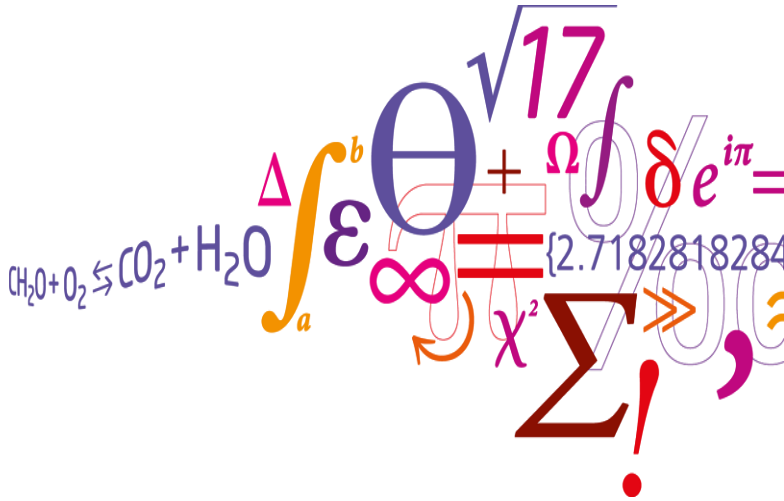
Microplastics in groundwater

Aiga Mackevica & Nanna B. Hartmann



DTU Environment
Department of Environmental Engineering

Overview

- **Part 1: Literature study**

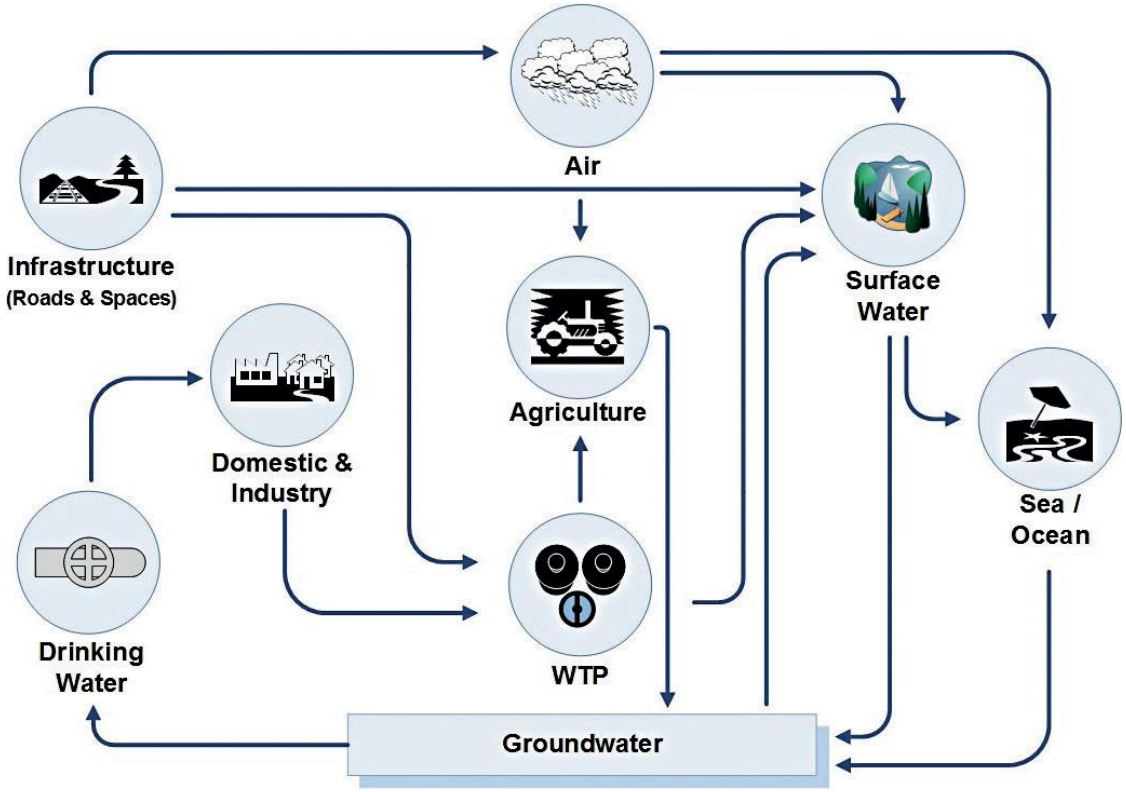
  Sources of microplastics in the environment and possible routes to groundwater

- **Part 2: Measurements of microplastics in groundwater**

  Sampling and analysis methods

Sources and sinks of microplastics

Potential pathways of microplastics to groundwater

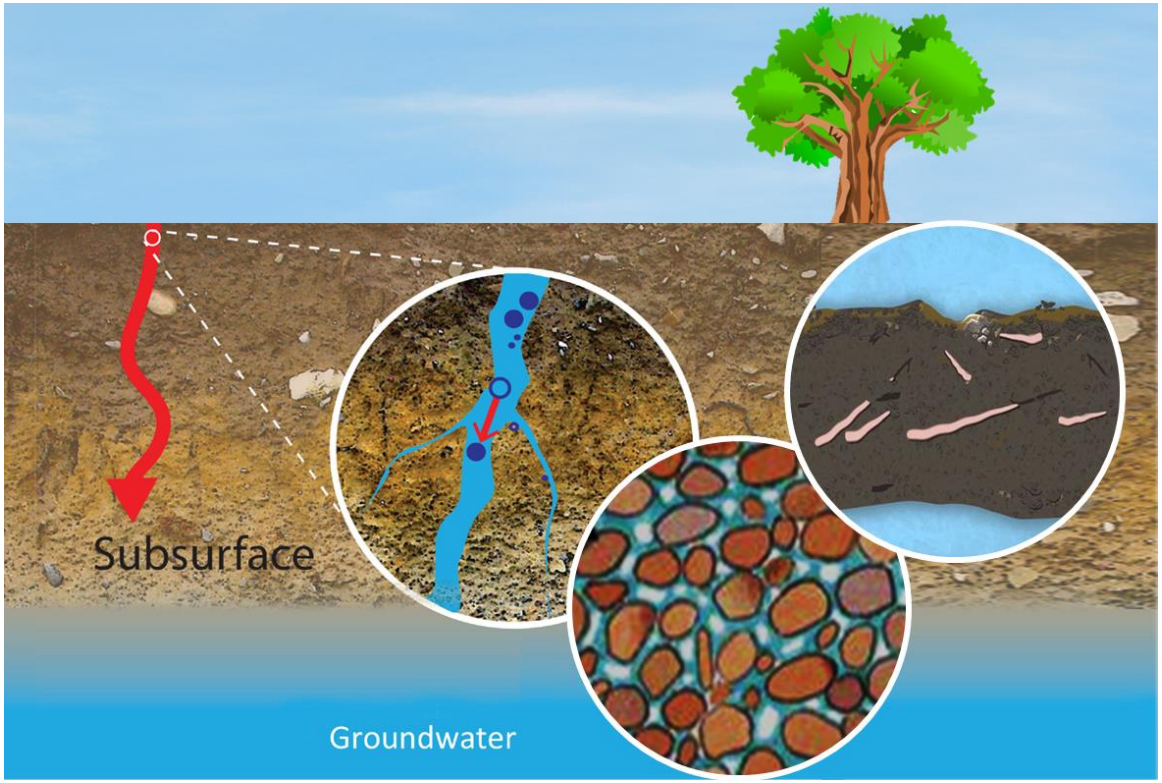


Venghaus and Barjenbruch, 2017. Czas. Tech. 1, 137–146

MP transport to groundwater

Possible transport mechanisms based on literature on colloid transport and nanoparticle transport through soil

- Leaching
- Bio-turbation
- Cracks and fractures



MP transport to groundwater

- Microplastics larger than **1 µm** are highly unlikely to reach groundwater
  - *Too large to seep through the pores*
  - *Density slows the leaching processes*

- However, possibility of minor contamination with MPs in the size of **colloids** (<1 µm) and **nanoparticles** (<100 nm) cannot be excluded
  - *Smaller microplastic particles can be more mobile, but extremely difficult to analyze*

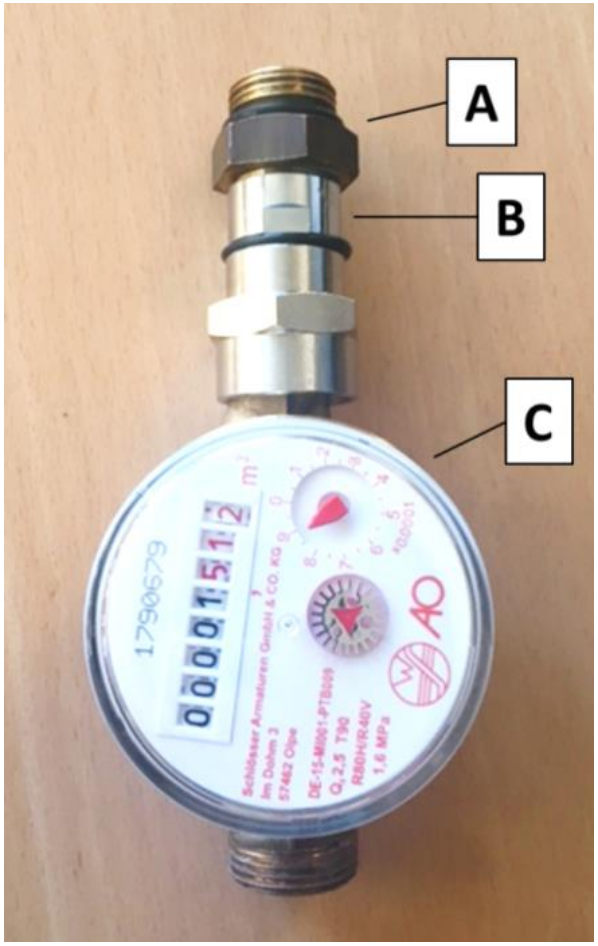
Part 2: Measurements of MPs in Danish groundwater

- **6 boreholes** in different locations in Denmark
- **3 sampling volumes** (10, 50 and 100L to account for contamination)

Sampling locations

	Lokalitet/ Vandværk	Forerør materiale	Dybde (m)	Geologi – grundvands-magasin
Novafos	Mortenstrup (Hørsholm)	PVC	Ca. 90	Kalk
Novafos	Mortenstrup (Hørsholm)	Stål	Ca. 85	Kalk
HOFOR	Assermølle (Lejre)	PVC	34	Kalk
HOFOR	Solhøj (Hedehusene)	PVC	36	Kalk
Rødekro vand	Rødekro Nord	PVC	148	Sand
Arwos	Farversmølle (Aabenraa)	PVC	64	Sand

Sampling equipment



- **A:** Mounting connection (chrome or brass)
- **B:** Filterholder (chrome) with a rubber ring to keep filter in place

  Steel filter with 10µm pore size
- **C:** Flowmeter

- **Closed system**
  - *Avoids contamination*
  - *Avoids aeration*

Aabenraa, Farversmølle vandværk

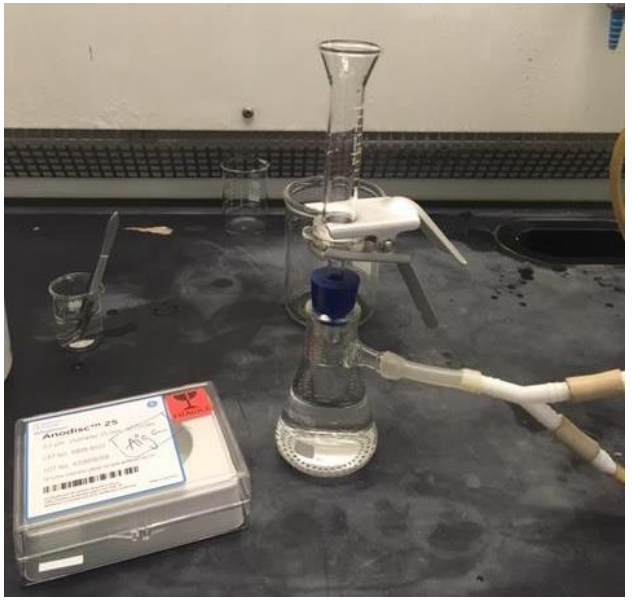
Mortenstrup, Hørsholm

Mortenstrup, Hørsholm

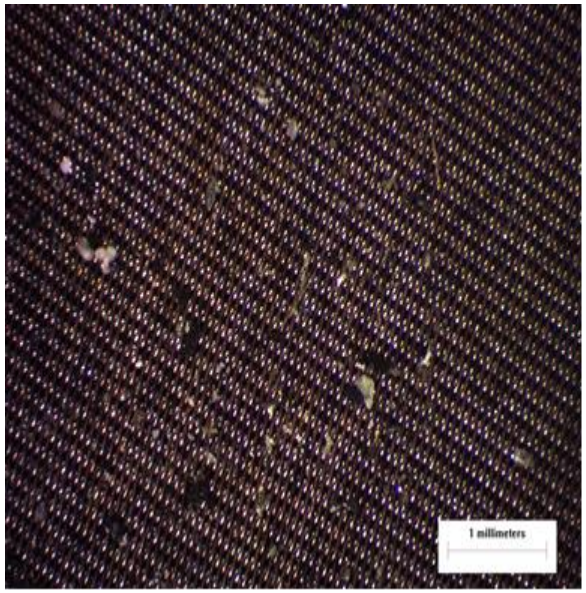
Sampling & analysis

- Sampling volumes 1x 10 L, 3x 50 L, 1x 100 L
- Visible light microscopy (all steel filter samples)
- FTIR identification of microplastics

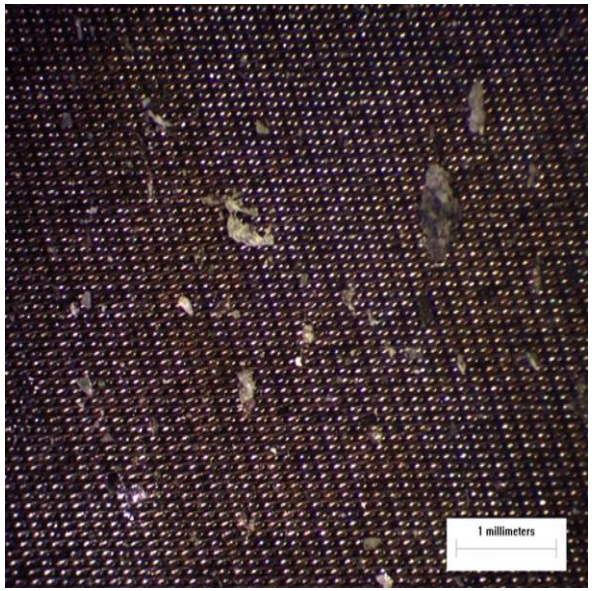
  Resuspension →
  filtration on Anodisc filter →
  µFTIR analysis



Mortenstrup (Hørsholm)
Novafos – MO105



50 L – replikat 1



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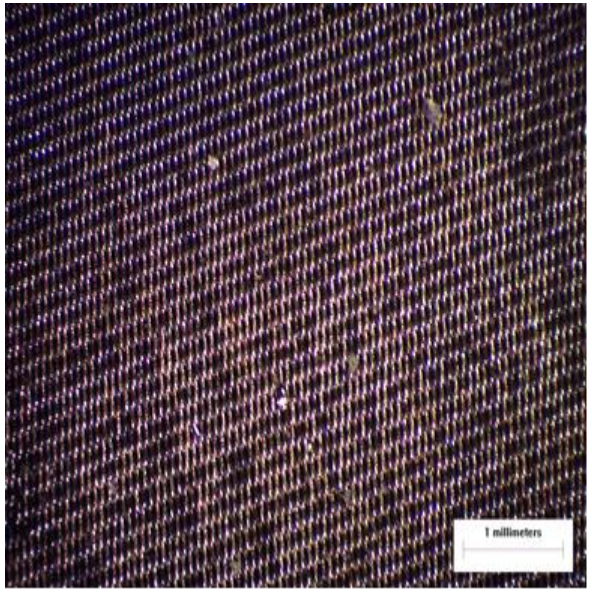
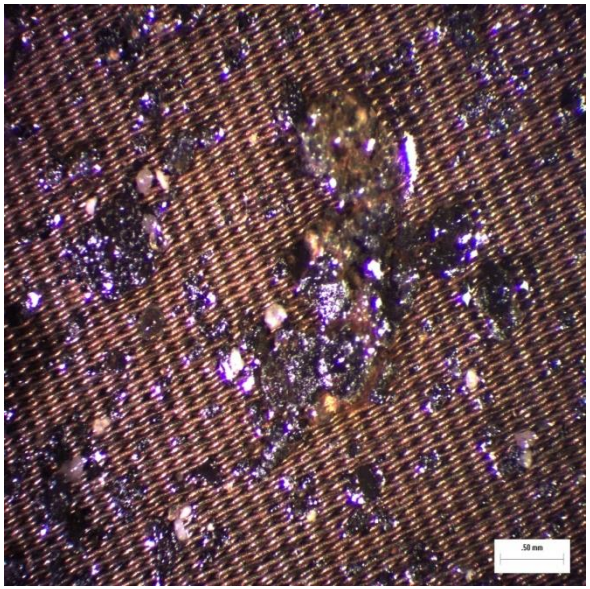


50 L – replikat 3

Mortenstrup (Hørsholm)
Novafos – MO108



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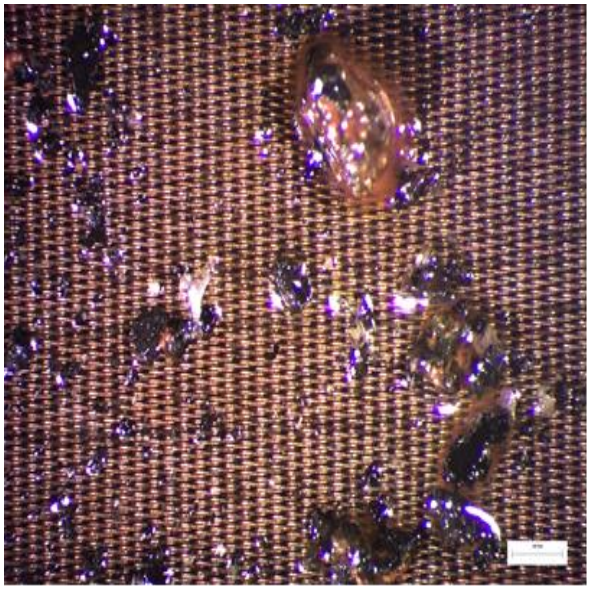

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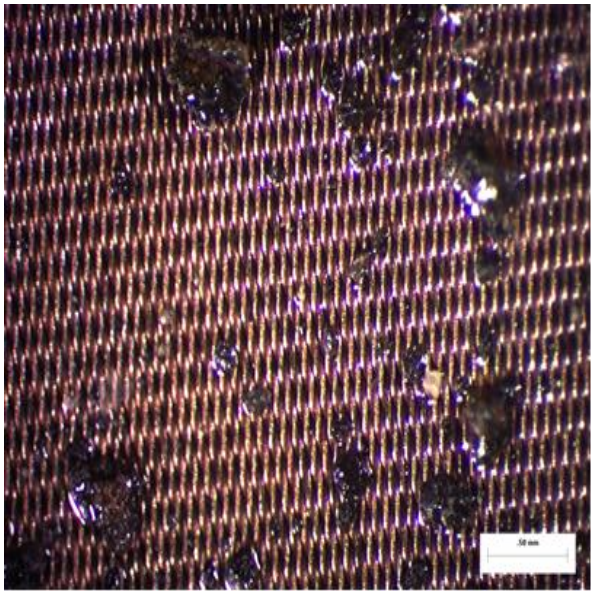
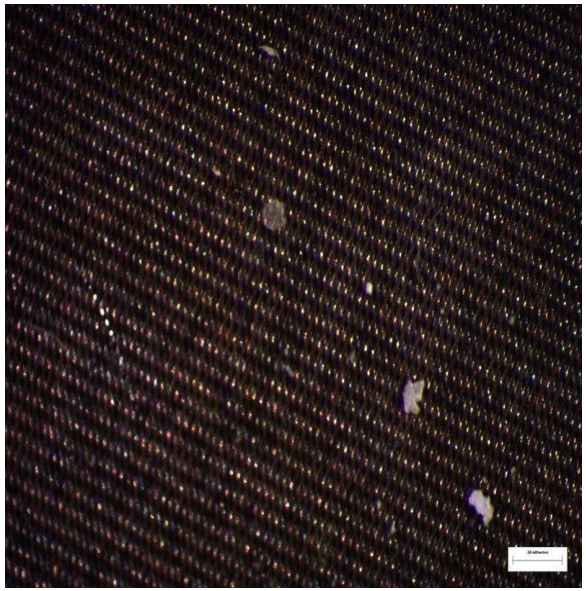


50 L – replikat 3

Solhøj (Hedehusene)
HOFOR



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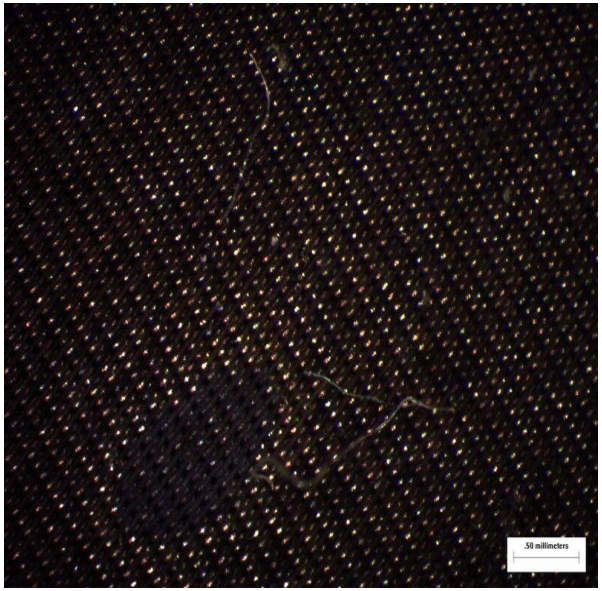

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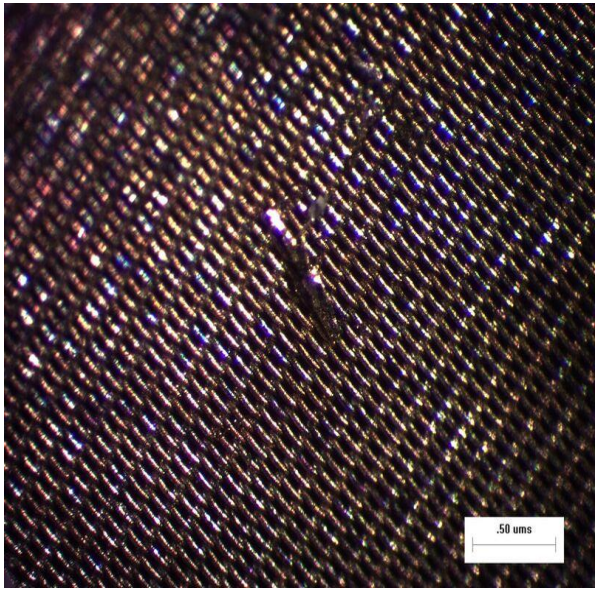
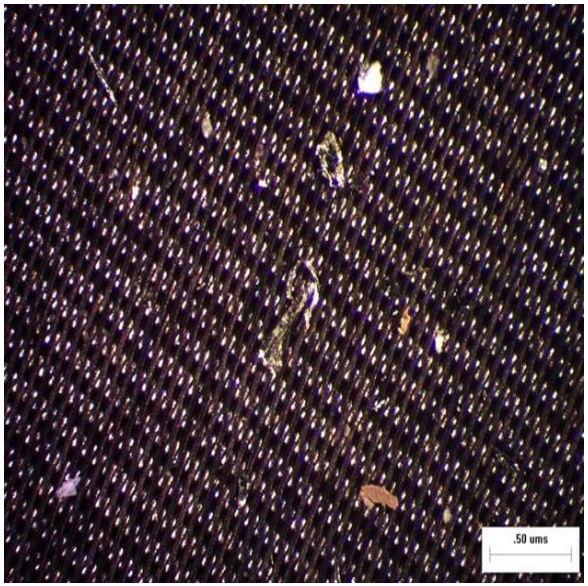


50 L – replikat 3

Farversmølle (Aabenraa)
Arwos



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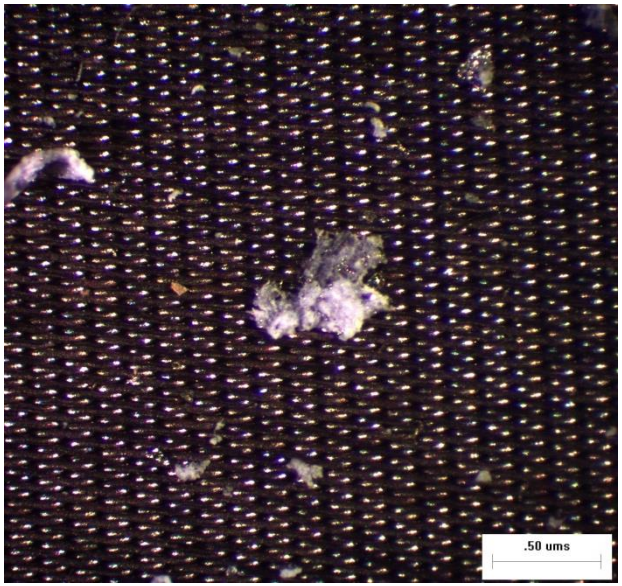
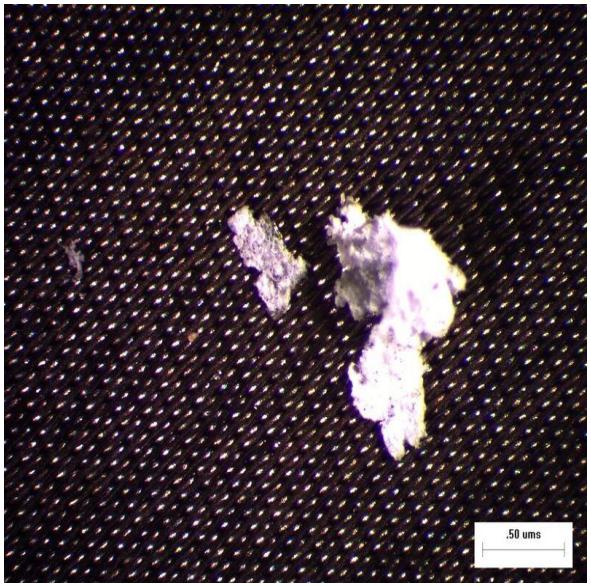


50 L – replikat 2



50 L – replikat 3

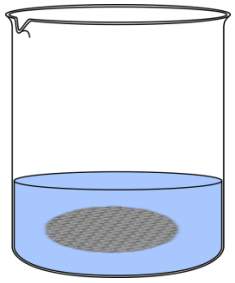
µFTIR samples

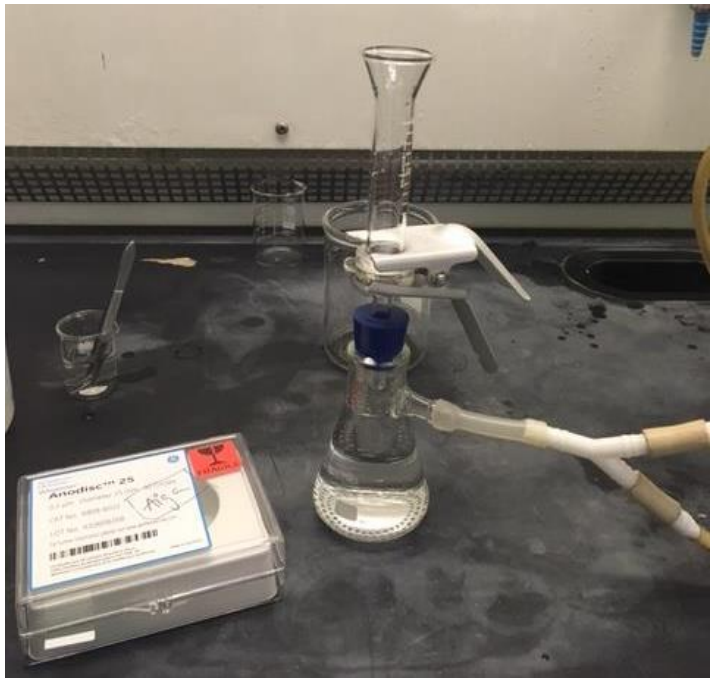
Resuspension in deionized water →

Ultrasonication →

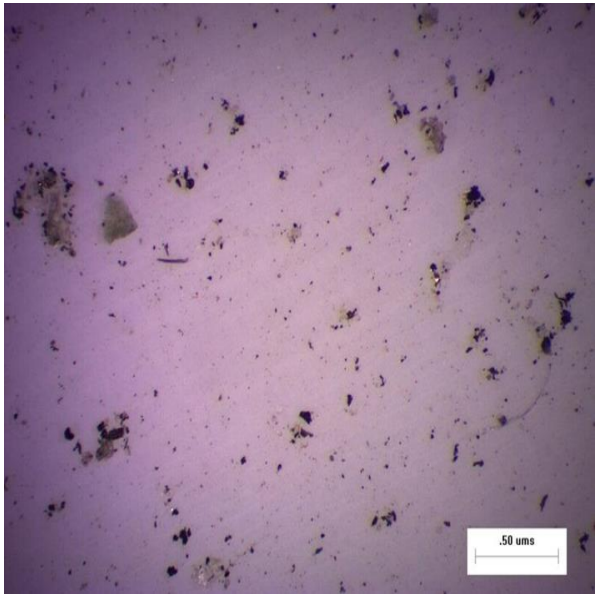
Filtration on Anodisc filter →

µFTIR analysis





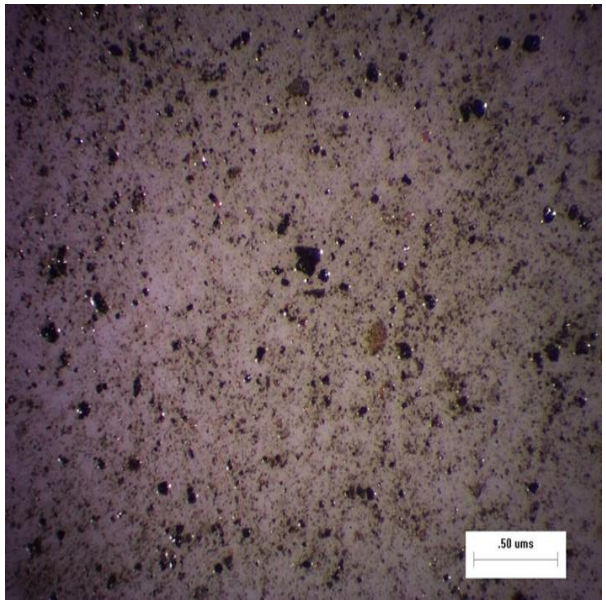
Anodisc filters



Mortenstrup (Hørsholm)

Novafos – MO105

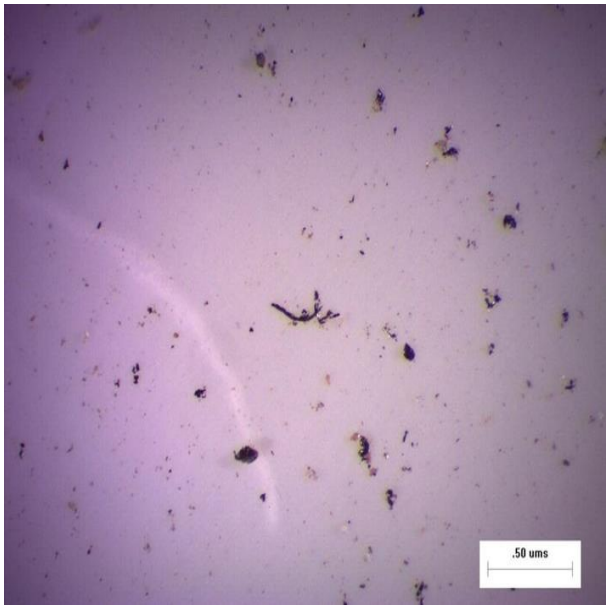
(50 L - replikat 3)



Mortenstrup (Hørsholm)

Novafos – MO108

(50 L - replikat 1)



Assermølle (Lejre)

HOFOR

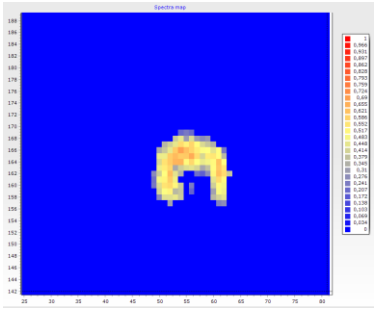
(50 L – replikat 2)

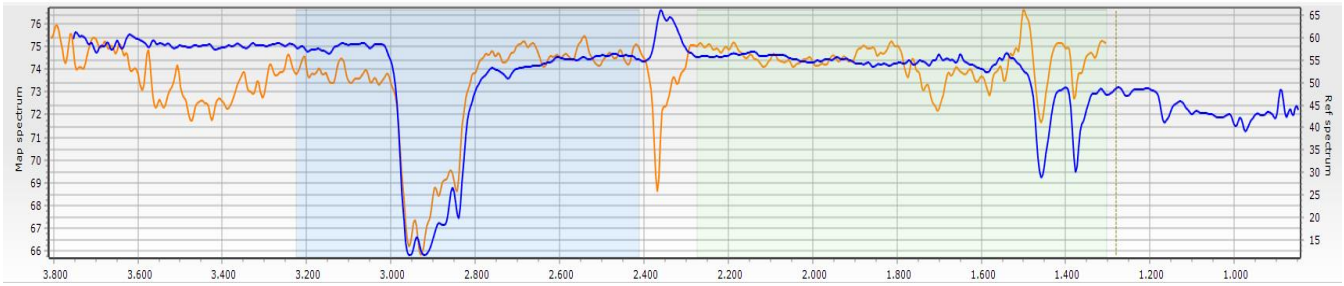
µFTIR analysis

- MPhunter software (Aalborg University)

- Fitting the collected spectra against a polymer reference library

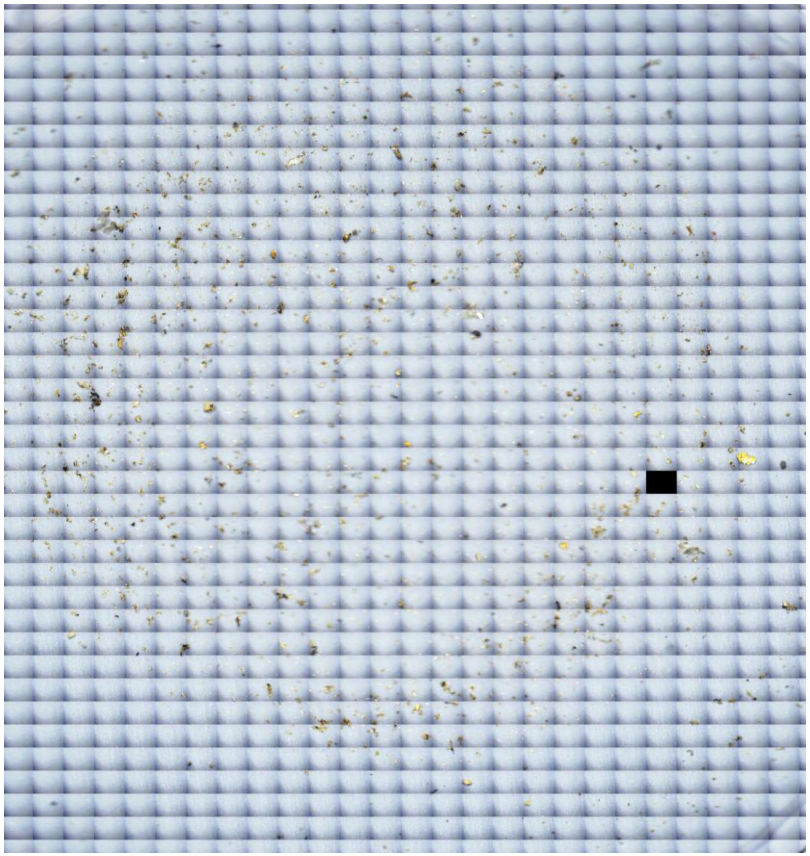
- Identifying MPs and natural particles





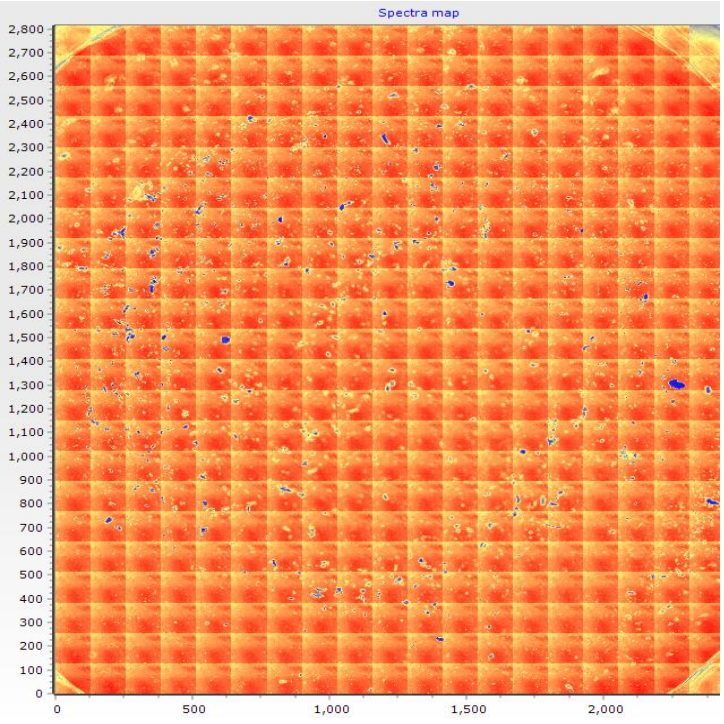
PP particle in blank Anodisc sample

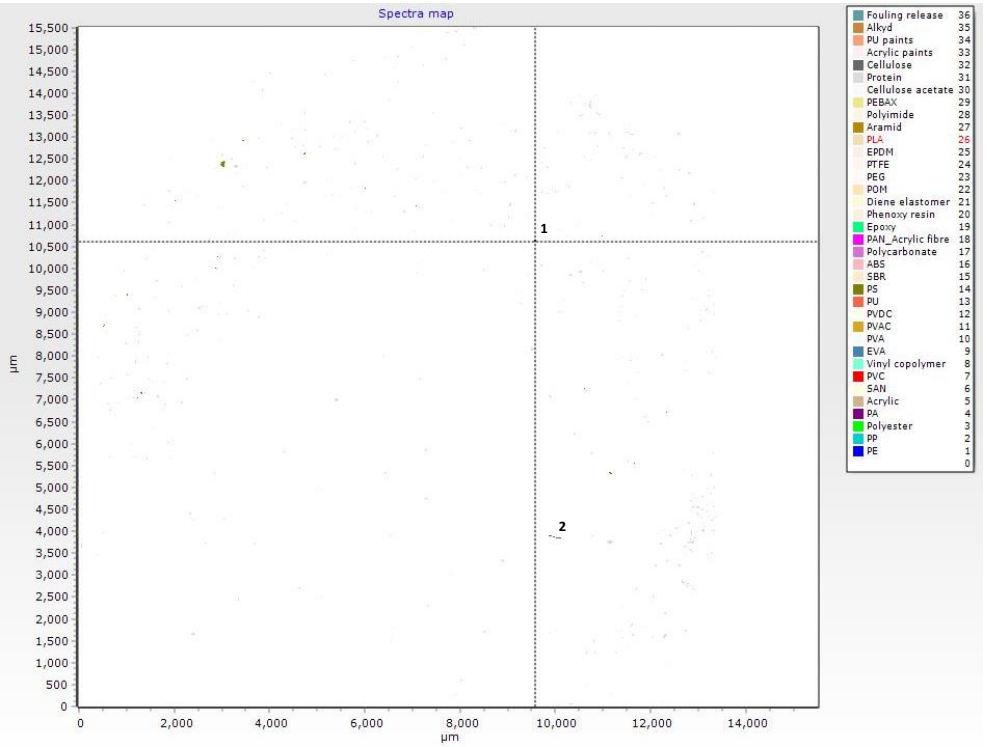
µFTIR analysis



Assermølle 100L

µFT-IR analysis



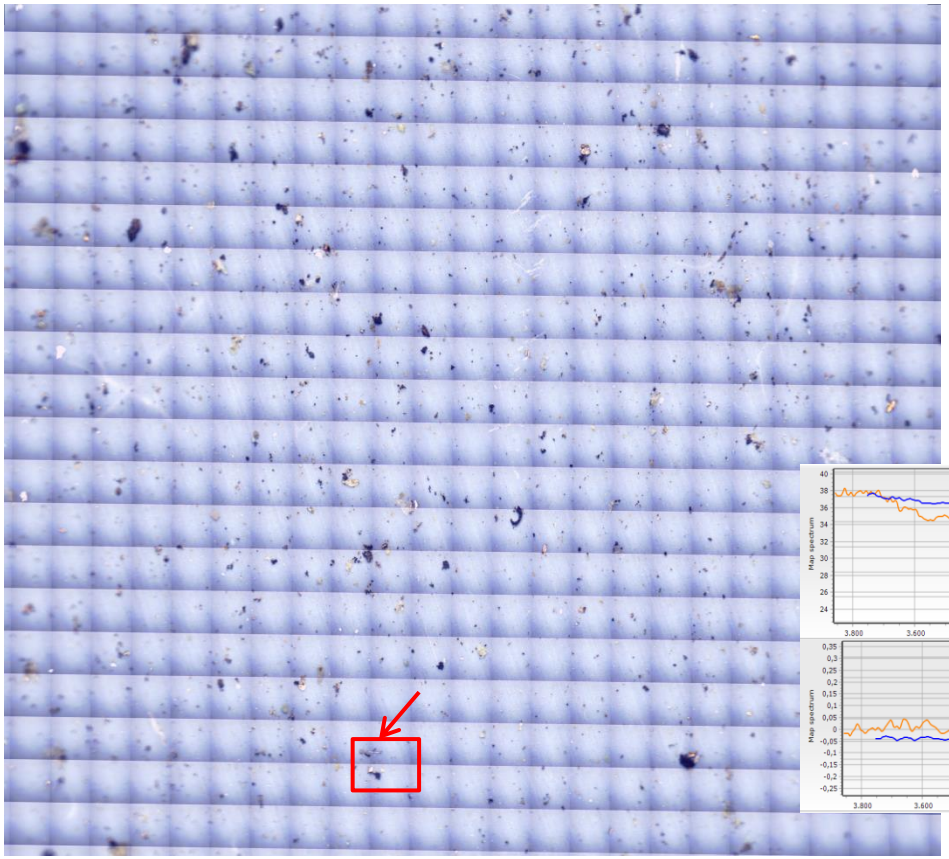


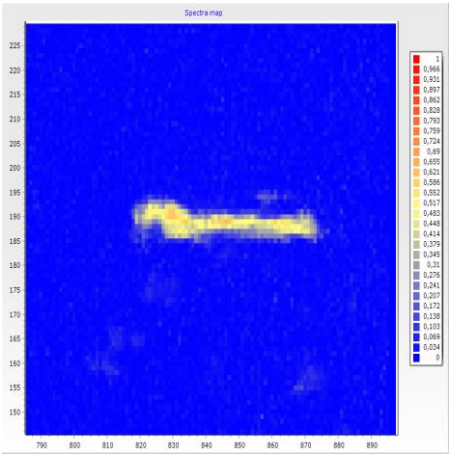
Assermølle 100L

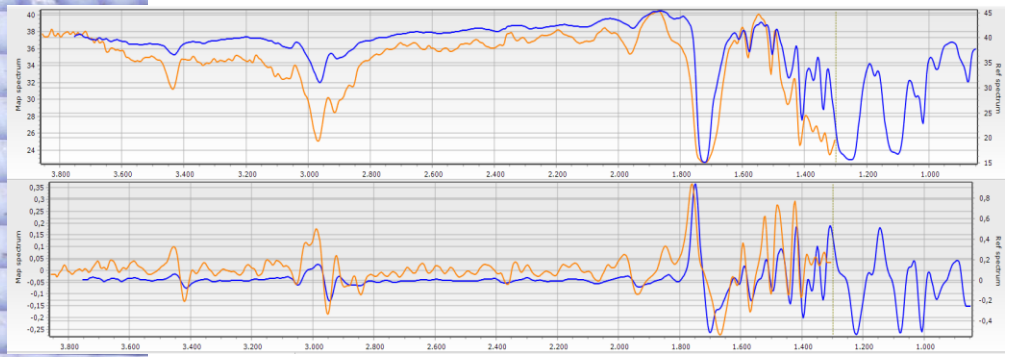
1: PA, 2: Cotton fiber

µFTIR analysis

- Mortenstrup (Hørsholm), 50L - replicate nr.3.
  - Results: PET particle (rod-shaped, ca. 250µm x 50µm)







Results summary

- Relatively few particles were identified as microplastics, **<10 microplastic particles per sample**
- **Most fibers** that were found on the filters turned out to be **inorganic** (probably from steel filter) or **natural** (cotton, cellulose)
- Three polyester fibers were found, possibly **contamination from clothing**
- No **PVC** particles found (material for most boreholes)

Results - Blank and control samples

Prøve	Partikeltype (mikroplast)	Antal	Naturlige partikler	Antal	Fibre
Blank Anodisc	PS	7	Protein Cellulose	33 3	
Kontrol, deioniseret vand	PP PA	1 1	Protein Cellulose	14 2	
Kontrol, rent stålfilter	PP PS	1 1	Protein Cellulose	765 4	Bomuldsfiber 1mm

Results – Assermølle and Mortenstrup

Prøve	Partikeltype (mikroplast)	Antal	Naturlige partikler	Antal	Fibre
Assermølle 10L	PA	1	Protein	165	
	PS	145	Cellulose	6	
Assermølle 50L, repl.nr.1	PP	1	Protein	644	
	Polyester	3	Cellulose	1	
	PA	4			
	PS	51			
Assermølle 100L	PA	1	Protein	455	Bomuldsfiber 295µm
	PS	15	Cellulose	2	
Mortenstrup MO108 10L	Polyester	5	Protein	159	Bomuldsfiber 521µm Polyester fiber 395µm
	Cellulose acetate	1	Cellulose	5	
	Acrylic paints	1			
Mortenstrup MO108 50L repl.nr.3	Polyester	3	Protein	743	Polyester fiber 414µm Bomuldsfiber 344µm, Protein-baseret fiber 5mm
	Cellulose acetate	3	Cellulose	10	
Mortenstrup MO108 100L	Acrylic paints	2			
	Cellulose acetate	1	Protein	397	
			Cellulose	2	
	Polyester	2			

Uncertainties and challenges

- **Analytical challenges** –
  - *Anodisc filters might not be the best substrate for FTIR analysis, since they are not completely IR transparent and absorb the "fingerprint" region of the spectrum*

- **Sample treatment** –
  - *Resuspension and filtration of collected samples results in **sample loss** and **introduces contamination***
  - *Variation of conditions between labs*

- ***Sample transportation and storage –***
  - *Turbulence during sample transportation may result in **sample loss** (particles are not fixed on the filter)*
  - *Storage in PS petri dishes can potentially introduce contamination*

Conclusions

- Based on the FTIR data, **most of the particles** found on the steel filters are **not microplastics**
- Most particles found are probably due to **contamination during sampling and storage**
- According to the literature study, the particles that were found are too big (>20 µm) to be coming from groundwater
- **Cleaner facilities** are needed for microplastic sample treatment to avoid contamination
- More advanced analytical methods are needed to **sample and identify microplastics <1 µm**

Acknowledgements

Thanks to:

- Novafos
- HOFOR
- Rødekro vand
- Arwos
- Aalborg University microplastics group - *Jes Vollertsen, Nikki Van Alst, Alvise Vianello and Marta Simon*
- Århus University – *Jakob Strand*