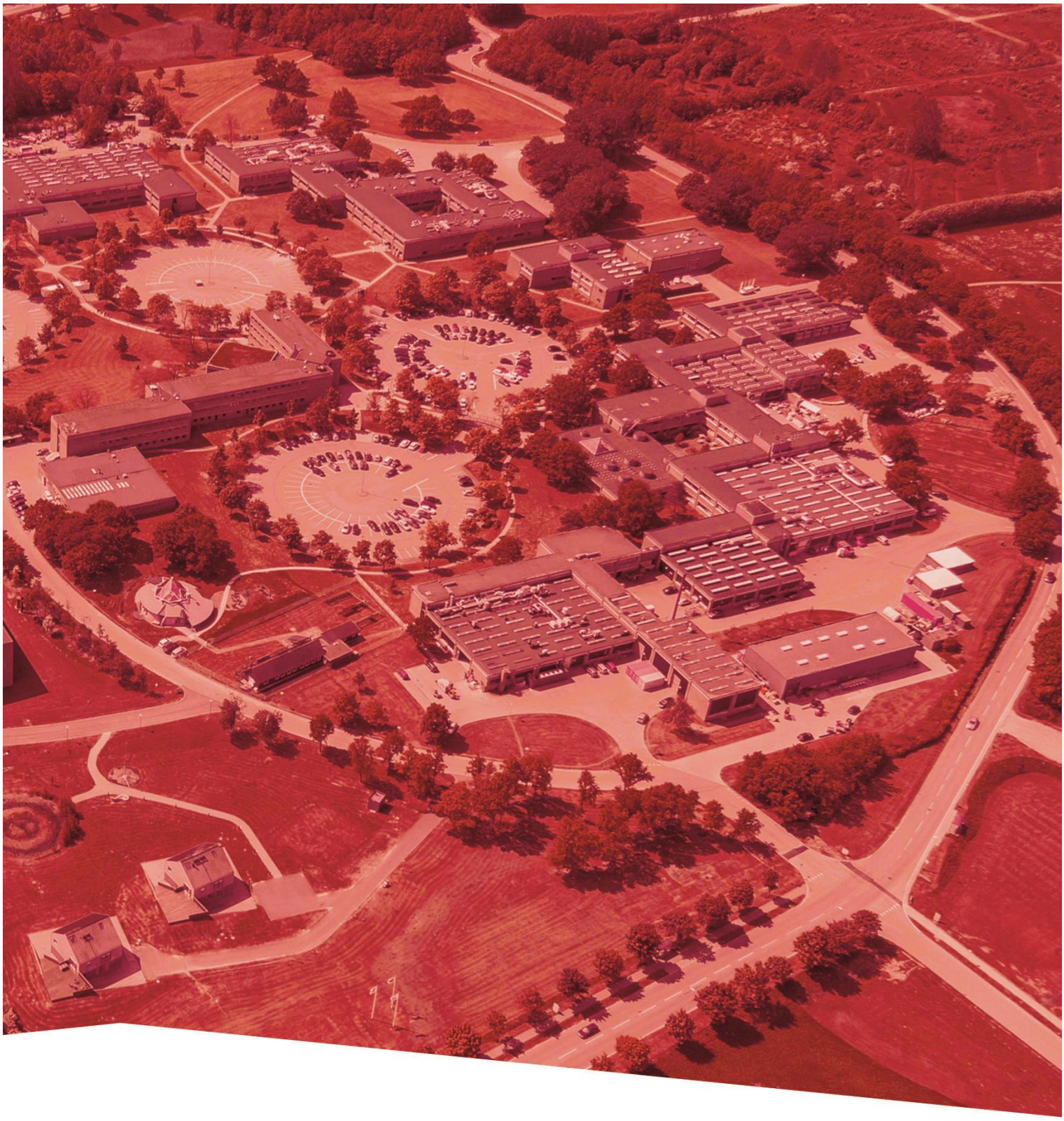

Monitoring the effects of RMM on artificial turf pitches

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Silkeborg Kommune and Dansk Boldspil Union

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1. Preface

Danish Technological Institute has been involved in documentation of the effects of installed RMM on an artificial turf pitch in Silkeborg.[1] The approach and preliminary results in this report is based on the work carried out on Silkeborgbanen.

As a reference, a breakdown of the mass balance for rubber granulate emissions to the environment from artificial turf pitches without risk management measures, based on German, Dutch, Norwegian, Swedish and Danish studies are shown in Figure 1 below.

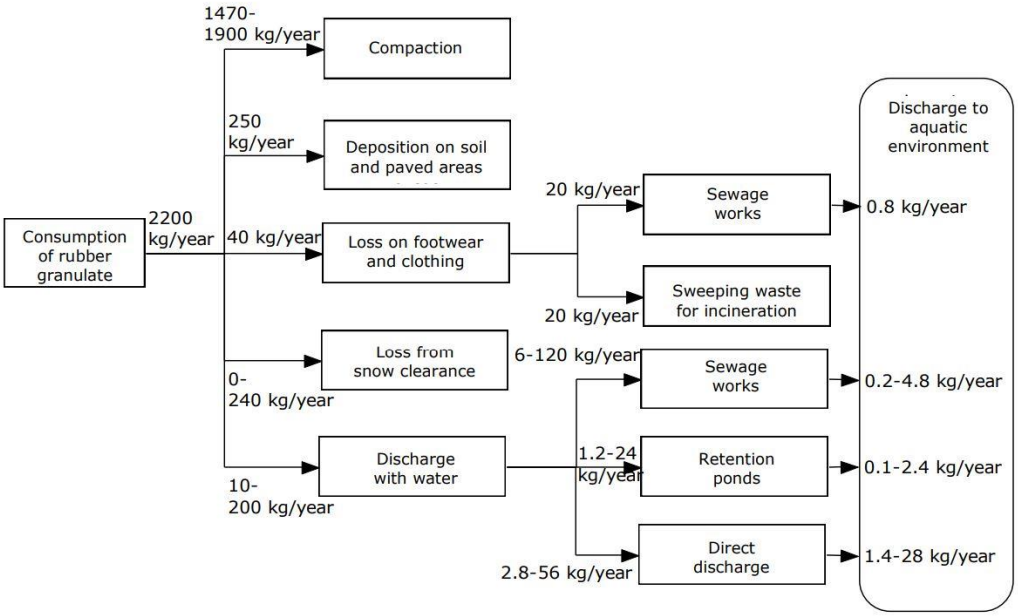

Figure 1: Mass balance for rubber granulates on pitches without RMM

Here, it is seen that the majority of the consumption of rubber granulate is due to compaction. However, this mass balance also illustrates the need for documentation of the effects of RMM, as these aim for a release the environment of less than 50 kg/year.
This mass balance also underlines that on an artificial turf pitch with granulate infill, the main pathways of emissions are:

- Over fences and barriers
- At player entry and exit points
- Transport with maintenance equipment
- Drainage water

[1] https://silkeborgbanen.dk/

To assess the total emissions from the pitches, monitoring of these pathways are essential. Following are our recommendations for methodologies for this and the preliminary results obtained at Silkeborgbanen.

2. Documentation of emissions from artificial turf pitches

2.1. Fences and barriers

As most artificial turf pitches are symmetrical with barriers on the side and ends of the pitches, it will typically be representative to measure the emission to the environment ubber granulates over the sides of the pitch on one quarter of the pitch. However, to study the effect of barrier hights, there are three different barrier hights at Silkeborgbanen and measurement fields installed as described below and as illustrated in Figure 2.

- Along the top side of the pitch, the barrier hight is 20 cm. Here two measurement fields are installed, one is near the corner flag, where a higher emission is often observed, and one in the middle of the top quadrant
- At the end of the pitch, there is a 40 cm barrier from the top to the centre of the pitch (behind the goal), where two measurement fields are installed
- At the end of the pitch, from the centre and down and along the bottom side, the barrier hight is 60 cm. Here two measurement fields are also installed symmetrical to the sampling fields for the 40 cm barrier.

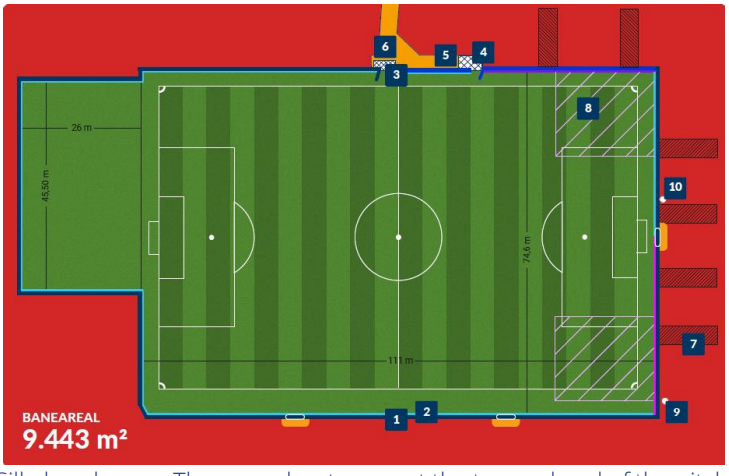

Figure 2: Illustration of Silkeborgbanen. The grayed-out areas at the top and end of the pitch represent the installed measurement fields.

Sampling on a measuring point is done on fields 60 cm wide and 200 cm long perpendicular to the fence. Measurements have been made two times, one after 149 days and one after a further 111 days.

In this study, sampling pads made from artificial turf (see Figure 3) was used. This ensures capture of the particles emitted and limits removal of particles from the sampling area caused by fx wind. The sampling areas are fixed by using proper fixation.

Figure 3: Sampling pads for granulate emitted over fences and barriers.

Results

The results are presented for each sampling position recalculated to emission in kg/pitch/year in Figure 4 and Table 1. For calculation a total circumference of the pitch of 360 m has been used.

Table 1 Emission over barriers (kg/pitch/year)

Test field	Position	Period 2	Period 3	Accumulated
1	Long side middle 20cm	6.05	53.32	26.33
2	Long side at corner 20cm	40.19	395.80 [2]	192.75
3	Goal side towards corner 40cm	1.51	25.28	11.70
4	Behind goal 40cm	8.13	3.52	6.19
5	Behind goal 60cm	0.62	1.68	1.08
6	Goal side towards corner 60cm	0.14 [3]	1.59	0.76

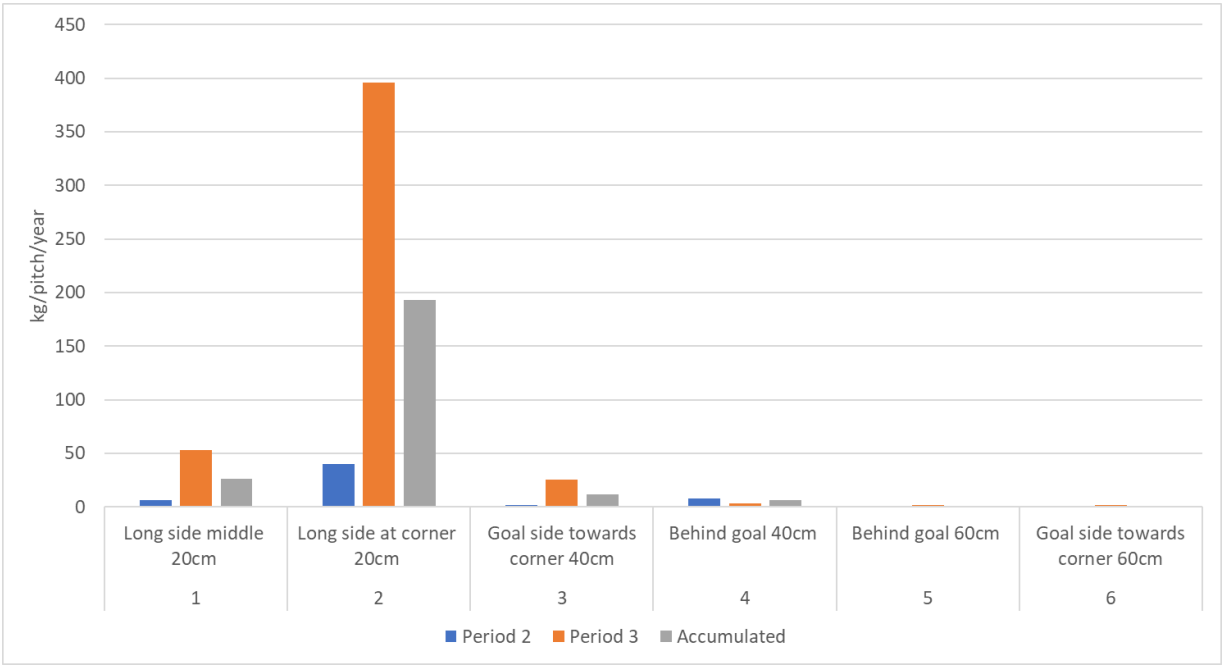

Figure 4 Emission over barriers (all heights)

[2] The analysed amount of rubber from the test field 0.6*200 cm was 200 grams
[3] The analysed amount of rubber from the test field 0.6*200 cm was 0,097 grams

The results show a high emission for the low barrier hight (20 cm) especially at the corner (from 26-192 kg accumulated).

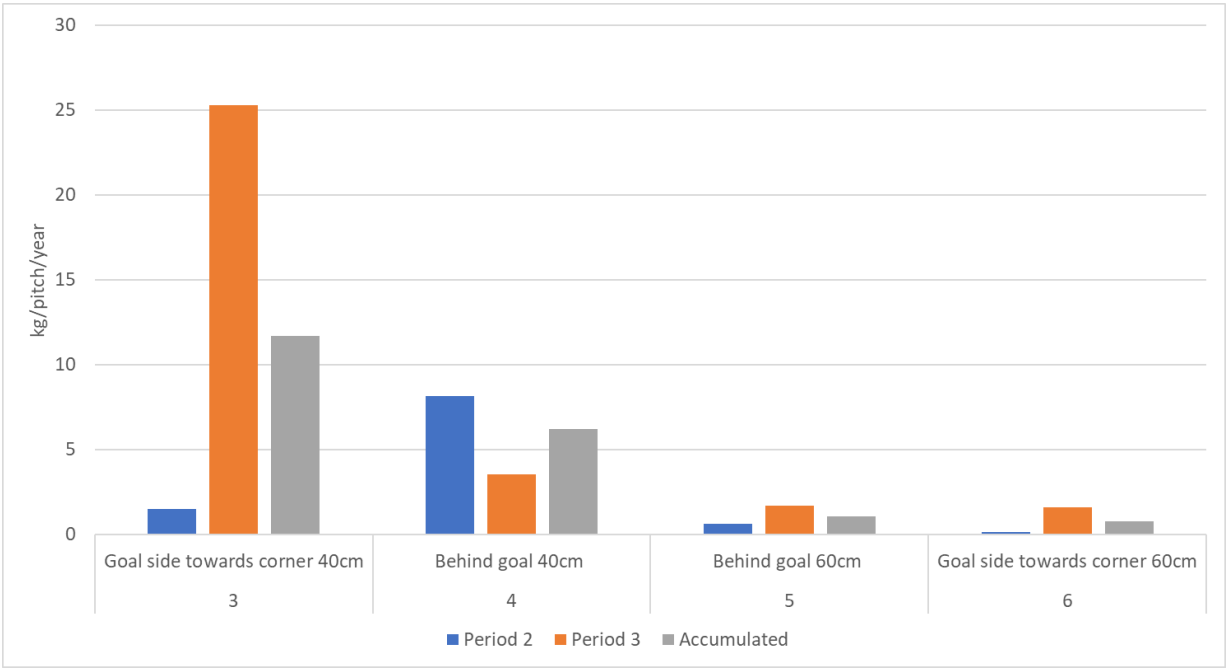

Figure 5 Emission over barriers (40-60 cm)

Figure 5 shows an accumulated emission at 40 cm barrier height of 9 kg/pitch/year and at 60 cm barrier height of 0,9 kg/pitch/year.

Thus, these results document the importance of barrier height for reducing the emission from playing (when ball hits fence) and from the equipment used for treating the pitch.

2.2. Players and Equipment

The study of emission of granulate via players have been conducted two times. These measurements have been done in such a way, that they are representative for the use of the pitch area e.g. in dry and wet condition and representative of typical use of the pitch. In Silkeborg, the focus of the sampling from players were in:

1. Infill material inside the shoes of the players
2. The sum of infill material outside shoes and on clothes.

Equipment used on the pitch, such as balls and cones also contain some material which was measured as required in the standard. When performing measurements of emission of granulate via players, it was without instructing the players to behave differently than a normal training/game session, as extra instruction can affect the way the players behave when exiting the pitch area.

Results

The emission of granulates from players and player equipment are shown in Figure 6 recalculated to kg/pitch/year.

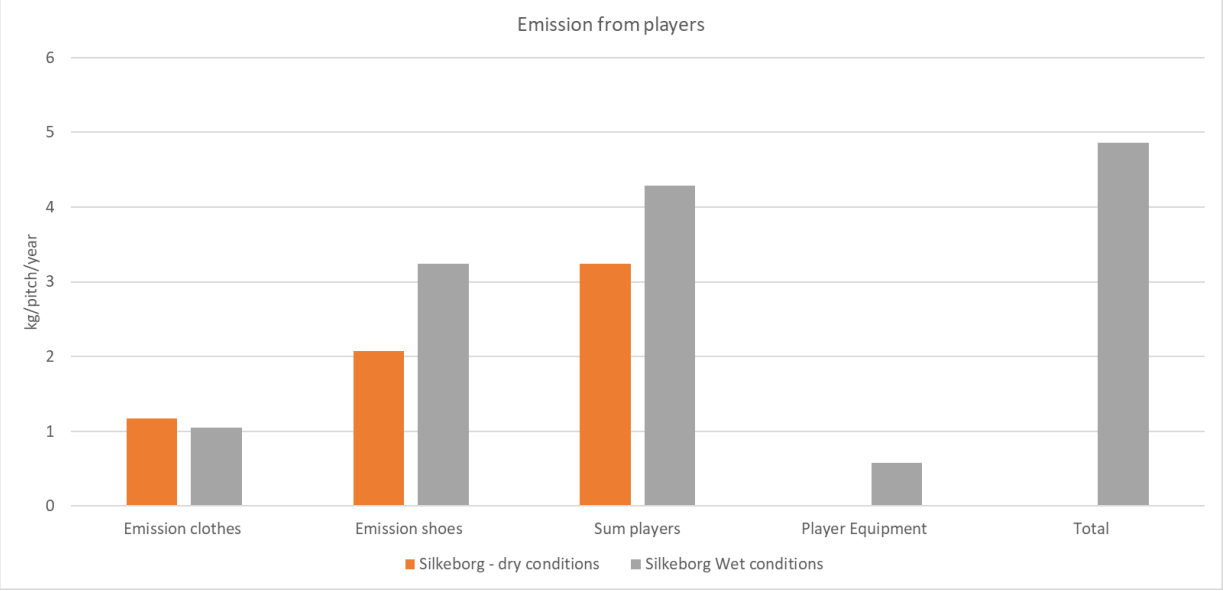

Figure 6 Emission from players and Player equipment

The maximum emission was 4.9 kg/pitch/year from players and player equipment. The figures shows that approximately 66-75% of the emission with players are from granulate in the shoes.

The measurements performed on granulates from players should be correlated with the actual use of the pitch, meaning the number of players using the pitch during a year and the weather conditions (wet/dry/snow) over the year.

2.3. Maintenance equipment

Measurement on maintenance equipment was performed two times in such a way that it was representative of typical use. Again, no special instructions were given to the operator of the equipment prior to sampling. The used equipment is a tractor which is used for pulling different tools for keeping the pitch. All tools are kept within the artificial turf area, except for the tractor, that leaves the area.

After the maintenance operation, the tools are left within the artificial turf area, end the tractor was cleaned as the normal procedure by the operating personnel (eg using pressurised air cleaning), the tractor was then transferred on to a plastic film, where remaining granulates were brushed off and collected.

Results

The results are shown in Table 2

Table 2 Rubber emission with equipment

	Test #1	Test #2
Rubber (grams)	4.64	7.37
Use times/year	50	50
Emission machines kg/pitch/year	0.23	0.37

In the table the emission per pitch per year has been calculated assuming use 50 times per year.

It is seen that the cleaning of the tractor is very effective with a calculated emission of only 0.2-0.4 kg/pitch/year.

2.4. Drainage

In our drainage analysis, we have found no contamination exceeding the Danish environmental objectives for Danish freshwater environments. Generally, most values are around or below Danish requirements in relation to drinking water. Nor have we found any microrubber – i.e. rubber granules or rubber granulate residue – in the drainage water.

We have also tested rain water and drainage water for PFAS. Results show PFAS values below the Danish limit values for aquatic environments and around or below the Danish requirements in relation to drinking water. In respect of PFAS, we have analysed both rain water and drainage water from Silkeborgbanen with rubber granulate as infill as well as on an artificial turf pitch with sand as infill ("Gødvad-banen2 by Dybkjærskolen). Nothing in our study indicates that rubber granulate as infill material should be a significant source of PFAS contamination.

2.5. Total emission

The total emission has been calculated for use with 40 cm and 60 cm barrier heights. The results are shown in Table 3 and Figure 7.

The figure shows that the majority of the observed emission is from players and over pitch barriers.

Table 3 Individual emissions and total emissions

	Period 2	Period 3 [4]	Accumulated
Players (maximum)	4.86	4.86	4.86
Fence (40 cm average)	4.82	14.40	8.94
Fence (60 cm average)	0.38	1.63	0.92
Machines	0.23	0.37	0.36
Drainage	0	0	0
Sum (40 cm fence)	9.91	19.63	14.16
Sum (60 cm fence)	5.47	6.86	6.14

[4] The emission from players are from period 2

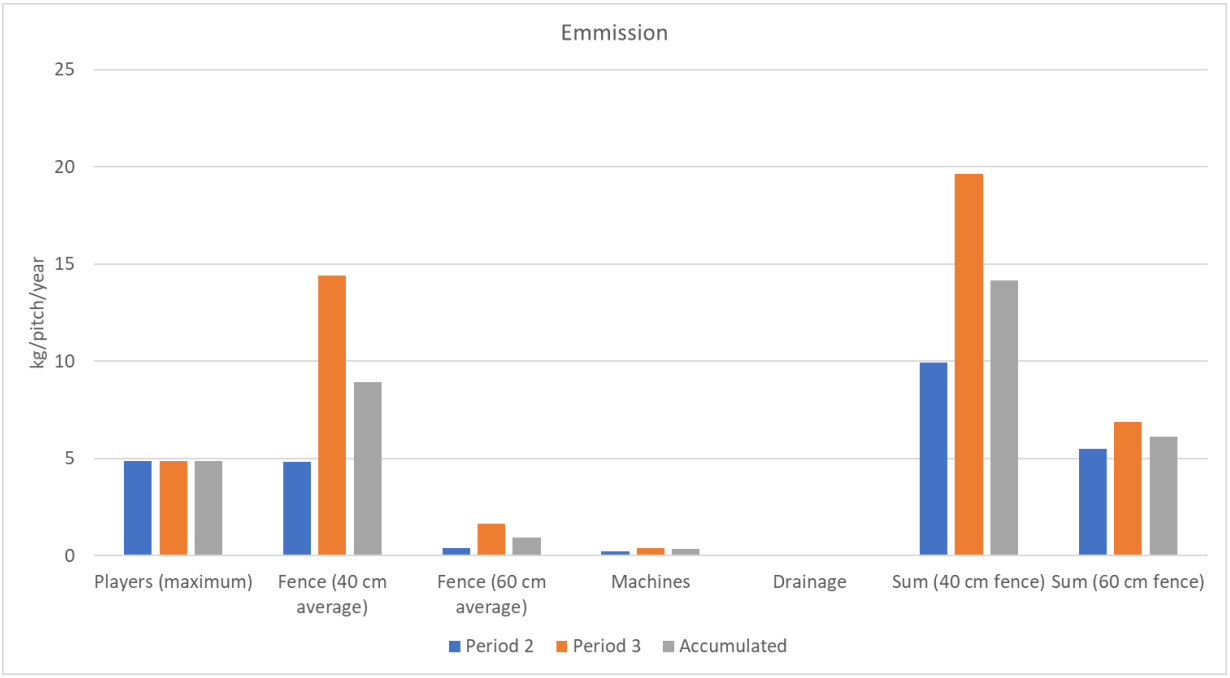

Figure 7 Individual emissions and total emission

When using barriers with a height of 40 cm the total accumulated emission for the two sampling periods is estimated to be below 20 kg/pitch/year and with use of 60 cm barrier height, the emission is estimated to be approx. 6 kg/pitch/year.

The emission to the environment will be less than this, as approx. 70% of the emission of granulates from players are from granulates in the shoes where it is likely, that these are partly emptied in the changing room or at home where the rubber granulates are cleaned away and sent to incineration. This reduces the emission to the environment to 2-3 kg/pitch/year when using 60 cm barrier height.

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