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# Life Cycle Assessment of Artificial and Natural Turf Sports Fields – Executive Summary

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# INTRODUCTION AND METHOD

Football is among the most popular sports globally. All that is needed for a football match is players, a ball and a sports field. However, the latter is not simply grass, but rather a precisely defined and constructed structure, which can be made of natural, hybrid or artificial turf. It is the aim of the city of Zurich to reduce both the primary energy consumption and the greenhouse gas emissions that are produced by each resident. In order to analyse and compare the environmental impact of different types of turf sports fields, Grün Stadt Zürich commissioned the Zurich University of Applied Sciences to carry out a Life Cycle Assessment (LCA) study.

In cooperation with the sports field experts who build and maintain the sports fields in the city of Zurich, primary data for the entire life cycle of the turf sports fields was collected. Based on this data, life cycle inventories were compiled for two sports fields using natural turf, two using artificial turf, and one using hybrid turf, covering all life cycle phases as summarised in Tab. S.1.

**Tab. S.1 Overview of different types of natural and artificial turf sports fields under study**

| Type | Description |
|---|---|
| Natural turf, no drainage | Natural turf without drainage layer |
| Natural turf, drainage | Natural turf with drainage layer according to DIN |
| Hybrid turf, reinforced | Hybrid turf using natural turf reinforced with plastic fibres |
| Artificial turf, unfilled | Artificial turf without infill made of plastic or other granulate |
| Artificial turf, filled | Artificial turf filled with granulate made of primary plastics |

The Life Cycle Inventory model includes the production and construction of the turf sports fields, as well as maintenance, renovation, dismantling and disposal. The LCA study does not include indirect environmental impacts caused by the users of the turf sports fields, such as during travel to and from the site or through the required sports clothing or nutrition. The data that was used for this study was derived from input data from the city of Zurich. The results, therefore, only have limited transferability to other geographical regions.

The functional unit of this study is defined as one hour of use of the respective artificial and natural sports field in the city of Zurich. Artificial turf fields can be used more intensively than natural turfs, which results in a higher number of annual usage hours. The consideration of different annual usage hours allows for a fair comparison of the different types of turf.

The study is largely based on the requirements of ISO 14040 / 14044 (ISO, 2006a; ISO, 2006b; ISO, 2017). The study was also subjected to a critical review in parallel with the study according to ISO 14040 / 14044 (ISO, 2006a; ISO, 2006b; ISO, 2017) by a committee of three independent experts:

This executive summary is derived from the full report from Itten et al. (2020). The full report on the study is available in German at https://doi.org/10.21256/zhaw-20774.

# ENVIRONMENTAL IMPACT PER HOUR OF FOOTBALL

The LCA includes a selection of the indicators recommended by the Joint Research Council of the European Commission for the Organisational and Product Environmental Footprint (Fazio et al., 2018) shown in Fig. S.1. Based on the theoretical maximum hours of use, which differs according to the type of turf, the unfilled artificial turf sports field has the lowest environmental impact of all the indicators examined, except for greenhouse gas emissions and primary energy demand over the entire life cycle. For the other turf sports field types, the results differ, depending on the environmental impacts studied.

In the case of the natural turf sports fields, the construction and operation life cycle stages alone cause more than 80 % of the environmental impacts for all of the indicators analysed shown in Fig. S.1. During operation, the environmental impact of natural and hybrid turf is significantly higher compared to artificial turf, especially for eutrophication, since the production of the required mineral fertiliser is energy-intensive and the emissions that result from its application have eutrophying effects.

The environmental impacts of artificial turf sports fields are driven by the construction and renovation life cycle stages, which account for more than 65 % of the environmental impacts for all indicators shown in Fig. S.1. The renovation stage has higher impacts for artificial turf sports fields compared to natural turf sports fields, due to the additional material required to replace the artificial turf layer.

The filled artificial turf sports field has the highest environmental impacts per hour of use for greenhouse gas emissions, freshwater eutrophication, mineral resource use as well as total primary energy demand and non-renewable primary energy demand, mainly due to the required filling material. The replacement as well as the disposal of the filling material causes additional impacts for the filled artificial turf sports fields in the renovation and operation life cycle stages. Furthermore, the filled artificial turf sports field causes microplastic emissions due to the discharge of filling material. There is no established methodology to account for the environmental impacts caused by microplastic emissions recommended by the Joint Research Council of the European Commission for the Organisational and Product Environmental Footprint (Fazio et al., 2018). Therefore, the microplastic emissions are not represented in Fig. S.1. The environmental impacts of microplastic emissions are discussed in a separate chapter in the full report for the study in German (Itten et al., 2020).

Accordingly, an unfilled artificial turf sports field is always the preferable option with lower environmental impacts compared to a filled artificial turf sports field for all the indicators analysed in this study.

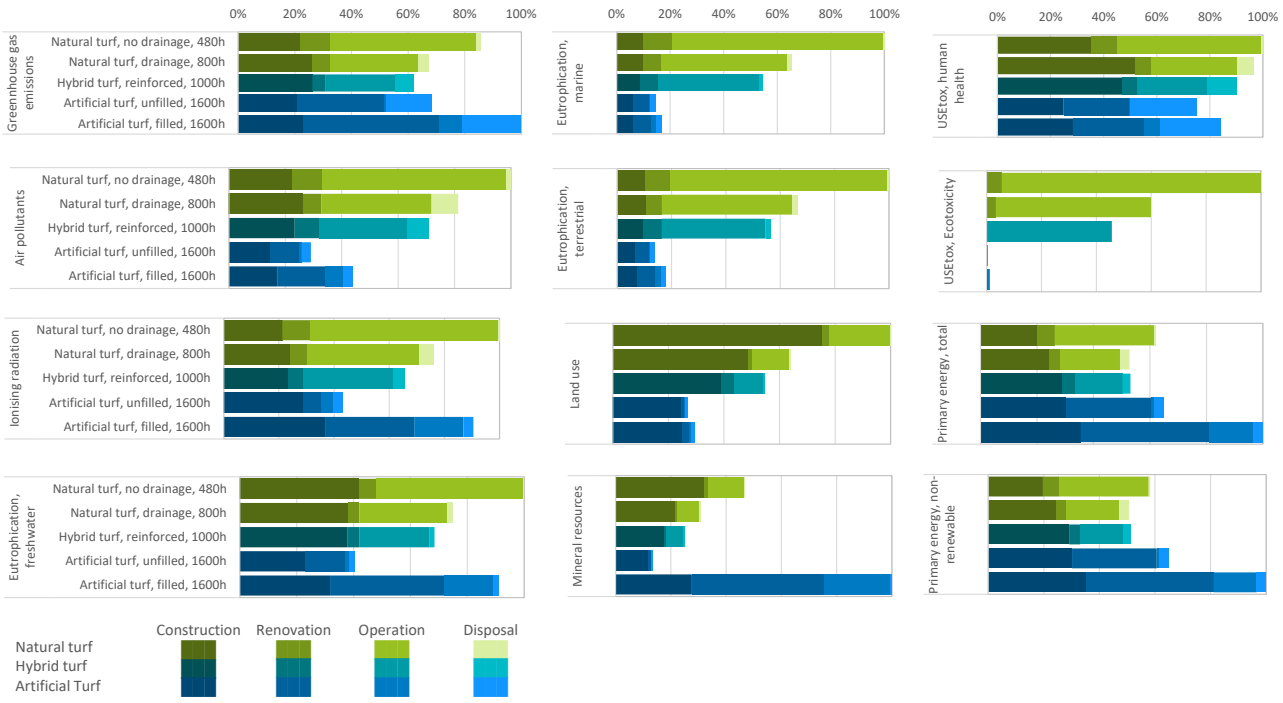


**Fig. S.1:** **Environmental impacts of the different turf sports fields per theoretical hour of use for the different midpoint categories according to the recommendations from Product Environmental Footprint by Fazio et al. (2018), greenhouse gas emissions by IPCC (2013), primary energy demand by Frischknecht et al. (2007), and human and eco-toxicity by USETox (Rosenbaum et al., 2011) divided into the contributions of construction, renovation, operation and disposal. The theoretical number of hours of use is 480 and 800 hours for natural turf without and with drainage layer construction, and 1,000 and 1,600 hours for hybrid and artificial turf sports fields, respectively.**

In addition to the midpoint indicators in Fig. S.1, the aggregated total environmental impacts according to the Ecological Scarcity Method according to Frischknecht et al. (2013) are shown in Fig. S.2. The comparison per hour of use considers the environmental impacts caused by the construction, operation and disposal of the sports fields as well as the annual usage hours. The results also show the differences between the theoretically possible and the actual annual usage hours accounted for in the city of Zurich.

The high result for hybrid turf in Fig. S.2 is subject to uncertainty, since for this type of turf usage data from only one hybrid turf sports field was available. The differences between natural turf and artificial turf are more robust. For both the theoretical and the effective annual usage hours, the unfilled artificial turf has the lowest environmental impact per hour of use.

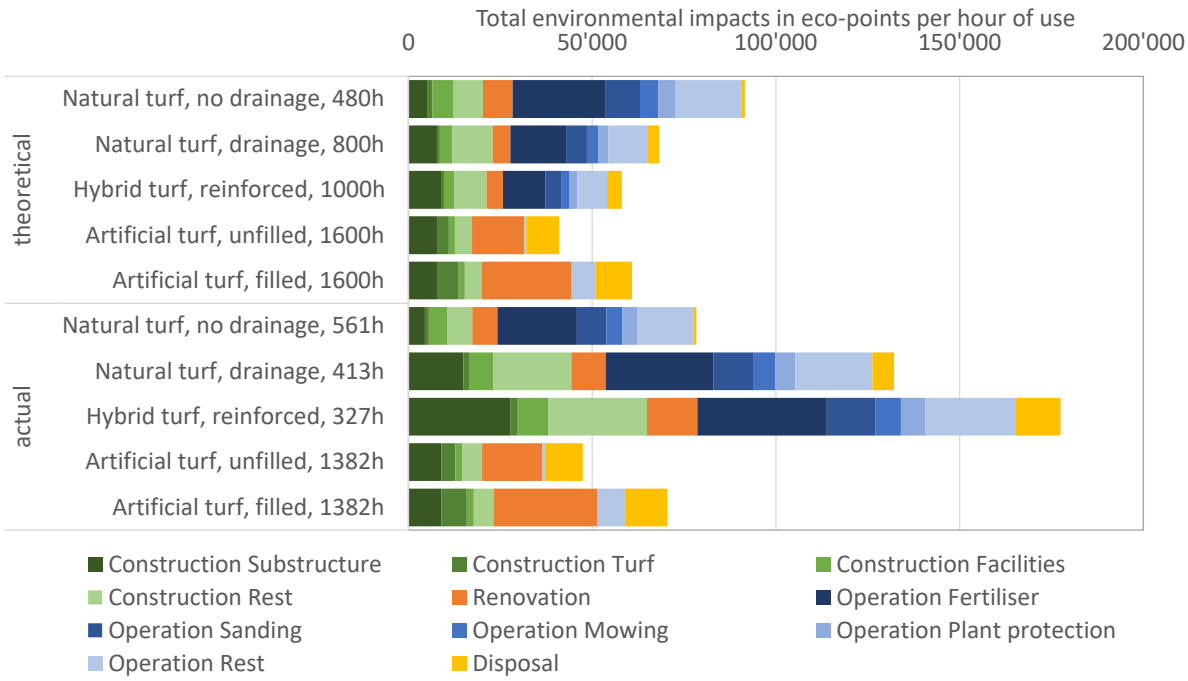


**Fig. S.2:** **Total environmental impacts of the different turf sports fields per theoretical and actual hour of use according to the ecological scarcity method (Frischknecht et al., 2013) divided into the 11 most important contributions from construction, renovation, operation and disposal.**

The annual usage hours have a major influence on the environmental impacts of sports turf, particularly because different types of turf for sports fields allow for different maximum annual usage hours. If the number of annual usage hours is identical, the natural turf without drainage causes the lowest total environmental impacts and the filled artificial turf causes the highest total environmental impacts according to the Ecological Scarcity Method 2013. However, since natural and hybrid turf allows for fewer hours of use, on average an artificial turf causes lower greenhouse gas emissions and a lower total environmental impacts per hour of use according to the Ecological Scarcity Method than a natural or hybrid turf. A natural turf with a drainage layer construction, which is played on for 800 hours per year, causes approximately the same amount of greenhouse gas emissions per hour of use as an unfilled artificial turf, which is played on for 1,600 hours. However, if an unfilled artificial turf is only used for 800 hours per year, it causes significantly more greenhouse gas emissions per hour of use than a natural grass turf with a drainage layer or a hybrid turf. Fig. S.3 shows the greenhouse gas emissions per hour of use for the different types of turf under study depending on the total annual usage hours.

The most important factor for the environmental impact is the annual usage hours. Artificial and hybrid turf can be played on for much longer per year than natural grass. At optimal capacity utilisation, artificial turf sports fields have significantly lower environmental impacts per hour of use.

However, the annual usage time not only depends on the turf type, but also on other factors like the existing infrastructure for lighting that allows for longer daily usage of the sports fields.

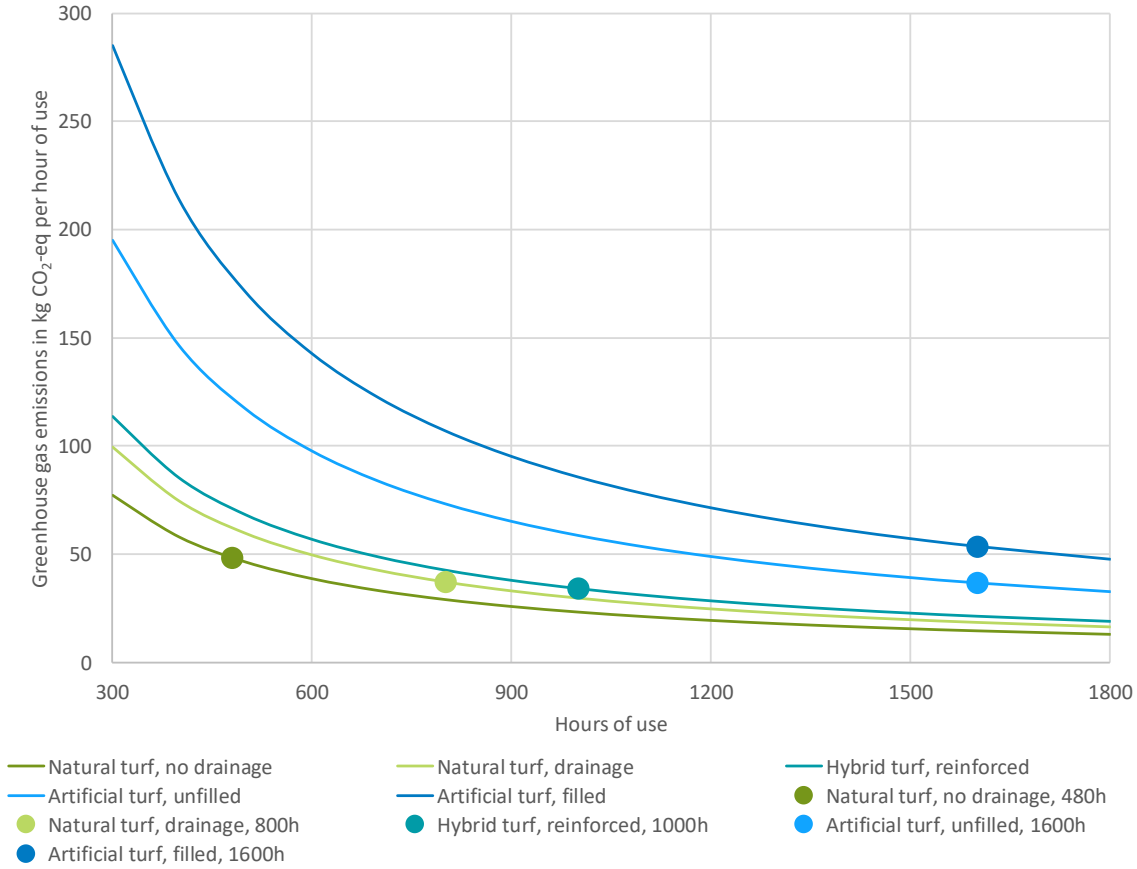


**Fig. S.3:** **Greenhouse gas emissions in kg CO2-eq according to IPCC (2013) per hour of use depending on the total hours of use per year visualised for the natural, hybrid and artificial turf sports fields under study; data points indicate the theoretical hours of use.**

## REDUCTION POTENTIALS FOR THE FOOTPRINT OF FOOTBALL

The environmental impact of artificial and natural turf sports fields can be effectively reduced by optimising the annual usage hours of the existing fields. The optimisation of the annual usage hours also efficiently reduces the pressure for the construction of additional sports fields. In general, intensively used pitches have significantly lower environmental impacts per hour of use than extensively used pitches. The data on annual usage hours suggests that the use of the existing turf sports infrastructure in the city of Zurich is not fully optimised. Therefore, before new construction or conversions are carried out, the utilisation of existing sports fields should first be increased.

When planning new sports turf, the number of hours of use should be estimated as accurately as possible so that the optimum type of turf can be selected for the sports field. This means that for high intensity of use, artificial turf is more environmentally sustainable, and for less intensive use, a form of natural grass is. In general, the chosen sites should allow for the highest possible number of annual usage hours.

At present, almost all artificial turf is produced from primary plastic. Environmental impacts caused by the construction of artificial turf sports fields could be reduced by using recycled secondary plastics. However, the use of recycled secondary plastics may also have adverse effects which increase the environmental impact, e.g. due to the use of plastic granulate contaminated with heavy metals made from scrap tires as infill for filled artificial turf sports fields.

A customer, such as the city of Zurich, could and should encourage artificial turf producers to use recycled secondary plastics in cases where these will have a positive impact on the environment. It could also be investigated whether existing artificial turf could be renewed or recycled instead of disposing it in municipal solid waste incineration plants.

The choice of turf type is only relevant for new construction or replacement of sports turf. For existing sports turf, however, there are possibilities to optimise the environmental impacts caused by the maintenance of the existing sports fields. In the case of the investigated natural and hybrid turf sports fields, fertilisation causes a high share of greenhouse gas as well as eutrophying emissions. With a reduced use of mineral fertiliser, these environmental impacts can be reduced accordingly.

Although mowing sports turf only contributes just under 6% of the total environmental impact of natural grass turf in drainage layer construction, this amount could be significantly reduced by transitioning from conventional mowing with diesel engines to mowing robots powered by certified green electricity.

With these recommendations, the life cycle assessment study supports the environmental optimisation of the planning and management of artificial and natural turf sports fields.

# REFERENCES


Fazio, S., Castellani, V., Sala, S., Schau, E., Zampori, L., & Diaconu, E. (2018). Supporting Information to the Characterisation Factors of Recommended EF Life Cycle Impact Assessment Method. Ispra, Italy: European Commission, Joint Research Centre, Institute for Environment and Sustainability.

Frischknecht, R., Büsser Knöpfel, S., Flury, K., Stucki, M., & Ahmadi, M. (2013). Swiss Eco-Factors 2013 According to the Ecological Scarcity Method. Methodological Fundamentals and Their Application in Switzerland (Umwelt-Wissen Nr. 1330) (p. 256). Berne: Federal Office for the Environment.

Frischknecht, R., Jungbluth, N., Althaus, H.-J., Doka, G., Dones, R., Heck, T., Hellweg, S., Hischier, R., Nemecek, T., Rebitzer, G., & Spielmann, M. (2007). Overview and Methodology. Dübendorf, CH: Swiss Centre for Life Cycle Inventories.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

ISO. (2006a). Environmental Management - Life Cycle Assessment - Principles and Framework. ISO 14040:2006; Geneva: International Organization for Standardization (ISO).

ISO. (2006b). Environmental Management - Life Cycle Assessment - Requirements and Guidelines. ISO 14044:2006. Geneva: International Organization for Standardization (ISO).

ISO. (2017). Environmental Management - Life Cycle Assessment - Requirements and Guidelines. ISO 14044:2006/AMD 1:2017. Geneva: International Organization for Standardization (ISO).

Itten, R., Glauser, L., & Stucki, M. (2020). Ökobilanzierung von Rasensportfeldern : Natur-, Kunststoff- und Hybridrasen der Stadt Zürich im Vergleich. Wädenswil, Schweiz: ZHAW Institut für Umwelt und Natürliche Ressourcen.

Rosenbaum, R. K., Huijbregts, M. A. J., Henderson, A. D., Margni, M., McKone, T. E., van de Meent, D., Hauschild, M. Z., Shaked, S., Li, D. S., Gold, L. S., & Jolliet, O. (2011). USEtox - the UNEP-SETAC Toxicity Model: Recommended Characterisation Factors for Human Toxicity and Freshwater Ecotoxicity in Life Cycle Assessment. International Journal of Life Cycle Assessment, 16(8), 710–727.