ENVIRONMENTAL AND HEALTH RISKS OF RUBBER INFILL

rubber crumb from car tyres as infill on artificial turf

summary

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Ons kenmerk / Our reference	A833860/R20060318/UHo/UHo
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Datum / Date	9 February 2007
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SUMMARY

Because of a discussion on the environmental and health aspects of rubber infill from shreddered car tyres a research was conducted, of which the results are reported here. The research was conducted from February till November 2006 and was guided by a committee with all parties concerned involved. The aim of the investigation was to generate independent data and to formulate conclusions on the potential environmental and health risks of the use of rubber infill from shreddered car tyres on artificial turf.

Work plan

The investigation consists of a literature research supplemented with experimental research to fill the gaps in the knowledge and to verify already available data.
For the literature research 17 research reports and 13 supplementary sources were investigated, In addition to that use was made of Dutch and European legislation and guidelines.
Additionally a separate literature research was conducted to allergies caused by skin contact with rubber products.

For the experimental investigation samples were taken on 3 production plants of rubber infill and samples were taken on 14 artificial turf pitches according to the FIFA protocol.
For the experimental environmental investigation rubber infill samples were analyzed of the composition and also on the leaching of several parameters. In these analyses fresh samples from production plants, samples from 1 year old pitches and samples from 3 year old pitches were investigated. Also laboratory weathering tests were used and the leaching of 1 year old and 3 year old infill samples was investigated. The data on the content and the leaching were compared with limit values from Dutch regulations and with ecotoxicological limit values for soil and surface water.

The experimental investigation on health aspects was focussed on the uptake of polycyclic aromatic hydrocarbons (PAH's) due to skin contact with rubber infill. A laboratory model migration test was applied to estimate the migration of PAH's from rubber infill into both massage oil and vaseline. Additionally, a field study was conducted among football players to determine the presence of PAH metabolites in the urine after they had intensive skin contact with rubber crumb on an artificial field pitch. The results from both the laboratory test and the field study were compared with internationally accepted health limit values for PAH's.

Composition of the rubber crumb

Hazardous substances in rubber infill are primarily heavy metals (especially zinc), volatile components (nitrosamines, xylenes), benzothiazoles, secondary amines and polycyclic aromatic hydrocarbons (PAH's). The zinc is due to zinc oxide, that is used as a vulcanisation aid in the rubber production

process. PAH 's are from high-aromatic oil that is used as additive in the production of car tyres. Nitrosoamines are formed during the vulcanisation process. Xylene is a solvent. Benzothiazoles are accelerators in the vulcanisation process and the secondary amines are antioxidants for the rubber.

Environmental risks

The environmental investigation was focussed on the parameters for which there are limit values in the Dutch Building Materials Decree.

- **air**

Based on the literature that we screened, we conclude that the emission of hazardous substances into air does not pose an environmental risk. This conclusion is supported by our analyses of the composition of rubber infill, where we find only very limited amounts of volatile components.

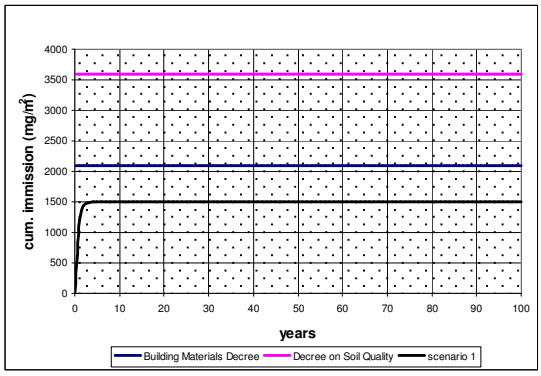
- **soil and groundwater**

For the assessment of the environmental risks we used the risk assessment method from the Dutch Building Materials decree, which formally only applies for stony building materials, such as sand and gravel. It is noted that this Building Materials Decree will be replaced by the Decree on Soil Quality in 2007. The limit values in the Decree on Soil Quality are not yet established.
This assessment method was chosen at the start of the investigation, because no other assessment method was available and the situation is analogous to the Building Materials Decree. For a first assessment of the environmental impact of non stony building materials one may use the assessment method of the Building Materials Decree, the concept Decree on soil Quality and other regulations on soil and water quality. The assessment does not imply a formal testing. The emissions to soil and water calculated in this report must be considered a first impression. No definite conclusions can be drawn.
From the content analyses on organic components according to the Building Materials Decree it is shown that all parameters comply with the limit values with the exception of one (exceeding of the limit value for xylenes) of the in total 8 samples that were analysed.
From the leaching analyses according to the Building Materials Decree it is shown that all parameters comply with the limit values with the exception of the leaching of zinc. The amount of zinc oxide in rubber crumb from truck car tyres is about two times higher than in rubber crumb from passenger car tyres. Our results also indicate that the leaching of zinc increases by weathering of the rubber infill. This is determined by comparing the leaching of zinc from samples from used fields with fresh samples and by laboratory weathering tests.

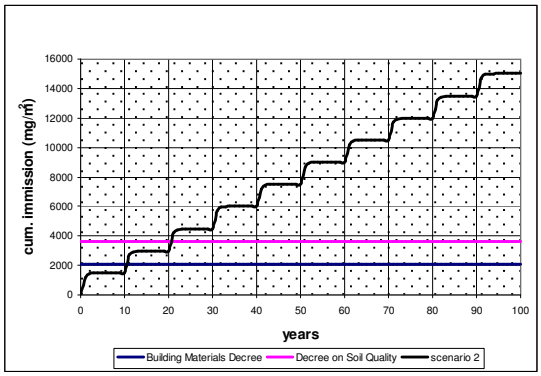
In comparing the leaching of zinc from the rubber infill directly with the limit values from the Building Materials Decree and the Decree on Soil Quality the leaching of zinc from the rubber is higher than the limit values. In a more realistic test, in which realistic values of density and layer thickness were taken into account, the leaching of zinc was assessed using the immission limit value of zinc from the

Building Materials Decree (2100 mg/m^2/year) and the calculated immission limit value of zinc from the Decree on Soil Quality (3600 mg/m^2/year)

- Scenario 1 uses realistic application thickness and does not take into account the life time of the infill (it is not renewed in 100 years)
- Scenario 2 also uses realistic application thickness and assumes a final life-time of the infill (it is renewed every 10 years).

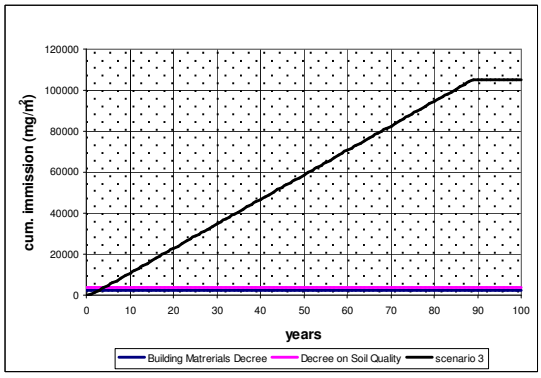


Scenario 1, no renewal of the infill



Scenario 2, renewal every 10 years

In scenario 2 the limit values of the Building Materials Decree are exceeded after 11 years. After 20 years the limit values from the Decree on Soil Quality are exceeded.
It is noted that the actual leaching can either be higher or lower. It might be lower due to a lower leaching in the field situation than in the column test. It might be higher due to the fact that the weathering of the rubber crumb has only partly been incorporated in the assessment. In a third scenario in which maximum effect of the weathering is included the limit values are exceeded after 3 to 4 years.



Scenario 3: Constant weathering of the rubber crumb.

So an exceeding of the limit values for the immission of zinc form the Building Materials Decree and the Decree on Soil Quality is calculated after 3 to 20 years depending on the scenario.
Further investigations might resolve this issue.
In addition to the leaching there might be a potential environmental risk in the spreading of rubber crumb around the fields. In case of inaccurate housekeeping soil might be contaminated with zinc and PAH's from rubber crumb.

- **surface water**

The ecotoxicological limit value for dissolved zinc in surface water is exceeded in scenario 2 and 3, if drainage water is drained off to surface water. In practice, most Dutch artifical turf fields have an open drainage system in which at least a part of the excess rain water will drain away into the soil. On heavy soil (clay grounds) one may expect a complete drain off into the surface water. The ratio between drain off into surface water and draining into soil is not known.
The estimated zinc load in surface water from rubber infill on artificial turf fields is approximately 0,08% of the total zinc load from all sources in the Netherlands. In the future this might increase to 0,5% because the number of fields with rubber infill in the Netherlands is expected to raise from 370 to 2500.

- **conclusion on environment risks**

The leaching of zinc is of major concern. Using the assessment methodology from the Building Materials decree, which does formally not apply to infill rubber, we calculate an exceeding of the limit values for the immission of zinc after 3 to 20 years of use.. The other components listed in the Building Materials Decree, will not exceed environmental limit values .

Health risks

Rubber crumbs contain a number of hazardous substances. At high exposure levels these substances may result in adverse health effects. The main question is what exposure levels actually occur when football players use the artificial turf pitches. Exposure might occur by swallowing, by inhalation and/or by skin contact. It is noted that for several substances in the rubber crumbs there are other sources in the living environment. For example, the background exposure to PAH's from food is approximately 4 ng PAH's per kg body weight (bw).

- **swallowing**

The content of heavy metals in rubber infill complies with the European Toy Directive and we therefore expect that heavy metals will not result in adverse health effects to the football players. The same applies to phthalates. Based on information presented in the literature, the intake of organic compounds, due to the swallowing of rubber infill, is not considered to be a relevant exposure scenario.

- **inhalation**

Based on air concentrations reported in literature (and also determined in our studies) we conclude that indoor and outdoor applications of rubber infill will not result in adverse health effects among sportsmen and others due to inhalation. However, indoor application requires sufficient ventilation to limit the concentration of fine dust.
In literature calculations are presented showing that the daily uptake of PAH's by inhalation of fine dust in an indoor hall by an adult, who is training for 20 hours a week during the winter season, is limited in comparison to the PAH uptake from other sources.

- **skin contact**

For the potential health risk of rubber infill due to skin contact, especially the exposure to organic components in the rubber is relevant, because these components may migrate from the rubber crumb into the skin.

PAH-components are found in the rubber infill in amounts of 20 to 40 mg/kg. Based on the results of migration experiments in the laboratory we estimated the uptake of PAH among football players due to skin contact with rubber infill.
In an exposure scenario for a professional football player a maximum average daily uptake was calculated of 0,12 ng/kg bw benzo[a]pyrene. Benzo[a]pyrene is a carcinogenic PAH-component, which is often used as a marker for the total PAH uptake. The advised limit value for the so-called 'negligible risk level' is 1 ng/kg bw. The calculated daily dermal uptake does not exceed this limit value.

In addition to the laboratory experiments, we conducted also a field study with volunteers. In this study football players had an intensive skin contact with rubber infill during a field training on the artificial turf pitch. All urine samples of the players were collected during the days before and after the training. The urine samples were analysed for 1-hydroxypyrene, a metabolite of pyrene, and a sensitive marker of internal PAH exposure. Despite an exposure scenario with relative intense skin contact with rubber infill we were not able to detect additional PAH intake unambiguously. It is concluded that additional dermal uptake, if it takes place at all, is limited and within the range of PAH-exposure from other sources in the environment and food.

Rubber infill contains a number of substances that may cause allergic reactions in persons that are already sensitized. Especially the aromatic amines in the rubber are suspected. It is very unlikely that substances in the rubber will cause skin irritation to non-sensitized persons . It can not be excluded that persons become sensitised due to exposure to rubber infill. How intensive the skin contact must be to cause sensitisation is not known.
Experimental research can give more insight in the possibility of skin sensitisation during sporting on rubber infill.
If persons show skin disorders after contact with rubber infill it is recommended to check whether this is related to oversensitivity to sensitizing substances in rubber. This can be done by using the patch-test with "black rubber mix".

- **conclusions on health risks**

Based on the available literature on exposure to rubber crumb by swallowing, inhalation and skin contact and our additional experimental and field studies on skin exposure, we conclude, that there is no significant health risk for football players due to the presence of rubber infill from used car tyres on artificial turf pitches.