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RELATIONSHIP BETWEEN RANGE OF THE EUPHOTIC ZONE AND VISIBILITY OF SECCHI DISC IN THREE LAKES OF ŁĘCZNA-WŁODAWA LAKE DISTRICT

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Summary. The measurements of the intensity and distribution of photosynthetic active radiation (PAR), were conducted in three lakes with different trophy and morphometry. One affirmed, that in spite high correlation between range of euphotic zone and visibility of Secchi disc, the value of conversion rate Z_{EUF}/Z_{SD} had changed since 1,4 to 5. Low values were in lake Rogóźno during blue-green algae bloom in metalimnion. However high values were in polimictic lake Głębokie Uścimowskie and lake Krasne and they be connected with large quantity of suspensions from sediments in water.

Key words: photosynthetic active radiation, euphotic zone, visibility of Secchi disc, weather conditions

INTRODUCTION

Distracting light suspension in natural water reservoirs is always, which causes that to given point of waters depth not only reaches from surface light penetrates but also distracted light from sides and from bottom [Kirk 1994].

With regard on distribution of PAR in water, so called euphotic zone, defined as depth on which reaches 1% of photosynthetic active radiation (PAR) measured near at hand under surface of water, was marked. The measurement of visibility of Secchi's disc (Zs_D) is universally applied describing light conditions parameter also. The range of euphotic zone in support about him was marked when Zs_D was multiplied by suitable value, the most often value is 1.7 but also 2 or 2.5. In lakes about water with large quantity of suspension where the light is strongly distracted, values grow to 3–5 [Moss 1998, Wetzel 2001].

The aim of this paper is, how the relationship between range of euphotic zone and visibility of Secchi disc changed under influence the chosen of factors, in three lakes of Łęczna-Włodawa Lakeland.

STUDY AREA AND METHOD

The investigations were made in three lakes laid in western part of Łęczna-Włodawa Lakeland: Lake Krasne (N51° 25"; E22° 57"), Lake Rogóźno (N51° 22"; E22° 58") and Lake Głębokie Uścimowskie (N51° 28"; E22° 55"). Two first lakes are dimictic and Lake Głębokie Uścimowskie polimictic is. Rogóźno and Głębokie have approximated to round shape, however Krasne Lake has higher coefficient of extension (Tab. 1). Krasne Lakes get turbid and full of biogens waters from adjacent fish ponds periodically. This fish ponds be reinforced from system of Wieprz-Krzna Canal (the information: Provincial Menagement of Melioration and the Water's Instalations in Lublin).

Table 1. Morphological and ecological features of lakes

Lake	Area, ha	Depth maks., m	Trophic status	Coefficient of extinsion
Krasne	75.9	33.0	mezotroficzne	2.0
Rogóźno	57.1	25.4	mezotroficzne	1.5
Głębokie U.	20.5	7.1	eutroficzne	1.7

The study was carried out during two summers periods in Rogóźno and Głębokie Uścimowskie 2006–2007, Krasne 2005 and 2007, from June to breakthrough of September and October, twice a month, this 48 terms was.

The intensity of PAR was measured using a Licor Li-250A light meter with an Li-192S probe. The measurements were made three times during date: it about hour 10, 12.30 and 14 and their arithmetical average to more far analyses' was used. The visibility of Secchci disc Z_{SD}. was also measured each time. The vertical coefficient of lights attenuation Kd [Kirk 1994] and the coefficients of elongation of lakes – as length/average width were calculated, speed of wind was got from IMGW. The concentration of chlorophyll *a* was estimated follow Nush [1980]. In statistical analyses non-linear Spearman's correlation coefficient was used [Sokal and Rohlf 1995].

RESULTS

The intensity of photosynthetic active radiation (PAR) decreased from June to October as well found differences between similarly terms in different years (for example in Głębokie Uścimowskie Lake in July 2006 year at the surface intensity of light 1122 $\mu mol^{-2} s^{-1}$ was but only 52 $\mu mol^{-2} s^{-1}$ in 2007 (Tab. 2). The lower boundary of the euphotic zone – Z_{EUF}, determined with the help of measures of PAR, dropped enough consistently from 5 to 8 m during both seasons in Rogóźno Lake. Similar range was affirmed in Krasne Lake, his changes were however more violent and without clear tendency. In Głębokie Uścimowskie

Table 2. Parameters describing conditions in studied lakes in measurements terms: I_0 – the intensity of light near at hand under surface of water, mmol m^{-2} s^{-1}, Kd – the vertical coefficient of attenuation, m^{-1}, Chl *a* – concentration of chlorophyll *a*, g m^{-3}

	Parameter	month year	VI	VI	VII	VII	VIII	VIII	IX	IX	X
Krasne	I_0	2005	-	1135	1554	1368	786	1044	956	835	647
		2007	1009	1042	198	1034	825	672	262	479	-
	Kd	2005	-	0.6	0.9	0.7	0.6	0.8	0.7	0.6	0.5
		2007	0.6	0.9	0.7	0.6	0.8	0.7	0.6	0.5	-
	Chl *a*	2005	-	7	9	10	10	12	8	9	11
		2007	8	13	11	7	14	14	10	9	-
Rogóźno	I_0	2006	-	1103	1047	956	1018	337	290	525	543
		2007	1022	1034	609	952	395	421	427	616	-
	Kd	2006	-	0.9	0.8	0.8	0.8	0.7	0.5	0.5	0.5
		2007	0.8	0.9	0.8	0.7	0.7	0.6	0.6	0.7	-
	Chl *a*	2006	-	8	6	15	13	6	8	4	6
		2007	11	12	12	6	9	7	4	5	-
Głębokie U.	I_0	2006	-	1283	1122	1138	308	838	866	613	344
		2007	1002	138	52	898	662	843	332	241	-
	Kd	2006	-	1.8	1.7	1.2	0.6	1.2	1.7	0.9	1.6
		2007	1.1	1.0	1.6	1.2	1.2	1.1	1.2	1.7	-
	Chl *a*	2006	-	62	39	20	22	23	47	15	21
		2007	19	14	36	21	19	21	32	55	-

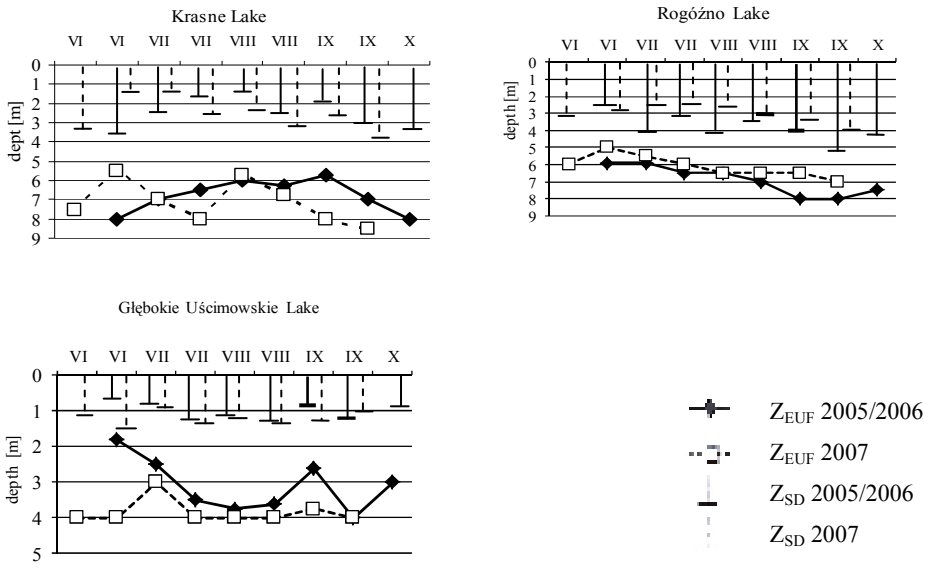

Fig. 1. Range of euphotic zone determined with the help of measures of PAR – Z_{EUF} and visibility of Secchi disc – Z_{SD} in studied lakes

Lake in July and August the range of euphotic zone was stable in both years of investigations but in remaining months, large differences in this range occurred (Fig. 1). The range of euphotic zone in all lakes, was connected with vertical attenuation's coefficient Kd, the Speraman's correlation between these parameters was the highest for lake Rogóźno, the r_S = -0.82; n = 16, however in Krasne and Głębokie he carried out adequately: -0.7 and -0.67. In these two lakes concentration of chlorophyll influenced on Z_{EUF} (Krasne r_S = -0.5, Głębokie r_S = -0.62; n = 16) what it was not affirmed for Lake Rogóźno.

The visibility of Secchi disc was defeated a lot of larger hesitations. In Lake Rogóźno values of Z_{SD} were the largest and changed in ranges 2–5 m in Krasne 1.5–3.9 m. The smallest values of Z_{SD} in Głębokie Lake were (0.5–1.8 m) (Fig. 1).

Despite this, that the visibility of Secchi disc – Z_{SD} and range of euphotic zone – Z_{EUF} were strongly connected (r_S = 0.82; n = 48) then the value of coefficient Z_{EUF}/Z_{SD} changed considerably. The lowest and the most stable they were for Lake Rogóźno: average about 2, maximally 2.8 and in year 2006 wrote down value below 2 (1.4 on beginning of July) (Fig. 2). In second mesotrophic lake – Krasne and eutrophic Głębokie Uścimowskie values Z_{EUF}/Z_{SD} were many higher. They carried out average about 3 and had changed from 2 to 4, in Krasne Lake case even 5. In this lake the values of Z_{EUF}/Z_{SD} were also the most diverse (Fig. 2).

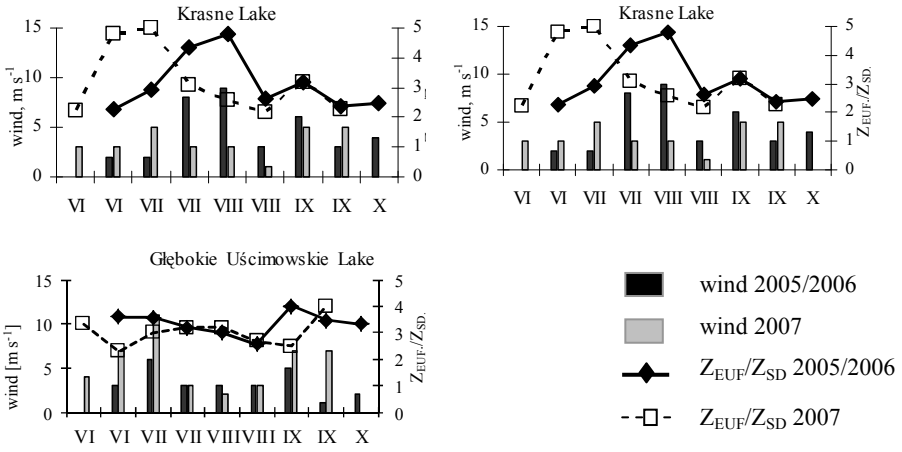

Fig. 2. Value of quotient of range of euphotic zone and visibility of Secchi disc (Z_{EUF}/Z_{SD}) and speed of wind in terms of investigations

The values of Z_{EUF}/Z_{SD} usually grew up when the speed of wind had growed, to be visible among measurements such dependence with June and July in year 2006 in Rogóźno, or August and September of the same year in Głębokie Lake, similarly in July and August of year 2005 in Krasne Lake (Fig. 2). But only in this last lake was affirmed the statistic significant correlation between values of Z_{EUF}/Z_{SD} and speed of wind r_S = 0,6; n = 16.

DISCUSSION

The intensity of PAR, reaching to surface of lakes, was approximate to marked by others authors in the same season of year in our geographical zone [Reinard and Pierson 2005].

The range of the euphotic zone, determined with the help of 1% PAR (Z_{EUF}) measures, in lakes Krasne and Rógóźno was similar like in others mesotrophic lakes [Tilzer *et al*. 1995]. Eutrophic Głębokie Uścimowskie Lake was also well irradiated usually, it was observed in eutrophic shallow lakes, overgrown plunged macrophites [Noges *et al*. 1998]. The range of euphotic zone diminished together with growth of scattering and absorption of PAR, who describes vertical attenuation's coefficient Kd [Wetzel 2001]. In lakes Krasne and Głębokie Uścimowskie fall of Z_{EUF} at growth of chlorophyll's concentration was caused larger absorption by phytoplankton [Kirk 1994, Gons *et al*. 1998, Moss 1998].

In studied lakes the visibility of Secchi disc was comparable to values passed for others lakes, about the same trophy [Kufel and Kufel 1999].

High values of Z_{EUF}/Z_{SD} conversion rate, observed in lakes Krasne and Głębokie Uścimowskie, were caused the presence of dead suspension probably. In such conditions the visibility of Secchi disc was small, while the large quantity of distracted light in depth waters was. Dependence such this, was affirmed in lakes with a lot of suspensions come from bottom's sediments for example [Gons *et al*. 1998, Moss 1998, Wetzel 2001, Pierson *et al*. 2003, Reinard *et al*. 2005]. Caused by stronger wind rolling, increase deliveries of suspension from bottom usually [Cristofor *et al*. 1994, Kufel and Kufel 1999]. The clear influence of strength of wind on rolling in Lake Krasne could was resulted, larger coefficient of extension than in two remaining lakes (the longer road for wind). It was in this lake the additional factor, the introducing of waters from the Wieprz-Krzna Canal system, on breakthrough of June and July, this could had particularly large influence in 2007 year. In Lake Rogóźno the basic meaning had unequal distribution of phytoplankton in water. It in period, when particularly low values Z_{EUF}/Z_{SD} were noted, there was low concentration of chlorophyll in superficial layers of water (Tab. 2) and for this goes, Secchi disc visibility was large (to 5 m). However very large metalimnethic water's bloom in deeper layers of water was noted, it was caused by blue-green algae *Planktothrix rubescens* [Lenard 2009], and this decided about range of euphotic zone. So large differences in algae's distribution could decide about lack of correlation between range of euphotic zone and concentration of chlorophyll in this lake.

CONCLUSION

The value of conversion rate of euphotic zone range and visibility of Secchi disc Z_{EUF}/Z_{SD} changed in large range in studied lakes. Affirmed, that on these changes in individual lakes, even the same trophic type, different factors had

influence. Larger, caused by wind rolling effected the growth of Z_{EUF}/Z_{SD}. Large influence had also unequal distribution of phytoplankton, when a lot of higher algae's number in metalimnion was observed values of Z_{EUF}/Z_{SD} diminished considerably. Wheatear's conditions, for example larger frequency of intensive winds can modify the light conditions in lakes.

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ZALEŻNOŚĆ POMIĘDZY ZASIĘGIEM STREFY EUFOTYCZNEJ I WIDZIALNOŚCIĄ KRĄŻKA SECCHIEGO W TRZECH JEZIORACH POJEZIERZA ŁĘCZYŃSKO-WŁODAWSKIEGO

Streszczenie. Pomiary natężenia i rozkładu promieniowania fotosyntetycznie czynnego (PAR) prowadzono w trzech jeziorach różniących się trofią i morfometrią. Stwierdzono, że pomimo wysokiej korelacji pomiędzy zasięgiem strefy eufotycznej a widzialnością krążka Secchiego, wartości przelicznika Z_{EUF}/Z_{SD} znacznie zmieniały się od 1,4 do 5. Niskie wartości obserwowano w jeziorze Rogóźno w czasie wywołanego przez sinice zakwitu w metalimnionie. Natomiast wysokie wartości w polimiktycznym jeziorze Głębokie i jeziorze Krasne związane były z dużą ilością w toni wodnej zawiesiny pochodzącej z osadów dennych.

Słowa kluczowe: promieniowanie fotosyntetycznie czynne, strefa eufotyczna, widzialność krążka Sechiego, czynniki pogodowe