Circularity Challenges of Artificial Turfs Plastic additives and recycling of artificial turf

Unlock Plastics Circularity 20.11.2024

Päivi Fjäder & Salla Selonen, Syke

PHOTO:

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Artificial turfs: In general

- Used in many purposes
- Especially on sport areas like football pitches
  - → in Finland 450
- Also used in playgrounds, athletics and baseball fields, golf courses, agility arenas, riding stables
- Landscaping of public and private spaces

Myllypuro Photos Päivi Fjäder, Syke

Artificial turfs: structure

- Different layers:
- Blades
  - polyethylene (PE), nylon (PA), polypropylene (PP)
- Filler material
  - the purpose in artificial turf is to keep the blades upright
  - synthetic polymers like styrene-butadiene rubber (SBR), which comes from recycled tires
  - other synthetic fillers include ethylene-propylene rubber (EPDM) and thermoplastic oligomers (TPO)
- Backing fabric
  - mainly consists of PP
- Underneath, depending on the intended use, also elastic layer (polyethylene- or polyurethane foam, SBR)
  - Structural layers

Photos: Olli Leino and Päivi Fjäder, Syke

Relevant legislation related to microplastics and chemicals

- REACH restriction for intentionally added microplastics (EU 2023/2055)→ concerns also crump rubber → must be replaced by 2031
- REACH ANNEX XVII sets also limit value for ∑PAH8 20 mg/kg → concerns recycled crumb rubber → requires ending of the waste status
- Additives are used in plastics to improve their properties, especially in materials with long lifespan
  - durability (resistance to UV -radiation) or safety reasons (to improve fire resistancy)
- Some of the additives are considered harmful to the environment or to human health → Persistent Organic Pollutants (POPs)
- Requirements in the legislation on EU -level
- POP –Regulation (2019/1021)
  - sets limit values in waste
  - also in products as Unintentional Trace Concentrations (UTC)

Challenges related to recycling of artificial turfs

- Many fields must be replaced soon
  - great volumes of artificial turf materials are expected to enter recycling streams
- Artificial turf materials are in general difficult to recycle
  - Removal and separation of filling materials (sand and crumb rubber) is hard
- Multilayer and multimaterial properties is challenging for mechanical recyling
- Chemical recycling (?)
  - Limitations with halogenated compounds
- It is also expected that in the future new materials might have shorter life span → organic based filling materials, fields without filling materials (amount of plastic is higher and it wears out more easily)
- How about chemical additives?

Harmful substances of interest In PlastLIFE

Addives

Artificial turfs

Plasticizers: phthalates

UV –stabilizers: benzotriatzoles

Surfactants/processing aids: PFAS

Flame retardants: (coming later)

Colorants/catalysts/vulcanizing aids: metals

Relevant for both: turf materials and crumb rubber

Target analyses were made from these substance groups

Substance group contains also POPs

Filling materials

Vulcanization and crosslinking agents: Hexa(methoxymethyl)melamine (HMMM)

Antioxidants: Alkylphenols, 6PPDs, *Bisphenols (also used as monomer and crosslinking agent etc.)*

Non Intentionally Added Substances (NIAS)

Impurities: PAHs

Previous studies in Finland

- Air quality problems related to artificial turf fields in indoor football arenas (TekoNurmi –project, THL)
  - VOCs and PAHs
- Transport of rubber granulates from football fields to the environment (TEKONURMI-project, Syke)
  - microplastics (crumb rubber) emissions to the environment
  - In case of SBR 20 000 – 40 000 ELTs are needed in one football pitch
- Reuse possibilities of artificial turfs → Tekonurmien hyötykäytön mahdollisuudet (Ramboll; Espoo, Helsinki, Lahti, Oulu, Tampere ja Vantaa)
  - Searching for new possibilities to recycle or reuse artificial turf materials
- PlastLIFE (Syke) & TERMINATE

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Study areas in PlastLIFE

- Five football pitches
- Puistola (as a reference; just renovated 2023 with biobased filling material)

- Pajamäki (HJK)
- Käpylä (2014)
- Myllypuro (2010)
- Pitäjänmäki (2011)



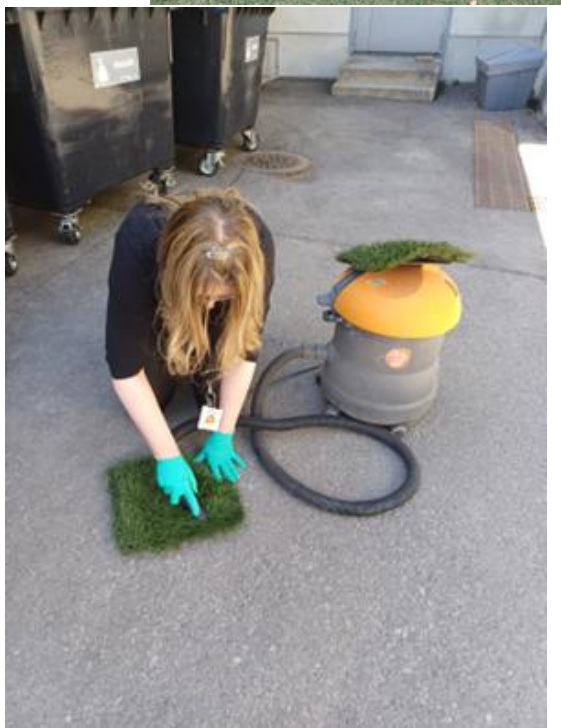
Photos Päivi Fjäder & Hanna Niemikoski, Syke

Research in PlastLIFE

- Chemical analyses
- Turf materials and crump rubber
- Smpling, Prehandling

- Target analyses for PFAS, phthalates, UV-stabilizers, metals, bisphenols, alkylphenols, PAHs

- Non-target screening
  - High-resolution mass spectrometry (HRMS)
  - Provides broader assessment of potential chemicals present in samples
    - Benzothiatzoles
    - PAHs
    - Phthalates
    - Etc.



Photos Hanna Niemikoski & Päivi Fjäder, Syke

Biotests for assessing health and environmental risks

- Estrogenicity test (A-YES, ISO 19040-2)
- Genotoxicity test (umuC, ISO 13829)
- Green algae growth (ISO 8692) and photosynthesis inhibition tests
- Light emission of bacteria (ISO 11348-3)
- Water flea tests (ISO 6341/ISO 10706)
- Fish embryo test (ISO 15088)
- Earthworm reproduction test (ISO 11268-2)
- Genotoxicity in higher plants: Vicia micronucleus test (ISO 29200)

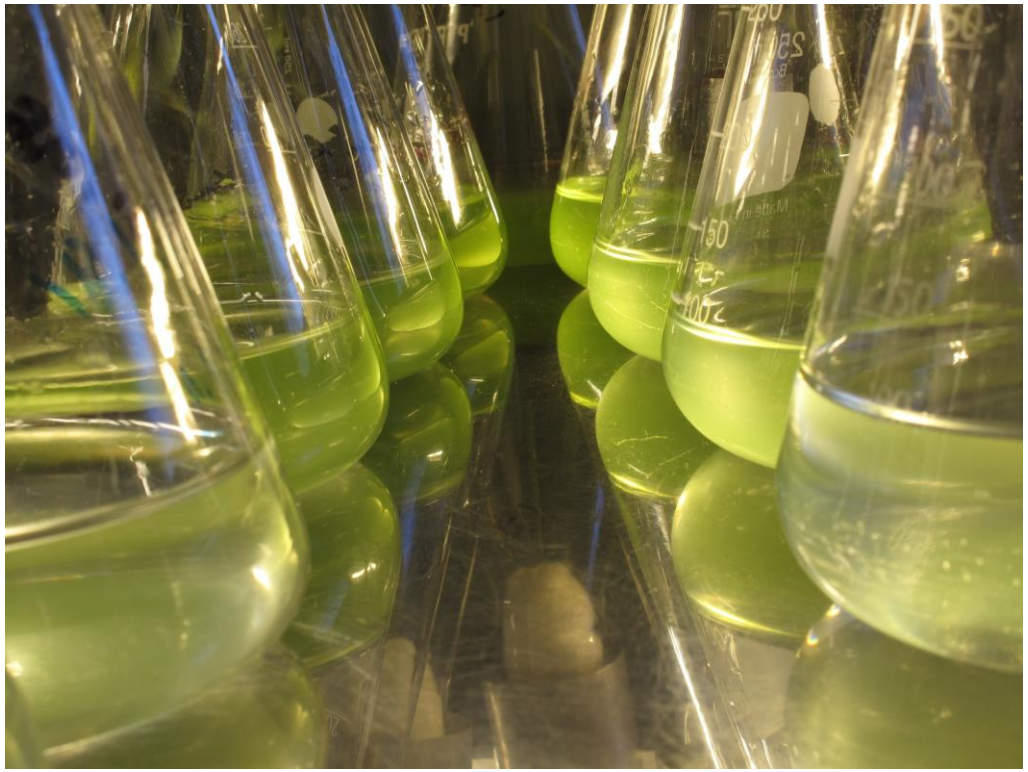
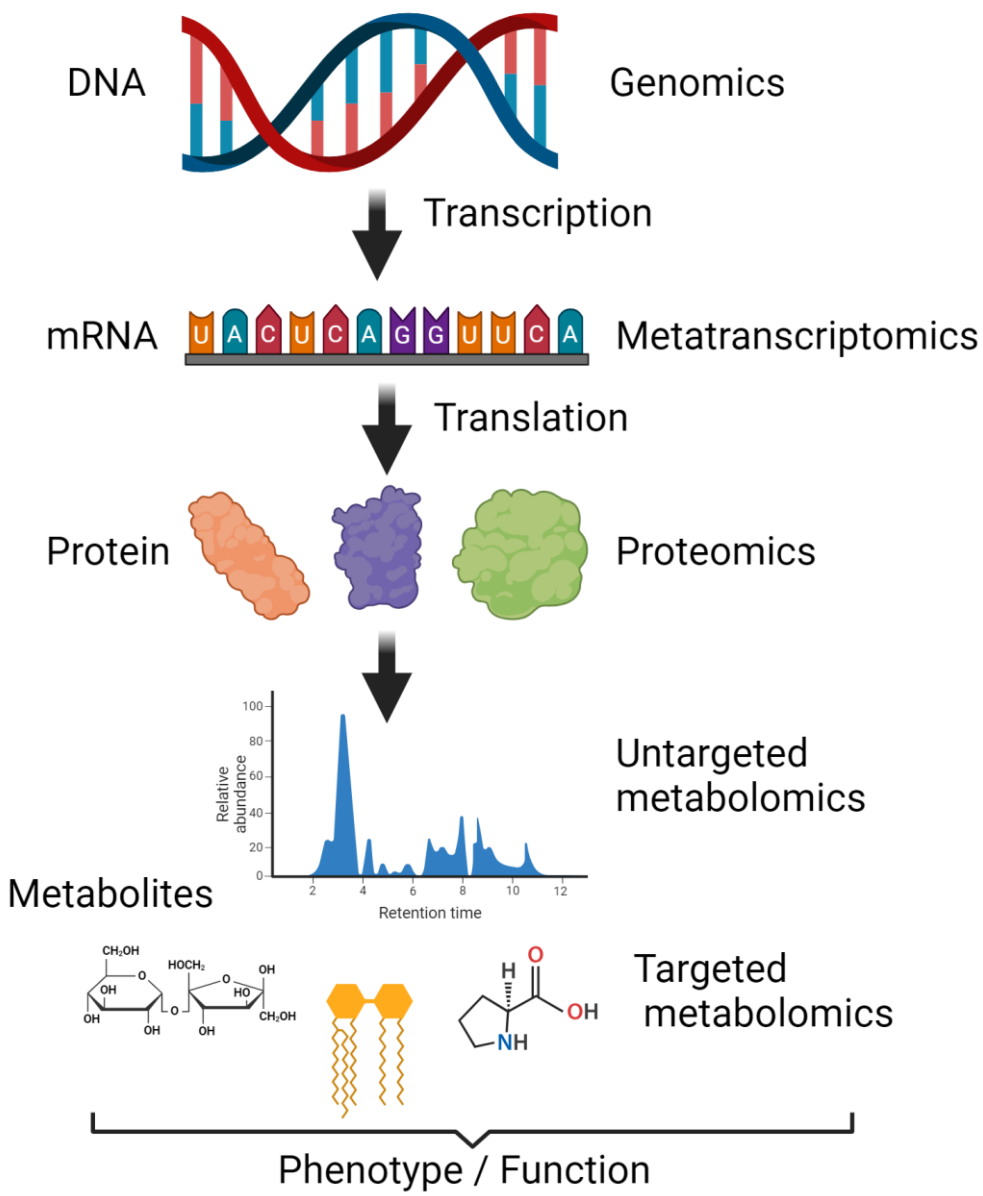


Photo Timo Vänni, Syke

Effects on molecular/biochemical level:“omics”

Sami Taipale, University of Jyväskylä

- Phenotype effects (such as growth or reproduction) are usually observed at high exposure concentrations
- More fine-scale molecular and biochemical level changes include:
  - gene expression (metatranscriptomics)
  - protein synthesis (proteomics)
  - metabolites (targeted and untargeted metabolomics).
- “Omics” are more sensitive than traditional methods and makes it possible to relate the effects on the mechanism of toxic action
- Water flea *Daphnia magna* were exposed to artificial turf materials → omics still to be measured



Results Artificial turfs

Photo Hanna Niemikoski, Syke

Results: PFAS

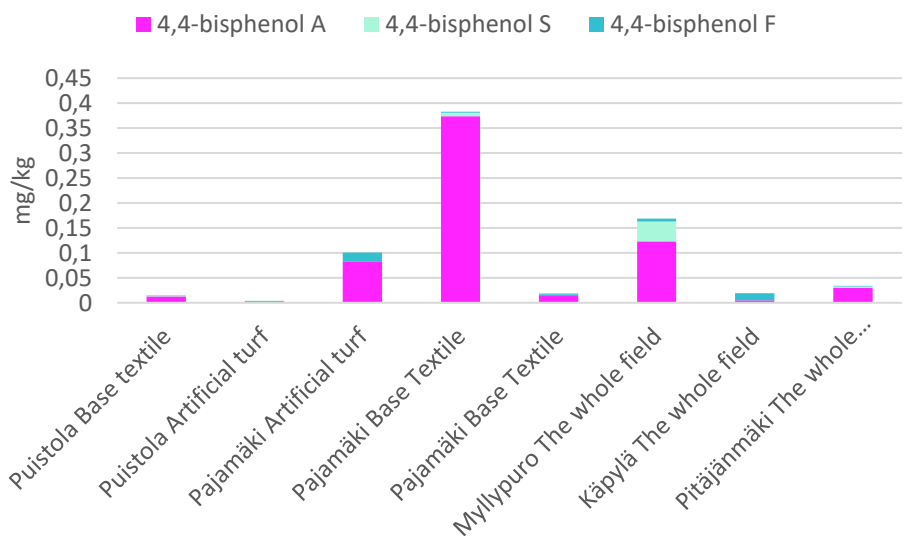
- 60 PFAS compounds analyzed by a LC-MS/MS method
- 8 blades and/or backing samples and 5 crumb rubber filling samples
- Estimated Limits of Quantitation (LoQ) were 3 µg/kg or lower for most of the analytes
- Concentrations at or close to LoQ except the crumb rubber filling sample taken from inside hall
- Concentration exceeds the current UTC limit value for PFOA-related compounds 1 mg/kg

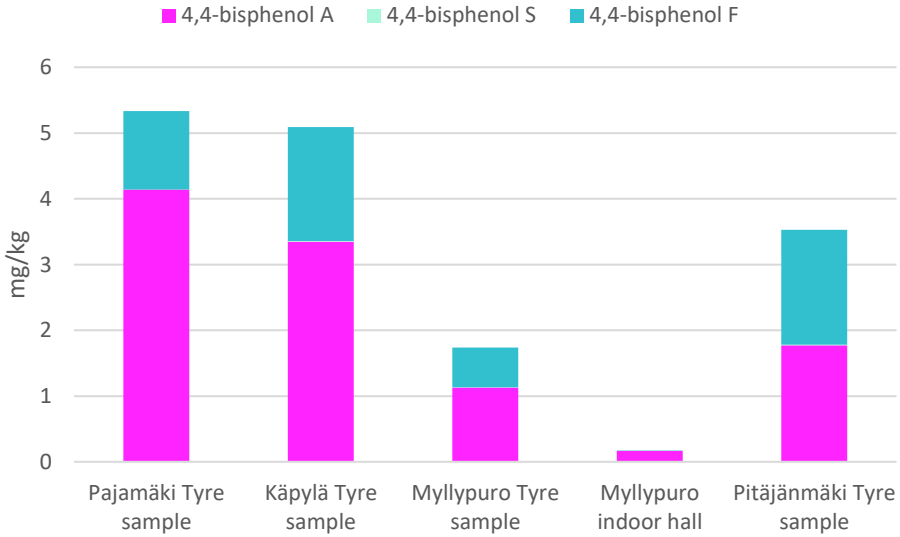
Blades and backing									
LIMS code	Details	Sampling location	PFBA (C4 PFCA)	PFHxA (C6 PFCA)	TFMS (C1 PFSA)	FBSA (C4 FASA)	PFHxSA (C6 FASA)	8:2 FTOH	N-EtFOSAA
1424-1486-1	Blades and backing	Myllypuro	<LOQ	<LOQ	<LOQ	0.01	(0.01)	<LOQ	<LOQ
1424-1490-1	Blades and backing	Käpylä	<LOQ	<LOQ	7	<LOQ	<LOQ	<LOQ	<LOQ
1424-1492-1	Blades and backing	Pitäjämäki	<LOQ	<LOQ	<LOQ	<LOQ	(0.02)	8.1	<LOQ
1424-1855-1	Blades	Puistola	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
1424-1856-1	Backing textile	Puistola	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
1424-1857-1	Blades	Pajamäki	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
1424-1858-1	Backing surface	Pajamäki	<LOQ	<LOQ	8	<LOQ	<LOQ	15	3
1424-1859-1	Backing textile	Pajamäki	<LOQ	2	5	<LOQ	<LOQ	<LOQ	9
Crumb rubber filling									
Käpylä			<LOQ	<LOQ	0.5	0.01	<LOQ	<LOQ	0.2
Pajamäki			<LOQ	4	0.4	<LOQ	<LOQ	<LOQ	<LOQ
Myllypuro outside environment			<LOQ	6	0.4	<LOQ	<LOQ	<LOQ	<LOQ
Myllypuro inside environment			0.4	**13**	2	<LOQ	<LOQ	**1500**	<LOQ
Pitäjämäki			<LOQ	6	0.5	<LOQ	<LOQ	<LOQ	(0.1)

Results: phenolic compounds

- Bisphenols and other phenolic compounds were analysed from the artificial turf and rubber samples in NILU

- Most compounds below LOQ or unable to analyse (matrix effects)
  - LOQs 0.09-13 µg/kg (0.00009-0.013 mg/kg)





Results: UV –stabilizers + phthalates

- **UV stabilizers**
- UV 329 & UV 326 were found almost from all fields
  - UV 326 concentrations varied 90–800 mg/kg (highest in Pajamäki)
  - In Puistola 0,9–1,8 mg/kg
- **UV 328** was found only from two fields
  - low concentrations 0,02–0,12 mg/kg (UTC 10 mg/kg not exceeded)

Phthalates

- DEHP was found with highest concentration 0,5–2,5 mg/kg
- DBP with concentrations 0,25–0,3 mg/kg
- DIBP with concentrations 0,05–0,07 mg/kg

Results crumb rubber

Photo Olli Leino, Syke

Results: UV stabillizers

- Filling material SBR, EPDM, TPO/TPE
  - Crumb rubber mainly SBR → ELT
  - Except Myllypuro's indoor EPDM

- UV 326 was found only in Pajamäki at concentration 400 mg/kg
  - Note that UV 326 concentrations in turf in Pajamäki was 800 mg/kg
- **UV 328 (POP)** variation in all samples 0,1–1,5 mg/kg
  - → highest concentration Myllypuro indoor sample
  - (UTC 10 mg/kg not exceeded)
- UV 234 (highest concentration 2 mg/kg in Myllypuro indoor) & UV 329 (in amost all samples 0,06–0,25 mg/kg)

Photos Päivi Fjäder, Hanna Niemikoski, Syke

Reslts: phthalates & PAHs

- In crumb rubber samples DEHP was found in concentrations 2–22 mg/kg
  - Note that concentrations were 10 times higher than compared to turf materials
- DEHP and DIBP was found in Myllypuro's indoor sample

- ∑PAH8 variation 1,6–2,6 mg/kg limit value for crumb rubber 20 mg/kg according to REACH did not exceed
- (∑PAH16 variation 4,3–15 mg/kg)

Kuva Hanna Niemikoski, Syke

Biotest Results

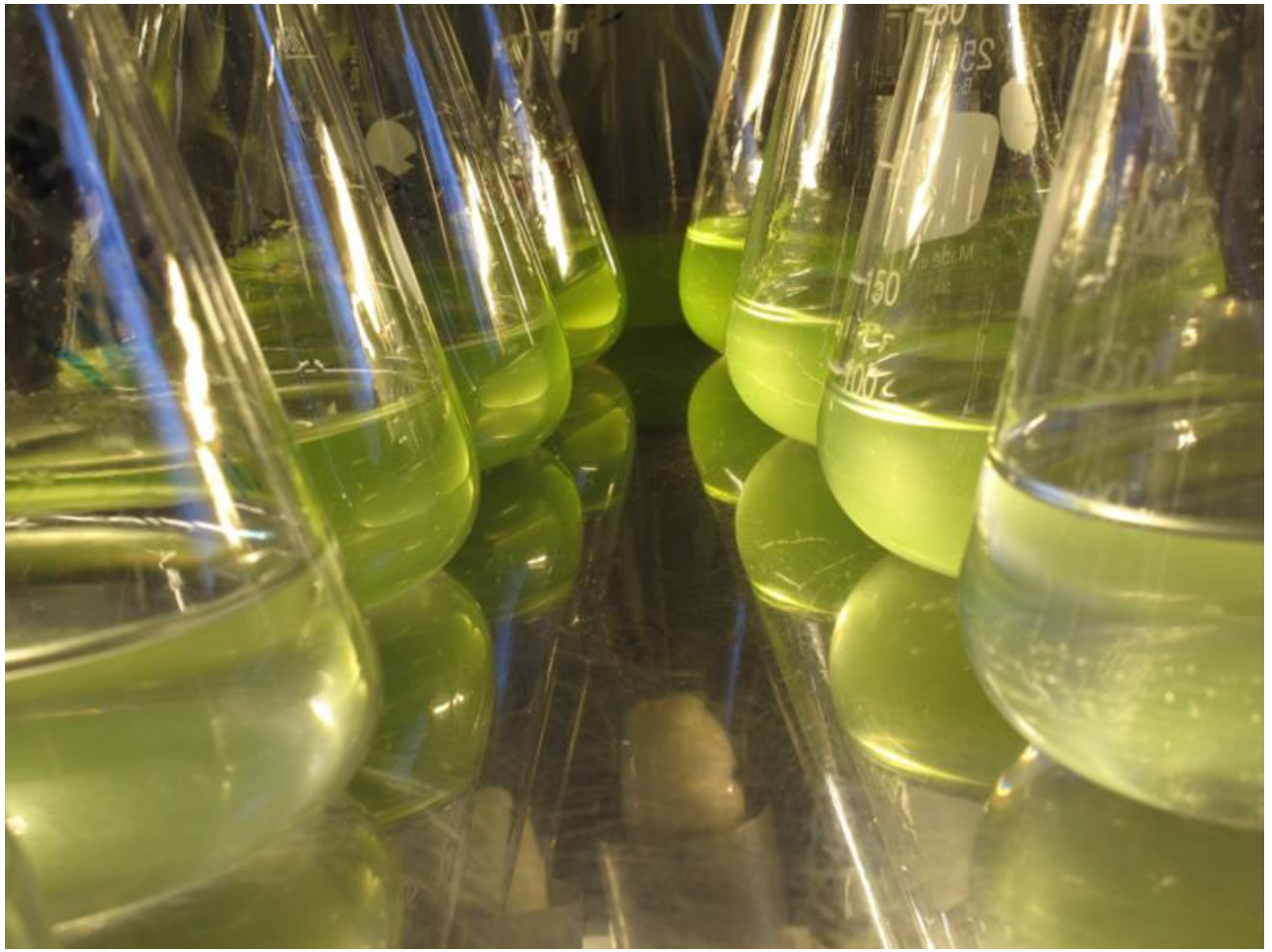


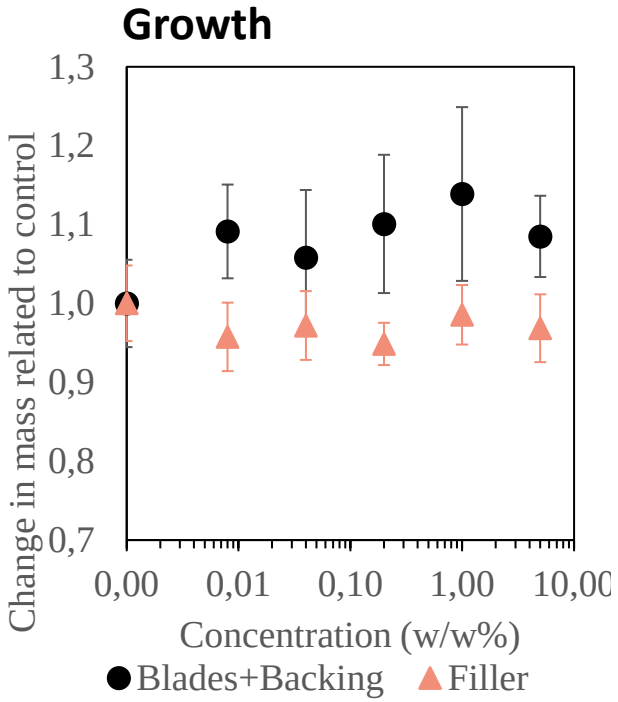
Photo Timo Vänni, Syke

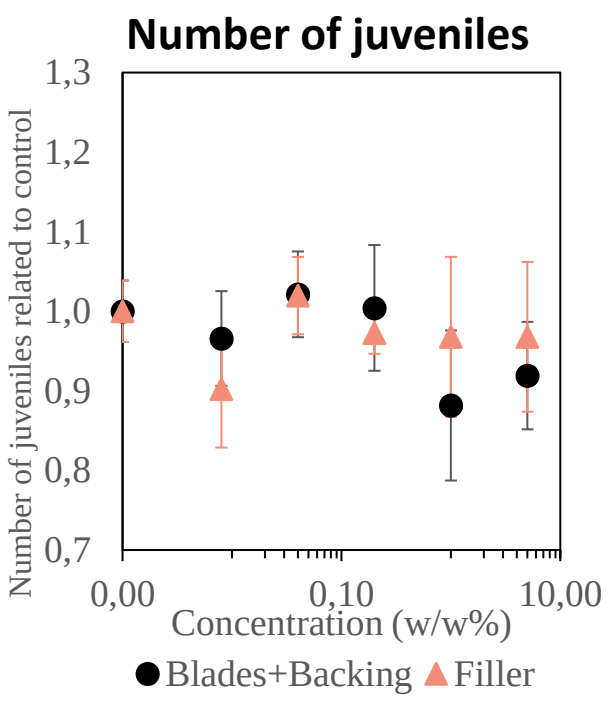
Biotest Results: Genotoxicity

- The genotoxic potential of whole turf and crump rubber were investigated by applying the genetically engineered bacterium *Salmonella typhurium* standard (ISO 13829:2000).
- The test measures the induction of the umuC-gene in response to genotoxic lesions in the DNA
- Five whole turf and four crump rubber ground samples (< 4mm) were extracted with **water** for 24 h and 7 days, and the bacteria were exposed to the extract in a dilution series
- None of the extracts caused genotoxic effects, nor were they cytotoxic
- Next, samples will be extracted with **methanol** and with **passive samplers** to investigate max genotoxic potential and the role of bioaccumalative additives.

Biotests: Effects on earthworms

- Two experiments on materials from Käpylä: 1) crushed Blades+Backing, 2) Filler
- Materials mixed in Lufa2.2 soil in concentrations: 0%, 0.008%, 0.04%, 0.2%, 1%, 5% (w/w)
- No effects on growth or number of juveniles (”babies”) produced, slight decrease in mass of juveniles in low concentrations of Blade+Backing
- Bioaccumulation of selected chemicals (concentrations in earthworms) will be measured





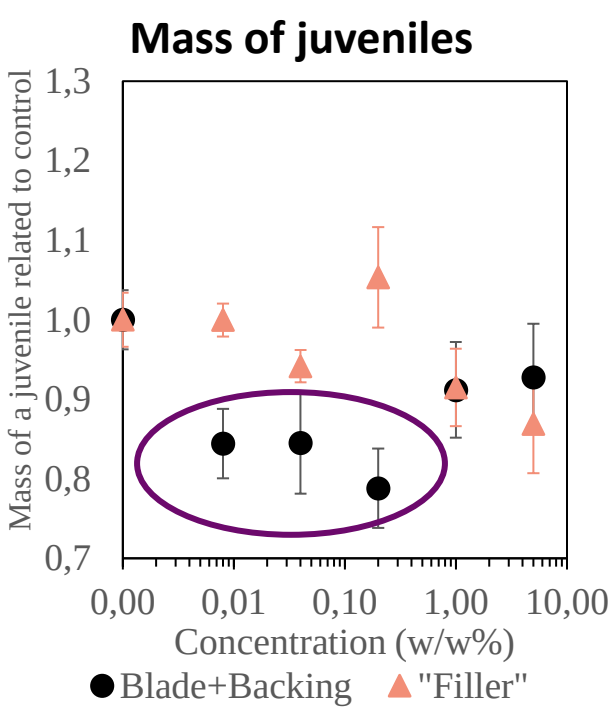


Photo Salla Selonen, Syke

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Summary and next steps

Finalizing the chemical analyses → non-target screening and flame retardants

Finalizing the biotests

Results of chemicals analyses will be publish in separate report under TERMINATE –project financed by the Ministry of Education and Culture

Artificial turfs do contain various additives and impurities, more research is needed

- In this study, only five football pitches (10-14 years old) were studied
- The POPs analyzed in this study, did not prevent recycling of these turf materials
- One crumb rubber sample was not in accordance with the current legislation – evaluation of recyclability of crumb rubber continues

Thank You!

Team

Syke: Heidi Ahkola, Venla Forsell, Sari Kauppi, Johanna Järvistö, Matti Leppänen, Hanna Niemikoski, Noora Perkola, Kirsi Rosendahl, Salla Selonen, Niklas Trebs, Jyrki Viidanoja

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