The water balance of a Sphagnum farming site in Northwest Germany

Kristina Brust¹, Andreas Wahren¹, Matthias Krebs², Greta Gaudig², Hans Joosten²

¹ Dr. Dittrich & Partner Hydro-Consult GmbH, Dresden
² Institute of Botany and Landscape Ecology, Ernst Moritz Arndt University Greifswald
Sphagnum farming

- field studies have demonstrated the feasibility of Sphagnum farming
- under natural conditions atmospheric water supply would provide enough water
- in drained landscape precipitation alone cannot ensure permanent wet conditions, particularly not in summer when evapotranspiration exceeds precipitation

→ Sphagnum farming sites require a water management system enabling irrigation, avoiding flooding

Investigation of water balance

1. In which periods do excesses and deficits occur?
2. What are the main sources of water loss?
3. How much water is needed to maintain the water table close below *Sphagnum* surface throughout the year?
Sphagnum farming site Hankhauser Moor

study site

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Sphagnum farming site Hankhauser Moor

Study site

Diagram showing:
- Phreatic water level gauges (F)
- Groundwater gauges (B)
- Gauges in surface waters (O)

Legend:
- Drainage channels
- Irrigation system
- Flow direction
- River 'Schanze'
- Groundwater flow direction
- Bog grassland

Scale: 100 m

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study site on former bog grassland
Stratigraphy: former bog grassland 'Hankhauser Moor'

- uppermost 30-50 cm were degraded
Stratigraphy: former bog grassland 'Hankhauser Moor'

- uppermost 30-50 cm were degraded → layer removed
- high saturated hydraulic conductivity 120cm/day in upper peat layer
- with increasing depth – hydraulic conductivity decreases
  → very limited vertical seepage
  → horizontal fluxes to adjacent drained areas
Components for calculating the water balance

\[ P + Q_{\text{in}} = ETR + Q_{\text{seepage}} + Q_{\text{out}} \pm \Delta S \]

- **\( P \)**: precipitation, \( Q_{\text{in}} \): inflow
- **\( ETR \)**: evapotranspiration, \( Q_{\text{seepage}} \): seepage, \( Q_{\text{out}} \): outflow
- **\( \Delta S \)**: change of water storage

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Components for calculating the water balance

• a combined concept of modelling and measurement:

Measured:
- P at weather station and for long-term simulations station Bremen 1993-2013
Study design
Components for calculating the water balance

- a combined concept of modell and measurement:

Measured:
- $P$ at weather station and for long-term simulations station Bremen 1993-2013
- $Q_{in}$ and $Q_{out}$ via surface water in outlet $\rightarrow$ calculation
Components for calculating the water balance

• a combined concept of modell and measurement:

Measured:
- \( P \) at weather station and for long-term simulations station Bremen 1993-2013
- \( Q_{\text{in}} \) and \( Q_{\text{out}} \) via surface water in outlet → calculation
- phreatic, surface and ground water level
Study design

(a) Study site

(b) Causeway
Peatmoss production strip
Irrigation ditch

(c) Phreatic water level gauges (F)
Groundwater gauges (B)
Gauges in surface waters (O)

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Components for calculating the water balance

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- phreatic, surface and ground water level

Modelled:
- ETR modelled via Romanov-Approach, ET from water surface (ditches) via Dalton-approach
- Q_{seepage} via phreatic, surface and groundwater level $\rightarrow$ modelled with the package Visual MODFLOW
- $\Delta S$ modelled with change of water level
Results

- phreatic water levels near peat surface and similar to water levels in the irrigation ditches
- water levels in drainage ditches and Schanze considerably lower
- groundwater level between level of phreatic water and that of drainage ditches

Water levels (August 2011 – October 2013)

Brust et al. submitted
Ground water flow

River Schanze

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In which periods do excesses and deficits occur?

- Driest period in spring

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In which periods do excesses and deficits occur?

- 2013 dry year: 709 mm compared to $\bar{8} 49$ mm yr$^{-1}$(1989-2013)
- annual cycle of ETR $\rightarrow$ spring and summer: ETR > P
- winter: ETR < P
- summer: ETR > P, water deficit: 280 mm in summer 2013

$\Rightarrow$ Irrigation is necessary to maintain a constant high water table

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In which periods do excesses and deficits occur?

- annual cycle of ETR → largest impact on water balance
- summer: ETR largest output flux → deficits: compensated with irrigation
- winter: outflow via ditches (water excess)
What are the main sources of water loss?

- 47% of incoming water is lost via ETR
- losses by seepage accounted for 24% of the total water losses
How much water is needed to maintain water table high?

- water demand trial site (8640 m²): 3100 m³ for the hydrological year 2013

![Diagram showing water demand, precipitation, evapotranspiration, and seepage over time from November 2012 to October 2013.](image-url)
How much water is needed to maintain water table high?

- Long term: mean water demand: 1600 m³/ha and year
• ETR high due to the all-year high water table → advection enhances ETR (oasis-effect)

• $Q_{\text{seepage}}$ 24% → horizontal fluxes to adjacent drained peatland

→ extra losses could be reduced, if the *Sphagnum* site would be surrounded by wetter areas and/or a larger size of the farming site

• measured $Q_{\text{in}}$ overestimated (malfunction of irrigation system in 2013)

• modelled water demand: $\sim 1600 \text{ m}^3$ per year and hectare
Conclusions

- Establishment of a Sphagnum farming site on drained bog proved to be successful.
- With controlled management the water levels were kept almost constantly close to surface level to ensure optimal growth of *Sphagnum* mosses.
- Water demand is high compared to ideal site conditions.
- Losses will decrease (lateral seepage, advection \(\rightarrow\) evapotranspiration) with increasing size of the Sphagnum farming site.
- Approach to assess necessary irrigation volumes is transferable to other sites when considering site-specific characteristics.
Irrigation inlet
Outflow
Total area
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Thanks for your attention!

...questions?