FLOATING CHAMBER A POTENTIAL TOOL FOR MEASURING CO_2 FLUXES OF AQUATIC PLANT COMMUNITIES

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Abbrevations: EC – eddy correlation; GIS – geographic information systems; IRGA – infrared gas-analyser; NDVI – normalized difference vegetation index; NEE – net ecosystem CO_2 exchange, PAR - photosynthetically active radiation; P_g – gross photosynthetic rate; P_{max} – maximal photosynthetic rate; T_a – air temperature

Introduction

Wetlands are valuable ecosystems that occupy about 6 % of the world's land surface or a minimum of 12 million km^2. They comprise both land habitats that are strongly influenced by water and aquatic ecosystems with special characteristics due to shallowness and proximity to land (Roggeri 1995, Finlayson et al. 1999). Wetlands macro-vegetation plays an important role in bio-filtration processes. Global warming is anticipated to modify many water ecosystems of the Earth. In submerged plants especially, the photosynthetic rate may be limited by a low availability of dissolved inorganic carbon (e.g. Maberly and Spence 1983; Sand-Jensen 1987)

Previous photosynthetic rate measurements of aquatic vegetation were carried out on infraindividual (leaf) level in lab (Søndergaard M. 1979) or under *in situ* (Rasse *et al.* 2003) or *in situ* like condition (e.g. Adamec 1997) but not revealed with gross photosynthetic rate of plant communities. Literature data of P_{max} based on either indirect estimation of biomass growing or stomatal conductance studies (e.g. Larcher 2001). Recently used *in situ* techniques, like EC (Monteith and Unsworth 1995) or remote-sensing (like GIS, NDVI in e.g. Loveland *et al.* 1991) not adequate for ecophysiological characterization of aquatic communities.

Our aim was to develop a chamber (measuring surface 0.2832 m^2) which is suitable for studying the CO_2-exchange of aquatic plant communities under *in situ* circumstances with fast and reproducible measurements. As far as we know our technique is a pioneer work to investigate the aquatic stands' NEE at microscale. Beside the description of the detailed technical parameters of our chamber, NEE of four natural wetland vegetations of different species composition, spatial pattern and vegetation dynamic were also measured and compared with reference data.

Methods

Study site and vegetation descriptions

The *in situ* study was conducted at a large dead channel of River Tisza, called Füred ox-bow (Hungary, 44°38'N, 20°45'E), near Tiszafüred in 7th and 8th of September, 2004. The selected aquatic communities (Borhidi 2003) were the fast-growing *Salvinio-Spirodeletum*, the macrophytes dominated *Ceratophyllo-Nymphaeetum albae*, *Nymphoidetum peltatae* and the dense community submerged *Ceratophylletum demersi.*

Description of the floating chamber and measuring circumstances

Stand CO_2-exchange, transpiration rate and stomatal conductance parallel with the micrometeorological variables (PAR, T_a) were measured by using a portable IRGA (CIRAS-

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2, PP Systems, Hitchin, UK) operating in open system, sampling the air in every 10 seconds at the opposite parts (for reference and analyzer data) of a round shape UV-B resistant water-clean perspex-chamber (Czóbel *et. al.* 2004) The chamber was placed and fixed to a round-shape hole in the middle axis of a rectangular polystyrene foam board (1 m by 2 m). The floating system has been anchored by woody rods in the middle in the stands of the selected communities in order to avoid the edge effect. All measurements were implemented on calm water surface. The following characteristics showed similar pattern during the measurements: the water temperature was 20°C, air temperature about 30°C and pH of water around 8. The water depth ranged between 1 and 1.7 m depending on the communities. Coenological investigations (percentage cover of each taxa in each layer and surface cover) were carried out in each selected plot parallel with the ecophysiological sampling.

Results and discussion

The presented results revealed that this novel technique is suitable to indicate the combined fluxes of various floating and submerged vegetations in aquatic ecosystems. Our study demonstrates one of the first results for stand gross photosynthetic rates for four characteristic European aquatic vegetation types. The measured mean NEE rates show similar values (Fig. 1.) than other mesoscale studies related to wetland CO_2 flux measurements (Larcher 2001). The Pmax rate of the measured floating and submerged associations in the same range (Fig. 1) as found in other studies based on other indirect methods (see e.g. Larcher 2001). The similarity of NEE values and its range provide further evidence for the reliability of this technique.

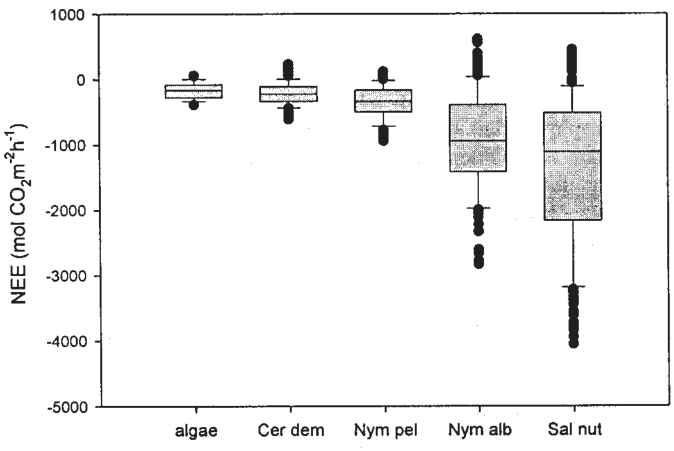

Figure 1. Net photosynthetic rate of selected plant communities of Füred ox-bow, Hungary

A unique way of measuring the gross photosynthesis of aquatic plant communities supports a clear trend of increment of CO_2 uptake among the sampled associations which is partly influenced by PAR. Despite the smaller leaves and similar surface cover the range of NEE was much wider in *Salvinio-Spirodeletum* association than in other floating vegetation. NEE data also refer to the nature of P_g, the higher the flux, the larger the peaks.

Conclusions

The applied method is seems to be an adequate technique for measuring net CO_2-gas exchange of different aquatic plant communities taken into consideration the dissimilarities between the floating and submerged vegetations during the data analyses. The floating set-up is feasible for partitioning both the measured or indirectly calculated wetland CO_2 fluxes based on mesoscale techniques (e.g. EC, NDVI) as well as to estimate accurately biomass growing and silting processes consequently. Further possible exploitation is the *in situ* bio-monitoring which has key importance in the wetland ecosystems. The photosynthetic qualities of the aquatic macrophytes as well as indirectly the chemical and physical quality of the water could be monitored by this portable equipment in accordance with the demonstrated ecophysiological sampling.

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References

Adamec L.(1997): Photosynthetic characteristics of the aquatic carnivorous plant *Aldrovanda vesiculosa* Aquatic Botany 59: 297-306

Borhidi A.(2003): Magyarország növénytársulásai. Akadémiai Kiadó, Budapest

Czóbel Sz., Balogh J., Fóti Sz.., Péli E.R., Szerdahelyi T., Szirmai O., Nagy Z., Tuba Z. (2004): Long-term effects of irrigation and fertilization on stand CO_2 fluxes and soil biochemical processes in a Hungarian loess grassland, In: Proceedings of the III. Alps-Adria Scientific Workshop (Dubrovnik, Croatia), pp.: 130-134.
Finlayson CM., Davidson NC., Spiers AG., Stevenson NJ. (1999): Global wetland inventory – current status and future priorities. Marine and Freshwater Research 50: 717 – 727
Larcher W. (2001): Ökophysiologie der Pflanzen. Verlag Publisher, Stuttgart
Loveland TR., Merchant JW., Ohlen DO., Brown JF. (1991): Development of a land-cover characteristics database for the conterminous U. S. – Photogrammetric Engineering and Remote Sensing 57: 1453-1463
Maberly SC., Spence DHN. (1983): Photosynthetic inorganic carbon use by freshwater plants. J. Ecol. 71: 705-724.
Micklin, PP. (1988): Desiccation of the Aral Sea: A Water Management Disaster in the Soviet Union. Science, Vol. 241.: 1170-1176
Monteith J L., Unsworth MH. (1995): Principles of Environmental Physics. – Edward Arnold, London - New York - Melbourne - Auckland
Rasse DP., Li JH., Drake BG. (2003): Carbon dioxide assimilation by a wetland sedge canopy exposed to ambient and elevated CO_2: measurements and model analysis Functional Ecology, Vol. 17: 222
Roggeri H. (1995): Tropical freshwater wetlands. Kluwer Academic Publishers. London
Sand-Jensen K. (1987): Environmental control of bicarbonate use among freshwater and marine macrophytes. In: Crawford, R.M.M. (Ed.), Plant Life in Aquatic and Amphibious Habitats. Blackwell, Oxford, pp. 99- 112.
Søndergaard M. (1979):. Light and dark respiration and the effect of the lacunal system on refixation of CO_2 in submerged aquatic plants. Aquatic Botany, Vol. 6: 269-283