ACCSCIENCE PUBLISHING

Explora: Environment and Resource

REVIEW ARTICLE

Assessing environmental and sustainability impacts of intentionally used microplastics from recycled tires in third-generation pitches: A Great Britain case study

Andrew Watterson[1]*, Maria Llompart[2], and Jacob de Boer[3]

[1]Faculty of Health Sciences and Sport, University of Stirling, Stirling, United Kingdom

[2]CRETUS, Department of Analytical Chemistry, Nutrition and Bromatology, Faculty of Chemistry, Universidade de Santiago de Compostela, Santiago de Compostela, Galicia, Spain

[3]Amsterdam Institute for Life and Environment, Faculty of Science, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

Abstract

Crumb rubber from recycled tires is widely used in synthetic sports pitches despite environmental and health concerns. The study presents a case study that draws, first, on existing relevant scientific literature, though it does not constitute a systematic review. Second, it identifies the chemical composition of crumb rubber and examines its environmental and public health effects. These two strands inform the subsequent policy and regulatory analysis of the limited number of policy documents from Great Britain, along with a consultancy report, addressing crumb rubber and third-generation (3G) pitches. Research shows that crumb microplastics are present and, according to the European Union, they produce a range of negative (eco)toxic and physical effects on living organisms, and cannot be contained effectively. Crumb rubber, therefore, cannot be used sustainably within Europe's circular economy and zero-plastic-pollution policies. Available policy alternatives were briefly considered in relation to risk assessments, life-cycle analyses, industry economic interests, and governmental and sporting-body sustainability policies. Finally, an analysis was provided on how government bodies, local authorities, and sports organizations have started to interpret and implement the consultancy report. Great Britain's policies appear to be partly based on flawed, incomplete, and selective assessments of evidence, with asymmetrical risk assessments. Nevertheless, they closely align with and reflect many of the policies and practices adopted by international sports bodies concerning 3G pitch materials. Questions remain regarding how precautionary public health and sustainability policies for crumb rubber derived from used tires and other sources can be improved.

Keywords: Crumb rubber; Microplastics; Environment; Sustainability; Circular economy; Great Britain

***Corresponding author:**
Andrew Watterson
(aew1@stir.ac.uk)

Citation: Watterson A, Llompart M, de Boer J. Assessing environmental and sustainability impacts of intentionally used microplastics from recycled tires in third-generation pitches: A Great Britain case study. *Explora Environ Resour*. 2026;3(2):025520091.
doi: 10.36922/EER025520091

Received: December 22, 2025

Revised: January 28, 2026

Accepted: February 6, 2026

Published online: April 17, 2026

1. Introduction

Global interest in the environmental and health impacts of tire wear particles is increasing. The intentional use of recycled tires as crumb rubber on sports pitches began as early as 1990, with later use on playgrounds despite the migration of crumb particles into the environment and onto sports equipment and clothing. In 2023, the European Union (EU) announced a phased ban on the use of microplastic crumb rubber infill in third-generation (3G) fields, beginning in 2031.

This study presents a case study that draws, first, on relevant scientific literature, although it does not constitute a systematic review. Second, it examines the chemicals in crumb rubber and their environmental and public health effects. These two strands inform the subsequent policy and regulatory analysis of the limited number of policy documents and consultancy reports from Great Britain (GB; England, Wales, and Scotland) that address crumb rubber and 3G pitches. This analysis is relevant to the ongoing global debate on the sustainability of 3G pitches that use crumb microplastics, often derived from end-of-life rubber tires. Accordingly, several key national, European, and global policies on crumb rubber were highlighted and briefly reviewed. A more detailed review then follows of the only recent United Kingdom (UK) government-commissioned document examining available options for addressing microplastics, including crumb rubber and its socio-economic impacts. The extent to which these options reflect the latest scientific literature on the potential environmental, sustainability, and health impacts of crumb chemicals is explored.

Additionally, a brief analysis is presented on how government bodies, local authorities, and sports organizations in GB have started to interpret and apply the consultancy report. Most have chosen the option supporting the continued use of crumb rubber, which the EU has considered unsustainable and incompatible with its zero-plastics objectives.

Crumb rubber in GB, derived primarily from used tire particles, is used as infills on sports pitches, playgrounds, landscaping areas, equestrian arenas, and other facilities, as well as on footpaths and tarmac surfaces.[1] Crumb rubber has a long, though often overlooked, history. Internationally, between 1970 and 1996, five patents were issued for the use of crumb rubber in soil applications, rather than its more established use in tarmac and asphalt. By 1990, reports indicated that an average of 12,000 tires were used to treat a football field.[2] Figure 1 illustrates the typical structure of a 3G pitch.

2. Methodology

A case study methodology was used because it permits detailed exploration of a specific topic, provides key aspects of the relevant evidence base, and offers explanations for policy developments and barriers.[3] In this instance, the bounding of the study, due to the small number of available policy studies in GB and the existence of only one key consultancy report, makes a case study approach especially effective and manageable. Case study limitations include potential researcher bias and limited generalizability. The topic, however, is defined precisely because of the limited number of GB policy publications on it, which reduces potential bias in selecting policy sources and reports. In addition, generalizability issues are less applicable when only one government-funded consultancy report is currently available in the public domain. Published research on crumb chemicals, associated environmental effects, and public health impacts can therefore be used to evaluate the accuracy, relevance, and validity of policy reports. Such evidence also offers important contextual grounding for the case study.

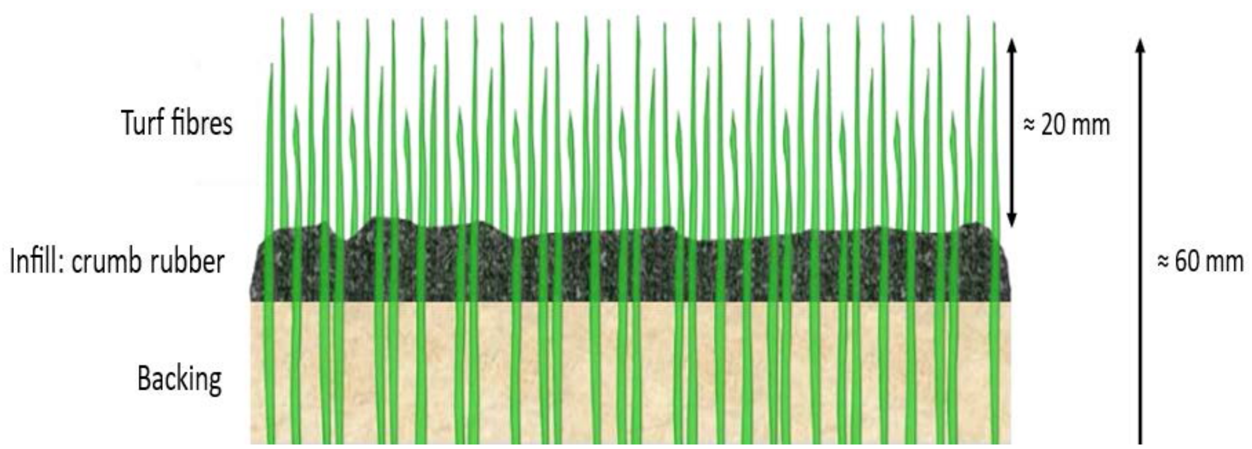

Figure 1. Components (layers) in synthetic turf sports pitches. Some standard dimensions are indicated in the picture. Image created by the authors.

3. Crumb rubber threats to the environment and human health

3.1. Crumb rubber chemicals

In the EU, action on microplastics—synthetic polymer particles below 5 mL that are organic, insoluble, and resist degradation—was included in the 2023 ban on crumb rubber, as it was the largest intentional source of microplastics in the environment. Table 1 lists the chemicals identified in studies of crumb rubber used on sports pitches and, in some cases, playground materials. These studies were mainly laboratory-based sampling investigations, with a small number of reviews. Specific chemical concentrations are not included in Table 1. Regulatory and guidance limits for crumb rubber differ across countries, reflecting varying health and environmental standards. These issues are beyond the scope of this study.

The UK's Department for Environment, Food, and Rural Affairs (DEFRA) reported in May 2025 that artificial sports pitches are a significant source of intentionally added microplastic pollution in the UK.[18] The environmental and public health impacts of crumb rubber occur throughout its

Table 1. A list of chemicals identified in crumb pitch and playground materials.

Substance class	Substances
16 EPA polycyclic aromatic hydrocarbons[4-7]	Naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]perylene, dibenzo[a,h]anthracene, benzo[g,h,i]perylene
Other polycyclic aromatic hydrocarbons[4,5,7]	Benzo[j]fluoranthene, benzo[e]pyrene, dibenzo[a,i]pyrene, dibenzo[a,h]pyrene
Plasticizers[7-9]	Bisphenol A; phthalates and adipates: dimethyl adipate, diethyl adipate, dimethyl phthalate, diethyl phthalate, diisobutyl phthalate, dibutyl phthalate, dimethoxyethyl phthalate, diisopentyl phthalate, dipentyl phthalate, benzylbutyl phthalate, diethylhexyl adipate, diisoheptyl phthalate, dicyclohexyl phthalate, di-2(ethylhexyl) phthalate, diphenyl phthalate, di-n-octyl phthalate, diisononyl phthalate, diisodecyl phthalate
Polychlorinated biphenyls (PCBs)[5]	PCB18, PCB28, PCB31, PCB33, PCB49, PCB52, PCB66, PCB70, PCB74, PCB91, PCB95, PCB99, PCB101, PCB110, PCB118, PCB128, PCB138, PCB141, PCB146, PCB149, PCB151, PCB153, PCB170, PCB174, PCB177, PCB180, PCB183, PCB187, PCB194, PCB196, PCB203
Chlorinated paraffins (CPs)[10]	Short-chain CPs, medium-chain CPs, long-chain CPs
Per- and polyfluoroalkyl substances[11]	Fluorotelomer alcohols
p-Phenylenediamine (PPD) antioxidants and transformation products[12-14]	6PPD, IPPD, 8PPD, 7PPD, 77PD, DPPD, DTPD, DNP, 6PPDQ, IPPDQ, 7PPDQ, DPPDQ, DTPDQ, 4-HDPA, 4-ADPA, 4s DPA, 4-NDPA, 1,3-DMBA
Other additives[4,7,11,14,15]	Vulcanizing and crosslinking agents: diphenyl guanidine, di-o-tolyl guanidine, hexamethoxymethyl melamine, 2-mercaptobenzothiazole, benzothiazole, N-cyclohexyl-2-benzothiazole sulfenamide, 4-tertbutylphenol, 2-hydroxybenzothiazole Antioxidants: butylhydroxyanisole, butylhydroxytoluene, 2,6-di-tert-butyl-p-cresol, 4-tert-octylphenol, 4-tert-butylphenol, 2,4-di-tert-butylphenol Organophosphate esters: triethyl phosphate, tris(2-chloroethyl) phosphate, triphenylphosphine oxide, tris(1-chloro-2-propyl) phosphate, tripropyl phosphate, tris(1,3-dichloro-2-propyl) phosphate, triphenyl phosphate, tri-n-butyl phosphate, diphenyl cresyl phosphate, tris(2-butoxyethyl) phosphate, bis(2-isopropylphenyl) phenyl phosphate, resorcinol bis(diphenyl phosphate), bis(4-isopropylphenyl) phenyl phosphate, tricresyl phosphate, 2-ethylhexyl diphenyl phosphate, butylated bis(4-isopropylphenyl) phenyl phosphate, isodecyl diphenyl phosphate, tris(2-isopropylphenyl) phosphate, tris(2-hydroxypropyl) phosphate, and tris(2-ethylhexyl) phosphate

(*cont'd...*)

Table 1. (*continued*)

Substance class	Substances
Metals, heavy metals, and metalloids[11,14-16]	Zinc, aluminium, iron, silicon, calcium, magnesium, potassium, sodium, cobalt, copper, manganese, titanium, barium, lead, chromium, arsenic, cadmium, strontium, boron, nickel, lithium, vanadium, antimony, selenium, molybdenum, bismuth, niobium, indium, uranium, beryllium, thallium, silver, and mercury
Volatile organic compounds[4,5,11]	Aniline, cyclohexane, methane, toluene, xylenes, benzene, methyl isobutyl ketone, cyclohexylamine, tert-butylamine, formaldehyde, cyclohexanone, styrene, 4-phenylcyclohexane
Polybrominated and polychlorinated substances[11]	Polychlorinated biphenyls, polybrominated diphenyl ethers

Abbreviation: EPA: Environmental Protection Agency.

life cycle—from processing, installation, and maintenance to removal and disposal—but relatively little research has examined the full life cycle or the exposure of workers engaged in these processes.[19-21]

3.2. Crumb rubber threats to health

Crumb rubber granules, often derived from shredded end-of-life tires, are a major source of intentionally added microplastic pollution across Europe, including GB, when used as infill in sports pitches and playgrounds. They are often considered a low-cost method of tire disposal and can be classified as a form of recycling. However, microplastics do not biodegrade and can persist in the environment for decades. They accumulate in oceans, freshwater, food, and drinking water, and exposure through ingestion or inhalation of microplastics and associated chemicals may have adverse effects on human health and ecosystems.

Crumb rubber infills contain hundreds of chemical agents with potentially adverse health effects, including carcinogenicity, mutagenicity, immunotoxicity, and reproductive and developmental effects.[21] Contaminants include polycyclic aromatic hydrocarbons (PAHs), heavy metals, per- and polyfluoroalkyl substances (PFASs), and antioxidants such as N-(1,3-dimethylbutyl)-N'-phenyl-*p*-phenylenediamine (6PPD).[11] Its transformation product, 6PPD–quinone, has been identified as the second most toxic chemical for aquatic life ever measured.[22] Both chemicals were recently detected in all crumb rubber samples tested from playgrounds and football pitches.[15] A 2019 literature review identified 306 constituents in crumb rubber, of which 197 met the a priori carcinogenicity criteria, and 52 were classified as known, suspect, or presumed carcinogens by the European Chemicals Agency (ECHA) and the United States (US) Environmental Protection Agency.[23]

The European Commission concluded in 2013 that articles should not be marketed to the general public if their rubber or plastic components, which come into direct or prolonged—or short-term repetitive—contact with human skin or the oral cavity under normal or reasonably foreseeable use, contain more than 1 mg/kg (0.0001% by weight of the component) of any listed PAHs.[24] Subsequently, the EU introduced a PAH restriction of 20 mg/kg for artificial turf infill granules, reflecting the potential for crumb rubber to release chemicals to field users and the surrounding environment. Crumb rubber chemicals can also leach into water,[13] and may produce a range of additional environmental effects.[25,26]

3.3. Crumb rubber threats to the environment

Norwegian researchers conducted a scoping review of the environmental impacts associated with chemical content loss from rubber granules and microplastics, using varied methods.[27] Most studies relied on field sampling, while three employed experimental methods. They identified numerous knowledge gaps regarding chemical losses but concluded that there are "substantial environmental consequences of using artificial turfs."[27(p10214)] Global analyses of crumb rubber from sports pitches have revealed exceedances of the 20 μg/g limit for the summation of eight ECHA-listed PAHs considered carcinogenic, along with other hazardous chemicals, such as 6PPD.[7,13,28,29] The largest study included samples from 17 countries across four continents, highlighting the global dimension of this problem.[7] Ultrasound-assisted extraction was used to isolate target compounds, followed by quantification by gas chromatography coupled to tandem mass spectrometry.

The Norwegian Environmental Agency in 2021, using field samples, reported artificial turfs represented a significant environmental issue in terms of waste, microplastic pollution, and leaching of chemicals.[30,31] Artificial turf is estimated to be the second-largest land-based source of microplastics released into the environment, despite recycling.[32] Italian researchers compared the environmental footprints of natural and artificial football pitches using the Product Environmental Footprint Approach, based on Life Cycle Assessment (LCA) methodology.[32] They concluded that improved recovery technologies are needed to make artificial turf "a really sustainable alternative to natural turf,"[32(p1)] and that natural turf also needs to adopt water- and energy-saving technologies. Environmental risks associated with the breakdown of nanoplastics from synthetic football fields have also been documented, including significant emissions measured in major cities.[33,34]

Estimates of 3G pitch crumb loss to the environment vary.[35,36] An average-sized pitch could need 1 to 5 tonnes of crumb each year as top-ups: 1–4% of the total crumb rubber on the pitch. Around 10% of the crumb is estimated to go into drains, and around 50% could be in soil and grass near pitches.[35-40]

In 2023, the UK pitch and playground installation trade body cited Scandinavian studies that first identified and measured infill loss from a pitch.[41,42] Such studies, based on estimates and observations, showed that up to 900 kg of infill could be lost from a pitch each year, with approximately 50% of this loss due to repeated clearances and to the disposal of snow containing infill during the Scandinavian winter months.

Specific chemicals may be used in the production of artificial grass. PFAS chemicals, bio-accumulative and persistent, are present in artificial grass and may be present in crumb rubber. PFAS can be added to artificial grass to shape the grass blades, prevent molten plastic from blocking machines, and improve ultraviolet protection for the grass and present blades, breaking.[39] PFAS was detected in 76% of the backing samples from artificial turf at 103 football fields in Stockholm.[39] These chemicals were detected in the crumb rubber used on various pitches and playgrounds. Some of their environmental and health effects are known. PFAS can leach into water supplies.[39] In the US, a town that upgraded an artificial turf field in 2021 found a two-fold increment in PFAS levels. Investigations showed that PFAS levels greatly exceeded the local groundwater PFAS limit of 20 ng/L.[40] US states, including Colorado, Massachusetts, California, and Connecticut, have already implemented bans on artificial turf containing PFAS.

4. Crumb rubber: National and international controls and impacts

The EU estimated that 95% of crumb rubber met current acceptable PAH levels. However, as many thousands of tonnes of crumb are being used on 3G pitches, significant quantities will still exceed EU levels. Industry claims top-ups of crumb rubber needed over a pitch's lifetime are extremely small, and figures have been improving each year. The UK Sports and Playgrounds Construction Association (SAPCA), a trade body, cites studies indicating that good field design, operation, and maintenance of artificial grass pitches can reduce infill migration by 98% from worst-case scenarios.[41,42] When thousands of tonnes of crumb are used annually, a 2% loss could still be highly polluting. SAPCA noted that up to 500 kg of infill in the UK could leave a full-sized pitch each year and enter the wider environment. Ground staff have reported examples of 3G pitches in GB where larger top-ups than those indicated above are required due to construction, siting, or maintenance issues.

Many "walk-through" visits to 3G pitches immediately reveal visible migration of crumb into the environment. Additional problems in GB and beyond have been reported with both artificial turf and crumb rubber dumped when pitches are disposed of and not "recycled" according to best practice.[14,41-45] Dumping of these materials, either through negligence or deliberate attempts to externalize economic and environmental costs away from producers and purchasers, undoubtedly occurs. Figure 2 illustrates the problem.

Studies also revealed other pathways where GB crumb infill migration could occur.[38] European and American research has highlighted microplastic pollution in the oceans from crumb rubber and artificial turf.[46-48] The Scottish government and the Scottish Environment Agency (SEPA) commissioned research to detect the presence of crumb rubber in marine litter and to propose measures to reduce pollution.[49-51]

Wider 3G pitch negative impacts are considerable.[52,53] A typical 60 m^2 artificial lawn may produce approximately 435 kg of CO_2, and hence significant carbon emissions from manufacturing. Only 8% of the environmental impact of artificial turf is due to maintenance. Renovation and disposal make up 45–48% and 20–23% of greenhouse gas emissions, respectively.

Major international health journals and the United Nations and WHO have begun to press for far greater action on plastics due to their dual threat to the environment and human health.[54,55] Continued use of crumb cannot meet society's present needs without compromising the ability of future generations to meet their needs.[54] Spreading microplastics around sports fields and playgrounds is therefore neither precautionary nor preventive, for environmental and public health reasons. There is little evidence of GB governments or sports bodies applying the precautionary principle when assessing the sustainability of crumb.[56]

Figure 2. Crumb rubber spreading from a Great Britain school's third-generation sports pitch to paths and nearby land. Photograph by the author (2024).

5. The sustainability case for removing exposures

5.1. Europe

The European Environment Agency observed in 2025 that:

> We are using resources faster than the planet can replenish them, creating pollution, destroying nature, driving climate change, and impacting people's health and well-being. A transition to a sustainable future will require a fundamental shift in production and consumption systems.[57(p1)]

Part of that transition globally will involve reducing microplastics, such as crumb rubber, in our environment, aligned with sensible zero-plastic objectives and a sustainable, effective circular-economy strategy.

The European Parliament defined the circular economy as: "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended."[58(p1)] The Lancet Commission on Global Pollution and Health also flagged the need for a stronger focus on hazardous chemical pollution.[59] Such a focus must now require greater scrutiny of materials. For example, recycled tires used as crumb rubber on sports pitches and playgrounds migrate into the wider environment, where skewed risk assessments have emerged.[60-62]

The EU's call for the phase-out of crumb rubber use on sports pitches under its microplastics policy specifically linked environmental, sustainability, and health factors as reasons for action. Other environmental concerns exist regarding microplastics from tire wear particles and chemical mixtures.[61,62]

5.2. Great Britain

Great Britain lags behind Europe in addressing the sustainability issues posed by microplastics. The UK parliament lacks specific legislation to develop a circular economy. Particular government departments, like GB's DEFRA in the past, did develop circular economy strategies.[63] In late 2025, a new circular economy strategy was announced, but not yet implemented, with chemicals and plastics as one of five priority areas for action.[63,64] England's Environment Agency attempted to review its Tire Derived Rubber Material Quality Protocol, which would undoubtedly have further informed policy on 3G pitches, as it aimed to draw on the latest available data and research. However, the whole process stalled because the industry trade body involved struggled to produce the required human health risk assessments. This suggests the official evidence base for some continued crumb uses may be inadequate.[18,63]

Scotland's Circular Economy (Scotland) Act in 2024[65] requires the government to prepare a circular economy strategy with objectives, means to deliver those objectives, and monitoring; however, sustainability is not mentioned.[66] The Scottish government, in practice, opted to defer to the UK government and delayed any effective action on the non-sustainability of crumb rubber on sports and playground surfaces.[43,44] Scotland also lacks a specific microplastics policy for crumb and artificial turf, and defers to the UK government's position on crumb.

6. Sustainable alternatives to artificial turf and crumb rubber 3G pitches that reduce chemical exposures

Non-synthetic alternatives to tire crumb rubber are available and sometimes used on pitches. These alternatives offer ecosystem benefits directly relevant to sustainability in ways crumb could not. Unlike artificial grass and crumb rubber, natural grass offers many environmental, direct public health, and biodiversity benefits.[53,67] Protecting outdoor green spaces improves human mental and physical health. Natural grass pitches may be treated with pesticides, but artificial grass surfaces may require pesticides to control grass and other plants growing beneath them.

Other benefits include improved soil health, quality, and stability. Natural grass increases oxygen production, whereas rubber and plastics do not. Extreme weather driven by climate change will lead to more flooding. Natural grass reduces stormwater runoff, unlike rubber and plastic surfaces, and could filter water to protect waterways and groundwater, and even recycle wastewater and biosolids. Natural grass also provides evaporative cooling, reduces sunlight glare to benefit humans, and provides habitat for vertebrates and invertebrates in depleted ecosystems, in ways that artificial playgrounds and 3G pitches cannot.[67] Since 2016, researchers have found that high temperatures due to climate change mean surface temperature on 3G crumb pitches is significantly higher than that on natural grass pitches.[68,69] In 2025, researchers again confirmed that natural grass, but not artificial grass, "was the recommended option when considering environmental sustainability, reduced chemical exposure, lower surface temperatures, and overall cost."[70(p1)]

Studies in 2024 compared the toxicity of crumb chemicals with alternative pitch and playground materials. They identified 11 emerging crumb pollutants, such as PPDs and vulcanizers, but infill alternative materials, including sand, coir/coconut fibers, and cork, were free of these pollutants.[14] In addition, the same authors investigated the metal/metalloid content and demonstrated the improved safety for the infill alternatives.[17]

In 2023, UK SAPCA provided information about alternative infills to crumb rubber available at that time.[42] These included vegetal (or organic) infills made from granulated cork, blends of granulated cork and coconut fiber, blends of granulated cork and olive stone husks, chipped timber, and crushed olive stone husks. SAPCA added, "many of these infills have been used in other European countries for a number of years, but experiences of them in the UK climate and on UK pitches, with their high levels of use, are still quite limited."[42(p9)] This raises the question of why the alternatives were not researched and trialed much earlier in GB, and why improved natural materials were not developed.

7. Microplastic producers' economic interest may influence sustainability and public health choices

Successive UK governments prioritized business interests over environmental protection. The costs and consequences of crumb rubber and artificial manufacture, use, and disposal have often been externalized by industry, with communities and the environment bearing economic and human costs. However, the rubber and plastics industries directly involved in producing materials for 3G pitches and playgrounds are relatively small in terms of the national economy, revenue generated, and number of employees.[70]

The UK artificial grass turf installation industry is even smaller than the tire and rubber recycling industry.[71] Industry analysts have noted the tensions between safety, the environment and growth for manufacturers and installers of artificial grass surfaces. Other commentators have noted that the industry's influence on sports policies have often gone unchallenged[72]

8. DEFRA and the DEFRA-commissioned report on microplastics

Successive UK governments have adopted deregulatory or "better regulation" policies that prioritize economic growth while downplaying environmental and sustainability.[1] The UK government continued to approve the use of crumb rubber on sports pitches from 2023 onwards, awaiting the DEFRA-commissioned Economics for the Environment Consultancy (EFTEC) report, completed with the UK Centre for Ecology and Hydrology. The report laid out risk management options for microplastics in crumb rubber, medical devices, sewage, detergents and maintenance products, oil and gas, and cosmetics.[73] The UK government, sports bodies, or local councils were not obliged to accept all or any of the crumb risk management options provided in the report.

8.1. The aims of the Economics for the Environment Consultancy report

The aims of the EFTEC report were specifically “to improve the understanding of the potential socio-economic, environmental, and human health impacts of intentionally added microplastics in the UK, and the implications of different policy actions that could control their emissionsto.”[74(p1)]

Crumb rubber was added to the UK government’s consultants’ brief as an afterthought, after work on the project had already begun. It is therefore perhaps not surprising that the EFTEC non-technical summary does not mention tires, recycled tires, or crumb rubber at all, indicating their low priority. The main EFTEC report mentions “tires” just three times. Firstly, it noted that a 2020 European risk assessment concluded there was no risk from the use of end-of-life tires in pitch infills, but the study had not measured and so could not assess PM_{10} and PM_{25} microplastics. Secondly, it noted the use of shredded end-of-life tires would be restricted in one of its risk management options to reduce microplastics. Thirdly, it noted another of its risk management options would allow its use.[74] The EFTEC report appendices mention “tires” only three times.

The report flagged various uncertainties and many data gaps and limitations that existed in the available evidence bases. These included limited or missing assessments of the human and environmental impacts from chemicals in microplastics and nanoplastics. The report did not produce a literature review, nor was it required to do so. It did highlight the important need for more research on ecotoxicology and a fuller understanding of the mechanisms of action of microplastics on page 147. From environmental pollution and sustainability perspectives, the research gaps in the report raise serious questions about the risk management options presented. The EFTEC report also appears to have relied heavily on industry data in some places and on a large number of industry stakeholders, which could be perceived as skewing the findings.

8.2. Risk management options in the Economics for the Environment Consultancy report

The key crumb rubber’s risk management options (RMOs) presented were to end crumb use and remove the material from pitches (RMO 1A–C) or contain crumb better on 3G pitches (RMO 2). RMO 2 has been favored by the UK government through improved containment measures.

The report emphasizes the need for behavioral change in pitch use and maintenance, as well as containment measures, under RMO 2. Behavioral change is always more challenging than removing exposure to environmental pollutants and ending emissions at the source. The control measures look overly optimistic in reducing emissions from sport surfaces by more than 90% in a lightly regulated, if not *de facto* deregulated, sector.

The EFTEC report lacks detailed public health and environmental costings in several places. It downplays non-synthetic pitch alternatives and ignores the shorter lifespan of synthetic pitches compared to natural grass pitches. It lacks a complete detail on crumb LCAs and underestimates the long-term costs of crumb rubber use relative to alternatives. Where the report does look at alternatives to crumb, it appears to have omitted some pertinent literature, some of which was discussed earlier in this paper.[1,27,52,53,67,69,75,76] These limitations all appear to have skewed the report in places. The neglected question in the report is “costs to whom?” when pollution is prevented or allowed. Nor is there discussion of how comprehensive those cost calculations are, given that many costs of continued use are externalized by manufacturers, suppliers, and installers and paid by communities, the wider environment, and the health service.

The report did identify crumb rubber in the UK as the primary source of intentionally added microplastics, a finding consistent with Canadian and EU research.[66] It further indicated that regulating intentionally added microplastics could prevent 72–100% of their emissions during 2024–2043. If the high figure of 98% containment of crumb rubber from 3G pitches, through improved engineering, drainage, and maintenance, is accepted, this would still result in pollution and sustainability problems. This is because many pitches required 12,000 tires for their initial construction. Hence, crumbs from the equivalent of 240 tires could enter the environment.[2] Furthermore, this does not account for the yearly top-ups with crumbs that such pitches require. Alternatively, ceasing to use crumb in pitches and playgrounds would immediately prevent new crumb pollution.

9. Discussion

United Kingdom policies, directly and indirectly, control pollution standards for environmental monitoring and the impacts of 3G pitch and playground crumb microplastic use. However, the UK inspection and regulation of crumb rubber manufacture, use, and disposal to protect workers, users, and the environment has been poor.[20] The EFTEC report was, as the sports construction industry pointed out, “the result of a collaboration between key stakeholders in response to questions and concerns regarding ‘Third Generation’ (3G) Artificial Grass Pitches.”[41(p1)] The organizations involved were Sport England, Sport Scotland, Sport Wales, the Grounds Management Association, the Football Foundation, the Football Association, Cymru Football Foundation, the Welsh Rugby Union, the Rugby Football League, SAPCA, and England Rugby. The statement does recognize "the difficulty in trying to balance the health and well-being benefits that come from the use of 3G pitches with environmental sustainability factors."[41] However, the focus remains on containment rather than on removing crumb rubber from 3G pitches.

National and international sports bodies, such as the International Federation of Association Football (FIFA) and World Rugby, greatly influence the choice of infill for sports pitches. They can determine which surfaces are acceptable in many sports through regulations, guidance, and certification.[77] FIFA's specifications for pitch approval in some settings seem geared toward allowing crumb and excluding sustainable alternatives. Hence, these bodies can have a stranglehold on the development and sale of new non-synthetic, lower-risk, sustainable, environmentally friendlier, less polluting infills or natural grass surfaces that fit easily within a circular economy.[6] The EFTEC report does not challenge FIFA guidance.

The EFTEC report does not identify a range of toxic compounds and metals now known to be present in crumb, which have already been researched and are cited in published articles.[7,17,23,29,33,54,78-83] In Europe, researchers found, in addition to regular PAHs, 21 other heterocyclic compounds in 10 crumb rubber soccer pitches in Amsterdam.[6] Researchers have highlighted the asymmetry between industry-generated negative studies on the adverse effects of chemicals accepted for use and those that produce positive results on the same chemicals. For the latter studies, higher burdens of proof were required, and rejection of findings more often occurred.[84,85] The EFTEC report appears to have failed to reference several critical studies showing crumb rubber's adverse effects on humans and the environment. There is just one reference to the impact of crumb on the immune system (on page 47) and none to immunotoxicity. There are no references at all to reproductive effects in the main body of the report, and just one reference each to the fetus and the placenta. There are no references to potential developmental effects in humans, and just one reference to the neurological impacts in the environment.

The EFTEC report has almost no coverage on crumb rubber LCAs and major circular economy targets. The UN Treaty on Pollution, which seeks to address the full life cycle of plastic, is mentioned briefly (on page 75). There is no specific mention of the disposal of 3G pitch crumb rubber, which is currently problematic and sometimes illegal despite recycling possibilities. This again raises regulation, inspection, and enforcement issues. The only references to disposal in the document are to sewage and sludge. If a full crumb LCA is missing, crumb costs and environmental and pollution impacts are minimized, and the dumping shown in Figure 3 can be overlooked.

Figure 3. Dumping of third-generation crumb rubber pitches in England. Photograph by the authors (2025).

Moreover, EFTEC underplays the societal costs of crumb microplastics versus alternatives. Assessing the short-, middle-, and long-term social and economic costs and consequences of using crumb is difficult. The report, however, has no detailed discussion of how benefits to society are ascertained or will be acted upon, nor have society's views been established anywhere in the report. Society is subordinated to the economic requirements of governments, sports clubs, professional sports bodies, and industry, but not to users, players, parents, and communities affected by 3G pitches and crumb dispersal. Nevertheless the report was commissioned and designed to assess if microplastic removal costs were likely to be acceptable to society.[18,74] The report provides minimal reference to public health. In this context, the report's stakeholder selection has been criticized for its heavy reliance on crumb rubber and associated industries and not on community and player interests.[86]

The EFTEC report's non-technical summary provides a snapshot of the project's focus on options for the sustainable use of crumb rubber. Again, there is no mention of the three critical elements—circular economy, sustainability, and the precautionary principle—in the summary that merit consideration. Sports bodies such as Sports England and the Wesh Football Foundation effectively downplay these elements and support the continued use of crumb rubber, as they have done over several years.[87-90]

Within Europe, ECHA evidenced multiple problems with crumb rubber infill from environmental, sustainability, and public health perspectives. In the 2010s, ECHA highlighted risks and broader concerns, for example, regarding PFAS exposures and deficient chemical safety data sheets.[91-93] The list of potentially hazardous chemicals found in 3G pitches that may damage the environment and public health (Table 1), based on recent research, is substantial.[4-16,94,95] It indicates the importance of precautionary policy-making and stronger regulation. Hence, the European Commission in 2023, unlike GB governments, produced measures to protect the environment through restricting intentionally added microplastics, including crumb rubber in 3G pitches.[96] This is against the backdrop of evidence that microplastics are pervasive, for example, in agricultural soils, with levels ranging from 1 to 80,000 particles/kg, although a lack of standardized methods hampers cross-study comparisons and global evaluation.[97] At the same time, there is also a global lack of knowledge and experience in microplastic removal.[98]

10. Conclusion

The English, Welsh, and Scottish governments do not accept the EU position that crumb rubber cannot be used sustainably within circular-economy and zero-plastic-pollution policies. Instead, they support continued use based on a crumb containment option recently proposed in an English consultancy report.

The EFTEC report and the risk management options chosen so far by the three GB governments, as outlined in the report, are problematic in places. They do not always look adequately evidence-based. There are, therefore, significant limitations and data gaps underpinning GB policy decisions regarding crumb rubber and its chemicals. These limitations also apply to crumb rubber policies for sports pitches adopted by international sports bodies such as FIFA and World Rugby. They are built into their policies, which support investment in and use of 3G pitches. In May 2025, after the EFTEC report was released, industry sources were clear that the UK government would continue to permit the use of crumb rubber infill on and in 3G pitches. Sports bodies supported the containment risk management option in the EFTC report rather than the EU phased ban on crumb in 3G pitches. The GB government responses illustrate the "do not look or ask, so do not find so, no problem" line of risk assessment and risk management. If all the interlinked health, environmental, climate, and sustainability risk factors created downstream by these crumb rubber microplastics on sports pitches and playgrounds are considered, then the GB governments would be wise to adopt comprehensive evidence-based sustainability policies underpinned by precautionary principles and accurate data, and cease new uses.

Acknowledgments

None.

Funding

None.

Conflict of interest

The authors declare no conflicts of interest.

Author contributions

Conceptualization: All authors
Visualization: Andrew Watterson, Maria Llompart
Writing–original draft: Andrew Watterson
Writing–review & editing: All authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Not applicable

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