UKTAG LAKES ASSESSMENT METHODS MACROPHYTES AND PHYTOBENTHOS

MACROPHYTES (FREE INDEX)

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 watercourses and their biological sampling.

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1.   Introduction

1.1   Geographic application of the method

The method described in this method statement has been developed for the implementation of the Water Framework Directive (2000/60/EC) in the United Kingdom. It can be applied to lakes in Northern Ireland.

1.2   Quality element assessed by the method

The method enables an assessment of the condition of the quality element, "macrophytes and phytobenthos", listed in Table 1.2.1 of Annex V to the Water Framework Directive.

1.3   Pressures to which the method is known to be sensitive

The method was designed to detect the impact on the quality element of nutrient enrichment. It may also be sensitive to other pressures or combinations of pressures.

1.4   Indicators of the quality element used

Within the QE Macrophytes and phytobenthos, the method uses the macrophytes and the following parameters are evaluated:

(i)   Maximum depth of colonisation (Zc);
(ii)   Mean depth of presence ;
(iii)   Percent relative frequency of *Chara*;
(iv)   Percent relative frequency of Elodeids;
(v)   Plant trophic index; and,
(vi)   Percent relative frequency of tolerant taxa.

2.   Sampling and analysis

In order to obtain the data from which values for each of the parameters are calculated, at least four 100 m transects perpendicular to the shoreline should be surveyed. These should be arranged to give an approximately equal spread around the perimeter of the lake.

Surveys should normally be conducted between July and early September.

Each 100 m transect should be divided into 5 m^2 quadrants and each quadrant should be surveyed in order to establish the presence and relative frequency of each of the macrophyte taxa present.

The following variables should also be recorded:

- Distance each 5 m^2 quadrant from shoreline (i.e. 0 – 5 m, 5 – 10 m, 10 – 15 m up to 95 – 100 m

- Maximum depth of colonisation (m)

- Distance Maximum of depth of colonisation is from shore (m)

- Depth at each quadrant ends (i.e. depth at 5 m, 10 m etc)

Once all transects have been completed, the number of quadrants in which each taxon that was recorded in the lake is determined.   The total number of occurrences of all taxa is then computed as the sum of the occurrences of each individual taxon.

3.   Procedure for deriving the ecological quality ratio for the parameter

3.1   Calculation of the measured value for each parameter

The **maximum depth of colonisation (Zc)** is the deepest point observed along the transect at which submerged or floating-leaved macrophytes (but not free-floating taxa) were observed to be growing. A value is not assigned where Zc is < 3 m <u>and</u> is between 80 and 100% of the maximum transect depth recorded.   This is done to prevent a low score being assigned to shallow lakes.

In order to convert the recorded Zc to a common scale, the lake is assigned to the decile in Column 1 of Table 2 that corresponds to the value of Zc in Column 3 of Table 2.

The **mean depth of presence** is the average of the depth at which each quadrant ends in which submerged or floating-leaved macrophyte taxa (but not free-floating taxa) were recorded.   A score is not assigned for the average depth of presence if it is < 1.8 m <u>and</u> is within 50% of the maximum transect depth. This is done to prevent a low score being assigned to shallow lakes.

In order to convert the recorded mean depth of presence to a common scale, the lake is assigned to the decile in Column 1 of Table 2 that corresponds to the value of mean depth of presence in Column 4 of Table 2.

The **percent relative frequency of *Chara* (RF% Chara)** is the sum of the RF% of all *Chara* spp. This metric is only included for lakes with an alkalinity $\geq$ 100 mg L^{-1} CaCO$_3$.

In order to convert the recorded RF% Chara to a common scale, the lake is assigned to the decile in Column 1 of Table 2 that corresponds to the value of RF% Chara in Column 6 of Table 2.

The **percent relative frequency of Elodoids (RF% Elodeids)** is the sum of the RF% of all taxa listed in Column 1 of Table 1 which were recorded in the lake and which are also recorded as "elodeid" in Column 4 of Table 1.

In order to convert the recorded RF% Elodeids to a common scale, the lake is assigned to the decile in Column 1 of Table 2 that corresponds to the value of RF% Elodeids in Column 5 of Table 2.

The following equation should be used to calculate the value for the parameter, **lake trophic score**:

$$\text{Lake trophic score} = \Sigma \ \{\text{Plant trophic score}_i\} \ / \ \text{Number of taxa present}$$

Where:
"i" refers to each taxon listed in Column 1 of Table 1 and identified as being present in the lake;
"Lake trophic score" refers to the average plant trophic score for all taxa recorded in the lake;
"Plant trophic score" refers to the plant trophic score in Column 2 of Table 1 which corresponds with the taxon listed in Column 1 of that Table; and,
"Number of taxa present" refers to the number of macrophyte taxa listed in Column 1 of Table 1 which were identified as being present in the lake.

In order to convert the recorded Lake trophic score to a common scale, the lake is assigned to the decile in Column 1 of Table 2 that corresponds to the value of the Lake trophic score in Column 2 of Table 2.

The **percent relative frequency of tolerant taxa (RF% tolerant taxa)** is the sum of the relative frequency of all taxa listed in Column 1 of Table 1 which were recorded in the lake which are also recorded as being 'tolerant' in Column 3 of Table 1.

In order to convert the recorded RF% tolerant taxa to a common scale, the lake is assigned to the decile in Column 1 of Table 2 that corresponds to the value of RF% tolerant taxa in Column 7. of Table 2.

The Free Macrophyte Index is the arithmetic mean of the deciles for the six metrics, maximum depth of colonisation, mean depth of colonisation, RF% Chara, RF% Elodeids; RF% tolerant and Lake Trophic Score

3.2   Assignment of the reference values for each parameter
Reference conditions were derived using modelling and expert judgement.

A reference value of 0.8 is used for all lakes.

3.3   Calculation of the EQR values for each parameter

The ecological quality ratio (EQR) for each parameter should be calculated using the following equation:

$$\text{Free macrophyte index} \ / \ 0.8$$

3.5 Classifying the condition of the quality element

In order to classify the condition of the quality element, the final EQR, determined according to 3.3, should be compared with the standards in column 2 of Table 3.

4. Glossary

"Functional group" means a group of organisms which exploit a resource in a similar way.

"Macrophytes" are larger plants of freshwater which are easily seen with the naked eye, including all vascular plants, bryophytes, stoneworts (Characeae) and macro-algal growths.

Table 1. List of floating and submerged taxa which are used in the calculation of parameters required for the Free Index

Column 1	Column 2	Column 3	Column 4
Taxa	Trophic score	Tolerant taxa	ELODEIDS
Apium inundatum			ELODEIDS
Callitriche hamulata	34	T	ELODEIDS
Callitriche hermaphrodita	68	T	ELODEIDS
Callitriche sp. (other)	68	T	ELODEIDS
Ceratophyllum demersum	62	T	ELODEIDS
Ceratophyllum submersum			ELODEIDS
Chara spp	23		
Elatine spp	15		
Elodea canadensis	48	T	ELODEIDS
Elodea nuttallii	48	T	ELODEIDS
Elodea sp. (other)			ELODEIDS
Eriocaulon septangulare	11		
Filamentous algae	39	T	ELODEIDS
Fontinalis antipyretica	26	T	ELODEIDS
Hippuris vulgaris	20		ELODEIDS
Isoetes lacustris	12		
Juncus bulbosus	15		
Lemna gibba			
Lemna minor	88	T	
Lemna polyrrhiza	145	T	
Lemna trisulca	31	T	
Litorella uniflora	34	T	
Lobelia dortmanna	10		
Myriophyllum alterniflorum	17		ELODEIDS
Myriophyllum spicatum	32	T	ELODEIDS
Myriophyllum verticillatum			ELODEIDS
Najas flexilis			ELODEIDS
Nitella spp.	20		ELODEIDS
Nuphar lutea	43	T	
Nymphaea sp.	21		
Nymphea alba	21		
Other Mosses	23		ELODEIDS

Species			
Potamogeton alpinus			ELODEIDS
Potamogeton berchtoldii	37	T	ELODEIDS
Potamogeton crispus	59	T	ELODEIDS
Potamogeton filiformis			ELODEIDS
Potamogeton friessi			ELODEIDS
Potamogeton gramineus	23		ELODEIDS
Potamogeton lucens	35	T	ELODEIDS
Potamogeton natans	34	T	NYMPHAEIDS
Potamogeton nodosus			ELODEIDS
Potamogeton obtusifolius	54	T	ELODEIDS
Potamogeton pectinatus	31	T	ELODEIDS
Potamogeton perfoliatus	28	T	ELODEIDS
Potamogeton polygonifolius			ELODEIDS
Potamogeton praelongus			ELODEIDS
Potamogeton pusillus			ELODEIDS
Potamogeton sp. (other)			ELODEIDS
Potamogeton x nitens			ELODEIDS
Potamogeton zizii			ELODEIDS
Ranunculus circinatus			ELODEIDS
Ranunculus penicillatus var penicillatus	7		ELODEIDS
Ranunculus sp.(other)			ELODEIDS
Sagittaria spp.	22		ELODEIDS
Sparganium angustifolium			ELODEIDS
Sparganium emersum	40	T	ELODEIDS
Sparganium minimum			ELODEIDS
Sparganium natans			ELODEIDS
Sparganium sp. (other)			ELODEIDS
Utricularia intermedia	7		ELODEIDS
Utricularia sp. (other)			ELODEIDS
Utricularia vulgaris	21		ELODEIDS
Zannichellia spp.			ELODEIDS

Notes:

1. "Other mosses" includes all mosses other than *Fontinalis antipyretica. F. squamosa* or *Sphagnum* spp.;
2. All filamentous algae (irrespective of genus) are amalgamated into a single record;
3. "*Callitriche* sp. (other)" refers to all members of the genus *Callitriche* with the exception of *C. hamulata* and *C. hermaphrodita*.   The same principle extends to *Elodea* sp. (other), *Potamogeton* sp. (other), *Ranunculus* sp. (other), *Sparganium* sp. (other) and *Utricularia* sp. (other).

Table 2. Table of scaled deciles for five metrics that had a log-linear response to spring TP. After Free *et al.* (2007)

Column 1 Scaled deciles	Column 2 Plant trophic	Column 3 Zc	Column 4 Mean depth of presence	Column 5 %RF Elodeids (functional group)	Column 6 %RF Chara	Column 7 %RF Tolerant

EQR						
1.0	<28.2	≥5.1	≥2.00	<19	≥67	<26
0.9	≥28.2 - <30.4	<5.1 - ≥4.1	<2.00 - ≥1.66	≥19 - <31	<67 - ≥61	≥26.0 - <37.9
0.8	≥30.4 - <31.8	<4.1 - ≥3.5	<1.66 - ≥1.49	≥31 - <37	<61 - ≥45	≥37.9 - <51.7
0.7	≥31.8 - <33.1	<3.5 - ≥2.9	<1.49 - ≥1.35	≥37 - <48	<45 - ≥29	≥51.7 - <60.4
0.6	≥33.1 - <34.0	<2.9 - ≥2.5	<1.35 - ≥1.25	≥48 - <53	<29 - ≥23	≥60.4 - <70.1
0.5	≥34.0 - <35.2	<2.5 - ≥2.1	<1.25 - ≥1.13	≥53 - <59	<23 - ≥10	≥70.1 - <77.9
0.4	≥35.2 - <38.2	<2.1 - ≥1.8	<1.13 - ≥0.94	≥59 - <65	<10 - ≥7	≥77.9 - <84.8
0.3	≥38.2 - <40.2	<1.8 - ≥1.6	<0.94 - ≥0.81	≥65 - <75	<7 - ≥5	≥84.8 - <90.0
0.2	≥40.2 - <43.7	<1.6 - ≥1.0	<0.81 - ≥0.30	≥75 - <80	<5 - ≥2	≥90.0 - <98.9
0.1	≥43.7	<1.0	<0.30	≥80	<2	≥98.9

Table 3: Aquatic macrophyte standards for lakes	
Column 1 **Condition of the quality element**	**Column 2** **EQR**
High	0.90
Good	0.68
Moderate	0.42
Poor	0.33

Annex 2: Worked example

The following data were obtained from a lough survey in Northern Ireland:

Column 1	Column 2	Column 3
Taxon	**% RF**	**Plant Trophic Score**
Chara sp.	6.90	23
Eleocharis acicularis	15.52	
Elodea canadensis	8.62	48
Fontinalis antipyretica	18.96	26
Littorella uniflora	13.79	34
Other moss	5.17	23
Nuphar lutea	12.07	43
Potamogeton lucens	13.79	35
Potamogeton perfoliatus	1.72	28
Potamogeton pusillus	1.72	
Sagittaria sagittifolia	1.72	22

This Lough has a mean annual alkalinity of 86 As this is less than the threshold of 100 mg L^{-1} CaCO$_3$, %RF Chara is not included in the calculation of the Free Macrophtye Index.

Eleocharis acicularis, is not included in Table 1 Column 1 so is ignored for subsequent analyses.

The other metrics are calculated as follows:

%RF Elodeids: *Elodea Canadensis, Fontinalis antipyretica*, other mosses, all three *Potamogeton* species and *Sagittaria sagittifolia* are all listed as 'Elodeids' in Column 4 of Table 1.   The sum of their relative abundances is 51.70.

The decile in Column 1 of Table 2 which corresponds to this value in Column 5 of Table 2 is 0.6.

Lake Trophic Score: Plant trophic scores for those taxa recorded in the lough are listed in Column 3 of the Table above. The sum of these is 282.   There are nine taxa recorded in Column 1 of the above table for which a Plant Trophic Score is available. Therefore, the Lake Trophic Score is:

$$282 / 9 = 31.3$$

The decile in Column 1 of Table 2 which corresponds to this value in Column 2 of that table is 0.8.

RF% tolerant taxa: *Elodea canadensis, Fontinalis antipyretica, Littorella uniflora, Nupha lutea, Potamogeton lucens* and *P. perfoliatus* are all recorded as being tolerant in Column 4 of Table 1.   The sum of their relative abundances is 69.0.

The decile in Column 1 of Table 2 which corresponds to this value in Column 7 of that table is 0.6.

The **maximum depth of colonisation** was 3.5 m.   The decile in Column 1 of Table 2 which corresponds to this value in Column 3 of that table is 0.7.

The **mean depth of presence** was 1.6 m. The decile in Column 1 of Table 2 which corresponds to this value in Column 4 of that table is 0.8.

The Free Macrophyte Index for this lake is the average of the deciles of the five component metrics:

$$= 0.6 + 0.8 + 0.6 + 0.7 + 0.8 / 5$$

$$= 0.7$$

The EQR is, therefore:

$$0.7 / 0.8 \quad = \quad 0.88$$

The lough is, therefore, classified as good status (see Table 3)

Annex 3: Further Reading

Free, G., Little, R., Tierney, D., Donnelly, K. & Caroni, R. (2007) A reference based typology and ecological assessment system for Irish lakes-preliminary investigations. ERTDI Report 57. 2007 University College Dublin.