Acta Agrophysica, 2003, 1(1), 61-67

LIGHT CONDITIONS OF PHOTOSYNTHETIC PRODUCTION OF EUPSAMMIC ALGAL COMMUNITY IN SANDY BEACH OF LAKE PIASECZNO (ŁĘCZNA-WŁODAWA LAKELAND)

Krzysztof Czernaś, Iwo Wojciechowski

Department of General Ecology, University of Agriculture
Akademicka str. 15, 20-950 Lublin, Poland
e-mail: kczeko@agros.ar.lublin.pl

Abstract. Earlier field examinations of the primary productivity of an eupsammic algal community in a sandy beach of Lake Piaseczno have shown vertical stratification of the primary production of algae and chlorophyll *a* concentration in the ground. The chlorophyll concentrations decreased almost uniformly or from the ground surface, or their highest values were reported in the layer of 10-20 mm, depending on the time of measurements. On the other hand, the highest quantities of primary production were reported at a depth of 30-40 mm under the sand surface, regardless of the date of investigation. In the same station, on eight days of July (1994) with different solar conditions, light intensity (in the range of 400-700 nm – PhAR i.e. Photosynthetically Active Radiation) was measured, using the differential photometer "Aquatic PAR-Meter" (of ®Sonopan). One of its two sensing elements measured the light intensity on the sand surface as 100%, while the other, covered by the required thickness of sand, simultaneously registered light intensity as a percentage of the above figures. The measurable figures of light intensity reached a depth up to 6 mm only, in spite of the fact that primary production of algae in the sand reached a depth of up to 60 mm at least and its maximal figures were recorded at a depth of 30-40 mm.

Keywords: light, sand, phytoeupsammon, chlorophyll concentration, primary production

INTRODUCTION

Among our papers concerning the eupsammic community of algae living in the sand of a beach at a lake shore [2-6], one addresses the vertical differentiation of this community in the sandy ground [2]. The research was carried out on two days – June 16 and September 9 (1987), in the coastal zone of Lake Piaseczno, in a permanent sampling station situated between the arable part of the catchment area and the lake, 1 m from the shore line. The beach was not overgrown by any

vascular vegetation. The vertical distribution of chlorophyll *a* concentration and primary production in the sand were examined.

The measurements of these parameters were carried out *in situ*, in cores of ground that were sliced using glass rings of required height, so that the results related to the successive layers, 1 cm thick, from the sand surface down to a depth of 6 cm.

The highest chlorophyll *a* concentration was recorded in the layer of 1-2 cm under the surface during the first research session (in June), and in the surface layer (0-1 cm) during the second research session, from where, in both cases, the concentration gradually and almost uniformly, decreased as the depth grew. The primary production of the eupsammic algae and the assimilation numbers of this community attained the highest values at a depth of 3-4 cm under the surface of sand during both sessions.

Since the edaphic conditions determining eupsammic productivity have been researched [3], the light conditions should have also been examined. The examinations of this factor were the purpose of this study especially due to scarcity of scientific literature concerning the light in ground. In the station where we studied the eupsammic community, also the examination of the vertical stratification of light were performed, with the assistance of a student, Miss Magdalena Bednarczyk [1]. The authors of the paper wish to thank her for her helpful collaboration.

MATERIALS AND METHODS

The field measurements of light intensity in the spectral range of 400-700 nm, known as PhAR or PAR (Photosynthetically Active Radiation), were carried out on eight days of July 1994 with different solar conditions, in the stable station of our permanent research location of the eupsammic community on a sandy beach on the east shore of Lake Piaseczno (see preceding chapter).

The measurements were carried out on three dark days (July 7, 8, 11), when the clouds exceeded 80%, and on five markedly sunny days (July 12, 14, 15, 20, 21), on each occasion between noon and 2.00 p.m. On July 21, the measurements were performed additionally in late afternoon (6.00 p.m.–7.00 p.m.), when the sunray gradient was low and a significant part of light was reflected on the surface of sand.

The research was performed using the prototype of differential photometer "Aquatic PAR-Meter" (®Sonopan in Białystok-City, Poland). It was equipped

with two identical photocells corrected with glass colored and milk-mat filters so as to catch with the same sensitivity the entire spectral range of radiation to be measured, from the sphere of 180° (from horizon to horizon). One of these sensing elements measured light intensity on sand surface as 100%, while the other was covered with the required thickness of sand and measured light intensity as a percentage of the values simultaneously registered on the surface of the beach. The digital meter was able to show both actual values ($\mu E\ m^{-2}\ s^{-1}$) and integrated values over longer periods (as $mE\ m^{-2}\ h^{-1}$).

The layers of sand covering the photocell were cut out from the nearest place of the beach with glass rings, from 1 mm to 10 mm high, every 1 mm. As it was impossible to cut, move, and put on the photocell the thinnest cores of sandy ground without any dislocation of their natural structure, the results obtained for the depth of 1 and 2 mm concerned disturbed layers of a sand positioned on the photocell. The deeper measurements were performed both with displacement of sand and without it.

The majority of the measurements were carried out at least twice.

RESULTS

The results of light measurements represented absolute values of PhAR integrated in one hour both on the surface of sand and under its layers of different thickness, expressed as percentages of absolute values on the ground surface. The former, absolute values of the PhAR on the surface of the ground on the respective days amounted to: 1.769 m E $m^{-2}\ h^{-1}$ on July 7, 2.372 m E $m^{-2}\ h^{-1}$ on July 8, 0.894 m E $m^{-2}\ h^{-1}$ on July 11, 2.8 and 4.828 m E $m^{-2}\ h^{-1}$ on July 12, 1.4 and 4.036 m E $m^{-2}\ h^{-1}$ on July 14, 4.646 m E $m^{-2}\ h^{-1}$ on July 15, 5.038 m E $m^{-2}\ h^{-1}$ on July 20, on July 21 at noon 4.463 and afternoon 4.464 m E $m^{-2}\ h^{-1}$. The relative values are presented in Table 1.

The deepest measurable results were obtained for 6 mm thick layer (0.1–0.22%, mean 0.16% – see Tab. 1). It is possible that in still deeper layers some results could be registered, too, because even at a depth of 10 mm impulses shorter than 1 second were observed at about 10-15 min. intervals. However, these pulses were probably too faint to be summed up as part of the integration process. The time of integration must have been too short or the values from such depth were too small to be recorded, due to taking up the whole memory of the data channel of photocell measuring the surface light, before any measurable value was noticed in the channel of light coming from the depth.

DISCUSSION

The penetration of light through sandy ground depended on several factors. One of them was dislocation of sand that caused about tenfold reduction of sand permeability (see Tab. 1).

The next factor decreasing the penetration of light into sand was the insolation. The percentages of light intensity under the surface were about twice higher for clouded sky than on sunny days. It seems to be caused by reflection of light on the sand surface – greater in clear weather than on dark days when light is diffused.

Also the time of day played here a significant role, e.g. the percentage values of lights at a depth of 1 mm of sand were over tenfold higher at noon of July 21 than in the afternoon of the same day (Tab. 1), despite the absolute values on the surface being almost equal (4.463 as against 4.464 m E $m^{-2} h^{-1}$). This may also be caused by reflection of light on the sand surface – greater at a smaller angular height of the Sun, and smaller at noon when the angular height of sunrays is greater.

However, the most important factor limiting the penetration of light energy into sandy ground is the thickness of its layer. Under optimal conditions – in the summer, at noon, on a sunny day when both the light intensity on the surface and the angular height of the Sun were highest, even the one-millimeter layer of sand reflected and absorbed altogether about 90% of surface light. The deepest layer lighted up with the remainder of light turned out to be at 6 mm.

It seems surprising, because the layer of the maximum chlorophyll concentration was situated (in June) at a depth of 10-20 mm, and the layer of the maximum photosynthetic primary production was at a depth of as far down as 30-40 mm. Then, both these parameters worked and reached the maximum level in complete darkness!

Initially, we suspected the short impulses recorded at a depth of 10 mm in 10-15 min. intervals (see the previous chapter) of delivering sufficient energy for photosynthesis. However, subsequent consultation with Professor Stanisław Mrówczyński, a physicist from the Warsaw University, explained that the impulses resulted from (nuclear) background radiation.

Table 1. The relative intensity of the PhAR (%) penetrating the sand layers of different thickness (mm) on the sandy beach of Lake Piaseczno in the respective days of July 1994, with a qualifications the insolation while measuring as cloudily (c) or sunnily (s)

Structure of sand layer	Thickness of sand layer	The mean and extreme percentage values of PhAR in relation to the PhAR values on the surface								
		7 July c	8 July c	11 July c	12 July s	14 July s	15 July s	20 July s	21 July s	21 July PM s
-	Surface	100%	100%	100%	100%	100%	100%	100%	100%	100%
Disturbed	1 mm	-	-	-	-	-	-	-	12.20 (11.9-12.5)	1.065 (0.9-1.23)
Disturbed	2 mm	-	-	-	-	-	-	5.955 (5.93-5.98)	-	2.24 (2.18-2.3)
Disturbed	3 mm	-	-	-	-	-	-	-	0.10	0.12
Disturbed	4 mm	-	-	-	-	-	-	0.09 (0.05-0.13)	-	-
Disturbed	5 mm	-	-	-	-	-	-	-	0.02	-
Disturbed	6 mm	-	-	-	-	-	-	0.045 (0.04-0.05)	-	-
Undisturbed	3 mm	-	-	-	1.077 (0.93-1.3)	-	1.13 (1.1-1.16)	-	-	-
Undisturbed	4 mm	0.848 (0.8-0.9)	-	-	-	1.115 (1.1-1.13)	-	-	-	-
Undisturbed	5 mm	-	0.548 (0.45-0.63)	0.946 (0.66-1.1)	0.025 (0.01-0.04)	0.25 (0.2-0.3)	0.06 (0.04-0.08)	-	-	-
Undisturbed	6 mm	-	-	-	-	-	0.16 (0.1-0.22)	-	-	-

CONCLUSIONS

1. The most important factor limiting the penetration of light energy into sandy ground is the thickness of its layer. The deepest layer lighted up reaches to 6 mm only.

2. Despite the shallow penetration of light into a sand, the layer of the maximum photosynthetic primary production is at a depth of 30-40 mm.

REFERENCES

1. **Bednarczyk M.**: Light Conditions in the Habitats of the Eupsammon of Piaseczno Lake, Master's Thesis written under the supervision of Prof. Iwo Wojciechowski in Department of General Ecology Univ. of Agriculture in Lublin (in Polish). Typescript, 1995.
2. **Czernaś K.**: Preliminary Investigations on Vertical Differentiation of Primary Productivity of Eupsammon and Hydropsammon (in Polish). Stud. Centre Physiographic Documentation Pol. Acad. Sci., 19, 393-400, 1991.
3. **Czernaś K.**: Productivity of the Psammic Algal Communities in the Near-shore Zone of the Meso-trophic Lake Piaseczno (Eastern Poland). Wat. Qual. Res. J. Canada 36, 537-564, 2001.
4. **Czernaś K.**: Role of the Phytopsammic Communities in the Near-shore Zone of Lake (in Polish). Wydawn. Akad. Roln., Lublin, 2002.
5. **Czernaś K., Krupa D., Wojciechowski I., Galek J.**: The Effect of Disturbance of the Substratum on Production of Psammolittoral Algae. Acta Hydrobiol., 32, 355-362, 1990.
6. **Czernaś K., Krupa D., Wojciechowski I., Galek J.**: Differentiation and Activity Changes of Algal Communities in the Shore Zone of Mesotrophic Piaseczno Lake in Years 1983-1985. Ekol. Pol., 39, 323-341, 1991.

WARUNKI ŚWIETLNE FOTOSYNTETYCZNEJ PRODUKCJI ZBIOROWISKA GLONÓW EUPSAMMONOWYCH W PIASZCZYSTEJ PLAŻY JEZIORA PIASECZNO (POJEZIERZE ŁĘCZYŃSKO-WŁODAWSKIE)

Krzysztof Czernaś, Iwo Wojciechowski

Katedra Ekologii Ogólnej, Akademia Rolnicza
ul. Akademicka 15, 20-950 Lublin; e-mail: kczeko@agros.ar.lublin.pl

Streszczenie. Terenowe badania pierwotnej produktywności eupsammonowego zbiorowiska glonów żyjących w piaszczystej plaży jeziora Piaseczno wykazały w gruncie pionową stratyfikację produkcji pierwotnej glonów i koncentracji chlorofilu *a* [2-6]. Koncentracja chlorofilu zależnie od terminu badań albo niemal równomiernie zmniejszała się od powierzchni gruntu, albo

jej największe wartości stwierdzano na głębokości 1-2 cm. Natomiast produkcja pierwotna była niezależnie od terminu badań największa na głębokości 3-4 cm.

W tym samym stanowisku, w ośmiu dniach lipca (1994) o zróżnicowanym usłonecznieniu, przeprowadzono pomiary intensywności światła (w zakresie 400-700 nm – PhAR, tj. fotosyntetycznie aktywnego promieniowania), przy użyciu różnicowego fotometru („Aquatic PAR-Meter" firmy ®Sonopan). Jedna z jego fotokomórek mierzyła intensywność światła na powierzchni piasku jako 100%, podczas gdy druga – przykryta odpowiedniej grubości warstwą piasku – rejestrowała intensywność światła jako procent wyżej wymienionej wartości. Wymierne wartości intensywności światła sięgały tylko do głębokości 0,6 cm, mimo że pierwotna produkcja glonów w piasku sięgała co najmniej do głębokości 6 cm, a największe jej wartości stwierdzano na głębokości 3-4 cm.

Słowa kluczowe: światło, piasek, fitoeupsammon, koncentracja chlorofilu, produkcja pierwotna