Swiss Study on Environmental Effects of Synthetic Sports Surfaces with Lysimeters (2006-2007)

Dr. Ralph Bergs

BASF Construction Chemicals Europe AG
Division CONICA Technik

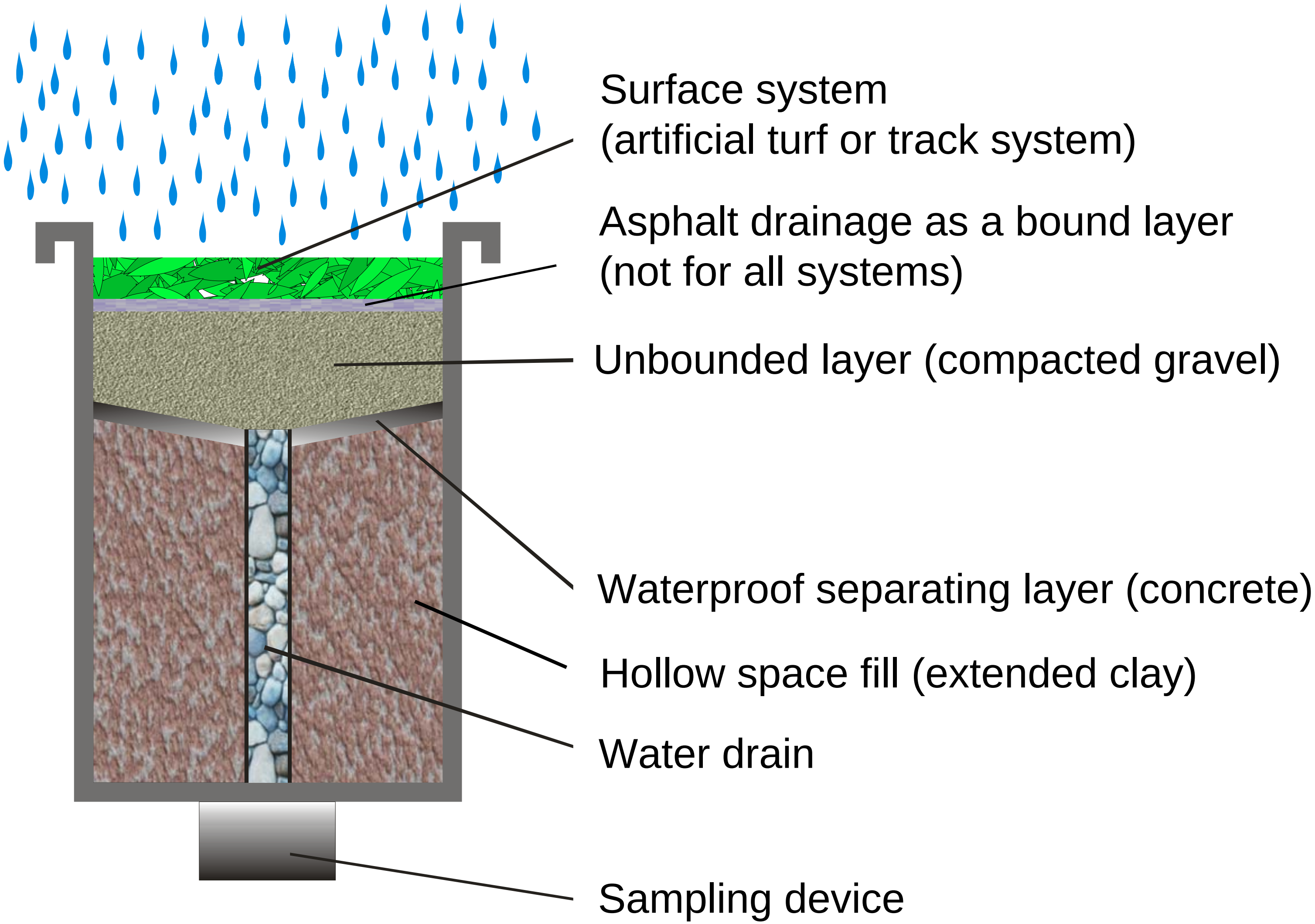
Investigations by Swiss Federal Office of Sports FOSPO (BASPO)

- In 2004 FOSPO set up a working group to update their guideline on the environmental compatibility of sports surfaces.
- The workgroup consisted of members of material producers and applicators of sports surfaces, test institutes, technical experts, the Swiss Federal Office for the Environment and the Office of Water conservation and waste management.
- The work group decided to carry out field tests under conditions which are ***as close to realistic as possible***.
- Lysimeters were chosen to deliver the most reliable and realistic test results.

Content

1. **Lysimeter design**
2. Test details
3. Test results
4. Comparison to eluate tests
5. Conclusion

Lysimeter Design



Lysimeter Design

View on water drain
and extended clay

Lysimeter Design

Concrete as water-proof separating layer

Lysimeter Design

Unbounded layer
(gravel)

Lysimeter Design

Impermeable
track system

Lysimeter Design

Test Area in Berne-Liebefeld (normally used for agricultural research)

Lysimeter Design

Lysimeters from below

Lysimeter Design

Devise for collecting the drained rain water

Content

1. Lysimeter design
2. **Test details**
3. Test results
4. Comparison to eluate tests
5. Conclusion

Main Steps within the Test

- *Preliminary analytical investigations:*

  The objective was not only to measure the DOC but also to identify and quantify individual selected chemical trace substances. Analytical methods had to be developed

- *Pilot test:*

  Based on the analytical results of one surface type over a 4 months period, the definitive measurement programme for the main test was established.

- *Main test:*

  The main test took place between May 2006 and May 2007

Overview of Tested Surfacing Systems

Artificial Turf	
Surface no. 1 (pitot test)	Artificial turf, pile hight 40 mm, infilled with EPDM granulates, peroxide-cured, on a 25 mm elastic layer *) and an asphalt drainage layer
Surface no. 2	Artificial turf, pile hight 70 mm, infilled with truck tyre rubber granules (recycled material)
Surface no. 3	Artificial turf, pile hight 40 mm, infilled with EPDM granulates, sulfur-cured, on a 25 mm elastic layer *)
Surface no. 4	Artificial turf, no infill
Elastic polyurethane-bound synthetic surfaces	
Surface no. 5	Water-permeable synthetic surface, 12 mm single layer EPDM on an asphalt drainage layer
Surface no. 6	Water-permeable synthetic surface, multilayer, 15 mm, 1st layer 9 mm PUR bounded recycled rubber granulates, 2nd layer 6 mm PUR bonded EPDM rubber granulates with 1.5 kg/sqm PUR spray coating, on an asphalt drainage layer
Surface no. 7	Water-permeable sandwich surface, multilayer 15 mm, 1st layer 10 mm PUR-bonded recycled rubber granulates, 2nd layer solid plastics 5 mm spread with EPDM rubber granulates on an asphalt drainage layer (water drainage direct into the gravel levelling layer through a hole in the middle of the surface)
Blank samples	
Surface no. 8	Gravel layer and gravel levelling layer (without synthetic surfaces)
Surface no. 9	Gravel layer, gravel levelling layer and asphalt drainage layer (without synthetic surfaces)
Surface no. 10	25 mm elastic layer *) on gravel layer and gravel levelling layer

*) 25 mm thick elastic layer of recycled rubber granulates installed in-situ (and PUR binder)

Overview of Analytical Measurements

Sum parameters	Individual substances *)
Dissolved organic carbon (DOC)	Aniline
Sum of dissolved organic nitrogen compounds (org-N)	Aryl-alkyl-p-phenylenediamines
	Benzothiazole
	Cyclohexylamine
	16 polycyclic aromatic hydrocarbons (PAH)
	Zinc
	Ammonium nitrogen
	Nitrate nitrogen
	Nitrite nitrogen

*) The individual organic substances are either used in rubber manufacture or may arise from various rubber chemicals as conversion or degradation products.
Plastizisers and UV stabilizing agents could not be analysed due to disproportionately high costs.

Precipitation Situation and Sampling

- Between end of December 2005 and mid-May 2007 **1658 mm** of precipitation was measured in Berne-Liebefeld (corresponds to 1658 litres of rain per sqm)
- During the main test (mid –May 2006 to mid-May 2007), the quantity of precipitation was **1100 mm**
- The majority of the precipitation water drained through the surfaces. Only in the summer months a certain amount of water evaporated prior to draining.
- Between end of December 2005 and mid-May 2007 **6 samples** were taken
- During the main test (mid –May 2006 to mid-May 2007), **4 samples** were taken

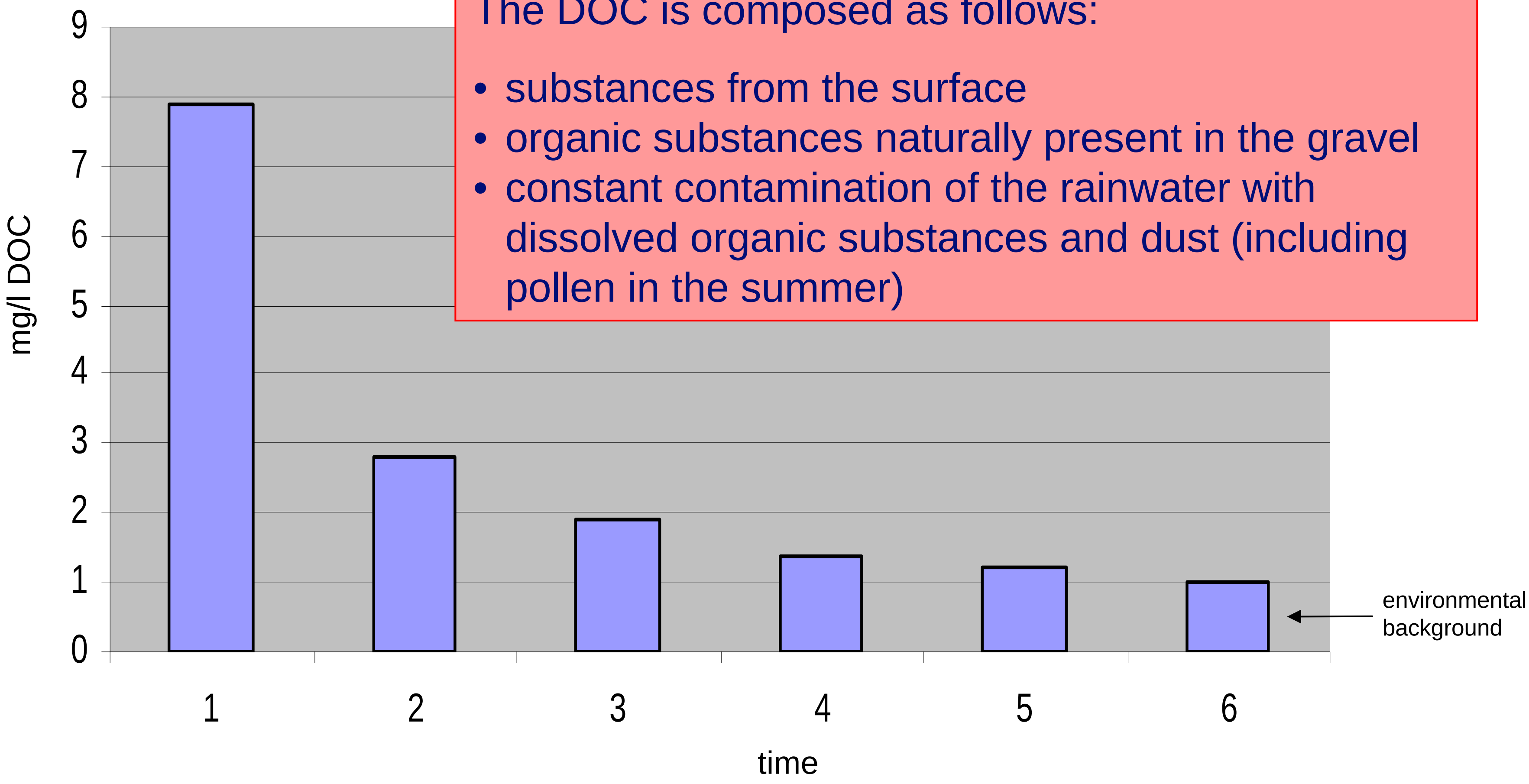
Content

1. Lysimeter design
2. Test details
3. **Test results**
4. Comparison to eluate tests
5. Conclusion

Typical Concentration Profile:
DOC Decrease in an Artificial Turf System

The DOC is composed as follows:

- substances from the surface
- organic substances naturally present in the gravel
- constant contamination of the rainwater with dissolved organic substances and dust (including pollen in the summer)



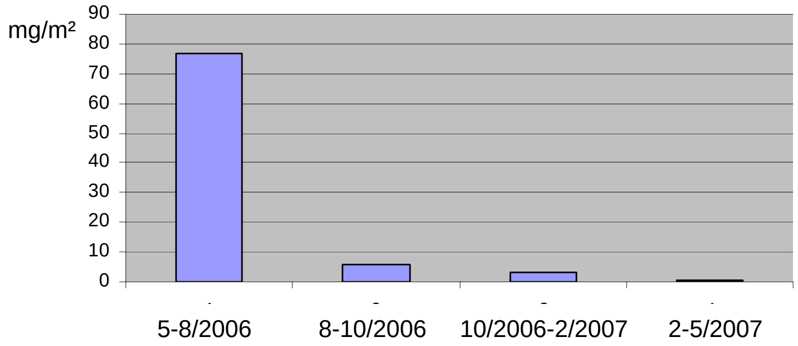
Conversion of Concentrations to Loads

Benzothiazole	4.3.-15.5.06	16.5.-14.8.06	15.8.-10.10.06	11.10.06-19.2.07
Concentration	0.170 mg/l	0.0185 mg/l	0.0129 mg/l	0.0025 mg/l
Percolation	448 l/m²	312 l/m²	234 l/m²	297 l/m²
Load	76.61 mg/m²	5.77 mg/m²	3.02 mg/m²	0.74 mg/m²
Absolute load per soccer field (7500 m²)	574.6 g	43.3 g	22.7 g	5.6 g

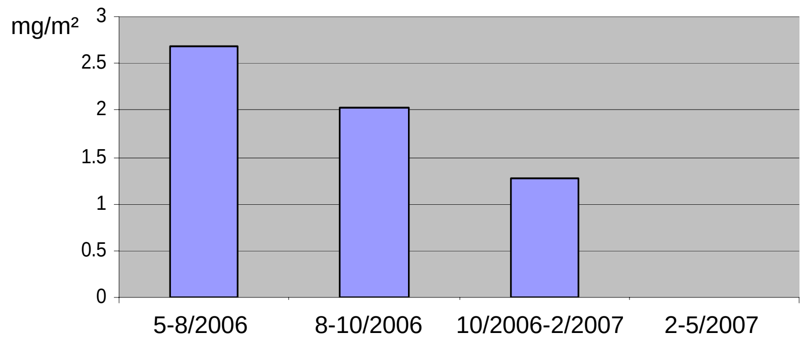
A total load can in most cases be estimated!

Typical Curve Progressions

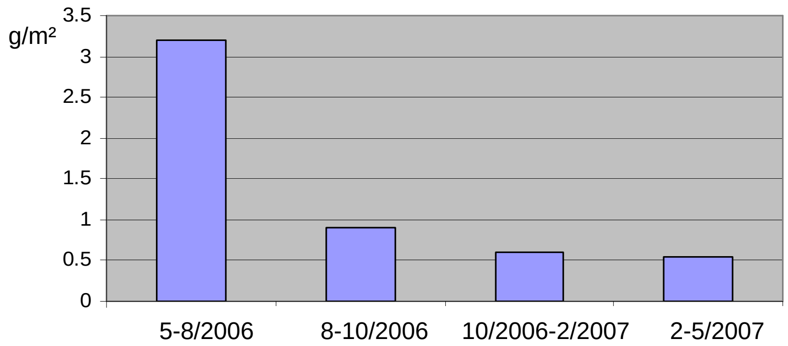
Benzothiazole



Aniline



DOC



- Independant of the analyzed substance, the load (or concentration) converges asymptotically the environmental background.
- The load (or concentration) profile is substance specific.

Most Important Results from Lysimeter Tests: Amines, DOC, org-N

- Organic substances are eluated by the rainwater in traces
- The concentrations of the measured substances decrease very rapidly initially, subsequently slowing down to a minimum.
- The concentration profile is substance specific.
- Towards the end of the test period (after a year) values have already fallen below the limit of determination for most of the individual substances.

Most Important Results from Lysimeter Tests: Polycyclic Aromatic Hydrocarbons (PAH)

- The very low PAH concentrations from the rubber containing sports surfaces were found at an identical level in the blank samples (gravel layer without surface)
- The very low PAH concentrations correspond to ambient (ubiquitous) contamination levels.

Most Important Results from Lysimeter Tests: Zinc

- Although rubber granules contain a significant amount of zinc oxide, none of the lysimeter tests revealed elevated zinc concentrations in the leakage water compared with the blank sample (gravel layer without surface).
- This is attributed to the elevated adsorption capacity of the unbound gravel subbase, i.e. all the zinc was retained in the gravel layer.

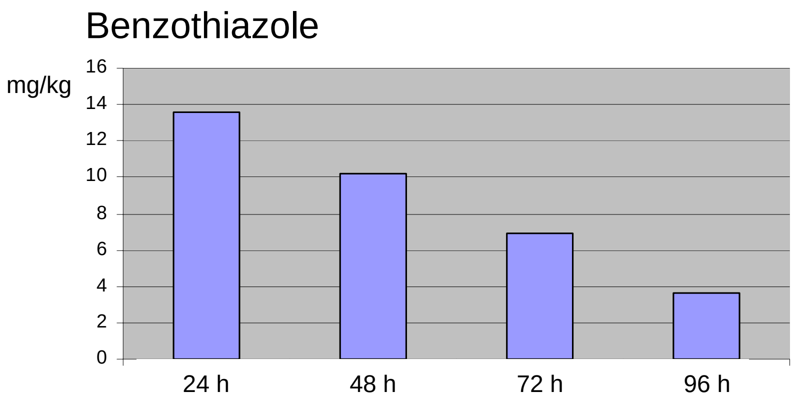
Content

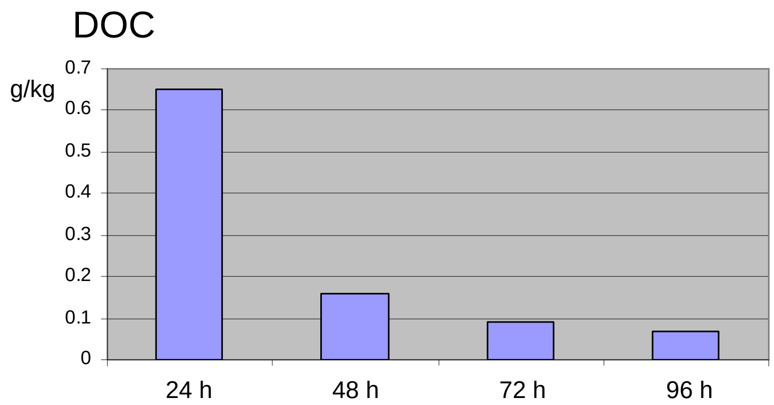
1. Lysimeter design
2. Test details
3. Test results
4. **Comparison to eluate tests**
5. Conclusion

Eluation Test according to DIN Standard

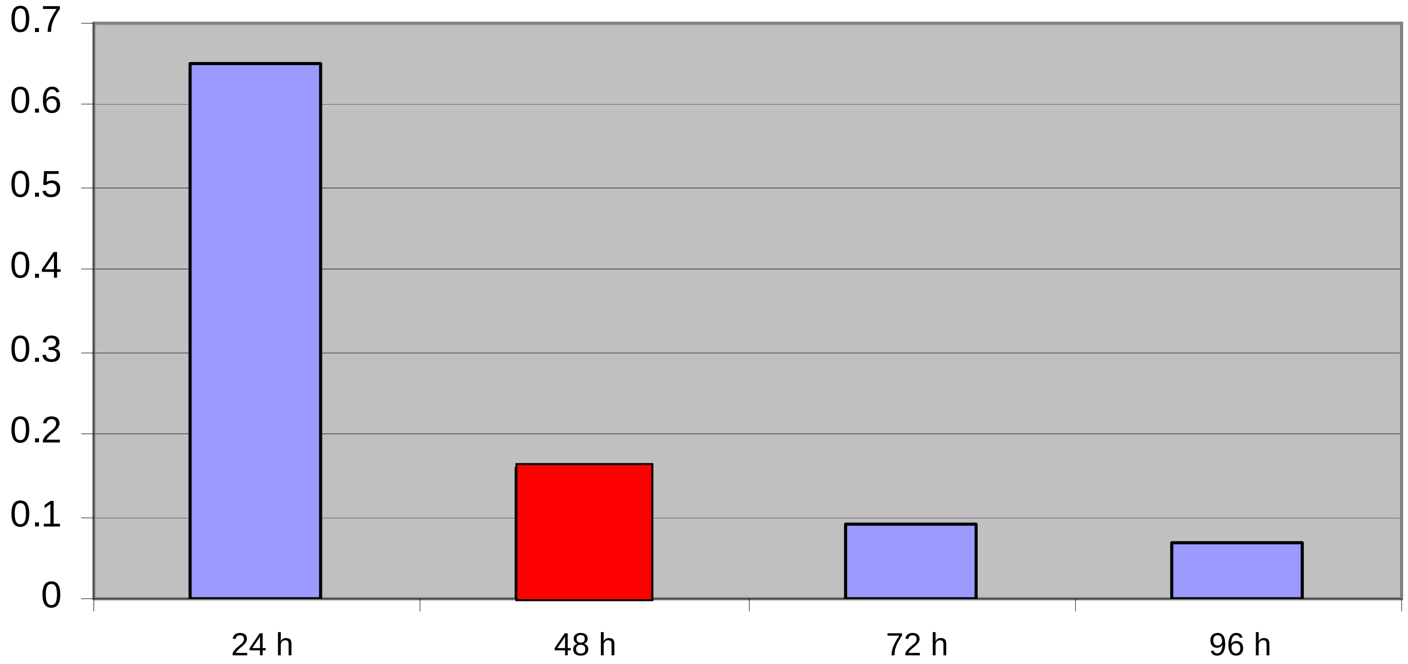
Example: repeated eluation of recycled rubber granules

Eluation with H_2O	Cyclohexyl-amin [µg/l]	Anilin [µg/l]	Benzothia-zol [µg/l]	PBN [µg/l]	IPPD [µg/l]	DOC [mg/l]	Zink [mg/l]
24h	235	117	542	<0.2	0.7	26	10.4
48h	<0.2	38.6	408	<0.2	0.6	6.4	0.834
72h	<0.2	42.2	275	<0.2	0.6	3.4	0.371
96h	<0.2	22.2	143	<0.2	0.8	2.7	0.264





How to Compare Eluation and Lysimeter Tests?



1. Concentrations must be converted into loads
2. Only the total load of a substance released to the environment is comparable to lysimeter tests

Comparison of Lysimeter Tests and Eluation Results

- Loads from lysimeter and from eluation tests show a similar curve progression (sharp load decline with time)
- For certain parameters (e.g. DOC), total loads are in the same magnitude
- For some parameters huge differences between the methods can be found (Zn, but not only!)
- The main difference seem to be due to the sand layer and the base court (compacted gravel) in the case of lysimeter tests (and real fields).

Content

1. Lysimeter design
2. Test details
3. Test results
4. Comparison to eluate tests
5. **Conclusion**

Conclusions from the Lysimeter Tests

- The analytically detectable trace substances are the same that can be found in road runoff as a result of tyre abrasion.
- Rubber undergoes ageing processes as a result of environmental influences (light, ozone, oxygen, heat). To what degree analytically measurable quantities of organic substances and zinc are released, can only be determined by long-term investigations over a number of years.
- Given the current level of knowledge, there are at present no real grounds for suspecting that sports surfaces might impair the water quality of watercourses or groundwater to any significant amount.
- Neither the small quantities of the leached substances nor their toxicological properties constitute any unacceptable potential risk for water resources on the basis of current knowledge.

Consequences from Experimental Results

- Test methods and limit values according to Guideline 105 on the environmental compatibility of resilient synthetic surfaces in outdoor installations (published in 1997) are rescinted.
- Guideline 112 replaces and supersedes Guideline 105.
- Guideline 112 contains simple guidance for planners, manufacturers and owners of sports grounds.
- The guidance is based on principles and and regulations set out in water conversation and chemical control legislation.
- By the way of precaution it is recommended to apply the principles of current good practice specified in the Guideline.

Literature

Guidelines 112 and 113 can be ordered from the FOSPO/BASPO webpage:

http://www.basposhop.ch/de/shop/default.aspx?Kat=55&cid=752B7FDA-B5DF-4857-825E-659484768D44

English versions:

Guidelines 113 (Behaviour on exposure to natural weather conditions) is already available,

Guideline 112 (Recommendations on environmental compatibility) will be available within a short time.