

CHAPTER 2

EVAPOTRANSPIRATION IN LITTORAL VEGETATION

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Transpiration in littoral hydrophytes and helophytes is supposed to be high as these plants live in areas, where water supply is not a limiting factor and thus they can transpire at the potential rate (Grundwell, 1986).

Littoral hydrophytes have very little control of their stomatal aperture. Their stomata can remain open even on sunny days at mid-day. Lack of stomatal control in hydrophytes has been discussed by Penman (1963), Idso (1968) and van Bavel (1968).

Total transpiration in littoral vegetation is enhanced by its large leaf surface area. Dense stands of *Phragmites australis*, *Typha latifolia*, *T. angustifolia* and *Glyceria maxima* can, for example, be 3 m tall and their leaf area index can exceed, B. Grundwell (1986) explains, the high evapotranspiration rate of littoral vegetation also by its low aerodynamical resistance to the heat flux between atmosphere and the plant stand. This conviction is based on measurements of several authors quoted by Grundwell (1986).

The literature on evapotranspiration in littoral vegetation is not rich. Reviews of the literature data have been written by Linacre (1976), Idso (1981), Ingram (1983) and Grundwell (1986). A great variation of sometimes contrasting results reported by various authors is mainly given by the methods used for evaluating the evapotranspiration. These methods involve mainly direct measurements with lysimeters, tanks and containers of different kind and size; or the evaluation of meteorological data such as the Bowen ratio or data from aerodynamical measurements.

The earliest results originate from measurements in tanks installed in the littoral zone of a North American lake (Otis, 1914, cited by Gessner, 1959, and Bernatowicz et al., 1976). The highest evapotranspiration rates for tanks with selected species were as follows: *Potamogeton nodosus*, *Typha latifolia*, *Acorus calamus*, *Pontederia cordata*, *Scirpus validus* and *Nymphaea odorata* - 0.138 to 0.648 mm h⁻¹, that of *Potamogeton nodosus* being the highest among all species followed.

Higher rates of evapotranspiration have been estimated (on the basis of gravimetric transpiration measurements) by Kiendl (1953 and 1954) for littoral stands of *Phragmites australis* and *Glyceria maxima* in Central

Europe. Maximum monthly sums of evapotranspiration were 384 mm (August) in *Phragmites* and 333.6 (July) in *Glyceria*. According to this author, under favourable meteorological conditions, the evapotranspiration in stands of these two species is much higher than the evaporation from a free water surface. For example, a stand of *Glyceria maxima* has been reported to evaporate 58 mm (sic!) during one single day. Gessner (1959) concluded on the basis of these results that stands of emerged littoral macrophytes act as "parasites in water economy of their habitats". But those estimates of evapotranspiration, extrapolated from results of gravimetric transpiration measurements, seem much too high.

Rudescu (1965) and Rodewald-Rudescu (1974) evaluated the evapotranspiration of *Phragmites australis* stands in the Danube delta using Popov-type lysimeters located at the Maliuc Experimental Station. His results also indicate a high evapotranspiration of reed stands: monthly sums of evapotranspiration even exceeded 500 mm. The ratio between transpiration and of evaporation of water within the reed stands changed during the season within the range of 1 to 3.2. Transpiration was three times as high as evaporation in the warmest months of the growing season.

Tuschl (1970) measured the transpiration of *Phragmites australis* plants at the Neusiedler See lake (Austria) during the 1966 and 1967 growing season, using the gravimetric method. The daily sums of transpiration attained markedly high values of 12 to 13 mm d⁻¹. Bernatowicz et al. (1976) studied evapotranspiration in stands of three helophytes: *Phragmites australis*, *Typha latifolia* and *T. Angustifolia*, growing in the Mazurian lakes (Poland). Their evapotranspiration was measured in tanks installed within stands of the same species in the littoral zone of the lake and simultaneously on an elevated dam near the lake. In the first case total seasonal evapotranspiration was about 400-600 mm, which was by about one third less than that in tanks installed on the dam.

Smid (1975) measured the evapotranspiration of a littoral stand of *Phragmites australis* in a large fishpond (Nesyt, Moravia, Czechoslovakia) by the method of heat balance. The daily sums of evapotranspiration fluctuated within the range of 1.4 to 6.9 mm during the season. Values of daily transpiration in three contrasting *Phragmites* stands (one terrestrial and two littoral) are given by Kvet (1973) and Rychnovska and Smid (1973). They were determined by the gravimetric method on four summer days and ranged between 6.9 and 11.4 mm d⁻¹.

The evapotranspiration of communities of helophytes, and commonly also of all plants inhabiting wetlands of different types, has been studied several times from the standpoint of whether this vegetation reduces or enhances evaporation as compared with that from open water. The E_t/E_w -ratio (where E_t is evapotranspiration of a plant stand and E_w is evaporation from open water) was used for comparing the data from

different habitats. The question of their ratio is explored in reviews by Linacre (1976), Idso (1981), Ingram (1983) and Grudwell (1986). Linacre (1976) concludes that tall helophytes reduce lake evapotranspiration while high values of E_t reported in the literature can be explained by the "oasis effect" and heat advection - usually not considered in evaluations of evapotranspiration. The "oasis effect" arises from advection of thermal energy from dry habitats adjacent to lakes or wetlands. This is true for many helophyte stands which form narrow stripes along lake or pond shores or along river banks surrounded by dry land, e.g. fields, steppes or arid lands.

Advection also affects the tank measurements, as stated by Grudwell (1986). Snyder and Boyd (1987), who measured evapotranspiration of *Eichhornia crassipes* and *Typha latifolia* cultivated in tanks, evaluated the peripheral surface area by which additional energy is intercepted by plants in the tanks. For example, the plant stands occupied 5.77 m² and the average peripheral area was 14.6 m² for *Typha latifolia*. This difference suggests that advection of energy played a considerable role in total energy consumed by the experimental stands for transpiration and evaporation.

On the contrary, Idso (1981) asserts that the presence of vegetation increased evaporative water loss from a water surface. Ingram (1983), evaluating bog and fen evaporation, concludes that "actual evapotranspiration from bogs is approximately equal to their potential evapotranspiration, while on the little evidence that from fens is greater".

Grudwell's (1986) conclusions are more differentiated:

- a) Evapotranspiration from hydrophyte stands can exceed that from open water due to the increase of surface area, lower aerodynamical resistance of stands, etc.;
- b) the conflicting results of various authors are due to poor experimental design;
- c) The E_t/E_w -ratio depends on the state of growth, species, climate and stand density;
- d) aboveground biomass and leaf area index can be useful indicators of the E_t/E_w -ratio.

The question whether the E_t/E_w -ratio is normally equal to, higher or lower than 1 in lake littorals thus remains unresolved, but the following practical conclusions can be made tentatively on the basis of various authors' data:

1. E_t/E_w is about 1 in large, continuous and more or less homogeneous communities of emergent hydrophytes and helophytes if the weather conditions are favourable for transpiration, the plants are vigorous and do not suffer from water stress. Under less favourable both weather conditions and plant state, E_t/E_w may be less than 1 in such stands. A thick litter cover, if present, strongly reduces evaporation from wetland vegetation.
2. $E_t/E_w > 1$ in ecotonal littoral, riparian and other similar plant communities forming relatively narrow stripes or islets of wetland vegetation surrounded by dry land. The E_t/E_w -ratio will increase with increasing heat advection from dry to wet areas and will also be positively correlated with the stand height, aboveground biomass and leaf area index - provided the plants are well supplied with water and weather conditions are favourable for transpiration.

TABLE 2.1
The Transpiration/Evaporation values within the reed bed

Place	Tr/E/(x/1)		Author
Hungary	1.1 - 1.9	(1931)	Haraszty (1931)
Berlin	1 - 7	(1950)	Kiendi (1953), Gessner (1959)
Hungary	1.1 - 1.9	(1931)	Ruttkay (1964)
Danube-delta	0.98-3.42	(1951-58)	Rudescu (1960 & 65)
Danube-delta	Mean 1.54	(1961)	Stoenescu & Voicu (1963)
Valdai	Mean 1.5	(1953)	Urivaev (1953)
Beni Ounif (Sahara)	Mean 3	(1954)	Stocker (1954)
Iłji-delta	Mean 1.8	(1954)	Kuznetzov (1959)
Iłji-delta	Mean 1.6	(1955)	Kuznetzov (1959)
Iłji-delta	Mean 1.8	(1957)	Ghelbuh (1960)
Iłji-delta	Mean 1.2	(1958)	Ghelbuh (1960)
Iłji-delta	Mean 1.6		Kuznetzov (1959)
Kengirsk-Area (Kazachstan)	0.5 - 0.6		Novikova (1963)

Source: Rodewald-Rudescu, 1974.

TABLE 2.2
Transpiration/Evaporation during different months

Date and place	Mean Evapotrans- kg/m ² day	Trans- piration kg/m ² day	Evapo- ration kg/m ² day	Tr/E-ratio
11.5 Berlin	6.24	3.20	3.24	1.0
25.5 Berlin	3.94	2.50	1.44	1.6
27.7 Berlin	12.06	9.82	2.24	4.4
22.8 Berlin	18.30	16.01	2.29	7.0
17.10 Berlin	3.51	2.79	0.72	3.9
June - Danube-delta	4.85	3.36	1.49	3.25
July - Danube-delta	12.08	8.06	4.02	2.0
August - Danube-delta	17.08	11.39	5.69	2.1
Sept. - Danube-delta	11.05	7.82	3.23	3.42

Source: Rodewald-Rudescu, 1974.

TABLE 2.3
Total transpiration in kg/m²/month

Month	Glycerietum 1951	Phragmitetum 1950
January	0.0	0.0
February	0.0	0.0
March	0.3	0.0
April	20.0	19.1
May	144.1	86.1
June	362.3	188.1
July	333.6	255.9
August	320.7	384.1
September	218.0	240.1
October	120.0	119.5
November	42.5	12.0
December	26.6	0.0
Total kg/m ² /Year	1588.1	1304.9

Source: Rodewald-Rudescu, 1974

TABLE 2.4
Transpiration/Evaporation (Tr/E) data,
most, of not all from within the stand

Plant		Tr/E	Investigated Area	Author
<i>Typha</i>	mean min.-max	1.75 1.2-3.0	Valdai (1949-56)	Kuznetzov (1959)
<i>Typha latifolia</i>		3.1	Europe (1914, 59)	Otis (1914) after Gessner (1959)
<i>Typha angustifolia</i>		0.5-0.6	Kazakhstan (1962)	Novikova (1963)
<i>Typha</i>	mean min-max	2.6 2.2-2.9	Nijnedevitzki (1953-55)	Evstigneev & Popov (1957)
<i>Typha</i>		1.75	Iajebitzi (1953)	Kuznetzov (1959)
<i>Typha</i>		1.85	See Ribnii-Sakril	Kuznetzov (1959)
<i>Carex</i>	mean min-max	1.45 1.0-2.0	Valdai (1949-56)	Kuznetzov (1959)
<i>Scirpus</i>	mean min-max	1.35 1.0-1.7	Valdai (1949-56)	Kuznetzov (1959)
<i>Scirpus validus</i>		1.2	Mid-Europe (1950-55)	Seidel (1955) Gessner (1959)
<i>Alisma plantago</i>	mean min-max	1.25 1.2-1.4	Nijnedevetzki (1953-55)	Evstigneev & Popov (1957)
<i>Acorus calamus</i>		2.5	Europe (1914, 59)	Otis (1914) after Gessner (1959)
<i>Pontederia cordata</i>		2.0	Europe (1914, 59)	Otis (1914) after Gessner (1959)
<i>Sparganium eurycarpum</i>		2.3	Europe (1914, 59)	Otis (1914) after Gessner (1959)
<i>Nymphaea odorata</i>		0.9-1.0		Otis (1914) after Gessner (1959)
<i>Nymphaea</i>		0.9-0.99	Valdai (1949-54)	Kuznetzov (1959)
<i>Lemna</i>	mean min-max	0.84 0.74-0.91	Nijnedvitzki (1951-54)	Kuznetzov (1959)

Source: Rodewald-Rudescu, 1974

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