UKTAG River Assessment Method

Macrophytes and Phytobenthos

Phytobenthos - Diatoms for Assessing River and Lake Ecological Quality (River DARLEQ3)

by

Water Framework Directive – United Kingdom Technical Advisory Group (WFD-UKTAG)

Health and safety statement

WARNING. Working in or around water is inherently dangerous; persons using this standard should be familiar with normal laboratory and field practice. This published monitoring system does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate health and safety practices and to ensure compliance with any national regulatory guidelines.

It is also the responsibility of the user if seeking to practise the method outlined here, to gain appropriate permissions for access to water courses and their biological sampling.

UKTAG Guide to Phytobenthos in Rivers
Diatoms for Assessing River and Lake Ecological Quality (DARLEQ3)

1   Introduction

This classification method enables the assessment of phytobenthos in rivers according to the requirements of the Water Framework Directive (WFD).   Phytobenthos refers to a mostly microscopic group of organisms called algae found attached to submerged surfaces such as stones and plant stems. Assessment focuses on the diatoms, a large and diverse group of algae using a tool called "DARLEQ3" (**D**iatoms for **A**ssessing **R**iver and **L**ake **E**cological **Q**uality, based on a metric called the Trophic Diatom Index (TDI).

DARLEQ3 forms one part of the quality element "macrophytes and phytobenthos". Macrophytes are assessed separately with a method called LEAFPACS2. An earlier version of DARLEQ (DARLEQ2) was evaluated and revised to include some minor changes to individual taxon scores, based on an improved understanding of their relationship to nutrient pressure (Environment Agency 2020). In combination with the macrophyte tool, DARLEQ3 provides an appropriate assessment to the overall quality element of macrophytes and phytobenthos.

DARLEQ3 and LEAFPACS2 results are combined to produce an overall classification for macrophytes and phytobenthos, using the worst class of either sub-element. In addition, the final combined class can be modified by taking into account the presence of bacterial tufts.

1.1   Metrics

The metric used to classify phytobenthos in rivers is the TDI, and the version used in DARLEQ3 is TDI5 LM. (LM indicates that the metric is based on data obtained by light microscopy. An alternative metric based on DNA analysis (TDI5 NGS) has been developed, and is available in DARLEQ3, but this metric has not been adopted for use in WFD classification).

Diatom taxa are each assigned a score from 1 (nutrient sensitive) to 5 (nutrient tolerant) and the computed TDI5 scores range from 0 (very low nutrients) to 100 (very high nutrients). The WFD requires derivation of ecological status as an EQR (Ecological Quality Ratio). The TDI5 EQR is calculated based on observed data and predicted reference values, resulting in an overall EQR representing an ecological status class of either High, Good, Moderate, Poor or Bad. The EQR scale ranges from 0 (bad ecological status) to 1 (high ecological status).

1.2   Environmental pressures to which the method is sensitive

The method is used to detect the impact of nutrient enrichment, primarily indicating response to phosphorus. However, other factors such as grazing by invertebrates and hydromorphological regimes such as flow can influence diatom abundance and composition. These may influence the overall classification result, but are not built into the classification method.

1.3   Geographic application

This assessment method is appropriate for all rivers in the UK.

1.4 Intercalibration

This is a process whereby all European Member States were required to compare WFD class boundary values for each biological quality element (e.g. phytobenthos, phytoplankton) to ensure similar levels are set across all countries. Once a classification method has been intercalibrated, the method must be adhered to by Member States for the purposes of WFD assessment and reporting. Intercalibration mainly focussed on the EQRs which define the class boundaries between High and Good, and Good and Moderate. DARLEQ2 was successfully intercalibrated for rivers, and DARLEQ3 has been subject to a checking procedure (JRC 2014), confirming that results using the TDI5 LM metric are sufficiently similar to those using TDI4 that a new intercalibration is not required. The DARLEQ3 EQR boundaries are:

High/good status	1.00
Good/moderate status	0.75
Moderate/poor status	0.50
Poor/bad status	0.25

Note that for operational purposes these boundaries are normalised to a scale of 0 – 1, as described below (section 3.1.1).

2   Data collection

2.1 Sample collection – location, frequency and sample volume

Samples of the biofilm which covers the upper surfaces of submerged cobbles or small boulders in rivers are collected by brushing or scraping with a clean toothbrush. Cobbles and small boulders are the preferred sampling substrate, but if there are no cobbles or small boulders present at the sampling site, the submerged stems of emergent macrophytes, such as *Phragmites australis*, *Sparganium erectum*, *Glyceria maxima* or *Typha* species, or leaves and stems of submerged macrophytes such as *Ranunculus* species and *Potamogeton* species are sampled instead. The sampling method is fully detailed and conforms to European Standards (CEN, 2014). Samples should be collected from mid-stream using a clean toothbrush, ensuring substrata have been submerged for at least 4 weeks prior to sampling.

2.1.1   Location

Samples must be representative of conditions in the river being studied, and should be collected from habitats with similar physical conditions at all sites, especially when collecting samples on repeat visits. Samples are ideally taken from riffles, runs, glides in rivers, from sites representative of the water body as a whole, and away from obvious human impacts. Location of sites near visible discharges should be far enough downstream for the discharge to have mixed fully with the river, and one should avoid sites where direct effects of organic pollution are obvious on the invertebrate fauna. This will obviously differ between catchments, but generally a site 200-500m downstream of a discharge may be most suitable. Samples should not be taken immediately after prolonged low flows or following periods of heavy rain.

2.1.2 Timing and Frequency

Two samples per year should be collected, one during spring (between March and May) and one during autumn (September to November). If this is not possible, summer sampling (June to August) is an alternative option as analysis of results has demonstrated that seasonal effects are not significant. Samples should be collected not less than two months apart.

2.1.3 Sample volume

Vigorous brushing of the substrate with a clean toothbrush in a plastic tray removes the diatom film from the surface of the substrate. In situations where submerged macrophytes have been sampled, cut random lengths are put into clean sampling bottles or bags and vigorously agitated to dislodge the attached diatoms. This process results in a nominal volume of sample collected that is easily transferred to a plastic container (volume 50-100mls). There is not a precise volume of sample required, but larger volumes should be avoided.

2.2   Sample analysis

If samples cannot be analysed soon after collection they should be preserved as soon as possible with Lugol's iodine (adding approximately 5-10% by volume). Samples are then digested to remove all internal contents of the diatom cell (the frustule), leaving clean 'valves' (digestion of the frustule generally results in separation of two valves). Permanent slides are prepared using Naphrax as a diatom mountant, and at least 300 undamaged valves of non-planktic taxa should be identified and counted using a high power microscope (x1000 magnification). The presence and number of valves is recorded of each diatom taxa present. The analytical method is fully detailed and conforms to European Standards (CEN, 2014).

2.3   Other data requirements

Alkalinity data are required as a predictor of reference (expected) conditions for the DARLEQ3 EQR. Data should be obtained from analysis of samples from the water body taken at monthly intervals over a period of at least one year, reported as mg/L $CaCO_3$. Alkalinity is the observed annual mean alkalinity of the site unless the observed annual mean alkalinity is <5 mg L^{-1} $CaCO_3$, in which case the value is set at "5"; or ≥250 mg L^{-1} $CaCO_3$, in which case the value is set at "250". It is recommended that the same alkalinity value is used as a predictor variable for both macrophyte and phytobenthos classifications.

Analysis carried out for the UKTAG (UKTAG, 2013) confirmed that a DARLEQ2 based assessment alone would generally give a reliable classification if alkalinity is < 75 mg L^{-1} $CaCO_3$ (because the diatom-based status is consistently lower than the macrophyte-based status over this range of alkalinity and will thus define the overall classification), whilst a LEAFPACS 2.0 based assessment alone is adequate at >200 mg L^{-1} $CaCO_3$ (because the macrophyte-based status is then consistently lower than the diatom-based status). In the middle range, both components are necessary (because neither one is consistently lower than the other) although, on average, an assessment based on DARLEQ2 alone would be a more reliable guide than LEAFPACS2 alone at alkalinities up to ~120 mg L^{-1} $CaCO_3$, whereas LEAFPACS2 alone will be a more reliable guide at alkalinities above this. This assessment based on DARLEQ2 also holds true for DARLEQ3.

2.3.1 Bacterial tufts

The normative definition in the WFD (Annex V) refers to the "displacement" of macrophytes and phytobenthos by bacterial tufts and coats at moderate status, implying a need to recognise a state where the organic loading is so high that heterotrophic organisms can out-compete phototrophic organisms. Bacterial tufts and coats are generally referred to as "sewage fungus", which include a mixture of heterotrophic bacteria, fungi and protozoans.

Presence of sewage fungus should be recorded in the field on all occasions a diatom sample is collected, recording cover: occasional (<30% of surface area); widespread (30-60% of surface area) or extensive (>61% of surface area), and density: trace (but only just detectable); thin (obvious presence but substrate not obscured); thick (thick enough to fully obscure substrate) or massive (occupies a significant proportion of the water column). Sewage fungus should only have the potential to downgrade from Moderate or worse class.

Currently UK agencies implement this where appropriate. A weight of evidence approach is adopted, where sewage fungus coverage and density (as an average over the assessment period) should over-ride the results of LEAFPACS and DARLEQ assessments to determine final status. This occurs in situations where LEAFPACS and DARLEQ assessments suggest status is Moderate or lower, and where the sewage fungus assessment suggests a lower class than the combined LEAFPACS and DARLEQ assessment.

2.4 Minimum data requirements

Confidence of classification will depend on the number of samples taken, and the proximity of the resulting EQR to a class boundary. Ideally a total of 6 samples (over 3 years) are recommended. In practice fewer may be used to produce a classification, although with a reduced confidence of class.

2.5 Typology

Typology defines waterbodies by factors which have a strong influence on their ecology; for calculation of river phytobenthos EQR, sites require input of annual mean alkalinity as detailed above.

3 Procedures for calculating metric EQR

The phytobenthos EQR is a ratio of observed to expected values. *Observed values* are taken from samples collected in the field and *expected values* (reference values) are predicted from alkalinity.

3.1 Calculating EQR for DARLEQ

3.1.1 Status class boundaries

To enable a confidence of class to be calculated for all 5 status classes it is necessary to make an arithmetic adjustment to the intercalibrated EQR boundary values, and the calculated EQRs, so that EQR values are constrained to a scale of 0 – 1. This is achieved by multiplying the intercalibrated boundary values, and the calculated EQR, by 0.8. Thus the operational boundary values are as shown below:

	Intercalibrated boundary	Normalised operational boundary
High/Good	1.00	0.80
Good/Moderate	0.75	0.60
Moderate/Poor	0.50	0.40
Poor/Bad	0.25	0.20

This procedure does not alter the classification outcomes, it simply changes the scale on which the class boundary values are calculated and assessed.

3.1.2 Manual calculation of EQR and status class

Calculation of phytobenthos EQR can be carried out manually as detailed below.

All diatom taxa are assigned a score from 1 (nutrient sensitive) to 5 (nutrient tolerant). The list of diatom taxa and their nutrient sensitivity scores is detailed in Appendix A.

The observed TDI for each sample is calculated using equations 1 and 2:

Observed value of river trophic diatom index $= (W \times 25) - 25$

Equation 1

where:

"W" is given by the equation:

$$W = \frac{\sum_{j=1}^{n} a_j \times s_j}{\sum_{j=1}^{n} a_j}$$

Equation 2

where:
"a_j" is the number of valves of taxon j, and
"s_j" is the nutrient sensitivity score in Appendix A corresponding to the taxon represented by j.

The expected (reference) value of the TDI (eTDI) is predicted from a regression equation derived from a subset of reference sites characterized by very low levels of human pressure. The model uses alkalinity, an environmental variable that reflects background geology and fertility.

The value for the expected TDI at reference conditions applicable to the river should be calculated using the following equation:

$$eTDI = 9.933 * Exp(Log_{10}(alkalinity)*0.81)$$ Equation 3

where:

"alkalinity" is the observed annual mean alkalinity of the river in mg/l $CaCO_3$ unless the observed annual mean alkalinity is < 5 mg L^{-1} $CaCO_3$, in which case the value is set at "5"; or ≥250 mg L^{-1} $CaCO_3$, in which case the value is set at "250".

The EQR is calculated using the following equation:

EQR = $\left(100 - \text{observed value of river trophic diatom index}\right) \div \left(100 - \text{reference value for river trophic diatom index}\right)$

Equation 4

The final EQR value for each sample is then normalised so that it conforms to a scale from 0-1. To normalize the EQR, multiply the EQR value by 0.8. This normalisation step allows the confidence of class to be calculated correctly.

Where the calculated EQR is > 1.0, its value should be set to "1".

3.1.3 Worked example
The following details a manual worked example from an analysis of a real sample collected from a site in the English Midlands:

Taxon name	Abundance (a = number of valves)	Nutrient sensitivity score (s)	a x s
Achnanthidium minutissimum type	12	2	24
Amphora montana	1	5	5
Amphora pediculus type	1	5	5
Cocconeis pediculus	5	4	20
Cocconeis placentula	61	3.1	189.1
Cyclotella atomus	1*	non-scoring	n/a
Cyclotella meneghiniana	3*	non-scoring	n/a
Diatoma vulgare	1	4	4
Encyonema minutum (E. 'ventricosum' agg)**	1	2.6	2.6
Encyonema silesiacum (E. 'ventricosum' agg)**	14	2.6	36.4
Fistulifera / Mayamaea spp.	1	3.9	3.9

Taxon name	Abundance (a = number of valves)	Nutrient sensitivity score (s)	a x s
Fragilaria vaucheriae	1	2	2
Gomphonema 'intricatum' type	3	2	6
Gomphonema clavatum	1	2	2
Gomphonema parvulum	3	3	9
Melosira varians	3	4	12
Navicula capitatoradiata	54	4	216
Navicula cryptotenella	107	4	428
Navicula gregaria	2	4	8
Navicula lanceolata	1	4	4
Navicula menisculus	1	4	4
Navicula minima	1	3	3
Navicula reichardtiana	1	4	4
Navicula tripunctata	2	5	10
Nitzschia fonticola	2	4	8
Nitzschia gracilis	1	3	3
Nitzschia palea	7	4	28
Nitzschia paleacea	3	3	9
Nitzschia sp.	1	3	3
Planothidium frequentissimum	2	3	6
Reimeria sinuata ('Reimeria sp.')**	6	3	18
Reimeria uniseriata ('Reimeria sp.')**	4	3	12
Rhoicosphenia abbreviata	7	4	28
Unidentified pennate diatom	1	3	3
	Σa = 311		**Σas = 1116**

*Non-scoring taxa recorded in the sample are not included in the calculation

**Taxonomic resolution by analyst more detailed than in the streamlined taxon list, but does not affect calculated result

The observed value for the river trophic diatom index for this sample is calculated as follows:

sum **as** for all taxa in sample = 1116

sum **a** for all taxa in sample = 311

Calculate W = sum as / sum a = 3.59

Calculate the observed value of TDI using equations 1 and 2:

$(W \times 25) - 25 = (3.59 \times 25) - 25 = 64.75$

The mean total alkalinity for this sample was 88.5 mg/l $CaCO_3$.

The reference value for the sample is:

$9.933 * Exp(Log_{10}(88.5)*0.81) = 48.1$

The EQR for the sample is:

$(100 - 64.75) / (100 - 48.1) = 35.25 / 51.9 = 0.68$

Normalise the EQR by multiplying by 0.8 to give a final EQR of:

0.68 x 0.8 = 0.544

An EQR of 0.544 gives a face value class of **Moderate** status (using the normalised boundary values)

An average of EQRs obtained over a year provides an annual EQR.

3.1.4 Automated calculation of EQR and status class

DARLEQ3 has been created using R (RCore Team 2019). A detailed user guide has been produced and is available through the following links. The R code (Version 0.9.8) can be downloaded from the UKTAG website or accessed at https://github.com/nsj3/darleq3. A Shiny app version is also available DARLEQ3 Shiny   . *NB Revisions are likely to be made and the calculator updated over time, it is important to check that the correct version is being used.*

4   Procedures for calculating statistical confidence in metric

The assessment of statistical error associated with each EQR entry is calculated within DARLEQ3 and is expressed as a "confidence of class", i.e. the statistical confidence we have of the metric falling into each of the five classes, from High to Bad. This also makes it possible to determine the statistical confidence of the river classifying as "worse than Good status".

5 References

CEN (2014). Water quality - Guidance standard for the routine sampling and preparation of benthic diatoms from rivers and lakes. EN 13946: 2014. Comité European de Normalisation, Geneva.

CEN (2014). Water quality – Guidance for the identification and enumeration of benthic diatom samples from rivers and lakes. EN 14407: 2014. Comité European de Normalisation, Geneva.

Environment Agency (2012). A streamlined taxonomy for the Trophic Diatom Index. Environment Agency Report SC070034/TR1.

Environment Agency (2020) Further development of a DNA based metabarcoding approach to assess diatom communities in rivers. Environment Agency Report SC160014/R

JRC (2014) Water Framework Directive Intercalibration Manual: Procedure to fit new or updated classification methods to the results of a completed intercalibration. Joint Research Centre Technical Report,

R Core Team (2019) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria https://www.R-project.org/.

UKTAG (2013) Final recommendations on new and updated biological standards. September 2013. UKTAG 2013. Biological standards 2013

Appendix A

The following table lists the UK streamlined diatom taxa, where recorded maximum relative abundance was ≥2% (EA, 2012) for use in TDI5 LM. * indicates sensitivity score changed from TDI4.

Taxa	Sensitivity score	Taxa	Sensitivity score
Achnanthes clevei	5	Diploneis marginestriata	5
Achnanthes exigua	3	Diploneis oblongella	3*
Achnanthes oblongella	1	Ellerbeckia arenaria	4
Achnanthes sp.	3	Encyonema 'ventricosum' agg.	2.6
Achnanthidium eutrophilum	2	Encyonema caespitosum	3*
Achnanthidium microcephalum	1	Encyonema gracile	1
Achnanthidium pyrenaicum	2	Encyonema hebridicum	1
Achnanthidium sp.	1*	Encyonema prostratum	3*
Achnanthidium subatomus	2	Encyonema sp.	2*
Adlafia minuscula	3	Encyonopsis cesatii	1*
Adlafia minuscula var. muralis	3*	Encyonopsis falaisensis	1
Amphipleura pellucida	3	Encyonopsis microcephala	1*
Amphora libyca	4	Eolimna minima	3
Amphora montana	5	Eolimna subminuscula	4
Amphora ovalis	5	Eolimna submuralis	5
Amphora pediculus type	5	Epithemia adnata	3*
Amphora sp.	4	Epithemia sorex	3
Amphora veneta	5	Epithemia sp.	1*
Bacillaria paradoxa	5	Epithemia turgida	2*
Brachysira brebissonii	1	Eucocconeis flexella	1
Brachysira vitrea	1	Eucocconeis laevis	1
Caloneis bacillum	4	Eunotia sp.	1.4
Caloneis hyalina	5	Fallacia helensis	5
Caloneis silicula	4	Fallacia indifferens	2
Caloneis sp.	3	Fallacia lenzii	5
Cavinula cocconeiformis	2	Fallacia pygmaea	5
Cavinula variostriata	3	Fallacia subhamulata	5
Cocconeis diminuta	5	Fistulifera/Mayamaea spp.	3.9
Cocconeis pediculus	4	Fragilaria bidens	3
Cocconeis placentula	3.1	Fragilaria capucina	1.2
Cocconeis scutellum	3	Fragilaria fasciculata	4
Cocconeis sp.	3	Fragilaria nitzschioides	3
Craticula accomoda	4	Fragilaria sp.	2
Craticula halophila	4	Fragilaria vaucheriae	2
Craticula molestiformis	4*	Fragilariforma sp.	2.5
Ctenophora pulchella	2	Frustulia krammeri	1
Cymatopleura solea	5	Frustulia sp.	2*
Cymbella affinis	2	Frustulia vulgaris	2
Cymbella cistula	2	Geissleria acceptata	4
Cymbella helvetica	2	Geissleria ignota	4
Cymbella lanceolata	4	Geissleria schoenfeldii	3
Cymbella sp.	3	Gomphonema 'intricatum' type	2*
Cymbellonitzschia diluviana	4	Gomphonema acuminatum	2
Delicata delicatula	1	Gomphonema angustatum	3
Denticula tenuis	2	Gomphonema anoenum	4
Diadesmis contenta	4*	Gomphonema clavatum	2
Diadesmis contenta fo. biceps	3	Gomphonema clevei	1
Diadesmis gallica	3	Gomphonema constrictum var. capitatum	2
Diatoma ehrenbergii	1		
Diatoma mesodon	1	Gomphonema gracile	1
Diatoma moniliformis	1	Gomphonema insigne	3*
Diatoma problematica	2	Gomphonema olivaceoides	2
Diatoma sp.	2	Gomphonema olivaceum	3
Diatoma tenue	1	Gomphonema parvulum	3
Diatoma vulgare	4*	Gomphonema pseudoaugur	5
Didymosphenia geminata	1	Gomphonema sp.	3
Diploneis elliptica	4*	Gomphonema tergestinum	4

Taxa	Sensitivity score
Gomphonema truncatum	2*
Gomphonema ventricosum	1
Gomphosphenia grovei	4
Gyrosigma acuminatum	5
Gyrosigma attenuatum	5
Gyrosigma nodiferum	5*
Gyrosigma scalproides	5
Hannaea arcus	1
Hantzschia abundans	5
Hantzschia amphioxys	4
Karayevia laterostrata	3
Kolbesia ploenensis	5
Lemnicola hungarica	5
Luticola goeppertiana	5
Luticola mutica	5*
Luticola sp.	4
Luticola ventricosa	3
Melosira varians	4
Meridion circulare	2
Meridion circulare var. constrictum	1
Navicula [small species]	4
Navicula angusta	1
Navicula capitata	4
Navicula capitatoradiata	4
Navicula cari	4
Navicula carteri	3
Navicula cincta	4
Navicula claytonii	3
Navicula cryptocephala	3
Navicula cryptotenella	4
Navicula digitoradiata	4
Navicula gregaria	4
Navicula hungarica	5
Navicula integra	5*
Navicula lanceolata	4
Navicula menisculus	4
Navicula modica	5
Navicula oblonga	4
Navicula radiosa	3
Navicula recens	5
Navicula reichardtiana	4
Navicula reinhardtii	4
Navicula rhynchocephala	2
Navicula schroeteri	5
Navicula slesvicensis	3
Navicula sp.	4
Navicula subrhynchocephala	4
Navicula subrotundata	4*
Navicula tenelloides	4
Navicula tripunctata	5
Navicula trivialis	4
Navicula veneta	4
Navicula viridula	4
Nitzschia acicularioides	3*
Nitzschia acicularis	3
Nitzschia amphibia	5
Nitzschia archibaldii	2
Nitzschia brevissima	5*
Nitzschia capitellata	4
Nitzschia clausii	5*
Nitzschia communis	5
Nitzschia disputata	2
Nitzschia dissipata	3

Taxa	Sensitivity score
Nitzschia dissipata var. media	3
Nitzschia filiformis	5
Nitzschia flexa	3
Nitzschia fonticola	4
Nitzschia fossilis	5
Nitzschia frustulum	3
Nitzschia gracilis	3
Nitzschia hantzschiana	2
Nitzschia heufleriana	4
Nitzschia inconspicua	4
Nitzschia lacuum	2
Nitzschia liebetruthii	2*
Nitzschia linearis	4
Nitzschia littoralis	4
Nitzschia microcephala	3
Nitzschia palea	4
Nitzschia paleacea	3
Nitzschia paleaeformis	5*
Nitzschia perminuta	3
Nitzschia perspicua	3
Nitzschia pusilla	4
Nitzschia recta	4
Nitzschia sigma	4
Nitzschia sigmoidea	5*
Nitzschia sociabilis	4
Nitzschia sp.	3
Nitzschia subacicularis	4
Nitzschia sublinearis	3*
Nitzschia supralitorea	5
Nitzschia tubicola	4
Nitzschia vermicularis	5*
Parlibellus protracta	4
Peronia fibula	1
Pinnularia sp.	2.2
Placoneis clementis	4
Placoneis elginensis	3*
Planothidium delicatulum	5
Planothidium dubium	3
Planothidium ellipticum	3
Planothidium frequentissimum	3
Planothidium granum	5
Planothidium lanceolatum	4
Planothidium rostratum	5
Planothidium sp.	4
Platessa conspicua	5
Psammothidium bioretti	1*
Psammothidium chlidanos	2
Psammothidium grishunun fo. daonensis	2
Psammothidium helveticum	2
Psammothidium lauenburgianum	5
Psammothidium levanderi	3
Psammothidium marginulatum	2
Psammothidium scoticum	2
Psammothidium sp.	2
Psammothidium subatomoides	2
Pseudostaurosira/Staurosira agg.	4*
Reimeria sp.	3
Rhoicosphenia abbreviata	4
Rossithidium sp.	1
Sellaphora joubaudii	4
Sellaphora pupula	4

Sellaphora seminulum	4
Taxa	Sensitivity score
Simonsenia delognei	5
Stauroneis anceps	2
Stauroneis kriegeri	2
Stauroneis sp.	3
Stauroneis thermicola	3
Staurosirella leptostauron	4
Staurosirella pinnata	4
Surirella angusta	3
Surirella brebissonii	3
Surirella crumena	3
Surirella islandica	3
Surirella linearis	1
Surirella minuta	4

Taxa	Sensitivity score
Surirella ovalis	5
Surirella roba	2
Surirella sp.	2
Surirella terricola	4
Synedrella parasitica	5
Synedra acus	3
Synedra famelica	5*
Synedra tenera	1
Synedra ulna	3*
Tabellaria sp.	1
Tryblionella acuminata	5
Tryblionella apiculata	5
Tryblionella debilis	4
Tryblionella hungarica	4
Tryblionella sp.	4