Q & A Synthetic Turf Pitches and PAHs

Q1: What is a polycyclic aromatic hydrocarbon (PAH), and why are they hazardous for human health?

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals that occur naturally in coal, crude oil, and gasoline, and therefore are present in the products obtained from those raw materials. They are also secondary products obtained from combustion processes (e.g., burning fuels, smoking tobacco, motor vehicles, etc.). PAHs can be formed both during biological processes and as products of incomplete combustion from either natural combustion sources (forest and bush fires, volcanoes) or man-made combustion sources (automobile emissions and cigarette smoke). In addition to that, they have long degradation periods, and recent studies have demonstrated that high accumulated concentrations can range from few to hundreds ng/g (nanograms of PAH per gram of soil) in the soil and ng/m^3 (nanograms of PAH per cubic meter of water or air) in water and atmosphere (Manzetti, 2013). PAHs can also be formed in the food when cooking at high temperatures and they can also be released to the air.

When exposed to single or short term to large amounts of PAHs, it can cause irritation of the eyes, skin irritation, and breathing passages, but those effects diminish and disappear when the contact with the contaminated source is over and not repeated in the short term. The main problem arises when there is a repeated or long-term exposure to those contaminants. In that case, PAHs are considered to promote the development of chronic diseases such as cancer, the type will depend on the routes of exposure, occurring mostly in the blood, the lungs, the bladder, and the liver.

Q2: Why PAHs are present in synthetic turfs?

One of the mostly used ingredient to build synthetic turfs is rubber granules from end-of-life tyres (ELT) (i.e., up to 90%) (Pronk *et al*., 2018). When tyres are manufactured to be used by vehicles, they must be designed to have a good balance of three key properties (1) abrasion resistance, (2) rolling resistance, and (3) wet skid resistance.

Tyres are generally made of rubber (40-60%) such as Natural Rubber (NR), Styrene Butadiene Rubber (SBR) and Butadiene Rubber (BR), to which other additives are added to provide the material with those mentioned properties, namely accelerators, activators, anti-degradants, sulphur and what is more relevant within this topic: carbon black (~20% of the tyres composition). Highly Aromatic (HA) oils in tyres were an important source of PAH in the past, and due to this potential hazard, their use was regulated by EU Directive 2005/69/EC, which forbids HA oils in rubber manufacturing. Any new tyre or tyre tread used for re-treading manufactured after first of January 2010 may not contain any HA oil. Another material known to contain PAHs used in tire manufacturing is carbon black. Carbon black is a form of elemental carbon used as reinforcement material in the tire rubber to give the tire its desired properties in abrasion resistance and tensile strength.

Q3: What is the concentration of PAH in synthetic turfs made from ELT?

According to the RIVM risk assessment on rubber granules (RIVM, 2017), ELT made infill material used in artificial turf pitches have an average of those PAHs content of 5.8 mg/kg dry weight and a maximum of 19.8 mg/kg. ECHA, the European Chemicals Agency, found in 2017 that new rubber granules manufactured from recycled tyres contain typically 0.2-22.8 mg/kg. In addition, the analysis of 1,373 samples all across Europe determined that the presence of those PAHs varied from 2.9 to 21 mg/kg, on average 11 mg/kg.

The European Chemical Agency has evaluated the potential effects that the presence of PAHs in infill material could have for players, concluding that infill material with levels of PAHs below 20 ppm are safe for players.

However, despite the fact that those values correspond to the average presence of the PAHs within the ELT composition, the concentration directly available to the final user exposed to the synthetic turfs is considerably lower, and does not represent a hazard for human health and the environment.

Q4: What are the PAH risks of exposure when using synthetic turfs?

When in contact with materials containing PAHs, they can be absorbed into the human organism through three main routes: (1) oral, (2) dermal, and (3) inhalation.

(1) Oral absorption: By ingesting the material of the turf field.
(2) Dermal absorption: By being in direct contact with the field material.
(3) Inhalation: By inhaling the vapours containing PAHs, that can be released from the field, particularly at high temperatures.

From those three routes, when doing a correct use of the sport installations, dermal absorption and inhalation are the ones that present major concerns. However, to let dermal adsorption to occur, human skin must be in direct contact with the rubber. As shown in Figure 1, rubber infill is under the synthetic grass in the carpet file, and therefore the direct contact of the users with the rubber is significantly limited.

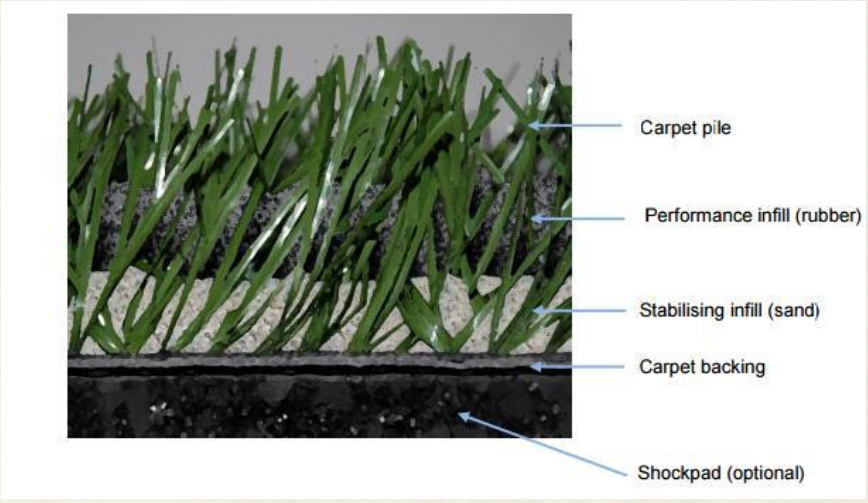

Figure 1. Schematic representation of an artificial turf system (Source: AVG, n/d).

Even if that would not be the case, a study developed by Fraunhofer (Gruber *et al.*, 2017) demonstrated that, under different conditions (i.e., contact time from 1-10 days, and temperatures between 20-60°C) PAHs migration through the skin is extremely low (i.e., maximum of 0.06 μg/person) and poses no elevated health risk.

Inhalation of PAHs could also occur, particularly when high temperatures that can be achieved within the fields in warm seasons or when directly exposed to the sunlight, and can promote the release of vapours containing PAHs from the infill.

This year (2019), RIVM, the National Institute for Public Health and the Environment of the Netherlands, released the results of an investigation done on the release of chemical substances (i.e., volatile organic compounds, aldehydes and PAHs) from a synthetic turf field during an exceptionally hot day in 2018, with temperatures of up to 37°C. The temperature of the rubber granulates achieved 70°C. The study concluded that even at very high temperatures, hardly any chemicals are released from a synthetic turf field with rubber granulate. The concentrations of the measured substances (incl. ECHA Annex XV - PAH) that the RIVM measured were so low that they are not expected to pose any health risk.

Q5: Then, is it safe to use sport installations that are built on rubber infill from ELT?

The presence of carcinogenic substances in rubber granulate made from old car tyres raised concerns that the use of this granulate as infill on synthetic turf pitches may directly affect the health of its users.

From the numerous studies that have been performed over the last decades to investigate whether there is indeed an elevated health risk from playing on pitches with this kind of infill, a review of available literature on these studies concluded that overall, there was no such risk (Cardno Chem Risk, 2013; Pronk *et al.*, 2018).

For example, a recent study by the National Institute for Public Health and the Environment (RIVM) from the Netherlands (Pronk *et al.*, 2018), analysed samples from 100 synthetic turf pitches on up to 79 substances (incl. ECHA Annex XV - PAH). Additionally, samples were also analysed for migration of PAHs, amongst other compounds, into sweat and the gastrointestinal track of users, and for evaporation of volatile substances into the air (e.g., at 60°C). The study concluded that, the presence of PAHs in the synthetic turf infill presents no appreciable health risk from playing sports on those pitches.

Therefore, it can be concluded that up to date, there is no evidence showing that the use of synthetic turf pitches presents a real health hazard for its users due to the presence of PAHs, and therefore, there is no reason to advise people against playing sports on such pitches.

Q6: What are the environmental benefits of ELT recycling and of the use of rubber granulates in synthetic turf?

The recycling of ELT brings substantial environmental and socio-economic benefits. Indeed, the biggest market share for recycled rubber from tyres, representing about 45% of the recycling routes in Europe, is the production of infill material for turfs (GHK, 2016).

As outlined by a report done by GHK and Bio-Intelligence Service for DG Environment of the European Commission, a single kilo of tyre recycling into rubber granulates used in synthetic turf fields or other end-use applications avoids the emission of 2.7 kilos eq. of CO_2, which represents net CO_2 savings of 270% (GHK, 2016). More specifically, compared to a cement kiln co-incineration route, the most realistic route for waste tyres in an event of a ban, recycling a kilo of tyres would save 1.1 kilos eq. of CO_2 (Niederberger *et al.*, 2013). More recently, a study based on life-cycle assessment (LCA), the global warming potential measured in terms of ton CO_2 equivalents per football field, is the lowest for artificial turf infill materials produced from recycled tyres (Styrene Butadiene Rubber - SBR) when compared to the other infill materials (Johansson, 2018). To give an order of magnitude, infill materials from SBR saves up to 30 times more CO_2 per football field than infill materials produced from thermoplastic elastomers (TPE) for a similar life span.

Q7: What can be further improved in order to establish realistic restrictions to the use of synthetic turfs in order to control the exposure of users to PAHs?

As outlined, the recycling of ELT brings substantial environmental (as stated in Q6) and socio-economic benefits. The increased availability and additional playing hours synthetic turf systems offered to the public represents a major positive effect on society's wellbeing. The additional playing hours, associated to the development of artificial pitches, promote many social impacts that directly improve many relevant aspects of the society regarding physical health, mental health, education and lifelong learning, active citizenship, crime reduction, and anti-social behaviour, amongst others, that can also be translated into an economic return.

Therefore, before a restriction in the use of synthetic fields is set up, and specially without having any trustable source of information that demonstrates that the use of those installations represent a hazard for human health; first, it is necessary to understand the impact of both: (1) gathering accurate information (i.e., harmonised methods for the sampling and testing of the material and the users) that describes the potential hazards for the users of the fields and, (2) the consequences of the closure of the European synthetic fields not only for society in general (i.e., promoting sports, social interactions, active citizenship, etc.) but also for the future of the tyre recycling industry and the environment (i.e., increase of CO_2 emissions, lack of credible alternative recycling routes, etc.).

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