INSTITUT FÜR SPORTBODENTECHNIK

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Environmental Effects of Sports Surfaces
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1. Introduction

Sport surfaces (football/soccer fields, athletic tracks, and playgrounds) are usually constructed with synthetic surface systems such as artificial turf or synthetic surfaces. These products are not environmentally neutral. They are chemically based products containing separate substances each of which need to be evaluated for its effect on the environment. The effect comes mainly from the post production separation of substances which is primarily due to disintegration by UV irradiation, mechanical stress (abrasion), off-gassing of elements and wash-off by rain water. The resulting decomposed and separated substances can be washed with rain water into a sewage system (water purification facility), the ground water table or adjacent open waters. In order to avoid unnecessary or unacceptable stresses to the environment such processes on sports facilities must also be scrutinized.

In both Germany and Switzerland, these issues have been under examination since the early 80's. As there were no existing legal regulations, the industry and governmental authorities joined forces to develop a plan for identification of surface products which obviously contain unwanted or unacceptable substances (so called pollutants). Their focus was on the effects to draining water. They began with the common agreement that substances such as Mercury, Lead, Cadmium, and Chromium (especially Chromium(VI)) are regarded as toxic heavy

metals which should not be released to the environment. In further negotiations, the degree of biological decomposition capacity in water and the toxic effects to micro organisms were addressed and test procedures were accordingly developed and introduced.

The same substances which contaminate underground soil and water may affect the health of the players. Human exposure is primarily through skin contact and inhalation. This human risk through this type of exposure was studied in France, Norway and the Netherlands. The concerns of which were organic complexes such as PAH, Cyclohexylamines, Benzothialzoles, etc.

All of these studies concerning health risks found that the relevant substances – when they are present at all – occur only in minimal amounts and these findings do not suggest that synthetic sports surfaces should be considered as a risk if they are properly installed. Nevertheless, there are a few scientists recommending a ban on certain components within the systems. These recommendations are mostly personal views which are not substantiated by test results.

2. UVP[1]-Concept Germany / Switzerland

The following statements refer mainly to the effects of sports surfaces on soil and ground water.

In meetings, some of them joint, regulations were developed in Germany and Switzerland which specified the determination method for leachable substances from synthetic surfaces (not artificial turf). In Germany, these regulations are still part of the German sport surface

[1] UVP = Environmental Compatibility Testing

standards DIN V 18035 part 6 and 7[2]. In Switzerland, the procedures were put in the ESSM[3] 105 regulation. However, the latter were withdrawn in 2006 as a result of the BASPO[4] 2005-2007 study and they are being replaced by the new recommendation designated as BASPO 112.

Test procedure: In performing the investigation, the synthetic surfaces for instance are cut into pieces with an edge size of 20mm. 100 grams of these pieces are placed in 1000ml of CO_2-saturated water and shaken for 24h. Then, the water is decanted, new water is added and the sample shaken for another 24h. From this leachat the amount of leached heavy metals is determined (unit = mg/l). This procedure was employed using many common sport surface products to find the normal range of variation in these substances. From this statistical basis, *orienting values* were derived which enable recognition of materials outside this range which were classed as "exceptional" and would need further scrutiny to evaluate the stress they might inflict on the environment. However, soon after this method was instituted it was forgotten to be a pragmatic concept and the *orienting values* imperceptibly were transformed to limiting values which conferred a legal character to the results which was and is not valid.

The leaching process occurs in CO_2-saturated water, i.e. in an acid environment. This inevitably leads to higher leaching values. The use of acidified water is justified with the argument that natural rain water is normally acid and the investigation should be as realistic as possible. However, a study in Austria revealed 2 points relevant here; first that rain water in Europe is not as acid as it was ten years ago as a result of environmental protection measurements, and second that the pH value of the rain water neutralizes very quickly after contact with the

[2] http://www.isss.de/conferences/Nyon2002/DIN18035-7V2002.pdf
http://www.isss.de/publications/UVP/UVP_DIN_18035-7eng.pdf
[3] ESSM = Swiss Federal School of Physical Education, Magglingen
[4] BASPO = Federal Authority of Sports = successor of ESSM

ground. This study shows that the use of acidified water is an artificial, unnecessary technique.

In addition, the auxiliary parameter DOC (Diluted Organic Carbon) is measured. The problem in using this as a parameter is that this is relevant only as a summary figure and cannot be interpreted by itself (isolated). The DOC value indicates the amount of organic substances (not limited to pollutants). Assessment of this figure as an individual value permits the assumption that the lower the DOC the less organic pollutants.

Toxicity to micro organisms: In order to understand the toxic effect of leached elements on micro organisms the Swiss Nitrification Test was introduced. With this procedure a certain amount of the leachat is added to a specified active organic mud suspension following which observations are made as to how the mud-contained microbes digest the organic ingredients of the leachat (indicator is the decrease of Ammonium content of the suspension). If the leachat has significant toxicity there is a decrease in the life activity of the microbes. The technical term is Nitrification Inhibition in [%]. According to the DIN the nitrification inhibition should be less than 50% after 32h. This test is controversial in its ability to be accepted as a true indicator of valid toxicity as it does not determine the type of toxic effect and its measurement accuracy is questionable.

This work in the area of environmental concerns has however found merit in that substances such as Lead, Chromium, Cadmium and Mercury have virtually disappeared from the European products. They are no longer part of any of the product formulations. This is not to say they have been totally eradicated as they can still be found in extremely small or trace amounts for instance in pigments.

In Germany, all open air sports surface installations must be tested according to this concept.

3. Swiss Study 2005-2007 (BASPO Study)

3.1 Problems with Artificial Turf Surfaces

When artificial turf surfaces containing elastic infill materials were introduced, a problem arose when the regulation designed for synthetic surfaces (athletic tracks) was applied to this new surface type without appropriate adjustment. The issue was the finding of zinc values up to 20 mg/l in the leaching test. The cause of this is clear - the infill granulate consists primarily of EPDM (synthetic rubber) or SBR (tire rubber) which are directly exposed to the leaching process whereas when they are in a synthetic surface, they are covered and protected by a polyurethane coating/binder which is relatively inert. Reaction to the finding of zinc was strong and the products strongly criticized. This finding should not have been surprising since zinc is a necessary constituent of rubber products (about 10’000 to 20’000 mg/kg) and it should have been an expected finding in the leachat. Rather the issue is why zinc is regarded a special risk. It is indispensable for the human organism. According to the World Health Organization (WHO), the effect of zinc is limited to an organoleptic effect (affecting the taste).

While Germany continues with this regulation, Switzerland moved forward and decided to scrutinize the issue through a study initiated to determine how much of the substances in question actually reached the water percolating from sports surfaces. The study was predicated on the basis that leaching tests in the lab do not provide a realistic picture of the pollution stress.

3.2 Test Program

The test program was begun in 2005 and continued until 2007.

For the field study, a variety of typical sports surfaces were installed in Lysimeter devices (see appended picture). These are commonly used in horticulture/agriculture science to investigate the loss of nutrients of plants. Lysimeters are reinforced Polyester tubes. They are about 1m wide and 1.5m high. They are equipped with an automatic water sampling system. Thus, the total amount of rain water percolating through or running off the sports surfaces could be collected and analyzed.

In Bern, 10 Lysimeters were equipped with the following set of surfaces:

List of surfaces

1. Artificial Turf with EPDM infill and Quartz sand on a permeable asphalt base and elastic layer 25mm
2. Artificial Turf with SBR rubber and Quartz sand infill on a mineral sub base
3. Artificial Turf with EPDM infill and Quartz sand on a mineral sub base and elastic layer
4. Artificial Turf without infill on a mineral sub base
5. Permeable Synthetic Surface EPDM 12mm on an asphalt base + elastic layer
6. Permeable Synthetic Surface EPDM + SBR (6mm + 9mm) with Spray Coat 1.5kg/m2
7. Sandwich Surface PUR coating + SBR base layer (5mm + 10mm)
8. Mineral Supporting Layer = 0-sample no. 1
9. Bituminous Supporting Layer on a mineral sub base = 0-sample no. 2
10. Elastic Layer of recycled SBR granules 25mm on a mineral sub base

All Lysimeter containers were filled with an unbound (mineral) supporting layer commonly used in Switzerland. Only the upper 65cm of the devices were used. Beneath this, an impermeable layer (concrete) was installed so that the water could flow into the collection containers. The design of the surfaces was similar to actual sports surfaces. The analysis of the collected water was performed after 300mm of precipitation.

Substances Sought

- Rubber chemicals: various aromatic Amines, Benzothiazoles, Anilin and Cyclohexylamines
- Polycyclic aromatic hydrocarbons (16 PAH)
- Sum of organic nitrogen compounds (total N-org)
- Sum of dissolved organic substances (DOC)
- Zinc

3.3 Results

The report of the field and lab investigation is available now: „Investigation into the behaviour of synthetic sports surfaces exposed to natural weather conditions“. These results reflect the conditions in Switzerland, Germany and Austria and are based on the typical synthetic sports surface products used in these markets.

Polycyclic Aromatic Hydrocarbons (PAH)

In all samples, also in the “0-sample no. 1” (control sample) which consisted of the unbound supporting layer only, the various PAHs determined were within the range of analytic determination limitations which is 0.02 µg/l. None of the surface systems including the surfaces with recycled granules showed any noticeable PAH concentration. PAHs are ubiquitous substances in the environment and in water. They are present in street water runoff and in purified sewage from communal

sewage purification plants as well as sewage sludge, in which case they may be determined to have much higher concentrations.

Various Substances

In surface systems with EPDM and recycled rubber infill several aromatic Amino complexes and Benzothiazoles were determined to be in the range of 10 – 330 µg/l. According to the results of the pre-test, it is expected that similar concentrations will be found in all street runoff and sewage waters as a consequence of common car tire abrasion. These complexes and substances are also ubiquitous in the aquatic environment.

The results of the study can be summarized as follows:

- From all types of sport surfaces, traces of organic substances are leached into water. In general, these are typical rubber chemicals. These are the same chemical substances which are found in street runoff and sewage water. The concentration of leached substances decreases rapidly over time and most of the individual substances fell short of the analytic determination limitations.

- Nearly non-detectable amounts of Polycyclic Aromatic Hydrocarbons (PAH) from rubber granules were found in the collected water.

- With the Lysimeter tests, no noticeably high Zinc levels were found. This is due to the absorption capacity of the mineral base (gravel). In part, the Zinc content of the falling rain water was actually higher than that of the percolated water.

- With today's knowledge, it is highly unlikely we will develop single test procedures which allow differentiation of the environmental stress of the various surface constituents.

- There is no reason for the assumption of diminished quality to open water or ground water, by sport surfaces if the surfaces are manufactured and built according to the State of the Technology. The initially leached amounts of the substances as well as the ecotoxicological properties of the various substances do not constitute a reasonable risk potential for the waters.

4. New Swiss Regulation BASPO 112

Based on the results of the BASPO study, a new regulation has been prepared (BASPO 112) which summarizes the recommendations on how to limit stress to the environment caused by chemical substances from sport surfaces.

According to this, the following substances shall be restricted from the formulation of all surfaces and from their components:

- Mercury Hg
- Cadmium Cd
- Lead Pb
- Chromium(VI) Cr(VI)
- Short to mid-size chained Phthalic acid esters
- 4,4 Methylen-bis(2-chloranilin) (MOCA)
- Secondary Amine which may form toxic Nitrosamines
- Halogen containing Elastomers

Compliance with the State of the Technology means that the European Chemical Law is followed: REACH (= **r**egistration, **e**valuation, **a**uthorization, and restriction of **ch**emicals). It contains limitations and bans on the aforementioned substances.

The new regulation also contains requirements for the installation, maintenance and disposal of surfaces.

At this time, however, no practical methods of determining the product content of certain pollutants and / or the threshold level(s) have been stipulated.in order to verify that products really meet the above conditions. This is determined by the fact that the BASPO committee is lead by a government agency which must not introduce new requirements which exceed existing legislation. It would be inevitable with those methods to set not only test procedures but also limits.

5. CEN TC 217 Task Group "Environmental Aspects

Standardization of sport surfaces on the European level is regulated by the CEN Technical Committee 217 (CEN = **C**omité **E**uropéen de **N**ormalization = union of European national standardization associations, equivalent to ASTM in the USA). Most of the technical standards in this area have now been published. The subject of the "Environment" comes under the Task Group „Environmental Aspects". There has not been much progress reported at this time and the group is currently discussing the transformation of the Lysimeter field test into a lab test with leachats replicating those found in the real-world Lysimeter tests. The issue of how to use the leaching analyses (i.e. which orienting/limiting values?) has not been addressed yet.

With respect to the Swiss BASPO study, the same goal can be achieved using the DIN procedure by skipping the limitating values or applying realistic values (i.e. taking measuring accuracy into account). Last but not least, is the question of if critical pollutants are present in crucial amount and what this indicates. This can be achieved most easily and cost effectively with the leaching method, which has over 20 years of proven effectiveness and reliability behind it.

The list of critical substances should be amended by PAH. Also, leaching tests with neutral water is sufficient and the nitrification test should be disregarded.

6. Final Remarks

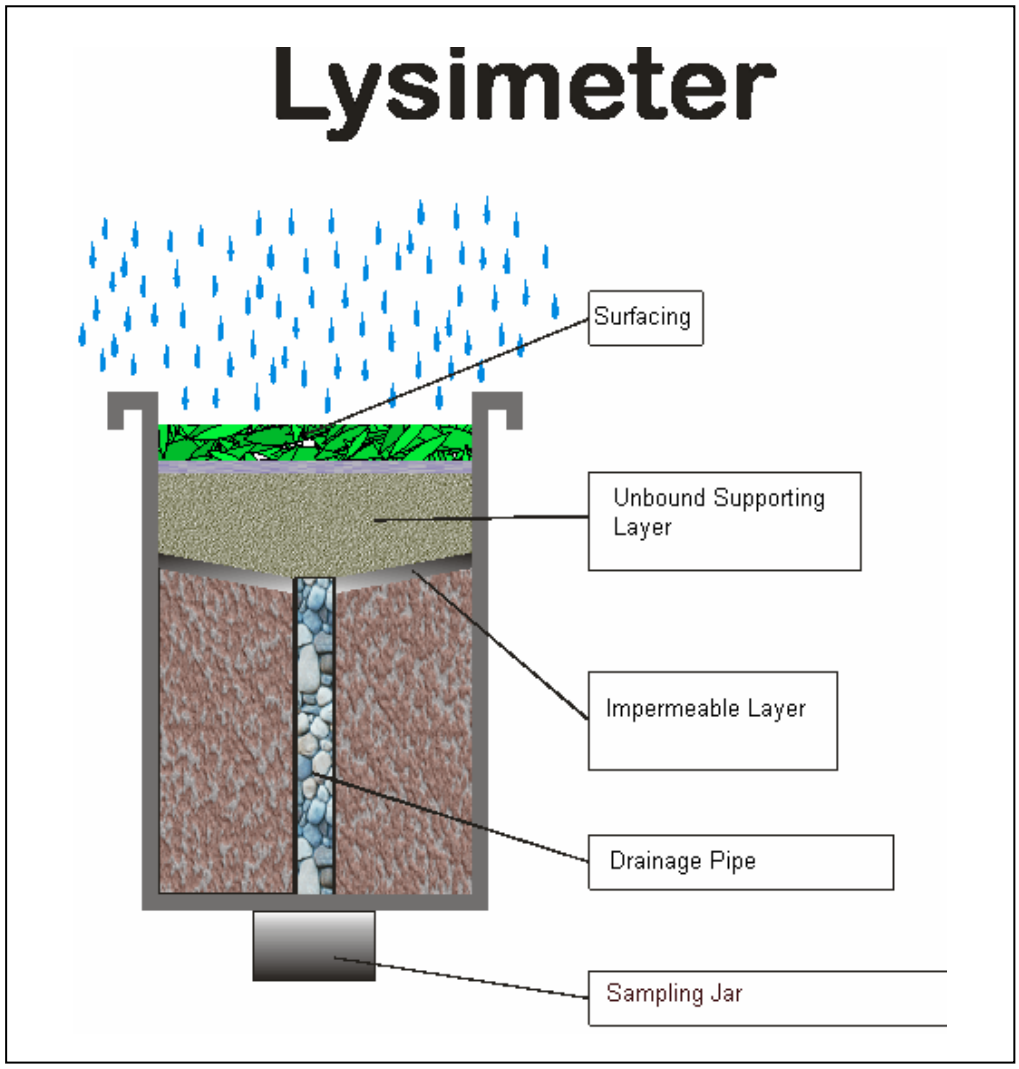
It was necessary to determine the actual pollutants possibly impacting the soil/underground and/or the water as a result of the sports surfaces under realistic conditions. The Swiss study did this in a systematical study which showed that the hitherto applied lab tests unrealistically overstated the situation as far as the quantitative results are concerned. It is merely necessary to detect the non-typical presence of pollutants with a general understanding that the results of such an investigation must be regarded in terms of order (and not of more than 1 numeric position) taking into account measuring uncertainty in order to assess the real world effect appropriately. The precise determination of the amount is not critical and it is of no consequence whether this amount is a bit more or less.

The Swiss study provided a positive determination that organic pollutants occur in minimal amounts (traces) only so that from an environmental point of view, no real risks exist when State of Technology rules are followed. Panicking is not called for and certainly out of place.

If the used infill granules in fields created a unique risk different from the same material which is released into the environment by car and truck tire abrasion in much, much higher amounts, the results of the Swiss study would not be plausible, but this is not the case. The field use is a one time application shown to have reducing levels of pollutants whereas the tires are a continuous, non-reducing source of pollutants currently accepted world-wide.

Unfortunately, the new Swiss regulation does not contain test and control methods. Although the Lysimeter tests revealed no actual risk, it cannot be assumed that products from unknown sources containing pollutants will not reach the market. These must be identifiable early enough to exclude them from site or product usage. The leaching method is the best method for doing this. Since the BASPO committee cannot introduce such methods (as explained above) including according assessment values (requirements) it will be the task of a voluntary self-limitation declaration/agreement to fill this gap. This means to set limits in respect to the surface components used as a contribution to reduction of stress to the environment and health risks.

As a closing remark: there is much discussion on Environmental Compatibility. This is a very large and mostly under explored / under defined field with as many opinions as options, mostly unproven. Thus, let us confine ourselves to using the term Environmental Conservation which means: stress the environment with as little pollutants as is possible and reasonable.


Lysimeter
Surfacing
Unbound Supporting Layer
Impermeable Layer
Drainage Pipe
Sampling Jar