

ISSS Technical Meeting

Laboratory Lysimeter for Testing Leaching

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Cagliari, 25th /26th October 2018

Outline

- 1. Introduction**
- 2. Laboratory Lysimeter**
- 3. Results**
- 4. Summary and Outlook**

1. Introduction: Interest in Hydraulic and Environmental Issues

- **Hydraulic problems with infiltration and leaching of rainwater**
- **Sports surface products may contain leachable substances of concern^{1,2}**
 - Test conditions have significant influence on leaching and exposure
- **New products or drainage systems for sport grounds: benchmark needed**



1 Nilsson, N.H., Malmgren-Hansen et al. (2008): Emissions and environmental and health assessment of chemical substances in artificial turf. Report, Danish EPA.

2 Wachtendorf, V., Kalbe, U., et al. (2017): Influence of weathering on the leaching behaviour of zinc and PAH from synthetic sports surfaces. Polymer Testing 63, 621-631.

1. Introduction: Laboratory Leaching Tests for Materials

- **EN 12457 (in DIN 18035): Characterization of waste - Compliance tank test**
- **CEN TS 16637-2: Dynamic Surface Leaching Test for Construction Products**

Criteria	EN 12457	16637-2 (DSLTL)
Test duration	2 days	64 days
Intervals	2	8
Water contact time	Constant 2 x 24 h	Increasing from 6 h to 28 days
ratio	L/S 10 L/kg	L/A 20 - 80 L/m ²
Total water contact (surface area)	20 L/kg	160 – 640 L/m ²
Long-term-extrapolation (life-cycle)	No	Yes
pH dependence into account	No	No

1. Introduction: System Testing in Lab and Field

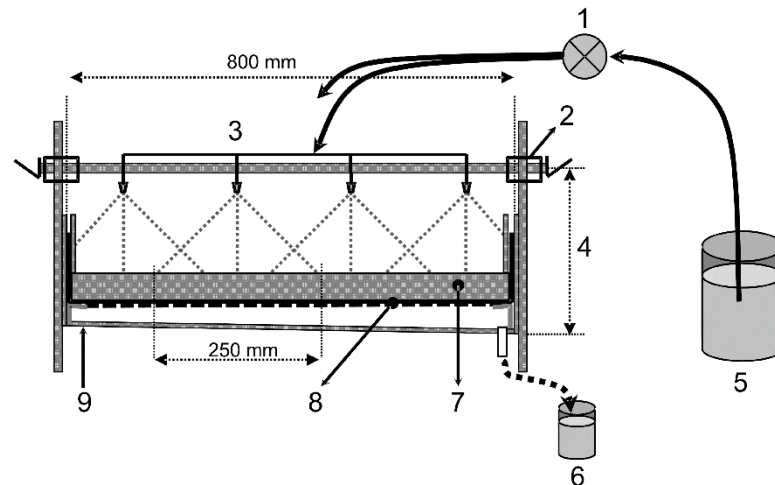
■ Laboratory system test (CEN TS 16384:2012)

- Test is running without the unbounded sub-layer

■ Field Lysimeter including the sub layer ³

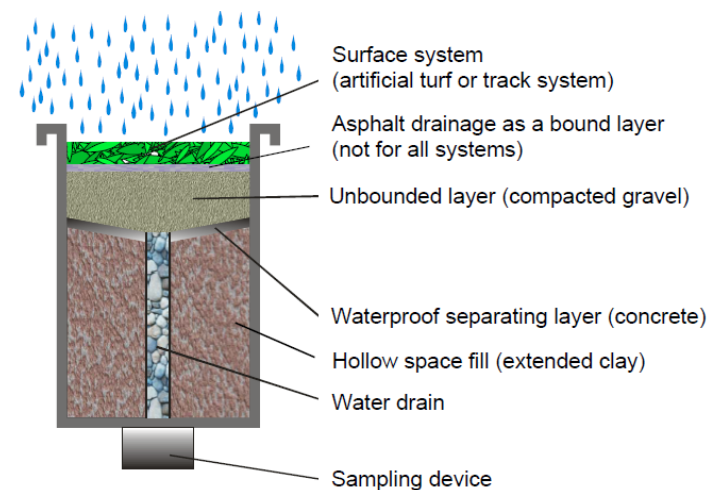
Lab System Test (Irrigation)^{1,2}

- 100 L/m² in 5 days (2x 10 L/m² d in 2 min)
- pH 6.5 to 7.5, L/S-ratio 13



Real System Test (Lysimeter)³

- 1100 L/m² precepitation in 1 year
- pH unknown (8?), L/S-ratio unknown



1 CEN/TS 16384:2012: Synthetic sport systems - Leaching test (DIN SPEC 18584)

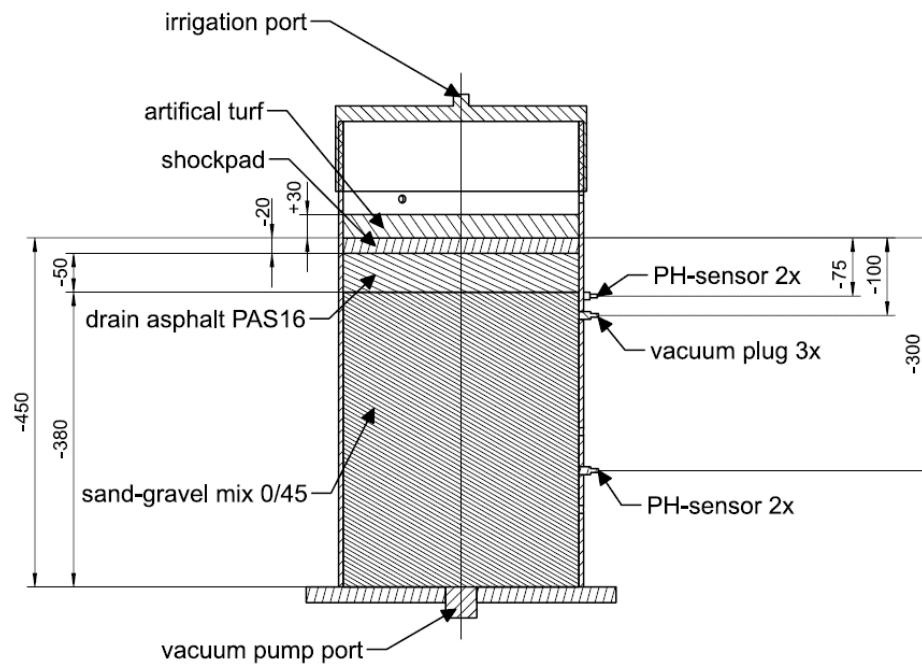
2 Kalbe, U., Krüger, O., et al. (2013): Development of Leaching Procedures for Synthetic Turf Systems Containing Scrap Tyre Granules. Waste Biomass, 4,:745-757

3 Müller, E. (2008): Kunststoff- und Kunststoffrasenflächen Verhalten unter natürlichen Witterungsverhältnissen. BASPO Federal Office of Sports, Magglingen, Switzerland.

2. Laboratory Lysimeter: Full System Test

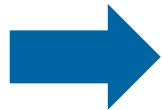
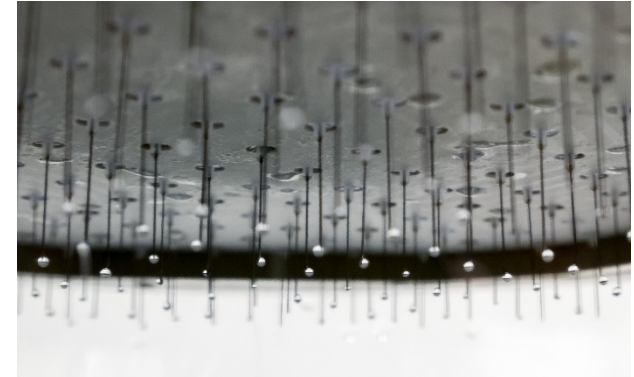
■ Equipped lab lysimeter with full system

- Column length: 70 cm
- Column diameter: 30 cm
- Sensors: 2 depths
- Sampling: 2 depths



2. Laboratory Lysimeter: Technical Specification

- **Peristaltic pump for defined water flux**
- **Irrigation head (162 needles)**
- **Monitoring of water flow and quality**
 - Water suction (unsaturated conditions)
 - pH, redox, electrical conductivity ...
- **Suction plate for controlled boundaries**
 - Water saturation at bottom avoided
- **Data Logger**
 - Interval-based multi Logger for all sensors detecting continuously parameters of interest



Standard Devices used to run the system simple as possible

2. Laboratory Lysimeter: Tested System (Example)

■ Artificial turf grass with infill

- EPDM-granules: 0.5-2.5 mm
- EPDM amount: 6 kg/m²

■ Shock pad (2 cm)

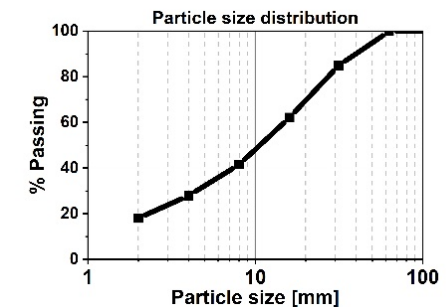
- Polypropylene foam (EPP, Neopolen® P)

■ Drain asphalt (5 cm)

- PAS 16, Bitumen 70/100

■ Unbound base layer (40 cm)

- Gravel-sand: 0/45 (max. 63 mm)
- Gravel (>2 mm): >85%
- Fine fraction (<0.063 mm): < 3%
- Hydraulic conductivity: 4×10^{-2} cm/s (1.44 m/h)



2. Laboratory Lysimeter: Operational Conditions (Example)

■ Irrigation (deionised water)

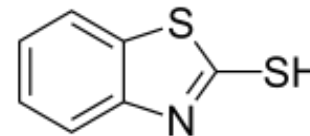
- Interval: 3x 6 h, 18 h drying between
- Intensity: 20 L/m² h, total 360 L/m² (1/3 of Swiss annual precipitation)
- Total: 26.4 L (3 x 8.8 L)

■ Sampling (pore water, outflow)

- 10 min, 30 min, 1 h, 2 h, 3 h, 6 h (max. 6)
- Pore water: syringe (see picture)

■ Substances (additives in EPDM)

- Zinc (ICP-MS, LOQ 0.001 mg/L dissolved):
Quality Standard surface and ground water total 0.02 mg/L and dissolved 0.005 mg/L
- Benzothiazole (LC-MS/MS, LOQ 0.1 µg/L):
proposed Acute Quality Standard 0.25 mg/L
([Swiss Ecotox Centre](#))



Benzothiazole
CAS 95-16-9

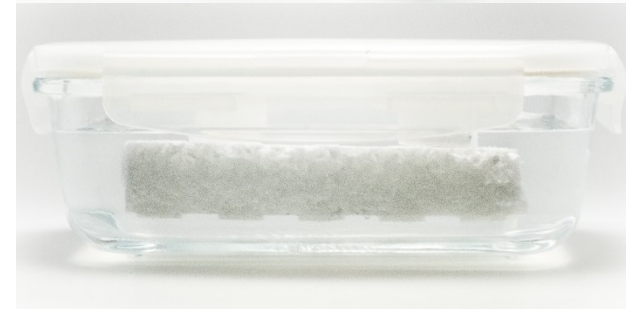
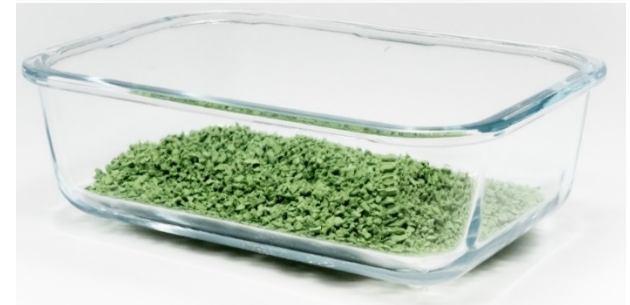
2. Laboratory Lysimeter: Operation

- Irrigation with water containing Brilliant Blue (food dye) for tracing flow paths



2. DSLT: Used as Product Test

- **DSLST usually for solid construction products**
- **Materials tested (duplicates)**
 - Reference area 100 cm²
 - EPDM granules (60 g), Turf grass, PP shock pad
 - Room temperature, in the dark, horizontal shaker
- **Water contact**
 - Intervals: 8 intervals with 6 h to 28 days
 - Total water contact time: 64 days
 - Amount of water: 8x 20 L/m² (160 L/m²)
= 3.3 L/kg corresponding to 6 kg/m² EPDM
- **Data processing**
 - Concentration pattern and cumulative emission
 - Extrapolation of long term leaching behaviour (e.g. 5 years)



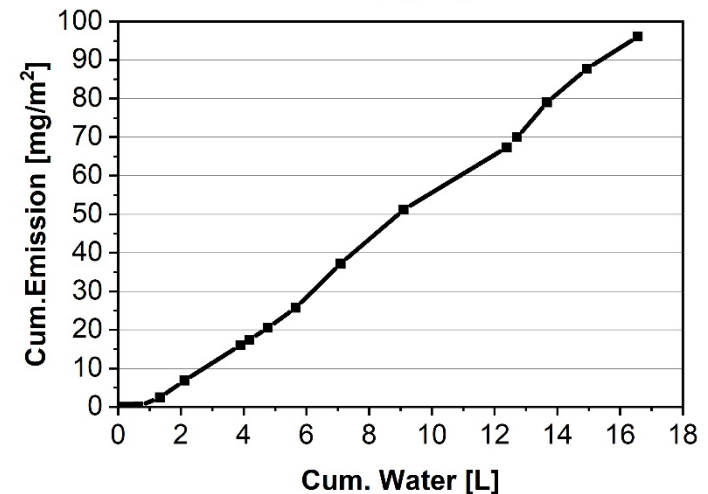
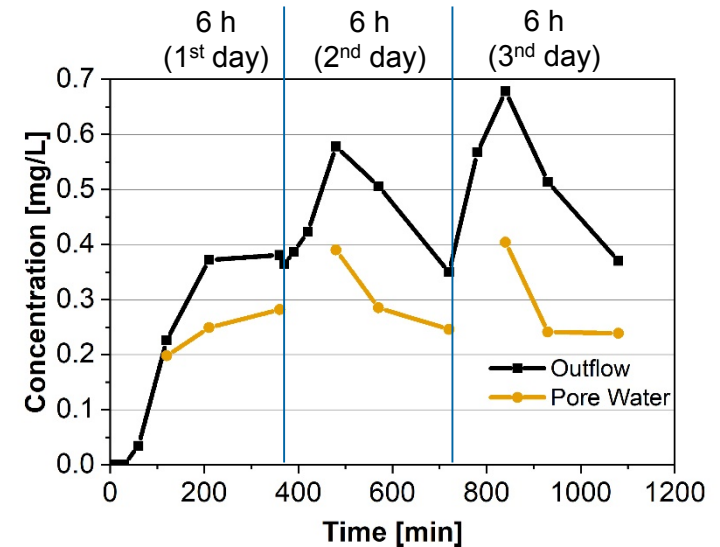
3. Results Lysimeter: Leaching of Zinc and Benzothiazole

■ Leaching of Zinc

- Zinc was not measured at all (total, dissolved)
- pH 8.0 to 8.4: precipitation of dissolved zinc, filtration of fine particles; adsorption

■ Leaching of Benzothiazole

- Breakthrough after 60 min (corresponding to irrigation of 20 L/m²)
- Pore water and outflow have similar concentration patterns
- Outflow concentrations significantly higher than pore water
- In last samples of each interval outflow around 0.35 mg/L
- Concentrations always above limit values
- Cumulated emission about 100 mg/m²



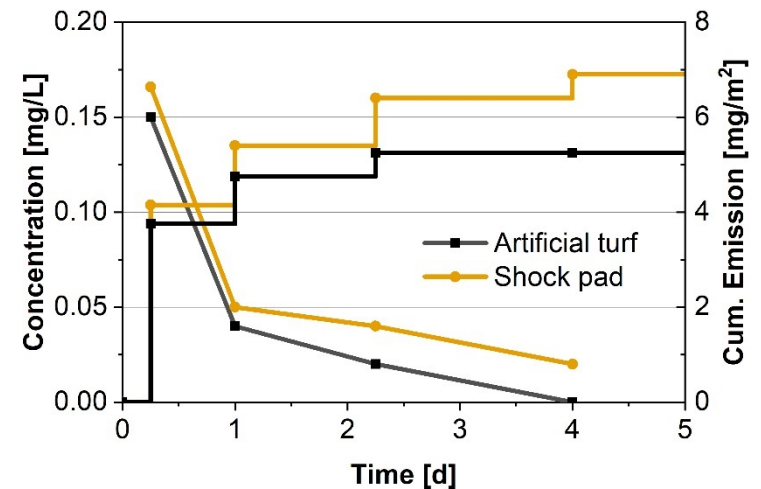
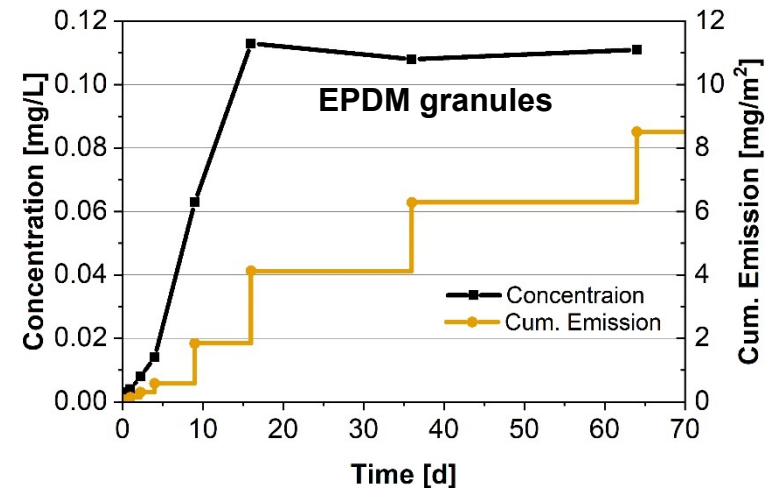
3. Results DSLT: Leaching of Zinc

■ EPDM granules

- Concentration of zinc is increasing with water contact time – diffusion / dissolution
- pH < 8.0 after 3 intervals: Zinc is present fully dissolved
- Low concentrations slightly above threshold value of 0.02 mg/L in surface water (GSchV)
- Zinc does not play a critical role in this EPDM product (is announced as “Zinc reduced”)

■ Artificial turf and shock pad

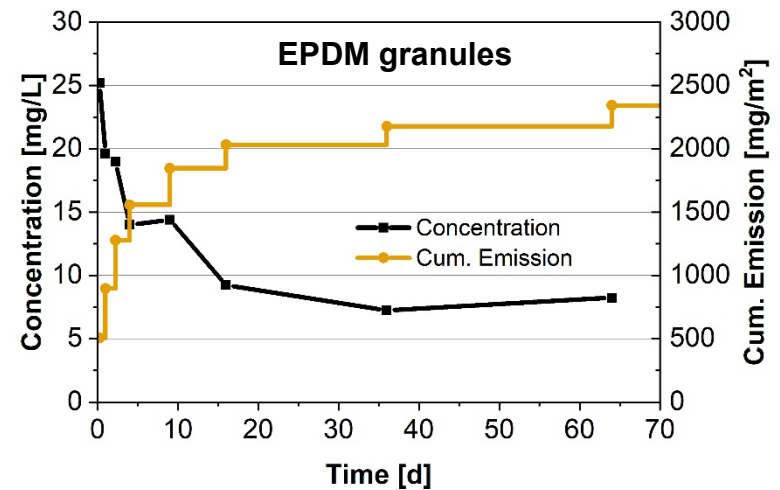
- Highest concentration of dissolved Zinc in first sample and rapidly decreasing – wash-off (Test stopped after 4 samples)
- Wash-off not relevant for life-cycles



3. Results DSLT: Leaching of Benzothiazole

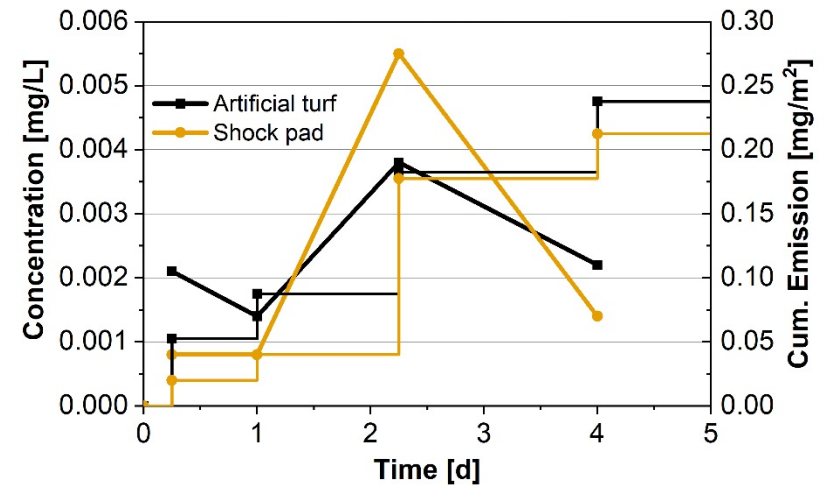
■ EPDM granules

- Concentrations of Benzothiazole are very high (max. 25 mg/L) and are decreasing stepwise with water contact time – wash-off and diffusion
- Concentration clearly above acute threshold value of 0.25 mg/L proposed for surface water – dilution factor of 20 to 100 needed



■ Artificial turf and shock pad

- Very low concentration of Benzothiazole – wash-off after contamination ...?
- Emission factor 10'000 lower than EPDM
- Not relevant for life-cycles



■ Benzothiazole is not affected by pH

3. Results: Emission of Benzothiazole in Lysimeter vs. DSLT

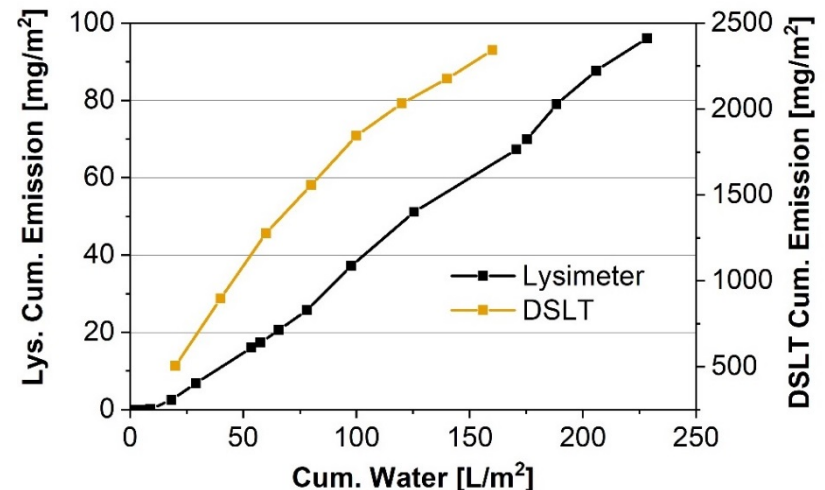
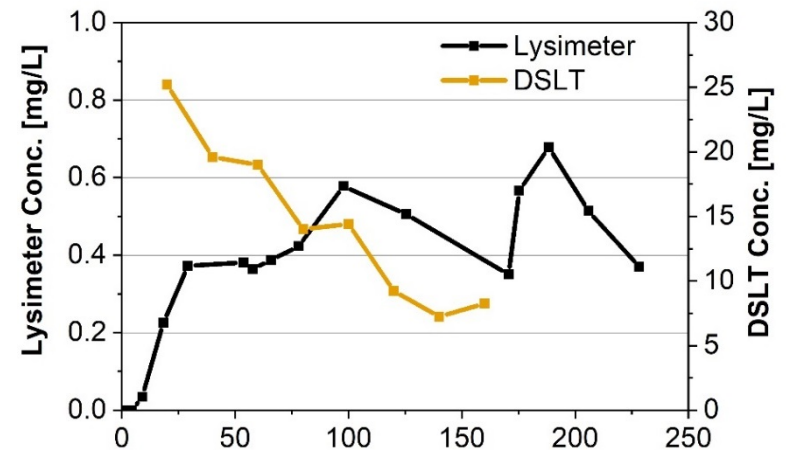
■ Concentrations

- DSLT factor 20 higher than lysimeter
- DSLT with initial decrease due to wash-off
- Maximum concentration in lysimeter not reached after 360 L/m² irrigation

■ Emission

- DSLT factor 16 more in 160 L than lysimeter
- Lysimeter test is characterized by shorter water contact time to EPDM and porous media in the sub-layer as typical for reality = release limited and interaction with matrix
- DSLT without interaction to a solid matrix reflecting potential emission (pool)?

■ DSLT easy to handle and promising by using an transfer factor, e.g. TF 20.



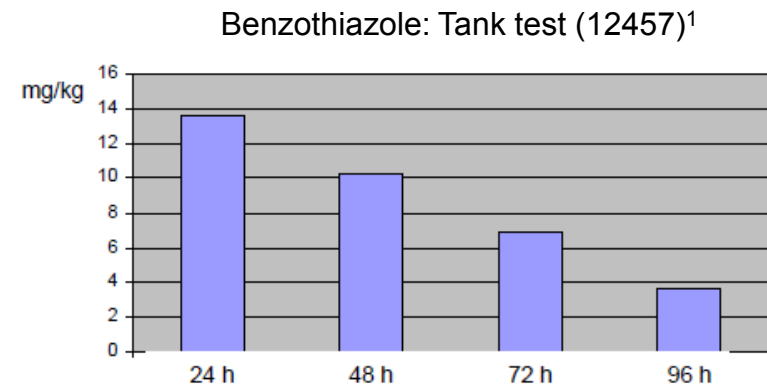
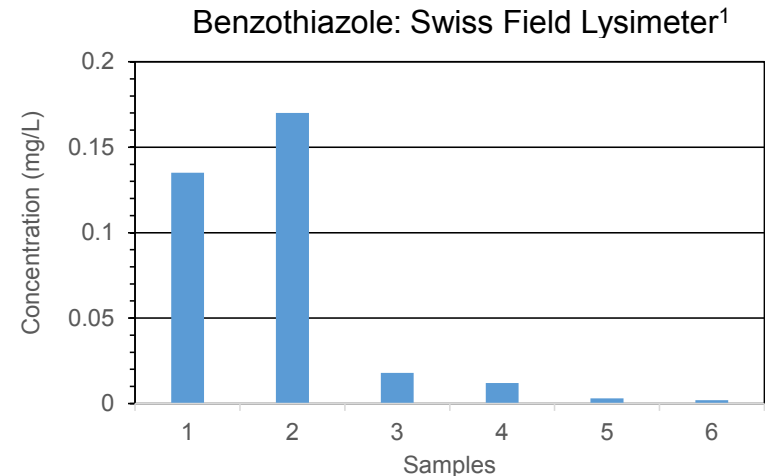
3. Results: Comparison to Swiss Study

■ Zinc (EPDM contained 0.03 – 21 g/kg)¹

- Field lysimeter: leaching of Zinc was not observed: similar to lab lysimeter (occurrence depends on entire system behavior)
- Tank test: Zinc was always observed (concentration level depend on product): similar to DSLT (the same for lab system test expected)

■ Benzothiazole

- Maximum concentration:
 - 0.21 mg/L in field lysimeter, in average low
 - 0.70 mg/L in lab lysimeter, in average high
 - 25 mg/L in DSLT
- Emission
 - 8 - 93 mg/m² in field lysimeter
 - 100 mg/m² in lab lysimeter
 - 2500 mg/m² in DSLT



¹ Müller, E. (2008): Kunststoff- und Kunststoffrasenflächen Verhalten unter natürlichen Witterungsverhältnissen. BASPO Federal Office of Sports, Magglingen, Switzerland.

4. Summary and Outlook: Tests

■ Lab lysimeter (Full Sytem Test)

- Rapid, reproducible, and realistic due to testing a system under unsaturated conditions
- Monitoring of different parameters, sampling of pore water, outflow and solid material
- Applicable also in the field to run a series of system tests at the same site

■ DSLT (16637-2, harmonized European standard for construction products)

- Leaching process can be derived, long-term behaviour assessed (e.g. 5 or 30 years)
- Possible variation: pre-treatment of materials by UV, higher temperature and pH in water
- For product characterization beneficial in combination with lab lysimeter

■ Tank test (12457)

- Delivers limited insight to substance release of materials (2 intervals, pH, porous media)
- Water contact time too short (we work on comparison between DSLT and tank test)

■ System test (CEN TS 16384:2012)

- Delivers no leaching information different to tank test or DSLT
- Useless and expensive material test

4. Summary and Outlook: Substances

■ **Zinc: Little emission of examined EPDM, shock pad and turf grass products**

- Lysimeters: pH > 8, Zinc is not mobile due to precipitation/filtration and adsorption
- DSLT / tank test: pH < 8, Zinc dissolved; test do not reflect real conditions with sub-layer

■ **Benzothiazole: High emissions of EPDM in DSLT and lab lysimeter**

- Concentrations above acute limit values are related to EPDM
- Turf grass without infill and shock pad do not release Benzothiazole

■ **Food dye Brilliant Blue**

- Tracing hydraulic conditions and transport pathways (make flow visible)

A scenic landscape photograph showing a town built on the shore of a large, calm lake. In the background, a range of mountains with significant snow cover stretches across the horizon under a clear blue sky. The town features several prominent buildings, including a church with a tall spire. The water reflects the sky and the distant mountains. In the foreground, there are some dry, brown reeds or grasses.

Thank you for your attention !

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