle dell' Aniene*
Aniene	ANI ₂₇	Roma "Nature Reserve Valle dell' Aniene*

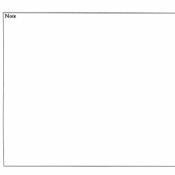
River	Code	Location
Nera	Nu_1	Borgo Cerreto
Nera	Nu_2	Terria
Nera	Nu_3	Castel del Lago
Nera	Nl_4	Narni scalo
Nera	Nl_5	dam lake S. Liberato
Farfa	FA1	Fosso Riana*
Farfa	FA2	ENEL water power plant*
Farfa	FA3	Ponte Sfondato*
Farfa	FA4	Casale S. Vittore*
Farfa	FA5	Ponte sul Farfa*
Farfa	FA6	Confluence Farfa – Tiber*
Farfa	FA7	Confluence Farfa – Tiber*
Treia	TRl_1	Civita Castellana *
Treia	TRl_2	Civita Castellana*
Treia	TRu_3	Monte Gelato*
Treia	TRu_4	Monte Gelato*

4. FORM FOR THE SAMPLING OF MACROPHYTES

Rilievo Trans Corso d'acqua e località Lat. Alt. n. foto PROFILO TRASVERSALE DELL'AL:	Long. Incl.
Lat. Alt. Exp. n. foto	Incl.
Alt. Exp.	Incl.
n. foto	1200
	LVEO
Profilo trasversale dell'al	LVEO
STATO DEL TERRITORIO CIRCOS	STANTE
foreste e boschi	riva destra 🗆 riva sinistra
prati, incolti	riva destra 🗆 riva sinistra
pascoli	riva destra 🗆 riva sinistra
aree ad agricoltura estensiva	riva destra 🗆 riva sinistra
aree ad agricoltura intensiva	riva destra 🗆 riva sinistra
aree industriali	
	riva destra 🗆 riva sinistra
aree ad urbanizzazione rada	riva destra riva sinistra riva destra riva sinistra riva destra riva sinistra

MORFOLOGIA ampiezza alveo di magra/ zona a ampiezza alveo di morbida / zona ampiezza alveo di piena ampiezza alveo bagnato	acquatic na acqua	a tica+sopracquatic	a (_m) _m) _m) _m)
CONDIZIONI IDRICHE DELL'A				
piena 🗆 t	magra		morbida	B.
TRASPARENZA DELL'ACQUA				
totale 🗆	parziale		nulla	
VELOCITÀ DELLA CORRENTE				
molta lenta	lenta			
media e laminare	media e	turbolenta	0	
elevata e turbolenta	molto e	levata e turbolenta		
compatto per artificializzazione SUBSTRATO DELL'ALVEO DI M roccia - massi - ciottoli - ghiaia - uniformemente compatto □ compatto per artificializzazione	sabbia		tabile 🗆	
FENOMENI EROSIVI IN ATTO				
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localizzati molto evidenti		riva destra	riva sinis	
ARTIFICIALIZZAZIONE DEL Co del fondo della sponda destra della sponda sinistra	ORSO D'		nva sini	our L
DATI FISICO-CHIMICI				
рН	Tem	peratura		°C
O ₂ discioltomg/l	Cone	lucibilità		μS/cm
Nitrati	Fost	ati		.mg/l
Ione Ammoniomg/l				40

Copertura a macrofite in alveo di morbida (A+SA)	%
Copertura a macrofite in alveo di magra (A)	%
Copertura a macrofite in zona sopraquatica (SA)	%
Copertura a macrofite (escluse alghe) in alveo bagnato	%
Copertura algale in alveo bagnato	%



Specie	(A)	(SA)
1	25	
2	26	
3	27	
4	28	
5	29	
6	30	
7	31	
8	32	,
9	33	
10	34	
11	35	
12	36	
13	37	
14	38	
15	39	
16	40	
17	41	
18	42	
19	43	,,
20	44	
21	45	
22	46	
23	47	
24	Superf	ficie rilevata (mq)

3. CHEMICAL AND PHYSICAL PARAMETERS

Some hydrological and chemico-physical characteristics of the sampled watercourses of the Tiber basin. For the watercourses with more sampling stations, we report the minimum and maximum values of parameter and for the longest rivers the data is relate to fluvial sectors.

watercourse	length (km)	water flow	water clearness	T (°C)	pH	O_2 (mgl^{-l})	conduct (µScm ⁻¹)	salinity	NH_4^+ (mgl^-)	NO_3^- (mgl^{-l})	$P0_4^{3-}$ (mgl^{-l})	n° stations
upper Tiber river	_	laminar	clear	6.6-26.4	7.4-8.5	6.4-11.3	273-494	0.0	0.01-0.14	0.10-1.00	0.05-0.57	5
middle Tiber river	405	laminar	clear enough	18.4-26.1	7.8-8.5	7.0-9.7	523-1900	0.0	0.04-0.18	0.45-1.50	0.07-0.32	6
lower Tiber river	405	slow	turbid	15.9-30.2	7.3-8.5	4.3-9.3	829-1551	0.8	0.04-2.00	0.45-7.90	0.03-0.35	44
mouth Tiber river		very slow	turbid	18.4-24.0	7.6-8.0	4.5-7.1	1073-5180	0.3-2.7	1.20-1.49	3.40-12.00	0.15-0.21	4
upper Aniene river		very turbulent	clear	9.1-13.7	8.4-8.6	7.0-12.0	327-445	0.0	0.05-0.11	0.00-2.10	0.01-0.06	8
middle Aniene river	99	laminar	clear	10.5-19.8	7.4-8.3	7.8-12.7	445-890	0.0	0.04-0.12	1.12-1.70	0.01-0.42	4
lower Aniene river		laminar	turbid	13.0-22.3	7.2-8.0	2.0-9.6	576-1980	0.0-0.8	0.04-4.86	0.55-14.11	0.01-0.27	7
upper Nera river	116	turbulent-laminar	clear	13.3-16.3	8.1-8.4	9.0-9.5	431-508	0.0	0.06-0.09	0.76-0.95	0.03-0.04	5
lower Nera river	110	slow	clear enough	21.1-23.6	7.3-7.9	6.5-8.9	672-1380	0.1-0.5	0.23-0.34	0.70-1.79	0.03-0.12	2
Farfa river	25	turbulent-slow	clear-clear enough	17.0-25.6	7.7-8.2	5.3-9.5	630-1823	0.1-0.7	0.04-0.75	0.44-10.19	0.00-0.90	7
Nestore river	53	turbulent-laminar	clear enough-turbid	21.5-23.7	7,9-8,1	6.7-9.9	1017-1344	0.3-0.5	0.04-0.16	0.81	0.79-0.60	2
Treia river	36	laminar	clear-clear enough	18.3-19.2	7.3-8.2	7.0-8.1	530-544	0.0	0.20-0.70	9.00-12.50	0.20-1.00	4
Clitunno river	60	laminar	clear	12.4-13.5	7.1-8.2	8.3 - 10.0	720-942	0.1-0.2	0.06-0.19	1.09	0.28-0.30	3
Timia river	30	slow	clear enough	21.1	8.0	9.3	769	0.1	0.04	2.20	0,0201389	1
Topino river	77	laminar	clear-turbid	21.1-24.5	8.3-8.5	7.6 - 9.7	373-785	0.0-0.1	0.02-0.21	0.65-1.50	0.02-0.30	2
Vigi river	22	turbulent	clear	15.2	8.4	9.3	422	0.0	0.02	0.30	0.03	1
Tignana-Stianta stream	2	turbulent	clear	17.3	8.3	11.0	442	0.0	0.01	0.28	0.05	1
Cerfone stream	31	laminar	clear-clear enough	22.0-23.8	8.2	8.4-8.8	489-501	0.0	0.01	0.47	0.20-0.26	3
Puglia stream	30	slow	clear enough	18.6	8.2	8.5	1100	0.3	0.23	1.13	0.08	1
Singerna stream	20	turbulent	clear	21.0	8.5	11.9	391	0.0	0.01	0.21	0.20	1
Soara stream	18	slow	clear	23.0	8.0	11.7	648	0.1	0.34	0.89	0.20	1
Sovara stream	26	turbulent	clear	24.5	8.4	9.9	479	0.0	0.01	0.84	0.20	1
Chiascio river	74	very slow	turbid	21.7	7.8	9.1	798	0.2	0.11	2.10	0.32	1
Argentina stream	36	very turbulent	clear	11.6	8.2	9.2	407	0.0	0,02	0.15	0.01	1
Assino stream	24	slow	clear	19.4	8.3	8.1	216	0.0	0.12	0.26	0.02	1
Caina stream	102	slow	turbid	24.3	8.3	7.1	1020	0.3	0.23	1.92	1.50	1
Campiano stream	15	turbulent	clear	15.7	8.0	6.9	375	0.0	0.23	0.19	0.06	1
Carpina stream	28	slow	clear	18.6	6.1	8.0	662	0.1	0.21	0.11	0.01	1
Corno stream	20	turbulent-laminar	clear	14.5	8.1-8.3	9.2	399-542	0.0	0.09-0.41	1.42	0.01-0.14	2
Fersinone stream	25	very slow	clear enough	23.3	8.2	9.4	590	0.0	0.33	0.62	0.10	1
Seano stream	20	slow	clear enough	18.8	8.3	7.9	600	0.0	0.06	0.32	0.20	1
Sordo stream	8	laminar	clear	13.6	8.1	9.2	573	0.0	0.62	0.78	0.20	1

4. LIST AND DISTRIBUTION OF TAXA FOUND IN THE WATERCOURSES OF THE TIBER BASIN.

Taxa	Tu ₁	Tu ₂	Tu ₃	Tu ₄	Tu ₅	Tu ₆	Tm ₇	Tm ₈	Tm ₉	Tm ₁₀	Tm ₁₁	Tm ₁₂	Tm ₁₃
Phanerogams aquatic													_
Alisma plantago-aquatica L.		r			+	r			1	+	+		r
Apium nodiflorum L. f. aquatica						+	r						1
Azolla filiculoides Lam.													
Berula erecta (Hudson) Coville f. fluitans													
Callitriche stagnalis Scop.													3
Ceratophyllum demersum L.													4
Eleocharis palustris (L.) Roemer & Schultes						+							
Elodea canadensis Michx.													
Groelandia densa (L.) Fourr													
Hippuris vulgaris L.													
Juncus gr. articulatus f. aquatica													
Lemna gibba L.	-	•	-		-	-	3	3	2	r	•	-	•
Lemna minor L.	•	•	•	•	•	•	-	1	-	•	•	•	•
Lemna trisulca L.	•	•	•	•	•	•	•	•	•	•	•	•	•
Mentha aquatica L. f. fluitans	•	•	•	•	•	+	•	•	•	•	•	•	•
Myriophyllum spicatum L.	•	•	•		•		•	•		•	•	•	•
Myriophyllum verticillatum L.	•	•	•		•	•		•	•	•		•	
Najas marina L. ssp. marina	•	•	•		•	•		•	•	•		•	
Nasturtium officinale R.Br. f. fluitans	•	1	•	2	•	i	2	i	+	2		•	
	•	1	•	2		1	2	1	+	2			
Persicaria amphibia (L.) Delarbre						;		:				:	
Potamogeton crispus L.						1		1	3			1	r
Potamogeton natans L.										:		:	3
Potamogeton nodosus Poir.									3	1	2	1	1
Potamogeton pectinatus L.												+	2
Potamogeton perfoliatus L.													
Potamogeton sp.1													
Potamogeton trichoides Cham. & Schltdl.													
Ranunculus trichophyllus Chaix ssp. trichophyllus													
Schoenoplectus lacustris (L.) Palla										+			
Sparganium erectum L. subp. Erectum									2	+			2
Spirodela polyrhiza (L.) Schleid.													
Veronica anagallis L. ssp. anagallis-aquatica f. fluitans		+		1		2	1	+	2	2			r
Veronica beccabunga L. f. fluitans										r			
Zannichellia palustris L.						2	+	r					1
Algae													
Achnanthes lanceolata (Breb.) Grunow													
Achnanthes minutissima Kuetz.						r		r					
Amphora ovalis(Kützing) Kützing								r	г		r		
Amphora pediculus (Kuetz.) Grunow	•	•	•	r	•	•	•	•	r	•	•	•	•
Anabaena sp. 1	•	•	•	•	•	•	•	•		•	•	•	
Ankistrodesmus falcatus (Corda) Ralfs	•	•	•			•		•	•	•		•	
Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et Flahault	•	•	•		•	•		•	•	•		•	
Audouinella hermannii (Roth) Dudy in de Candolle	•	•	+		•	•		•	•	•		•	
Bangia atropurpurea (Roth) C. Agardh	•		+					•		•			
	•												
Basicladia sp.		•										•	
Caloneis sp.									r		r		
Chaetophora elegans (Roth) C. Agardh													
Chamaesiphon conferviculus A. Braun													
Chamaesiphon incrustans Grunow in Rabenhorst													
Chara sp.									+				
Characium sp.													
Chroococcus turgidus (Kutzing) Nageli													
Cladophora glomerata L.		3	2	r	+	1	4	5	1		+		
Closteriopsis acicularis (G. M. Smith) J. H. Belcher et Swale													
Closterium closterioides (Ralfs) A. Louis et Peeters									r				
Closterium ehrebergii Meneghini ex Ralfs		r		r				r	r		r		
Closterium kuetzingii Brebison													
Closterium praelongum varietà brevius (Nordstedt) Willi Krieger									r				
Cocconeis pediculus Ehrenberg		+	r	r	r	r	•	r	r		+		•
Cocconeis placentula Ehrenberg	•		•	•	•	•	•	•	•	•	+	•	
Coelastrum microporum Nageli in A. Braun	•	•	•	•	•	r	•	•	•	•	-	•	•
Coenochloris fottii (Hindak) Tsarenko		•			•	1		•	r	•		•	•
Cochochions form (Thirdax) Tsaichiku			•			•		•	1	•			

Cosmarium botrytis Meneghinini ex Ralfs		r							r				
Cosmarium bioculatum Brébisson ex Ralfs													
Cosmarium granatum Brébisson in Ralfs													
Cosmarium humile (F. Gay) Nordstedt in De Toni													
Cosmarium impressulum Elfving		r											
Cosmarium laeve Rabenhorst				r									
Cosmarium meneghinii Brébisson in Ralfs													
Cosmarium punctulatum Brébisson													
Cyclotella meneghiniana Kützing	•	r	•	•	•	•	•	•	r	•	r	r	
Cymatopleura solea (Brebisson) W. Smith	•	1	•		•	•			1		1	1	
Cymatopleura sp									r		r		
Cymbella minuta Hilse													
Cymbella affinis Kützing									r				
Cymbella helvetica Kützing		r						r	r		r		
Cymbella sp.1									г				
Cymbella sp.2											r		
Cymbella sp.3													
Cymbella sp.4	•	+	•	•	•	•	•	•	•	•	r	•	
Diatoma mesodon (Ehrenberg) Kützing			•	•	•	•	•	•	•	•		•	
Diatoma sp.			•	•		•	•	•			•	•	
		r	•	•		•			r		•		
Diatoma vulgaris Bory									r				
Diploneis sp.											r		
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh													
Epithemia sp.													
Eunotia sp.													
Fragilaria sp.		r		r		r			r				
Gomphonema acuminatus									r				
Gomphonema olivaceum (Hornemann) Brebisson		r		r				r	r		r		
Gomphonema parvulum Kützing	•	•	•	•	•	•	•	•	r	•	•	•	
Gomphonema sp.1			•	•		•	•	•	r		•	•	
		r							I				
Gomphonema sp.2											•		
Gomphonema sp.3													
Gyrosigma attenuatum (Kützing) Rabenhorst						r		r	r		r	r	
Hantzschia amphioxys (Ehr.) Grun.													
Hapalosiphon fontinalis (C.Agardh) Bornet													
Klebsormidium flaccidum (Kutzing) P.C. Silva, Mattox et W.H.													
Blackwell													
Kyliniella sp.		•		•			•	•	•	•	•	•	
	•		•	•	•	•	•		•		•	•	
Lemanea fluviatilis (L.)C. Agardh			•	•			•						
Lyngbya lutea (C.Agardh, Gomont) Gomont											•		
Lyngbya aestuarii (Liebman) Gomont									r				
Lyngbya kuetzingii Schmidle													
Lyngbya lutescens (Meneghini) Hansgirg													
Lyngbya martensiana (Meneghini) Gomont													
Lyngbya sp.													
Melosira varians Agardh	-	•	-	+	+	r		+	<u>.</u>	r	r	-	
Merismopedia elegans A.Braun in Kutzing	•	i	•	r	т.	1		т	т -	1	r	r	
Microcystis flos-aque (Wittrock) Kirchner		1	•	1		•	•	•			1	1	
					r								
Microspora amoena (Kutzing) Rabenhorst		+		+									
Monoraphidium arcuatum (Korshikov) Hindak													
Monoraphidium contortum (Thuret) komarkova-Legnerova											r		
Mougeotia sp.													
Navicula cryptocephala Kützing								r					
Navicula cryptotenella Lange-Bertalot						r		r	r				
Navicula gregaria Donkin									+		+		
Navicula lanceolata (Agardh) Ehrenberg			•		•	•	•				•	•	
			•			•	•	r			•		
Navicula sp.1		+						. ·	+				
Navicula sp.1 Navicula sp.2	•	+		•					+				
Navicula sp.1 Navicula sp.2 Navicula sp.3	· · ·	+	· · ·	•			· · ·		+				
Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4		+					· ·	r	+		+	· · ·	
Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.5		+					· · · · ·		+		•	·	
Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4		+						r	+		+		
Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith								r	+ r		+		
Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow								r	r		+ +		
Navicula sp. 1 Navicula sp. 2 Navicula sp. 3 Navicula sp. 4 Navicula sp. 5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith								r			+		
Navicula sp. 1 Navicula sp. 2 Navicula sp. 3 Navicula sp. 4 Navicula sp. 4 Navicula sp. 5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp. 1		+ +						r r	r		+ +		
Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.5 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1								r r	r		+ +		
Navicula sp. 1 Navicula sp. 2 Navicula sp. 3 Navicula sp. 4 Navicula sp. 5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp. 1 Nitzschia sp. 1 Nitzschia sp. 2 Nostoc punctiforme (Kutzing) Hariot		r							r r		+ + · · · ·		
Navicula sp. 1 Navicula sp. 2 Navicula sp. 3 Navicula sp. 4 Navicula sp. 4 Navicula sp. 5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp. 1 Nitzschia sp. 1 Nitzschia sp. 2 Nostoc punctiforme (Kutzing) Hariot Oedogonium sp. 1								r r	r		+ +		
Navicula sp. 1 Navicula sp. 2 Navicula sp. 3 Navicula sp. 4 Navicula sp. 5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp. 1 Nitzschia sp. 1 Nitzschia sp. 2 Nostoc punctiforme (Kutzing) Hariot		r							r r		+ + · · · ·		

Oocystis borgei Snow								r	r				
Oscillatoria amoena (Kutzing) Gomont				r								2	
Oscillatoria amphibia (C.Agardh) Gomont													
Oscillatoria brevis Gomont													
Oscillatoria formosa Bory													
Oscillatoria limnetica Lemmermann													
Oscillatoria limosa (C. Agardh) Gomont				r					r				
Oscillatoria sp.1					+								
Oscillatoria sp.2													
Oscillatoria sp.3													
Oscillatoria subbrevis Lemmermann													
Oscillatoria tenuis (C.Agardh) Gomont				r								+	
Palmodyction viride Kützing													
Pandorina morum (O. Müller) Bory de Saint-Vincent									r				
Pediastrum boryanum (Turpin) Meneghini								r	r				
Pediastrum boryanum var. cornutum (Raciborski) Sulek													•
Pediastrum duplex Meyen	•				•				r				
Pediastrum integrum Nageli Pediastrum simplex Meyen					•				r				•
Pediastrum tetras (Ehrenberrg) Ralfs					•								•
Phacus sp.	•			•	•	•	•	•					
Phormidium retzii (C. Agardh) Gomont	•		•		•	•		•					•
Phormidium sp.	•		•		•	•		•					•
Phormidium valderianum (Delponte) Gomont	•		•	r	•	•		•	r r		r	3	•
Pinnularia sp.1	•			•	•	•		•	•		•		•
Pinnularia sp.2	•			•	•	•		•					•
Rhodostichus expansus													
Rhoicosphenia sp.													
Scenedesmus arcuatus (Lemmermann) Lemmermann									r				
Scenedesmus communis e.h.Hegewald								r	r		r		
Scenedesmus ellipticus Corda									r				
Scenedesmus falcatus Chodat									r				
Scenedesmus granulatus W. West & G.S. West		+							r				
Scenedesmus obtusus Meyen													
Scenedesmus serratus (Corda) Bohlin													
Selenastrum sp.													
Spirogyra communis (Hassall) Kutzing													
Spirogyra fluviatilis Hilse in Rabenhorst							:		:				
Spirogyra sp.		2		:	2		1	+	1	+	+	+	•
Spirogyra sp.1 Spirogyra sp.2				1	•			•					•
Staurastrum dilatatum Ehr.	•			•	•	•	•	•					
Stigeoclonium sp.	•		•		•	•		•					•
Surirella brebissonii Krammer & Lange-Bertalot		•		•	•	•	•	•	r	•	•		
Surirella sp.		r							r		r		
Synedra ulna (Nitzsch) Ehrenberg													
Tabellaria flocculosa (Roth) Kützing		r							+				
Trachelomonas hispida (Perty) F. Stein ex Deflandre													
Trachelomonas sp.								r	r				
Ulothrix tenuissima Kützing		r											
Ulothrix zonata (Weber & Mohr) Kützing													
Uronema elongatum Hodgetts				:	:			:	:				
Vaucheria germinata (Vaucher) De Candolle	•	•		4	4	3		2	4			+	
Zygnema sp.	•	•	•	•	•	•	•	•	•				•
Bryophytes mosses Hygroamblystegium fluviatile (Hedw.) Loeske													
Cinclidotus aquaticus (Hedw.) Bruch & Schimp.					•			•					•
Cinclidotus fontinaloides (Hedw.) P. Beauv.					•			•	1				•
Cratoneuron filicinum (Hedw.) Spruce				•	•	•	•	•	1				
Dialytrichia mucronata (Brid.) Broth.	1	•	•	•	•	•				•		•	
Fissidens viridulus (Sw.) Wahlemb		•		•	•	•	•	•	•	•	•		
Fontinalis antipyretica Hedw.	i			•	•	•		•					•
Fontinalis sp.													
Hygroamblystegium tenax (Hedw.) Jenn.													
Leptodictyum riparium (Hedw.) Warnst.													
Orthotrichum stramineum Horsch. Ex Brid.													
Palustriella commutata (Hedw.) Ochyra													
Plagiomnium affine (Blandow ex Funck) T.J. Kop													
Plagiomnium undulatum (Hedw.) Schimp.													

Platyhypnidium riparioides (Hedw.) Dixon.	1												
Rhynchostegium sp. Bryophytes liverworts	•		•	•	•						•	•	
Aneura pinguis (L.) Dumort.													
Conocephalum conicum (L.) Dumort.				·	·	· ·							:
Conocephalum sp.													
Lunularia cruciata (L.) Lindb.													
Marcantia polymorpha L.													
Pellia endiviifolia (Dicks.) Dumort.													
Riccia fluitans L.												<u>. </u>	
Phanerogams riverbank species													
Aegopodium podagraria L. Agrostis stolonifera L.		1	r		2		1						1
Agrosus stoionnera L. Alternanthera philoxeroides (Mart.) Griseb.		1	I		2	•	1						1
Anagallis arvensis L. ssp. arvensis	•	•		•	•	•	•	•	•	•	•	•	•
Angelica sylvestris L.	:	:	:	:		r	+	:	:	:	:		:
Apium nodiflorum (L.) Lag. ssp. nodiflorum										1			
Arctium lappa L.													
Artemisia annua L.													
Artemisia verlotiorum Lamotte											+		
Artemisia vulgaris L.											+		
Arundo donax L.													
Arundo plinii Turra Atriplex patula L.	•			•	•	•					•	•	•
Berula erecta (Huds.) Coville					•	•							2
Bidens frondosa L.	:	:	:	:		r	:	:	:	:	i		
Bidens tripartita L.		r					1	+	+	2		+	r
Butomus umbellatus L.													
Cardamine sp.													
Carex hirta L.													
Carex otrubae Podp.													
Carex paniculata L. ssp. paniculata Carex pendula Huds.					+	r							
Carex pseudocyperus L.	•		•	т	т	1	•				•	•	•
Chenopium album L.	•	•	•	•	•	•	•	•	•	•	•		
Chenopodium ambrosioides L.						·							
Chenopodium polyspermum L.													
Cirsium arvense (L.) Scop.											+		
Cirsium creticum (Lam.) d'Urv.								r					
Cirsium palustre (L.) Scop.													
Conium maculatum L. ssp. maculatum Conyza canadensis (L.) Cronq.	•			•	•	•					•	•	•
Cyperus eragrostis Lam.					•	•							
Cyperus fuscus L.				r						3	2		
Cyperus longus L.											-		
Cyperus rotundus L.													
Datura stramonium L. ssp. stramonium													
Dipsacus fullonum L.											+		
Dorycnium rectum (L.) Ser. Echinochloa crus-galli (L.) Beauv.	•	•									•		
Eclipta prostrata (L.) L.					•	•				+			
Eleusine indica (L.) Gaertner ssp. indica							•						
Epilobium hirsutum L.					+	+	+	r	+	+	r		
Epilobium montanum L.													
Epilobium tetragonum L. ssp. tetragonum													
Equisetum arvense L. ssp. arvense			2										
Equisetum ramosissimum Desf.													
Equisetum telmateja Ehrh. Erigeron annuus (L.) Desf.										r			
Erigeron sumatrensis Retz.					•	•				I			
Eupatorium cannabinum L. ssp. cannabinum		r	r	r				+		+	+		r
Galinsoga parviflora Cav.													
Galium palustre L. ssp. elongatum (C. Presl.) Lange								1					r
Glyceria fluitans (L.) R. Br.													
Glyceria notata Chevall.			r		+								
Holcus lanatus L.													
Holoschenus romanus (L.) Fritsch. Hypericum androseum L.	•	•	г					•			•		
Hypericum androseum L. Hypericum perforatum L.		•	r	•	•	•	•		•	•	+	•	
11) perseam perioratum E.	•	•	•		•	•	•	•		•		•	•

Hypericum tetrapterum Fr.													
Iris pseudacorus L.													
Juncus acutus L.													
Juneus articulatus L.		1	1	r	2					3	r		+
Juncus bufonius L.													
Juncus conglomeratus L.				r	r			r		1			
Juncus effusus L. ssp. effusus										+			
Juncus inflexus L.			r		r								
Lactuca saligna L.	•	•	•	•	•	•	•	•		•	•	•	•
Leersia oryzoides (L.) Sw.	•			•		•		•		2	•	+	
Lycopus europaeus L.		:	•					•		+	•	+	•
		+		+	+	r			+	+		+	
Lysimachia nummularium L.						•	•				•		•
Lysimachia vulgaris L.						•	•				•		•
Lythrum hyssopifolia L.								•	r	:	:		:
Lythrum salicaria L.		:		+		r			1			+	1
Mentha aquatica L. ssp. aquatica		1	r	+	+	1				+	2	+	
Mentha longifolia (L.) Hudson													
Mentha pulegium L. ssp. pulegium													
Mentha spicata L.											r		
Mentha suaveolens Ehrh. ssp. suaveolens													
Mentha x piperita L.													
Myosotis scorpioides L. ssp. scorpioides													
Nasturtium officinale R.Br. ssp. officinale					1	2							
Paspalum distichum L.	•	•	•	•	•	-	•	•		•	2	+	•
Persicaria lapathifolia (L.) Delarbre	•	+	•	•	•	•	•	•	+	•	-	•	•
Persicaria maculosa (L.) Gray	•	т		+		2		r	т		•		
			+	+		2		I		r			
Petasites hybridus (L.) P. Gaertn., B. Mey. & Scherb.	•		r		+	•		•			•	•	;
Phalaris arundinacea L. ssp. arundinacea						•	•		:		•		1
Phragmites australis (Cav.) Trin. ssp. australis									1		•		
Phytolacca americana L.						•					•		
Piptatheum miliaceum (L.) Coss. ssp. miliaceum													
Plantago major L.													
Polypogon monspeliensis (L.) Desf.													
Polypogon nodosum													
Polypogon viridis (Gouan) Breistr.					r								
Pulicaria dysenterica (L.) Bernh.													
Ranunculus repens L.						r	1						r
Ranunculus sceleratus L.													
Raphanus raphanistrum L. ssp. raphanistrum													
Rorippa amphibia (L.) Besser	•	-	-	r	•	•		-				-	+
Rorippa silvestris (L.) Besser	•	-	-	-	r	•		-	+		2	+	
Rumex conglomeratus Murray	•					•	•	•	•	•	-		•
Sambucus ebulus L.	•			•		•		•			•		
Samolus valerandi L.	•	•		•		•		•			•	•	
Scirpoides holoschoenus (L.) Sojak						•	•		•		•		•
		•									+		
Scrophularia auriculata L. ssp. auriculata	•			r		r	r	•			+	•	r
Scutellaria galericulata L.						•	•				•		•
Senecio erucifolius L.													
Senecio mikanioides Otto ex Walp.											•		
Silene latifolia Poir. ssp. alba (Mill.) Greuter & Burdet											+		
Solanum dulcamara							r	r	+		r		
Solanum lycopersicum L.													
Solanum nigrum L. ssp. nigrum													
Stachys palustris L.											r		+
Stellaria aquatica (L.) Scop.													
Symphyotrichum squamatum (Spreng.) G.L. Nesom													
Teucrium scordum L.													
Tussilago farfara L.													
Typha angustifolia L.					r					i			
Typha latifolia L.	•	r r	1	•	r	•	•	•		•	•	•	•
Urtica dioica L. ssp. dioica				•	4	•		•			+	•	
Veronica anagallis-aquatica L. ssp. anagallis-aquatica						2							•
					r						+		
Veronica beccabunga L.		+	r		+	r					•		
Xanthium orientale L. ssp. italicum (Moretti) Greuter	•	•	•		•		•		•		•		<u> </u>

	Tl ₁₄	Tl ₁₅	Tl ₁₆	Tl ₁₇	Tl ₁₈	Tl ₁₉	Tl ₂₀	Tl ₂₁	Tl ₂₂	Tl ₂₃	Tl ₂₄	Tl ₂₅	Tl ₂₆	Tl ₂₇	Tl ₂₈	Tl ₂₉	Tl ₃₀	Tl ₃₁	Tl ₃₂	Tl ₃₃	Tl ₃₄	Tl ₃₅	Tl ₃₆	Tl ₃₇	Tl ₃₈	Tl ₃₉	Tl ₄₀
Phanerogams aquatic species		- 15	10	- 1/	10	17	20			20	24	20	20		20		50	- 51	32	33		33					
Alisma plantago-aquatica L.	+		r		+									+									r				
Apium nodiflorum L. f. aquatica																											
Azolla filiculoides Lam.									+	4		2	3		1	1				+		4	1			2	1
Berula erecta (Hudson) Coville f. fluitans																											
Callitriche stagnalis Scop.			+						+	1											2	+	+				
Ceratophyllum demersum L.									1	1							4	3			1	+	2		2		1
Eleocharis palustris (L.) Roemer & Schultes									-	Ţ.										Ċ	-		-				
Elodea canadensis Michx.																											
Groelandia densa (L.) Fourr			•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Hippuris vulgaris L.	-	-	-	-	•	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus gr. articulatus f. aquatica		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Lemna gibba L.		•	•	•	•	•	•	•	•	2	•	•	•	•	•	·	•	•	•	÷	•	•	•	•	•	•	•
Lemna minor L.		•	•	•	•	i	•	•	1	_	•	•	1	•	i	i	•	•	•	1	•	•	•	•	•	·	1
Lemna trisulca L.		•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•		•
Mentha aquatica L. f. fluitans		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Myriophyllum spicatum L.		•	1	•	·	3	1	•	2	2	2	1	1	1	•	2	1	i	•	1	1	1	2	•	2	·	2
Myriophyllum verticillatum L.			1	3	2	1	1		2	2	2	1	1	1		1	1	+	•	1	1	1	2	•	2	-	1
Najas marina L. ssp. marina			•	5	2	1	•				•	•				1		2	1		•	1	•	•	•	2	1
Najas marina L. ssp. marina Nasturtium officinale R.Br. f. fluitans		2				•			•	•							+	4	1	•		1	•		•	2	•
		2				•			•	•										•		•	•	т	•		•
Persicaria amphibia (L.) Delarbre	:		•						•				•											•	•		:
Potamogeton crispus L.	+		•						•				•					1					1	•	•		+
Potamogeton natans L.				3	i							3	4	4	2	4			5	3	2	4			2	2	
Potamogeton nodosus Poir. Potamogeton pectinatus L.	2	1	2	3	1	3	1	4	3	5	4	3	4	4	2	4		+	5 1	3	2	2	4	3	2	2	4
	2	+				3			+	2				1	2			+	1		2	2	1				+
Potamogeton perfoliatus L.		•	•	•					•	2		•	•	•		•	•	1	•		•	•	•				•
Potamogeton sp.1		•	•	•					•	•		•	•	;		•	•	;	;		•	•	•				•
Potamogeton trichoides Cham. & Schltdl.														1				1	1								
Ranunculus trichophyllus Chaix ssp. trichophyllus				-								-							-					:			
Schoenoplectus lacustris (L.) Palla		+		+	+			:		+	+	-	+						-		+	r	+	I			
Sparganium erectum L. subp. Erectum			+	1	4		+	1		1	1	+	+	1	+						1					:	:
Spirodela polyrhiza (L.) Schleid.		:				+				1			:		+					+						1	2
Veronica anagallis L. ssp. anagallis-aquatica f. fluitans		2								+			1														
Veronica beccabunga L. f. fluitans																											
Zannichellia palustris L.							+		+													+					
Algae																											
Achnanthes lanceolata (Breb.) Grunow																											
Achnanthes minutissima Kuetz.																											
Amphora ovalis(Kützing) Kützing																											
Amphora pediculus (Kuetz.) Grunow																											
Anabaena sp. 1					1	r											+						+				
Ankistrodesmus falcatus (Corda) Ralfs																										r	
Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et Flahault																											
Audouinella hermannii (Roth) Dudy in de Candolle																											
Bangia atropurpurea (Roth) C. Agardh																											
Basicladia sp.																											
Caloneis sp.																											
Chaetophora elegans (Roth) C. Agardh										+																	
Chamaesiphon conferviculus A. Braun																											
Chamaesiphon incrustans Grunow in Rabenhorst																								1			
Chara sp.																											1
Characium sp.																											
Chroococcus turgidus (Kutzing) Nageli																											
Cladophora glomerata L.	2	+	r		1	3	1	1	1	+		1			1	+	4	3			2	2	1	+	2	1	2
Closteriopsis acicularis (G. M. Smith) J. H. Belcher et Swale																											
Closterium closterioides (Ralfs) A. Louis et Peeters																											
Closterium ehrebergii Meneghini ex Ralfs																+											
Closterium kuetzingii Brebison			•	•	•		•	•	•	•	r	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•
Closterium praelongum varietà brevius (Nordstedt) Willi Krieger			•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Cocconeis pediculus Ehrenberg				•	•	r	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	r	•	r r	r r
Cocconeis placentula Ehrenberg	•		•			1	•			•	•		•		•	•	•				•				•		
Coelastrum microporum Nageli in A. Braun	•		•		•	•	•	•	•	•	•		•		•		•	•			•	•	•	•	•	•	•
Coenochloris fottii (Hindak) Tsarenko				•		•					•	•		1	•	•			•	•			•				
																	1										
Cosmarium botrytis Meneghinini ex Ralfs																											
Cosmarium botrytis Meneghinini ex Ralfs Cosmarium bioculatum Brébisson ex Ralfs				:						•	r	:		:					:						•		
Cosmarium botrytis Meneghinini ex Ralfs Cosmarium bioculatum Brébisson ex Ralfs Cosmarium granatum Brébisson in Ralfs			•								r						:		:					•			
Cosmarium botrytis Meneghinini ex Ralfs Cosmarium bioculatum Brébisson ex Ralfs		•			· · ·		· · ·		· · ·		r		· ·											· ·	· ·	· · ·	•

Cosmarium laeve Rabenhorst																r	r										
Cosmarium meneghinii Brébisson in Ralfs							•										r						r				
Cosmarium punctulatum Brébisson																r											
Cyclotella meneghiniana Kützing		r								r																	
Cymatopleura solea (Brebisson) W. Smith																											
Cymatopleura sp																											
Cymbella minuta Hilse																											
Cymbella affinis Kützing																											
Cymbella helvetica Kützing	r										r																
Cymbella sp.1								•																			
Cymbella sp.2 Cymbella sp.3			•																								•
Cymbella sp.4	•			•	•	•	•	•	•	•	•	•	•	•	•	•			•		•	•	•	•			
Diatoma mesodon (Ehrenberg) Kützing	•	•		•	•	•	•	•	•	•	•	•	•	•	•				•	•	•	•	•	•		•	
Diatoma sp.	•			•	•		•	•		•			•	•	•	•				•					•		
Diatoma vulgaris Bory																											
Diploneis sp.																											
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh																											
Epithemia sp.																											
Eunotia sp.																											
Fragilaria sp.																+										r	r
Gomphonema acuminatus																											
Gomphonema olivaceum (Hornemann) Brebisson	r																									r	
Gomphonema parvulum Kützing			•																								•
Gomphonema sp.1 Gomphonema sp.2																											
Gomphonema sp.3			•			•		•		•	•						•									•	•
Gyrosigma attenuatum (Kützing) Rabenhorst	r r	•	•	•	r r	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•			•	•	•	•
Hantzschia amphioxys (Ehr.) Grun.		•		•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•	•		•	•		
Hapalosiphon fontinalis (C.Agardh) Bornet									Ċ			Ċ						:			Ċ		:	·			
Klebsormidium flaccidum (Kutzing) P.C. Silva, Mattox et W.H. Blackwell														r													
Kyliniella sp.																											
Lemanea fluviatilis (L.)C. Agardh																											
Lyngbya lutea (C.Agardh, Gomont) Gomont					Γ																						
Lyngbya aestuarii (Liebman) Gomont																											
Lyngbya kuetzingii Schmidle						r								1												r	
Lyngbya lutescens (Meneghini) Hansgirg																											
Lyngbya martensiana (Meneghini) Gomont Lyngbya sp.																										r	
Lyngoya sp. Melosira varians Agardh			•					•		•	•					i										1	
Merismopedia elegans A.Braun in Kutzing		•	•	•	1	1	•	•	•	•	•	•	•	1	•	1	1		•	•	•			•	•	1	1
Microcystis flos-aque (Wittrock) Kirchner	•			•	•		•	•		•			•	•	•	•				•					•		
Microspora amoena (Kutzing) Rabenhorst																r										+	Ċ
Monoraphidium arcuatum (Korshikov) Hindak																											
Monoraphidium contortum (Thuret) komarkova-Legnerova																											
Mougeotia sp.										2																	
Navicula cryptocephala Kützing																											
Navicula cryptotenella Lange-Bertalot	r				r																						
Navicula gregaria Donkin								•																			
Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1																											
Navicula sp.1	•					•	•	•	•	•	•	•	•	•	•	•	•			•	•	•					
Navicula sp.3	•			•	•		•	•		•			•	•	•	•				•					•		
Navicula sp.4																											Ċ
Navicula sp.5																											
Nitzschia acicularis (Kützing) W. Smith																											
Nitzschia dissipata (Kützing) Grunow																											
Nitzschia palea (Kützing) W. Smith																											
Nitzschia sp.1																											
Nitzschia sp.2																											
Nostoc punctiforme (Kutzing) Hariot																	r									:	
Oedogonium sp.1						r										1	+	1					r			+	+
Oedogonium sp.2 Oocystis borgei Snow	•	•	•				•		٠				•	•	•	•				•					•	•	•
Oscillatoria amoena (Kutzing) Gomont		1			· r					· r	•						1				•		r				
Oscillatoria amphibia (C.Agardh) Gomont	•	1	•	•			•	•		1	•	•	•	•	•	•	•			•	•	•		•	•	•	•
Oscillatoria brevis Gomont				:	r		:	:				:	:		:	:			:		:	:					
Oscillatoria formosa Bory																											
Oscillatoria limnetica Lemmermann	1				r					r	1																

Oscillatoria limosa (C. Agardh) Gomont	r	r			r	r																		r			
Oscillatoria sp.1																											
Oscillatoria sp.2																											
Oscillatoria sp.3 Oscillatoria subbrevis Lemmermann		•		•							:						•					•	:			:	
Oscillatoria tenuis (C.Agardh) Gomont							•		•	1	+	•	•	I					•				+			+	+
Palmodyction viride Kützing	•			•	1		•		•	•			•	•		•		•					•	•	•		•
Pandorina morum (O. Müller) Bory de Saint-Vincent	•			•	•		•		•	•		•	•	•	•	•	•		•	•	•		•		•		•
Pediastrum boryanum (Turpin) Meneghini	•		•		•	•	•	•	•				•			•							•		•	•	
Pediastrum boryanum var. cornutum (Raciborski) Sulek															Ċ						Ċ						· ·
Pediastrum duplex Meyen														r													
Pediastrum integrum Nageli																											
Pediastrum simplex Meyen																							r				
Pediastrum tetras (Ehrenberrg) Ralfs																r	r										
Phacus sp.																											
Phormidium retzii (C. Agardh) Gomont																											
Phormidium sp.																											
Phormidium valderianum (Delponte) Gomont	1	2			r					+							r									r	
Pinnularia sp.1	r																										
Pinnularia sp.2																											
Rhodostichus expansus															-												
Rhoicosphenia sp.																											
Scenedesmus arcuatus (Lemmermann) Lemmermann														r		r	r						r				
Scenedesmus communis e.h.Hegewald													•														
Scenedesmus ellipticus Corda													•														
Scenedesmus falcatus Chodat						r							•														
Scenedesmus granulatus W. West & G.S. West																											
Scenedesmus obtusus Meyen		•		•													•					•					
Scenedesmus serratus (Corda) Bohlin Selenastrum sp.		•		•													•					•					
Spirogyra communis (Hassall) Kutzing					•		•		•			•	•														•
Spirogyra communis (Hassaii) Kutzing Spirogyra fluviatilis Hilse in Rabenhorst		•		•							r r						•					•	r				
Spirogyra sp.	1				1		•		•		1	•	•				1				:		1				1
Spirogyra sp.1		•	•	•		•	•	•	•	•	1	•	•	•	•	•	1	+	•	•	+	•	1	•	•		+
Spirogyra sp.2				•			•					•	•		•				•		•		I				
Staurastrum dilatatum Ehr.	•			•	•		•		•		1		•	•		•		•					•	•	•		•
Stigeoclonium sp.		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Surirella brebissonii Krammer & Lange-Bertalot		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Surirella sp.															Ċ						Ċ						· ·
Synedra ulna (Nitzsch) Ehrenberg																											
Tabellaria flocculosa (Roth) Kützing																										r	r
Trachelomonas hispida (Perty) F. Stein ex Deflandre																											
Trachelomonas sp.																											
Ulothrix tenuissima Kützing										+																	
Ulothrix zonata (Weber & Mohr) Kützing																											
Uronema elongatum Hodgetts						r				+																r	
Vaucheria germinata (Vaucher) De Candolle	3	3	1		1					r													1			r	
Zygnema sp.																											
Bryophytes mosses																											
Hygroamblystegium fluviatile (Hedw.) Loeske																											
Cinclidotus aquaticus (Hedw.) Bruch & Schimp.																											
Cinclidotus fontinaloides (Hedw.) P. Beauv.																											
Cratoneuron filicinum (Hedw.) Spruce Dialytrichia mucronata (Brid.) Broth. A.L.M. guim.		•		•													•					•					
Fissidens viridulus (Sw.) Wahlemb																											
Fontinalis antipyretica Hedw.					•		•		•			•	•											2			•
Fontinalis sp.(Palustriella commutata)					•		•		•			•	•											2			•
Hygroamblystegium tenax (Hedw.) Jenn.		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•
Leptodictyum riparium (Hedw.) Warnst.		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•
Orthotrichum stramineum Horsch. Ex Brid.	•			•	•		•		•				•	•		•		•					•	•	•		•
Palustriella commutata (Hedw.) Ochyra				•	•		•	•		•	•	•		•		•				•		•			•		
Plagiomnium affine (Blandow ex Funck) T.J. Kop			•		•	•	•	•	•	•	•	•	•	•	•		•		•	•	•	•				•	•
Plagiomnium undulatum (Hedw.) Schimp.				•	•		•	•		•	•	•		•		•				•		•			•		
Platyhypnidium riparioides (Hedw.) Dixon.			•		•	•	•	•	•	•	•	•	•	•	•		•		•	•	•	•				•	•
Rhynchostegium sp.				•	•		•	•		•	•	•		•		•				•		•			•		
Bryophytes liverworts			•		•	•	•	•	•	•	•	•	•	•	•		•		•	•	•	•				•	•
Aneura pinguis (L.) Dumort.																											
Conocephalum conicum (L.) Dumort.					•		•																				
Conocephalum sp.		:	:	:		:				:	:							:				:	:				
I II .	-													-													

Lunularia cruciata (L.) Lindb.																											
Marcantia polymorpha L.				•	٠			•			•			•	•		•					•			•	•	•
Pellia endiviifolia (Dicks.) Dumort.		•	•	•	•			•		•											•	•		•			
Riccia fluitans L.			:				:						:	Ċ					:		:		:				Ċ
Phanerogams riverbank species																											
Aegopodium podagraria L.																											
Agrostis stolonifera L.			+	1				1	+	2					1										+		
Alternanthera philoxeroides (Mart.) Griseb.																											
Anagallis arvensis L. ssp. arvensis																											
Angelica sylvestris L.				r		+		1	+	+	+	+		+	+					+						r	+
Apium nodiflorum (L.) Lag. ssp. nodiflorum	+	+																						1			+
Arctium lappa L.	+																										
Artemisia annua L.	+																					r					
Artemisia verlotiorum Lamotte																											
Artemisia vulgaris L.				+								:	:			:											
Arundo donax L.												1	1	+		2									+	+	
Arundo plinii Turra							•		•				+									•					
Atriplex patula L. Berula erecta (Huds.) Coville			2	2	2		:	:	•				i	2	i	:				:		•		:	+	r	:
Bidens frondosa L.	2				-		T.	1	•	1	1		1	-	1	Ŧ.			•	-			:	Ŧ.	+	+	1
Bidens tripartita L.	2	-	-	-	-		-	•	•	-	1	-	т	-	-	-				-	1	-	-	-	-	-	1
Butomus umbellatus L.					+			•						•								•					
Cardamine sp.			:					:		:			:	:	:	:	:		:		:	:				:	:
Carex hirta L.															+												
Carex otrubae Podp.								+	1	+	+		1	+	+						r				1		+
Carex paniculata L. ssp. paniculata									1		r			1		1			+	2						+	+
Carex pendula Huds.				+		1		+	2	+		+	+	+	1	+								+			2
Carex pseudocyperus L.									2	1	2	+	1	1	1	1			+	1	+	+			1	+	1
Chenopium album L.																											
Chenopodium ambrosioides L.	1																				+						+
Chenopodium polyspermum L.																											
Cirsium arvense (L.) Scop.																											+
Cirsium creticum (Lam.) d'Urv.								;							:	;											
Cirsium palustre (L.) Scop.								1			r		+		1	1	•	•						•			•
Conium maculatum L. ssp. maculatum Conyza canadensis (L.) Cronq.	•																										
Cyperus eragrostis Lam.					•								•	•	•		•	•	•			I				•	•
Cyperus Cragrosus Lain. Cyperus fuscus L.	2		•		1	•	•	•	•	•			•	•	•	•	•	•	•	•	2	2	3	•	•	•	•
Cyperus longus L.	-		•	•	•	•	•	•	•	•	•	•		+	•	•		•		•	-	-	5	•	•	•	•
Cyperus rotundus L.															Ċ												•
Datura stramonium L. ssp. stramonium																											
Dipsacus fullonum L.																									1		
Dorycnium rectum (L.) Ser.													+	+						+							
Echinochloa crus-galli (L.) Beauv.	1	1											+	1							1				+		
Eclipta prostrata (L.) L.																					+						
Eleusine indica (L.) Gaertner ssp. indica																											
Epilobium hirsutum L.				+	+				+	+	1		+	+													
Epilobium montanum L.																									•		
Epilobium tetragonum L. ssp. tetragonum	•																				:				+		
Equisetum arvense L. ssp. arvense Equisetum ramosissimum Desf.					•								:	•	•		•	•	•		+					•	•
Equisetum telmateja Ehrh.						•		i					+	1	•		•	•	•			•				•	•
Erigeron annuus (L.) Desf.	•	•	•	•		•	•			•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	
Erigeron sumatrensis Retz.		•				•																					
Eupatorium cannabinum L. ssp. cannabinum		+		+						+			r	+	1	2								+		Г	
Galinsoga parviflora Cav.	+																					r					
Galium palustre L. ssp. elongatum (C. Presl.) Lange	1			+	+	+	1	1	2	2	2	1	1	+	1	+			+	+	+	+			+	+	1
Glyceria fluitans (L.) R. Br.																											
Glyceria notata Chevall.				+										2													
Holcus lanatus L.														+													
Holoschenus romanus (L.) Fritsch.																											
Hypericum androseum L.																											
Hypericum perforatum L.													:	:													
Hypericum tetrapterum Fr.			:	2									+	+								:	:		:	:	
Iris pseudacorus L. Juncus acutus L.	+		+	2	1	1	•	5	•	1	1	2	+	3		1	•		1	3	2	1	+		+	+	1
Juneus actuus L. Juneus articulatus L.	2	+	1		•		•		•		•	•		•			•	•		+	1	i	1		+		
Juneus bufonius L.	1	_	1	т	•				•				т	·				•	т		1	+	2		т		•
Juncus conglomeratus L.	1	•			•			+	1					т				•			+	_	4	+			
Juneus congromeratus L.	•		•	•	•		•	-	1		•	•		•	•					•	-			-	-	•	•

Juncus effusus L. ssp. effusus								+	+				+									1				
Juncus inflexus L.	r				+			+	+												+			+		
Lactuca saligna L.																										
Leersia oryzoides (L.) Sw.		+												+	1			+		+	1	1		+		
Lycopus europaeus L.	1		+	1	1		1	+	2	2	1	1	1	1	+	1		+	1	2	1	+	+	2	+	1
Lysimachia nummularium L.																										
Lysimachia vulgaris L.	+	1					1	2			r		+	+				+	1							
Lythrum hyssopifolia L.			r																							
Lythrum salicaria L.	1	2	+	2	+			+	1	1	1	1	1	1	+	2		1		2	2	+	+	2		+
Mentha aquatica L. ssp. aquatica	1	+	3	2	2	+	1	1	1	2	2	2	2	3	1	r		1	+	3	1	r		1	+	1
Mentha longifolia (L.) Hudson																										
Mentha pulegium L. ssp. pulegium																				1						
Mentha spicata L.																										
Mentha suaveolens Ehrh. ssp. suaveolens																										
Mentha x piperita L.																										
Myosotis scorpioides L. ssp. scorpioides				1					+	+	1		1	1					+	+	+					
Nasturtium officinale R.Br. ssp. officinale	+		1																			+				
Paspalum distichum L.		2	2		1			+		1				1						2	+	2				
Persicaria lapathifolia (L.) Delarbre			+					r												+	+			+		
Persicaria maculosa (L.) Gray	2	1	2	1						1				1						1		1		+		
Petasites hybridus (L.) P. Gaertn., B. Mey. & Scherb.					+																		+			
Phalaris arundinacea L. ssp. arundinacea		4	+	3	1	2			+	+	1	1		2	+	2		1				+				1
Phragmites australis (Cav.) Trin. ssp. australis		+		+		4		2	2	+	2	+		2	5	3		5	1	1	+			+		1
Phytolacca americana L.																										
Piptatheum miliaceum (L.) Coss. ssp. miliaceum																										+
Plantago major L.	1																			+		r				
Polypogon monspeliensis (L.) Desf.																										+
Polypogon nodosum																										
Polypogon viridis (Gouan) Breistr.	+		1							+			+												r	+
Pulicaria dysenterica (L.) Bernh.	+		r										1	+	+							+		r		
Ranunculus repens L.			+				1	2		+	+	1	1	+							+					+
Ranunculus sceleratus L.	+		r		+					r										+		+		+	+	+
Raphanus raphanistrum L. ssp. raphanistrum																										
Rorippa amphibia (L.) Besser	2	1	r		+														+	+		+				
Rorippa silvestris(L.) Besser																										
Rumex conglomeratus Murray																								1		
Sambucus ebulus L.		1										+										1				
Samolus valerandi L.																										
Scirpoides holoschoenus (L.) Sojak									1				1						+							
Scrophularia auriculata L. ssp. auriculata			+	+	+			+	1	1	1	+	1	+	+	2		2	2	r			1	+	+	2
Scutellaria galericulata L.					+					+	+								+							
Senecio erucifolius L.																										
Senecio mikanioides Otto ex Walp.																						+				
Silene latifolia Poir. ssp. alba (Mill.) Greuter & Burdet	:			:																						
Solanum dulcamara L.	1			1				+			+			+		+							+		r	
Solanum lycopersicum L.																										
Solanum nigrum L. ssp. nigrum				:	:						:	:		:					:		:					
Stachys palustris L.			+	1	1			r	+		1	1	+	2	+				1		1					
Stellaria aquatica (L.) Scop.	+								+																	
Symphyotrichum squamatum (Spreng.) G.L. Nesom																				r	r					
Teucrium scordum L.																										
Tussilago farfara L.			r																			r				
Typha angustifolia L.			:	:	:															:				:		:
Typha latifolia L.	+		1	1	2					+										2		+		2		1
Urtica dioica L. ssp. dioica	:		2		:			2					:	:				:			:	:	:			+
Veronica anagallis-aquatica L. ssp. anagallis-aquatica	1		1	+	2				+	+	+		1	1	+	•		1	r	+	2	1	1		r	
Veronica beccabunga L.		:	;	1	1		+	•							•	+				1	1	•	+		+	+
Xanthium orientale L. ssp. italicum (Moretti) Greuter	1	+	1	•													 •			+	•		•		<u> </u>	

	Tl_{41}	Tl_{42}	Tl_{43}	Tl_{44}	Tl_{45}	Tl_{46}	Tl_{47}	Tl_{48}	Tl_{49}	Tl_{50}	Tl_{51}	Tl_{52}	Tl_{53}	Tl_{54}	Tl_{55}	Tl_{56}	Tl ₅₇	Tmou ₅₈	Tmou59	Tmou ₆₀	Tmou ₆₁
Phanerogams aquatic species																					
Alisma plantago-aquatica L.			r			1	+			+			+			r					
Apium nodiflorum L. f. aquatica																					
Azolla filiculoides Lam.													1								
Berula erecta (Hudson) Coville f. fluitans																					

Callitriche stagnalis Scop.																+				
Ceratophyllum demersum L.		+	+		1	+	1			. 1	1 .	2								+
Eleocharis palustris (L.) Roemer & Schultes																				
Elodea canadensis Michx.																				
Groelandia densa (L.) Fourr																				
Hippuris vulgaris L.																				
Juncus gr. articulatus f. aquatica																				
Lemna gibba L.	r		2	2	1		1													
Lemna minor L.	+		1				1			. +	٠.	1						r		
Lemna trisulca L.																				
Mentha aquatica L. f. fluitans																				
Myriophyllum spicatum L.	4	4	1	3	4	4	3	1	4	5 3	3 2	3		1	3	4	2	r		1
Myriophyllum verticillatum L.																				
Najas marina L. ssp. marina						+														
Nasturtium officinale R.Br. f. fluitans																				
Persicaria amphibia (L.) Delarbre						1	+			1 .							+			
Potamogeton crispus L.								1												
Potamogeton natans L.																				
Potamogeton nodosus Poir.	1	+	+	2	+	1	2	2	2	+ 2	2 2	+	1	1	1	1				1
Potamogeton pectinatus L.	2	5	4	1	5	5	1	3	3	5 1	1 3	2	3	3	2	2	1	1	1	1
Potamogeton perfoliatus L.																				
Potamogeton sp.1																				
Potamogeton trichoides Cham. & Schltdl.						+					. +									
Ranunculus trichophyllus Chaix ssp. trichophyllus																				
Schoenoplectus lacustris (L.) Palla	2	2	+	+	1	1	2	2	2	2 3	3 2	+		+	r	1	1			
Sparganium erectum L. subp. Erectum	+			+	+		+	1	+	. 1	1 +	1								
Spirodela polyrhiza (L.) Schleid.												+								
Veronica anagallis L. ssp. anagallis-aquatica f. fluitans												+								
Veronica beccabunga L. f. fluitans															1					
Zannichellia palustris L.																				
Algae																				
Achnanthes lanceolata (Breb.) Grunow																				
Achnanthes minutissima Kuetz.	•	•	•	•		•	•	•					•	•	•				•	
Amphora ovalis(Kützing) Kützing		•	•					•				•		•	•			•	•	
	•	r	•	•	•	•			•			•		•	•	•		•	•	
Amphora pediculus (Kuetz.) Grunow		r			. +															
Amphora pediculus (Kuetz.) Grunow Anabaena sp. 1		r			+				r		· ·									
Amphora pediculus (Kuetz.) Grunow Anabaena sp. 1 Ankistrodesmus falcatus (Corda) Ralfs	•	r			+				r			•	•							
Amphora pediculus (Kuetz.) Grunow Anabaena sp. 1 Ankistrodesmus falcatus (Corda) Ralfs Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et		r			+				r											
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Cymatopleura solea (Brebisson) W. Smith																				
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Cymatopleura sp																				
Cymbella minuta Hilse																				
Cymbella affinis Kützing																				
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Cymbella helvetica Kützing																				
Cymbella sp.1																				
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Cymbella sp.2																				
Cymbella sp.3																				
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Cymbella sp.4																		•		
Diatoma mesodon (Ehrenberg) Kützing																				
Diatoma sp.																		•		
Diatoma vulgaris Bory																				
Diploneis sp.																				
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh																				3
Epithemia sp.																				
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Eunotia sp.																				
Fragilaria sp.									-											
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Gomphonema acuminatus																				
Gomphonema olivaceum (Hornemann) Brebisson		r																		
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Gomphonema parvulum Kützing																		•		
Gomphonema sp.1																				
Gomphonema sp.2																				
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Gomphonema sp.3																				
Gyrosigma attenuatum (Kützing) Rabenhorst																				
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Hantzschia amphioxys (Ehr.) Grun.																				
Hapalosiphon fontinalis (C.Agardh) Bornet																	+			
Klebsormidium flaccidum (Kutzing) P.C. Silva, Mattox et																				
W.H. Blackwell			•	•									•			•	•	•	•	•
Kyliniella sp.																				
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Lemanea fluviatilis (L.)C. Agardh																				
Lyngbya lutea (C.Agardh, Gomont) Gomont																				
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Lyngbya aestuarii (Liebman) Gomont																				
Lyngbya kuetzingii Schmidle															1		+			+
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Lyngbya lutescens (Meneghini) Hansgirg																				
Lyngbya martensiana (Meneghini) Gomont																				
Lyngbya martensiana (Meneghini) Gomont	•	•		•				•						•			•	•	•	•
Lyngbya sp.																				
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Riccia fluitans L.										<u>. </u>					<u>. </u>						
Phanerogams riverbank species																					
Aegopodium podagraria L.																					
Agrostis stolonifera L.																					
Alternanthera philoxeroides (Mart.) Griseb.														+							
Anagallis arvensis L. ssp. arvensis																					r
Angelica sylvestris L.																					
Apium nodiflorum (L.) Lag. ssp. nodiflorum																1	+				
Arctium lappa L.																					
Artemisia annua L.						+										3	+	+	+		
Artemisia verlotiorum Lamotte																		+	+		
Artemisia vulgaris L.	:																	+			r
Arundo donax L.	1				+											:					
Arundo plinii Turra																1			+		
Atriplex patula L.	;	:	:	:		;															
Berula erecta (Huds.) Coville	1	1	+	+ 1	- ;	1 2			:	2			:		:	:	1				
Bidens frondosa L.	+	+	1	1	1	2	r	+	+	2	•		+	•	+	+	1	:	:		
Bidens tripartita L. Butomus umbellatus L.		+	+		1	•	•											1	+		•
Cardamine sp.				•	•				•			•							•	•	
Carex hirta L.				•	•				•			•							•	•	
	•	•				•	•	•	•	•	•			•	•			•	•		•
Carex otrubae Podp. Carex paniculata L. ssp. paniculata		•	•		•	•	•	•		•	•	•			•			•	•		•
Carex pendula Huds.	•		•	•		•			•												
Carex pseudocyperus L.	•	•				•	•	•	•	•	•			•	•			•	•		
Chenopium album L.	•		•	•		•			•								1				
Chenopodium ambrosioides L.	•			•	•	•	•	•	•	•		•	•			•	т	+	•	•	•
Chenopodium polyspermum L.	•	т			•	•	•				т				т	•		т		•	
Cirsium arvense (L.) Scop.	•	•		•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•
Cirsium creticum (Lam.) d'Urv.	•	•		•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•
Cirsium palustre (L.) Scop.	•	•		•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•
Conium maculatum L. ssp. maculatum	•	•	•	•		•	•	•	•	•	•	•		•				·			•
Conyza canadensis (L.) Cronq.	•	•	•	•		•	•	•	•	•	•	•		•							r r
Cyperus eragrostis Lam.		r																			
Cyperus fuscus L.																3					
Cyperus longus L.	•	r			•	•	•	•	•	1	•		•	•				•	•	•	•
Cyperus rotundus L.		+	+		Ċ		Ċ						Ċ				Ċ		· ·		
Datura stramonium L. ssp. stramonium																	+				
Dipsacus fullonum L.																					
Dorycnium rectum (L.) Ser.																					
Echinochloa crus-galli (L.) Beauv.			r		2	4	1	1	1	3	r					1					
Eclipta prostrata (L.) L.																					
Eleusine indica (L.) Gaertner ssp. indica																					
Epilobium hirsutum L.											r										
Epilobium montanum L.																					
Epilobium tetragonum L. ssp. tetragonum																					
Equisetum arvense L. ssp. arvense													+								
Equisetum ramosissimum Desf.																					+
Equisetum telmateja Ehrh.																					
Erigeron annuus (L.) Desf.																					
Erigeron sumatrensis Retz.																					r
Eupatorium cannabinum L. ssp. cannabinum																					
Galinsoga parviflora Cav.																					
Galium palustre L. ssp. elongatum (C. Presl.) Lange																					
Glyceria fluitans (L.) R. Br.																					
Glyceria notata Chevall.	•		•			•									•						
Holcus lanatus L. Holoschenus romanus (L.) Fritsch.						•		•		•		•			•			•	•		
						•		•		•		•			•			•	•		
Hypericum androseum L. Hypericum perforatum L.						•		•		•		•			•			•	•		
		•			•	•	•	•	•	•				•			•	•	•	•	•
Hypericum tetrapterum Fr. Iris pseudacorus L.					•	•	•	•	•	•				•			•	•	•	•	1
	1	+				•		•		•		•			•			•	•		1
Juncus acutus L. Juncus articulatus L.						•									•						
Juncus articulatus L. Juncus bufonius L.						•		•		•		•			•	:		•	•		
Juncus butonius L. Juncus conglomeratus L.															•	+					
Juncus congiomeratus L. Juncus effusus L. ssp. effusus		•			•	•	•	•	•	•				•			•	•	•	•	•
						•		•		•		•			•			•	:		•
Juncus inflexus L. Lactuca saligna L.															•				+		
Lactuca odligila L.		•				•	•	•					•								r

Leersia oryzoides (L.) Sw.																					
Lycopus europaeus L.	+	+	r	+	1	+	+	+	+	+	+		+		+	1		1	r	r	1
Lysimachia nummularium L.																					
Lysimachia vulgaris L.					3												+				
Lythrum hyssopifolia L.															1	r					
Lythrum salicaria L.	2	2	3	+	2	3	+	1	2	2	+		+	2	1	2	2	2	r		1
Mentha aquatica L. ssp. aquatica		+								1											
Mentha longifolia (L.) Hudson																					
Mentha pulegium L. ssp. pulegium																					
Mentha spicata L.																					
Mentha suaveolens Ehrh. ssp. suaveolens																					
Mentha x piperita L.																					
Myosotis scorpioides L. ssp. scorpioides																					
Nasturtium officinale R.Br. ssp. officinale						+	+								+		+				
Paspalum distichum L.		3	2			2				2						+	+				
Persicaria lapathifolia (L.) Delarbre					1	1		1		+									+		
Persicaria maculosa (L.) Gray			1		+	1				+						r	+	+			
Petasites hybridus (L.) P. Gaertn., B. Mey. & Scherb.																					
Phalaris arundinacea L. ssp. arundinacea	1	1					+		+	i	1			3	1		1	+			
Phragmites australis (Cav.) Trin. ssp. australis	•	•	•	•	i	2		•	•	•	•	•	•		•	•	•		2		5
Phytolacca americana L.	•	•	•	•	•	-		•	•	•		•	•			•	•	•	-		_
Piptatheum miliaceum (L.) Coss. ssp. miliaceum	-	-	-	-	-	-	-	•	•	-	-	-	•	-	•	-	-	-	-	-	-
Plantago major L.	•	•	•	•		•		•	•	•		•	•		1	•	•	•			•
Polypogon monspeliensis (L.) Desf.	•	•	•	•		•	•	•	•	•	•	•	•			•	•	•			•
Polypogon nodosum	•	•	•	•	•	•		•	•	•		•	•			•	•	•			•
Polypogon viridis (Gouan) Breistr.	•		•	•	•	•		•	•	•		•	•		•	•	•	•			•
Pulicaria dysenterica (L.) Bernh.	•	т	•	•			-			•	т	•									
Ranunculus repens L.	•	•	•	•						•		•									
Ranunculus sceleratus L.	•	•	•	•			•	•		•		•		•							
Raphanus raphanistrum L. ssp. raphanistrum	•	•	•	•						•		•							1		r
Rorippa amphibia (L.) Besser	1	1		•	1	1		•		1		•		•		1			•		1
Rorippa silvestris (L.) Besser	1	1	-	•	1	1	-			1	т	•					т				
Rumex conglomeratus Murray	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•			•
Sambucus ebulus L.	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	i		•
Samolus valerandi L.	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•		•
Scirpoides holoschoenus (L.) Sojak	•	•	•	•	•	•		•	•	•		•	•			•	•	•			•
Scrophularia auriculata L. ssp. auriculata	•	•	•	•	•	•		•	•	3		•	· ·			•	•	•			_
Scutellaria galericulata L.	•	•	•	•	•	•		•	•	5	•	•			•	•	•	•			
Senecio erucifolius L.	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•			•
Senecio mikanioides Otto ex Walp.	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•			•
Silene latifolia Poir. ssp. alba (Mill.) Greuter & Burdet	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•			•
Solanum dulcamara L.	•	•	•	•	•	•	•	•	•	•	•	•	•		•	i	•	i			•
Solanum lycopersicum L.	•	•	•	•	•	•		•	•	•		•	•			•	·	·			•
Solanum nigrum L. ssp. nigrum	•	•	+	•	•	•		•	•	•		•	•			•	+	+			•
Stachys palustris L.	+																				
Stellaria aquatica (L.) Scop.																					
Symphyotrichum squamatum (Spreng.) G.L. Nesom																					
Teucrium scordum L.																					
Tussilago farfara L.	-	-	-	-	-	-	-	•	•	-	-	-	•	-	•	-	-	-	-	-	-
Typha angustifolia L.	•	•	•	•	•	•		•	•	•		•	•			•	•	•			•
Typha latifolia L.	•	•	•	•	•		•	•	•	•	•	•	2		•	·	•	•			•
Urtica dioica L. ssp. dioica	•				•												+	i		•	
Veronica anagallis-aquatica L. ssp. anagallis-aquatica	+	2	i		•	i		•	•	+	+	•	•	i				•			1
Veronica beccabunga L.	i	-	•	•	•	•	•	•	•	i		•	•	•	1	2	1	•			+
Xanthium orientale L. ssp. italicum (Moretti) Greuter		•	•	•	•	•	•	•	•	+	•	•	•	•		-	+	+	•		
Autonom offentale L. SSP. Rancum (Moretti) Offentel						•	<u> </u>	<u> </u>			<u> </u>		<u> </u>	•	•	•	т	т	•		 <u> </u>

	ANu ₁	ANu ₂	ANu ₃	ANu ₄	ANu ₅	ANu ₆	ANu ₇	ANu ₈	ANu ₉	ANm ₁₀	ANm ₁₁	ANm ₁₂	ANm ₁₃	ANm ₁₄	ANm ₁₅	ANm ₁₆	ANm ₁₇	ANm ₁₈	ANI ₁₉	ANI ₂₀	ANI ₂₁	ANI ₂₂	ANI ₂₃	ANI ₂₄	ANI ₂₅	ANI ₂₆	ANI ₂₇
Phanerogams aquatic species																											
Alisma plantago-aquatica L.																		1			1	1					
Apium nodiflorum L. f. aquatica					+					1					1						1						
Azolla filiculoides Lam.																											
Berula erecta (Hudson) Coville f. fluitans										1	2	2				1		2				2	+				
Callitriche stagnalis Scop.										2	+			+		1	1				1	2					
Ceratophyllum demersum L.																											
Eleocharis palustris (L.) Roemer & Schultes																											
Elodea canadensis Michx.																4	1			5		3					
Gradandia danca (L.) Fourr																											

Hippuris vulgaris L.											-															
Juneus gr. articulatus f. aquatica																										
Lemna gibba L.																										
Lemna minor L.																										
Lemna trisulca L.																										
Mentha aquatica L. f. fluitans					1						•			•												
Myriophyllum spicatum L.											•			•												
Myriophyllum verticillatum L.										-																
Najas marina L. ssp. marina					- ;					-			•		•		-			:						
Nasturtium officinale R.Br. f. fluitans	1				1					-			•		•		-			1						
Persicaria amphibia (L.) Delarbre										-			•			 2 2					:					
Potamogeton crispus L. Potamogeton natans L.										-	•			•		2 2	1				1					
Potamogeton nodosus Poir.										-	•			•	•	1 2										
Potamogeton pectinatus L.	•										•		•	•	•	1 2	•	•				2	2	3	4	3
Potamogeton perfoliatus L.	•										•		•	•	•		•	•				-		,	4	3
Potamogeton sp.1			•	•			•			•	•				•				•		•	•			•	•
Potamogeton trichoides Cham. & Schltdl.			•	•			•			+	•					 2 2	i		•		+	•			•	•
Ranunculus trichophyllus Chaix ssp. trichophyllus			•					i		2	2				i		3			i		•		•	•	
Schoenoplectus lacustris (L.) Palla										-	-															
Spar ganium erectum L. subp. Erectum																1 1				1	+					
Spirodela polyrhiza (L.) Schleid.																										
Veronica anagallis L. ssp. anagallis-aquatica f. fluitans			+		+		r	r		1					1		2		r	2	+					
Veronica beccabunga L. f. fluitans		1									-				1						2					
Zannichellia palustris L.																				2						
Algae																										
Achnanthes lanceolata (Breb.) Grunow					-	-														-	-					-
Achnanthes minutissima Kuetz.					r																					
Amphora ovalis(Kützing) Kützing																										
Amphora pediculus (Kuetz.) Grunow														r												
Anabaena sp. 1								r			+			Г				•								
Ankistrodesmus falcatus (Corda) Ralfs Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et Flahault																										
Audouinella hermannii (Roth) Dudy in de Candolle										-	•			•	•											
Bangia atropurpurea (Roth) C. Agardh								1			-			:	•		-							1		
Basicladia sp.						+		1		-				+								•		1		
Caloneis sp.	•										•		•	•	•		•	•				•		1		
Chaetophora elegans (Roth) C. Agardh	•										•		•	•	•		•	•				•				
Chamaesiphon conferviculus A. Braun	•	•	•	•			•			•	-		•	•	•			•	•		•	•	•		•	
Chamaesiphon incrustans Grunow in Rabenhorst	+		r			r		i					r									•		•	•	
Chara sp.														i												
Characium sp.																										
Chroococcus turgidus (Kutzing) Nageli																										
Cladophora glomerata L.	2	3	2			2		2	+		+	1	+	1	r		+	1	+		2			2	r	1
Closteriopsis acicularis (G. M. Smith) J. H. Belcher et Swale											r															
Closterium closterioides (Ralfs) A. Louis et Peeters																										
Closterium ehrebergii Meneghini ex Ralfs																	1									
Closterium kuetzingii Brebison											•			•												
Closterium praelongum varietà brevius (Nordstedt) Willi Krieger						:					•			•												
Cocconeis pediculus Ehrenberg	+	+	+			1		r		-			+	r	r	1 .				r						
Cocconeis placentula Ehrenberg										-	•			•	•											
Coelastrum microporum Nageli in A. Braun Coenochloris fottii (Hindak) Tsarenko										-	•			•	•											
Cosmarium botrytis Meneghinini ex Ralfs	•										•		•		•		•	•				•				
Cosmarium bioculatum Brébisson ex Ralfs		•						•		•			•	•	•		•	•			•	•		•		
Cosmarium granatum Brébisson in Ralfs			•					•														•		•	•	
Cosmarium humile (F. Gay) Nordstedt in De Toni														r												
Cosmarium impressulum Elfving														r												
Cosmarium laeve Rabenhorst											-															
Cosmarium meneghinii Brébisson in Ralfs																										
Cosmarium punctulatum Brébisson																										
Cyclotella meneghiniana Kützing			r		г		r	•						+			r	•								
Cymatopleura solea (Brebisson) W. Smith											-															
Cymatopleura sp Cymbella minuta Hilse		•				•	•	•		•			•	•	•		•	•		•	•		•	•	•	•
Cymbella affinis Kützing					•		•						•	•	•			•		•		•	•	•	•	
Cymbella helvetica Kützing	•	•				r		•			•		•		•			•				•	•	•	•	•
Cymbella sp.1		r r	r r	•	r r		r r	•					•	•	•			•	•			•		•	•	
Cymbella sp.2			r		r		r																			
Cymbella sp.3					-		r																			
Cymbella sp.4																										
Diatoma mesodon (Ehrenberg) Kützing											-															
Diatoma sp.											-															
Diatoma vulgaris Bory			r																							
Diploneis sp.																										
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh																								2		+
Epithemia sp.			r								-															
Eunotia sp.					r			r						г												
Fragilaria sp.						r	r							+												
Gomphonema acuminatus																										
Gomphonema olivaceum (Hornemann) Brebisson								r			-			+			+									
Gomphonema parvulum Kützing								•										•								
Gomphonema sp.1			r		r					-																

Gomphonema sp.2			r															•									
Gomphonema sp.3			r																								
Gyrosigma attenuatum (Kützing) Rabenhorst	-		r			Г																					
Hantzschia amphioxys (Ehr.) Grun.	-																										
Hapalosiphon fontinalis (C.Agardh) Bornet	-																										
Klebsormidium flaccidum (Kutzing) P.C. Silva, Mattox et W.H. Blackwell																											
Kyliniella sp.																											
Lemanea fluviatilis (L.)C. Agardh	1		1				1	•											•								
Lyngbya lutea (C.Agardh, Gomont) Gomont	-										-		-		-												
Lyngbya aestuarii (Liebman) Gomont							•							:					•								
Lyngbya kuetzingii Schmidle							•	1						+					•								
Lyngbya lutescens (Meneghini) Hansgirg						1	•	•											•								
Lyngbya martensiana (Meneghini) Gomont			-		-				-				•	•		•		•		•		-	•	•	•	•	
Lyngbya sp.	-									•			•	•		•										•	
Melosira varians Agardh	-				r	i		i	2	•		i		÷	1			i	i		3					•	i
Merismopedia elegans A.Braun in Kutzing				•			1		-								•	1			5						
Microcystis flos-aque (Wittrock) Kirchner	-									•			•	•	•	•										•	
Microspora amoena (Kutzing) Rabenhorst	-							i		•			•	÷	•	•										•	
Monoraphidium arcuatum (Korshikov) Hindak		•			•	•	•					•	•		•	•	•		•						•		
Monoraphidium contortum (Thuret) komarkova-Legnerova			•				•	•				•		•		•			•					•	•	•	
Mougeotia sp.	-		-		r	•	•			-	-	-	-	-			-	•	•	•	•				-		-
Navicula cryptocephala Kützing					-							-												•			· ·
Navicula cryptotenella Lange-Bertalot																											
Navicula gregaria Donkin																											
Navicula lanceolata (Agardh) Ehrenberg																											
Navicula sp. 1		r	r		г		г																				
Navicula sp.2		r	r		r		r																				
Navicula sp.3		r	r																								
Navicula sp.4																											
Navicula sp.5																											
Nitzschia acicularis (Kützing) W. Smith					r																						
Nitzschia dissipata (Kützing) Grunow																											
Nitzschia palea (Kützing) W. Smith																											
Nitzschia sp.1			r		Γ						-																
Nitzschia sp.2			r																								
Nostoc punctiforme (Kutzing) Hariot				+							-																
Oedogonium sp.1		+						+			r			г	r	r			+	r	+						+
Oedogonium sp.2											-																
Oocystis borgei Snow	-													r					+								
Oscillatoria amoena (Kutzing) Gomont	-							r																			
Oscillatoria amphibia (C. Agardh) Gomont																											r
Oscillatoria brevis Gomont																											
Oscillatoria formosa Bory	-									-			•	-													-
Oscillatoria limnetica Lemmermann																											
Oscillatoria limosa (C. Agardh) Gomont	-			:						;	+		•	r	:					r							-
Oscillatoria sp.1	-			+			r			1	-		-		+											+	
Oscillatoria sp.2	-										-		-		-												
Oscillatoria sp.3 Oscillatoria subbrevis Lemmermann							•	•											•								i
Oscillatoria suodievis Lemmennanii Oscillatoria tenuis (C.Agardh) Gomont							•	•											•								1
							•	•											•								-
Palmodyction viride Kützing			r				•												•								-
Pandorina morum (O. Müller) Bory de Saint-Vincent Pediastrum boryanum (Turpin) Meneghini	-									-			•	-													-
Pediastrum boryanum (Turpin) Menegnini Pediastrum boryanum var. cornutum (Raciborski) Sulek	-										-		-		-												
Pediastrum duplex Meyen							•	•						-					•								-
							•	•						I .					•								-
Pediastrum integrum Nageli Pediastrum simplex Meyen			•						•							•			•						•		
Pediastrum tetras (Ehrenberrg) Ralfs			•						•							•											
Phacus sp.																											
Phormidium retzii (C. Agardh) Gomont																											
Phormidium sp.																			+								
Phormidium valderianum (Delponte) Gomont																											+
Pinnularia sp.1		r	r												-												
Pinnularia sp.2			r																								
Rhodostichus expansus				+																							
Rhoicosphenia sp.			r		г																						
Scenedesmus arcuatus (Lemmermann) Lemmermann								r						+					+								
Scenedesmus communis e.h.Hegewald														+													
Scenedesmus ellipticus Corda											-																
Scenedesmus falcatus Chodat														+													
Scenedesmus granulatus W. West & G.S. West																											
Scenedesmus obtusus Meyen														Г													
Scenedesmus serratus (Corda) Bohlin														Г													
Selenastrum sp.														:				:	+								
Spirogyra communis (Hassall) Kutzing														3				2		+							
Spirogyra fluviatilis Hilse in Rabenhorst								:																			:
Spirogyra sp.	r	+			+			1																			1
Spirogyra sp.1																											
Spirogyra sp.2			•																						•		-
Staurastrum dilatatum Ehr.													r														
Stigeoclonium sp.																											+
Surirella brebissonii Krammer & Lange-Bertalot																											

Surirella sp.																											
Synedra ulna (Nitzsch) Ehrenberg																											
Tabellaria flocculosa (Roth) Kützing			r			r								+													
Trachelomonas hispida (Perty) F. Stein ex Deflandre																											
Trachelomonas sp. Ulothrix tenuissima Kützing																			•								
Ulothrix tentissima Kutzing Ulothrix zonata (Weber & Mohr) Kützing		•		i										1			•				1						
Uronema elongatum Hodgetts		•													r												
Vaucheria germinata (Vaucher) De Candolle		i	i	1	4	1	5	i		2	+	+	4	2	2	2		4		2	2					4	
Zygnema sp.										-				+	-	-				-	-						
Bryophytes mosses																											
Hygroamblystegium fluviatile (Hedw.) Loeske	-	1								-																	
Cinclidotus aquaticus (Hedw.) Bruch & Schimp.				1																							
Cinclidotus fontinaloides (Hedw.) P. Beauv.	-		+	2						-											5						
Cratoneuron filicinum (Hedw.) Spruce										-			•														
Dialytrichia mucronata (Brid.) Broth.	-			:							-		-														
Fissidens viridulus (Sw.) Wahlemb Fontinalis antipyretica Hedw.		•		1		ż	•		3	i		i	•			i	•				i .						
Fontinalis antipyrenca riedw.			2			2		3	3	1	2	1				1			•		1	2	•			•	
Hygroamblystegium tenax (Hedw.) Jenn.	i	•	•	•		•	•		•			•					•		•								•
Leptodictyum riparium (Hedw.) Warnst.			•	•		•	•						•			•			•		•		3		•	•	•
Orthotrichum stramineum Horsch. Ex Brid.			:		2																						
Palustriella commutata (Hedw.) Ochyra																											
Plagiomnium affine (Blandow ex Funck) T.J. Kop		1		+																							
Plagiomnium undulatum (Hedw.) Schimp.	1	1																									
Platyhypnidium riparioides (Hedw.) Dixon. (Rhinchostegium			+				+																				
riparioides (Hedw.) C.E.O. Jensen)	2	2		2	•		•			•	•		•	•	•	•	•		•	•			•	•			•
Rhynchostegium sp.																											
Bryophytes liverworts Aneura pinguis (L.) Dumort.																											
Conocephalum conicum (L.) Dumort.			•					•	•	•			•	•				•	•		•		•	•	•	•	•
Conocephalum sp.		+					•	•						:		:								:		:	
Lunularia cruciata (L.) Lindb.	+	Ċ	Ċ	+												Ċ											
Marcantia polymorpha L.		+		+																							
Pellia endiviifolia (Dicks.) Dumort.	+			+																							
Riccia fluitans L.																											
Phanerogams riverbank species																											
Aegopodium podagraria L.																						+					
Agrostis stolonifera L.	-							1			2		-	2				1					1			1	
Alternanthera philoxeroides (Mart.) Griseb.																											
Anagallis arvensis L. ssp. arvensis Angelica sylvestris L.		•				i	•	:	•		i	•	•			i	•			:							
Aligenca sylvestris L. Apium nodiflorum (L.) Lag. ssp. nodiflorum		•	•	•		1	i	+	•		1	•		i		1	•		•	+		Ť					1
Arctium lappa L.			•	•							-						•	•	•	•	•	•	•	•	•	•	
Artemisia annua L.			Ċ	Ċ												Ċ											
Artemisia verlotiorum Lamotte	_																										
Artemisia vulgaris L.																											
Arundo donax L.	-									-										2							2
Arundo plinii Turra										-			•														
Atriplex patula L.										:				:		:							:				
Berula erecta (Huds.) Coville										1		2		1		1						1	1			:	
Bidens frondosa L. Bidens tripartita L.																		1	•		+		•		+	1	
Butomus umbellatus L.	•	•											•	•			•										
Cardamine sp.			Ċ	Ċ												Ċ											
Carex hirta L.																											
Carex otrubae Podp.																											
Carex paniculata L. ssp. paniculata											:																
Carex pendula Huds.	+						1	1	+		1										+	+					
Carex pseudocyperus L. Chenopium album L.	•	•			-	•			•				•		•												
Chenopodium ambrosioides L.			•					•	•	•			•	r				•	•		•		•	•	•	•	•
Chenopodium polyspermum L.																											
Cirsium arvense (L.) Scop.																											
Cirsium creticum (Lam.) d'Urv.																											
Cirsium palustre (L.) Scop.																											
Conium maculatum L. ssp. maculatum																											
Conyza canadensis (L.) Cronq.																											
Cyperus eragrostis Lam.																											
Cyperus fuscus L.					+													1							1		
Cyperus longus L.																		1									
Cyperus rotundus L.																											-
Datura stramonium L. ssp. stramonium																											-
Dipsacus fullonum L.																											
Dorycnium rectum (L.) Ser.																											
Echinochloa crus-galli (L.) Beauv. Eclipta prostrata (L.) L.																											
Denpu prosum (L.) L.		•	•	•				•		•			•	•	•	•	•	•	•	•			•	•	•	•	
Eleusine indica (L.) Gaertner ssp. indica Epilobium hirsutum L.	i		+					1	+		1	1		1				+									
Epilobium hirsutum L.	i		+					1	+		1	1		1				+									
Epilobium hirsutum L. Epilobium montanum L.	i		+					1	+	-		1						+	•				•	•			
Epilobium hirsutum L.	i		+			•		1	+		1	1		1		· +		+							· ·		

Equisetum ramosissimum Desf.																										
Equisetum telmateja Ehrh.								1								+										
Erigeron annuus (L.) Desf.								+			г			+												
Erigeron sumatrensis Retz. Eupatorium cannabinum L. ssp. cannabinum					i	i		:		-	-			- ;				1	· 1			1				1
Galinsoga parviflora Cav.															•	•	•						•			
Galium palustre L. ssp. elongatum (C. Presl.) Lange											+			+		+				1						
Glyceria fluitans (L.) R. Br.																										
Glyceria notata Chevall.																										
Holcus lanatus L.																										
Holoschenus romanus (L.) Fritsch.																										
Hypericum androseum L.																										
Hypericum perforatum L.																										
Hypericum tetrapterum Fr.																										
Iris pseudacorus L.											1	1				1	1									
Juneus acutus L.										-						•	•									
Juncus articulatus L. Juncus bufonius L.			+					2																		
Juncus buronius L. Juncus conglomeratus L.																										
Juncus effusus L. ssp. effusus								•							•	•	•						•			
Juncus inflexus L.																										
Lactuca saligna L.																										
Leersia oryzoides (L.) Sw.												:		:											:	
Lycopus europaeus L.	•									+	+	1	•	1	•	+		•	+	•			+	+	1	
Lysimachia nummularium L.											:	:											•			
Lysimachia vulgaris L. Lythrum hyssopifolia L.											1	1											•			
Lythrum salicaria L. Lythrum salicaria L.					i					+	i			i	•					i	+	+	+	+	i	+ 1
Mentha aquatica L. ssp. aquatica		Ċ					+			· ·		2		1				1			Ċ	i		Ċ		
Mentha longifolia (L.) Hudson			+		+			1																		
Mentha pulegium L. ssp. pulegium																										
Mentha spicata L.														+												
Mentha suaveolens Ehrh. ssp. suaveolens											+															
Mentha x piperita L. Myosotis scorpioides L. ssp. scorpioides														+												
Nasturtium officinale R.Br. ssp. officinale		Ċ																								+ .
Paspalum distichum L.																		1								
Persicaria lapathifolia (L.) Delarbre					+									2				3				+				
Persicaria maculosa (L.) Gray					:	:		:				1				:				:		1				. +
Petasites hybridus (L.) P. Gaertn., B. Mey. & Scherb.				+	1	1	+	1	+	2	5	3 2				1				1 2	;	1	i			
Phalaris arundinacea L. ssp. arundinacea Phragmites australis (Cav.) Trin. ssp. australis										2	5	2		+		+			3	4	1	1	1	+		1 .
Phytolacca americana L.								+																		. i
Piptatheum miliaceum (L.) Coss. ssp. miliaceum																										
Plantago major L.																										
Polypogon monspeliensis (L.) Desf.																										
Polypogon nodosum Polypogon viridis (Gouan) Breistr.								i							+			•								
Pulicaria dysenterica (L.) Bernh.	•					+		1		•				т	•		•									
Ranunculus repens L.	+				+		i																			
Ranunculus sceleratus L.																										
Raphanus raphanistrum L. ssp. raphanistrum																										
Rorippa amphibia (L.) Besser																							•			
Rorippa silvestris (L.) Besser Rumex conglomeratus Murray	•																			-						
Sambucus ebulus L.	•	•	•	•			•			•	•		•		•	•	•		•			•	•	•		
Samolus valerandi L.		Ċ										•														
Scirpoides holoschoenus (L.) Sojak																										
Scrophularia auriculata L. ssp. auriculata			+					+			+	1		+							+	+			1	+ r
Scutellaria galericulata L.																										
Senecio erucifolius L.																						+				2 .
Senecio mikanioides Otto ex Walp. Silene latifolia Poir. ssp. alba (Mill.) Greuter & Burdet	•				•	•		•	•	•						•	•		•				•			
Solanum dulcamara L.	•					•		•			1			1	•	•	•	•			•					1 1
Solanum lycopersicum L.	•				+		+			•	1	1		1	•		•									
Solanum nigrum L. ssp. nigrum							•	•									•									
Stachys palustris L.																										
Stellaria aquatica (L.) Scop.														+												
Symphyotrichum squamatum (Spreng.) G.L. Nesom																										
Teucrium scordum L.																										
Tussilago farfara L.	•							:			•		•	•	•			•		•					•	
Typha angustifolia L. Typha latifolia L.								1																		
Typha latitolia L. Urtica dioica L. ssp. dioica								2																		4 3
Veronica anagallis-aquatica L. ssp. anagallis-aquatica														2								i				+ +
Veronica beccabunga L.														+				+								
Xanthium orientale L. ssp. italicum (Moretti) Greuter														г												

	TRu1	TRu2	TRI3	TRI4	FA1	FA2	FA3	FA4	FA5	FA6	FA7	Nu ₁	Nu ₂	Nu ₃	NI ₄	NI ₅
Phanerogams acquatic species												•			-	
Alisma plantago-aquatica L.																+
Apium nodiflorum L. f. aquatica												2				
Azolla filiculoides Lam.																
Berula erecta (Hudson) Coville f. fluitans												1	2			1
Callitriche stagnalis Scop.	1	4	+			+	+	+				1	2	+	2	4
Ceratophyllum demersum L.								+		+						+
Eleocharis palustris (L.) Roemer & Schultes																2
Elodea canadensis Michx.																
Groelandia densa (L.) Fourr											•			•		
Hippuris vulgaris L.																
Juncus gr. articulatus f. aquatica	•			•		•			•	•				•		
Lemna gibba L. Lemna minor L.				•							•					
Lemna trisulca L.			1		•	•			•	•	•		1	1	2	•
Mentha aquatica L. f. fluitans	•		•	•	•			•			•		1	1	•	•
Myriophyllum spicatum L.		•	•	•		•	•		•	1	•	•	•	i	3	•
Myriophyllum verticillatum L.		•	•	•		•	•		•	1	•	•	•	1	3	•
Najas marina L. ssp. marina			•	•						4	4		•	•	•	
Nasturtium officinale R.Br. f. fluitans		i	+	+			2	2		-	7		•		•	+
Persicaria amphibia (L.) Delarbre	•				•	•	-	-	•	•	•		•	•	•	
Potamogeton crispus L.		i										+	1		+	
Potamogeton natans L.	•	•	•	•				•					•			+
Potamogeton nodosus Poir.			•	•				1	1							
Potamogeton pectinatus L.					:					5	5				2	
Potamogeton perfoliatus L.		+								1						
Potamogeton sp.1																
Potamogeton trichoides Cham. & Schltdl.																r
Ranunculus trichophyllus Chaix ssp. trichophyllus								1				2	+			
Schoenoplectus lacustris (L.) Palla						+	+	+								
Sparganium erectum L. subp. Erectum		+											1	1		2
Spirodela polyrhiza (L.) Schleid.																
Veronica anagallis L. ssp. anagallis-aquatica f. fluitans		2	+				+					2	r			+
Veronica beccabunga L. f. fluitans								r								
Zannichellia palustris L.							4	1					1		2	3
Algae																
Achnanthes lanceolata (Breb.) Grunow			r													
Achnanthes minutissima Kuetz.			г													
Amphora ovalis(Kützing) Kützing			r													
Amphora pediculus (Kuetz.) Grunow			r													
Anabaena sp. 1																
Ankistrodesmus falcatus (Corda) Ralfs																
Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et Flahault																
Audouinella hermannii (Roth) Dudy in de Candolle																
Bangia atropurpurea (Roth) C. Agardh			r			r								r		
Basicladia sp.				•				•					•			
Caloneis sp. Chaetophora elegans (Roth) C. Agardh			r	•										r		
Chamaesiphon conferviculus A. Braun	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Chamaesiphon incrustans Grunow in Rabenhorst				•							•	i				
Chara sp.			1	•	•	1			•	•	•	-	1	-		•
Characium sp.	•		•	•	•	•	•	+	•	•	•	•	•	•	•	•
Chroococcus turgidus (Kutzing) Nageli	•		•	•		•			•	•			•	•		r r
Cladophora glomerata L.	1		3	1	3	1	2		•	•	•		1	2		·
Cladophora giomerata L. Closteriopsis acicularis (G. M. Smith) J. H. Belcher et Swale	1		3	1	3	1	2		•	•	•	-	1	4		+
Closterium closterioides (Ralfs) A. Louis et Peeters													•		•	
Closterium ehrebergii Meneghini ex Ralfs		•				r		•	•	•		r	•	•	•	•
Closterium kuetzingii Brebison			•	•							•					
Closterium praelongum varietà brevius (Nordstedt) Willi Krieger		•				•		•	•	•			•	•	•	•
Cocconeis pediculus Ehrenberg		:	r		r	1		:				r	:	+	:	:
Cocconeis placentula Ehrenberg																
Coelastrum microporum Nageli in A. Braun			•	•		•			•	•		•		•		•
Coenochloris fottii (Hindak) Tsarenko	•	•	•	•	•	2	•	•	•	•	•	•	•	•	•	•
Cosmarium botrytis Meneghinini ex Ralfs	•	•	•		•											+
Cosmarium bioculatum Brébisson ex Ralfs		•				•		•	•	•			•	•	•	•
Cosmarium granatum Brébisson in Ralfs	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Cosmarium humile (F. Gay) Nordstedt in De Toni			•	•		•			•	•	•					
Cosmarium impressulum Elfving	•	•	•	•	•	•	•	•	•	•	•	•	•	r	•	•
impressuum zu ing																

Cosmarium laeve Rabenhorst																
Cosmarium meneghinii Brébisson in Ralfs																
Cosmarium punctulatum Brébisson																
Cyclotella meneghiniana Kützing			Γ													
Cymatopleura solea (Brebisson) W. Smith																
Cymatopleura sp			r													
Cymbella minuta Hilse																
Cymbella affinis Kützing																
Cymbella helvetica Kützing												r		r		
Cymbella sp.1	·	•		•	•	•		•	•	•	•	•	•	•	•	•
Cymbella sp.2	•	•	-	•	•		•	•		•		•	•		•	
Cymbella sp.3	•			•	•		•									
			I	•												
Cymbella sp.4	•														•	•
Diatoma mesodon (Ehrenberg) Kützing			r													
Diatoma sp.																
Diatoma vulgaris Bory			r													
Diploneis sp.			Γ													
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh																
Epithemia sp.																
Eunotia sp.																
Fragilaria sp.	r		r			r	r					r		r		
Gomphonema acuminatus																
Gomphonema olivaceum (Hornemann) Brebisson						1						r		r		
Gomphonema parvulum Kützing		:	:			-										
Gomphonema sp.1	·	•		•	•	•		•	•	•	•	•	•	•	•	•
Gomphonema sp.1 Gomphonema sp.2	•			•	•	•	•	•	•		•		•			
Gomphonema sp.2 Gomphonema sp.3	•		1	•	•		•									
				•												
Gyrosigma attenuatum (Kützing) Rabenhorst			r	•										r	•	
Hantzschia amphioxys (Ehr.) Grun.			r													
Hapalosiphon fontinalis (C.Agardh) Bornet						+										
Klebsormidium flaccidum (Kutzing) P.C. Silva, Mattox et W.H.																
Blackwell	•	•		•												
Kyliniella sp.																
Lemanea fluviatilis (L.)C. Agardh																
Lyngbya lutea (C.Agardh, Gomont) Gomont																
Lyngbya aestuarii (Liebman) Gomont																
Lyngbya kuetzingii Schmidle																
Lyngbya lutescens (Meneghini) Hansgirg																
Lyngbya martensiana (Meneghini) Gomont	•		•	•	•					•		•		•	•	•
Lyngbya sp.	•		•	•						•		•		•	•	•
			2	2	•	:			:					:	•	
Melosira varians Agardh	1	I	2	2		+	I	I	+		•	I		+		
Merismopedia elegans A.Braun in Kutzing				•										r	•	r
Microcystis flos-aque (Wittrock) Kirchner	:	:														
Microspora amoena (Kutzing) Rabenhorst	1	1														
Monoraphidium arcuatum (Korshikov) Hindak						+								:		+
									•					:		+
Monoraphidium contortum (Thuret) komarkova-Legnerova																+
Mougeotia sp.	•	•					:									+
Mougeotia sp. Navicula cryptocephala Kützing					· · ·	+				· · · ·				·		+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot		· · · ·														+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin																+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot									· · · · · · · · · · · · ·							+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp. 1						*			· · · · · · · · · · · · · · · ·							+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg						*										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2						*										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp. 1 Navicula sp.2 Navicula sp.3																+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp. 1 Navicula sp. 2 Navicula sp. 3 Navicula sp. 4						*										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5						*								· · · · · · · · · · · · · · · · · · ·		+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith						+										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow						+										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith						+										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.2 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia dissipata (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1						+										+
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.1 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.2						*										
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.1 Nostoc punctiforme (Kutzing) Hariot						*										
Mougeotia sp. Navicula cryptoteephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.1 Nostoc punctiforme (Kutzing) Hariot Oedogonium sp.1						+										
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.5 Notsoc punctiforme (Kutzing) Hariot Oedogonium sp.1 Oedogonium sp.1 Oedogonium sp.2						+										
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.1 Ostoc punctiforme (Kutzing) Hariot Oedogonium sp.1 Oedogonium sp.2 Oocystis borgei Snow						+										
Mougeotia sp. Navicula cryptoteephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia sp.1 Nitzschia sp.1 Nitzschia sp.1 Nostoc punctiforme (Kutzing) Hariot Oedogonium sp.1 Oedogonium sp.1 Oedogonium sp.2 Oocystis borgei Snow Oscillatoria amoena (Kutzing) Gomont						+ 	· · · · · · · · · · · · · · · · · · ·									
Mougeotia sp. Navicula cryptocephala Kützing Navicula cryptotenella Lange-Bertalot Navicula gregaria Donkin Navicula lanceolata (Agardh) Ehrenberg Navicula sp.1 Navicula sp.2 Navicula sp.3 Navicula sp.4 Navicula sp.5 Nitzschia acicularis (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith Nitzschia palea (Kützing) W. Smith Nitzschia sp.5 Nostoc punctiforme (Kutzing) Hariot Oedogonium sp.1 Oedogonium sp.2 Oocystis borgei Snow Oscillatoria amoena (Kutzing) Gomont Oscillatoria amoena (Kutzing) Gomont						+										
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Oscillatoria limnetica Lemmermann							r	r								
Oscillatoria limosa (C. Agardh) Gomont																
Oscillatoria sp.1																+
Oscillatoria sp.2																r
Oscillatoria sp.3																r
Oscillatoria subbrevis Lemmermann								r								
Oscillatoria tenuis (C.Agardh) Gomont			r					r				r				
Palmodyction viride Kützing																
Pandorina morum (O. Müller) Bory de Saint-Vincent	•		•	•	•	•	•		•			•		•	•	•
Pediastrum boryanum (Turpin) Meneghini			•	•	•	•	•	•	•	•	•	•		•	•	•
Pediastrum boryanum var. cornutum (Raciborski) Sulek			•		•							•			•	
Pediastrum duplex Meyen																
												I		I		
Pediastrum integrum Nageli		•				•			•	•				•	•	
Pediastrum simplex Meyen																
Pediastrum tetras (Ehrenberrg) Ralfs						•			•	•						
Phacus sp.			r			•			•	•						
Phormidium retzii (C. Agardh) Gomont																
Phormidium sp.																
Phormidium valderianum (Delponte) Gomont						1								r		+
Pinnularia sp.1			r													
Pinnularia sp.2																
Rhodostichus expansus																
Rhoicosphenia sp.																
Scenedesmus arcuatus (Lemmermann) Lemmermann																r
Scenedesmus communis e.h.Hegewald														r		r
Scenedesmus ellipticus Corda	•	•	•	•	•	•	•		•	•	•	•		•	•	•
Scenedesmus falcatus Chodat						•			•			•	•		•	•
Scenedesmus granulatus W. West & G.S. West			•		•							•			•	
		•			•	•			•	•		•	•	1	•	
Scenedesmus obtusus Meyen					•	•			•	•		•		•	•	
Scenedesmus serratus (Corda) Bohlin		•				•			•	•					•	
Selenastrum sp.						•			•	•						
Spirogyra communis (Hassall) Kutzing																
Spirogyra fluviatilis Hilse in Rabenhorst																
Spirogyra sp.		r				4		+	+			r		+		1
Spirogyra sp.1																
Spirogyra sp.2																
Staurastrum dilatatum Ehr.																
Staurastrum dilatatum Ehr. Stigeoclonium sp.														:		
Stigeoclonium sp.				:												
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot				•												
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp.				· ·												
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg	r		r r	· · ·								· · · · ·			· · · · ·	
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing												· · · · · ·	· · · · · ·	r	· · · · · · ·	
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre											· · · · · · · · · · · · · · · · · · ·	·	·		·	·
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp.						+						·	·			·
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing													·		· · · · · · · · · · · · · · · · · · ·	·
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing						· · · · · · · · · · · · · · · · · · ·							·		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing Uronema elongatum Hodgetts																·
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing Uronema elongatum Hodgetts Vaucheria germinata (Vaucher) De Candolle												· · · · · · · · · · · · · · · · · · ·				
Stigeoclonium sp. Surirella brebissonii Krammer & Lange-Bertalot Surirella sp. Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing Uronema elongatum Hodgetts Vaucheria germinata (Vaucher) De Candolle Zygnema sp.													- - - - - - - - - - - - - - - - - - -			·
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Conocephalum sp. Lunularia cruciata (L.) Lindb.											•					
Marcantia polymorpha L.		•												•		
Pellia endiviifolia (Dicks.) Dumort.																
Riccia fluitans L.																
Phanerogams riverbank species																
Aegopodium podagraria L.							•	;								;
Agrostis stolonifera L. Alternanthera philoxeroides (Mart.) Griseb.							+	1					•			1
Anagallis arvensis L. ssp. arvensis						•	•	•			•	•	•	•		•
Angelica sylvestris L.				:	Ċ	:	:	:	+		:	+	r	:	2	
Apium nodiflorum (L.) Lag. ssp. nodiflorum				r	2	2	2	2	+					+	1	
Arctium lappa L.																
Artemisia annua L.																
Artemisia verlotiorum Lamotte						+										
Artemisia vulgaris L. Arundo donax L.	•	•	•	•	•	•						•		•	•	•
Arundo plinii Turra	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Atriplex patula L.						r										
Berula erecta (Huds.) Coville			r		1		+	+								
Bidens frondosa L.	+	2	2	1		r	+	+	1							
Bidens tripartita L.			r													
Butomus umbellatus L. Cardamine sp.			•			•						•	•	•		•
Carex hirta L.	•					•	i			•	•	•	•	•		•
Carex otrubae Podp.									·						·	
Carex paniculata L. ssp. paniculata																
Carex pendula Huds.	+	+			+	1	+	1	1			r	r	+	r	
Carex pseudocyperus L.																
Chenopium album L. Chenopodium ambrosioides L.								•	:				•	•		
Chenopodium polyspermum L.							•	•	+		•	•	•	•		•
Cirsium arvense (L.) Scop.																
Cirsium creticum (Lam.) d'Urv.																
Cirsium palustre (L.) Scop.		+				+										
Conium maculatum L. ssp. maculatum																
Conyza canadensis (L.) Cronq.	•	•	•													
Cyperus eragrostis Lam. Cyperus fuscus L.	•		1	1	•	•						•		•	•	•
Cyperus longus L.		+							•					•		
Cyperus rotundus L.																
Datura stramonium L. ssp. stramonium																
Dipsacus fullonum L.																
Dorycnium rectum (L.) Ser. Echinochloa crus-galli (L.) Beauv.	•	•	•		•	1	+									
Echinochioa crus-gani (L.) Beauv. Eclipta prostrata (L.) L.	•					•				•	•	•	•	•		•
Eleusine indica (L.) Gaertner ssp. indica	· ·	·	r												·	
Epilobium hirsutum L.		+				1	+					+		+	+	
Epilobium montanum L.																
Epilobium tetragonum L. ssp. tetragonum						:		•								
Equisetum arvense L. ssp. arvense Equisetum ramosissimum Desf.						1		+						•		•
Equisetum telmateja Ehrh.					+	1			+			r				
Erigeron annuus (L.) Desf.																
Erigeron sumatrensis Retz.																
Eupatorium cannabinum L. ssp. cannabinum	+	+			+	+	+	+	1			+	r		r	
Galinsoga parviflora Cav. Galium palustre L. ssp. elongatum (C. Presl.) Lange	•	•	+													:
Glyceria fluitans (L.) R. Br.						•	•	•			•	•	•	•		+
Glyceria notata Chevall.						r	•	•						•		
Holcus lanatus L.																
Holoschenus romanus (L.) Fritsch.																
Hypericum androseum L.																
Hypericum perforatum L.																
Hypericum tetrapterum Fr. Iris pseudacorus L.										•	1					i
Juncus acutus L.		+	•							•				•	•	
Juneus articulatus L.			r				+									+
Juncus bufonius L.		+														

Janes Jane																	
James surfaces	Juncus conglomeratus I.		+														
Jances infereus L. Lectica synaded C.J. So. Lectica synaded C.J. So.		•		•	•	•	•		•			•	•	•		•	
Lection as surplies (L. 5 w.		•	•	•	•	•		i	•		•		•		•	•	
Leenia orysoides (L.) SW.					•				•		•	•	•	•	•		
Speciments compared		•	•	•	•	•		•	•		•		•		•	•	
Lysinachia valgaria i.			i			1	•		:	:		•	•	:	•		T
Systems in volgents		-	1	1		1	•	т	т	Τ.		•	•	т	•	т	1
Lythum sulscia L							•										
Lightness alicaria			:				•										
Menth apaptic L. Hustoon Menth apaptic L. Hustoon Menth apaptic L. Hustoon Menth apaptic L. Hustoon Menth apaptic L. Sep policy and Menth apaptic L. Sep polic			+														
Memba nogificial (L) Hadson		•		:		Г	-	-				•	+	•	:	•	:
Memlan spietain S. Sp. palegimm S. Sp. palegimm S. Sp. saveolens S. Sp. saveole				1			1	1	+	+					1		1
Mentha suspecials Link, sp. suaveolens Mentha special Link, sp. suaveolens Mentha supportial Link, special Link, s			•														
Menha suveolens Enh. sup-auevolens Myosots scorpioides L. sp., scorpioides Myosots scorpioides R. sr., scorpioides Myosots			+						•			•		•	•	•	
Membra x piperial L																	
Mysosis scorpioides																	
Nasturium officinale R Br. sps. officinale																	
Paspallar distichum L			:	:	:		:	:		:							
Persicaria lapathfolia (L.) Delurbre			2	1	1			1	•	2				•			
Persiatis Partia maculosa (L.) Gray									1								
Petasies hybridus C P. Cagertin, B. Mey, & Scherch			:	2	:		+	+		+						•	
Phalaris arundinacea L. sps, aundinacea			1		2												+
Phragnics australis (Cav) Trin. ssp. australis		1				1	2	1	+					r			
Physicate mm finaceum (L.) Coss. ssp. miliaceum Plantago major L. Plantago major L. Polypogom nonspeliensis (L.) Desf. Polypogom nonspeliensis (L.) Desf. Polypogom nonspeliensis (L.) Desf. Polypogom nodis (Gouan) Breistr. Pulicaria dysenterica (L.) Bernh. Pulicaria (L.) Bernh. Pulicari																	
Piptaleum miliaceum (L.) Coss. ssp. miliaceum Plantago migor L. Polypogon monspeliensis (L.) Desf. Polypogon monspeliensis (L.) Desf. Polypogon monspeliensis (L.) Desf. Polypogon viridis (Gouan) Breistr. Polypogon viridis (Gouan) Pol							r		+			1					+
Plantago major L Polyogogon modosum Polyogogon modisi (Gouan) Breistr. Polyogogon modisi (Gouan) Breistr. Pulicaria dysenterica (L.) Bermh. Ranunculus repens L. Ranunculus sepens L. Ranunculus sepen																	
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Veronica beccabunga L. +		•		1				•					+			+	
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Phanerogams aquatic species																												
Alisma plantago-aquatica L.							r										r			+			+			r		
Apium nodiflorum L. f. aquatica		2	1			3		+	2				2			+						1						2
Azolla filiculoides Lam.																												

Berula erecta (Hudson) Coville f. fluitans		. 2	2					2				1														
Callitriche stagnalis Scop.	•	2 3	2		T.	•	•	1			•	1 .		•	•		•	•					•	•		
Ceratophyllum demersum L.		2 3	2		+	•		1	1	•			•		•		•					•				
Eleocharis palustris (L.) Roemer & Schultes									1									I								
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Elodea canadensis Michx.														•												
Groelandia densa (L.) Fourr		+ .																								
Hippuris vulgaris L.		3 .	2																							
Juncus gr. articulatus f. aquatica		2 .																								
Lemna gibba L.	+																									
Lemna minor L.	1	. r	1			r	+		+		1									r	r					
Lemna trisulca L.		+ .	1																							
Mentha aquatica L. f. fluitans																				+						
Myriophyllum spicatum L.	2	r 2									3					2		+								
Myriophyllum verticillatum L.		+ .																								
Najas marina L. ssp. marina																										
Nasturtium officinale R.Br. f. fluitans		. r	2	1		2		1		2		3 .			r					1	1					1
Persicaria amphibia (L.) Delarbre																										
Potamogeton crispus L.			+															5						+		
Potamogeton natans L.	•					•	•	•	•	•	•		•	•	•	•	•	-	•	•	•	•	•			
Potamogeton nodosus Poir.	3		•		•	2	•	•	3	•	·		•	•	÷	•		•	1		•	•	•	•		•
Potamogeton pectinatus L.	5		•		•	-	r	•	3	•	3		2	•	-	•		•	1		•	•	•	•		•
Potamogeton perfoliatus L. Potamogeton perfoliatus L.	•		•		•	•	1	•	5		5		-	•	•	•	•	•		•		•	•	•		•
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Potamogeton trichoides Cham. & Schltdl.			:		•						•			;												
Ranunculus trichophyllus Chaix ssp. trichophyllus	-	. 3	1		+			4	:					4												
Schoenoplectus lacustris (L.) Palla	:		:			+		:	1	:								:								:
Sparganium erectum L. subp. Erectum	1 .	+ .	1				+	1	2	1							+	3								1
Spirodela polyrhiza (L.) Schleid.																										
Veronica anagallis L. ssp. anagallis-aquatica f. fluitans		r .	1	1	+		+	2		+		. 1		r	1		r	1		Γ	1			+		+
Veronica beccabunga L. f. fluitans							+					+ .			+					Γ			+			1
Zannichellia palustris L.		1 .	+		1							. +								1	1					
Algae																										
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Achnanthes minutissima Kuetz.														r	r											
Amphora ovalis(Kützing) Kützing												. r			r											
Amphora pediculus (Kuetz.) Grunow	•		•			•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•		
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Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et Flahault Audouinella hermannii (Roth) Dudy in de Candolle Bangia atropurpurea (Roth) C. Agardh Basicladia sp. Caloneis sp. Chaetophora elegans (Roth) C. Agardh Chamaesiphon conferviculus A. Braun Chamaesiphon incrustans Grunow in Rabenhorst Chara sp. Chrococcus turgidus (Kutzing) Nageli Cladophora glomerata L. Closteriopsis acicularis (G. M. Smith) J. H. Belcher et Swale Closterium closterioides (Ralfs) A. Louis et Peeters Closterium herbergii Meneghini ex Ralfs Closterium praelongum varietà brevius (Nordstedt) Willi Krieger Cocconeis pediculus Ehrenberg Cocconeis placentula Ehrenberg Coconochloris fottii (Hindak) Tsarenko Cosmarium botrytis Meneghinini ex Ralfs Cosmarium bioculatum Brébisson ex Ralfs Cosmarium granatum Brébisson ex Ralfs Cosmarium granatum Brébisson in Ralfs Cosmarium granatum Brébisson in Ralfs Cosmarium impressulum Elfving							4						3	· · · · · · · · · · · · · · · · · · ·												· · · · · · · · · · · · · · · · · · ·
Aphanizomenon flos-aquae (Linnaeus) Ralfs, Bornet et Flahault Audouinella hermannii (Roth) Dudy in de Candolle Bangia atropurpurea (Roth) C. Agardh Basicladia sp. Caloneis sp. Chaetophora elegans (Roth) C. Agardh Chamaesiphon conferviculus A. Braun Chamaesiphon incrustans Grunow in Rabenhorst Chara sp. Chrococcocus turgidus (Kutzing) Nageli Cladophora glomerata L. Closteriopsis acicularis (G. M. Smith) J. H. Belcher et Swale Closterium closterioides (Ralfs) A. Louis et Peeters Closterium ehrebergii Meneghini ex Ralfs Closterium praelongum varietà brevius (Nordstedt) Willi Krieger Cocconeis pediculus Ehrenberg Cocconeis pediculus Ehrenberg Coclastrum microporum Nageli in A. Braun Coenochloris fottii (Hindak) Tsarenko Cosmarium bottytis Meneghinini ex Ralfs Cosmarium bottytis Meneghinini ex Ralfs Cosmarium brebisson ex Ralfs Cosmarium granatum Brébisson in Ralfs Cosmarium granatum Brébisson in Ralfs Cosmarium granatum Brébisson in Ralfs Cosmarium humile (F. Gay) Nordstedt in De Toni Cosmarium impressulum Elfving Cosmarium laeve Rabenhorst									3				3		· · · · · · · · · · · · · · · · · · ·				4							· · · · · · · · · · · · · · · · · · ·
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Cosmarium punctulatum Brébisson																												
Cyclotella meneghiniana Kützing							•					•						•						•				
Cymatopleura solea (Brebisson) W. Smith		1	•		1	•	•	1	•	•	•	•	•	•		1	r	•	•	•	•	•	•	•		•	•	•
Cymatopleura sp		•			•	•	•		•		•	•	•				r	•	•	•	•			•	•	•	•	
Cymbella minuta Hilse		•		•	•	•	•	•	•	•	•	•	•	•		r	r		•	•	•	•	•	•	•	•	•	•
Cymbella affinis Kützing														r		r	r											
Cymbella helvetica Kützing		r												r		r	r											r
Cymbella sp.1																	r											
Cymbella sp.2																	r											
Cymbella sp.3											r																	
Cymbella sp.4																												
Diatoma mesodon (Ehrenberg) Kützing																												
Diatoma sp.																												
Diatoma vulgaris Bory											r			r		r												
Diploneis sp.																												
Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh																												
Epithemia sp.																												
Eunotia sp.											r																	r
Fragilaria sp.											+			r		r	r								r			
Gomphonema acuminatus																												
Gomphonema olivaceum (Hornemann) Brebisson		r									+			r		r	r							r				r
Gomphonema parvulum Kützing														r		r	r											
Gomphonema sp.1																	r											
Gomphonema sp.2																	r											
Gomphonema sp.3					•				•			•												•				
Gyrosigma attenuatum (Kützing) Rabenhorst Hantzschia amphioxys (Ehr.) Grun.														r			r									r		
Hapalosiphon fontinalis (C.Agardh) Bornet							•							•								•						•
Klebsormidium flaccidum (Kutzing) P.C. Silva, Mattox et W.H. Blackwell																												
Kyliniella sp.									•			•									•							
Lemanea fluviatilis (L.)C. Agardh					•				•			•							2		•			•		•		
Lyngbya lutea (C.Agardh, Gomont) Gomont		•			•		•					•						•	2					•			I	•
Lyngbya aestuarii (Liebman) Gomont		•			•	•	•		•		•	•	•	•				•	•	•	•			•	•	•	•	
Lyngbya kuetzingii Schmidle		•	•		•	•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•		•		•
Lyngbya lutescens (Meneghini) Hansgirg		•			•	•	•		•		•	•	•	•				•	•	•	•			•	•	•	•	
Lyngbya martensiana (Meneghini) Gomont	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•		•		•	•		•	•	•		•
Lyngbya sp.	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•		•		•	•	•	•	•	•		•
Melosira varians Agardh		r	+	+	i	•	•	2	•	i	•	i	•	•		r	+		•	•	•	•	+	•	+	•	•	•
Merismopedia elegans A.Braun in Kutzing		r						r																	Ċ	r		
Microcystis flos-aque (Wittrock) Kirchner																										-		
Microspora amoena (Kutzing) Rabenhorst																												
Monoraphidium arcuatum (Korshikov) Hindak								r																				
Monoraphidium contortum (Thuret) komarkova-Legnerova																												
Mougeotia sp.																												
Navicula cryptocephala Kützing		г														r	r							r				
Navicula cryptotenella Lange-Bertalot		r									r			r		л.	r							r	r			r
Navicula gregaria Donkin																												
Navicula lanceolata (Agardh) Ehrenberg																r	r											
Navicula sp.1											+					r												
Navicula sp.2											+																	
Navicula sp.3																												
Navicula sp.4																												
Navicula sp.5																												
Nitzschia acicularis (Kützing) W. Smith																												
Nitzschia dissipata (Kützing) Grunow Nitzschia palea (Kützing) W. Smith		r														r	r	•							•			
							•							•								•						
Nitzschia sp.1 Nitzschia sp.2							•							•								•						
Nitzschia sp.2 Nostoc punctiforme (Kutzing) Hariot																	I											
	•	•				•			•	•	•	•	•		3	·	•	•		•		•		2			1	•
Oedogonium sp.1 Oedogonium sp.2		•			I	•	4	1	•			•	•	+	3	r				•		•			1	1		•
Occystis borgei Snow		•			•	•	•		•			•	•							•		•						•
Oscillatoria amoena (Kutzing) Gomont		•				•			•			•	•							•		•						•
Oscillatoria amphibia (C.Agardh) Gomont	•	•					7"	7	•		•	•	•	•	•	•		•							•			•
Oscillatoria brevis Gomont		•			•	•	•	•	•		•	•	•	•				•				•						•
Oscillatoria formosa Bory			•				•	•			•					•	•				r r	•	•					
Oscillatoria limnetica Lemmermann	:		:	:		Ċ		:	:	:				:	:	:			:		•			:		r	:	
Oscillatoria limosa (C. Agardh) Gomont		r					Ċ				+					Ċ					+	·						
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Oscillatoria sp.1																				+						
Oscillatoria sp.2							•						•							•		•				
Oscillatoria sp.3 Oscillatoria subbrevis Lemmermann	•														;											:
Oscillatoria tenuis (C.Agardh) Gomont				1			•		•				1	1	1			•		•		•		1		+
Palmodyction viride Kützing	•	1 .			•	•	•	•	•	1		. +	•	1	•		•	•	•	•		•	•	•	•	
Pandorina morum (O. Müller) Bory de Saint-Vincent	•						•	•	•				•	•	•		•	•		•		•	•	•	•	
Pediastrum boryanum (Turpin) Meneghini	•			r r			r	•	•				•	•	•		•	•		•		•	•	•	•	
Pediastrum boryanum var. cornutum (Raciborski) Sulek	•				•	•	r	•	•	•	•			•	•	•	•		•	•		•	•	•		
Pediastrum duplex Meyen	•			r	•	•	•	•	•					•	•		•	•	•	•		•	•	•	•	
Pediastrum integrum Nageli							+																			
Pediastrum simplex Meyen	i.								·																	
Pediastrum tetras (Ehrenberrg) Ralfs																										
Phacus sp.																										
Phormidium retzii (C. Agardh) Gomont		r i	r .																					r		
Phormidium sp.																										
Phormidium valderianum (Delponte) Gomont																										
Pinnularia sp.1		r .												r												
Pinnularia sp.2																										
Rhodostichus expansus																										
Rhoicosphenia sp.																										
Scenedesmus arcuatus (Lemmermann) Lemmermann																										
Scenedesmus communis e.h.Hegewald				+			r					. r			r									r		
Scenedesmus ellipticus Corda							r																			
Scenedesmus falcatus Chodat																										
Scenedesmus granulatus W. West & G.S. West																										
Scenedesmus obtusus Meyen																										
Scenedesmus serratus (Corda) Bohlin		•				•		•	•								•									
Selenastrum sp. Spirogyra communis (Hassall) Kutzing		•				•		•	•								•									
Spirogyra fluviatilis Hilse in Rabenhorst							:		•				•		•			•		•		•	:		•	
Spirogyra sp.		1					+		•	3			•		•			•	1	•		•	÷		:	
Spirogyra sp.1		1					•		•			. 1	•		•			•	1	•		•			+	
Spirogyra sp.2	•				•	•	•	•	•				•	•	•		•	•	•	•		•	-	•	•	•
Staurastrum dilatatum Ehr.	•						•	•	•				•	•	•		•	•		•		•	•	•	•	
Stigeoclonium sp.	•			•			•	•	•	•	•		•	•	•	•	•	•		•	•	•	•	•		•
Surirella brebissonii Krammer & Lange-Bertalot	•				•	•	•	•	•					r	r		•	•	•	•		•	•	•		
Surirella sp.	-				-			-		-					r		-	-	-					-	•	
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Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing					•							r		r										r		r
Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre			· · ·									r		r r										r		r
Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp.								·				. r		r r	r									r		r
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Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing						· · · · · · · ·						r		r r	r									r		. r
Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing Uronema elongatum Hodgetts														. r r	r		· · · · · · · · ·						r	. r		. r
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Synedra ulna (Nitzsch) Ehrenberg Tabellaria flocculosa (Roth) Kützing Trachelomonas hispida (Perty) F. Stein ex Deflandre Trachelomonas sp. Ulothrix tenuissima Kützing Ulothrix zonata (Weber & Mohr) Kützing Uronema elongatum Hodgetts Vaucheria germinata (Vaucher) De Candolle Zygnema sp.						: : : : : :			:			. r		. r r 										. r		r
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Marcantia polymorpha L. Pellia endiviifolia (Dicks.) Dumort.		•	•	•	•	•		•											•		•					•
Riccia fluitans L.		+																								
Phanerogams riverbank species																										
Aegopodium podagraria L.																										
Agrostis stolonifera L.				+	2			1									1	2		1	+	1	+		3	
Alternanthera philoxeroides (Mart.) Griseb.																										
Anagallis arvensis L. ssp. arvensis																										
Angelica sylvestris L.																r										
Apium nodiflorum (L.) Lag. ssp. nodiflorum							r							r	+				1			+			+	
Arctium lappa L.	•																									
Artemisia annua L.																										
Artemisia verlotiorum Lamotte																										
Artemisia vulgaris L.	+																									
Arundo donax L.	•																									•
Arundo plinii Turra	•																									•
Atriplex patula L.	-		•		•	•			•	•					•	•			;		•					
Berula erecta (Huds.) Coville Bidens frondosa L.											:						:		1			:			2	•
	+		•		•	•			•	•	+			r	•	•	+					+	r		•	
Bidens tripartita L. Butomus umbellatus L.		•	•	•				r	•		+		•						•		r				•	
		•		•				•	2																	
Cardamine sp. Carex hirta L.		•	•	•				•	2				•						•		•				•	
Carex otrubae Podp.			•		•	•	•	•		•			•	•	•	•	•	•	•	•	•					
Carex otrubae Podp. Carex paniculata L. ssp. paniculata		•		•				•																		
Carex pendula Huds.							•	•					•	•					•	•			•			•
Carex pseudocyperus L.	•	•	•	•	•	•	•	•	•	•	-	•	•	•	1	•	1	•	•	•	•	•	•		1	
Chenopium album L.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	
Chenopodium ambrosioides L.	•		•		•	•	•	•	•	•	•		•	•				•	•	•			•	•	•	
Chenopodium polyspermum L.	•		•		•	•	•	•	•	•	•		•	•				•	•	•			•	•	•	
Cirsium arvense (L.) Scop.	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•		•	•	•	•	•	•	•
Cirsium creticum (Lam.) d'Urv.	•	•	•	•	•	+	•	•	r	•	•	•	+	r	•	•	•		•	•	•	•	•	•	•	•
Cirsium palustre (L.) Scop.																										
Conium maculatum L. ssp. maculatum																		·								
Conyza canadensis (L.) Cronq.										+																
Cyperus eragrostis Lam.																										
Cyperus fuscus L.	-																									
Cyperus longus L.									1																	
Cyperus rotundus L.																										
Datura stramonium L. ssp. stramonium																										
Dipsacus fullonum L.																										
Dorycnium rectum (L.) Ser.																										
Echinochloa crus-galli (L.) Beauv.																										
Eclipta prostrata (L.) L.																										
Eleusine indica (L.) Gaertner ssp. indica																										
Epilobium hirsutum L.	-				2	r		r	1	1			2	+		r						+	r		+	
Epilobium montanum L.	-												r													
Epilobium tetragonum L. ssp. tetragonum																										
Equisetum arvense L. ssp. arvense	•												r	r		+	+									•
Equisetum ramosissimum Desf.	-		•		•	•			•	•					•	•					•				•	
Equisetum telmateja Ehrh. Erigeron annuus (L.) Desf.	-		•		•	•			•	•					•	•					•				•	
Erigeron sumatrensis Retz.							•	•			•		•	•					•	•			•			•
Eupatorium cannabinum L. ssp. cannabinum	· •			1		•	ż	•	•	•	•		i		•			•		•			•	· i		
Galinsoga parviflora Cav.	1	1	т	1	т	•	-	•	•	•	•	1	1	1		1	т		-	•	т	т	•	1	т	
Galium palustre L. ssp. elongatum (C. Presl.) Lange		1	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•		•	•	•	•	•	•	•
Glyceria fluitans (L.) R. Br.			•	•	+	•	•	•	•	•	•	•	+		•	•	•	•		•	•	•	•	•	•	•
Glyceria notata Chevall.																										
Holcus lanatus L.								•					r													
Holoschenus romanus (L.) Fritsch.								:					-							+						
Hypericum androseum L.																										
Hypericum perforatum L.																										
Hypericum tetrapterum Fr.																										
Iris pseudacorus L.			+																							r
Juncus acutus L.																										
Juneus articulatus L.							r							1			+			+		r				
Juncus bufonius L.																										
Juncus conglomeratus L.							+															+				
Juncus effusus L. ssp. effusus																										
*																										

Juncus inflexus L.							+						r	r														
Lactuca saligna L.																												
Leersia oryzoides (L.) Sw.																												
Lycopus europaeus L.	1	r	r	r			1	+		+	1			r	r		+		+	+	+	+	+		+	1		+
Lysimachia nummularium L.																	r			r			r					
Lysimachia vulgaris L.	i	+	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•		•		•	•		•	•	•	•
Lythrum hyssopifolia L.	•		•	•	•	•	•	•	•	•	1	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•
Lythrum salicaria L.						•			•	:	1						•	•			1	•						
Mentha aquatica L. ssp. aquatica	-	+	1	1	•		2			-		•		1	1		:		:	1	2		т	:		T.		
Mentha longifolia (L.) Hudson		-	1	•	;		2	-		•		•	:	1			Τ.		Τ.	1	2			+		-		:
				•	1					•			+											•				+
Mentha pulegium L. ssp. pulegium																												r
Mentha spicata L.													r															
Mentha suaveolens Ehrh. ssp. suaveolens																												
Mentha x piperita L.																												
Myosotis scorpioides L. ssp. scorpioides				1																								
Nasturtium officinale R.Br. ssp. officinale																										2		
Paspalum distichum L.	+							+			+										+							
Persicaria lapathifolia (L.) Delarbre					+															+								
Persicaria maculosa (L.) Gray			r					r									r					r	+					
Petasites hybridus (L.) P. Gaertn., B. Mey. & Scherb.					1	2																						
Phalaris arundinacea L. ssp. arundinacea							1																					
Phragmites australis (Cav.) Trin. ssp. australis	2		1							2		2										1						
Phytolacca americana L.	_	-	-	-		-	-	-	-	_	-	_	-	-	-	-	•	-	•	-	-	-	•		•	-	-	•
Piptatheum miliaceum (L.) Coss. ssp. miliaceum		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•		•
Plantago major L.		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•		•
Polypogon monspeliensis (L.) Desf.		•		•		•	•	•	•	•	•			•			•	•		•		•	•			•		
Polypogon nodosum						•				•	•			•				•	•							•		
Polypogon nodosum		•		•																			•	•	•	•		•
Polypogon viridis (Gouan) Breistr.				•						•														•				
Pulicaria dysenterica (L.) Bernh.							:															:						
Ranunculus repens L.			+				1				+											I			+			
Ranunculus sceleratus L.																												
Raphanus raphanistrum L. ssp. raphanistrum																												
Rorippa amphibia (L.) Besser																			r					r		r		
Rorippa silvestris (L.) Besser								1									+											
Rumex conglomeratus Murray																												
Sambucus ebulus L.																												
Samolus valerandi L.		r																										
Scirpoides holoschoenus (L.) Sojak														r														
Scrophularia auriculata L. ssp. auriculata	+		+	+	+	r	+			+	+	3	+		r	r			1	2		r			r	+		+
Scutellaria galericulata L.																												
Senecio erucifolius L.																												
Senecio mikanioides Otto ex Walp.																												
Silene latifolia Poir. ssp. alba (Mill.) Greuter & Burdet																												
Solanum dulcamara L.					r	r			+				+			+	+					+					r	
Solanum lycopersicum L.																												
Solanum nigrum L. ssp. nigrum	-	-	-	-		-	-	-	-	-	-		-	-	-		-	-		-	-	-	-	-	•	-	-	-
Stachys palustris L.	+	•	•	•	•	•	+	•	•	•	•	•	•	•	r	•	•	•		•		•	•		•	•	r	•
Stellaria aquatica (L.) Scop.		•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•		•
Symphyotrichum squamatum (Spreng.) G.L. Nesom		•		•		•		•	•		•			•			•			•		•	•					•
Teucrium scordum L.		:				•	•			•	•			•			•				•			•				
		+				•				•	•			•				•	•							•		
Tussilago farfara L.						•	•			•	•			•										•				
Typha angustifolia L.																							:					
Typha latifolia L.							+							r						2			1					
Urtica dioica L. ssp. dioica										+																:		
Veronica anagallis-aquatica L. ssp. anagallis-aquatica							r			+			+											r		1		
Veronica beccabunga L.							+														r					+		
Xanthium orientale L. ssp. italicum (Moretti) Greuter																												

5. MACROPHYTIC INDICES; DESCRIPTIONS OF THE METHODOLOGIES FOR MTR, GIS AND IBMR

The following describes the methodologies of three macrophytic indices: MTR, GIS and IBMR.

Mean Trophic Rank, MTR (Newman et al., 1997)

First proposed by Holmes (Holmes 1995, 1996) and then improved with the subsequent publication of the guidance manual issued by Environment Agency of England (Newman et al., 1997), which identisies MTR as the standard methodology for the monitoring of waterways under the European Union Urban Waste Water Treatment Directive (UWWTD, 91/271/EEC). MTR is a method suitable for monitoring running watercourse, applicable throughout Great Britain, and based on the presence and abundance of aquatic macrophytes. The Mean Trophic Rank measures the impact of eutrophication on the macrophytic community, expressed as a biotic index with a score ranging from 10 to 100, where 100 corresponds to circumstances in which there is no kind of impact due to nutrients. The method is based on the attribution of an indicator value to 129 different species of macrophytes, according to their sensitivity or tolerance to high nutrient content. This value, referred to as Species Trophic Rank (STR), ranges from a minimum of 1 to a maximum of 10. Species with a high score are associated with oligotrophic watercourses, while those with low values include plant species tolerant to eutrophication or with wide ecological amplitude.

MTR was developed in particular to assess the impact of phosphate enrichment in running water courses. The method appears capable of responding to changes in the content of phosphates, even at concentrations below 1.0 mg/l or even 0.5 mg/l. The level of eutrophication due to nitrates cannot instead be determined with MTR.

The principle of the method is to observe, identify and record the species of macrophyte present in a stretch of water of standard length. A semi-quantitative estimate of the percentage of total coverage is also carried out, and each species is assigned a value of individual coverage (Species Cover Value) based on its abundance.

Sampling must be carried out only on plants that are located within the aquatic area, i.e. the area that is submerged more than 85% of the time. Bank vegetation is thus excluded, i.e. that part of the riverbed that is submerged more than 50% but less than 85% of the time (Newman *et al.*, 1997).

The stretch surveyed has a standard length of 100m and should be representative of the watercourse in question and possibly be distant enough from any localized disturbance factors (bridges, dikes, dams, etc.). The method foresees in the field estimation of the total and of the specific percentage cover. Then, according to the specific percentage cover, a Species Covers Value is assigned adopting one of the two following scales:

Table a: Specific percentage cover classes for the Mean trophic rank (Newman et al., 1997).

Scale A		Scale B		
(for 500)	m surveys)	(for 100	m surveys)	
A1	<0.1 %	C1	<0.1 %	r
A2	0.1-1 %	C2	0.1-1 %	+
A3	1-5 %	C3	1-2.5 %	1
A4	5-10 %	C4	2.5-5 %	1
A5	>10 %	C5	5-10 %	2-
		C6	10-25 %	2
		C7	25-50 %	3
		C8	50-75 %	4
		C9	>75 %	5

The calculation of the MTR score follows a set of steps. First, each species present in the field and listed in the table below is assigned the corresponding score, the Species Trophic Rank (STR), which assigns to certain species an indicator value:

Table b:List of indicator taxa and their related score (STR - Species Trophic Rank) (Newman et al., 1997)

ALGAE					
	STR		STR		STR
Batrachospermum spp.	6	Cladophora spp. (eccetto C. aegagropila)	1	Enteromorpha spp.	1
Hildebrandia rivularis	6	Hydrodiction reticulatum	3	Lemanea fluviatilis	7
Stigeoclonium tenue	1	Vaucheria spp.	1		
LIVERWORTS				_	
Chiloscypus polyanthos	8	Jungermania atrovirens	8	Marsupella emarginata	10
Nardia compressa	10	Pellia endiviifolia	6	Pellia epiphylla	7
Scapania undulata	9				
MOSSES			•		•
Amblystegium fluviatile	5	Amblystegium riparium	1	Blindia acuta	10
Brachytecium plumosum	9	Brachytecium rivulare	8	Brachytecium rutabulum	3
Bryum pseudotriquetrum	9	Calliergum cuspidatum	8	Clinclidotus fontinaloides	5
Dichodontium flavescens	9	Dichodontium	9	Dicranella palustris	10

		pellucidum			
Fontinalis antipyretica	5	F		Hygrohypnum	
1,5		Fontinalis squamosa	8	ochraceum	9
Hygrohypnum luridum	9	Hyocomium armoricum	10	Philonotis fontana	9
Polytrichum commune	10	Racomitrium aciculare	10	Rhyncostegium riparioides	5
Sphagnum spp.	10	Thamnobryum alopecurum	7	Inputionals	
PTERIDOPHYTES	<u>I</u>	uropeeurum			
Azolla filiculoides	3	Equisetum fluviatile	5	Equisetum palustre	5
DICOTYLEDONS	J	Equiscium nuviaine	1 3	Equiscium parusuc	3
Apium inundatum	9	Apium nodiflorum	4	Berula erecta	5
Callitriche		Callitriche hamulata	9	Callitriche obtusangula	5
(specie indeterminate)		Cumurene mamarata	_	Cumminene obtusungunu	3
Ceratophyllum demersum	2	TT:ii-	4	Littorella uniflora	8
Lotus pedunculatus	8	Hippuris vulgaris			
Myriophyllum alterniflorum	8	Menyanthes trifoliata Myriophyllum	9	Montia fontana Myriophyllum	8
Wynophynum atternmorum	0	spicatum	3	(specie indeterminate, eccetto M. aquaticum)	0
Nuphar luteum	3	Nymphaea alba	6	Nymphoides peltata	2
Oenanthe crocata	7	Oenanthe fluviatilis	5	Polygonum amphibium	4
Potentilla erecta	9	Ranunculus	5	Ranunculus aquatilis	5
		(spp del sottogenere Batrachium)			
Ranunculus circinatus	4	Ranunculus flammula	7	Ranunculus fluitans	7
Ranunculus hederaceus	6	Ranunculus omiophyllus	8	Ranunculus peltatus	4
Ranunculus penicillatus	5	Ranunculus penicillatus (subspecie penicillatus)	6	Ranunculus penicillatus (subspecie pseudofluitans)	5
Ranunculus trichophyllus	6	Ranunculus sceleratus	2	Rorippa amphibia	3
Rorippa nasturtium-aquaticum (Nasturtium officinale)	5	Rumex hydrolapathum	3	Veronica (specie indeterminate o ibridi)	4
Veronica anagallis-aquatica	4	Veronica catenata	5	Veronica scutellata	7
Viola palustris	9				
MONOCOTYLEDONS					
Acorus calamus	2	Alisma plantago- aquatica	3	Alisma lanceolatum	3
Bolboschoenus maritimus	3	Butomus umbellatus	5	Carex acuta	5
Carex acutiformis	3	Carex riparia	4	Carex rostrata	7
Carex vesicaria	6	Catabrosa aquatica	5	Eleocharis palustris	6
Eleogiton fluitans	10	Elodea canadensis	5	Elodea nuttallii	3
Glyceria maxima	3	Liouca canduciisis	3	Hydrocharis morsus-	J
. ,		Groenlandia densa	3	ranae	6
Iris pseudacorus	5	Juneus bulbosus	10	Lemna gibba	2
Lemna minor			3	Lemna trisulca	4
	4	Lemna minuta	3		
Phragmites australis	4	Potamogeton (specie indeterminate)	3	Potamogeton alpinus	7
Phragmites australis Potamogeton berchtoldii		Potamogeton (specie indeterminate)	3	Potamogeton alpinus	7
	4	Potamogeton			·

		pectinatus		perfoliatus	
Potamogeton polygonifolius	10	Potamogeton praelongus	6	Potamogeton pusillus	4
Potamogeton trichoides	2	Sagittaria sagittifolia	3	Schoenoplectus lacustris	3
Sparganium emersum	3	Sparganium erectum	3	Spirodela polyrhiza	2
Typha latifolia	2	Typha angustifolia	2	Zannichellia palustris	2

Once each taxa is given the Species Trophic Rank, this value is multiplied by the cover coefficient (Species Cover Value), given on the basis of the A or C scale (table a), to obtain the Cover Value Score for each individual specie.

To finish, the summation of the Cover Value Scores of all the indicator species (i.e. that are present in the table above) is divided by the sum of the Species Cover Values and the result multiplied by 10 to give the Mean Trophic Rank.

$$MTR = \frac{\sum SCV}{\sum CVS} \cdot 10$$

The value obtained is not however used to classify the site by conferring a quality class. Rather it provides a generic indication on the state of stretch of water in question:

- sites with an MTR score greater than 65 are unlikely to be eutrophic. However, these sites may be at risk of becoming eutrophic and the value of MTR should be compared with that expected for a stretch of water that is physically similar;
- sites with an MTR score less than 25 are severely damaged by eutrophication, or by organic pollution, or by toxicity, or are physically damaged;
- sites with an MTR score ranging between 25 and 65 are likely to be eutrophic or at risk of becoming so.

However, given that the MTR value could also only be lowered by the physical characteristics of the site, the MTR score should be compared with a value expected in a stretch of water that is morphologically similar. This fact is probably more relevant in sites with an MTR score ranging between 45 and 65; below a value of 45 it is likely that the site shows an impact due to eutrophication. Sites with a large number of species that are not affected can often have an MTR score ranging between 45 and 65. This is due to the

large number of species with a Species Trophic Rank value ranging between 4 and 6, lowering the MTR score to a range between 40 and 60. Sites that are clearly not affected (for example those with more than 20 species present) should be recognized as such within this category. The Mean Trophic Rank has the advantage of being an index based on a larger number of indicator species compared to the Macrophyte Index Scheme, since the table takes into account nearly 129 taxa. The method of calculation is more rigorous, as it is starts with semi-quantitative coverage data that is not based on totally arbitrary judgments.

The coverage allocation scale brings, however, limitations to the methodology, as it requires the discrimination between levels of cover that are very close, such as 2.5 and 5%.

One of the major limitations in applying the MTR in other countries is that this methodology has been devised and created with a specific purpose. The MTR was in fact elaborated to meet the demands of the Urban Waste Water Treatment Directive (UWWTD), as a tool to monitor the impact on the macrophytic community due to organic discharges (Newman *et al.*, 1997). This index may therefore not be suitable for more generic biomonitoring purposes, which involve for example the need to assess the impact of diffuse sources of pollution.

Lastly, great attention should be paid when using the MTR in sites presenting few indicator taxa: it seems plausible to calculate the MTR for sites that have at least 5 indicator taxa and to consider the result valid with certainty only when at least 10 indicator taxa are found (Holmes, 1995). The number of species taken into account by the MTR is high; however it is calibrated to the British context and many species listed in the table are not very common in Italy.

Groupement d'Intérêt Scientifique, GIS (Haury et al., 1996)

The GIS indices (Haury *et al.*, 1996) arise from studies of a French working group comprising technicians and researchers called the "Groupement d'Intérêt Scientifique", and can be used to monitor the quality of running waterways in different contexts – climatic, of mineralization, of pH, of trophic dynamics and of physical environment.

The group has formalized several types of indices that include the survey of the aquatic population and of the aquatic population at the optimal riverbed level (during wet periods when the river flows with plenty of water). The indices developed by the GIS entail that the inventory of plant species is carried out between May and October, on stretches of water that are at least 50m long, preferably homogeneous in terms of flow conditions and shading. Furthermore, together with the indices of presence/absence, indices of abundance/dominance are also considered.

Table c: coverage ratios attributed to different species according to their percentage of site coverage (Haury et al., 1996).

Percentage of coverage r	Description	abundance/dominance coefficient
+	few individuals with very limited coverage	0,5
r < 5%	fairly numerous individuals with coverage below 5%	1
$5\% \le r < 25\%$	individuals very numerous and cover between 5 and 25%	2
25% ≤ r < 50%	individuals very numerous and cover between 25 and 50%	3
$50\% \le r < 75\%$	individuals very numerous and cover between 50 and 75%	4
$r\!\geq 75\%$	individuals very numerous and cover than or equal to 75%	5

GIS indices make reference to two distinct areas within the riverbed, defining as riverbank the portion of the river bed that is inundated for at least 40% of the year and as aquatic the area that is permanently submerged (Holmes and Whitton 1977, Haury *et al.*, 1996).

For natural waterways, the aquatic zone coincides with the water level during dry periods when the river runs with little water, while the riverbank zone coincides to the water level during wet periods, when the river flows with plenty of water.

GIS indices take into account as indicators 200 taxa: certain genuses of algae and mosses, certain species of liverworts and mosses, few

pteridophytes and numerous phanerogams.

For each indicator taxon, specific coefficient of increasing sensitivity are defined (Csi), ranging between 1 and 10.

The score ranges from a minimum value of 0, assigned to taxa that live in heavily degraded waters with high organic pollution and characterized by colonies of heterotrophic fungi and bacteria, to a maximum value of 10, for species that colonize environments with good water quality without detectable signs of pollution.

Table d: List of indicator taxa and relative score (Haury et al., 1996)

ALGAE AND CYANOBACTERIA	Csi (A)	Csi (A+R)
Audouinella sp.	4	4
Batrachospermum sp.	8	8
Chara sp.	6	6
Cladophora aggregate	3	3
Drapalnaldia sp.	9	9
Enteromorpha sp.	2	2
Hildenbrandia rivularis	7	7
Hydrodictyon reticulatum	2	2
Lemanea sp.	7	7
Melosira sp.	4	4
Nitella sp.	6	6
Oscillatoria sp.	3	3
Phormidium sp.	2	2
Rhizoclonium sp.	4	4
Spirogira sp.	5	5
Stigeoclonium sp.	1	1
Ulothrux sp.	5	5
Vaucheria sp.	2	2
BRYOPHYTES - LIVERWORTS		
Chiloscyphus polyanthus	7	7
Conocephulum conicum		7
Lunularia cruciata		5
Marcantia polymorpha		6
Marsupella aquatica		9
Marsupella emarginata		9
Nardia compressa	10	10
Nardia acicularis	10	10
Pellia sp.		6
Porella cordeana		7
Porella pinnata	7	7
Porella platyphylla		7
Riccardia pinguis	7	7
Riccardia sinuata	7	7

Riccia fluitans	3	3
Scapania undulata	8	8
Solenostoma crenulata	10	10
Solenostoma triste	10	10
MOSSES		
Amblystegium fluviatile	5	5
Amblystegium riparium	3	3
Amblystegium tenax		7
Brachythecium rivulare		7
Cinclidotus aquaticus	6	6
Cinclidotus danubicus	5	5
Cinclidotus fontinaloides	5	5
Cinclidotus riparus	6	6
Cratoneuron commutatum	7	7
Cratoneuron filicinum		8
Drepamocladus aduncus		7
Fissidens sp.	7	7
Fontinalias antipyretica	5	5
Fontinalias squamosa	9	9
Hookeria lucens		8
Hygrohypnum dilatatum	10	10
Hygrohypnum luridum	10	10
Hygrohypnum ochraceum	10	10
Hyocomium armoricum	10	10
Mnium punctatum		8
Octodiceras fontanum	5	5
Pachyfissidens grandifrons	6	6
Philonotis caespirosa		7
Platyhypnidium rusciforme	5	5
Rhacomitrium aciculare		9
Schistidium rivulare		9
Sphagnum gr. nundatum	10	10
Sphagnum gr. palustre		9
Thamnium alopecurum		7
PTERYDOPHYTES		
Azolla filiculoides	3	3
Azolla caroliniana	3	3
Osmunda regalis		7
Equisetum fluviatile	6	6
Equisetum palustre	5	5
PHANEROGAMS DICOTYLEDON		
Apium inundatum	7	7
Apium nodiflorum	5	5
Berula erecta	6	6
Callitriche hamulata	6	6

Callitriche obtusangula	4	4
Callitriche platycarpa	5	5
Callitriche stagnalis	6	6
Callitriche truncata	6	6
Caltha palustris	6	6
Cartdamine umura		7
Ceratophyllum submersum	2	2
Chrysosplenium alternifolium		7
Chrysosplenium oppositifolium		7
Galium palustre	6	6
Helodes palustris	8	8
Hippuris vulgaris	4	4
Hottonia palustris	6	6
Hydrocotyle vulgaris	7	7
Lycopus europaeus	,	5
Lysmachia momullaria		6
Lysmachia thyrsiflora		6
Lysmachia vulgaris		6
Lythrum salicaria		5
Mentha aquatica	6	6
Mentha longifolia	0	7
Montia fontana		7
Myosotis gr. scorpioides	6	6
	O	5
Myosoton aquaticum	7	7
Myriophillum alterniflorum	3	3
Myriophyllum spicatum	5	5
Myriophyllum verticillatum		3
Nusturium officinale	4	
Nuphar luteum	4	4
Nymphaea alba	6	6
Oenanthe aquatica	5	5
Oenanthe crocata	6	6
Oenanthe fluviatilis	4	4
Peplis portula		6
Petasites hybridus		6
Pencedanum palustre		6
Polygonum amphibium	4	4
Polygonum hydropiper	4	4
Potentilla palustris	7	7
Ranunculus aquatilis	5	5
Ranunculus baudotii	5	5
Ranunculus circinatus	5	5
Ranunculus flammula	7	7
Ranunculus fluitans	4	4
Ranunculus hederaceus	5	5

Ranunculus hololeucos	9	9
Ranunculus omiophillos	9	9
Ranunculus peltatus	6	6
Ranunculus penicillatus var. calcareus	6	6
Ranunculus penicillatus var. penicillatus	6	6
Ranunculus rionii	4	4
Ranunculus sardous		5
Ranunculus sceleratus	4	4
Ranunculus trichophyllus	4	4
Rorippa amphibia	3	3
Rumex hydrolapathum		3
Scrophularia auriculata		5
Scrophularia umbrosa		5
Scutellaria galericulata		6
Sibthorpia europaea		7
Sium latifolium		3
Solanum dulcamara		5
Stachys palustris		5
Stellaria alsine		7
Trapa natans	4	4
Veronica anagallis-aquatica	5	5
Veronica beccabunga	4	4
Veronica catenata	5	5
Veronica scutelluta		6
Viola palustris		8
PHANEROGAMS MONOCOTYLEDONS		
Acorus calamus	4	4
Agrostis stolonifera	4	4
Alisma lanceolatum	4	4
Alisma plantago-aquatica	4	4
Alopecorus geniculatus		4
Alopecorus fulvus		5
Butomus umbellatus	4	4
Carex acuta		6
Carex acutiformis		5
Carex elata		6
Carex nigra		8
Carex paniculata		6
Carex paniculata		7
Carex pseudocyperus		4
Carex riparia		4
Carex rostrata		8
Carex vesicaria		6
Catabrosa aquatica	6	6
Cyperus vegetus		6

Eleocharis acicularis	7	7
Eleocharis palustris	6	6
Elodea canadensis	5	5
Elodea densa	4	4
Elodea callitrichoides	3	3
Elodea nuttallii	3	3
Eriophorum angustifolium	3	8
Glyceria fluitans	6	6
Glyceria naxima	3	3
•	3	5
Glyceria notata	4	4
Groenlandia densa		
Hidrocharis morsus-ranae	5	5
Iris pseudocorus	5	
Juncus aentiflorus	_	7
Juncus articulatus	5	5
Juncus bufonius		6
Juncus bulbosus	7	7
Juncus conglomeratus	4	
Juncus effusus	5	
Juncus inflexus	5	
Juncus ranarius		6
Juncus subnodulosus		8
Leersia oryzoides		4
Lemna gibba	2	2
Lemna minuscola	3	3
Lemna minor	5	5
Lemna trisulca	6	6
Luronium natans	7	7
Molinia coerulea		7
Najas marina	3	3
Nymphoides peltata	4	4
Phalaris arundinacea	5	5
Phragmites australis	4	4
Potamogeton acutifolius	6	6
Potamogeton alpinus	6	6
Potamogeton berchtoldii	5	5
Potamogeton coloratus	10	10
Potamogeton compressus	3	3
Potamogeton crispus	4	4
Potamogeton friesii	5	5
Potamogeton gramineus	4	4
Potamogeton helveticus	4	4
Potamogeton lucens	4	4
Potamogeton natans	6	6
Potamogeton nitens	5	5
0-10/1 /11/01/0	3	3

Potamogeton nodosus	2	2
Potamogeton obtusifolius	5	5
Potamogeton pectinatus	1	1
Potamogeton perfoliatus	4	4
Potamogeton panormitanus	5	5
Potamogeton polygonifolius	9	9
Potamogeton spathulatus	7	7
Potamogeton trichoides	4	4
Potamogeton variifolius	6	6
Sagittaria sagittifolia	3	3
Scirpus fluitans	8	8
Scirpus lacustris	4	4
Scirpus maritimus		4
Scirpus setaceus		8
Scirpus sylvaticus		6
Scirpus tabernae-montani	6	6
Sparganium angustifolium	10	10
Sparganium emersum	5	5
Sparganium erectum	5	5
Sparganium minimum	6	6
Spirodela polyrhiza	3	3
Typha angustifolia		4
Typha latifolia	3	
Vallisneria spiralis	3	3
Wolffia arhiza	4	4
Zannichellia palustris	2	2

It is possible to calculate different GIS indices: for the aquatic zone (A), for the aquatic + riverbank zone (A + R), and both for presence/absence and for abundance/dominance, according to the following formulas:

$$GIS(aq)abundance / do \min ance = \frac{\left(\sum ADi \cdot CSi\right)}{\sum ADI}$$

$$GIS(aq)$$
 presence | absence = $\sum \frac{CSi}{n}$

The value of each GIS index can vary between 1 and 10 along a gradient of increasing sensitivity.

The authors of the methodology suggest on the basis of statistical studies,

that there is a correlation between the values given by the indices and the concentrations in water of ammonia nitrogen and orthophosphates, approximately so:

GIS > 7 for concentrations below 50 mg/l;

5 < GIS < 7 for concentrations ranging between 50 mg/l and 100 mg/l;

GIS < 5 for concentrations greater than 100–150 mg/l;

As this division of the intervals does not allow good discrimination in situations of medium to high degradation, most of the stations sampled, because they are characterized by this type of degradation, would fall within the lower range, even though displaying very different trophic loads. Hence the need to use a scale with 5 intervals, as structured and elaborated by certain Italian authors (Azzollini *et al.*, 2003) following a study on the applicability of different macrophytic indices including GIS. In this scale, each of the 5 GIS intervals is assigned a colour conventionally used in the monitoring of waterways, to make it easier to discriminate and read the results. The final GIS value obtained is then correlated with a numerical scale that refers to 5 different levels of organic pollution, expressible by an overall assessment of water quality:

Table e: Conversion table for GIS values in quality classes

GIS value	Assessment	Quality classes	Reference colour
8,2 <gis<10< td=""><td>Unpolluted environment or not altered significantly</td><td>Class I</td><td>Blue</td></gis<10<>	Unpolluted environment or not altered significantly	Class I	Blue
6,4 <gis<8,2< td=""><td>Environment with moderate symptoms of pollution or alteration</td><td>Class II</td><td>Green</td></gis<8,2<>	Environment with moderate symptoms of pollution or alteration	Class II	Green
4,6 <gis<6,4< td=""><td>Polluted environment</td><td>Class III</td><td>Yellow</td></gis<6,4<>	Polluted environment	Class III	Yellow
2,8 <gis<6,4< td=""><td>Highly polluted environment</td><td>Class IV</td><td>Orange</td></gis<6,4<>	Highly polluted environment	Class IV	Orange
GIS<2,8	Heavily polluted environment	Class V	Red

Macrophyte Biological Index for River, IBMR (AFNOR, 2003)

This index represents an improvement on an earlier system published by the Group of Scientific Interest "Macrophytes of Inland waters" (Haury *et al.*, 1996). The IBMR is used for assessing eutrophication in running waters.

Two criteria are considered for each macrophyte taxon. The scores (CSi), range from 0 (heavy organic pollution with heterotrophic taxa) to 20 (oligotrophy). The overall value for "water quality" is determined by two nutrients: orthophosphate and ammonium, with heavy organic pollution indicated by the presence of sewage fungi. The species distribution range across four trophic classes (oligotrophic, mesotrophic, eutrophic, hypertrophic) that are recorded using a coefficient of ecological amplitude (Ei): coefficient 1, representing wide amplitude, covers three trophic classes, and coefficient 3, representing a very narrow amplitude, is restricted to just one class.

The surveys should be conducted along 50-100m long stretches, which include both fast and slow flowing water habitats.

Table f: K_i coefficient values based on the percentage of coverage (AFNOR, 2003).

K _i VALUES	DESCRIPTION	% COVERAGE
1	Species is only present	coverage < 0,1%
2	Species present with poor coverage	$0.1\% \le \text{coverage} < 1\%$
3	Species quite frequent with slight coverage	$1\% \le \text{coverage} < 10\%$
4	Species with average coverage	$10\% \le \text{coverage} < 50\%$
5	Species very abundant or with high coverage	coverage ≥ 50 %

Table g: Taxa considered for the calculation of the IBMR with relative specific scores for

oligotrophy (Csi) and ecological amplitude (Ei) (AFNOR, 2003).

	Cs _i	Ei		Cs _i	Ei
HETEROTROPHIC ORGANISMS					
Leptomitus sp.	0	3	Sphaerotilus	0	3
ALGAE					
Audouinella sp. Bory de St Vincent	13	2	Bangia atropurpurea Lyngbye	10	2
Batrachospermum sp. Roth	16	2	Binuclearia sp. Wittrock	14	2
Chaetophora sp. Schrank	12	2	Chara globularis Thuill.	13	1
Chara hispida (L.) Vaillant	15	2	Chara vulgaris L.	13	1
Cladophora sp. Kützing	6	1	Diatoma sp. Bory de St Vincent	18	3

Draparnaldia sp. Bory de St Vincent	18	3	Enteromorpha intestinalis Link	3	2
Hildenbrandia rivularis Nardo	15	2	Hydroddictyon reticulatum Roth	6	2
Hydrurus foetidus C. Agardh	16	2	Lemanea gr. fluviatilis Bory de St Vincent	15	2
Lyngbya sp. C. Agardh	10	2	Melosira sp. C. Agardh	10	1
Microspora sp. Thuret	12	2	Monostroma sp. Thuret	13	2
Mougeotia sp. C. Agardh + Mugeotiopsis sp. C. Agardh+ Debarya sp. Wittrock	13	2	Nitella flexilis L. Agardh	14	2
Nitella gracilis (Smith) Agardh	14	2	Nitella mucronata (A. Br.) Miquel	14	2
Nostoc sp. Vaucher	9	1	Oedogonium sp. Link	6	2
Oscillatoria sp. Vaucher	11	1	Phormidium sp. Kützing	13	2
Rhizoclonium sp. Kützing	4	2	Schizomeris sp. Kützing	1	3
Sirogonium sp. Kützing	12	2	Spirogyra sp. Link	10	1
Stigeoclonium sp. Link (eccetto S. tenue)	13	2	Stigeoclonium tenue Link	1	3
Tetraspora sp. Link	12	1	Thorea ramissossima Bory de St Vincent	14	3
Tolypella glomerata Leonhardi	12	2	Tolypella prolifera Leonhardi	15	3
Tribonema sp. Derbès & Solier	11	2	Ulothrix sp. Kützing	10	1
Vaucheria sp. De Candolle	4	1	Zygnema sp. C. Agardh	13	3
LICHENS	l				
Dermatocarpon weberi (Ach.) Mann.	16	3	Collema fluviatile (Huds) Steud	17	3
BRYOPHYTES - LIVERWORTS				ı	
Chiloscyphus pallescens (L.) Corda	14	2	Chilloscyphus gr. polyanthus (L.)	15	2
Marsupella aquatica (Lindenb.) Shiffn	19	2	Corda Marsupella emarginata (Ehrh.) Dum	20	3
Nardia acicularis S. F. Gray	20	3	Nardia compressa (Shook.) Gray	20	3
Porella pinnata L.	12	2	Riccardia multifida (L.) Gray	15	2
Riccardia pinguis (L.) Gray	14	2	Riccardia sinuata (Dicks.) Trev.	15	2
Riccia fluitans (L.)	8	3	Scapania paludosa K. Müll.	20	3
Scapania undulata (L.) Dum	17	3	Solenostoma crenulatum (Sm.) Mitt.	20	3
Solenostoma triste (Nees) K. Müll.	19	3			
BRYOPHYTES - MOSSES					
Amblystegium fluviatile (Hedw.) B., S., & G. (= Hygroamblistegium fluviatile)	11	2	Amblystegiu riparium (Hedw.) B., S., & G.(= Leptodictyum riparium)	5	2
Amblystegium tenax <i>Hedw. Jenn.</i> (= Hygroambl. tenax)	15	2	Brachytecium plumosum (Sw.) B. e.	18	3
Brachytecium rivulare B. e.	15	2	Cinclidotus danubicus Schiffn. & Baumgartner	13	3
Cinclidotus fontinaloides (Hedw.) P. Beauv.	12	2	Cinclidotus riparius (Web. & Mohr.) Arnott	13	2

Roth Drepanocladus aduncus (Hedw.) Drepanocladus fluitans (Hedw.) Warnot. Fissidens crassipes Br. Eur. 12 2 Fissidens polyphyllus Br. Eur. 13 Fissidens polyphyllus Br. Eur. 14 3 Fissidens rufulus Br. Eur. 14 3 Fissidens rufulus Br. Eur. 15 3 Fissidens pusillus Wils. 16 3 Fissidens wiridulus (Sw.) Fontinalis antipyretica Hedw. 16 3 Hygrohypnum dilatatum (Schimp. 17 3 Hygrohypnum ochraceum (Wils.) 18 3 Loeske 19 3 Hygrohypnum ochraceum (Wils.) 19 3 Loeske 19 3 Hygrohypnum ochraceum (Wils.) 19 3 Loeske 19 3 Hygrohypnum ochraceum (Wils.) 19 3 Loeske 19 Octodiceras fontanum (La Pyl.) 19 3 Lindb. 10 Orthotrichum rivulare turn 15 3 Pachyfissidens grandifrons (Brid.) 11 Lindb. 12 Schimp. 13 Philonotis gr. fontana Milde 18 3 Pachyfissidens grandifrons (Brid.) Lindb. 18 3 Pachyfissidens grandifrons (Brid.) Lindb. 19 Schimp. 10 Philonotis gr. fontana Milde 18 3 Pachyfissidens grandifrons (Brid.) Lindb. 10 Philonotis gr. fontana Milde 18 3 Pachyfissidens grandifrons (Brid.) Lindb. 10 Philonotis gr. fontana Milde 18 3 Pachyfissidens grandifrons (Brid.) Lindb. 10 Philonotis gr. fontana Milde 18 3 Pachyfissidens grandifrons (Brid.) Lindb. 18 3 Eur.) Fleisch.(= Rhynchostegium riparioides) 19 Andrew (Fleisch.) 10 Philonotis calcarea (B. & S.) 18 2 Schimp. 10 Phayphpidium rusciforme (Br. Brid.) 10 Phayphidium rivulare (= Grimmia rivularis Brid.) 15 3 Sphagnum gr. denticulatum (S. 20 3 inundatum Russ.) 16 3 Pachyfissidens grandifrons (Br. Brid.) 17 3 Agrostis stolonifera L. fo Aq. 18 2 Equisetum pluviatile L. (= E. 12 2 Elimosum) 18 2 Equisetum pluviatile L. (= E. 12 2 Elimosum) 19 2 Alisma plantago-aquatica L. 20 3 Agrostis stolonifera L. fo Aq. 20 4 Alisma plantago-aquatica L. 20 5 Alimiche hamulata Kitzing ex. 21 1 Callitriche obtusangula Le Gall 21 Callitriche hamulata Kitzing ex. 22 2 Callitriche hamulata Kitzing ex. 23 2 Callitriche bamulata Kitzing ex. 24 2 Callitriche bamulata Kitzing ex. 25 2 Cartaphyllum submersum L. 26 2 Catabrosa aquatica (L.) Beauv. 27 2 2 Elodea canadensis Michx 28 2 Elodea canadensis Michx 29 2 2 E	Cratoneuron commutatum (Hedw.)	15	2	Cratoneuron filicinum Hedw.	18	3
Warnot. Fissidens crassipes Br. Eur. 12 2 Fissidens minutulus 14 3 5 5 5 5 5 5 5 5 5	Roth			Spruce		
Fissidens polyphyllus Br. Eur. Fissidens rufulus Br. Eur. Fontinalis antipyretica Hedw. Fontinalis squamosa Hedw. Fontinalis dariesi Schimp. Hygrohypnum dilatatum Ipparobypnum dilatatum Ipparobypnum ochraceum (Wils.) Fontinalis squamosa Hedw. Fontinalis squamosa Hedw. Fontinalis dariesi Schimp. Fyrohypnum dilatatum Ipparobypnum ochraceum (Wils.) Fyrohypnum ochraceum (Islaum Ipparobypnum ochraceum (Islaum Ipparobypnum ochraceum (Islaum Ipparobypnum Ipparobypnum ochraceum (Islaum Ipparobypnum Ipparobypnum ochraceum (Islaum Ipparobypnum Ipparobypnum Ipparobypnum Ipparobypnum Ipparobypnum Ipparobyp		15	3		14	2
Fissidens rufulus Br. Eur. Fontinalis antipyretica Hedw. Fontinalis squamosa Hedw. Fontinalis squamosa Hedw. Fontinalis squamosa Hedw. Hygrohypnum luridum (Hedw.) Jenn. Hygrohypnum luridum (Hedw.) Jenn. Hygrohypnum ochraceum (Wils.) Loeske Hygrohypnum armoricum (Brid.) Wijk & Marg. (= H. flagellare) Orthotrichum rivulare turn Fontinalis duriaei Schimp. Loeske Hygrohypnum ochraceum (Wils.) Loeske Octodiceras fontanum (La Pyl.) Lindb. Orthotrichum rivulare turn Fontinalis duriaei Schimp. Hygrohypnum ochraceum (Wils.) Loeske Octodiceras fontanum (La Pyl.) Lindb. Philonotis gr. fontana Milde Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Philonotis gr. fontanum (La Pyl.) Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Philonotis gr. fontanum (La Pyl.) Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Playrohypnum dilatatum (La Pyl.) Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Playrohypnum dilatatum (La Pyl.) Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Fontinalis duriaei Schimp. Playrohypnum dilatatum (La Pyl.) Fontinalis duriaei Schimp. Fontinalis duriaei Sc	Fissidens crassipes Br. Eur.	12	2	Fissidens minutulus	14	3
Fontinalis antipyretica Hedw. 10	Fissidens polyphyllus Br. Eur.	20	3	Fissidens pusillus Wils.	14	2
Fontinalis squamosa Hedw. Hygrohypnum luridum (Hedw.) Jenn. Hygrohypnum luridum (Hedw.) Jenn. Hygrohypnum luridum (Hedw.) Jenn. Hygrohypnum ochraceum (Wils.) Loeske Hygrohypnum ochraceum (Wils.) Loeske Hygrohypnum ochraceum (Wils.) Loeske Hygrohypnum ochraceum (Wils.) Loeske Cotodiceras fontanum (La Pyl.) 7 3 Beachyfissidens grandifrons (Br. Schimp.) Philonotis gr. fontana Milde 18 3 Philonotis calcarea (B. & S.) 18 2 Schimp. Philonotis gr. fontana Milde 18 3 Philonotis calcarea (B. & S.) 18 2 Schimp. Phatyhpnidium rusciforme (Br. Eur.) Fleisch.(= Rhynchostegium riparioides) Schistidium rivulare (= Grimmia 15 3 Sphagnum gr. denticulatum (S. 20 3 inundatum Russ.) Sphagnum palustre L. 20 3 Thamilum alopecurum (Hedw.) 15 2 B. e. PTERYDOPHYTES Azolla filiculoides lam. 6 3 Equisetum fluviatile L. (= E. 12 2 limosum) Equisetum palustre L. 10 1 PHANEROGAMS Acorus calamus L. Alisma lanceolatum With 9 2 Alisma plantago-aquatica L. Apium inundatum L. (= Sium inundatum Rus.) Berula erecta (Huds.) Coville (= 14 2 Butomus umbellatus L. 9 2 2 Sium erectum, Siella erecta) Callitriche hamulata Kitzing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kitzing 10 1 Callitriche stagnalis Scop. 12 2 Cara rostrata Stokes 15 3 (Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. Elocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2	Fissidens rufulus Br. Eur.	14	3		11	2
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Hygrohypnum luridum (Hedw.) Jenn. 19 3 Loesske 10 10 10 10 10 10 10 1	Fontinalis squamosa Hedw.	16	3		19	3
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Schistidium rivulare (= Grimmia rivularis Brid.) Sphagnum palustre L. 20 3 Thamnium alopecurum (Hedw.) 15 2 PTERYDOPHYTES Azolla filiculoides lam. 6 3 Equisetum fluviatile L. (= E. 12 2 limosum) PHANEROGAMS Acorus calamus L. Alisma lanceolatum With 9 2 Alisma plantago-aquatica L. Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= 14 2 limosus m.) Berula erecta (Huds.) Coville (= 14 2 limosus m.) Berula erecta (Huds.) Coville (= 14 2 limosus m.) Berula erecta (Huds.) Coville (= 14 2 limosus m.) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Elodea canadensis Michx	Eur.) Fleisch.(= Rhynchostegium	12	1	Rhacomitrium aciculare (Hedw.)	18	3
PTERYDOPHYTES Azolla filiculoides lam. Equisetum palustre L. 10 1 PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kiitzing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kiitzing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. 12 2 Elodea canadensis Michx Equisetum fluviatile L. (= E. 12 2 2 Ilimosum) Equisetum fluviatile L. (= E. 12 2 2 Ilimosum) Agrostis stolonifera L. fo Aq. 10 1 Alisma plantago-aquatica L. 8 2 Apium nodiflorum (L.) Lag. 10 1 (Helosciadium n., Sium n.) Butomus umbellatus L. 9 2 Callitriche obtusangula Le Gall 8 2 Callitriche stagnalis Scop. 12 2 Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. 12 2 2 2 2 Ceratophyllum demersum L. 5 2 2 2 Eleocharis palustris (L.) Roemer & 12 2 2 Elodea canadensis Michx 10 2 Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Elodea canadensis Mich	Schistidium rivulare (= Grimmia	15	3		20	3
PTERYDOPHYTES Azolla filiculoides lam. Equisetum palustre L. 10 1 PHANEROGAMS Acorus calamus L. Alisma lanceolatum With 9 2 Alisma plantago-aquatica L. Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= 14 2 Butomus umbellatus L. Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. Equisetum fluviatile L. (= E. 12 2 limosum) Agrostis stolonifera L. fo Aq. 10 1 Alisma plantago-aquatica L. 8 2 Apium nodiflorum (L.) Lag. 10 1 (Helosciadium n., Sium n.) Butomus umbellatus L. 9 2 Callitriche obtusangula Le Gall 8 2 Carex rostrata Stokes 15 3 Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2	Sphagnum palustre L.	20	3		15	2
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PHANEROGAMS Acorus calamus L. 7 3 Agrostis stolonifera L. fo Aq. 10 1 Alisma lanceolatum With 9 2 Alisma plantago-aquatica L. 8 2 Apium inundatum L. (= Sium inundatum) 17 3 Apium nodiflorum (L.) Lag. 10 1 Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) 18 Butomus umbellatus L. 9 2 Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) 19 Callitriche platycarpa Kützing 10 1 Callitriche stagnalis Scop. 12 2 Callitriche truncata ssp. occidentalis (Rouy) Schotsman 10 2 Carex rostrata Stokes 15 3 Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & Schultes 10 2 Elodea canadensis Michx 10 2						
Acorus calamus L. 7 3 Agrostis stolonifera L. fo Aq. 10 1 Alisma lanceolatum With 9 2 Alisma plantago-aquatica L. 8 2 Apium inundatum L. (= Sium inundatum) 17 3 Apium nodiflorum (L.) Lag. 10 1 Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) 14 2 Butomus umbellatus L. 9 2 Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing 10 1 Callitriche stagnalis Scop. 12 2 Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & Schultes		6	3	Equisetum fluviatile L . (= E.	12	2
Alisma lanceolatum With 9 2 Alisma plantago-aquatica L. 8 2 Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. Eleocharis palustris (L.) Roemer & Schultes Apium nodiflorum (L.) Lag. 10 1 Callitriche obtusangula Le Gall 8 2 Callitriche obtusangula Le Gall 8 2 Carex rostrata Stokes 15 3 Carex rostrata Stokes 15 3 Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum demersum L. Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2	Azolla filiculoides lam.			Equisetum fluviatile L . (= E.	12	2
Apium inundatum L. (= Sium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. Eleocharis palustris (L.) Roemer & Sium n.) Apium nodiflorum (L.) Lag. 10 1 Callitriche obtusangula Le Gall 8 2 Callitriche obtusangula Le Gall 8 2 Carex rostrata Stokes 15 3 Ceratophyllum submersum L. 2 Eleocharis palustris (L.) Roemer & 12 Eleocharis palustris (L.) Roemer & 12 Elodea canadensis Michx 10 2	Azolla filiculoides <i>lam</i> . Equisetum palustre <i>L</i> .			Equisetum fluviatile L . (= E.	12	2
inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kiitzing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kiitzing 10 1 Callitriche stagnalis Scop. 12 2 Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & Schultes	Azolla filiculoides <i>lam.</i> Equisetum palustre <i>L.</i> PHANEROGAMS	10	1	Equisetum fluviatile L. (= E. limosum)		
Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche platycarpa Kützing 10 1 Callitriche stagnalis Scop. 12 2 Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & Schultes	Azolla filiculoides <i>lam</i> . Equisetum palustre <i>L</i> . PHANEROGAMS Acorus calamus <i>L</i> .	10	3	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq.	10	1
Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing 10 1 Callitriche stagnalis Scop. 12 2 Callitriche truncata ssp. occidentalis (Rouy) Schotsman 10 2 Carex rostrata Stokes 15 3 Carex vesicaria L. 12 2 Catabrosa aquatica (L.) Beauv. 11 2 Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & Schultes 12 2 Elodea canadensis Michx 10 2	Azolla filiculoides <i>lam</i> . Equisetum palustre <i>L</i> . PHANEROGAMS Acorus calamus <i>L</i> . Alisma lanceolatum <i>With</i> Apium inundatum <i>L</i> . (= Sium	10 7 9	3 2	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag.	10 8	1 2
Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. Eleocharis palustris (L.) Roemer & Schultes 10 1 Callitriche stagnalis Scop. 12 2 Carex rostrata Stokes 15 3 Carex vesicaria (L.) Beauv. 11 2 Ceratophyllum submersum L. Elodea canadensis Michx 10 2	Azolla filiculoides <i>lam</i> . Equisetum palustre <i>L</i> . PHANEROGAMS Acorus calamus <i>L</i> . Alisma lanceolatum <i>With</i> Apium inundatum <i>L</i> . (= Sium inundatum) Berula erecta (<i>Huds.</i>) Coville (=	10 7 9 17	3 2 3	Equisetum fluviatile L . (= E. limosum) Agrostis stolonifera L . fo Aq . Alisma plantago-aquatica L . Apium nodiflorum (L) Lag . $(Helosciadium\ n.,\ Sium\ n.)$	10 8 10	1 2 1
(Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Elodea canadensis Michx	Azolla filiculoides lam. Equisetum palustre L. PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp.	10 7 9 17 14	3 2 3	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag. (Helosciadium n., Sium n.) Butomus umbellatus L.	10 8 10 9	1 2 1 2
Ceratophyllum demersum L. 5 2 Ceratophyllum submersum L. 2 3 Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Schultes	Azolla filiculoides lam. Equisetum palustre L. PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata)	10 7 9 17 14 12	3 2 3 2	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag. (Helosciadium n., Sium n.) Butomus umbellatus L. Callitriche obtusangula Le Gall	10 8 10 9	1 2 1 2 2 2
Eleocharis palustris (L.) Roemer & 12 2 Elodea canadensis Michx 10 2 Schultes	Azolla filiculoides lam. Equisetum palustre L. PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis	10 7 9 17 14 12 10	1 3 2 3 2 1	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag. (Helosciadium n., Sium n.) Butomus umbellatus L. Callitriche obtusangula Le Gall Callitriche stagnalis Scop.	10 8 10 9 8	1 2 1 2 2 2
Schultes	Azolla filiculoides lam. Equisetum palustre L. PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman	10 7 9 17 14 12 10	1 3 2 3 3 2 1 1 1 2	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag. (Helosciadium n., Sium n.) Butomus umbellatus L. Callitriche obtusangula Le Gall Callitriche stagnalis Scop. Carex rostrata Stokes	10 8 10 9 8 12 15	1 2 1 2 2 2 2 3
	Azolla filiculoides lam. Equisetum palustre L. PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L.	10 7 9 17 14 12 10 10 12	1 3 2 3 2 1 1 2 2	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag. (Helosciadium n., Sium n.) Butomus umbellatus L. Callitriche obtusangula Le Gall Callitriche stagnalis Scop. Carex rostrata Stokes Catabrosa aquatica (L.) Beauv.	10 8 10 9 8 12 15	1 2 1 2 2 2 3
	Azolla filiculoides lam. Equisetum palustre L. PHANEROGAMS Acorus calamus L. Alisma lanceolatum With Apium inundatum L. (= Sium inundatum) Berula erecta (Huds.) Coville (= Sium erectum, Siella erecta) Callitriche hamulata Kützing ex Koch(= C. intermedia ssp. hamulata) Callitriche platycarpa Kützing Callitriche truncata ssp. occidentalis (Rouy) Schotsman Carex vesicaria L. Ceratophyllum demersum L. Eleocharis palustris (L.) Roemer &	10 7 9 17 14 12 10 10 12 5	1 3 2 3 2 1 1 2 2 2	Equisetum fluviatile L. (= E. limosum) Agrostis stolonifera L. fo Aq. Alisma plantago-aquatica L. Apium nodiflorum (L.) Lag. (Helosciadium n., Sium n.) Butomus umbellatus L. Callitriche obtusangula Le Gall Callitriche stagnalis Scop. Carex rostrata Stokes Catabrosa aquatica (L.) Beauv. Ceratophyllum submersum L.	10 8 10 9 8 12 15 11	1 2 1 2 2 2 3

Groenlandia densa (L.) Fourr. (= Potamogeton densus)	11	2	Helodes palustris Spach (Hypericum elodes L.)	17	3
Hippuris vulgaris L.	12	2	Hottonia palustris L.	12	2
Hydorcharis morsus-ranae L.	11	3	Hydrocotyle vulgaris L. fo aq.	14	2
Iris pseudacorus L.	10	1	Juncus bulbosus L.	16	3
Juncus subnodulosus $Schrank$ (= J . $obtusiflorus$) fo Aq .	17	3	Lemna gibba L.	5	3
Lemna minor L.	10	1	Lemna trisulca L.	12	2
Littorella uniflora (L.) Ascherson	15	3	Luronium natans (L.) Rafin (= Alsima natans)	14	3
Lycopus europaeus L.	11	1	Mentha aquatica L.	12	1
Menyanthes trifoliata L.	16	3	Montia fontana L. agg.	15	2
Myosotis gr. palustris (= M . scorpioides L .)	12	1	Myriophyllum alterniflorum DC.	13	2
Myriophyllum spicatum L.	8	2	Myriophyllum verticillatum L.	12	3
Najas marina L.	5	3	Najas minor L.	6	3
Nasturtium officinale sl R. Br.(= Rorippa nasturtium-aquaticum L.)	11	1	Nuphar lutea (L.) Sibth. % Sm.	9	1
Nymphaea alba L.	12	3	Nymphoides peltata (S. G. Gmelin) O. Kuntze	10	2
Oenanthe aquatica (L.) Poiret	11	2	Oenanthe crocata L.	12	2
Oenanthe fluviatilis (Bab.) Colerman	10	2	Phalaris arundinacea L.	10	1
Phragmites australis Cav. Trin.	9	2	Polygonum amphibium L.(= Persicaria amphibia L. Gray)	9	2
Polygonum hydropiper L. fo Aq. (Persicaria hydropiper L. Delarbe)	8	2	Potamogeton acutifolius Link	12	3
Potamogeton alpinus Balbis	13	2	Potamogeton berchtoldii Fieber	9	2
Potamogeton coloratus Hornem.	20	3	Potamogeton compressus L.	6	3
Potamogeton crispus L.	7	2	Potamogeton friesii Rupr.(= P. mucronatus)	10	1
Potamogeton gramineus L.	13	2	Potamogeton lucens L.	7	3
Potamogeton natans L.	12	1	Potamogeton nodosus Poiret (= P. fluitans)	4	3
Potamogeton obtusifolius Mert & Koch	10	2	Potamogeton panormitanus $Biv (= P. pusillus L.)$	9	2
Potamogeton pectinatus L.	2	2	Potamogeton perfoliatus L.	9	2
Potamogeton polygonifolius Pourret	17	3	Potamogeton praelongus Wulfen	13	2
Potamogeton trichoïdes <i>Cham. & Schelcht</i>	7	2	Potentilla palustris (L.) Scop.	16	3
Ranunculus aquatilis L.	11	2	Ranunculus circinatus Sibth. (= R. divaricatus)	10	2
Ranunculus flammula L. (forma acquatica)	16	3	Ranunculus fluitans Lam.	10	2

Ranunculus hederaceus L.	12	3	Ranunculus ololeucos Lloyd	19	3
Ranunculus omiophyllus Ten.	19	3	Ranunculus peltatus Schrank. var. penicillatus	12	2
Ranunculus trichophyllus Chaix	11	2	Rorippa amphibia (L.) Besser	9	1
Sagittaria sagittifolia L.	6	2	Scirpus fluitans L.	18	3
Scirpus lacustris <i>L.</i> (= Schoenoplectus lacustris)	8	2	Scirpus sylvaticus L.	10	2
Sparganium angustifolium Michaux	19	3	Sparganium emersum Rehmannfoglie corte (<20 cm)	13	2
Sparganium emersum Rehmann foglie lunghe (> 20 cm)	7	1	Sparganium erectum L.	10	1
Sparganium minimum Wallr	15	3	Spirodela polyrhiza (L.) Schleiden	6	2
Trapa natans L.	10	3	Typha angustifolia L.	6	2
Typha latifolia L.	8	1	Vallisneria spiralis L.	8	2
Veronica anagallis-aquatica L.	11	2	Veronica beccabunga L.	10	1
Veronica catenata Pennel	11	2	Wolffia arhiza (L.) Horkel & Wimmer	6	2
Zannichellia palustris L.	5	1			

Percentage cover (exact numeric value) is estimated in the field for all the macrophytic taxa (i), and ordered in classes according to a coverage scale (Ki) ranging from 1 (1: < 0,1%; 2: 0,1 - <1%; 3: 1 - <10%; 4: 10 - <50%; $5 \ge 50\%$) to 5, enabling the inclusion in the subsequent calculation of the index.

$$IBMR = \frac{\sum_{i=1}^{n} E_{i} \cdot K_{i} \cdot Cs_{i}}{\sum_{i=1}^{n} E_{i} \cdot K_{i}}$$

With reference and comparison to the previous French index (Haury *et al.*, 1996), the macrophyte scores were modified so as to fit a scale ranging over five levels and relating to trophic status (decreasing from oligotrophic to hypertrophic):

IBMR > 14 = very good;

 $14 \ge IBMR > 12 = good;$

 $12 \ge IBMR > 10 = moderate;$

 $10 \ge IBMR > 8 = poor;$

 $8 \ge IBMR = bad.$

The ranking system for bioindication was based on both botanical censuses and physico-chemical analyses of the stream water.

Table h: Trophic categories for the classification of the station based on the IBMR value, with

relative colour for mapping (from AFNOR, 2003).

TROPHIC LEVEL	IBMR	COLOUR
Very low	IBMR > 14	blue
Low	$12 < IBMR \le 14$	green
Average	$10 < IBMR \le 12$	yellow
High	$8 < IBMR \le 10$	orange
Very high	$IBMR \leq 8$	red

Some limitations are nevertheless apparent.

For example, in certain rivers flowing over mobile substrata and where macrophytes are scarce, the watercourse stretch surveyed should exceed 100m. When only a few taxa are present, these must be strong indicators for the IBMR to be used with confidence.

6. LIST AND DISTRIBUTION OF THE ALGAE AND CYANOBACTERIA FOUND IN THE WATERCOURSES OF THE TIBER BASIN.

Taxon	watercourses	_
Division Cyanophyta		_
Order Chroococcales		
Chamaesiphon conferviculus A. Braun	Vig	
Chamaesiphon incrustans Grunow in Rabenhorst	Nu; Tr; Fa; Au	
Chroococcus turgidus (Kützing) Nägeli	NI	
Merismopedia elegans A. Braun in Kützing	Tu; Tm; Tmou; Sov; Clit; Nes; Nu; N1	
Microcystis flos-aquae (Wittrock) Kirchner	Tu	
Order Oscillatoriales		
Lyngbya lutea (C. Agardh & Gomont) Gomont	TI	
Lyngbya aestuarii (Liebman) Gomont	Am; Au; Tmou	
Lyngbya kuetzingii Schmidle	Tm; Tl; Am	
Lyngbya lutescens (Meneghini) Hansgirg	Sea	
Lyngbya martensiana (Meneghini) Gomont	TI T	
Oscillatoria limnetica Lemmermann	Tl; Tmou; Fa; Sov	
Oscillatoria limosa (C. Agardh) Gomont	Tu; Tm;Tl; Tmou; Am; Al; Top; Frs; Clit	
Oscillatoria subbrevis Schmidle	Tl; Tmou; Al; Fa; Clit; Sov; Vig; Crn; Cam; Cai; Car	
Oscillatoria amoena (Kützing) Gomont	Tu; Tm; Tl; Au; Tr; Fa; Nes; Crn; Nes	
Oscillatoria amphibia (C. Agardh) Gomont Oscillatoria brevis Gomont	Al Ti	
	Frs	
Oscillatoria formosa Bory Oscillatoria spp.		
11	Tm; Tu; Tl; Al; Nl; Pug; Tr; Fa; Nu; Top; Clit; Cmp; Ass Tu: Tl	
Oscillatoria tenuis (C. Agardh) Gomont Phormidium retzii (C. Agardh) Gomont	Sov; Clit	
Phormidium valderianum (Delponte) Gomont	Tu; Tm; Tl; Tmou; Nl; Fa; Al	
Order Nostocales	Tu; Tm; Ti; Tmou; Ni; Fa; Ai	
Anabaena sp.	Tl; Sov; Au; Am	
Aphanizomenon sp.	TI	
Nostoc punctiforme (Kützing) Hariot	Tu; Tl; Sing; St; Nl	
Order Stigonematales	1u, 11, 3ing, 3t, 1vi	
Hapalosiphon fontinalis (C. Agardh) Bornet	Tmou; Fa	
Division Rhodophyta	Tillou, Ta	_
Order Bangiales		_
Bangia atropurpurea (Roth) C. Agardh	St; Nu; Tr; Fa; Au; Am	
Order Acrochaetiales	St, Nu, 11, Pa, Au, Alli	
Audouinella hermannii (Roth) Duby in De Candolle	Tu; Clit; Au	
Lemanea fluviatilis (L.) C. Agardh	St; Cerf	
Division Euglenophyta	St, CCII	_
Order Euglenales		_
Phacus sp.	Tr	
Trachelomonas hispida (Perty) F. Stein ex Deflandre	Cmp	
Trachelomonas sp.	Car; Tm	
Division Xanthophyta	Car, Till	_
1 7		_
Order Vaucheriales	T., T., Tl. T., C., G., G., G., A., C., A., C.	
Variable De Cardalla	Tu; Tm; Tl; Tmou; Sov; Cerf; Car; Sea; Ass; Soa; Top;	
Vaucheria geminata (Vaucher) De Candolle	Clit;	
Dill D. III I I I	Pug; Nu; Nl; Cmp; Crn; Vig; Tr; Fa; Au; Am	_
Division Bacillariophyta		_
Order Coscinodiscales	T T TITL A T N CI': C C C	
Cyclotella meneghiniana Kützing	Tu; Tm; Tl; Tmou; Am; Tr; Nes; Clit; Crn; Cmp; Car	
Melosira varians Agardh	Tl; Tmou; Car; Sea; Soa; Top; Tim; Clit; Nes; Nu; Cmp; Crn; Tr; Fa; Au; Am; Al	
Order Diatomales	,, - w , - w , - w , - w	
Diatoma mesodon (Ehrenberg) Kützing	Tr	1
Diatoma sp.	Tu; Tm	
Diatoma vulgaris Bory De Saint-Vincent	Tr; Tm; Top; Cmp; Ass	
rangara Bory De Saint Tincont	,, -op,p,	

Tu; Tm; Tl; Au; Am; Tr; Fa; Nu; Top; Soa; Cmp; Ass; Fragilaria sp. Car Synedra ulna (Nitzsch) Ehrenberg TrTabellaria flocculosa (Roth) Kützing Tu; Tm; Tl; Sov; Ass; Nu; Cmp; Vig; Fa; Au; Am Order Eunotiales Eunotia sp. Top; Au; Am; Vig Order Achnanthales Achnanthes lanceolata (Bréb.) Grunow Tr; Cmp; Car Tu: Tm: Tr: Cmp: Car Achnanthes minutissima Kützing Tl; Tmou; Sing; St; Sov; Cerf; Car; Ass; Top; Clit; Nu; Cocconeis pediculus Ehrenberg Tr: Fa: Au: Am Cocconeis placentula Ehrenberg Tm Order Naviculales Tu: Tm: Tl: Am: Tr: Ass: Car Amphora ovalis (Kützing) Kützing Tu: Tm: Tl: Am: Tr Amphora pediculus (Kützing) Grunow Tr; Tm; Nu Caloneis sp. Cymatopleura solea (Brebisson) W. Smith Car Car: Tm: Tr Cymatopleura sp. Cymbella minuta Hilse Cmp; Car Tm; Cmp; Ass; Car Cymbella affinis Kützing Tu; Tm; Tl; Au; Nu; Clit; Vig; Cmp; Ass; Car Cymbella helvetica Kützing Cymbella spp. Car: Tu: Tm: Tr: Top Diploneis elliptica (Kütz.) Cleve Tr: Tm Gomphonema acuminatum Ehrenberg Tm Tu; Tm; Tl; Au; Am; Tr; Fa; Nu; Top; Clit; Sing; Vig; Gomphonema olivaceum (Hornemann) Brebisson Cmp: Ass: Car Gomphonema parvulum Kützing Car; Ass; Cmp; Tm Gomphonema spp. Tr; Tu; Tm; Car Gyrosigma attenuatum (Kützing) Rabenhorst Tu: Tm: Tl: Au: Tr: Nu: Sov: Ass: Car Hantzschia amphioxys (Ehrenberg) Grunow Navicula cryptocephala Kützing Car; Cmp; Sing; Clit; Tm Navicula cryptotenella Lange-Bertalot Tu; Tm; Tl; Tr; Top; Soa; Clit; Sing; Vig; Cmp; Ass; Car Navicula gregaria Donkin Tm Navicula lanceolata (Agardh) Ehrenberg Tm; Cmp; Car Navicula spp. Cmp; Top; Tu; Tm; Tr; Nu Tu; Tm Nitzschia acicularis (Kützing) W. Smith Tm

Nitzschia palea (Kützing) W. Smith Nitzschia dissipata (Kützing) Grunow Nitzschia spp.

Pinnularia spp.

Surirella brebissonii Krammer & Lange-Bertalot Surirella sp.

Tm· T1

Tl; Tmou; Sing

Tm; Clit; Cmp; Car

Tl; Tr; Clit; Cmp

Car: Cmp: Tm Tr; Tm; Car

Tr; Tu; Car

Division Chlorophyta Order Chlorococcales

Ankistrodesmus falcatus (Corda) Ralfs

Characium spp.

Closteriopsis acicularis (G. M. Smith) J. H. Belcher &

Coelastrm microporum Nägeli in A. Braun Coenochloris fottii (Hindak) Tsarenko Monoraphidium arcuatum (Korshikov) Hindak Monoraphidium contortum (Thuret) Komarkova-

Legnerova

Oocystis borgei Snow

Pediastrum boryanum (Turpin) Meneghini Pediastrum boryanum var. cornutum (Raciborski)

Sulek

Pediastrum duplex Meyen Pediastrum integrum Nägeli

Tu: Tl Tm: Tl: Fa Nes Tm

Tm; Tl; Nl; Am Tm; Nes; Crn

Nes

Tm; Tl; Nu; Crn; Am Tm; Nes; Am

T1 Pediastrum simplex Meyen Pediastrum tetras (Ehrenberg) Ralfs T1 Scenedesmus granulatus W. West & G.S. West Nu: Tu Scenedesmus arcuatus (Lemmermann) Lemmermann Tl; Nl; Au; Am Scenedesmus communis E.H. Hegewald Tu; Tm; Sov; Car; Ass; Nes; Nu; N1; Crn; Am Scenedesmus ellipticus Corda Tm: Nes Tl: Am Scenedesmus falcatus Chodat Scenedesmus obtusus Meyen Am Scenedesmus serratus (Corda) Bohlin Am Order Oedogoniales Tl; Tmou; Sov; Ass; Soa; Nes; Cai; Nl; Cmp; Crn; Tr; Fa; Oedogonium spp. Au: Am: Al Pandorina morum (O. Müller) Bory de Saint-Vincent Tm Order Chaetophorales Chaetophora elegans (Roth) C. Agardh Microspora amoena (Kützing) Rabenhorst Tu; Tl; Tmou; Nl; Tr; Fa; Au; Am Stigeoclonium tenue (Agardh) Kützing Tmour Al Tl: Tmou; Sea; Soa; Cai Uronema elongatum Hodgetts Order Klebsormidiales Klebsormidium flaccidum (Kützing) Silva, Mattox & тı Blackwell Order Ulotrichales Ulothrix tenuissima Kützing Tl; Tmou; Nes; Am Ulothrix zonata (Weber & Mohr) Kützing Sea: Crn Order Chladophorales Tu: Tm: Tl: Tmou: Sing: St: Sov: Car: Ass: Soa: Top: Cladophora glomerata (L.) Kützing Tim; Clit; Nes; Cai; Frs; Pug; Nu; Nl; Crn; Vig; Tr; Fa; Au: Am: Al Order Ulvales Enteromorpha flexuosa (Wulfen ex Roth) J. Agardh Tmour Al Order Zygnematales Closterium closterioides (Ralfs) A. Louis & Peeters Tm: Top Closterium ehrebergii Meneghini ex Ralfs Tl; Sov; Car; Ass; Clit; Nu; Crn; Fa; Am Closterium kuetzingii Brébisson Closterium praelongum var. brevius (Nordstedt) Willi Tm Krieger Cosmarium botrytis Meneghinini ex Ralfs Tu: Tm: Nl: Crn: Am Cosmarium bioculatum Brébisson ex Ralfs Cosmarium granatum Brébisson in Ralfs Nes Cosmarium humile (F. Gay) Nordstedt in De Toni Am Cosmarium impressulum Elfving Tu: Am Cosmarium laeve Rabenhorst T1 Cosmarium meneghinii Brébisson in Ralfs T1 Cosmarium punctulatum Brébisson T1 Mougeotia sp. T1 Spirogyra communis (Hassall) Kützing T1: Am: A1 Tl: Soa: Top: Nes Spirogyra fluviatilis Hilse in Rabenhorst Tu; Tl; Tmou; St; Ass; Soa; Clit; Frs; Nu; Nl; Tr; Fa; Au; Spirogyra spp.

Tu - Tiber River, upper section; Tm - Tiber River, middle section; Tl - Tiber River, lower section; Tmou - Tiber River, mouth; Nu - Nera River, upper section; Nl - Nera River, lower section; Al - Aniene River, upper section; Am - Aniene River, middle section; Al - Aniene River, lower section; Sing - Singerna Stream; St - Stianta Ditch; Sov - Sovara Stream; Cerf - Cerfone Stream; Car - Carpina Stream; Sea - Seano Stream; Ass - Assino Stream; Soa - Soara Stream; Top - Topino River; Tim - Timia River; Clit - Clitunno River; Nes - Nestore River; Cai - Caina Stream; Frs - Fersinone Stream; Pug - Puglia Stream; Cmp - Campiano Stream; Cm - Corno Stream; Vig - Vigi River; Tr - Treia River; Fa - Farfa River.

Sov; Sea; Ass; Soa; Nes; Frs; Crn; Fa; Am

Tm; Tl; Sea; Ass; Soa; Fa; Am

Zygnema sp.

Chara sp.

Order Charales