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Synthetic turf from a chemical perspective

– a status report

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Background

Synthetic turf is used for football pitches around the world. This turf has many advantages, being hard-wearing and easier to maintain than natural grass. These pitches allow the football season to be extended, independently of the weather.

Synthetic turf often contains rubber granulate from waste tyres, which in turn contain several substances with hazardous properties. A discussion is currently being carried out in several European counties, including Norway, Italy and Germany, concerning the properties of synthetic turf and the possible risks of using it. Many municipalities in Sweden have requested information and advice, as have manufacturers, representatives from football, and the general public. The Swedish Chemicals Inspectorate (KemI) has consequently prepared this report in order to discuss the properties and use of synthetic turf from a chemical perspective.

This report provides a comprehensive survey and an assessment based on current knowledge. It is based to a large extent on results of investigations and assessments that have recently been carried out in Norway. Information has also been obtained from companies that deliver and install synthetic turf surfaces, the Swedish Football Association, sports administrations, environmental administrations, representatives from the recycling industry, and from the Swedish Standards Institute (SIS). KemI has also been in contact with the Swedish Work Environment Authority, the Swedish Environmental Protection Agency, and the Norwegian Pollution Control Authority (SFT). Suppliers, representatives from football and authorities exchanged experiences concerning synthetic turf at a meeting held at KemI on 18 January 2005.

The scope of the report is limited to synthetic turf that contains granulate from recycled tyres used for football pitches. Synthetic turf that contains other material, such as new rubber, thermoplastics and rubber-coated sand, have not been assessed. Other uses of recycled tyres, such as their use in playgrounds, for horse-riding surfaces and other sporting activities, have also not been assessed.

KemI hopes that it will be possible to use this report as a basis for product development in synthetic turf companies, and for facilitating local decisions and assessments when laying synthetic turf surfaces. Synthetic turf from a chemical perspective – a status report

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Summary

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Synthetic turf often contains rubber granulate from waste tyres, which in turn contain several substances of very high concern. A discussion is currently being carried out in several European countries, including Norway, Italy and Germany, concerning the properties of synthetic turf and the possible risks of using it. Many municipalities in Sweden have requested information and advice, as have manufacturers, representatives from football, and the general public. The Swedish Chemicals Inspectorate (KemI) has consequently prepared this report in order to discuss the properties and use of synthetic turf from a chemical perspective.

The report briefly describes the health and environmental properties of certain substances, it summarises results from some relevant investigations into synthetic turf, and it describes the work for standardisation that is currently being carried out in Europe. Furthermore, Swedish environmental quality objectives and guidelines for the assessment of water quality and air quality are presented. KemI's overall assessment is based on the material presented here.

Recycling Tyres

It is often a good strategy to recycle material from worn-out products for reasons of energy economy and the efficient use of resources. This recycling, however, may conflict with attempts to minimise the risk of using chemicals.

Tyres contain substances of very high concern

Tyres contain several substances that are substances of very high concern. These substances may persist in the environment, they may be bioaccumulative, carcinogenic, reprotoxic, or mutagenic. This is true of, for example, polycyclic aromatic hydrocarbons (PAHs), phthalates and certain metals. These substances should not be released into the environment and thus waste tyres should not be used for synthetic turf surfaces. The environmental objectives set down by the Swedish parliament state that substances of very high concern should be phased out from newly produced articles.

Environmental Risks and Health Risks

Although substances of very high concern are present in synthetic turf, this may not necessarily be a direct risk for human health or the environment. The direct risk depends on the extent to which people and the environment are exposed to the hazardous substances.

The health risks for players are probably low

Measurement of indoor air and exposure calculations have shown that there is probably a small health risk associated with simply being on or playing on synthetic turf surfaces that use rubber from recycled tyres. The exposure levels and any allergic reactions, however, have been poorly studied. Exposure to these substances from other sources, such as car exhaust, must also be taken into consideration to achieve a total assessment of health risks.

There is a local environmental risk

Current knowledge allows the conclusion to be drawn that synthetic turf that contains rubber from recycled tyres may give rise to local environmental risks. Investigations have shown that zinc and phenols can leach from the rubber granulate, and these substances can affect aquatic and sediment-dwelling organisms, if they reach neighbouring water courses. The total amount of these substances

that leaches from synthetic turf is small, and thus any effect on the environment that they have is expected to be local.

KemI's Recommendations

Synthetic turf that contains substances of very high concern should not be used when laying new surfaces

Material that contains substances of very high concern should not be used, as specified by the environmental objectives of the Swedish parliament. This means that granulate formed from recycled rubber should not be used when laying new surfaces of synthetic turf.

New solutions must be developed and requested – the responsibility of companies

It is the responsibility of companies to ensure that synthetic turf is safe for people and the environment. Swedish companies should place demands on their suppliers and they should provide the drive required to develop better alternatives. The sports administrations in the municipalities and others who are involved when new surfaces are to be laid should request information about the contents of chemicals, and they should pose demands during the purchasing process and during installation such that substances of very high concern are not released into the environment. It is important that the recycled rubber in synthetic turf is replaced by material that truly is better from the point of view of health and the environment.

Existing synthetic turf surfaces may remain in place

The rubber from recycled tyres that is present in newly laid synthetic turf surfaces need not be immediately replaced, since the current health and environmental risks are assessed as being small. In the long term, however, the rubber should be replaced by alternatives. Material that contains less hazardous substances should be used when it is necessary to add new rubber. Furthermore, the recycled rubber should be replaced when it displays signs of break-down and the formation of smaller particles.

More knowledge is needed

Certain investigations and assessments have been carried out in order to illuminate the risks of using synthetic turf, but there remain major gaps in our knowledge. This is particularly true with respect to the extent to which the hazardous substances are released from the rubber, and the subsequent exposure to these substances of people and the environment. The responsibility for investigating and assessing the health and environmental risks lies with the companies that manufacture and supply synthetic turf. These companies should seek more knowledge and they should spread this knowledge as long as rubber from recycled tyres remains in synthetic turf surfaces. It is also appropriate that water quality in association with synthetic turf surfaces should be followed up and analysed.

Swedish summary/Sammanfattning

Många konstgräsplaner för fotboll anläggs runt om i världen. Fördelarna med konstgräsplaner är många. De är tåligare och mer lättskötta än vanliga gräsplaner. De gör att fotbollssäsongen kan förlängas, oberoende av väder.

Konstgräs innehåller ofta gummigranulat från uttjänta däck som i sin tur innehåller ett flertal ämnen som har farliga egenskaper. Det pågår en diskussion om konstgräsets egenskaper och eventuella risker i flera europeiska länder bl.a. Norge, Italien och Tyskland. Många svenska kommuner, tillverkare, fotbollsrepresentanter och allmänhet har efterfrågat information och vägledning. Av den anledningen har Kemikalieinspektionen (KemI) sammanställt denna rapport för att belysa konstgräs ur ett kemikalieperspektiv.

I rapporten ges en kort beskrivning av vissa ämnens hälso- och miljöfarliga egenskaper, resultat från några aktuella undersökningar av konstgräs samt av det standardiseringsarbete som pågår inom Europa. Dessutom presenteras svenska miljömål och riktvärden för bedömning av vatten- och luftkvalitet. Utifrån detta material gör KemI en sammanfattande bedömning.

Återanvändning av däck

Ur ett energi- och resursperspektiv är det ofta bra att återanvända material från uttjänta produkter. Denna återanvändning kan dock komma i konflikt med strävan att minska kemikalieriskerna

Däck innehåller särskilt farliga ämnen

Däck innehåller flera ämnen med särskilt farliga egenskaper. De kan vara långlivade, bioackumulerande, cancerframkallande, reproduktionsstörande eller arvsmassepåverkande. Det gäller t.ex. polycykliska aromatiska kolväten (PAH), ftalater och vissa metaller. Dessa ämnen bör inte spridas i miljön och därför bör inte uttjänta däck användas i konstgräsplaner. I enlighet med Riksdagen miljömål ska ämnen som har särskilt farliga egenskaper fasas ut från nyproducerade varor.

Miljö- och hälsorisker

Även om det förekommer särskilt farliga ämnen i konstgräs är det inte liktydigt med en direkt risk för människors hälsa och för miljön. Den direkta risken beror på i viken utsträckning människor och miljö exponeras för de farliga ämnena.

Hälsorisken för spelare är sannolikt liten

De mätningar av inomhusluft och exponeringsberäkningar som gjorts indikerar att det sannolikt innebär en liten hälsorisk att vistas och spela på konstgräsplaner med gummi från återvunna däck. Exponeringen samt eventuella allergiska reaktioner är dock dåligt undersökta. För en total hälsoriskbedömning behöver även exponering för ämnena via andra källor, t.ex. bilavgaser, beaktas.

Det finns en lokal miljörisk

Utifrån den kunskap som finns tillgänglig kan man konstatera att konstgräs, som innehåller gummi från återvunna däck, kan medföra lokala miljörisker. Undersökningar har visat att zink och fenoler kan läcka ut från gummigranulaten och om ämnena når intilliggande vattendrag kan de påverka vattenlevande och sedimentlevande organismer. Eftersom den totala mängden av ämnen som läcker ut från konstgräset är begränsad förväntas den eventuella effekten på miljön att vara endast lokal.

KemI:s rekommendationer

Konstgräs som innehåller särskilt farliga ämnen bör inte användas när nya planer ska anläggas

I enlighet med Riksdagens miljömål bör material som innehåller särskilt farliga ämnen inte användas. Det innebär att granulat av återvunnet gummi inte bör användas när nya konstgräsplaner ska anläggas.

Nya lösningar behöver utvecklas och efterfrågas – företagen har ansvaret

Det är företagens ansvar att se till att konstgräsen är säkra för människor och för miljön. De svenska företagen bör ställa krav på sina leverantörer och driva på utvecklingen av bättre alternativ. Kommunernas idrottsförvaltningar och andra som är involverade när nya planer ska anläggas bör efterfråga information om kemikalieinnehållet och ställa krav vid upphandling och anläggning så att särskilt farliga ämnen inte sprids i miljön. Det är angeläget att det återvunna gummit i konstgräset ersätts med material som verkligen är bättre från hälso- och miljösynpunkt.

Befintliga konstgräsplaner behöver inte tas bort

Gummi från återvunna däck som finns i de nyanlagda konstgräsplanerna behöver inte omedelbart bytas ut eftersom hälso- och miljöriskerna i dagsläget bedöms vara små. Däremot bör gummit på sikt ersättas med andra alternativ. När påfyllnad av nytt gummi behöver göras bör material som innehåller mindre farliga ämnen användas. Dessutom bör det återvunna gummit bytas ut när det visar tecken på att brytas ned och finfördelas.

Mer kunskap behövs

Vissa undersökningar och bedömningar har gjorts för att belysa riskerna med konstgräs, men det finns fortfarande stora kunskapsluckor framför allt när det gäller i hur stor utsträckning de farliga ämnena frigörs från gummit och hur människa och miljö sedan exponeras för dem. Ansvaret för att utreda och bedöma hälso- och miljörisker vilar på företagen som tillverkar och levererar konstgräs. Så länge gummi från återvunna däck finns kvar på konstgräsplaner bör företagen ta fram mer kunskap och sprida den vidare. En uppföljning och analys av vattenkvaliteten i anslutning till konstgräsplaner är också lämplig att genomföra.

Introduction

Synthetic turf is mainly used for football pitches, but it is used also for other sporting surfaces, golfing greens, gardens, indoor gardens, school playgrounds and trade fairs.

There are currently approximately 150 football pitches of synthetic turf in Sweden. These include both large pitches used for elite football and small pitches that are used mainly by children and young people. Most pitches are located outdoors, although a few are located indoors. Many new surfaces will be laid in the near future: in Stockholm alone there are plans for 30 new synthetic turf surfaces.

It has been estimated that 90% of the existing synthetic turf surfaces in Sweden contain rubber from recycled tyres. The rubber granulate is imported from the tyre recycling industry in other European countries, where it is produced by mechanical disintegration of the tyres. Representatives of the Swedish recycling industry have stated that no further chemicals are added to the granulate.

Recycling and Swedish Environmental Objectives

Economic use of resources is a fundamental principle of a sustainable environment, and the re-use of material is consistent with this objective. It is, however, an important precondition that recycling is not made more difficult by chemical substances, and that the recycling does not counteract other environmental objectives. Vehicle tyres contain several substances of very high concern, and thus recycling of such products for use in synthetic turf may conflict with the Swedish environmental objective: *A Non-Toxic Environment*.

The Swedish parliament has laid down 16 environmental objectives, one of which is the achievement of a non-toxic environment. These objectives have been supplemented with three strategies, developed to achieve the objectives. One of these strategies is the strategy to achieve non-toxic cycles that require few resources.

The interim target 3 for a non-toxic environment states that newly produced articles are to be free from substances of very high concern, as far as is possible. Substances of very high concern include substances that:

- are persistent or are bioaccumulative
- are carcinogenic
- are mutagenic or reprotoxic
- disturb hormonal balance
- are severely allergenic
- are mercury, cadmium or lead.

Existing articles that contain substances with the properties above or mercury, cadmium or lead, are to be handled in such a manner that the substances are not released into the environment.

Interim target 4 for a non-toxic environment states that the health and environmental risks associated with the use of chemical substances (not covered by interim target 3) are to be reduced continuously. The occurrence and use of chemical substances that impede the recycling of materials is to decrease during the same period.

The strategy to achieve non-toxic cycles that require few resources states that policies within, mainly, waste management, chemical management and product management, must be co-ordinated such that measures are taken from a comprehensive perspective taking into account the effect that materials and substances have on the environment during their complete lifecycle (Government Bill 2004/05:150).

More information can be found at: www.kemi.se / A Non-Toxic Environment / Giftfri miljö.

Chemicals Legislation

The laws governing chemicals that are relevant to synthetic turf surfaces are included in the Swedish Environmental Code (1998:808) and legislation derived from the Code, including the Chemical Products and Biotechnical Organisms Ordinance (1998:941).

The general rules of consideration, etc., stated in the Environmental Code[1] state that anyone who pursues an activity must:

- obtain the knowledge that is necessary, and
- implement protective measures, comply with restrictions, and take any other precautions that are necessary to combat damage or detriment to human health or the environment.

Chemical legislation places various rigid requirements for information on chemical products and other products, which are designated as "articles". Synthetic turf is regarded as "an article", while the rubber granulate that is the raw material for synthetic turf is a "chemical product".

Section 3 of the Chemical Products and Biotechnical Organisms Ordinance (1998:941) states that anyone who handles professionally articles that contain a chemical product that may be harmful to humans or the environment due to its properties must, through labelling or through another method, supply the information required to protect human health and the environment.

New European legislation known as REACH is expected to come into force in 2007. This will cover chemical substances and it will place certain requirements onto substances of very high concern when they are included in articles.

More information about legislation can be found at: www.kemi.se / Legislation / Författningar.

Waste Disposal Legislation

The Ordinance on Producers' Responsibility for Tyres (1994:1236) states that waste tyres are to be collected. The degree of collection and recycling of tyres is now essentially 100% in Sweden. Most of these tyres are used in Sweden to produce energy,(which is used) mainly in the cement industry.

The EU has adopted a Waste Directive, which is currently under review. The present legislation is unclear with respect to the definition of waste. This has given rise to uncertainties in the boundary region between "waste" and "resource" (which is the region in which rubber granulate from tyres is located). It is the opinion of KemI that this must be clarified, and we have stated this to the Swedish government. One aspect that is important is that the requirements for information about the contents of hazardous chemical substances must not be lower for products containing recycled material than they are for products with newly produced materials.

The Swedish Environmental Protection Agency is principally responsible for issues related to waste management and recycling. For more information, visit: www.naturvardsverket.se.

[1] The Environmental Code, Chapter 2, Sections 2-3.

Synthetic Turf Products

Several suppliers of synthetic turf operate in Sweden. The website of the Swedish Football Association lists the Swedish suppliers and the synthetic turfs that have been approved for football use according to UEFA.
This information can be found at: www.svenskfotboll.se.

Several different types of synthetic turf are available, but the principle is usually the same. The turfs comprise plastic fibres of polyethene, polypropylene or nylon, which are attached to a plastic web of polypropylene or polyester. Sand and rubber granulate is filled between the fibres. The sand provides weight and holds the plastic web in place, while the rubber provides elasticness.

The thickness of the rubber layer differs between turfs, but is usually approximately three cm. A rubber pad is sometimes placed under the synthetic turf, in which case the layer of rubber granulate does not have to be so thick. The principle source of rubber granulate is recycled tyres that are imported from the European recycling industry. Granulate of newly manufactured rubber (EPDM rubber), however, may be used. Newly manufactured rubber granulate is considerably more expensive, and this means that most purchasers choose recycled rubber.

New filling material is being developed, and some alternatives are currently available, including rubber-covered sand and granulates of thermoplastics.

The lifetime of synthetic turf depends on how and how much it is used. The new type of synthetic turf using rubber has not been commercially available very long and thus few pitches have become worn out. This means that there is little information about how the properties of synthetic turf change with time.

Synthetic turf is not totally maintenance-free. It must be washed and brushed, and new rubber must be added if the turf is to perform well.

Substances in Tyres

BLIC (Bureau de Liaison des Industries du Caoutchouc) listed the average contents of a used European tyre in 2001 and found that it contained 63 substances. Forty percent of the tyre is rubber: approximately half of the rubber is natural rubber, while the other half is synthetic rubber. Natural rubber is obtained from the rubber tree, *Hevea brasiliensis*. Synthetic rubber is principally of the type SBR (styrene-butadiene rubber), which is very similar to natural rubber.

Other substances that are used in relatively large amounts in tyres are carbon black (a reinforcing agent), aromatic oils (plasticizers), sulphur (vulcanising agent), zinc oxide (activators). Several metals are also used.

More information is available in, among other sources, KemI Report 6/94 “Nya hjulspår – en produktstudie av gummidäck” (“New Paths – A Study of Rubber Tyres as a Product”), 1994, and KemI Report 3/03 “HA-oljor i bildäck” (“HA Oils in Vehicle Tyres”), 2003.

Brief descriptions of the properties of certain substances are given below. Further information about specific substances can be obtained from the KemI databases at www.kemi.se / Databases /Databaser, and from the ECB database ESIS (European Chemical Substances Information System) at www.ecb.jrc.it.

Polyethene and Polypropylene

Polyethene and polypropene are two plastics that chemically are very similar. They contain polymers of carbon and hydrogen, and are manufactured from cracked petroleum. The polymer chains in polyethene and polypropene are mostly straight, and the material becomes soft and pliable when warm. These plastics contain additives, principally stabilisers, which slow down the reaction of the polymers with air and under the influence of light.

Rubber/Latex

Rubber material is produced from rubber with different additives. Rubber comprises elastic polymers that are either obtained directly from plants (natural rubber) or manufactured from petroleum (synthetic rubber). Natural rubber is produced from sap (latex) that is tapped from certain trees. The actual polymer in natural rubber is sometimes called “latex” and it may have allergenic properties, since it contains traces of the plant proteins. There are many different types of synthetic rubber based on different starting materials, and this allows the desired properties to be obtained. The most common types of synthetic rubber are styrene-butadiene rubber (SBR) and ethene-propylene rubber (EPDM). Vulcanising agents and accelerators are used during the manufacture. Fillers, plasticisers and antioxidants are added in order to improve the technical properties of the rubber.

Aromatic Oils and PAHs

High aromatic oils include polycyclic aromatic hydrocarbons (PAHs). This is a large group of substances, many of which are harmful for health and the environment. Most of the PAHs in the oil are persistent, bioaccumulative and carcinogenic. These are substances that the environmental objective *A Non-Toxic Environment* states must be phased out.

Sweden has been working actively within the EU to prohibit high aromatic oils in tyres. The EU decided in the summer of 2005 to introduce limits for the concentrations of PAHs in newly manufactured tyres. The new regulations will come into force in 2010. This will in the long term lead to lower levels of PAHs in the rubber from recycled tyres.

Table 1: *Some important properties of the PAHs that are components of HA oils. The table has been reproduced from KemI Report 3/03, "HA-oljor i bildäck" ("HA Oils in Vehicle Tyres").*

Substance	**Persistent**	**Bioaccumulative**	**Carcinogenic[2] (category 2)**
Anthanthrene			**(+)**
Benz(a)anthracene	+	+	+
Benz(a)pyrene	+	+	+
Benzo(b)fluoranthene	+	+	+
Benzo(e)pyrene		+	**?**
Benzo(g,h,i)perylene	+	+	**-**
Chrysene	+	+	**(+)**
Dibenz(a,h)anthracene	+	+	**(+)**
Fluoranthene	+	+	**?**
Indeno (1,2,3-c,d)pyrene	+	+	**(+)**
Pyrene	+	+	**?**

The criteria for persistency and bioaccumulation are derived from TGD[3].

+ = persistent, bioaccumulative or classified as carcinogenic in category 2 in the classification list used throughout the EU (KIFS 2001:3).
(+) = has caused cancer in experimental animals, but has not been classified as carcinogenic.
? = there are too few studies available to determine whether the substance is carcinogenic.
- =.negative result.
No symbol = no studies are available.

PAHs are spread in society not only in tyres but also through vehicle exhaust, wear on road surfaces, and the burning of wood. They are also spread when creosote is used and in the form of tobacco smoke.

More information is available in KemI Report 3/03 "HA-oljor i bildäck – förutsättningar för ett nationellt förbud", ("HA Oils in Vehicle Tyres – Prospects for a National Ban"), 2003.

Phthalates

Phthalates are esters produced from phthalic acid (an aromatic dicarboxyl acid) and various alcohols. They are used as solvents and plasticisers in plastics, where they function by inserting themselves between the polymer molecules. Phthalates are not chemically bound to the rubber polymers, and they can leach from the material.

Certain phthalates are suspected of affecting human reproductive health, i.e. they are reprotoxic. Diethylhexyl phthalate (DEHP), dibutyl phthalate (DBP) and butylbenzyl phthalate (BBP) have been classified as reprotoxic. These substances are to be phased out, according to the environmental objective *A Non-Toxic Environment*.

Phenols

The phenols that are used as additives for rubber and other polymers include various alkyl phenols (such as tert-butyl phenol). The alkyl phenols act as antioxidants. They protect the material from break-down through reaction between the polymers and the oxygen in air. The alkyl phenols are not chemically bound to the rubber polymer and can thus leach from the material.

[2] Source IPCS, 1998.
[3] Technical Guidance Document within the programme for existing substances within the EU.

These substances are persistent and bioaccumulative, and they can give long-term effects on the environment. They have been given priority in the task of reducing risk according to the environmental objective.

Metals

Zinc

Zinc is the metal that is present at highest levels in synthetic turf, and it is therefore expected that this metal will be the one that is spread to the environment in greatest amounts. Zinc is essential for living organisms, and it is therefore actively absorbed, but it becomes harmful at high levels. The solubility of zinc depends heavily on the pH. It is most commonly present as free zinc ions in acid solution.

Lead

Lead affects reproductive health, and can damage the nervous system and lead to poor cognitive development, among other effects. Foetuses and young children are particularly susceptible. The uses of lead include batteries, PVC, electronic circuits, ammunition, fishing weights and balance weights. The environmental objective *A Non-Toxic Environment* has stipulated that the use of lead is to be phased out by 2010.

Copper

Copper is essential for living organisms as zinc is, and copper is therefore also actively absorbed. Copper is also harmful at high levels. The solubility of copper depends heavily on the pH.

Chromium

Several different forms of chromium exist. It is used in steel alloys, in paint, wood treatment agents, surface treatment of metals, and in corrosion protection agents. Hexavalent chromium is chemically highly active and has a high oxidation potential. It is carcinogenic and mutagenic. The use of hexavalent chromium in electronic components will be prohibited after 1 July 2006, and its use in vehicles will be prohibited after 1 July 2007. The environmental objective *A Non-Toxic Environment* has stipulated that the use of hexavalent chromium is to be phased out by 2010.

Cadmium

Cadmium is toxic to humans, other animals, and plants, and it is readily absorbed by plants. The substance is stored in the human body (in the kidneys and liver) and may contribute to poor liver and kidney function, and osteoporosis. The main use of cadmium is in batteries. Its use in pigment, stabilisers and surface treatment agents is prohibited in Sweden. The environmental objective *A Non-Toxic Environment* has stipulated that the use of cadmium is to be phased out by 2010.

Reports and Assessments

Summaries of several reports and assessments of synthetic turf are given below. These assessments have been carried out at the Luleå University of Technology, IVL The Swedish Environmental Research Institute and at various research institutions in Norway.

Several measurements and assessments of synthetic turf have been carried out in Norway in the period 2004 - 2005. The Norwegian Pollution Control Authority (SFT) stated its opinion of the risks associated with synthetic turf at the end of January 2006. The overall assessment is that simply being on synthetic turf made with rubber granulate from recycled tyres does not constitute a

health risk, but that there are uncertainties with respect to the risk of developing asthma and allergies of the air passages caused by latex allergens in indoor facilities. The authority believes that leaching of substances from granulate from recycled tyres may involve a risk for the local environment. SFT recommends that granulate from recycled tyres is not used when laying new synthetic turf surfaces. It is not, however, necessary to remove granulate from surfaces that have been laid. More information is available at: www.sft.no.

Technical and Environmental Properties of Tyre Shreds Focusing on Ground Engineering Application (Tommy Edeskär, Luleå University of Technology, 2004)

This report summarises knowledge concerning the use of recycled tyres in ground engineering applications. It deals with shredded tyres where the shred size is 5-30 cm and it deals primarily with the ground engineering properties. The report does deal with the chemical composition to a certain extent, and with the leaching of substances to drainage water and the effect on the environment. The author concludes that shredded tyres contain substances that have the potential for pollution, primarily PAHs, phenols and zinc.

Leaching of most of the substances is low at neutral pH. At alkali pH, in contrast, leaching of organic compounds, zinc, copper and lead, is expected.

Table 2 below shows the concentrations of a number of substances in the rubber granulate, while Table 5 shows the concentrations in run-off water.

The report recommends that the use of shredded rubber is limited to non-sensitive regions until more knowledge of the environmental effects is available.

Potenstielle helse- og miljöeffekter tillknyttet kunstgressystemer (Byggforsk - Norges Byggforskningsinstitutt, 2004)

Potential Health and Environmental Effects Associated with Synthetic Turf Systems (Byggforsk - SINTEF Building and Infrastructure, 2004)

Tests have been carried out using granulate from recycled rubber (using two different particle sizes), newly manufactured rubber granulate (EPDM), and synthetic grass fibres. Rubber and fibres have been analysed, and the run-off water from rubber and fibres. A degassing test of the rubber granulate has also been carried out.

Table 2 shows the concentrations of a number of substances in the rubber granulate, while Table 5 shows the concentrations in run-off water.

The levels of PAHs and of zinc in the recycled rubber exceed SFT's "guideline values for extended use in highly sensitive areas". The granulate from recycled rubber emitted gaseous alkylated benzenes. Newly manufactured EPDM rubber contains lower levels of hazardous substances than recycled rubber, except for chromium and zinc. This rubber emits lower amounts of volatile organic pollutants. The fibres of synthetic grass contain a significant amount of zinc, and leaching from these fibres is also significant. The fibres constitute such a small part of the total mass that this is not considered to be a problem.

Byggforsk suggests that an extended assessment of environmental risks is carried out.

Table 2: *Some of the substances found in rubber granulate*

Substance	Recycled rubber (mg/kg)[4]	Recycled rubber (mg/kg)[5]		EPDM rubber[4] (mg/kg)	50 % Recycled + 50% EPDM (mg/kg)[6]	EPDM rubber (mg/kg)[5]
		Coarse particles	Fine particles			
Lead	<9.95	20	15	8	1.2	1.0
Cadmium	<1.99	2	1	<0.5	<0.1	0.12
Copper	32.1	70	20	<3	4.0	7.1
Chromium	<1.99	<2	<2	5,200	2.2	11
Mercury	-	0.04	0.04	<0.03	<0.005	-
Zinc	174	17,000	7,300	9,500	18,000	2,100
Phenol 4-t-octylphenol Iso-nonylphenol	- -	33,700 21,200	27,800 9,120	- 1,120	- -	- -
Benzoapyrene	3	3	3.1	0.12	1.4	<0.05
Total PAHs	62	76	74	1	20	<1.3

Miljörisikovurdering av kunstgresssystemer (Norsk institutt for vannforskning (NIVA), 2005)

Evaluation of the Environmental Risks of Synthetic Turf (The Norwegian Institute for Water Research (NIVA), 2005)

NIVA has assessed environmental risks, based on the results of Byggforsk's report "Potential Health and Environmental Effects Associated with Synthetic Turf Systems" and on results from evaluations of substances carried out across the EU. NIVA has used the EU method for assessing risk, described in the Technical Guidance document[7]. The method is based on calculating the ratio: PEC/PNEC for individual substances, where PEC is the *predicted environmental concentration* (defined as the predicted concentration of the substance in the environment) and PNEC is the *predicted no-effect concentration* (defined as the highest concentration that does not lead to any effects on the environment). The greater this ratio, the greater the risk for the environment.

NIVA has assumed that leaching of substances through the run-off of surface water during precipitation is the greatest risk for the environment. The effects on aquatic organisms in water and in sediment in a small stream have been calculated. The results show that there is a risk for effects on aquatic organisms both in the water and in the sediment. Zinc contributes most to this risk, with smaller contributions from octylphenol and PAHs (when using the sum of the values for the individual PAHs).

[4] Values from "Technical and Environmental Properties of Tyre Shreds Focusing on Ground Engineering Applications", Tommy Edeskär, Luleå University of Technology, 2004.
[5] Values from "Potential Health and Environmental Effects Associated with Synthetic Turf Systems (Byggforsk - SINTEF Building and Infrastructure, 2004).
[6] Values from "Air-Borne Pollution in a Football Hall with Synthetic Turf", Stockholm Muncipality, 2004.
[7] "Technical Guidance Document in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances and Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market."

Table 3: *Substances for which the risk ratio PEC/PNEC exceeds 1, showing a risk for effects on the environment.*

Substance	**PEC/PNEC water**	**PEC/PNEC sediment**
Zinc	40	371
4-t-octylphenol	2.9	2.9
Total PAHs	1.1	0.1

It is expected that the substances will leach from the synthetic turf slowly, and this means that aquatic organisms may be affected for many years. The total amount of hazardous substances that leaches from the synthetic turf is small, and any environmental effects are expected to be local.

Måling av luftforurensning i innedors kunstgresshaller (Norsk institutt for luftforskning (NILU), 2005)

Measurement of Air-Borne Pollution in Halls with Synthetic Turf (Norwegian Institute for Air Research (NILU), 2005)

NILU carried out measurements in three halls with synthetic turf. These halls were:

1. Manglerudhallen – synthetic turf one year old containing granulate from recycled rubber mixed with green rubber of unknown type
2. Valhall – newly laid synthetic turf (2 months old when measured) containing granulate from recycled rubber
3. Östfoldhallen – synthetic turf 10 months old with granulate of thermoplastic.

Halls 1 and 2 had raised levels of air-borne dust measured by $PM_{2.5}$, levels that lay just under the national guideline of 20 $\mu g/m^3$. The guideline was exceeded in Hall 1 (both for $PM_{2.5}$ and for PM_{10}) when the ventilation was operating at less than maximum intensity in conditions of low outdoor temperature.

The air-borne dust in Halls 1 and 2 contained significant amounts of rubber from the granulate, 50% in Hall 1 and 35% in Hall 2. The air-borne dust in all three halls contained PAHs and phthalates (principally dimethyl phthalate (DMP), also dibutyl phthalate (DBP) and diethylhexyl phthalate (DEHP)).

Table 4: *Air measurements in Norwegian halls with synthetic turf. Information taken from "Measurement of Air-Borne Pollution in Halls with Synthetic Turf", (NILU, 2006)*

	Manglerud-hallen	Valhalla	Östfoldhallen
PAH[8] **(ng/m^3)**			
PM_{10}	1.15	0.56	0.38
Gas phase	0.02	<0.01	0.01
Phthalates[9] **(ng/m^3)**			
$PM_{2.5}$	37.3	81.2	84.9
PM_{10}	131.4	134.4	117.1

The concentration of volatile organic compounds (VOCs) was higher in the two halls (Hall 1 and Hall 2) that contain granulate from recycled rubber than it was in the hall with granulate of thermoplastic. It is, however, principally levels of chemicals that are known to be in recycled tyres

[8] Measured as benzoapyrene.
[9] Total phthalates.

that have been measured, and further investigations are required to measure levels of chemicals that it is expected will be released from thermoplastic. All three halls contained organic compounds that have been identified in the current investigation.

The report concludes that the use of granulate from recycled rubber involves significant negative effects on the indoor climate.

Kunstgressbaner – vurdering av helserisiko for fotballspillere (Nasjonalt folkehelseinstitutt og Radiumhospitalet, 2006)

Synthetic Turf Surfaces – Evaluation of Health Risks for Footballers (The Norwegian Institute of Public Health and The Norwegian Radium Hospital, 2006)

An assessment of health risks has been carried out, based on the results of the NILU report "Measurement of Air-Borne Pollution in Halls with Synthetic Turf". Several worst-case scenarios have been established in which factors such as the type of training, the volumes inhaled during activity, the absorption of substances through the lungs, and the body weight of the athletes have been considered. Calculations have been carried out for VOCs, PAHs, PCBs, benzene, phthalates and alkyl phenols. The results, together with information about the doses of the substances that are known to give harmful effects, allow the conclusion to be drawn that no increased health risk is associated with the use of halls having synthetic turf with recycled rubber. The result is true for children, young people and adults.

Vehicle tyres contain large amounts of latex, and they therefore also probably contain latex allergens. There is no information available about the levels of latex in the granulate from recycled tyres that is used, and it has therefore not been possible to evaluate the risk of allergic reaction to latex.

Luftföroreningar i en fotbollshall med konstgräs (IVL och Södertälje kommun, 2004)

Air-Borne Pollution in a Football Hall with Synthetic Turf (IVL and Södertälje Municipality, 2004)

IVL took samples of the air in Västergård's football hall on 15-16 March 2004. The levels of air-borne dust in the hall were measured when personnel were working and when sporting activities were being carried out. A rubber mixture consisting of 50% shredded vehicle tyres and 50% newly manufactured EPDM rubber was analysed in parallel with the air measurements. (The rubber contained 1 mg/kg lead and 1 mg/kg benzoapyrene.) The researchers assumed that the fractions of lead and benzoapyrene in the air-borne dust corresponded to those in the rubber. They compared the calculated levels of lead and benzoapyrene in the dust with the limit values laid down by the Swedish Work Environment Authority for occupational exposure, and with the guidelines for outdoor air (environmental quality objective as specified by IVL Report B1553 "Air Quality in Suburban Areas"). The values were significantly under the limit values and the guidelines, with the exception of benzoapyrene. The calculated level of this substance (0.075 ng/m^3) measured during activity in the hall was only just under the target value for the year 2020 for outdoor air (0.1 ng/m^3). It is thus possible that the level sometimes exceeds this value. See Tables 6 and 7.

Luftföroreningar i en fotbollshall med konstgräs (IVL och Stockholm stad, 2004)

Air-Borne Pollution in a Football Hall with Synthetic Turf (IVL and Stockholm Municipality, 2004)

IVL took samples of the air in Spånga football hall on 8-9 March 2004 in a similar manner to that used in Södertälje. The Stockholm City Sports Administration had commissioned analysis of the rubber granulate, see Table 2.

It was assumed that all particles in the air-borne dust originated from the shredded vehicle tyres. The calculated levels of PAHs and heavy metals from samples taken while personnel worked in the hall were significantly lower than the limit values of the Swedish Work Environment Authority. The calculated values from samples taken during sporting activities were assessed by IVL to be clearly acceptable, compared to the guidelines for outdoor air. See Tables 6 and 7.

Comparative life-cycle assessment of the utilisation of used tyres (IVL and Svensk Däckåtervinning AB ("The Swedish Tyre Recycling Organisation"), 2006)

The study aimed to assess the most advantageous use from an environmental point of view for recycled tyres in a comparative analysis. Six different uses of worn-out tyres were compared:

- Energy recovery for cement production (replaces coal, pet coke and iron ore)
- Energy recovery in district heating plant (replaces coal and other renewable energy sources)
- Granulate for synthetic turf surfaces (replaces newly manufactured EPDM rubber)
- Shredded tyres as cover for landfill sites (replaces gravel)
- Shredded tyres in sound insulation (replaces expanded clay aggregate)
- Asphalt production (replaces gravel and bitumen).

The effect on the environment within each use was first compared, i.e. the environmental effect of using worn-out tyres was compared with that of an alternative material or fuel (given above within brackets). These results were subsequently ranked for all six uses relative to each other. The results showed that:

- The use of tyres for synthetic turf gave the greater environmental benefit with respect to energy recovery and the emission of lead, nickel, chromium and cadmium. The next best use was in cement manufacture.
- Use for synthetic turf was clearly the least advantageous use with respect to emission of copper, zinc, mercury and PAHs to water. All other uses were similar in this respect.

KemI comments: It should be noted that the comparative analysis did not include the environmental effects of the manufacture of the tyres, while the environmental effects of the manufacture of EPDM rubber have been included. The study does not, therefore, show the complete environmental effect of the tyres. The study has compared recycled tyres with EPDM rubber, and thus these results cannot be used to draw any conclusions between the alternatives from the perspective of the complete lifecycle. Nor can they be used when considering alternative substances such as thermoplastic for synthetic turf surfaces.

European Guidelines

There are currently no common guidelines within the EU for the considerations that must be taken to protect human health and the environment around us when laying and using synthetic turf.

FIFA/UEFA

FIFA/UEFA has published quality requirements for synthetic turf. These requirements concern principally the technical properties of the surface relevant to playing football, and there are no requirements or recommendations with respect to safety or the environment. More information is available at: www.svenskfotboll.se, www.fifa.com and www.uefa.com.

German Standard for Synthetic Turf

The German Institute for Standardization (DIN) has published "Sports Grounds Part 7; Synthetic Turf Areas. Determination of Environmental Compatibility (DIN 18035-7:2002-06)".

The standard states that synthetic turf layer must be in a condition that hygiene and health of neighbours and users are not endangered by:

- release of harmful gases and dangerous particles to the air
- pollution or contamination of water and soil
- in respect to usage and disposal after use, the following must be observed:
    - use of materials with low content of pollutants
    - restriction to as few as possible material types
    - easy separation of individual layers
    - priority use of worn-out materials by recycling or combustion rather than dumping.

The standard establishes limiting values for the contents of substances in soil and ground water for, among other substances, lead (0.04 mg/l), cadmium (0.005 mg/l), chromium (0.05 mg/l), mercury (0.001 mg/l), and zinc (3.0 mg/l or 0.5 mg/l, depending on the method used to measure the level).

The requirements given above are to be ensured by regular sampling. The standard specifies the test methods that should be used.

EU Standard for Outdoor Synthetic Turf

The standard "Surfaces for Sports Areas – Synthetic Turf Surfaces Primarily Designed for Outdoor Use (prEN 15330)" is currently under development within the EU. Sweden does not currently have a representative in the European working group, while Norway is represented both through The Football Association of Norway (NFF) and through The Ministry of Culture and Church Affairs (KKD).

Holland has suggested that the following environmental and health-related requirements are to be included in the standard:

- The surface layer of synthetic turf shall not contain or release any substances that are
    - carcinogenic, mutagenic or reprotoxic
    - persistent, bioaccumulative and toxic (PBT)
    - very persistent and very bioaccumulative (vPvB)
    - toxic in contact with skin, very toxic in contact with skin or may cause sensitisation in contact with skin.
- Rubber in synthetic turf shall not exceed 0.85% by weight of substances that
    - may cause cancer
    - may cause heritable genetic damage

- may cause cancer by inhalation
- are very toxic to aquatic organisms and that can cause long-term harmful effects on the aquatic environment
- toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment
- are harmful for aquatic organisms, may cause long-term adverse effects in the aquatic environment
- may impair fertility
- may cause harm to the unborn child.

EU Standard for Recycled Tyres

CEN has worked within the EU towards the publication of a common standard (pr EN 14243) for the use of recycled tyres. Sweden has participated in this work through SIS. The standard was not approved at its final vote in the summer of 2005. This means that the final result will not be a standard: it will be published as a technical report.

Swedish Guidelines

There are no Swedish guidelines for the laying of synthetic turf. There are, however, various guidelines and limiting values for some of the substances that are present in synthetic turf with respect to air pollution, soil contamination, and water pollution. These cannot be directly applied to emissions from synthetic turf, but they can be used – with a degree of care – to set the results obtained during investigations of synthetic turf surfaces into perspective.

Air Pollutants – Occupational Exposure

Legislation governing the workplace environment states limiting values for the levels in air of a number of substances in “Föreskrifter om hygieniska gränsvärden och åtgärder mot luftföroreningar (AFS 2005:17)” (“Occupational Exposure Limit Values and Measures against Air Contaminants”). These limits are valid for occupational exposure and are valid for the exposure of adults for one working day. Children and young people are often more sensitive to the effects of chemicals than adults, and this must be taken into consideration with regard to synthetic turf. Furthermore, physical activity levels are higher when playing football than they are during occupational work. This should also be taken into consideration when comparing the air quality of halls containing synthetic turf with the limiting values for occupational exposure.

The hygienic limiting value for lead is 0.1 mg/m^3 (total dust) and the value for PAHs (measured as benzoapyrene) is 0.002 mg/m^3.

Pollutants in Outdoor Air

IVL The Swedish Environmental Research Institute has presented limiting values for the levels of certain substances in outdoor air in the report B1667, “Luftkvalitet i tätorter” (“Air Quality in Suburban Areas”) 2005. The limiting values have been defined in order to assess the air pollution within suburban areas. Air pollutants in suburban areas often arise from a large number of sources, the largest one of which that contributes to poor air quality being emissions from traffic. Five types of pollutant are the most significant causes of health problems in the air in suburban areas, one of these being PAHs. Outdoor pollutants cause a number of negative effects on health and it has been assessed that over 1,000 deaths per year in Sweden can be attributed to these effects. Cancer, cardiovascular disease, allergies and asthma are some of the health problems that are associated with air pollutants in suburban areas.

The limiting value (measured as annual mean exposure) for heavy metals (measured as lead) is 0.5 μg/m^3. The limiting value for PAHs (measured as benzoapyrene) is 0.0001 μg/m^3, which is to be achieved by the year 2020.

The levels of PAHs in most Swedish suburban areas exceed the target value. It is particularly suburban areas that have a neighbouring industrial area and suburban areas in which much wood is burned for heating in which the risk of exceeding the limiting value is greatest. The annual mean value for benzoapyrene in 2002 at Hornsgatan in Stockholm was 0.39 ng/m^3.

Polluted Surface Water

The condition of the environment can be assessed by comparing the level of a substance with an established limiting value. Swedish guidelines have been defined for contaminated soil, polluted surface water and polluted ground water. The term “polluted areas” is used to denote storage areas for waste, and areas of soil, ground water or sediment that have received considerably higher levels of pollutant than the surrounding through local emissions. The guidelines for this reason cannot be directly applied to areas that neighbour synthetic turf pitches.

The condition of the environment is considered to be serious when the measured level of a substance exceeds the guideline by a factor of between three and ten.

The values that have been defined as involving an increased risk for biological effects in surface water are: lead 3 μg/l, cadmium 0.3 μg/l, copper 9 μg/l, chromium 15 μg/l, and zinc 60 μg/l.

The website of the Swedish Environmental Protection Agency gives guidelines for polluted regions: www.naturvardsverket.se.

Summary of Environmental Aspects

The investigations that have been published allow the conclusion to be drawn that synthetic turf that contains recycled rubber may give rise to local environmental risks. The Norwegian assessment of environmental risk showed that there is a risk for effects on aquatic organisms both in the water and in the sediment, since hazardous substances leach out through the surface run-off during precipitation. Zinc contributes most to this risk, with smaller contributions from phenols and PAHs. The total amount of hazardous substances that leaches from synthetic turf is small, and thus any effect on the environment that they have is expected to be local.

Relating the levels of leaching from the tests using synthetic turf to the guideline for polluted surface water (the level that involves an increased risk of biological effects) shows that the guideline is exceeded for zinc and lead, and for copper at high pH. Relating the values to those of the German DIN standard for synthetic turf shows that the levels of zinc and lead exceed those specified by the standard. The guideline does not apply to synthetic turf surfaces, while the standard is valid for values in ground water, and this means that these comparisons must be treated with great caution since they are not really directly applicable.

Several factors influence to a significant degree how great the risk for the environment is. These factors include the local ground conditions, the type of drainage, and the sensitivity of the region. The risk is also influenced by the composition of the filler material, its particle size, and its age. This means that an assessment of risk must be made for each individual case at a local level for the assessment to be reliable.

Table 5: *Results from leaching tests related to the German DIN standard (for soil and for ground water), Swedish guidelines for polluted surface water, and Canadian criteria for surface water. It should be noted that a direct comparison cannot be made between the results from leaching tests and the limiting values, since the limiting values were not defined for this purpose. The comparisons do, however, give a certain indication.*

Substance	Leaching 1[10] (µg/l)		Leaching 2[11] (µg/l)			German synthetic turf standard (µg/l)	Guideline: polluted surface water (µg/l)
	pH 7	pH 13.6	Coarse recyc.	Fine recyc.	EPDM		
Lead**	8.44	48.8	-	-	-	40	3
Cadmium**	0.078	0.12	-	-	-	5	0.3
Copper*	5.77	383	-	-	-	-	9
Chromium**[12] / *	2.95	5.96	-	-	-	500	15
Mercury**	<0.02	0.039	-	-	-	1	-
Zinc*	1,310	7,050	2,290	1,220	80	3,000	60
Phenol* 4-t-octylphenol Iso-nonylphenol	- 2-50[13] 5-7	- - -	- 3,600 1,120	- 2,950 568	- - -	-	-
Benzoapyrene**	<0.01	<0.02	<0.01	<0.01	-	-	-
Total PAHs	11	3.4	-	-		-	-

** The use of this substance should be phased out, according to interim target 3 of *A Non-Toxic Environment.*

* Reducing the use of this substance has been given priority in interim target 4 of *A Non-Toxic Environment*.

[10] Results from leaching tests (as specified by EN 12457) presented in "Technical and Environmental Properties of Tyre Shreds Focusing on Ground Engineering Application", Tommy Edeskär, Luleå Technical University, 2004.

[11] Values from "Potential Health and Environmental Effects Associated with Synthetic Turf Systems" (Byggforsk - SINTEF Building and Infrastructure, 2004).

[12] Hexavalent chromium is carcinogenic and is subject to interim target 3.

[13] Measured as µg/kg.

Summary of Health Aspects

The information available makes it difficult to make a reliable assessment of risk when it comes to health aspects. Results are available from few measurements in few halls on few occasions, and it is thus most appropriate to regard these as random samples rather than the basis of generally applicable assessments of risk.

All measurements of indoor air give results that lie under the established guidelines for occupational exposure and for the natural environment, and they thus indicate that there are no risks involved following exposure by air. The concentrations in halls were in two cases just under the applicable guideline.

Table 6: *Measurements of air in Swedish halls using synthetic turf, relative to limiting values for occupational exposure.*

	Spånga[14]	Södertälje[15]	Limiting value for workplace environment
PAH[16] **(ng/m^3)**	0.2	0.6	2,000
Lead (ng/m^3)	0.1	<1	100,000

Table 7 *Measurements of air in Swedish halls using synthetic turf, relative to limiting values for indoor air.*

	Spånga[17]	Södertälje[18]	Limiting value for outdoor environment
PAH[19] **(ng/m^3)**			0.1[20]
$PM_{2.5}$	0.008	0.075	
PM_{10}	0.03	-	
Lead (ng/m^3)			5,000
Total	-	<1	
$PM_{2.5}$	0.000007	-	
PM_{10}	0.00003	-	

NIVA concludes in the report that the use of recycled rubber results in a deterioration of the indoor environment. The Norwegian exposure calculations, however, show that there is no risk of this affecting health. These calculations have been carried out taking into consideration the type of training, the volume of air inhaled, the absorption of substances through the lungs, and the body weight of the player.

[14] Values from "Air-Borne Pollution in a Football Hall with Synthetic Turf", Stockholm Municipality, 2004.
[15] Values from "Air-Borne Pollution in a Football Hall with Synthetic Turf", IVL, 2004.
[16] Measured as benzoapyrene.
[17] Values from "Air-Borne Pollution in a Football Hall with Synthetic Turf", Stockholm Municipality, 2004.
[18] Values from "Air-Borne Pollution in a Football Hall with Synthetic Turf", IVL, 2004.
[19] Measured as benzoapyrene.
[20] Target value to be achieved by the year 2020.

Ventilation in the halls affects the quality of the air profoundly. It must be assumed that air circulation is better for synthetic turf surfaces located outdoors than it is indoors, and this will give lower exposure.

The results and discussion above demonstrate the exposure through inhaled air. The total risk associated with inhalation at synthetic turf surfaces depends also on the addition of hazardous substances from other sources. The risk during inhalation is therefore higher for synthetic turf surfaces that are located in regions with high traffic density, since the total exposure to substances such as PAHs and lead will be greater.

The health risks are not connected only with air pollution caused by synthetic turf, and exposure may take place by other mechanisms. Examples are the attachment of rubber particles to clothing which is subsequently placed in contact with the skin, and the accidental swallowing of rubber granulate by players or small children. Exposure by such mechanisms has been poorly studied, and there is no information available about the risk of allergic reactions. These aspects should be studied in order to obtain a comprehensive assessment of health risks.

Conclusions

Recycling Tyres

It is often a good strategy to recycle material from worn-out products for reasons of energy economy and the efficient use of resources. This recycling, however, may conflict with attempts to minimise the risk of using chemicals. It is important before the new use of the material is started to determine whether it will lead to people or the environment being exposed to hazardous chemicals. A recycling perspective and a consciousness of chemical aspects should be included at the production stage, in order to be able to manage recycled material to a greater degree and in a safe manner.

Tyres contain substances of very high concern

Tyres contain several substances that are substances of very high concern. These substances may persist in the environment, they may be bioaccumulative, carcinogenic, reprotoxic, or mutagenic. This is true of, for example, polycyclic aromatic hydrocarbons (PAHs), phthalates and certain metals. These substances should not be released into the environment and thus waste tyres should not be used for synthetic turf surfaces. The environmental objectives set down by the Swedish parliament state that substances of very high concern should be phased out from newly produced articles.

Work is currently under way to reduce the levels of hazardous substances in tyres. The levels of PAHs will be regulated within the EU with effect from 2010. This means that the levels of substances of very high concern in tyres will, in time, decrease. It will, however, take time before PAHs disappear completely from rubber, and tyres contain more substances than just PAHs that have hazardous properties. It is important for this reason that the future recycling processes take place in a controlled and safe manner in order to avoid the spread and distribution of substances of very high concern.

Synthetic turf contains substances of very high concern, but this does not necessarily mean that it is a direct risk for human health and the environment. The direct risk depends on the extent to which humans and the environment are exposed to the hazardous substances.

Environmental Risks and Health Risks

The use of tyres in synthetic turf surfaces means that both humans and the environment will be exposed to recycled tyres in an uncontrolled manner that may lead to risks. It can be expected that the hazardous substances in the tyres are more readily released and spread when the tyres have been shredded to give a granulate with small granules than is the case when the use involves larger pieces of tyre in other contexts.

There is a local environmental risk

Current knowledge allows the conclusion to be drawn that synthetic turf that contains rubber from recycled tyres may give rise to local environmental risks. Investigations have shown that zinc and phenols can leach from the rubber granulate, and these substances can affect aquatic and sediment-dwelling organisms, if they reach neighbouring water courses. The total amount of these substances that leaches from synthetic turf is small, however, and thus any effect on the environment that they have is expected to be local. Other sources may also contribute to increased levels of these substances in water courses.

The health risks for players are probably low

Measurement of indoor air and exposure calculations have shown that there is probably a small health risk associated with simply being on or playing on synthetic turf surfaces that use rubber from recycled tyres. The exposure levels and any allergic reactions, however, have been poorly studied. Exposure to these substances from other sources, such as car exhaust, must also be taken into consideration to achieve a total assessment of health risks.

KemI's Recommendations

Do not select synthetic turf that contains substances of very high concern when laying new surfaces

Material that contains substances of very high concern should not be used, as specified by the environmental objectives of the Swedish parliament. This means that granulate formed from recycled rubber should not be used when laying new surfaces of synthetic turf.

The Norwegian authorities have issued a similar recommendation. The Netherlands has also suggested that a similar requirement is included in the EU standard "Surfaces for sport areas – Synthetic turf surfaces primarily designed for outdoor use".

New solutions must be developed and requested –the responsibility of companies

It is important that the recycled rubber in synthetic turf is replaced by material that truly is better from the point of view of health and the environment. It is the responsibility of companies to ensure that the products that are delivered are safe for people and the environment. The contents of new materials should be known and they should preferably have been assessed from the point of view of a total lifecycle effect on the environment. This means that companies must have expert knowledge about their products. Swedish companies should place demands on their suppliers and they should provide the drive required to develop better alternatives.

The sports administrations in the municipalities and others who are involved when new surfaces are to be laid should request information about the contents of chemicals, and they should pose demands during the purchasing process and during installation such that substances of very high concern are not released into the environment.

Existing synthetic turf surfaces may remain in place

The rubber from recycled tyres that is present in newly laid synthetic turf surfaces need not be immediately replaced, since the current health and environmental risks are assessed as being small. In the long term, however, the rubber should be replaced by alternatives. Material that contains less hazardous substances should be used when it is necessary to add new rubber. Furthermore, the recycled rubber should be replaced when it displays signs of break-down and the formation of smaller particles.

More knowledge is needed

It is difficult to assess the magnitude of the risk posed for human health and the environment by the use of synthetic turf using recycled rubber. The risk depends on the extent to which the hazardous substances are released from the rubber, and the subsequent exposure to these substances of people and the environment. Certain investigations and assessments have been carried out in order to illuminate the risks of using synthetic turf, but there remain major gaps in our knowledge. The responsibility for investigating and assessing the health and environmental risks lies with the companies that manufacture and supply synthetic turf. These companies should seek more knowledge, and they should spread this knowledge, as long as rubber from recycled tyres remains in synthetic turf surfaces. It is also appropriate that water quality in association with synthetic turf surfaces should be followed up and analysed.

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