Supplementary Information to:

Charophyte variation in sensitivity to eutrophication affects their potential for the trophic and ecological status indication

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Table S1. Main geographical, hydromorphological and physicochemical characteristics of lakes inhabited (*Chara* lakes) and not inhabited by charophyte communities (Non-*Chara* lakes). s – standard deviation; MW U-test – Mann-Whitney U-test

Parameter	Abb.	*Chara* lakes			Non-*Chara* lakes			MW U-test	
		Mean	*Min-max*	*s*	*Mean*	*Min-max*	*s*	Z adj.	*p*-value
%area covered by charids **	%Char	**14.5**	0.02-99.9	28.29	**-**	-	-	-2.55	0.0110
No. of stonewort communities **	S_Char	**2**	1-16	1.9	**-**	-	-	-6.38	<0.0001
Altitude m a. s. l. *	ALT	**106**	11-229	39.9	**85**	0-242	38.6	-11.55	<0.0001
Area (km^2) *	A	**1.47**	0.25-113.40	7.97	**1.00**	0.24-71.40	5.43	-11.33	<0.0001
Mean depth (m) *	Z_{mean}	**7.5**	0.5-38.7	4.71	**4.2**	0.6-15.2	2.76	2.83	0.005
Water reaction pH **	pH	**8.3**	7.3-9.1	0.23	**8.4**	7.5-9.5	0.30	8.59	<0.0001
Alkalinity meq L^{-1}) **	Alk	**2.7**	0.3-9.1	0.80	**3.0**	0.3-5.8	0.79	6.74	<0.0001
Conductivity (µS cm^{-1}) **	Cond	**309**	60-784	111.3	**379**	45-3490	283.9	10.67	<0.0001
Colour (mgPt L^{-1}) **	Colour	**13**	3-53	8.0	**22**	5-165	19.5	14.31	<0.0001
Total phosphorus (mgP L^{-1}) **	TP	**0.040**	0.003-0.243	0.032	**0.082**	0.005-0.915	0.106	-17.45	<0.0001
Total nitrogen (mgN L^{-1}) **	TN	**1.09**	0.32-4.31	0.542	**1.86**	0.52-7.20	1.072	16.80	<0.0001
Secchi disk reading (m)**	SD	**2.6**	0.4-6.5	1.20	**1.0**	0.3-5.7	0.76	-2.55	0.0110
Chlorophyll *a* (µg L^{-1}) **	Chl-*a*	**9.5**	0.8-122.4	13.37	**37.7**	1.2-212.5	38.68	-6.38	<0.0001

* Data for 267 *Chara* lakes and 237 non-*Chara* lakes (no replicate surveys included)

** Data for 404 surveys from *Chara* lakes and 336 surveys from non-*Chara* lakes (replicate surveys included)

Table S2. List of hydrophyte communities identified in 692 lowland lakes in Poland surveyed in the years 2005-2015 together with the results of the OMI analysis; communities arranged according to the OMI values in descending order. Phytosociological systems for vascular plants according to Brzeg and Wojterska (2001) and Matuszkiewicz (2002), while for charophytes according to Pełechaty and Pukacz (2008) and Urbaniak and Gąbka (2014) were used. OMI – Outlying Mean Index; Tol – Tolerance Index, Rtol – residual tolerance; charophyte communities marked with grey, *p*-values for niches significant at $p < 0.05$ marked in bold

No.	Plant community	Dominant species	Abbreviation	inertia	OMI	Tol	Rtol	Std. obs	Pvalue
1	*Isoëtetum lacustris* Szańk. et Kłos. 1996 n.n.	*Isoëtes lacustris* L.	ISOË LACU	17.5	16.79	0.10	0.64	1.5	**0.037**
2	*Myriophyllo-Littorelletum* Jeschke 1959 f. with Littorella uniflora (L.) Ascherson	*Littorella uniflora* (L.) Ascherson	LITT UNIF	17.9	15.33	0.52	2.01	3.6	**0.012**
3	*Lobelietum dortmannae* (Osvald 1923) R.Tx. Ap. Dierss. 1972	*Lobelia dortmanna* L.	LOBE DORT	17.2	15.27	0.37	1.54	3.4	**0.013**
4	*Nupharetum pumilae* Oberd. 1957 ex Th.Müller et Görs 1960	*Nuphar pumila* (Timm) DC.	NYMP PUMI	16.8	9.74	4.54	2.56	1.6	**0.028**
5	*Nitelletum mucronatae* Tomaszewicz 1979 ex Hrivnák et al. 2001	*Nitella mucronata* (A. Braun) Miquel	**NITE MUCR**	10.5	8.48	0.99	0.99	2.1	**0.038**
6	*Myriophyllo-Littorelletum* Jeschke 1959 f. with *Myriophyllum alterniflorum* DC.	*Myriophyllum alterniflorum* DC.	MYRI ALTE	15.0	7.88	4.37	2.76	2.5	**0.026**
7	Community of *Warnstorfia fluitans* (Hedw.) Loeske	*Warnstorfia fluitans* (Hedw.) Loeske	WARN FLUI	9.2	6.90	0.73	1.53	0.8	0.071
8	*Nitelletum opacae* Corillion 1957	*Nitella opaca* (Agardh ex Bruzelius) Agardh	**NITE OPAC**	10.1	6.85	0.94	2.33	2.7	**0.024**
9	*Nitelletum flexilis* Corillion 1957	*Nitella flexilis* (Linné) Agardh	**NITE FLEX**	7.3	5.31	0.62	1.37	1.9	**0.024**
10	*Ceratophylletum submersi* Soó 1928	*Ceratophyllum submersum* L.	CERA SUBM	11.1	5.29	2.89	2.91	3.7	**0.014**
11	*Charetum filiformis* (Jeschke 1959) Krausch 1964 em. Dąmbska 1966	*Chara filiformis* Hertzsch	**CHAR FILI**	7.0	5.12	0.45	1.46	2.9	**0.019**
12	*Lychnothamnetum barbatii* (Gołdyn 1984) Brzeg et M. Wojterska 2001	*Lychnothamnus barbatus* (Meyen) Leonhardi	**LYCH BARB**	5.7	4.84	0.01	0.88	0.1	0.860
13	*Nymphaeetum albo-candidae* (Hejny 1950) Pass. 1957 f. with *Nymphaea candida* J.Presl	*Nymphaea candida* J. Persl	NYMP CAND	8.6	4.68	1.76	2.20	0.4	0.256
14	Community of *Platyhypnidium riparioides* (Hedw.) Dixon	*Platyhypnidium riparioides* (Hedw.) Dixon	PLAT RIPA	5.9	4.26	0.84	0.83	1.7	0.052
15	*Lemno-Spirodeletum polyrrhizae* W.Koch 1954	*Spirodela polyrrhiza* (L.) Schleid.	SPIR POLY	7.5	3.94	0.82	2.74	0.9	0.060

No.	Plant community	Dominant species	Abbreviation	inertia	OMI	Tol	Rtol	Std. obs	Pvalue
16	*Charetum hispidae* Margalef 1947	*Chara hispida* Linné	**CHAR HISP**	6.3	3.76	1.14	1.39	0.3	0.567
17	Community of *Potamogeton acutifolius* Link	*Potamogeton acutifolius* Link	POTA ACUT	3.8	3.72	0.01	0.02	-0.2	0.664
18	*Nitelletum gracilis* Corillion 1957	*Nitella gracilis* (Smith) Agardh	**NITE GRAC**	9.8	3.71	1.94	4.11	2.4	**0.029**
19	*Charetum delicatulae* Doll 1989 ex Gąbka et Owsianny 2010	*Chara delicatula* Agardh	**CHAR DELI**	6.2	3.53	1.05	1.64	11.2	**0.001**
20	*Charetum intermediae* (Corillion 1957) Fijałkowski 1960	*Chara intermedia* A. Braun	**CHAR INTE**	5.7	3.31	0.28	2.15	0.5	0.113
21	*Utricularietum neglectae* Th.Müller et Görs 1960 em. Pass. 1978	*Utricularia australis* R. Br.	UTRI AUST	3.4	3.04	0.09	0.25	0.0	0.958
23	Community of *Potamogeton nodosus* Poir.	*Potamogeton nodosus* Poir.	POTA NODO	8.3	3.03	1.03	4.27	0.6	0.102
24	*Charetum polyacanthae* Dąmbska 1966 ex Gąbka et Pełechaty 2003	*Chara polyacantha* A. Braun 1859	**CHAR POLY**	9.3	2.91	2.22	4.12	2.1	**0.030**
25	*Charetum vulgaris* Corillion 1957	*Chara vulgaris* Linné	**CHAR VULG**	5.5	2.78	0.66	2.03	1.4	**0.044**
26	*Lemnetum minoris* Soó 1927	*Lemna minor* L.	LEMN MINO	12.4	2.72	1.41	8.31	2.7	**0.018**
27	*Potametum pectinati* (Hueck 1931) Carstensen 1955	*Stuckenia pectinata* (L.) Börner	POTA PECT	21.2	2.69	10.35	8.17	12.6	**0.001**
28	*Charetum rudis* Dąmbska 1966	*Chara rudis* (A. Braun) Leonhardi	**CHAR RUDI**	6.2	2.65	1.31	2.28	5.1	**0.007**
29	*Hippuridetum vulgaris* Pass. 1955	*Hippuris vulgaris* L.	HIPP VULG	3.3	2.52	0.09	0.69	0.1	0.810
30	*Charetum globularis* Zutshi ex Šumberová et al. 2011	*Chara globularis* Thuiller	**CHAR GLOB**	5.1	2.27	0.95	1.92	18.2	**0.001**
31	Community of *Leptodictyum riparium* (Hedw.) Warnst.	*Leptodictyum riparium* (Hedw.) Warnst.	LEPT RIPA	3.0	2.22	0.12	0.67	1.1	0.062
32	*Lemno-Hydrocharitetum morsus-ranae* (Oberd. 1957) Pass. 1978	*Hydrocharis morsus-ranae* L.	HYDR MORA	7.9	2.10	1.43	4.41	2.7	**0.017**
33	Community of *Potamogeton berchtoldii* Fieber	*Potamogeton berchtoldii* Fieber	POTA BERC	5.3	2.08	0.53	2.64	0.9	0.099
34	*Lemno-Utricularietum vulgaris* Soó 1928 ex. 1947	*Utricularia vulgaris* L.	UTRI VULG	4.1	1.54	0.48	2.07	7.8	**0.003**
35	*Lemnetum trisulcae* (Kelhofer 1915) R.Knapp et Stoffers 1962	*Lemna trisulca* L.	LEMN TRIS	3.6	1.54	0.56	1.48	9.4	**0.001**
36	*Nitellopsidetum obtusae* (Sauer 1937) Dąmbska 1961	*Nitellopsis obtusa* (Desvaux) Groves	**NIPS OBTU**	6.2	1.42	1.17	3.57	33.9	**0.001**

No.	Plant community	Dominant species	Abbreviation	inertia	OMI	Tol	Rtol	Std. obs	Pvalue
37	*Charetum contrariae* Corillion 1957	*Chara contraria* A. Braun ex Kützing	**CHAR CONT**	5.7	1.38	0.62	3.66	1.7	**0.025**
38	*Potametum obtusifolii* (Carst. 1954) Segal 1965	*Potamogeton obtusifolius* Mert. & W.D.J. Koch	POTA OBTU	4.0	1.37	0.68	1.94	-0.1	0.846
39	*Elodeetum canadensis* Eggler 1933	*Elodea canadensis* Michx.	ELOD CANA	7.5	1.34	1.21	4.92	19.9	**0.001**
40	*Charetum asperae* Corillion 1957	*Chara aspera* Will.	**CHAR ASPE**	6.6	1.30	1.51	3.75	2.4	**0.026**
41	*Charetum tomentosae* Corillion 1957	*Chara tomentosa* Linné	**CHAR TOME**	5.9	1.18	1.50	3.18	20.4	**0.001**
42	Community of *Potamogeton trichoides* Cham. & Schecht.	*Potamogeton trichoides* Cham. & Schltdl.	POTA TRICH	6.0	1.12	1.69	3.23	0.0	0.954
43	*Nymphaeo albae-Nupharetum luteae* Nowiński 1928 f. with *Nuphar lutea* (L.) Sibth. & Sm.	*Nuphar lutea* (L.) Sibth. & Sm.	NUPH LUTE	8.6	1.07	3.24	4.35	89.7	**0.001**
44	Community of *Potamogeton pusillus* L.	*Potamogeton pusillus* L.	POTA PUSI	3.2	1.06	0.10	2.08	-0.4	0.272
45	*Nymphoidetum peltatae* (Allorge 1922) Bellot 1951	*Nymphoides peltata* (S. G. Gmel.) Kuntze	NYMP PELT	2.4	0.99	0.47	0.98	-0.4	0.394
46	*Najadetum intermediae* (W.Koch 1926) Lang 1973 f. with Najas minor (All.)	*Najas minor* All.	NAJA MINO	2.2	0.85	0.44	0.89	-0.4	0.540
47	*Potametum filiformis* W.Koch 1928 f. with *Potamogeton praelongus* Wulfen	*Potamogeton praelongus* Wulfen	POTA PRAE	2.3	0.82	0.25	1.22	0.1	0.903
48	*Potametum natantis* Soó 1927 ex Podbielkowski et Tomaszewicz 1978	*Potamogeton natans* L.	POTA NATA	5.8	0.80	1.18	3.81	3.4	**0.012**
49	*Potametum filiformis* W.Koch 1928 f. with *Potamogeton filiformis* Pers.	*Stuckenia filiformis* (Pers.) Börner	POTA FILI	1.9	0.70	0.15	1.08	-0.5	0.240
50	*Potametum compressi* Tomaszewicz 1979	*Potamogeton compressus* L.	POTA COMP	6.1	0.65	1.15	4.29	1.0	0.129
51	*Nymphaeo albae-Nupharetum luteae* f. with *Nymphaea alba* L.	*Nymphaea alba* L.	NYMP ALBA	8.6	0.63	2.14	5.83	8.2	**0.001**
52	*Potametum filiformis* W.Koch 1928 f. with *Potamogeton alpinus* L.	*Potamogeton alpinus* Balb.	POTA ALPI	2.4	0.58	0.43	1.35	-0.4	0.485
53	*Potametum friesi* Tomasz. 1979	*Potamogeton friesii* Rupr.	POTA FRIE	3.9	0.57	0.64	2.65	0.6	0.242
54	*Myriophylletum verticillati* Gaudet 1924	*Myriophyllum vercillatum* L.	MYRI VERT	5.7	0.56	0.35	4.77	0.7	0.230
55	*Fontinaletum antipyreticae* Kaiser 1936	*Fontinalis antipyretica* Hedw.	FONT ANTI	4.3	0.50	0.58	3.24	4.5	**0.007**
56	*Zannichellietum palustris* (W.Koch 1926) Lang 1967	*Zannichellia palustris* L.	ZANI PALU	2.2	0.39	0.25	1.60	-0.6	0.168

No.	Plant community	Dominant species	Abbreviation	inertia	OMI	Tol	Rtol	Std. obs	Pvalue
57	*Ranuncutetum circinati* (Sauer 1937) Segal 1965	*Ranunculus circinatus* Sibth.	RANU CIRC	3.9	0.36	1.12	2.43	6.2	**0.004**
58	*Stratiotetum aloidis* (Nowiński 1930) Miljan 1933	*Stratiotes aloides* L.	STRA ALOI	7.7	0.29	0.36	7.05	2.0	0.051
59	*Polygonetum natantis* Soó 1927 ex Brzeg et M.Wojterska 2001	*Persicaria amphibia* (L.) Delarbre	POLY AMPH	11.3	0.27	1.58	9.40	0.6	0.407
60	Community of *Potamogeton crispus* L.	*Potamogeton crispus* L.	POTA CRIS	5.7	0.27	1.50	3.91	-0.1	0.877
61	*Potametum lucentis* (W. Koch 1926) Görs 1977	*Potamogeton lucens* L.	POTA LUCE	5.2	0.21	1.92	3.12	3.0	**0.018**
62	*Najadetum marinae* Fukarek 1961	*Najas marina* L.	NAJA MARI	5.5	0.17	0.97	4.38	0.2	0.812
63	*Myriophylletum spicati* Soó 1927 ex Podbielkowski et Tomaszewicz 1978	*Myriophyllum spicatum* L.	MYRI SPIC	6.7	0.15	1.63	4.96	4.4	**0.010**
64	*Ceratophylletum demersi* Hild 1956	*Ceratophyllum demersum* L.	CERA DEME	5.9	0.03	1.42	4.50	2.4	**0.038**
65	*Potametum perfoliati* (W. Koch 1926) Pass. 1964	*Potamogeton perfoliatus* L.	POTA PERF	5.3	0.03	0.81	4.47	-0.2	0.842

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Table S3. Typical values (medians) of the main environmental parameters in lakes where charophyte communities were found; the median values below 10‰ and above 90‰ are marked in bold and shaded with blue and red, respectively; for the communities found in one or two lakes raw values are presented; key to the name abbreviations is given in Table S2 and to the parameter abbreviations in Table S1; the communities ordered according to OMI value in descending order except for *C. tenuispinae*, *C. strigosae* and *N. syncarpae* not included in the OMI analysis (see Table 2)

Abbreviation	N (lakes)	N (lake-years)	pH	Alk (meq l^{-1})	Cond (µs cm^{-1})	Colour (mgPt l^{-1})	TP (µgP l^{-1})	TN (mgN l^{-1})	SD (m)	Chl*a* (µgP l^{-1})	ALT (m a.s.l.)	Area (km^2)	Zmean (m)
CHAR CONT	40	46	8.4	2.5	318	10	42	1.20	**2.9**	**8.0**	85	1.80	7.4
CHAR ASPE	43	53	8.3	2.3	302	12	32	1.10	3.5	5.6	105	1.41	8.8
CHAR TOME	152	198	8.3	2.7	308	13	34	1.10	**2.8**	**8.2**	99	1.55	6.9
NIPS OBTU	216	302	8.3	2.7	317	12	37	1.07	**2.7**	**9.6**	101	1.50	7.7
NITE GRAC	11	12	8.3	2.2	277	10	38	1.01	3.2	**8.0**	91	1.32	8.9
CHAR FRAG	143	187	8.3	2.7	301	12	35	1.02	3.0	**8.5**	113	1.74	8.2
LYCH BARB	3	4	**7.9**	2.5	275	13	**53**	1.07	3.7	**8.2**	71	0.76	7.0
CHAR POLY	11	11	8.3	**2.0**	283	10	31	0.99	3.1	6.2	103	1.78	5.5
CHAR RUDI	38	43	8.4	2.6	281	**7**	**24**	1.01	3.5	6.5	125	1.41	7.7
CHAR VULG	22	27	8.4	2.6	270	10	31	0.87	3.1	7.7	121	2.10	9.6
CHAR DELI	67	82	8.3	2.4	282	11	32	0.95	3.0	7.7	106	1.52	7.9
CHAR INTE	23	24	8.4	**2.8**	284	12	33	0.91	3.3	7.3	97	1.74	8.2
CHAR HISP	12	13	8.3	2.4	290	**20**	28	1.18	3.2	6.6	112	2.81	8.7
NITE OPAC	6	7	8.4	2.1	**444**	**7**	31	**1.21**	**5.1**	**4.5**	101	2.81	10.7
NITE FLEX	32	37	8.4	2.3	273	9	30	0.91	3.5	5.8	122	1.74	9.6
CHAR FILI	23	25	8.3	2.7	305	10	26	1.07	3.7	6.3	87	1.74	7.3
NITE MUCR	6	7	8.4	2.5	248	**7**	35	**0.71**	**4.9**	**4.7**	117	2.81	9.5
CHAR TENU	2	2	**8.5**	2.2	225	**7**	**25**	**0.74**	**5.1**	6.7	152	2.50	8.8
CHAR STRI	1	1	8.4	2.6	238	**6**	**13**	0.91	**5.5**	**2.7**	229	3.11	38.7
NITE SYNC	1	1	**7.8**	**0.3**	**60**	**7**	**22**	**0.65**	**4.9**	**4.7**	154	0.89	9.5

Fig. S1. Niche ordination of 65 hydrophyte communities identified in 692 surveys of lowland lakes along the axis 1 of the Outlying Mean Index analysis; key to the name abbreviations is given in Table S2; open circles – charophyte communities; closed circles – other hydrophyte communities