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Missing the goal: Comments on a comparative life cycle assessment of natural and artificial football turf

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Dear Editor,

Environmental impacts of football (soccer) turfs have received notable attention in the scientific literature in recent years, particularly regarding the comparison between natural turf (NT) consisting of grass on soil and artificial turf (AT) made mainly from synthetic materials. The discussion involves aspects such as irrigation and herbicide use on NT, carbon capture in NT, the fossil origin and climate impact of AT, waste treatment of AT, and the release of microplastic and chemicals from AT (Bø et al., 2024; Cheng et al., 2014). To holistically assess these aspects, life cycle assessment (LCA) has been applied in several studies. Itten et al. (2020) compared NT and AT for the city of Zurich, Switzerland, including the construction, maintenance, renovation, dismantling and disposal of the turf. Russo et al. (2022) also compared NT and AT in a life-cycle perspective but for Italian conditions, applying the European Product Environmental Footprint (PEF) approach. Zeilerbauer et al. (2024) performed an LCA based on the data from Itten et al. (2020) but added microplastic release and physical impacts on biota. Falsafi et al. (2025) analysed the end-of-life phase of AT under different scenarios, including incineration and recycling in Finland and Denmark. These studies highlight several challenges in LCA of turfs, including capturing the use capacity of turfs, assessing the impacts of microplastic release from AT, modelling the potential use of recycled and reused materials in AT production, and modelling the subsequent end of life of AT.

In this comment, we focus on a recent article in *Cleaner Environmental Systems* by Säberg et al. (2025). They performed an LCA comparing NT and AT for Swedish conditions. Their main conclusion is that "[NT] exhibited the highest overall environmental impacts", mainly because of negative impacts (credits) from energy generated during incineration of the AT's fibres, backing and shock pad. We welcome efforts to apply LCA to contribute to the discussion on the comparison between NT and AT in Sweden. However, an LCA is only as good as its underlying modelling, assumptions, and data. We have identified nine debatable modelling choices in the LCA by Säberg et al. (2025), some of which relate to the challenges highlighted in the previous literature cited above. These nine modelling choices are detailed below, along with their potential influence on the result.

First, the functional unit in Säberg et al. (2025) is 1 m^2 of turf area. Similarly, Russo et al. (2022) and Falsafi et al. (2025) applied a surface-based functional unit of 7140 m^2. The Product Environment Footprint Category Rules (PEFCR) for synthetic turf also recommends 1 m^2 as functional unit, although it explicitly states that the PEFCR does not cover NT (ESTC, 2024), meaning that it is not necessarily a relevant functional unit for comparing NT and AT. A surface-based functional unit misses out on the different use capacities of NT and AT. Säberg et al. (2025) assume that both turfs are used between April and October, i.e., during late spring, summer and early autumn in Sweden. This might be a reasonable assumption for NT, although it depends on the latitude. But AT can be shovelled from snowfall during winter and is in some places used all year around. Also, more intensive usage of AT compared to NT is possible, meaning more football trainings and matches per day (although this influences the AT's lifetime – see further below). Overall, AT has higher use capacity in terms of hours per year, approximately a factor of 10 depending on latitude. A functional unit that considers use capacity would have allowed for a more relevant comparison between NT and AT. Indeed, the definition of relevant and comparable functional units is strongly emphasized in LCA guidelines (ISO, 2006a, 2006b). An example of a functional unit that captures differences in use capacity is considered by Itten et al. (2020) and Zeilerbauer et al. (2024): 1 h of turf use. Considering the higher use capacity of AT, a use capacity-based functional unit could potentially alter results by a factor of 10.

Second, different football fields have differently intensive

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maintenance depending on the type of field (elite *versus* community/amateur) and location (e.g., latitude). For example, non-elite NTs are, to the best of our understanding, normally not irrigated 3 times per week, as assumed in Säberg et al. (2025), especially not in places with much rain. Clarifying the type of the field would have facilitated the interpretation of the LCA study's results. According to Säberg et al. (2025), maintenance contributes from approximately 40% to >90% of the impacts of NT depending on impact category and turf lifetime, which could be notably reduced given less intensive maintenance, e.g., at non-elite NTs.

Third, the assumed baseline lifetime of 10 years in Säberg et al. (2025) is, to the best of our understanding, at the higher end for AT. In Gothenburg, 5-10 years is considered common practice for AT, depending on the intensity of use. The additional lifetimes of 20 and 30 years applied in Säberg et al. (2025) are notably high for AT. Given intensive use, a shorter lifetime than 10 years would have seemed more reasonable, such as the 8 years recommended in the PEFCR for synthetic turf (ESTC, 2024). Different scenarios for high and low intensive use of AT would have been relevant to consider and relate to the lifetime. NT, on the other hand, can last 30 years or more, as applied by Itten et al. (2020). Comparing AT with a lifetime of 8 years to NT with a lifetime of 30 years would reduce construction impacts of NT by more than a factor of three compared to AT.

Forth, the turfs are described as modelled “in a Swedish context” in Säberg et al. (2025), which implies a Swedish geographical scope. However, data was mainly obtained from one single city (Sundsvall) located in the geographical centre of Sweden. Data from a broader range of locations, or average Swedish data, would have been needed to claim a Swedish geographical scope. Most football fields are located in the south of Sweden, where most people live and the largest cities are located. The football fields in Sundsvall thus poorly represent average Swedish football fields in terms of climate. Climate, in turn, affects maintenance activities such as irrigation of NT and ploughing of AT, and in particular the use capacity of NT, thus influencing the results in several ways.

Fifth, microplastic release has been at the core of the environmental debate about AT, and as pointed out in the LCA study, several studies have been devoted to this topic. Concerns about microplastic include impacts from leached chemicals but also from the plastic particles themselves (Bø et al., 2024; Cheng et al., 2014; Hua et al., 2024). It is mentioned in Säberg et al. (2025) that freshwater and terrestrial ecotoxicity impacts are included to assess the effect of microplastic, whereas chemicals leaching from the microplastics were omitted. However, there are no reports of the magnitude of microplastic release to be found in the LCA study, nor of which characterization factors were used to assess the toxicity impacts of such release. Thus, it remains unclear whether and how microplastic release was considered in the study. Zeilerbauer et al. (2024) included microplastic release, and found comparatively low ecosystem impacts in a life-cycle perspective, but only considered physical impacts on biota from the microparticles, not toxic impacts from microparticles or leached chemicals.

Sixth, Säberg et al. (2025) appear to exclude risk mitigation measures typically required to limit microplastic emissions from ATs. In Sweden, AT facilities where rubber granulates (such as SBR) may disperse into the environment are considered environmentally hazardous activities under the Environmental Code (Sw. *Miljöbalken*). Operators are therefore required to implement risk mitigation measures such as those outlined in the European technical guidance CEN/TR 17519:2020 (Swedish Institute for Standards, 2020), including for example the installation of perimeter barriers, containment zones, drainage traps, filtration systems, entrance cleaning infrastructure, and maintenance procedures aimed at minimizing microplastic dispersion. Omitting such measures risks representing an idealized system rather than a regulatory-compliant AT installation. Since equivalent measures are not required for NT, this exclusion may bias the comparison, although the exact impact of such exclusions is difficult to estimate without detailed studies.

Seventh, Säberg et al. (2025) do not seem to account for near-term regulatory requirements or technological innovations. The European Union has prohibited the purchasing of plastic such as SBR for turfs, mainly due to microplastic release, starting from 2031 (Commission Regulation [EU] 2023/2055, 2023). This means that ATs containing SBR will likely not be a viable option in the near future. While it is understandable that an LCA might wish to inform regulation rather than adapt to it, it would seem relevant to also include scenarios compliant with likely near-future regulatory requirements. For example, it would have been relevant to also include novel types of turf materials not under the same regulatory scrutiny, such as biodegradable plastic, cork, coconut, and non-infill. Due to their inherently different compositions, such turf materials might exhibit notably different environmental impacts compared to both NT and AT.

Eighth, the end-of-life modelling in Säberg et al. (2025) appears to be favourable to the AT in several ways, as summarized in Fig. 1. 100% reuse of sand and styrene butadiene rubber (SBR) is assumed in the main scenario, making them free of burden. However, to the best of our understanding, reuse of SBR and sand is not always done in practice. Also, as shown in the sensitivity analysis of the LCA study, changing to newly produced SBR has a considerable influence on the results. The SBR is then assumed to be produced from recycled tires, with only tire collection, cutting, granulation, and transport to the AT included, but no impacts from the tire production and use. This implies a cut-off modelling of the recycled tires (Ekvall et al., 2020). In other approaches to modelling recycling, such as the Circular Footprint Formula applied by Russo et al. (2022), some of the impacts of the tire production and use would be allocated to the SBR and its use in the AT. Thus, both the reused (main scenario) and recycled (sensitivity analysis) SBR scenarios have relatively low impacts due to modelling choices in the LCA study. Furthermore, the incineration of the fibres, backing and shock pad is assumed to generate energy that can substitute other energy generation, leading to a large credit, without which the AT would have higher impacts than the NT according to the LCA study. However, the modelling of this substitution is not clear. It is described only as “energy recovery”, but no description of what the recovered energy substitutes is provided. Clarifying what is substituted would have improved the transparency of the LCA considerably, and different scenarios would have been relevant to consider in light of the strong influence this substitution has on the results. Considering that the incineration of fossil waste plastic has high climate impact, it would seem likely that some sort of environmentally malign energy must have been substituted to yield negative climate impact. For example, substituting average Swedish electricity (mainly hydro, wind and nuclear) or similar low-carbon energy with burning of fossil plastic would likely not yield negative climate impact. Without these beneficial assumptions for end of life, the AT would have lower impacts than the NT, according to Säberg et al. (2025): “[W]ithout recycling, [AT] would represent the highest environmental burden among the evaluated alternatives.”

Nineth, diesel-driven tractors are considered for NT maintenance in the main scenario in Säberg et al. (2025), while electric lawn moaners are considered in one scenario of the sensitivity analysis. We acknowledge that there is currently a mix of these two modes of maintenance in Sweden. However, electrification is ongoing in many societies and is particularly prominent in the Nordic countries. For example, the city of Gothenburg is investing heavily in electric machines and currently has approximately 70% electric vehicles in its maintenance fleet. We thus suggest that considering electric lawn moaners for NT would have been a more relevant main scenario for a study aiming at capturing the current and near-future situation. The sensitivity analysis results from Säberg et al. (2025) suggest this would lead to an impact reduction of approximately 10-20% for NT depending on impact category.

Considering these debatable modelling assumptions, we believe that the LCA study by Säberg et al. (2025) misses the stated goal of conducting “a comprehensive cradle-to-grave life cycle assessment (LCA) of

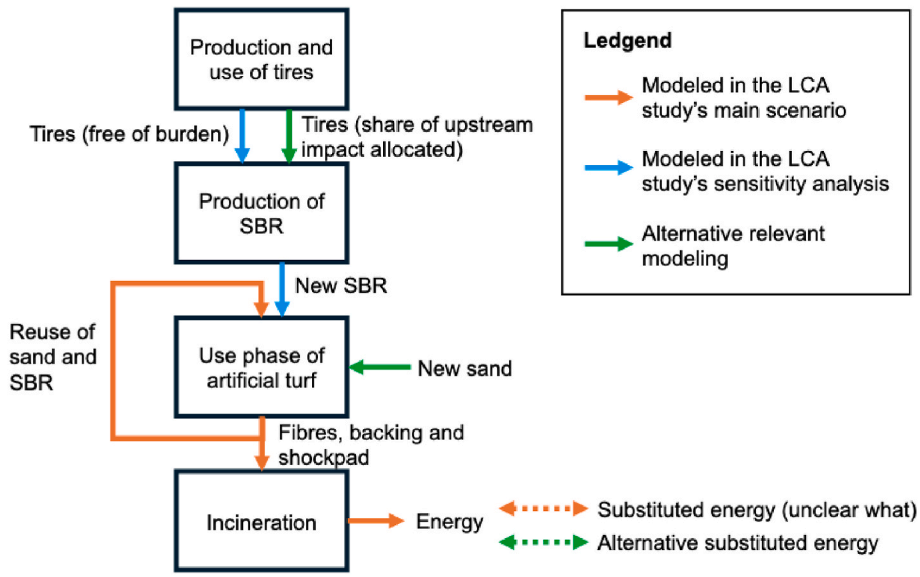

Fig. 1. Our understanding of the end-of-life modelling in the LCA study by Säberg et al. (2025) (orange and blue arrows), and alternative relevant modelling (green arrows). SBR = styrene butadiene rubber.

artificial and natural football turfs, encompassing the construction, use, maintenance and end-of-life phases over operational lifespans of 10, 20 and 30 years". Of these debatable modelling choices, most seem to favour the AT, which the authors suggest has lowest impacts. However, applying a functional unit that does not consider use capacity probably rather favours the NT. Since the modelling choices point in different directions, it is not obvious what the outcome of the assessment would be if they were altered. We therefore recommend additional LCA studies comparing AT, NT, and other turf options to provide relevant environmental guidance in this area, preferably in collaboration with a broader range of actors involved in planning, procuring, building, maintaining, and using turfs.

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Rickard Arvidsson: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft. **Malin Hjalmarsson Maxvall:** Conceptualization, Formal analysis, Investigation, Project administration, Writing – review & editing. **Martina Persson:** Conceptualization, Formal analysis, Investigation, Project administration, Writing – review & editing. **Pernilla Holgersson:** Conceptualization, Formal analysis, Investigation, Writing – review & editing. **Johanna Berlin:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare no competing interests.

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Data availability

No data was used for the research described in the article.

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