Microplastics in a University Wastewater Treatment Plant and a Small Community Aerated Wastewater Stabilization Pond

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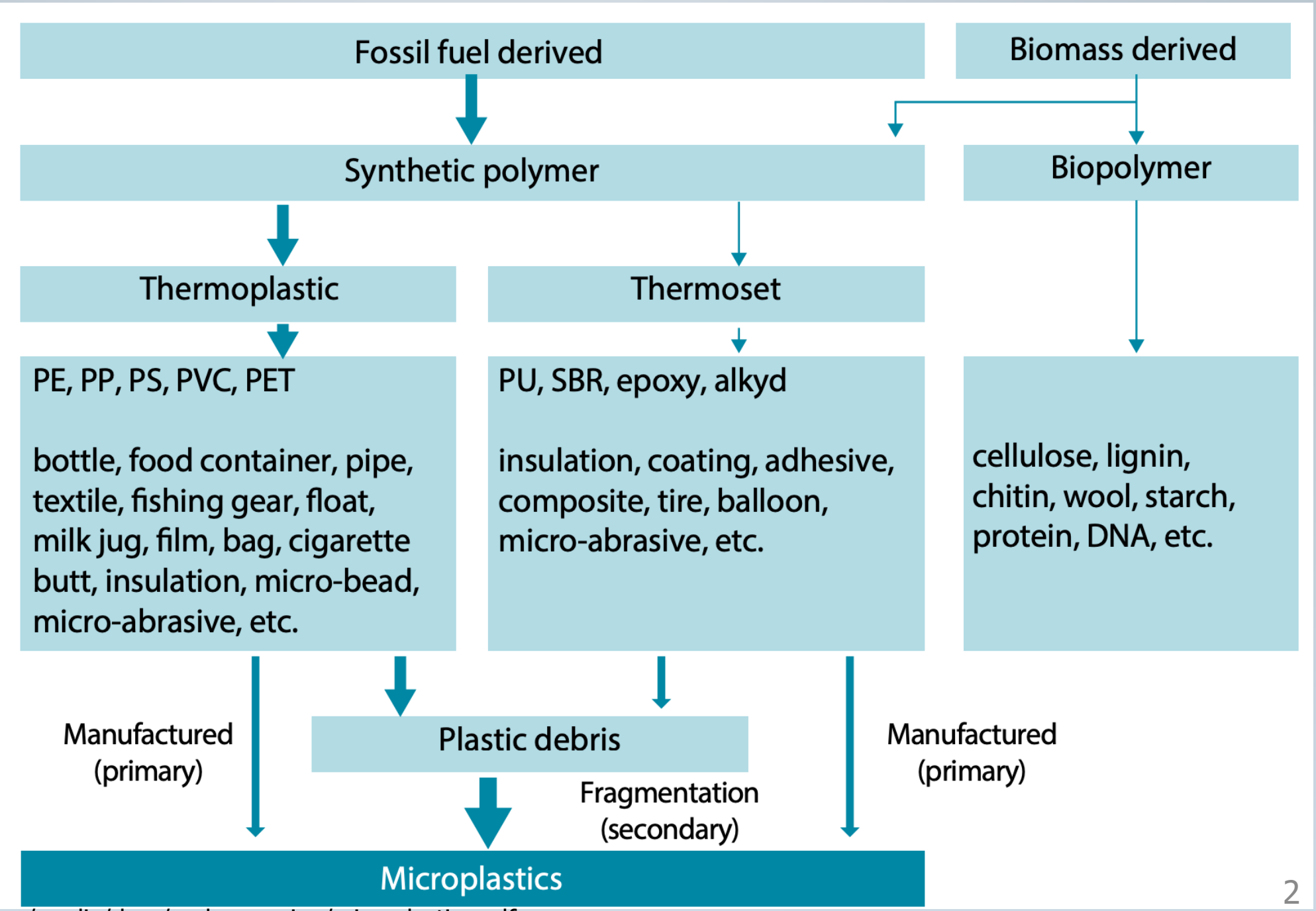
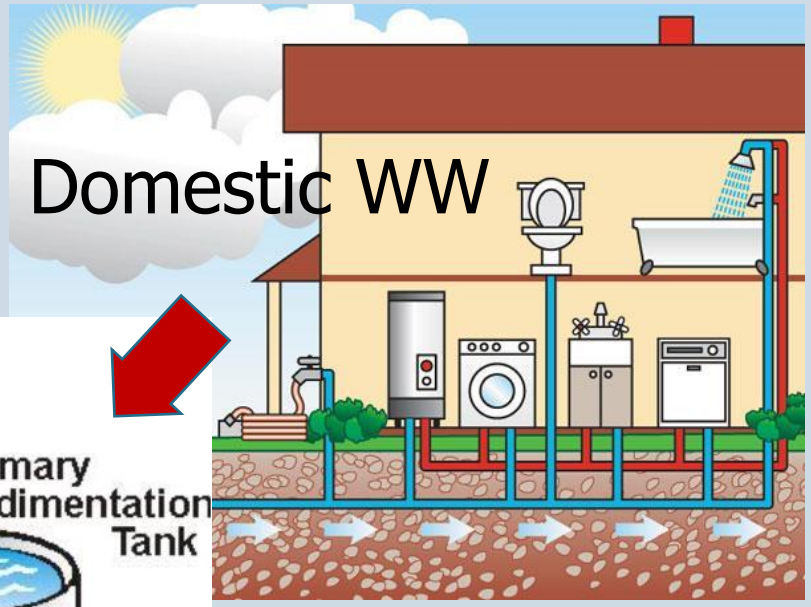
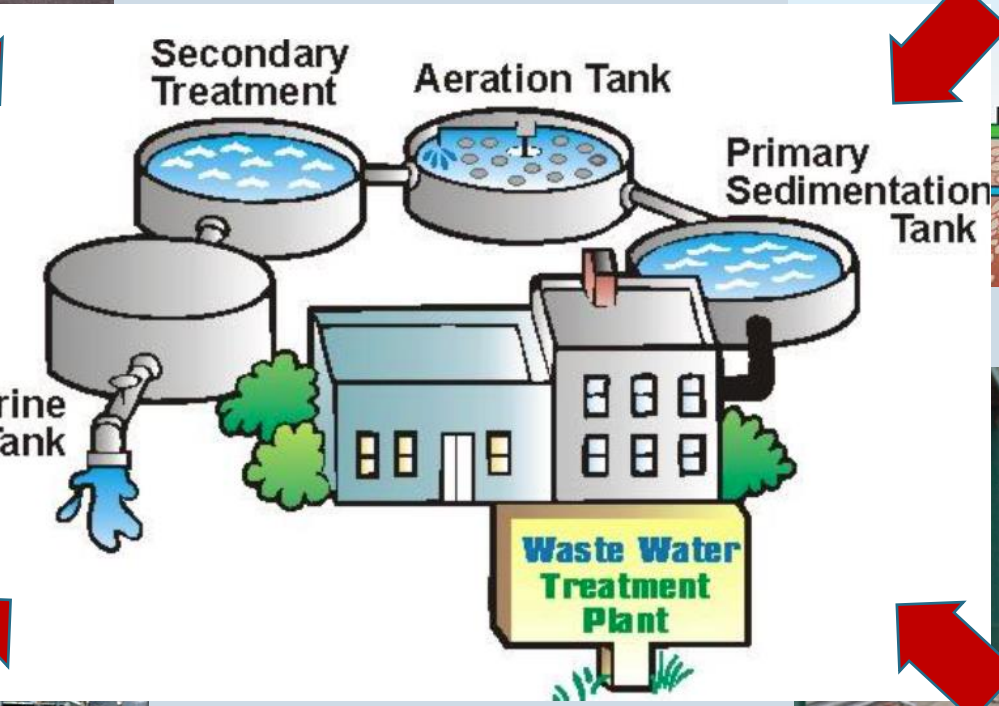
Types of Polymers & Micro-plastics



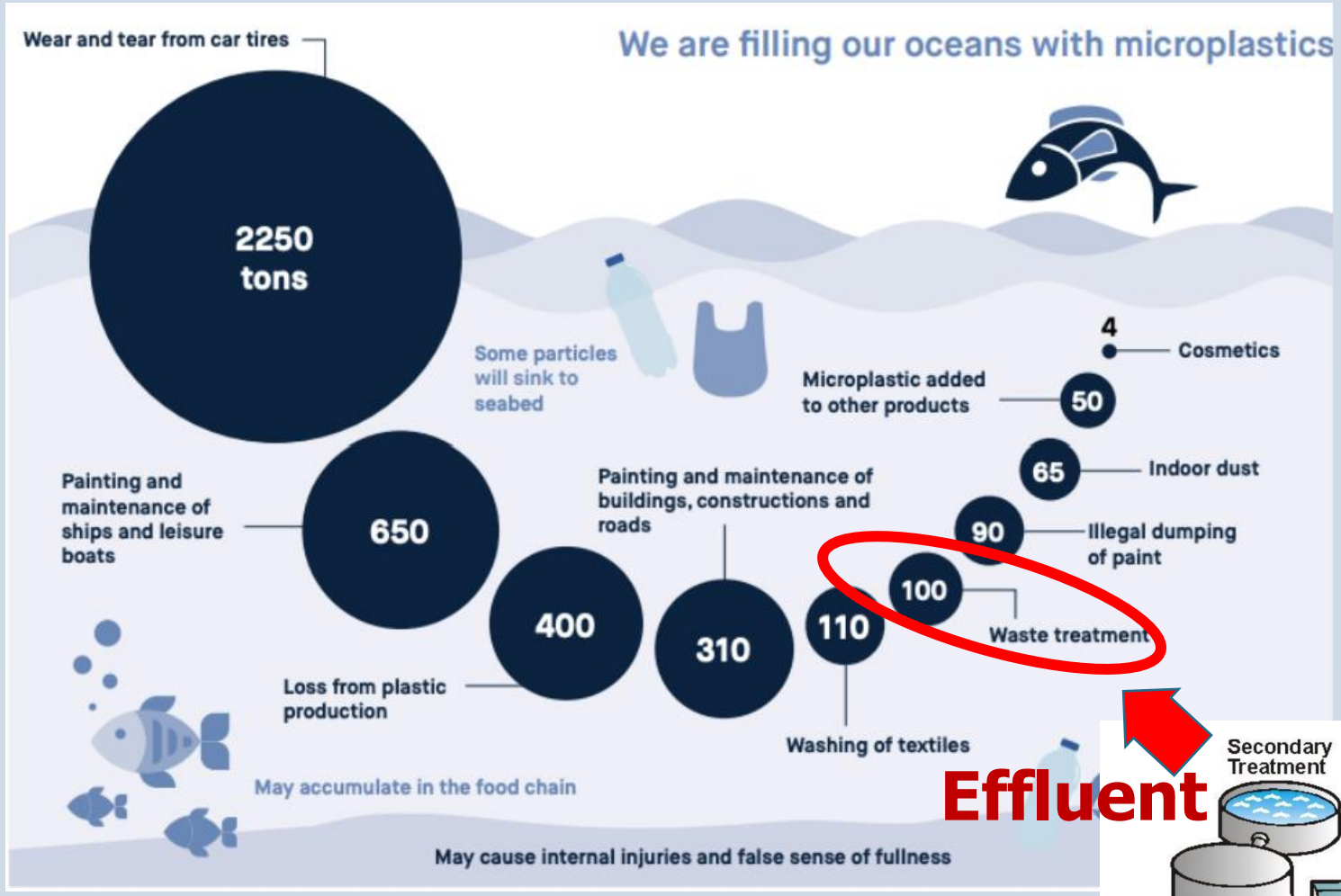
Source:https://uneplive.unep.org/media/docs/early_warning/microplastics.pdf

WWTPs: A Sink for Microplastics



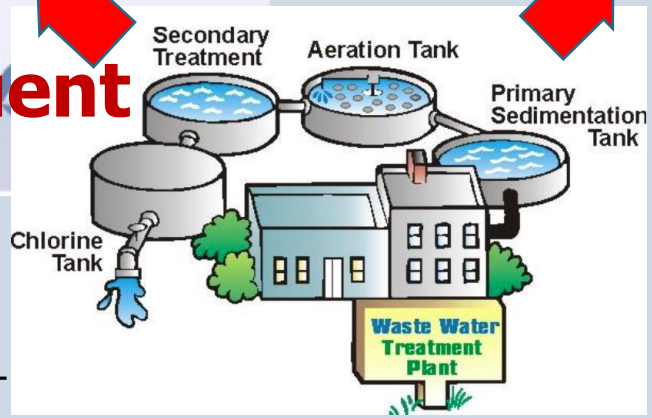


WWTPs: A Source for Microplastics



Sludge

Effluent



Fertilizer

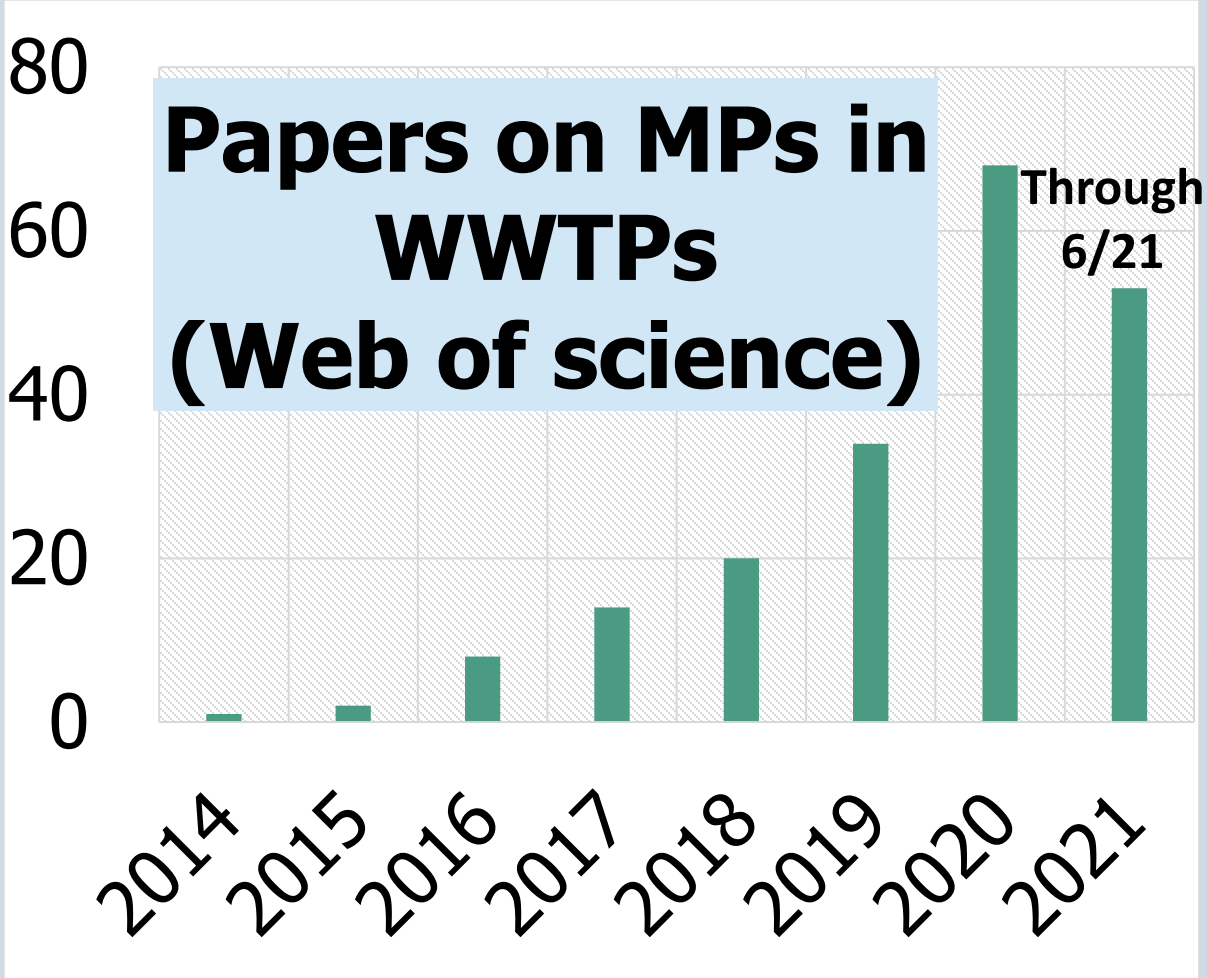
Landfills

Incineration

Source: https://mirpurifoundation.org/wp-content/uploads/2018/05/Perils-of-Plastic_Dra.-Lu%C3%ADza-Mirpuri.pdf

Motivation

- WWTPs were not designed for MPs, yet typically remove >95% by mass.
- Most MPs transfer to sludge, but effluent still contains MP levels above receiving waters.
- There are many reports on MPs in WWTPs, but few, if any, on the types, distribution, and fate of MPs in:
  - A university WWTP with variable flows due to drastic population changes on-campus
  - Aerated wastewater stabilization ponds (WSP) found in rural & small communities worldwide



Objectives

- Assess the prevalence, distribution, & fate of MPs in 2 understudied WW treatment systems:
  - A University WWTP
    - Spatially (within different compartments)
    - Temporally (with different flow regimes)
  - A community WSP
    - Spatially (within different compartments)
    - Temporally (seasonally)
- Characterize the types, shapes, colors, & sizes of MPs to help understand their sources, transport, & fate.

University of Mississippi WWTP

WWTP at University of Mississippi

Typical Flows:

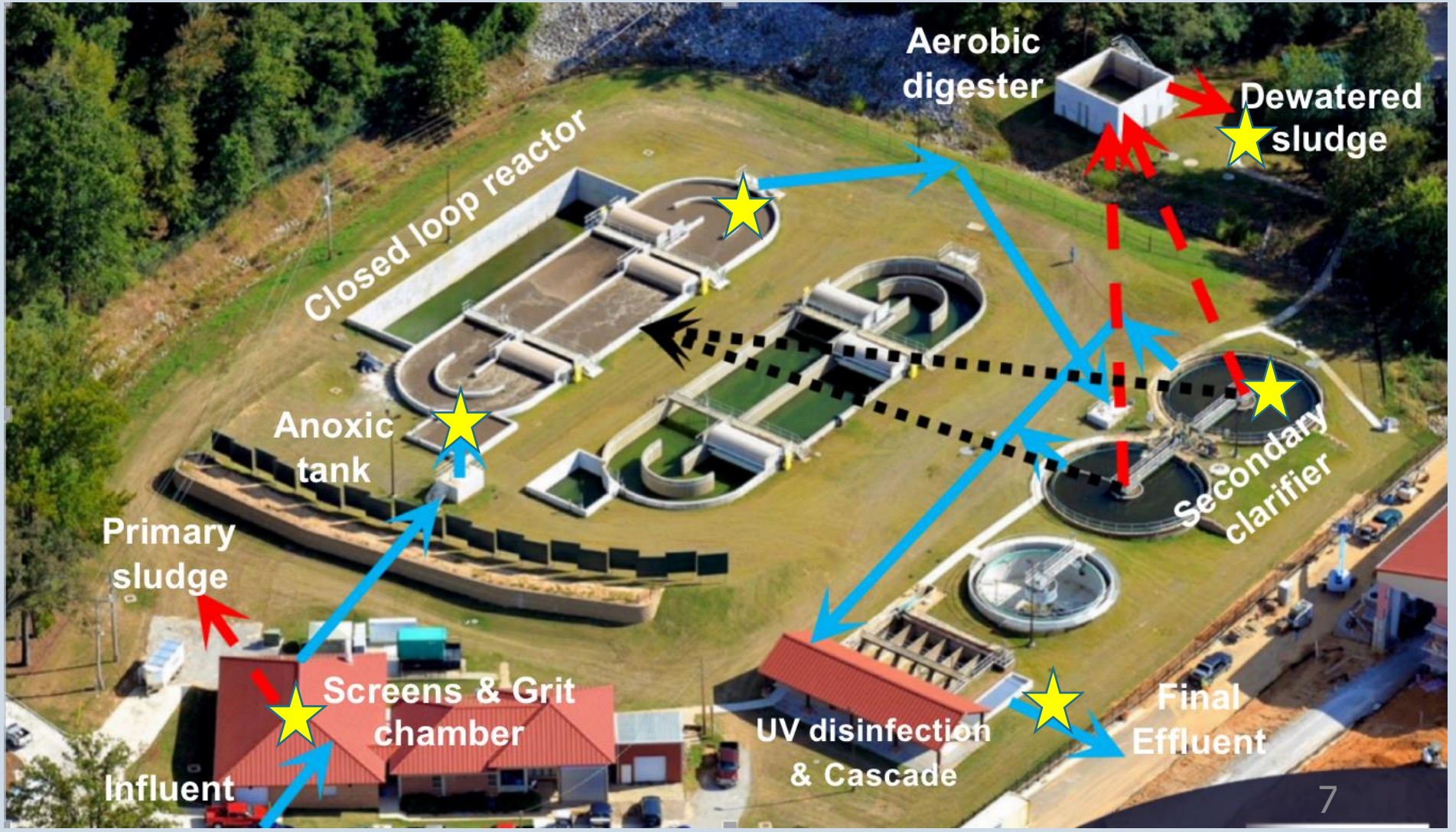
Summer:
<0.1 MGD

Semester:
~0.7 MGD

Football games:
>1.2 MGD

Summer 2020

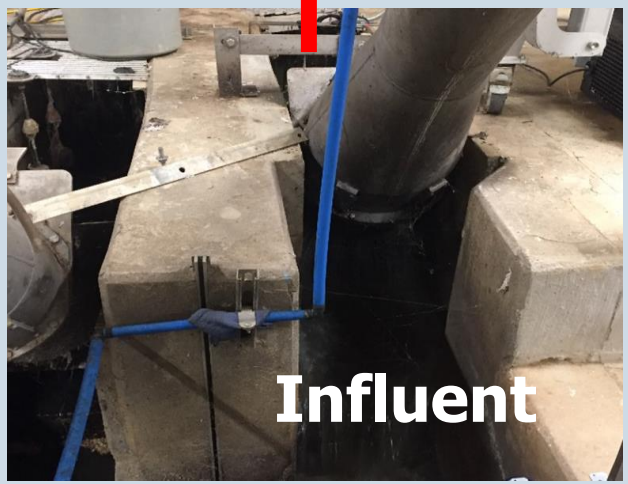
This Fall (delay due to Covid-19)



Sampling UM's WWTP for MPs

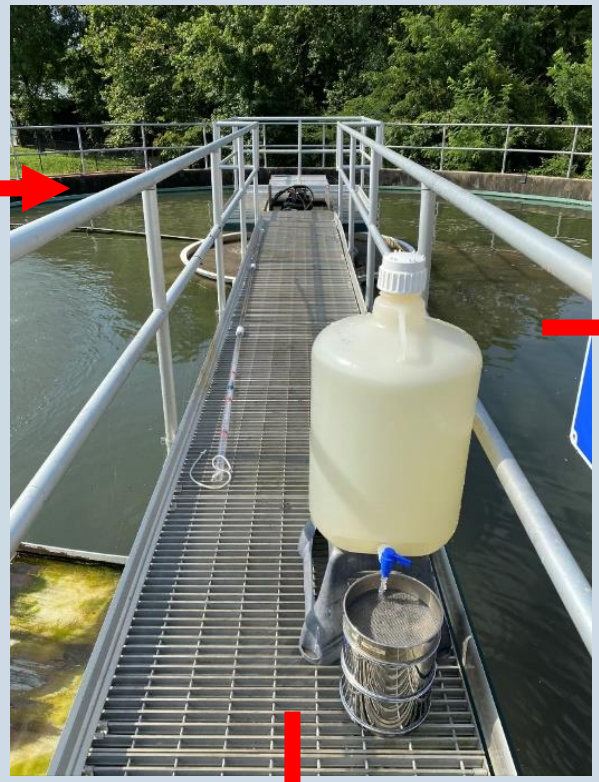
Anoxic tank

Influent



Closed Loop Reactor

2° Treatment



UV-Treatment

De-Watered Sludge

Effluent

Sampling

Site (n=3)	Summer 2020 Semester break	Fall 2020 (Covid-19) semester
Influent:	1 L	1 L
Biological unit:	1 L	37.5 L
Secondary unit:	50 L	50 L
Effluent:	50 L	50 L

1 L mason jars

50 L carboy container

1 mm

125 µm

45 µm

Sample Preparation

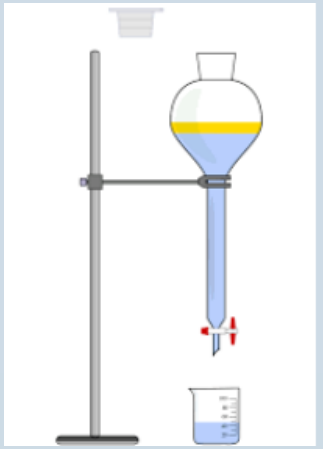
1 L grab samples:

Concentrated MPs

37.5 L or 50 L samples:

Concentrated MPs

Wet peroxidation

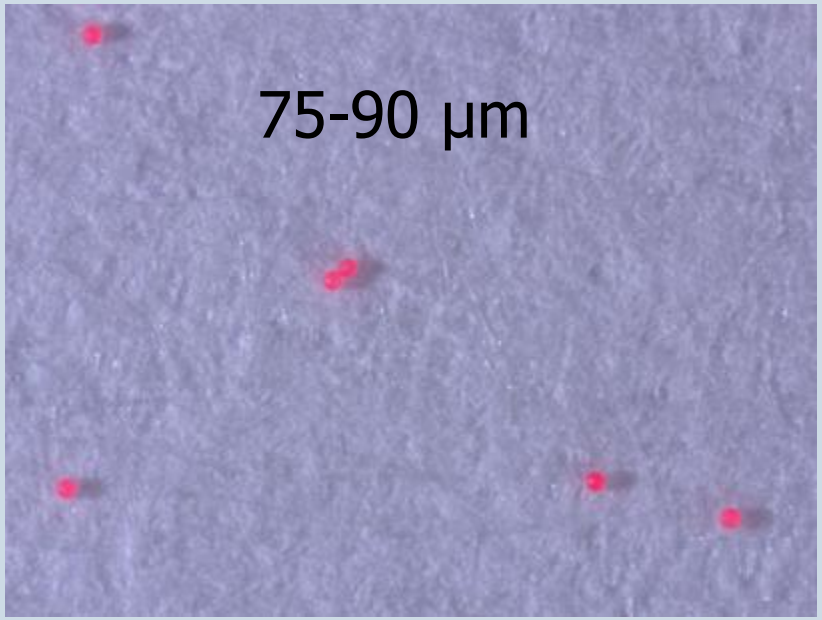


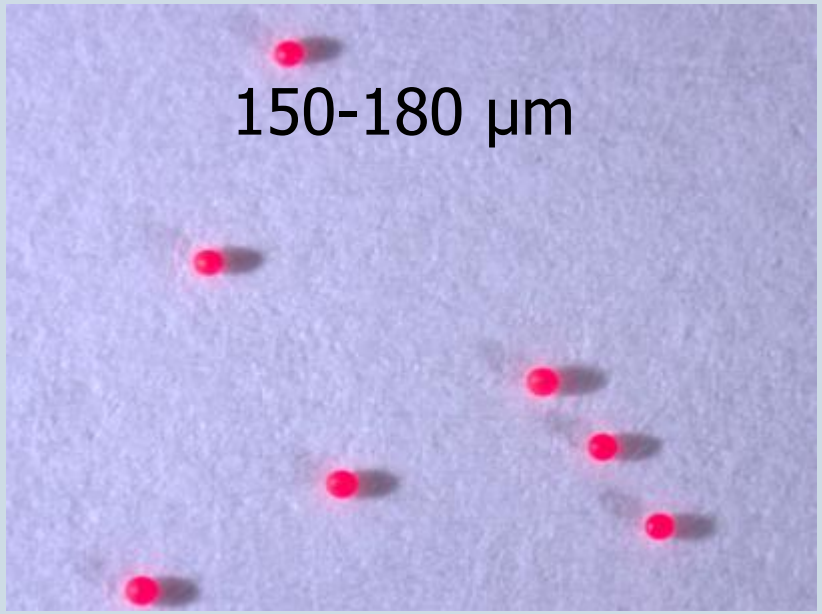
1.6 g/cm^3 $ZnCl_2$ solution

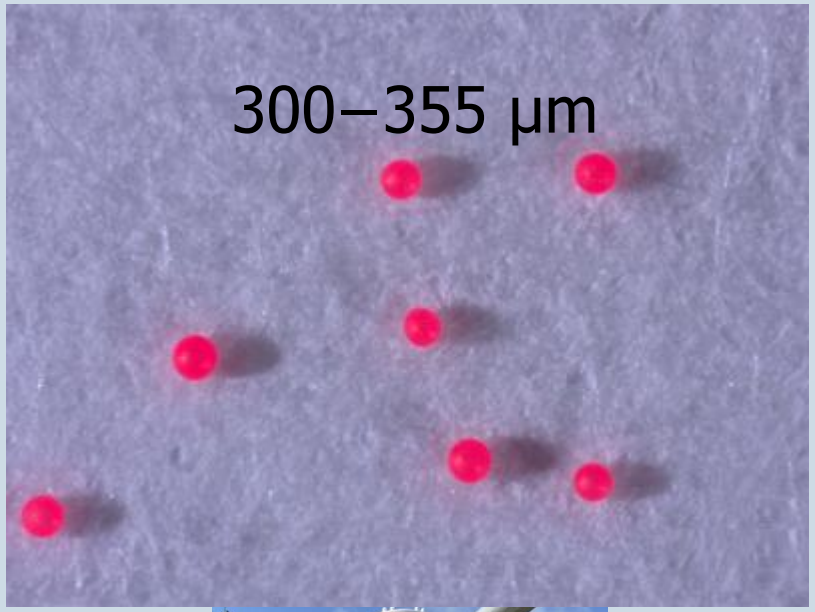
SEM-EDS

ATR and μ-FTIR

Quality Control: Spikes and Blanks







Spiked Samples:

Biological unit

Secondary clarifier

Treated effluent

Procedural Blanks:

1 L DI Water

QA Results

Spikes

Site	Size fraction (µm)	Recovery (%)
Closed loop reactor	75-90	45
	150-180	50
	300–355	60
Secondary clarifier	75-90	75
	150-180	85
	300–355	95
Final effluent	75-90	85
	150-180	95
	300–355	95

Blanks

Mean: 1.2 particles/L

(<1% of field samples)

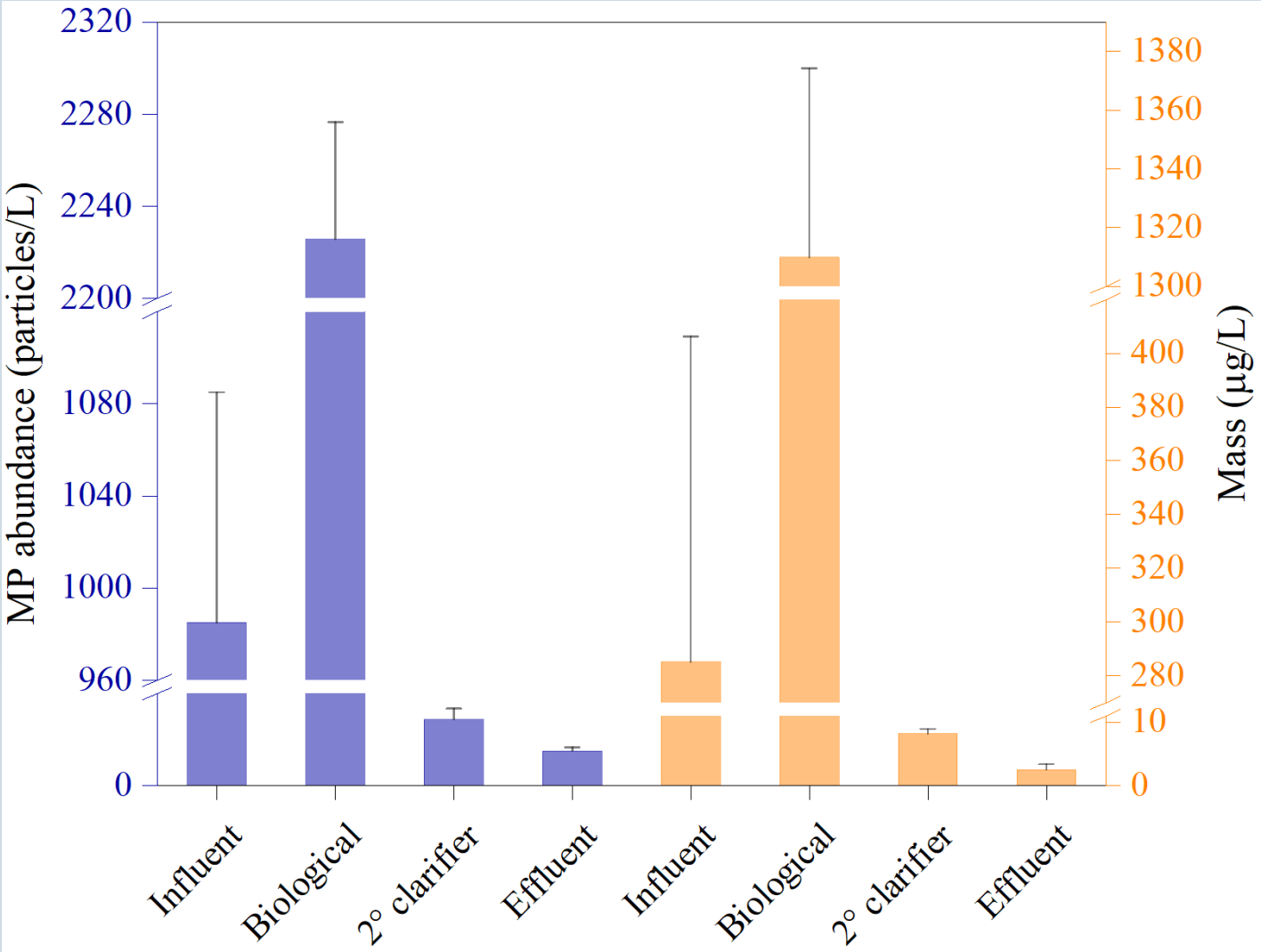
71% Polyacrylamide

21% Polyester

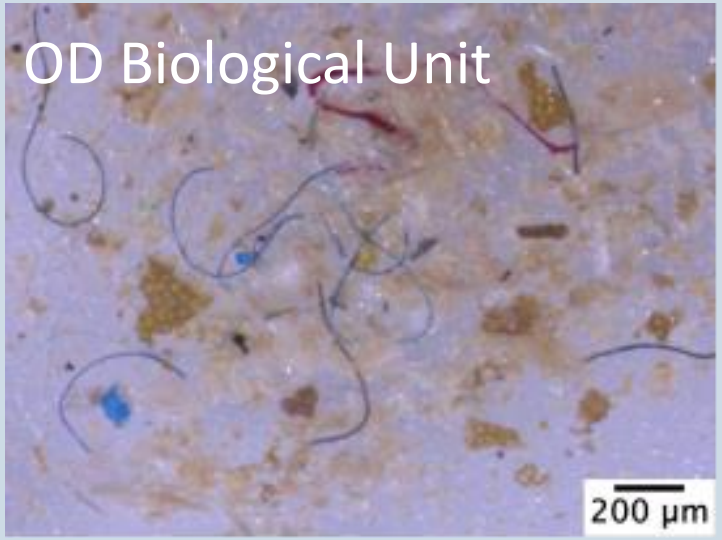
8% Acrylic paint

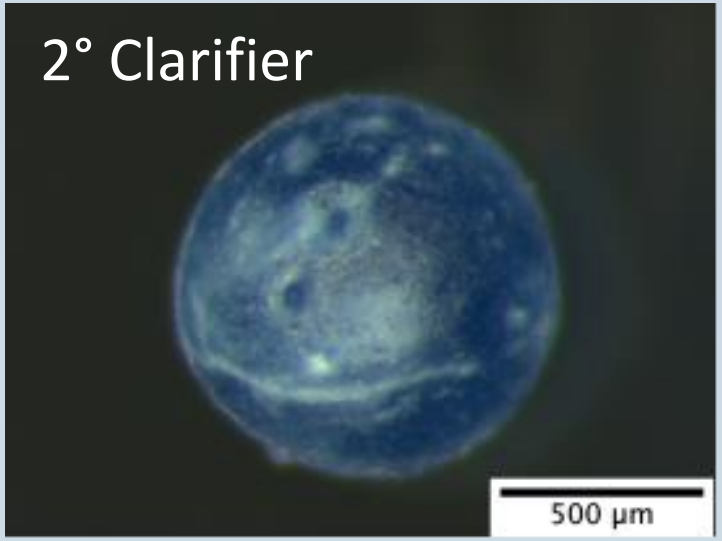
Microplastic Abundance

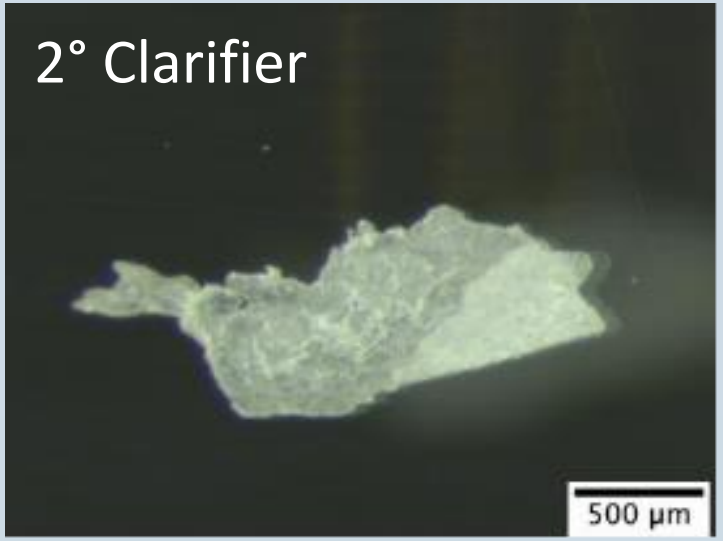
- Influent had relatively high levels
- 98.2% and 98.8% of MPs were removed based on conc. & mass, respectively.
- Most of MPs were transferred to the sludge;
- Still ~12 particles/L were present in the treated effluent.

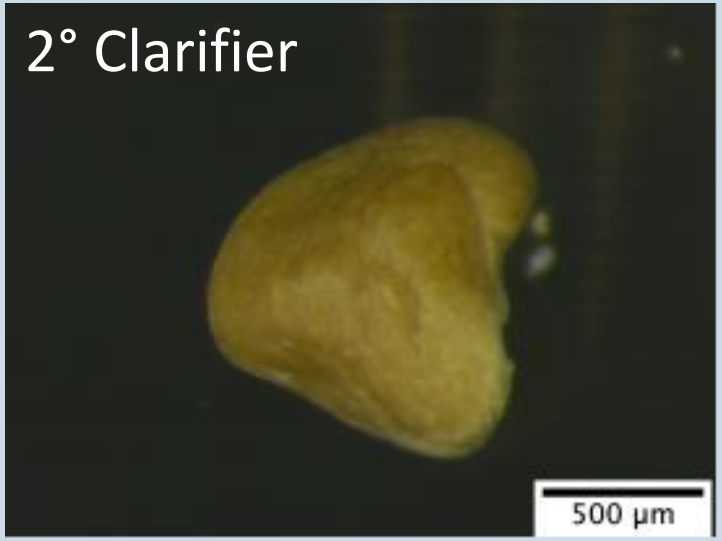


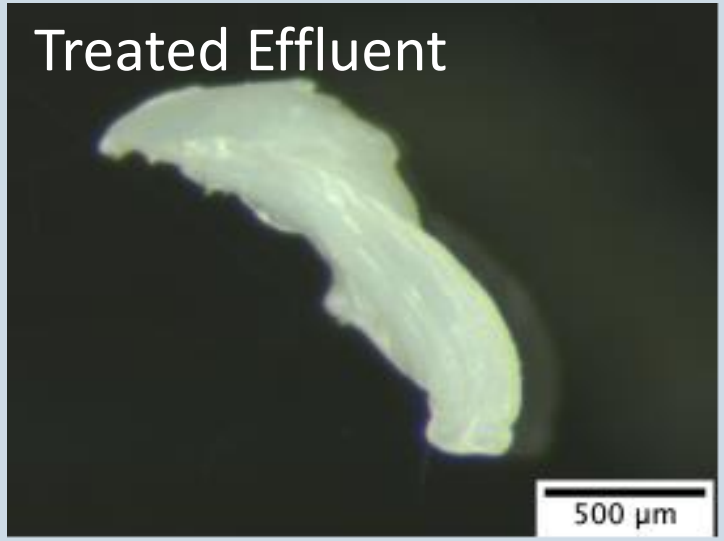
Microplastic Morphologies

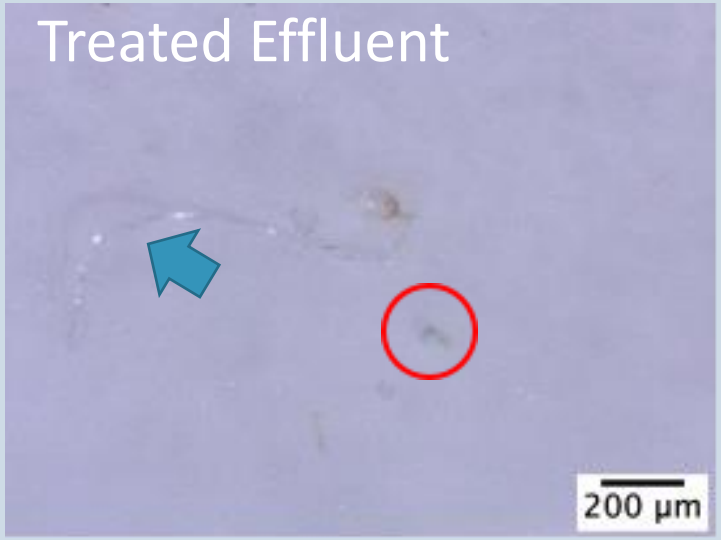






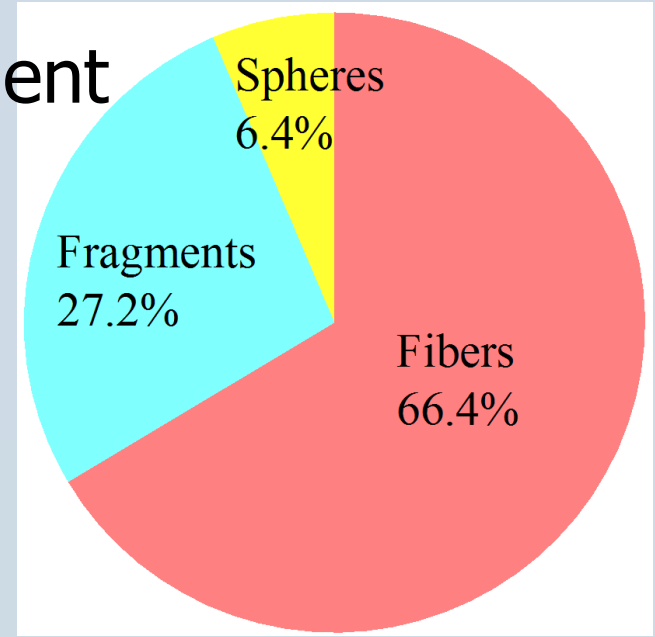




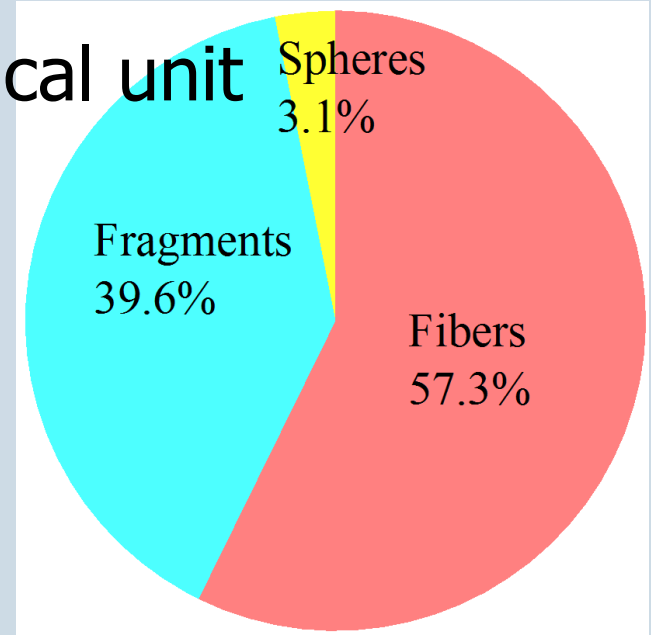


Microplastic Morphologies

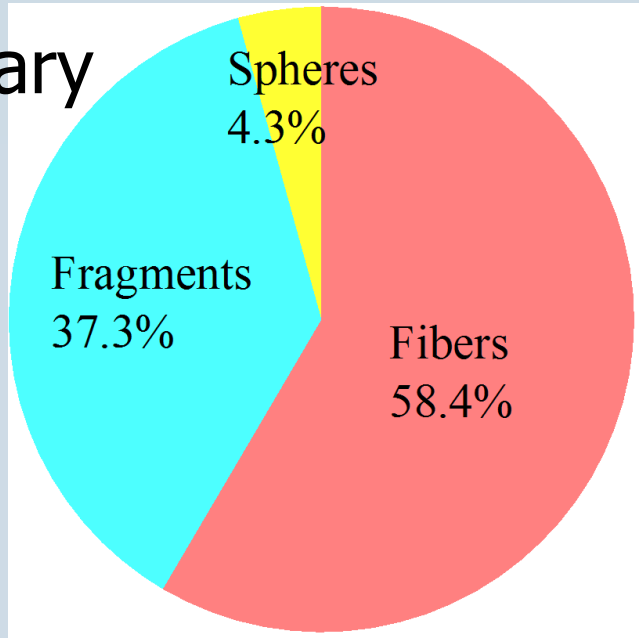
Influent



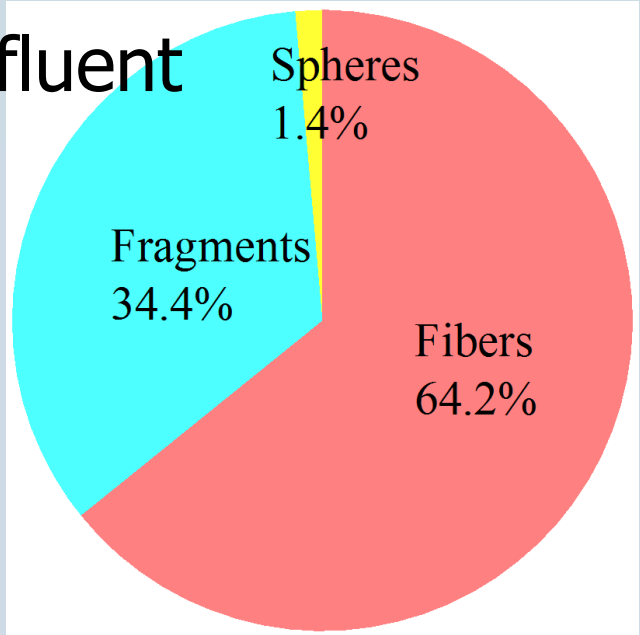
Biological unit



Secondary clarifier

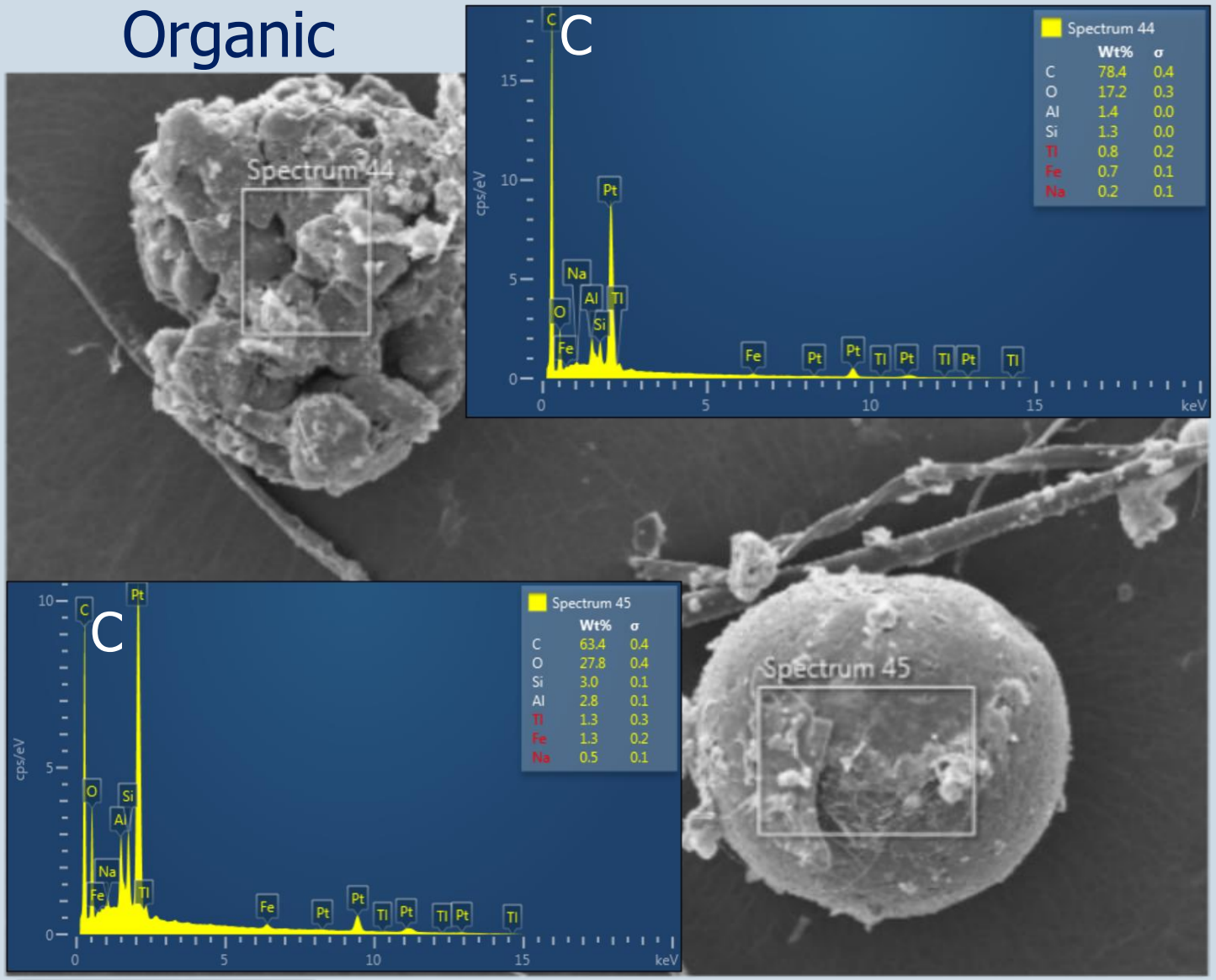


Treated effluent

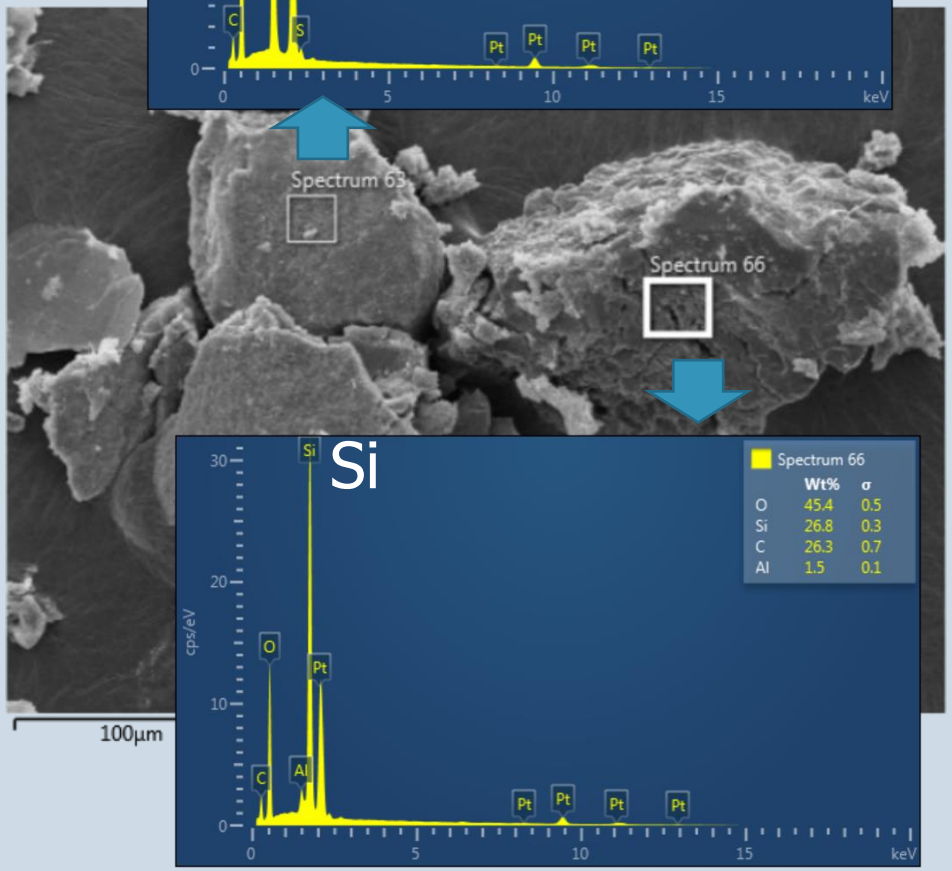


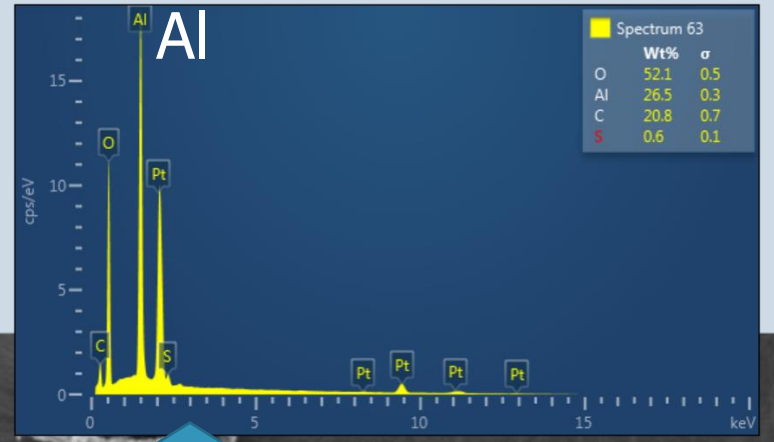
SEM/EDS Analysis

Organic

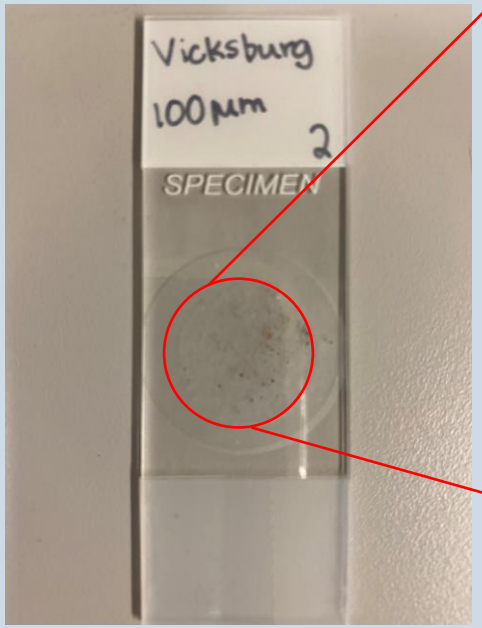


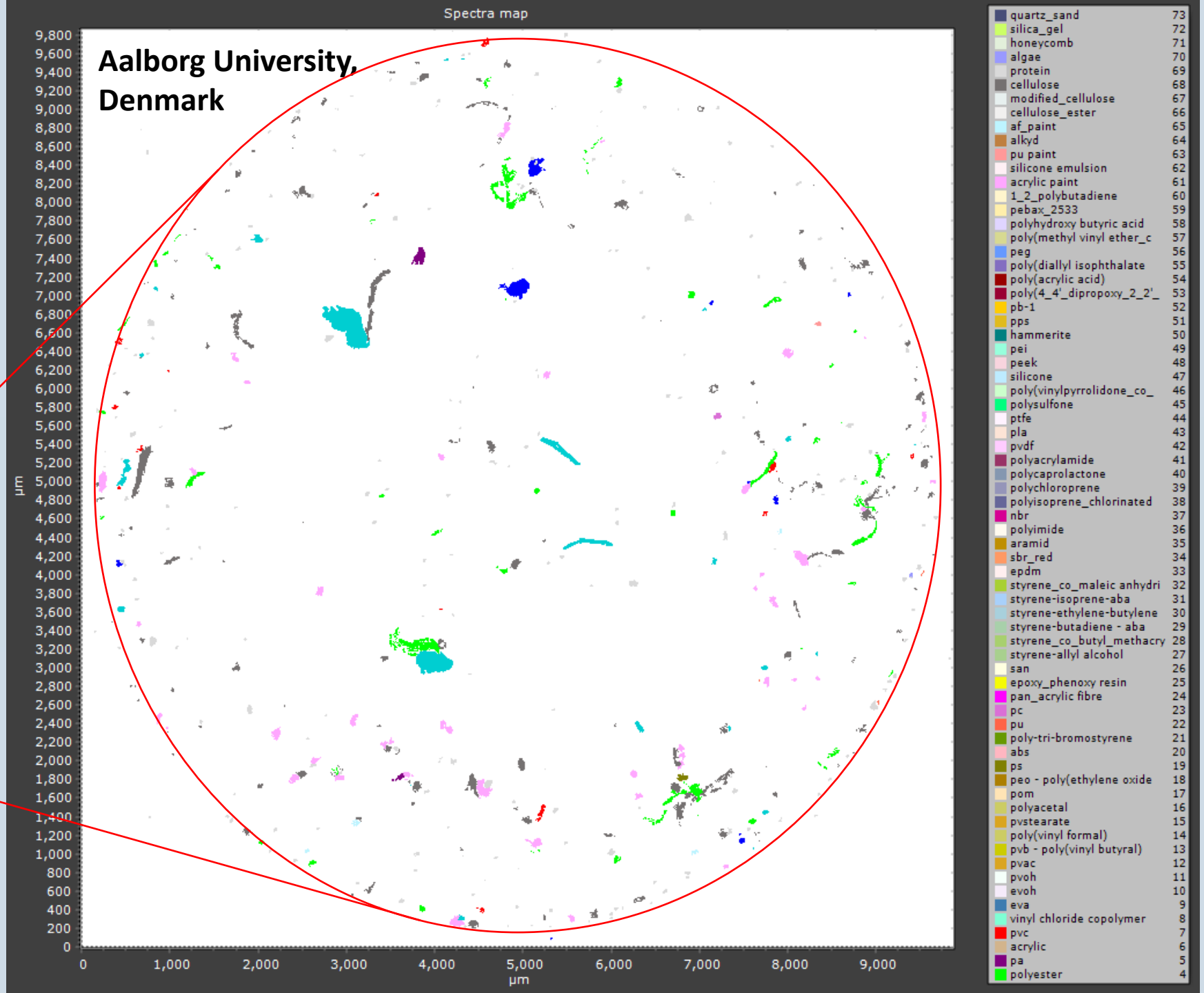
Inorganic





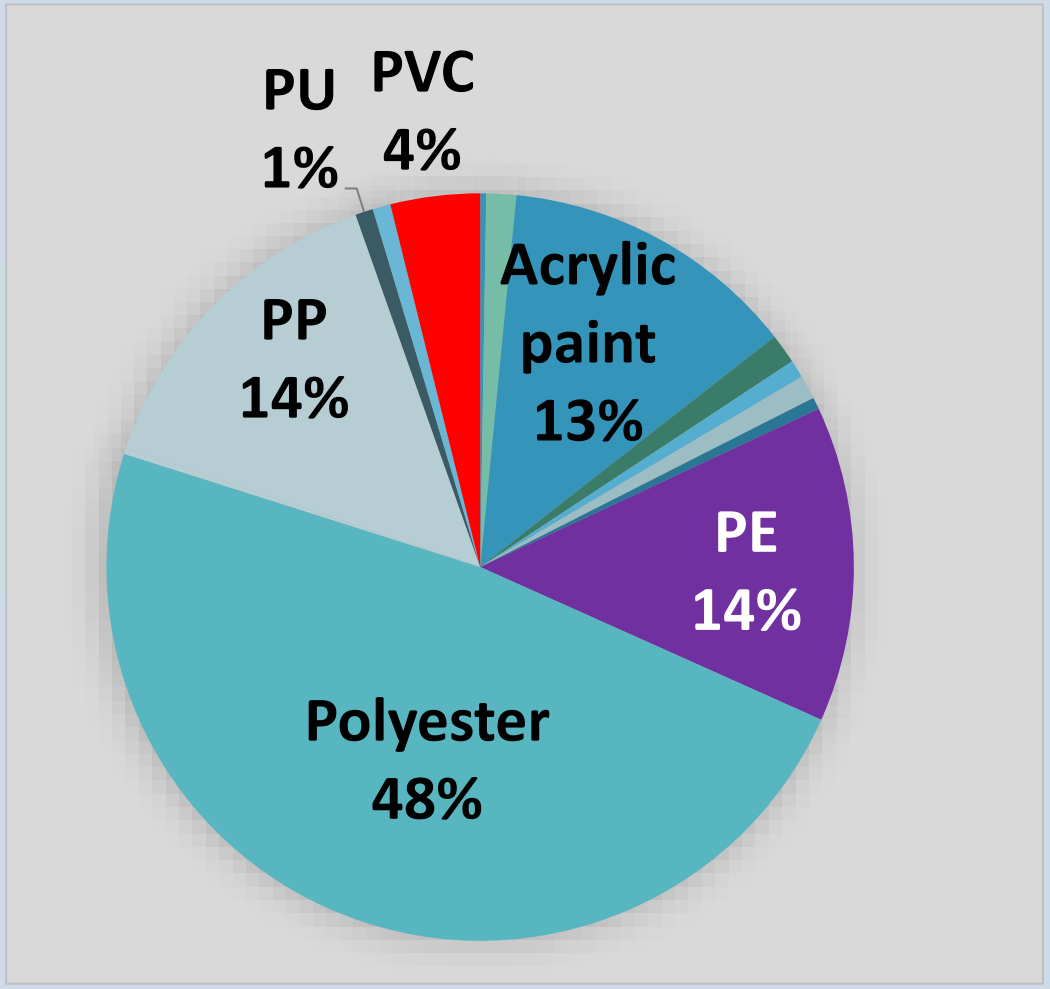
Polymer Compositions by µFTIR using siMPle software



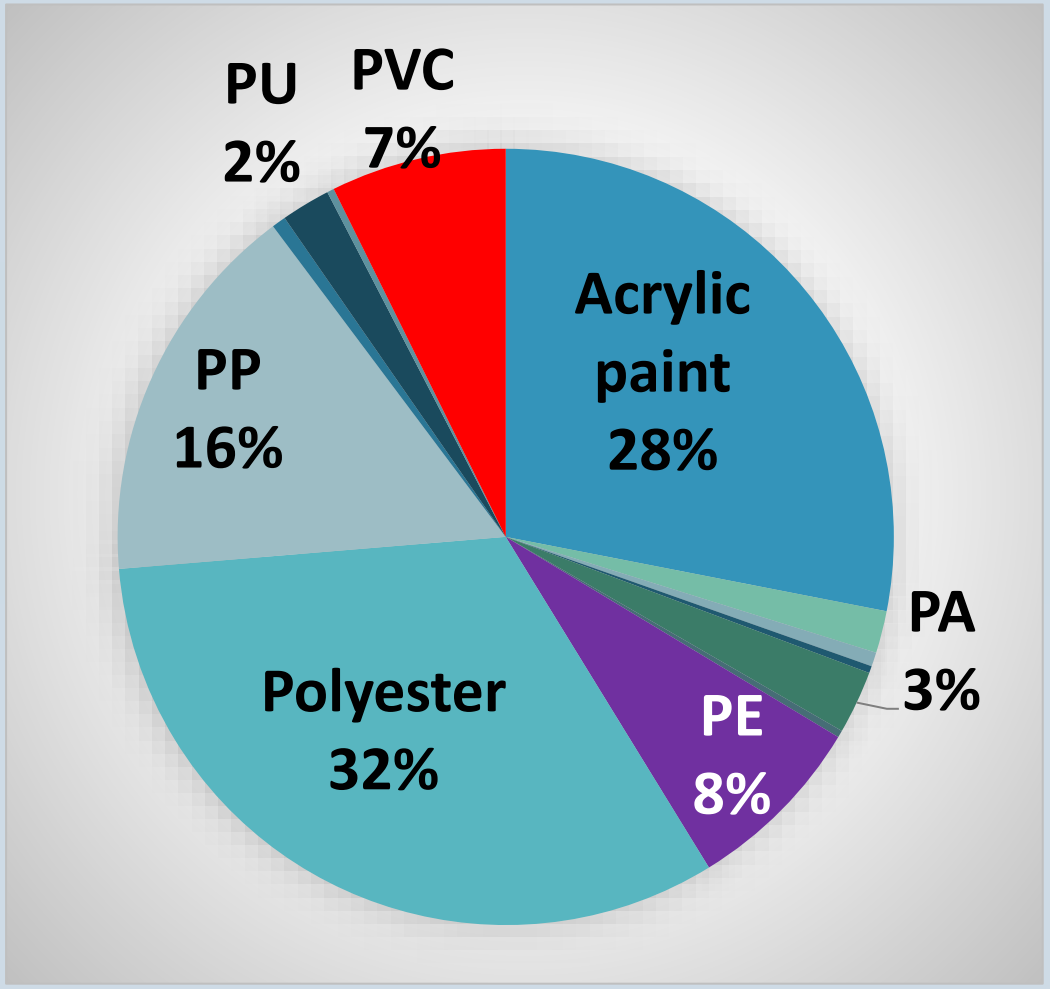


Polymer Compositions

Influent

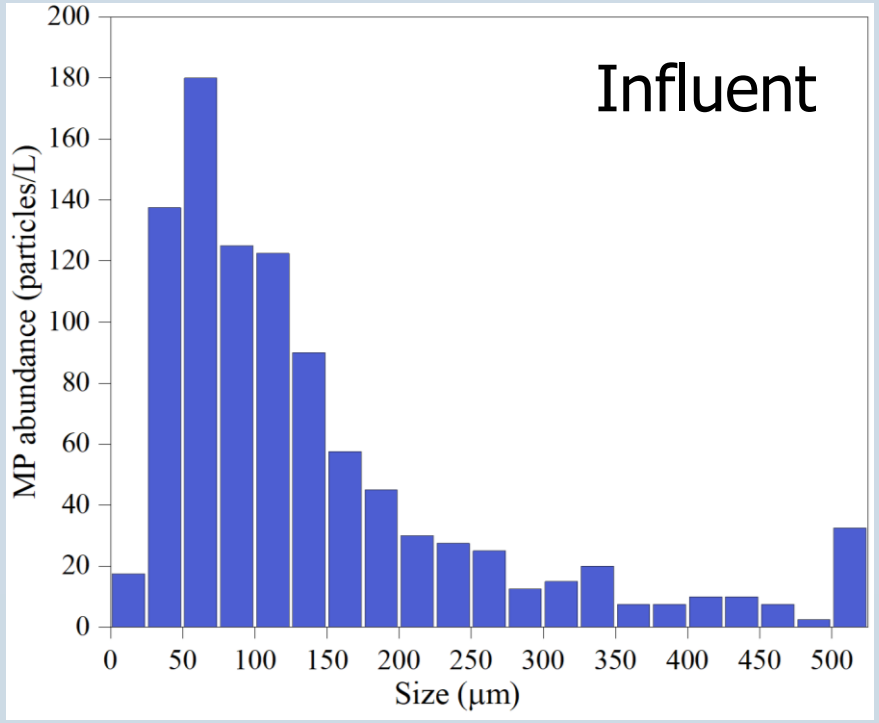


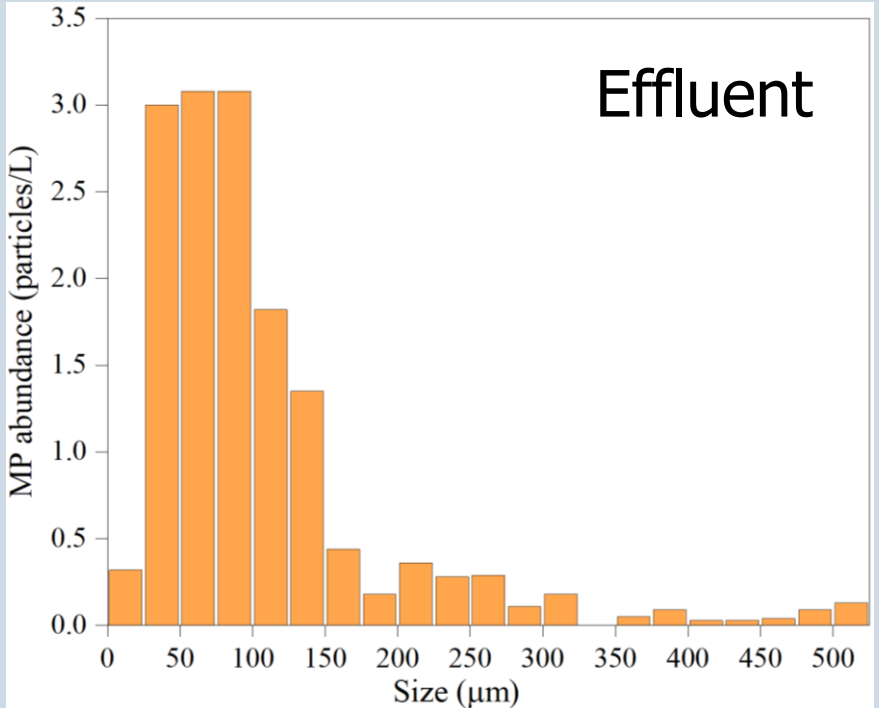
Effluent



Particle Size Distribution

- The smallest particles were most abundant
- The influent had a greater proportion of larger particles compared to the effluent whose particles were mostly <150 µm
- Size distribution was similar during the two low-flow sampling periods



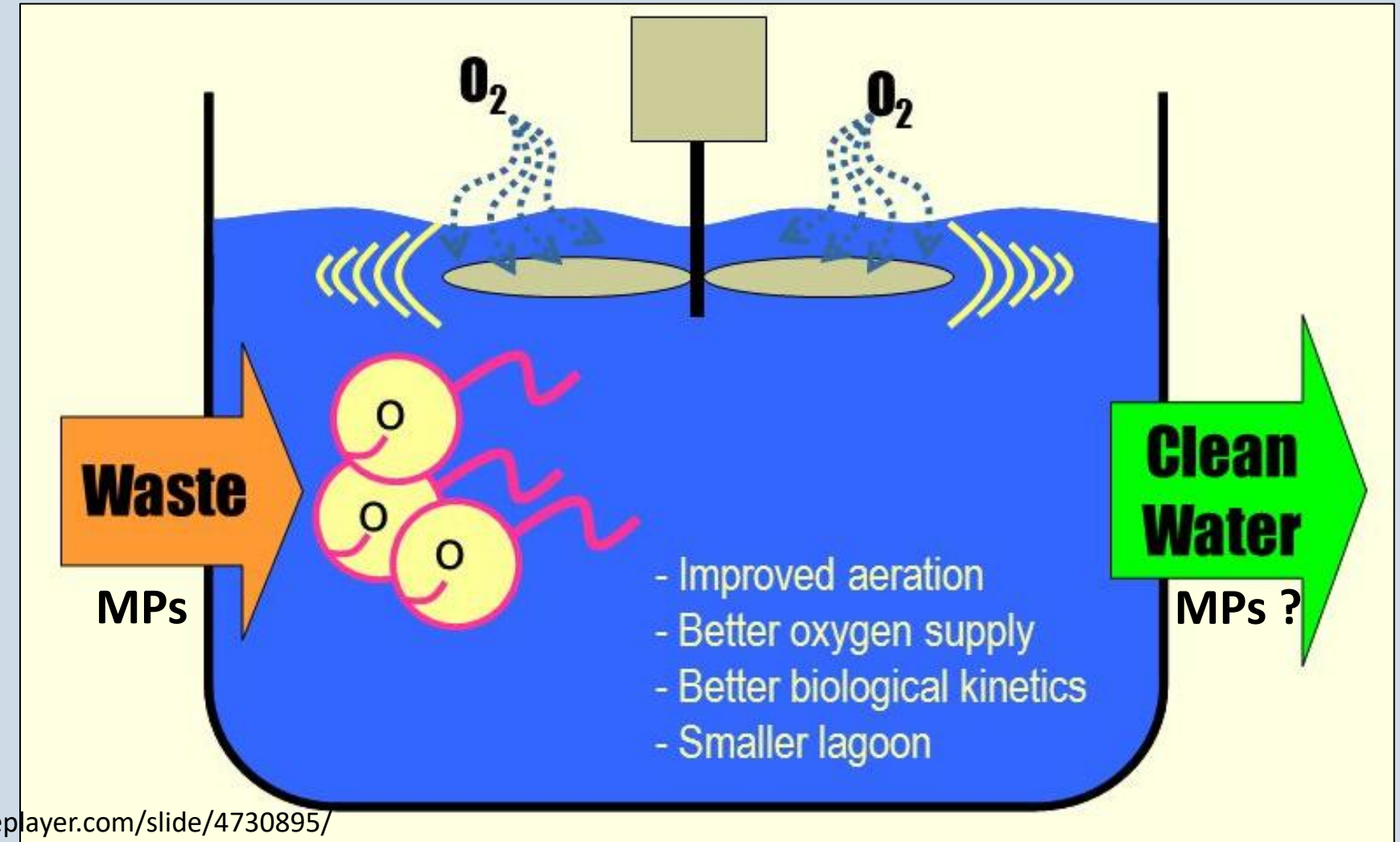


Conclusions to University WWTP Study

- >98% of the MPs were removed.
- Fibers were the predominant morphology.
- >99% of MPs were smaller than 500 µm.
- Polyester was the most abundant polymer in both raw sewage & treated wastewater.
- Abundances were similar for the two low-flow sampling periods.
- **Future**: Sampling this fall during higher flow periods to assess the influence of ↑ student population

Wastewater Stabilization Pond Study

- Commonly used in rural and small communities worldwide.
- Overlooked source of MP pollution?



Source: https://slideplayer.com/slide/4730895/

Wastewater Stabilization Pond Study

Sampling Sites

WSP serves ~500 houses.

Treated Effluent to Sardis Lake

Sampling

Site (n=3)	Summer	Winter
WSP Water	50 L	50 L
WSP Effluent:	50 L	50 L
WSP surface algae:	1 L	1 L
WSP Sediment:	125 mL	125 mL
Wellsgate Lake Water:	50 L	50 L

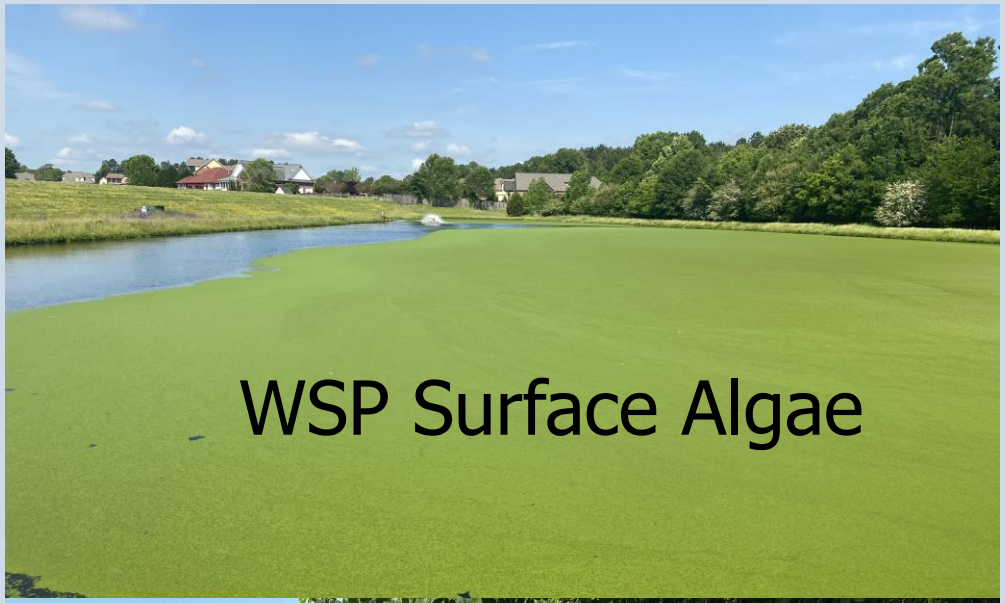
1 L mason jars

50 L carboy container

Sampling Photos

Wellsgate Lake

WSP Effluent



Sample Preparation in Laboratory

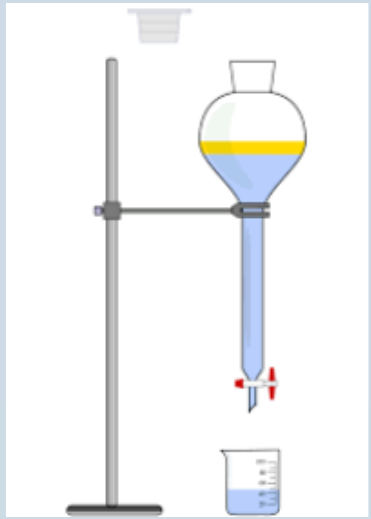
Concentrated MPs

Dry algae

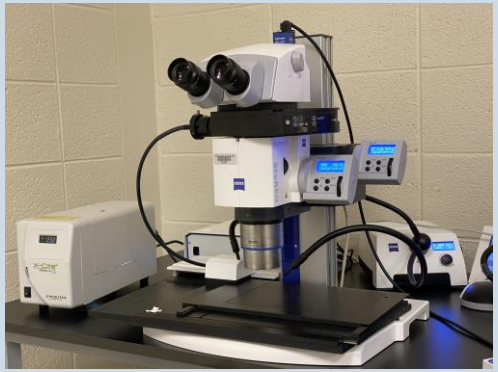
Dry sediment

Remove fraction >1 mm

Wet peroxidation



Density Separation

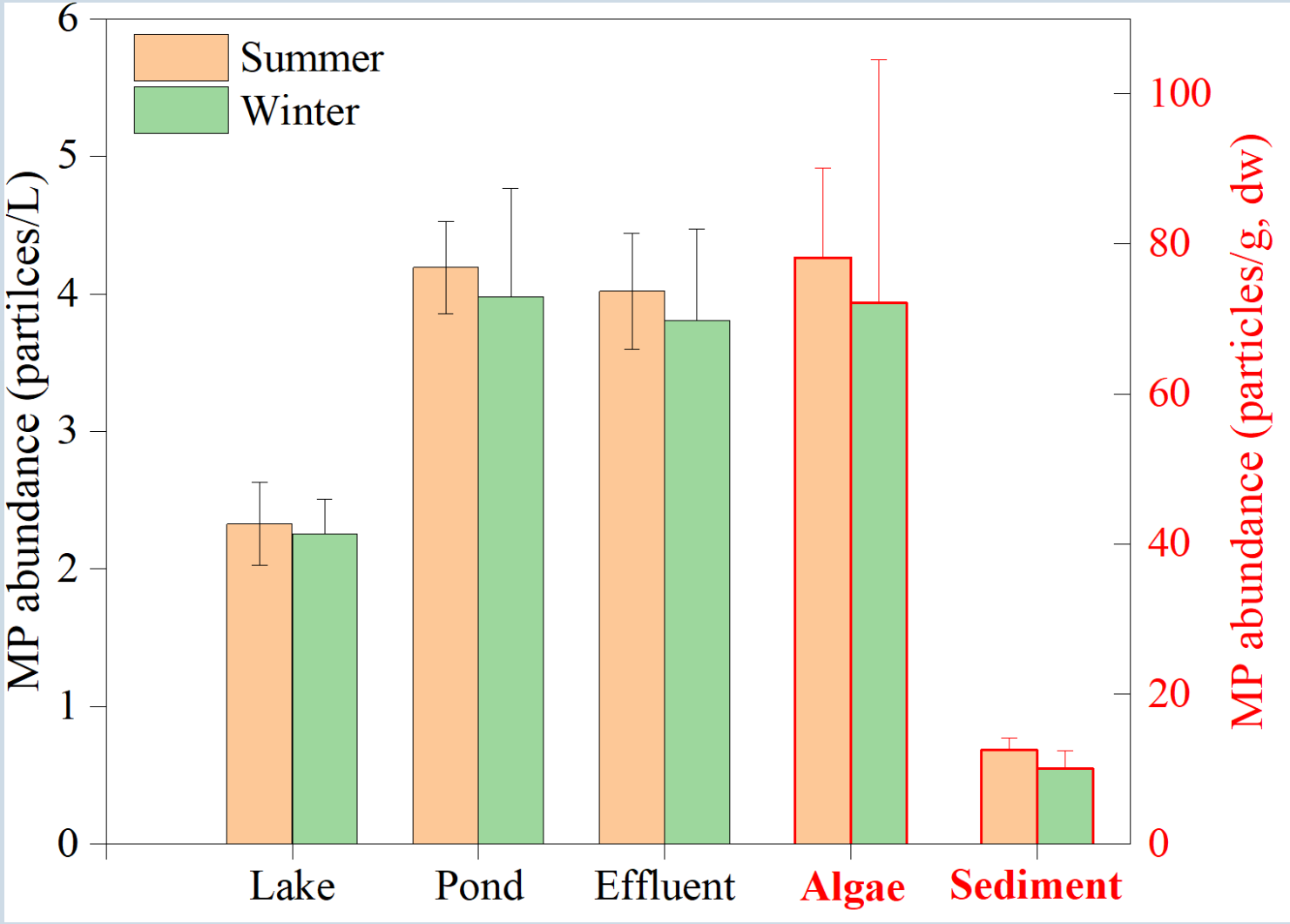


Stereomicroscope

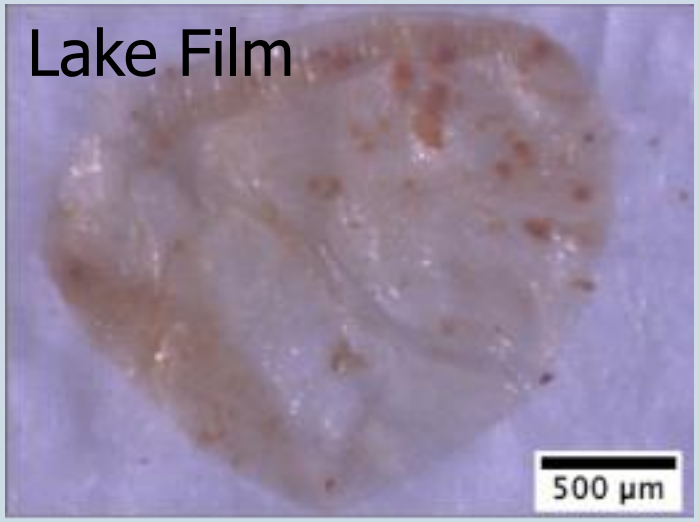
ATR and µ-FTIR

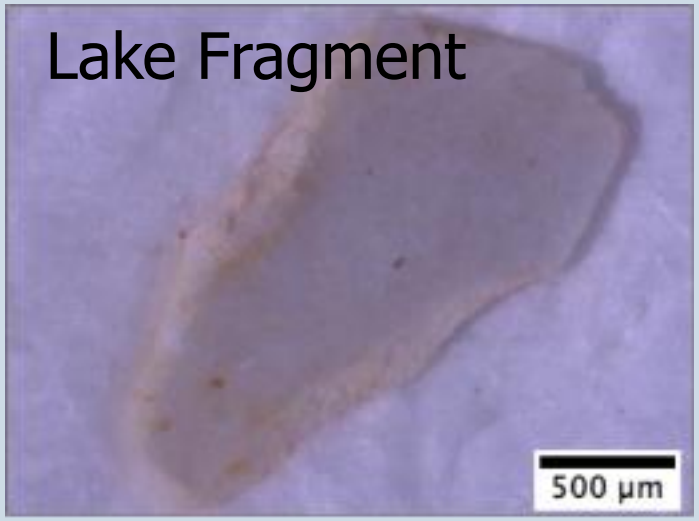
MP Abundances

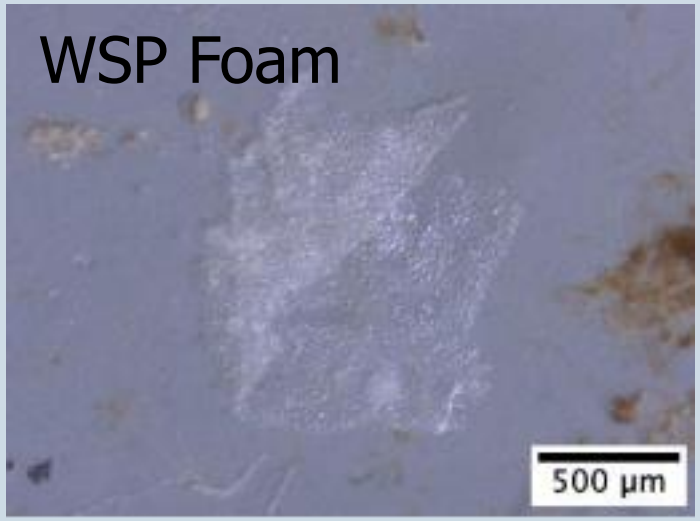
- Algae/surface scum had high MP abundances
- Seasonal variation was not observed.
- ~3 MPs/L are discharged from the WSP

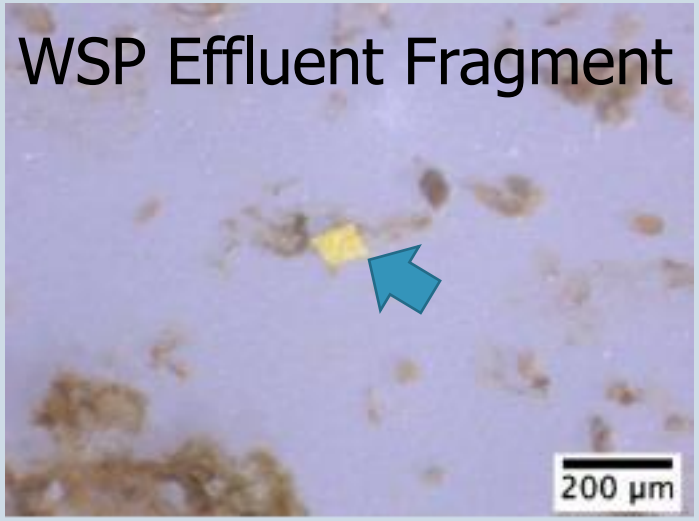


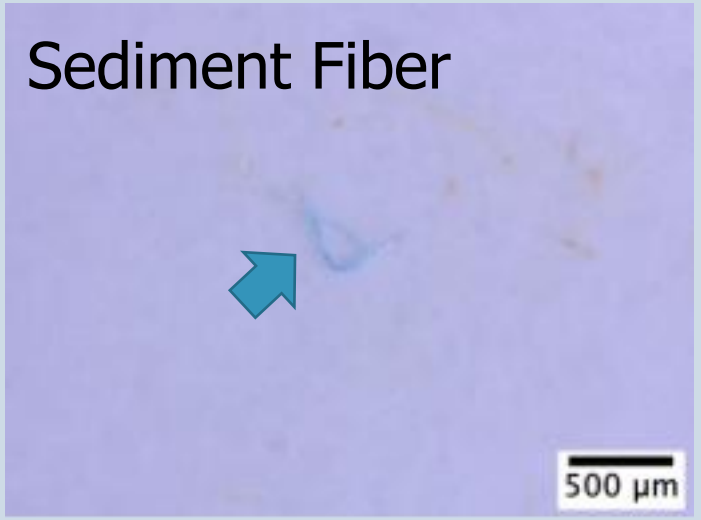
Microplastic Morphologies





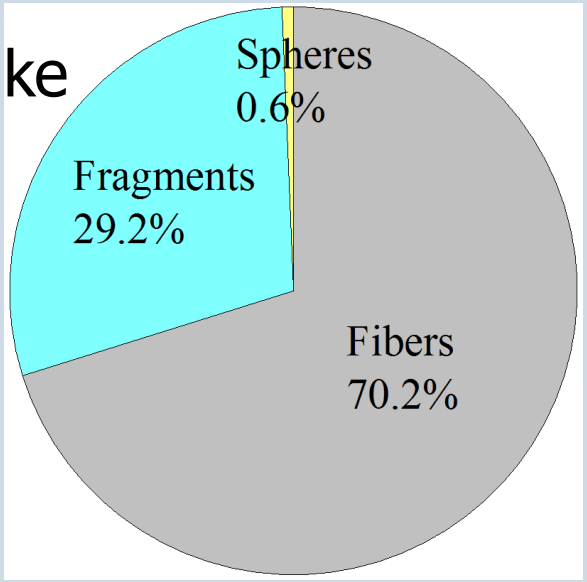




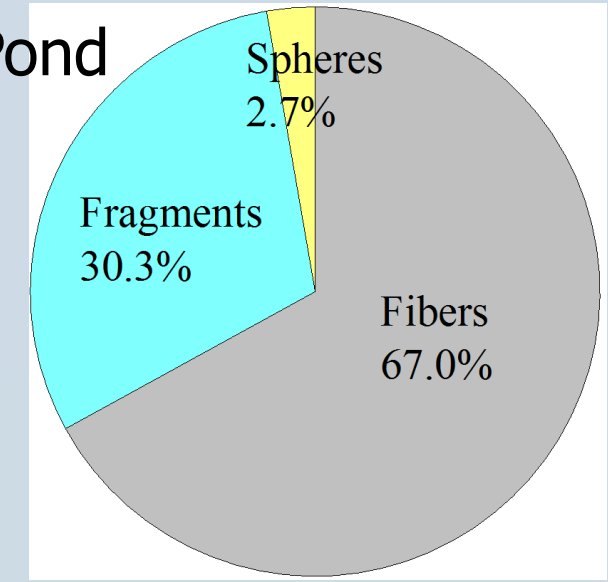


Microplastic Morphologies

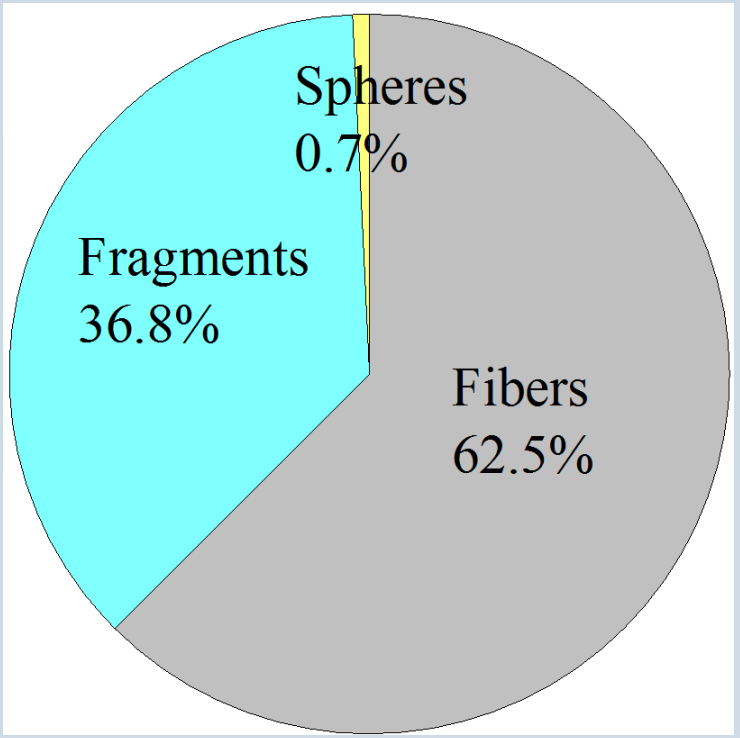
Lake



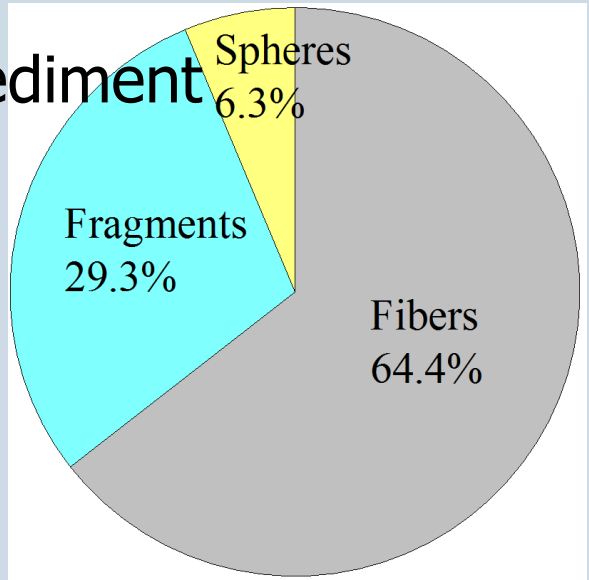
Pond



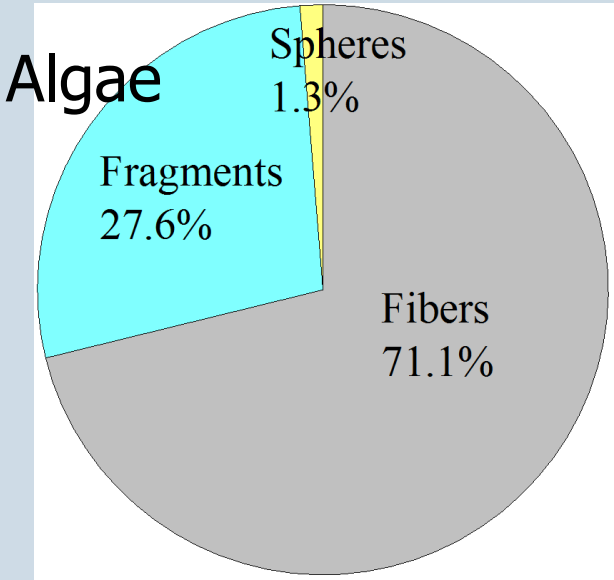
Effluent



Sediment

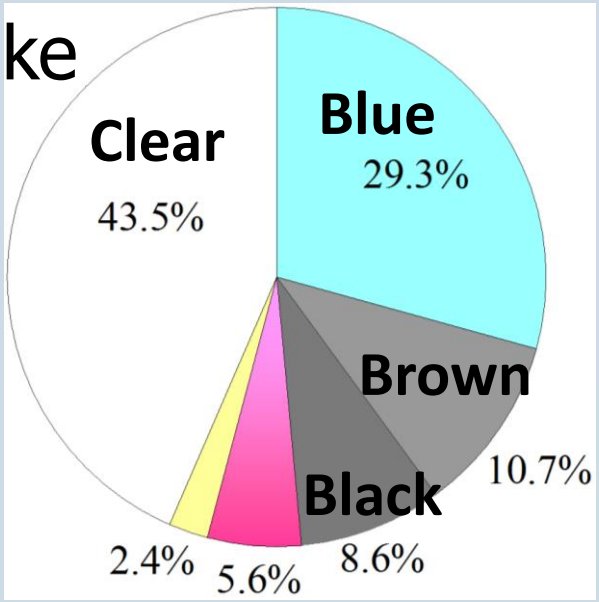


Algae

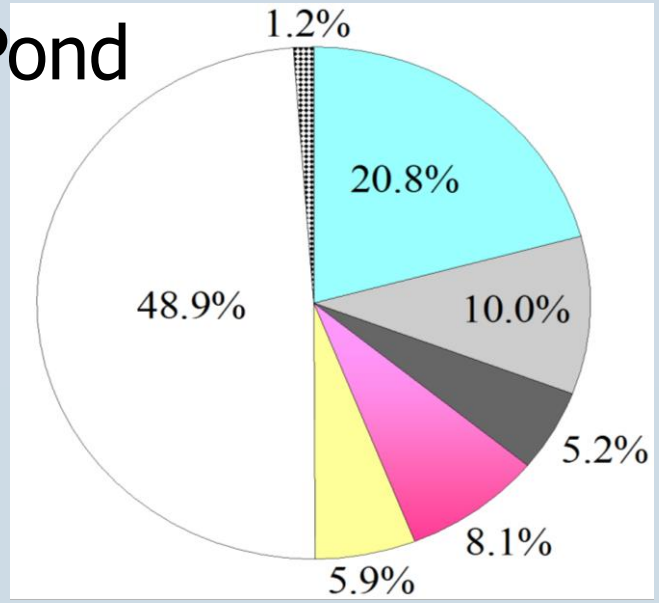


Color Distribution

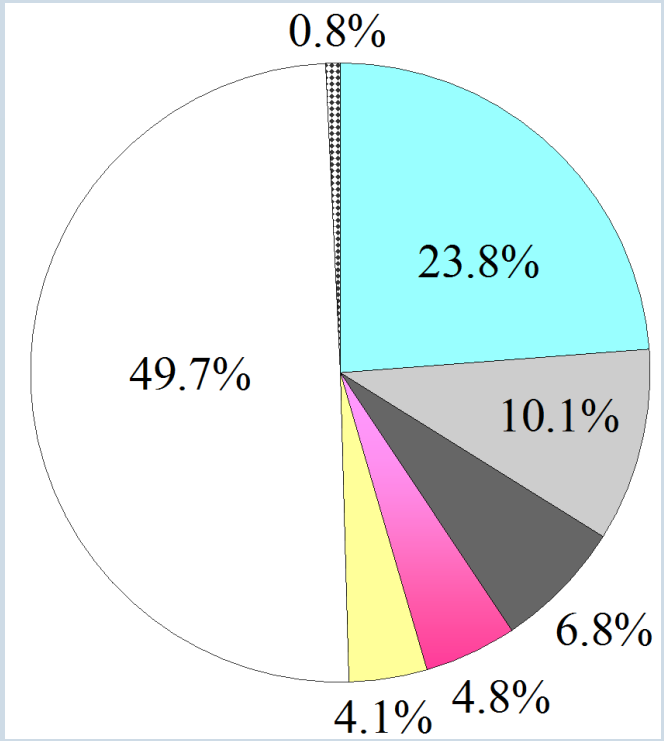
Lake



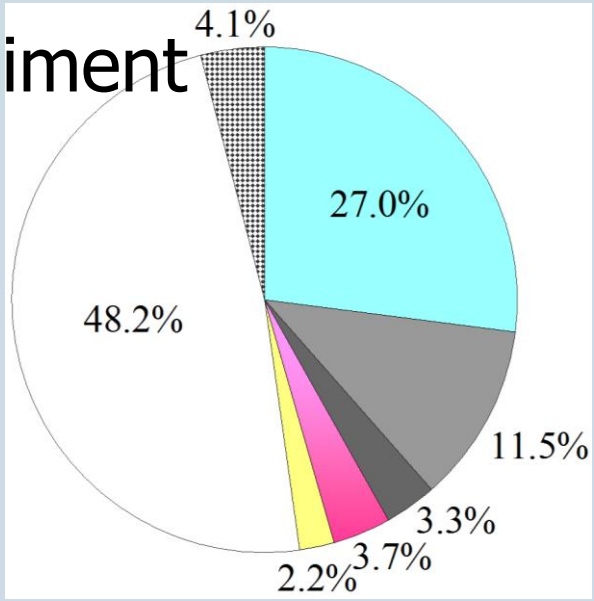
Pond



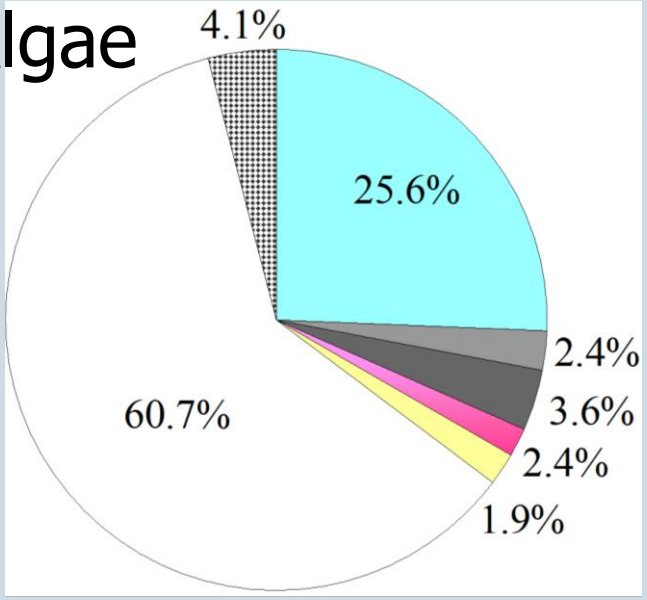
Effluent



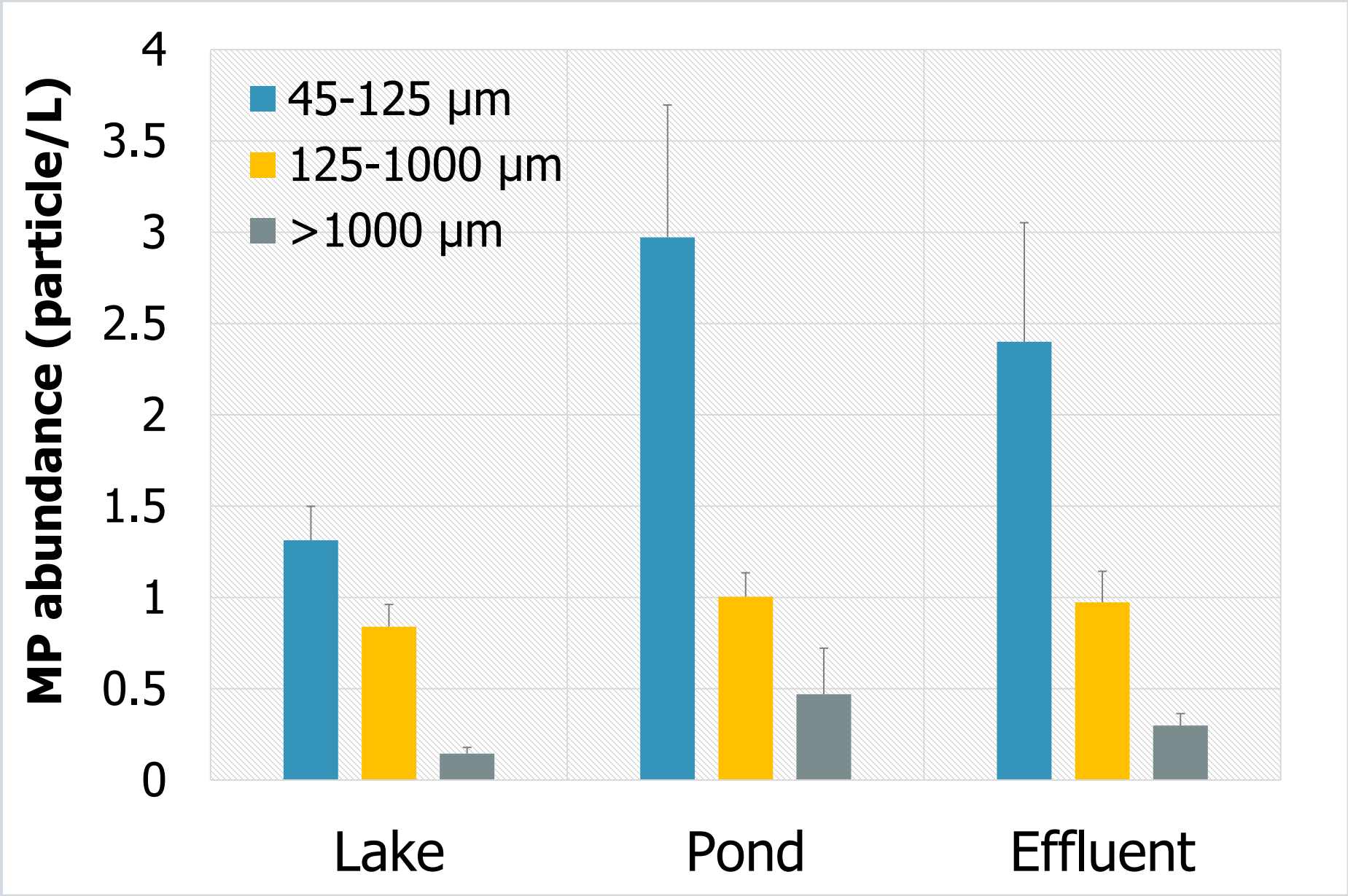
Sediment



Algae



Particle Sizes



- Smaller particles were most abundant.

Conclusions to WSP Study

- Surface algae had high MP concentrations.
- Fibers were predominant, followed by fragments & beads.
- Clear and blue were the two dominant colors.
- There were no differences between seasons.
- Smaller MPs were most abundant.
- WSPs are effective at removal of MPs (~low levels in the effluent)
- **Future**: The influent will be measured to quantify removal rates

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