MICROPLASTICS

Gastrointestinal interaction and potential consequences for animal health and consumer safety

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What is microplastic?

https://www.aquatechwatersystems.com/blog/wp-content/uploads/2021/10/microplastics-bottle.jpg

Microplastic: 100 nm – 5 mm
Nanoplastic: <100 nm (cellular uptake)

Primary micro-/nanoplastic is the result of targeted production for industrial purposes, e.g. cosmetics, hygiene products

Secondary micro-/nanoplastic is the results of physical and chemical errosion of plastic litter

Thompson et al. 2004: Marine plastic litter degrades into microscopic particles

Ng et al. 2018: 63’000 – 430’000 t/a of microplastic accumulating in European soil

Sources in agroecosystems:
- → General environmental pollution
- → Tire wear
- → Plastic film (ensiling film, mulch film)
- → Sewage sludge
- → … etc.. What circulates in the feed chain?

MICROPLASTICS IN FINLAND

1. Agricultural and environment

- SYKE's MicrAgri project identified realistic on-farm plastic sources: mulch films, silage bales, irrigation systems, pesticides/fertilisers, machinery coatings and atmospheric deposition.
- The PAPILLONS project places agricultural plastics in a Nordic/European sustainability context and highlights long-term contamination pathways in food production systems.

MicrAgri; PAPILLONS

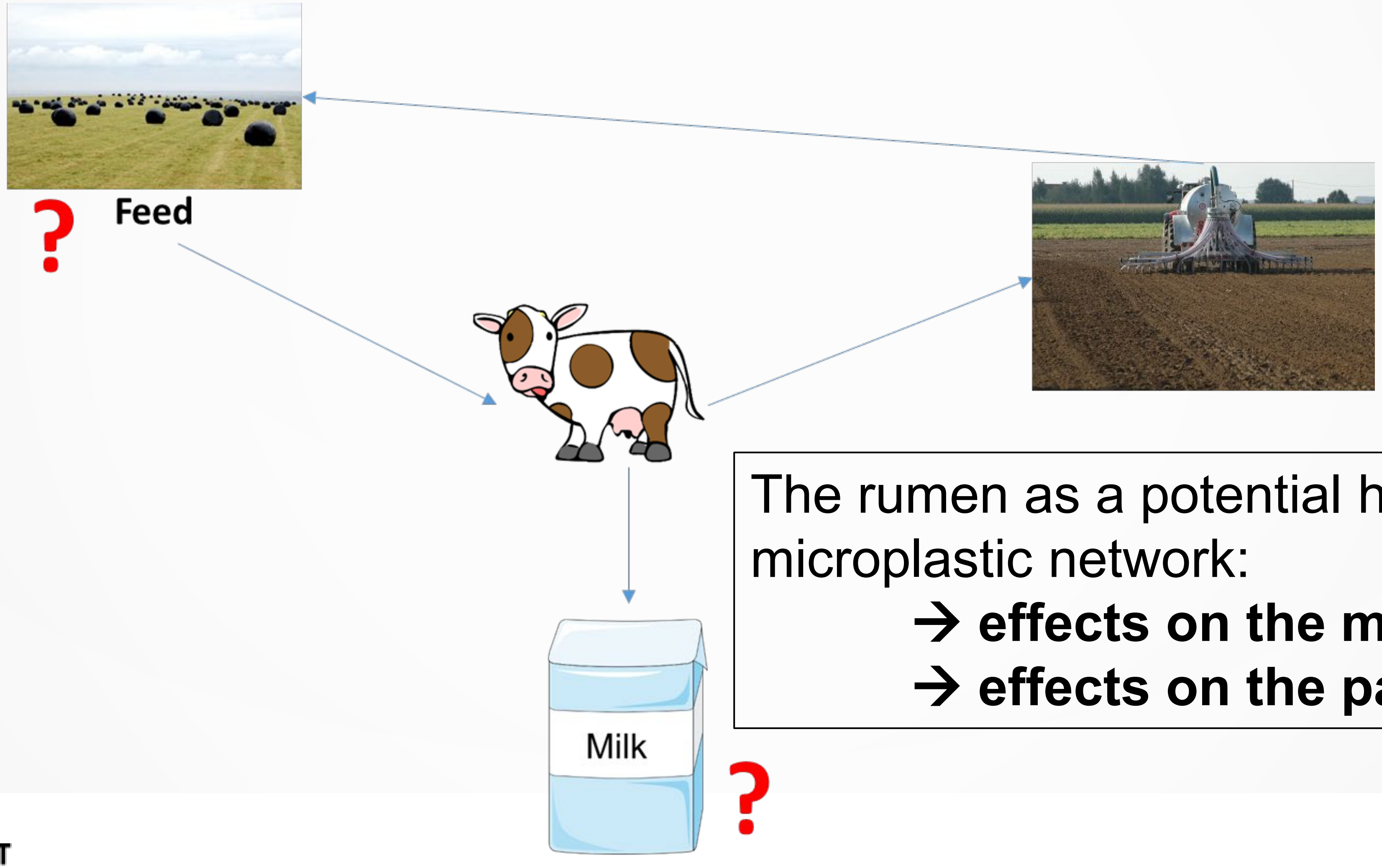
2. Water and fish

- Imaging-FTIR work in Finnish fish detected MPs in perch (17%) and vendace (25%); most particles were <100 µm.
- Remote waters in the Finnish Sámi area still contained 45–423 particles m^{-3}, showing that background exposure is measurable even outside urban hotspots.

Räisänen et al. 2022; Soininen et al. 2024

Eichinger et al. 2025, J. Hazard. Mat. 500: 140481
https://doi.org/10.1016/j.jhazmat.2025.14048

RESEARCH QUESTION



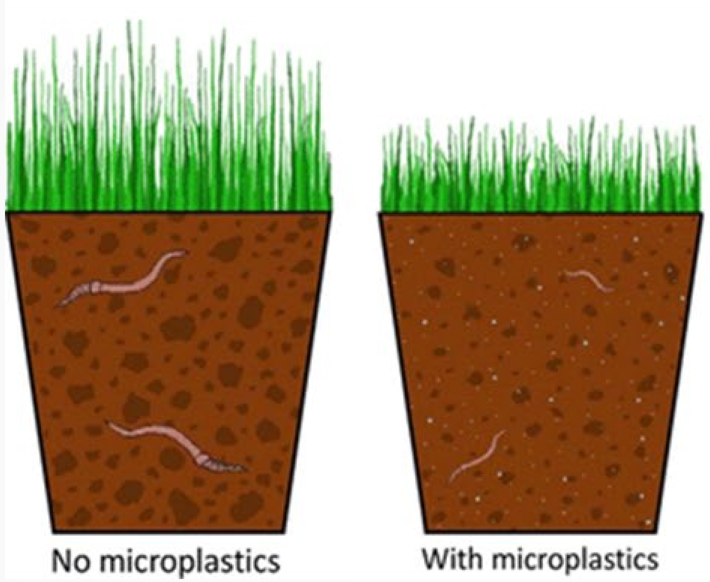
The rumen as a potential hub in the microplastic network:

→ **effects on the microbiome?**

→ **effects on the particles?**

Microplastic-Microbiota interaction

Boots et al. 2019: Effects of PLA, HDPE and microplastic clothing fibers



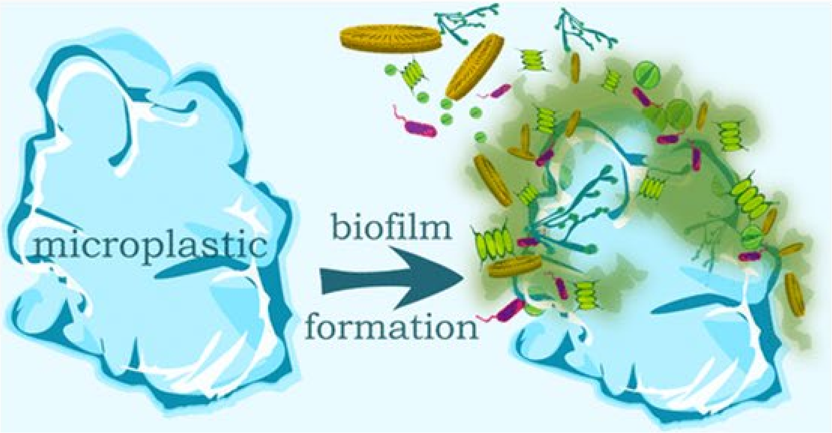
Above ground

Germination success ↓ **(PLA, fibers)**
Shoot length & biomass ↓ **(PLA)**
Chlorophyll

Below ground

Root biomass ↓ **(independent of source)**
Earthworm biomass ↓ **(HDPE)**
Soil structure ↓
pH ↓ **(HDPE)**

Rummel et al. 2019: Biofilm formation and effects on fate of microplastics

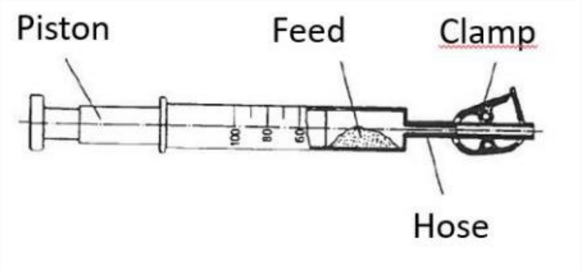


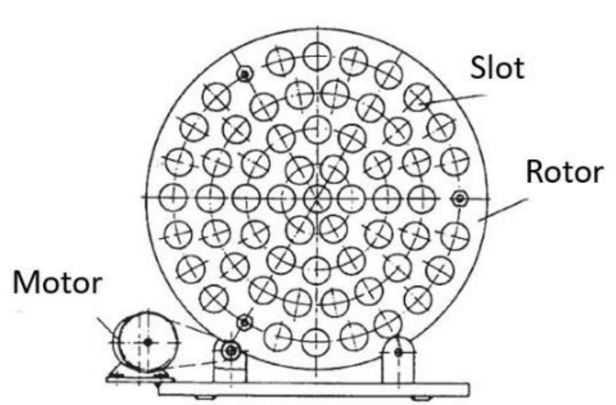
«Biofilm-plastic interactions have the capacity to influence the fate and impacts of microplastic by modifying the physical properties of particles»

MATERIAL AND METHODS

The Hohenheim Gas Test:

1) Incubator, 39°C
2) Rotor, 1 m/min
3) 24 h incubation
4) Rand. distribution of pistons





Incubation mix

1) 250 mg DM barley or hay
2) (0), 0.5, 5.0, 35, 70 mg plastic
3) 24 h incubation
4) Rumen fluid + buffer

Plastic applied at <125 or 125-500 µm

- polylactide (PLA)
- polyhydroxy butyric acid (PHB)
- high-density polyethylene (HDPE)
- polyvinyl chloride (PVC)
- polypropylene (PP)

MATERIAL AND METHODS

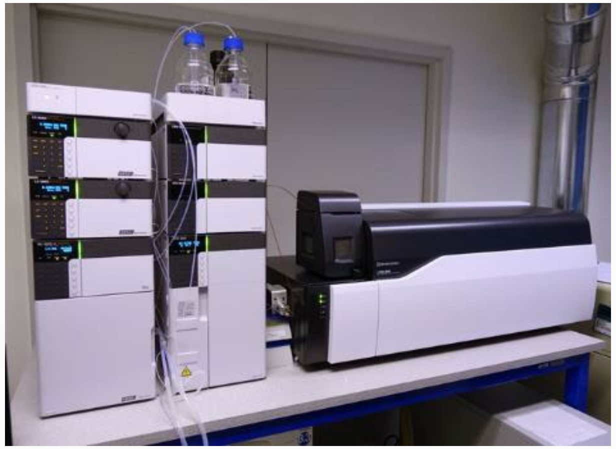
Analysis of:
1. **Microbial metabolic activity**
2. **Microbial metabolic regulation**
3. **Microbial structure (phylum level)**
4. **Incubate dry matter loss**
5. **Rumen fermentation parameters**

Sampling

1) Removal of incubates into ice bath
2) Centrifugation (20’000 g, 30 min, 4 °C)
3) Snap freezing of rumen fluid for NMR

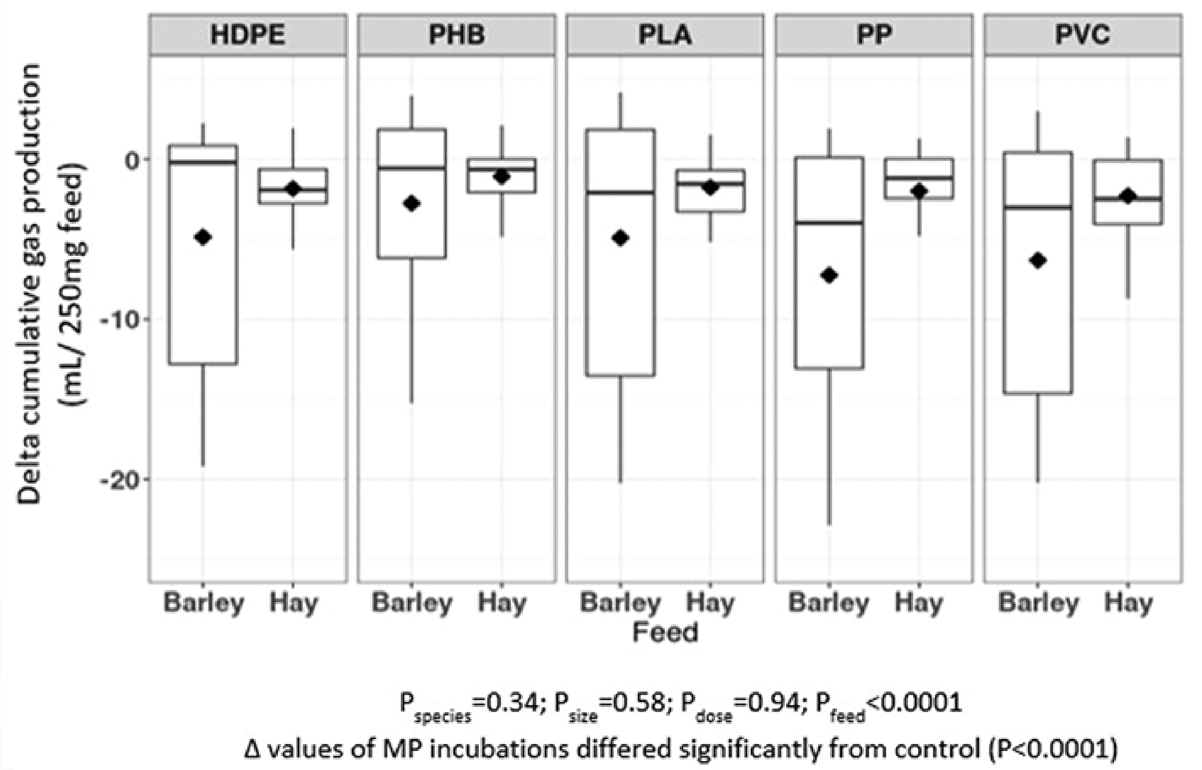
NMR untargeted metabolomics

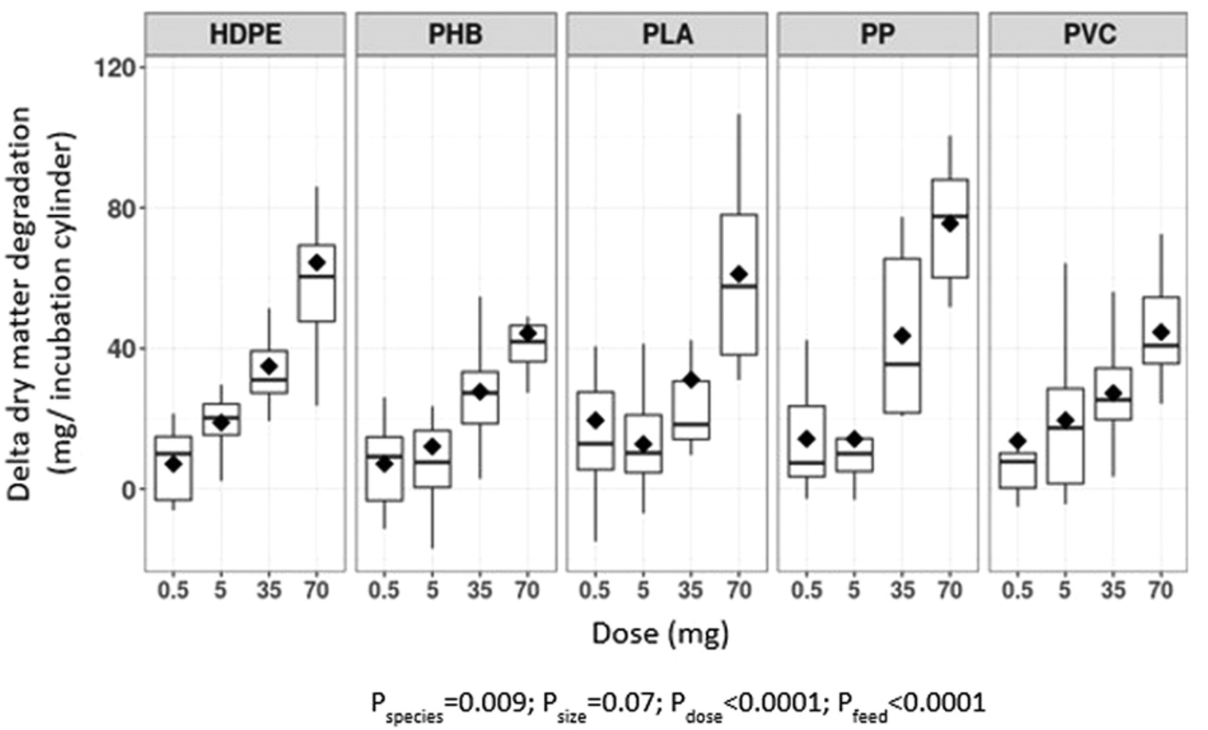
LC-MS/MS untargeted metaproteomics



GC targeted fermentation parameters

MICROBIAL METABOLIC ACTIVITY

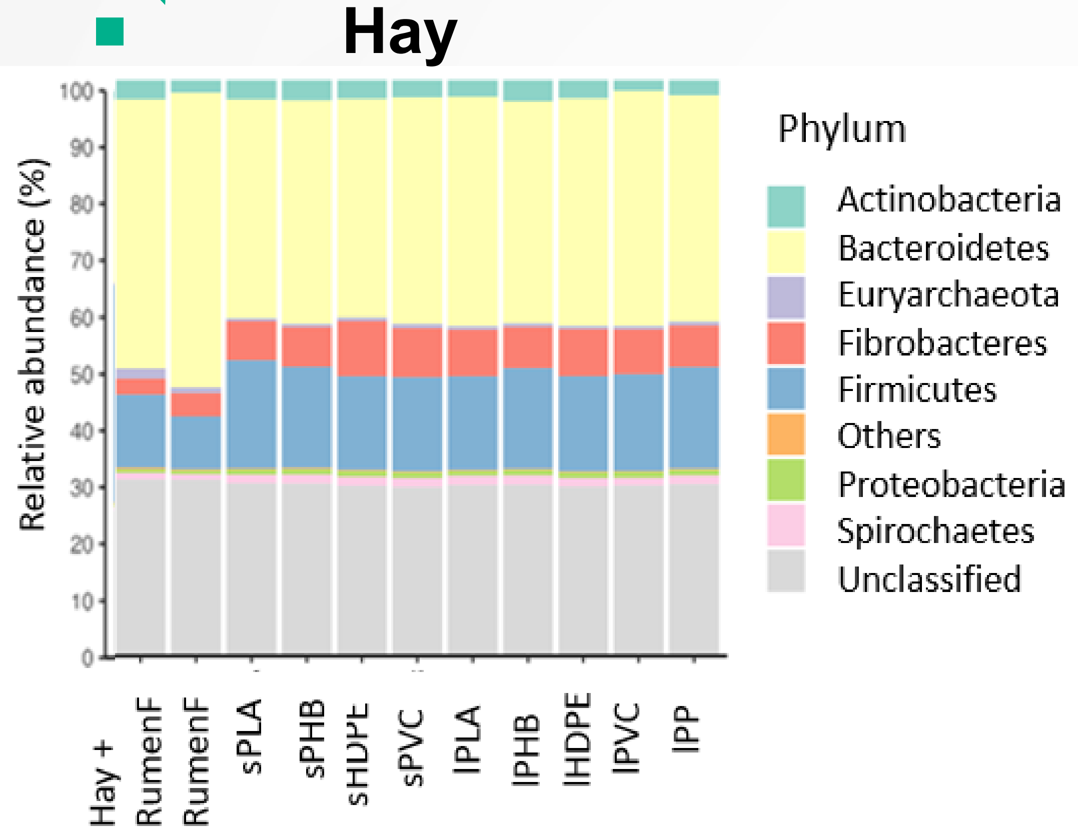


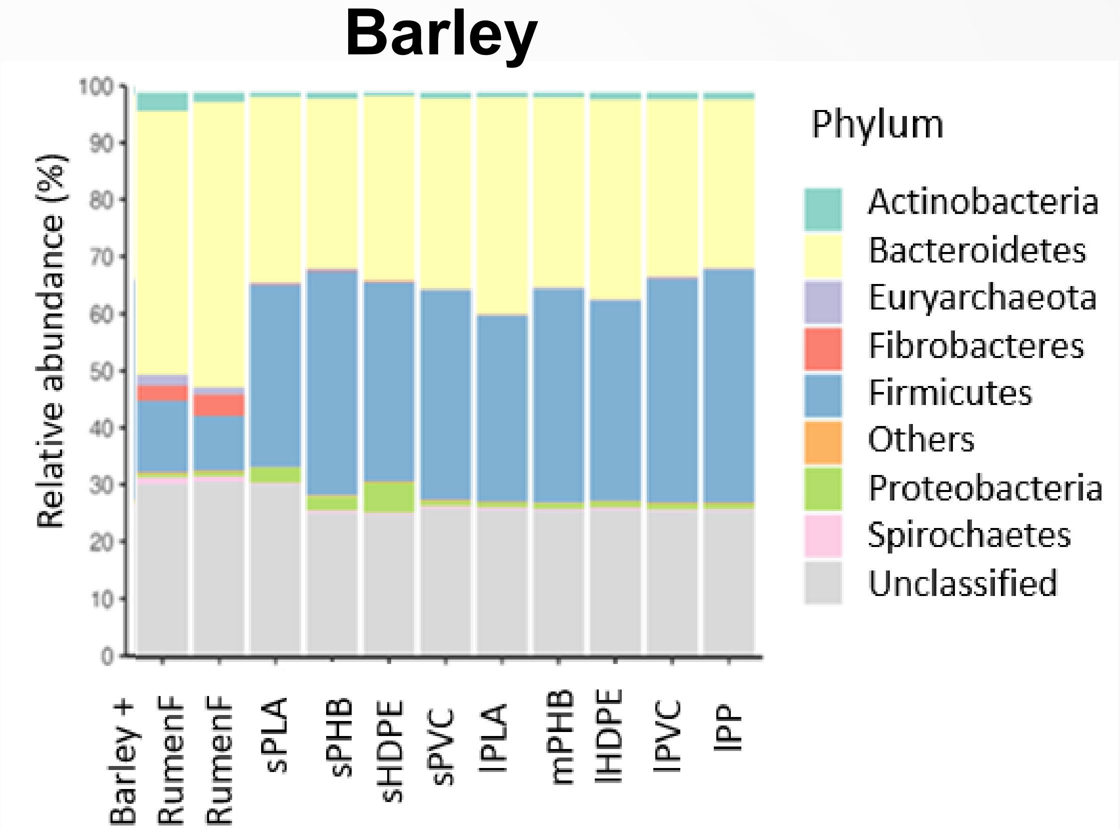


Ruminal gas production declined in the presence of microplastic, irrespective of type/dose of plastic or feed

Total dry matter increased dose-dependently → **<u>plastic breakdown</u>**
<u>Slope differed betw. type/feed</u>

METAPROTEOMICS: PHYLUM LEVEL

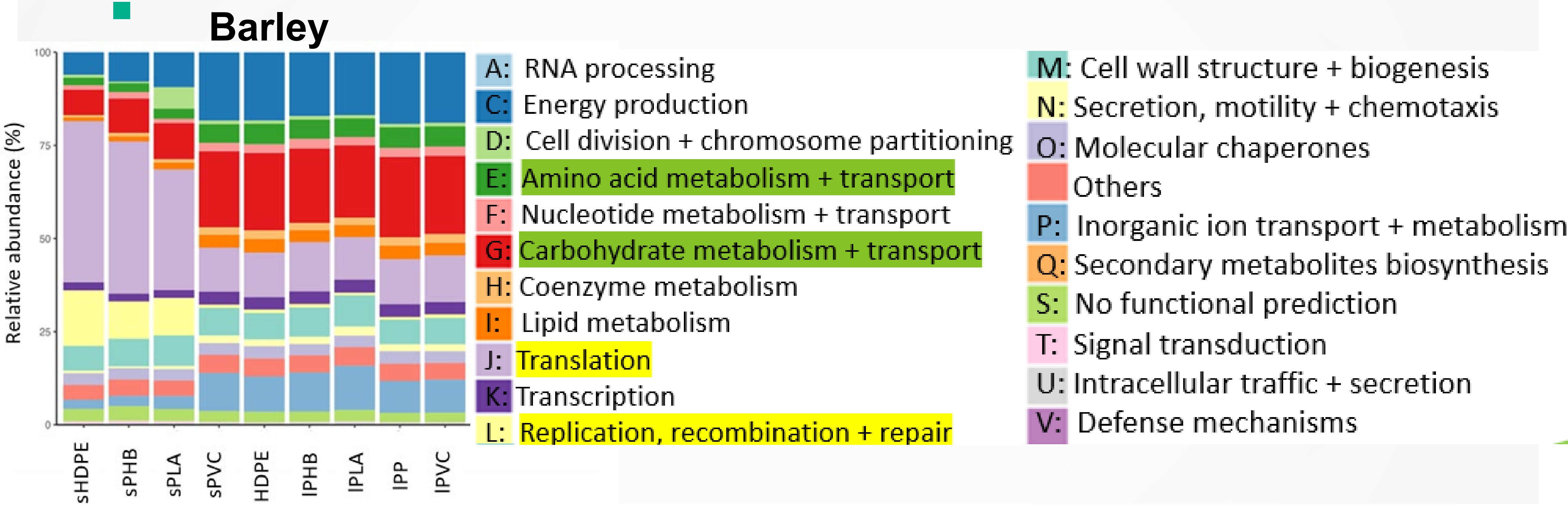




- Taxonomical differences between hay and barley as well as microplastic and control incubations.
- Barley + microplastic incubations showed a **rise in Firmicutes** and parallel **drop in Bacteroidetes**.

Stress!

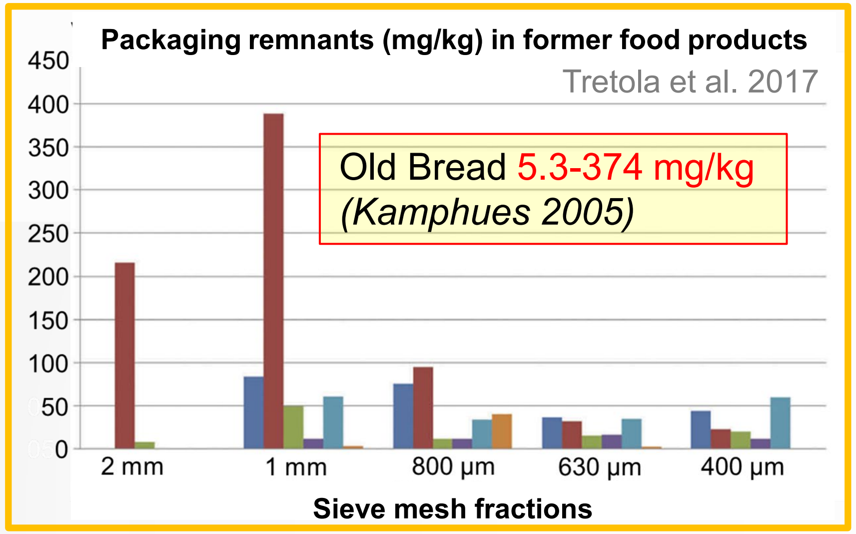
METAPROTEOMICS: METABOLIC REGULATION



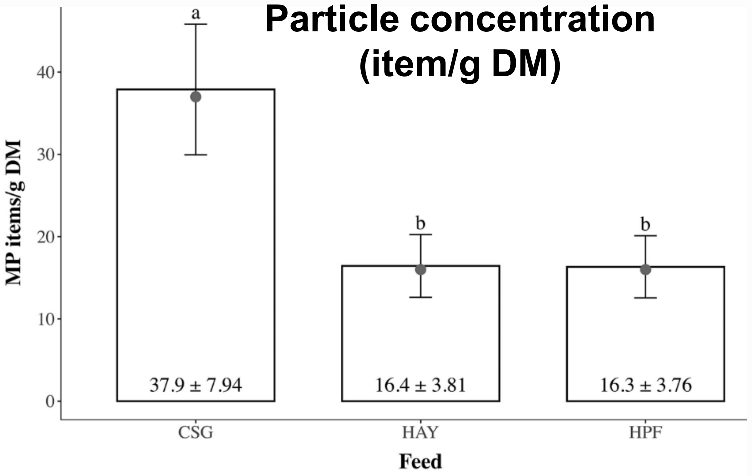
- Almost no proteins were regulated in hay + plastic incubations compared to Barley (2211 of 7570).
- Barley + plastic: **upregulation of** translation, replication, recombination , repair and **downregulation of** amino acid metabolism/transport, carbohydrate metabolism/transport } **Stress!**

PLASTIC CONTAMINATION OF FEED

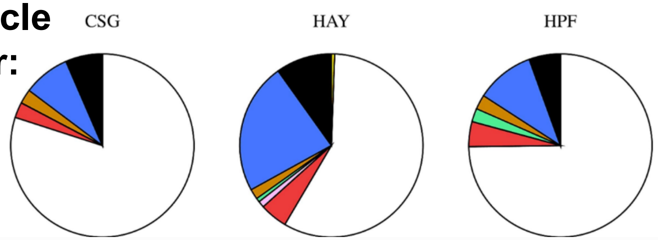
Patrucco et al. 2025

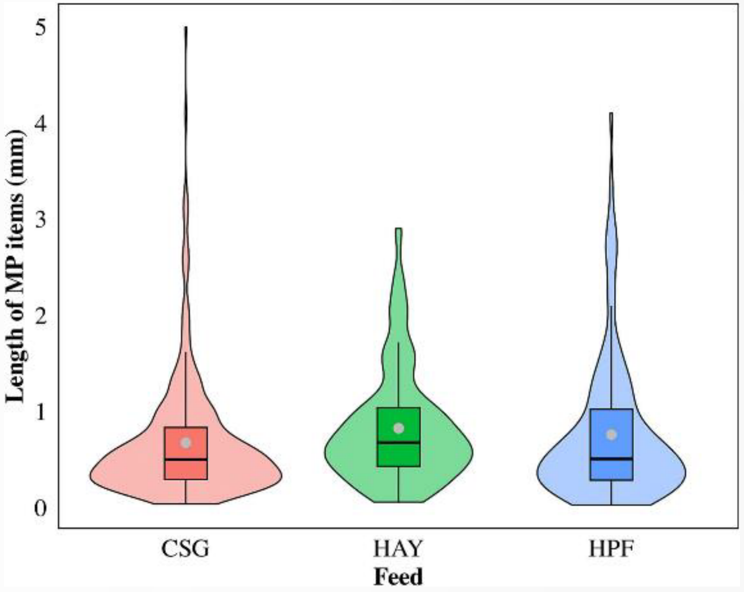


Visible plastic debris in discarded bakery goods for feeding purposes



Particle color:





Length of MP items (mm)

Microplastic polymers found in the three types of feed expressed in percentages

Feed	LDPE	HDPE	PA	p-value
CSG	88±5.2 [86.7] (a)	10±6.6[11.1] (b)	2±1.6 [2.2] (b)	<0.0001
HAY	73±10.3[77.8] (a)	25±7.1[22.2] (b)	2±3.2 [–] (c)	<0.0001
HPF	74±30.8 [88.2] (a)	18±17.6 [11.8] (ab)	8±13.3 [–] (b)	0.0209

CSG, corn silage; HPF, high-protein feed; LDPE, low-density polyethylene; HDPE, high-density polyethylene; PA, polyamide

RUMINANT: STATE-OF-KNOWLEDGE

Study	Model / polymer	Main finding	Implication
Eichinger et al. 2025	In vitro rumen; PE/PS/PVC/PET mix	↓ cumulative gas; ↑ total DM disappearance; metaproteome shifted toward translation / replication–repair	MPs interacted with fermentation biology → All MPs but with differences between sources → No obvious dose-effect except for particle degradation
Tassone et al. 2024	In vitro rumen + post-ruminal; PET	Ruminal CP and NDF degradability decreased; post-ruminal digestibility also affected	Impaired ruminal and intestinal hay degradation
Tassone et al. 2025	In vitro rumen; LDPE	Lower asymptotic gas production but faster fermentation rate	Polymer exposure impaired concentrate fermentation with associated reduction in metabolizable energy
Abid et al. 2025	In vitro sheep rumen; PET, LDPE, PA	↓ degradability, ↓ microbial efficiency, ↓ protozoa; LDPE strongest at highest dose	Disruption of ruminal breakdown with plastic source (LDPE strongest) and source effects

- Independent studies from Turin confirm our observations mostly
- Our initial hypothesis of the rumen and gastrointestinal tract in general, as an important hub in microplastic redistribution in agroecosystems can be confirmed.

MONOGASTRIC/CHICKEN: STATE-OF-KNOWLEDGE

Piglets (in vivo)

- 150 mg/kg diet polystyrene MPs increased diarrhoea and impaired intestinal barrier function.
- The study also reported oxidative stress / inflammation and reduced intestinal angiogenesis via ROS/METTL3-related signalling.
- Interpretation: gut-function impairment is already experimentally plausible in swine.

Zou et al. 2024

Laying hens – tracer study

- After oral dosing with radiolabelled 11.1 mg/kg BW PS-MP, 96.8 ± 14.5% of the dose was recovered in excreta on withdrawal day 1.
- Blood, eggs and tissues together contained <1% of the dose.
- Interpretation: systemic transfer to eggs can be low even when gut exposure is real.

Shelver et al. 2024

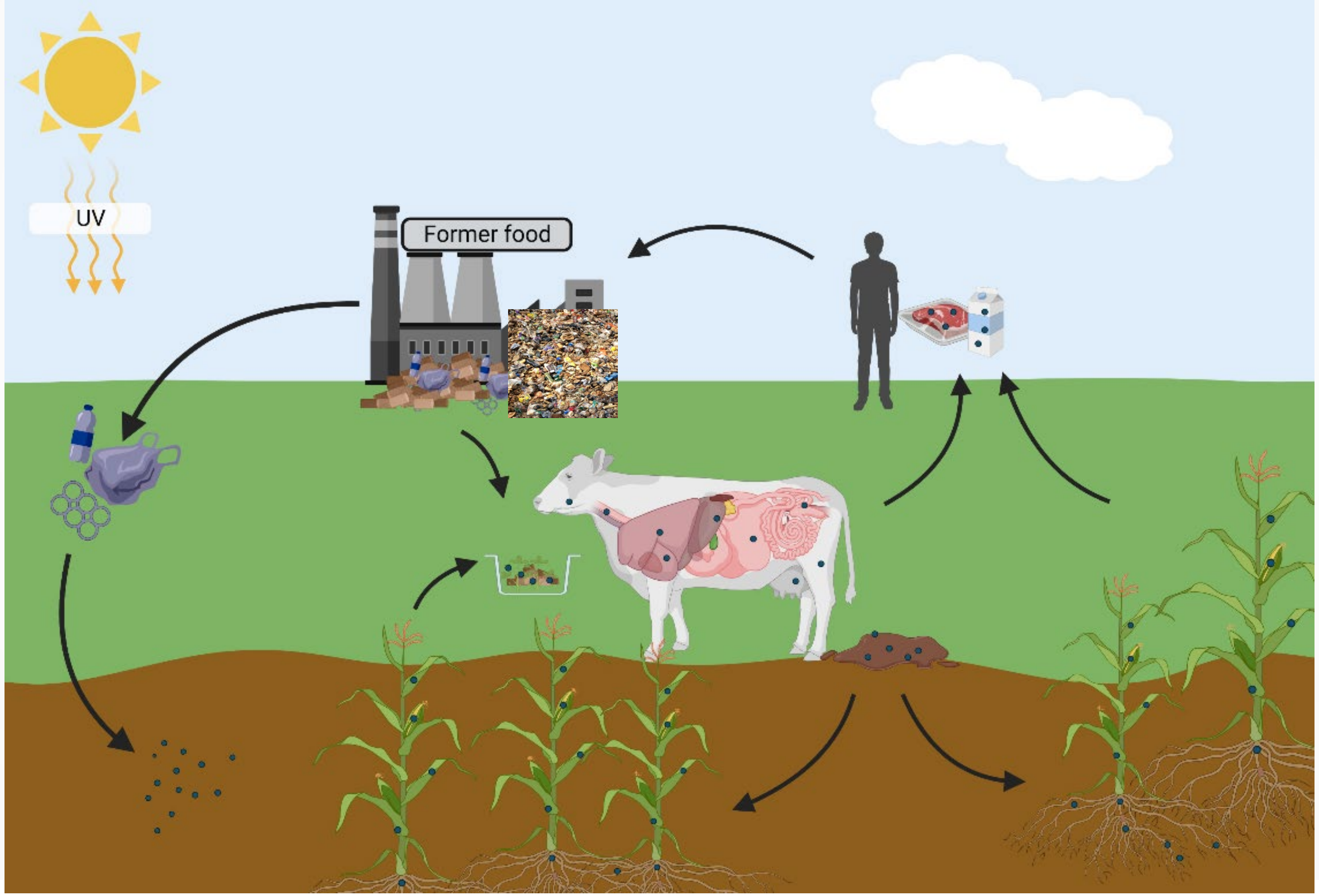
Laying hens – chronic nanoplastic exposure

- 10 mg/kg diet: Intestinal accumulation, villus shortening, goblet-cell loss and tight-junction disruption were observed.
- Cecal microbiota shifted and egg-quality traits declined (egg weight, shell traits, Haugh units).
- Interpretation: gut effects can translate into production-relevant quality signals.

Hu et al. 2025

- Some initial evidence suggests some pathological response:
  → *Reproducibility?*
- Microplastic does not but nanoplastic does affect product measures
  → *Degradation potential in farm animal digestive systems should be a top priority in future research*

MODEL PROPOSAL – MICROPLASTIC EXPOSURE OF FARM ANIMALS



PROPOSAL: ONE-HEALTH CONCEPT OF MICROPLASTICS

1. Feed / farm sources

- Silage films, storage/handling plastics, water and airborne fibres. fibres.
- Former food products and agricultural plastics make exposure plausible before the animal stage.

Farm-animal GI interaction

- Fermentation / digestibility / microbiota shifts
- Barrier, immune and oxidative-stress signalling
- Particle transformation + limited translocation
- Outcome: excretion, product signal or performance effect

2. Animal function / production

- Rumen fermentation, barrier integrity, protozoa and microbiota can change.
- This is the most plausible near-term feed-safety consequence from current data.

3. Environmental safety / recirculation

- Faeces, slurry and litter appear to be major elimination routes in tracer studies.
- That returns MPs to soil and nutrient cycles and links feed safety to agroecosystem safety.

4. Consumer / product safety

- Egg / milk transfer can be low in in tracer studies, but product matrices remain methodologically methodologically difficult.
- Post-animal contamination (e.g. milk handling/processing) can still dominate the observed signal.

NEXT STEP: ESTABLISHING AN ANALYTICAL PLATTFORM TO ENABLE TRANSFER STUDIES

Platform	What it delivers best	Main limits in feed / products	Current Finnish readiness
Cleanup / digestion	Makes complex organic matrices measurable; preserves particles for later ID	The real bottleneck for feed, milk, egg and excreta; blank control and recovery testing are decisive	Finnish method-development exists, including protease-assisted cleanup
µFTIR / FPA-FTIR imaging	Particle counts, size, morphology and polymer class at routine throughput	Typically misses the smallest particles; practical lower bound often ~10–20 µm	SYKE and UEF both have FTIR-based capability
µRaman	Higher spatial resolution and confirmatory polymer ID for small particles / fibres	Slow throughput and fluorescence problems are common in biological matrices	UEF SIB offers confocal Raman imaging
Py-GC/MS	Polymer mass load, including very small particles not seen as particles	No particle counts, no size, no morphology; cannot separate contamination routes alone	SYKE and Finnish method papers already show active capability

Questions?

- We are currently preparing a Makera Proposal to monitor the situation on Finnish Dairy and Egg Farms (feed, products, excreta).
- If someone wants to choin us in an active or consulting role, please reach out !!!!