SHALLOW LAKE EUTROPHICATION AND CLEANUP

International Experiences

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Lake Eutrophication

Control → P Load → Algae

This is a lake

This is a lake
Comparison of various lakes: OECD assessment (annual average Chl-a vs normalized P load)

Transfer of experiences
Lake Balaton
First Warning

Area: 600 km²
Depth: 3 m
LAKE BALATON: EXTERNAL PHOSPHORUS LOAD

KESZTTHELY BASIN (1945-2002)

Total P (t/year)

Load increase: tourism and agriculture
LAKE BALATON: ALGAL BIOMASS

KESZTHELY BASIN (1945-2002)

Clorophyll-a (mg/m³)

- July - August
- Yearly average

Control strategy & DM
Lake Balaton: Control and Impacts

Control → P Load → Algae

Cylindrosp. Raciborskii → No Reaction
Travelling with C. Raciborskii
Lake Balaton: Control and Impacts

Control -> P Load -> Algae

Global Stress

Cylindrosp. Raciborskii

No Reaction

Sediment Renewal

Sudden Improvement

1919

1946

1983

1994

1995
THE ROLE OF THE SEDIMENT
THE ROLE OF THE SEDIMENT

WASTEWATER TREATMENT

DEPOSITION FROM THE ATMOSPHERE

NON-POINT SOURCES

EXTERNAL LOAD

INTERNAL LOAD

OUTFLOW

SEDIMENTATION

SEDIMENT
LAKE BALATON: EXTERNAL LOAD

KESZTHELY BASIN (1945-2002)

Total P (t/yr)

160
140
120

Inflow
Catchment for calibration
Catchment for simulation
Shoreline area
Non-point sources: scales, models and estimations

Spatial scale
- Soil profile, paved area: m²
- Agricultural field settlement: km²
- Small to medium catchment: 1000 km²
- Large watershed: 10⁶ km²

Temporal scale
- Minute
- Hour
- Day
- Year

Model complexity
- Aggregation
- Strategic analysis

Processes, research
- SWMM, STORMNET

Field management, planning of good agricultural practice
- ARES

Watershed management planning (lumped or distributed parameter models)
- PhosFate

Advanced tools
- SWAT, GWLF, WETSPA
- MONERIS

Advanced tools
Diffuse P loads: Zala River basin areal distributions (cell level, long-term average)

- **DP emission [kg/ha/a]**
- **PP emission [kg/ha/a]**
- **TP loads [kg/a]**
- **TP retention [%]**

<table>
<thead>
<tr>
<th>DP emission</th>
<th>PP emission</th>
<th>TP loads</th>
<th>TP retention</th>
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<tr>
<td>0.00</td>
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<td>1</td>
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<td>10000</td>
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LAKE BALATON: LOAD RESPONSE

KESZTHELY BASIN (1945-2002)

Clorophyll-a (mg/m³)

- July-august
- Yearly average

DIFFUSE LOADS
Lake Balaton
Phosphorus load and algal biomass

Hysteresis: structural changes & sediment

- Decreasing load 1988-1993
- Eutrophic state 1977-1987
- Increasing load 1965-1976
- Drought 1999-2003

Annual average chlorophyll concentration [mg m^{-3}]

TP load [t year^{-1}]
Lessons

❖ Lake - watershed problem: scientific knowledge is there

❖ Time lag and unusual load responses: sediment, blue-greens and non-point sources

❖ Approach: - data and monitoring (present state)
  - nutrient limitation (P and/or N)
  - external load estimates (background-, non-controllable-, point- and diffuse sources)
  - internal load (sediment)
  - likely load-response and targets
  - control measures and costs
  - action plan
  - implementation & institutions

❖ Total load control is not enough

❖ Many hypertrophic shallow lakes in China