A comparison of evapotranspiration rates for willow and reed in a riverine fen

First measurement results

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Introduction – The investigation area

Situation of the area

[Map showing the investigation area, City of Rostock, River Warnow, Baltic Sea, andInvestigation area.]
Introduction – The investigation area

Aims of the study:

- quantify the evapotranspiration
- get characteristic plant resistance parameters
The reed stand

dense reed vegetation

Ground water
dipp well

Ditches

level of surface above sealevel

0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

0 5 10 15 20 m
The willow stand

![Map of the willow stand with level of surface above sealevel and ditches indicated]

- Ground water dipp well
- Willow
- Ditches

Level of surface above sealevel:

- 0.15
- 0.2
- 0.25
- 0.3
- 0.35
- 0.4
- 0.45
- 0.5

Distance in meters:

- 0 m
- 5 m
- 10 m
- 15 m
- 20 m
Method

Meteorological measurement program

- calculate Evapotranspiration by using Penman-Monteith equation with estimated $r_s$ and $r_a$

Hydrological measurement program

- calculate Evapotranspiration by using diurnal fluctuations of groundwater level

Method I

Estimating of $r_s$ and $r_a$ by comparing different values of the two methods

characteristic plant resistance parameters for Penman-Monteith equation

Method II
Method I – Meteorological measurement program

Penman - Monteith - equation

\[ ETa = \frac{1}{L^*} \times \left( s \times (Rn - G) + \frac{\rho \times c_p}{r_a} \times (e_s(T) - e) \right) \]

- **constant factors**: air density \( \rho \), specific heat of the air \( c_p \), psychrometric constant \( \gamma \)
- **meteorological variables**: measured
- **botanic/meteorological variables**: estimated parameters for reed and willow
Method II – Hydrological measurement program

Using of *diurnal ground water level fluctuation* to calculate the daily evapotranspiration rate

\[ ETa = \left\{ (H_1 - L) + \left[ (H_2 - L) \cdot \frac{T_1}{T_2} \right] \right\} \cdot S \]

„Draw down recharge method“
(Hays, 2003)

\( S \) = storage coefficient
The storage coefficient – a **non constant** value

<table>
<thead>
<tr>
<th>water level under surface (m)</th>
<th>storage coefficient (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>0.05</td>
<td>0.029</td>
</tr>
<tr>
<td>0.10</td>
<td>0.044</td>
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<tr>
<td>0.15</td>
<td>0.054</td>
</tr>
<tr>
<td>0.20</td>
<td>0.054</td>
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<tr>
<td>0.25</td>
<td>0.060</td>
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<td>0.30</td>
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<tr>
<td>0.70</td>
<td>0.095</td>
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<tr>
<td>0.80</td>
<td>0.098</td>
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<tr>
<td>0.90</td>
<td>0.103</td>
</tr>
<tr>
<td>1.00</td>
<td>0.108</td>
</tr>
</tbody>
</table>

(Trübger 2005)

**Including:**
- **dual porosity** (based on Durner, 1994)
- **Van Genuchten parameters**
An application of the storage coefficient function

![Graph showing ground water level and storage coefficient over time.](image)

- Ground water level (m above sea level)
- Storage coefficient

**Surface**

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[Diagram details include time and values for ground water level and storage coefficient over a specific period.]
Results – The hydrologic situation on 09.08.2004

- at the willow stand

- sight depression ground water to the central willow

ground water dipp well

ground water level

m above sealevel

flow direction

0 5 10 15 20 m

willow

0.1

0.125

0.15

0.175

0.2

0.225

0.25

0.275

0.3

0.325

0.35

- at the reed stand

- sight depression ground water

- no significant ground water flow direction

- cone of depression of ground water to the central willow
Results – The Draw down recharge method – at the willow stand

ground water level

- an example of the willow stand

evapotranspiration-rates from wells beneath the willow

evapotranspiration-rates from wells outside the willow

ground water level
Results – The Draw down recharge method – at the *willow* stand

- **maximum Eta in the central willow**

- **ground water dipp well**

- **evapotranspiration rates**
  - mm/d
Results – The Draw down recharge method – at the *reed* stand

- uniform distribution of Eta at the reed stand

- dense reed vegetation

- ground water dipp well

- evapotranspiration rates

- mm/d
Results – A comparison

Penman – Monteith:
- Eta - willow
- Eta - reed

Draw down recharge
Method:
- Eta - willow
- Eta - reed
Final remarks

- this estimation shows differences between the Eta rates for willow and reed in the following areas (based on diurnal ground water fluctuations):

  ➔ cone of depression of ground water beneath the willow

  ➔ the area distribution of Eta at the two stands

  ➔ max Eta_{willow} = 10,0 mm/d - max Eta_{reed} = 7,0 mm/d

  cf. previous literature: 8,8 to 10,0 mm/d 7,0 to 10,0 mm/d

- the using of Penman-Monteith equation with plant resistance factors should be used with caution

- Eta could be calculated more simply and more accurately by using diurnal ground water fluctuations
Thank You for Your attention
The „oasis-effect“

Graph showing evapotranspiration rates for willow and reed, net radiation, and ground water level over time.
Method II - Hydrological measurement program

The willow site

View to the willow stand

Groundwater dip well
Results – The Draw down recharge method – at the *reed* stand

Evapotranspiration-rates from all wells at the *reed* stand

Ground water level - an example of the *reed* stand
Method II – Hydrological measurement program

accounting equation:

\[ \text{Eta} = P + I - \text{CA} - \text{dWS} - \text{dGW} + (\text{GW}_{\text{in}} - \text{GW}_{\text{out}}) \]

- \( P \) - precipitation
- \( I \) - influent seepage
- \( \text{CA} \) - capillary action
- \( \text{dWS} \) - Water storage
- \( \text{dGW} \) – ground water fluctuation
- \( \text{GW}_{\text{in}} \) - inflow GW
- \( \text{GW}_{\text{out}} \) - outflow GW

\[ \text{Ea} = \text{dGW} \]