Appendix 19
Environmental Plastics

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EPIC identified research priorities to improve our understanding of synthetic turf and its potential issues- Submitted to the Office of the Chief Scientist, NSW

On the request of the Office of the NSW Chief Scientist and Engineer, the Environmental Plastics Innovation Cluster (EPIC) at the University of Newcastle has identified research priorities to fully understand the potential risks associated with microplastics and chemical exposure from synthetic turf, including *in-situ* and *ex-situ* experiments in parallel:

- Immediate measures to capture 99% of the microplastics: Stormwater and surface water drain more than 10kgs per annum of fine microplastics <10um (from the confidential study completed by EPIC in 2022), therefore, by targeting these known sources, at least 99% of the potential spread of microplastics can be prevented immediately.
- Microplastics could also originate from other sources, such as road wear and abrasion of tyres. We must set up a standard protocol for extracting microplastics from stormwater that could accurately differentiate turf plastics from the other suspended materials.
- Treatment solutions for micro and nano plastics in waste and grey water- using advanced treatment technologies that extract more than filtration can.
- Transportation of the samples from the field to a laboratory can also increase the uncertainties of the result. EPIC has been receiving samples within the state and interstate in non-plastic containers; biofouling and rust formation occurred in a short period, affecting the analysis of fine-size microplastics (Bhagwat et al., 2021). and we have developed site-specific protocols to maintain quality assurance and quality control. EPIC developed a site-specific quality control protocol and an apid on-site analysis method quantifying microplastics in laundry water samples from NSW health linen facilities. This method is currently susceptible to high concentrations, and work is in progress for low engagement and various sample matrices.
- *In-situ* long-term weathering studies incorporating chemical mixtures and microbial interactions. Besides the consequences of microplastics and associated chemicals, the association of microbes with plastics has more significant environmental implications as microplastics may select for unique microbiome participating in environmentally essential functions; despite this, the functional potential of the microbiome associated with different types of plastics is understudied. We demonstrated that microplastic surfaces exhibit unique microbial profiles and niche partitioning among the substrates through whole-genome sequencing. In particular, the abundance of *Vibrio alginolyticus* and *Vibrio campbellii* suggested that microplastic pollution may pose a potential risk to the food chain(Bhagwat et al., 2021). We have also demonstrated that weathering underpins the sorption and desorption of chemicals in microplastics; mixed contaminants such as PAHs and metals may be released from some of the synthetic turf components, have higher toxicity and are highly bioavailable than those in isolation (Carbery et al., 2018; Idowu et al., 2019, Carbery et al., 2022-under review, Thavamani et al., 2012a&b).
- Seasonal and climate effects on the microplastics and chemical release. Unravelling exposures and uptake over different seasons may prove helpful in understanding the release patterns fully. Extreme climatic conditions in Australia and proven heat generation make it a solid case to develop a

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quantitative measure of the *in-situ* and *ex-situ* flux of microplastics and chemical mixtures due to the ageing and weathering of turf materials.

- Relative environmental and human health risk assessment studies to contextualise the potential risks from synthetic turf on sports players and nearby residents.
- Transparent consideration of potential alternatives. Based on overseas progress and trend, other manufactured granular infill materials include elastomer, polymer, or organic substances such as coconut fibre, cork, and ground walnut shells. These alternative materials may be used more commonly in the future.

Background context

Synthetic turf has changed considerably since its inception. Playing surface is a critical component of the athletic environment, playing a role in performance and athlete safety. Many synthetic turf fields consist of not only synthetic grass but also rubber granules that are used as infill. The material's environmental and human health effects in third-generation synthetic turf components have been the subject of much debate. Still, they are based on the minimal information available to date. The main concerns are the release of microplastics and any associated toxic chemicals.

Plastics contain multiple chemicals –intentionally or unintentionally inserted into plastic – including those used to convey specific properties such as colour, flexibility, strength, fire resistance and water repellency. These chemicals can be released into the environment and available to organisms (Menichini, 2011; Negev et al., 2022). Based on limited overseas studies, synthetic turf pitches may be one of the substantial sources of microplastics in the environment (European Chemical Agency Report, 2018; Reef Clean AUSMAP Rubber Crumb Report, 2021). Some of these chemicals may be degraded by microorganisms (Bhagwat et al., 2021), and qualitative and quantitative evidence on the risks are still unknown.

Weathering of plastic material and potential risks associated with synthetic and hybrid turf use

Weathering underpins the fate and behaviour of plastics in the environment. Much of the existing academic research on this topic is based on virgin characteristics of plastics, based on limited samples, which do not consider the ageing and weathering influence on microplastics and chemical release (Carbery et al., 2018).

Third-generation infill systems have been reported to have surface temperatures as high as 93°C (Jastifer et al., 2019). This is possible because the infill material has been shown to have very low heat flux, and most of the energy from the sun goes into heating the exposed pile fibres, which have low specific heat. Thus, the surface temperature is driven by the total amount of solar radiation. Such a high-temperature forms cracks and generates nano plastics (Carbery et al.,2022, Under review), and also, under extreme conditions, chemicals are transformed into toxic metabolites, which are highly bioavailable.

Existing studies do not incorporate fields with a range of ages, adjacent contaminant sources, geographic location, synthetic turf manufacturers, use patterns, etc. With the small sample size, we cannot distinguish the effects of field age or indoor/ outdoor facility on the microplastic emission and associated chemical flux.

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Turf architecture encourages more aeration and sunlight and water penetration, which could accelerate weathering; synthetic turf could act as an initial sink with the gradual release over time. From our involvement with two confidential studies on the safety of synthetic turf, synthetic turfs generally consist of different layers of filaments; rubber granulates and crushed; the top layer of artificial turf (monofilament and slit form) is made of straws with a mixture of material of polypropylene (PP), polyamide polyolefin, and polyurethane. Straws with a length of 3-6 cm are typically filled with sands and rubber granulates to make the straws stand up. Rubber granulates' materials depend on the surface's design, and the granulates' size varies from 0.8 mm to 3 mm. The fibres of modern systems have a pile height of 40 to 70 mm and have been made of polyethylene, nylon, or polypropylene. However, polyethylene fibres are the most popular currently. Some of these materials are not fully characterised, and these unknown components remain uncertainties in risk evaluations. Non-specific sampling and analytical methods are still needed to describe synthetic turf fields fully.

Capabilities of EPIC

The Environmental Plastics Innovation Cluster (EPIC) at the University of Newcastle has set up research programs that underscore the many unknowns and uncertainties surrounding current knowledge of plastic's health effects and pioneered plastic weathering research in 2015. We investigated the long-term weathering of plastics in various environments that may influence microplastics' transport, fate and toxicity. Using an advanced analytical approach, we demonstrate that ageing and weathering processes alter the surface morphology, surface chemistry, crystallinity, thermal stability, particle size and adsorption of chemical compounds to plastic surfaces over time, releasing plastic degradation products (Carbery et al., 2022, Nat Mat Deg, under review).

Determining the hazards posed by microplastics requires understanding their transformation due to weathering processes. Despite their perceived risks, limited information exists on synthetic turfs' weathering and associated risks. From the extrapolation of our *in-situ* weathering experiments, the plastic types used in synthetic turf could lose between 0.25 and 0.37 kg of rubber/m^2/year on average (more loss will be from the infill materials). Apart from stormwater and runoff, people's shoes and clothes could transport microplastics from the field.

EPIC has also set up an inventory of weathered plastics of all polymer types, aged at different time scales showing that plastic weathering influences its interactions with chemical and biological hazards such as pathogens (Bhagwat et al., 2021; Raju et al., 2018).

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