LYSIMETER RESEARCH
Results of the 14-year-work of the "Lysimeter Research Group"

Universität für Bodenkultur Wien
Department für Wasser-Atmosphäre-Umwelt

University of Natural Resources and Applied Life Sciences, Vienna

Institute for Hydraulics and Rural Water Management

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LYSIMETER RESEARCH
14-year-work of the "Lysimeter Research Group"

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- **Lysimeter Research Group**
- **Lysimeter – Definition**
- **Research Tasks – Applications**
  - Agriculture
  - Remediation of Brownfield Sites
- **Limitations of Lysimetry**
- **Strategies to improve Effectiveness**
- **Recommendations**
- **Conclusions - Opportunities**

LYSIMETER RESEARCH GROUP

Arbeitsgruppe Lysimeter Research Group

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- is a platform for interdisciplinary exchange of information between researchers and practitioners on an international level.
- initiates, coordinates and contributes details to specific fields of research
- Its focus is on different kinds of LAND-USE AND THEIR EFFECTS ON AQUATIC SYSTEMS
- more details: www.lysimeter.at

LYSIMETER Definition

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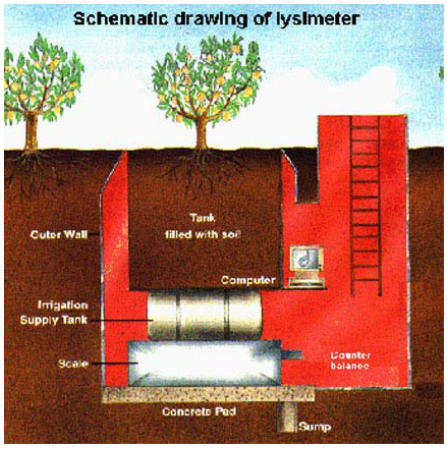

- Lysimeters are containers filled with soil,
- seepage water is measured directly,
- percolating water is collected - either gravimetrically or by applying negative soil water pressure.

LYSIMETER
Fields of Research and Application

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LYSIMETRY

Soil Science, Hydrology, etc.

Agriculture

- anthropogenic substance input
- water and nutrient balances
- comparison of different cultivation systems
- effectiveness groundwater protection measures

Ecology Environment Protection

- seepage water quantity prediction
- data of seepage water quality
- effectiveness of surface-sealing systems
- source term determination

AGRICULTURE
Grassland
Extensification of Land-Use

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Long-year lysimeter experiments (e.g. Gumpenstein)

low potential of nutrient (especially NO_3-N) losses

- independent on fertilizer type
- even with „over-fertilizing“
- lower risk of groundwater contamination

Reason: high yield →
potential of high nutrient withdrawal

Problem: with further extensification (fallow land) →
intensification of nutrient losses

(Eder 1997)

AGRICULTURE
Hydromorphic Soils
Soils influenced by Groundwater

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Lysimeter-Station Paulinenaue (Germany):

experiments to determine the nitrogen-loss of different plants with different groundwater-levels:

nitrogen-loss decreases with:

- nitrogen withdrawal by yield
- higher evapotranspiration
- higher groundwater-level

With praxis-oriented fertilizing (< 200 kg N/ha/a) no danger for groundwater contamination!

groundwater lysimeters!

(Behrendt 1996)

REMEDIATION
Effectiveness of Surface Sealings (1)

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Lysimeter-Facility of ARC Seibersdorf (Austria) with special Remediation-Lysimeters filled with 1,5 m of 20 years old municipal waste:

4 different top cover systems of old landfills

- 0,5 m / 1,0 m substrate layer
- compacted clay layer covered with 0,5 m s.
- waste “inertisated” and covered with 0,5 m s.

Vegetation: combination of Alfalfa and Populus-trees

REMEDIATIONS
Effectiveness of Surface Sealings (2)

How was the amount of seepage water and the emission of landfill gases influenced?

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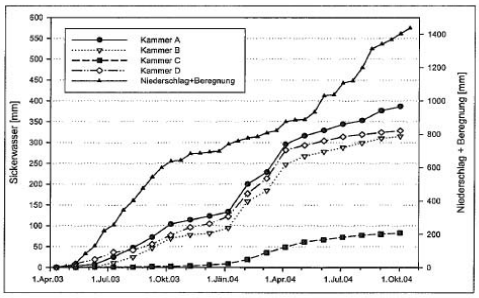

Abbildung 1: **Kumulativer Sickerwasseranfall aus den 4 Kammern des Altlastenlysimeters sowie Niederschlag inklusive Beregnung im Zeitraum April 2003 bis Oktober 2004.**

Seepage Water

as expected: highest amount in chamber A – smallest amount in chamber C

Methane Gas

no methane detected in chamber A

High variation in gas content in chamber D

(Wimmer 2005)

LIMITATIONS OF LYSIMETRY
Lysimeter Failures

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Lysimeters shall build a **representative part of the site** to be examined, but the following parameters/effects are a common source for lysimeter failures:

- **Size of Lysimeter Surface**
- **Border-Effects**
- **Oasis-Effects**
- **Surface-Phenomenons at the Lysimeter Base**

LIMITATIONS OF LYSIMETRY
Size of Lysimeter Surface

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- **to compensate border effects and**
- **to ensure a representative stock of plants**
  - to gain a useable median despite certain genetic differences between the individuals
  - necessary area is plant-specific

e.g. Maize: 100.000 plants/ha
→ 2 m² (20 plants)

LIMITATIONS OF LYSIMETRY
Border Effects

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- **limitation of rooting space**
  (reason: lysimeter too small)
- **uncontrolled leaking of surface water**
  (reason: no compound between soil and lysimeter wall)
- **unnatural „heating“ of soil**
  (reason: additional radiation at the lysimeter border)

LIMITATIONS OF LYSIMETRY
Oasis Effects

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Lysimeter plants must grow under the same micro-climatically conditions as the surrounding vegetation, especially:

- relative humidity
- surface temperature
- available evaporation energy (radiation energy, convective energy)

LIMITATIONS OF LYSIMETRY
Phenomenons on the Lysimeter Base

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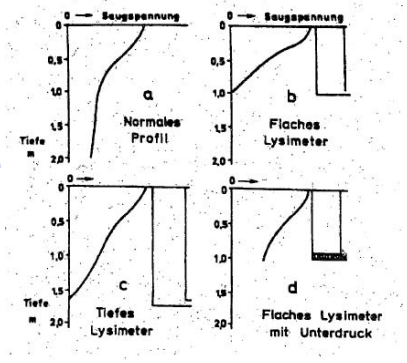
due to the interruption of the natural soil profile:

- disturbance of the natural water movement
- change of „natural pressure situation“

→ **Influence on the suction-power development**



Klaghofer, 1991

STRATEGIES
TO IMPROVE EFFECTIVENESS

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Lysimeter Station Großobrigen, Germany

(Roth 1994)

PARAMETER	REQUIREMENT	REALISATION
Micro-Climate	no Oasis-Effect	▪lysimeters in large fields (distance to field border approx. 200m) ▪no bare soil between lysimeter and field
Lysimeter Size **Depth**	▪Typical „planting structure“; ▪representative number of plants ▪No limitation of rooting space	2 m² lysimeter surface 2,5 m depth
Soil Water Balance	▪No change of soil profile ▪Close compound between soil and lysimeter ▪No build-up of water	▪Undisturbed soil (Monolith) ▪Suction Plate

STRATEGIES
TO IMPROVE EFFECTIVENESS

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Lysimeter Station Gumpenstein, Austria

(Eder 2003)

Comparison between a Chamber-Lysimeter and a monolithic Field-Lysimeter *(3 years)*

Chamber-Lysimeter
9 concrete chambers
Depth: 1 m
Surface: 1 m²
Disturbed (=artificially filled) soil
Gravitation Lysimeter

Field-Lysimeter
5 cylinders
Depth: 1,5 m
Surface: 1 m²
Monolith (undisturbed)
Gravitation Lysimeter

STRATEGIES
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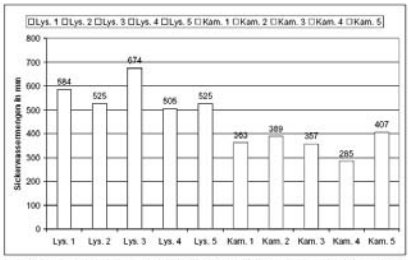

Abbildung 3: **Durchschnittliche Sickerwassermengen in mm aus den Jahren 2000, 2001 und 2002, Gumpensteiner Monolith- und Kammerlysimeter**

Results after 3 years of Research:

- **average amount of percolating water:**
  - Chamber Lysimeter: 360 mm
  - Field Lysimeter: 500 mm
- **average amount of nitrogen loss**

RECOMMENDATIONS
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- **lysimeters with cylindrical containers**
- **monolith lysimeters**
- **integration into the surrounding vegetation**
- **Quality Management!!!**

  although it is difficult to define common quality standards for the variety of lysimeters and their use

CONCLUSIONS
OPPORTUNITIES

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The fields of applications for lysimeters are wide,

but every lysimeter must be designed for its specific application considering question and location!

Success and quality of lysimeter-studies depend very much on:

- exchange of experience
- cooperation between users / researchers / producers of lysimeter technology

→ **Lysimeter Research Group** Arbeitsgruppe Lysimeter Research Group

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