



Tracking of Micro- and Nanoplastics Through Wastewater Treatment Plants: The Difference Between Municipal and Industrial Wastewater Treatment

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Outline

- Definitions
- Preliminary investigation
 - WWTP sampling locations and methods
 - Laboratory methods
 - Comparison of NMP characteristics by sampling method
 - Nano – and microplastic characterization
 - Inter – instrument agreement
- Ongoing research efforts
- Q&A

Characterization and Quantification of Nano- and Microplastics in Environmental Samples

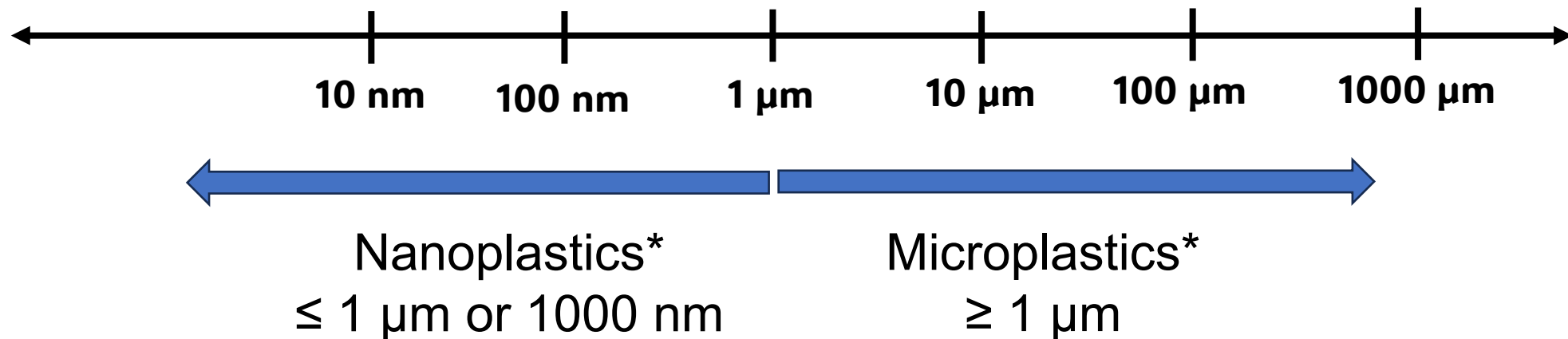
- Land Remediation and Technology Division (LRTD)
- Environmental samples: lakes, rivers, WWTPs (influent, effluent, sludge), and soils
- Project Goals
 - Method development
 - Improve understanding of plastic contamination in urban watersheds
 - Elucidate relationship between plastic contamination from urban watersheds to freshwater bodies

Definitions

How do you define microplastics and nanoplastics?

“Microplastics are particles that consist of solid polymeric materials to which chemical additives or other substances may have been added” – *California State Water Resources Control Board, 2020*

NMP = nano – and microplastics



**size definitions for this presentation, other size definitions exist*

Nano – and microplastics data gaps

What are we trying to find?

- Sampling and Analysis
 - What methods/instrumentation can be used for **NP detection and-characterization** in environmental samples?
 - What is an **acceptable variability** from **sampling methods**?
 - What is an **acceptable variability** from **detection methods**?
- Plastic contamination management
 - What are the **characteristics** (e.g., size, distribution, type, concentration) of NMP found in **wastewater effluent from different source types**?

Preliminary investigation

- Does sampling method effect NMP counts, types, and size distribution?
- What are the NMP characteristics?
 - Concentration
 - Size distribution
 - Polymer type
- Insights into combining NMP identification methods
 - Nanoparticle tracking analysis (NTA)
 - Laser Direct Infrared (LDIR)
 - Particle analyzer

WWTP sampling locations and methods

WWTP (A)

- Average daily flow rate = ~5.5 MGD^[2,3]
- Domestic wastewater source^[2]

WWTP (B)

- Average daily flow rate = ~100 MGD^[4, 5]
- 30%^[6]-50%^[7] of influent from industrial sources

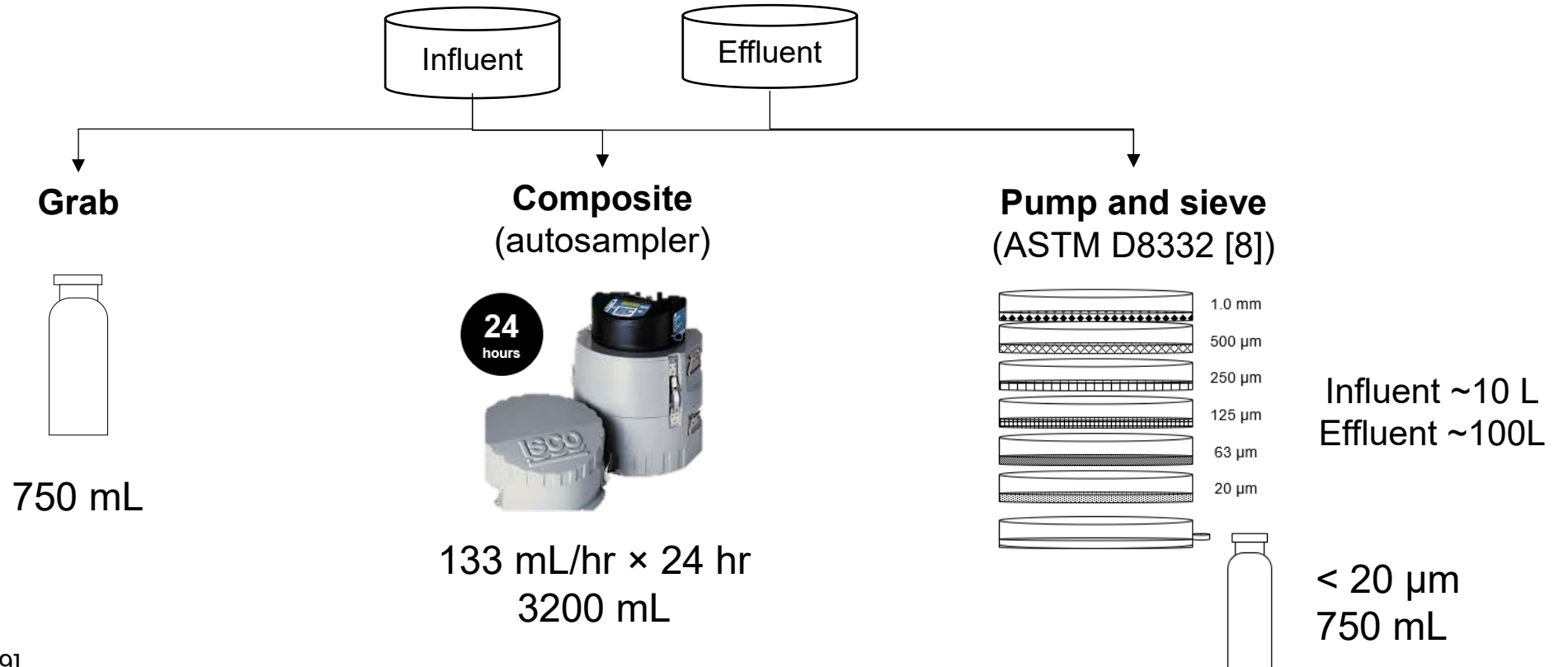


Image source: Teledyne ISCO [9]

WWTP sampling locations and methods

WWTP (A)

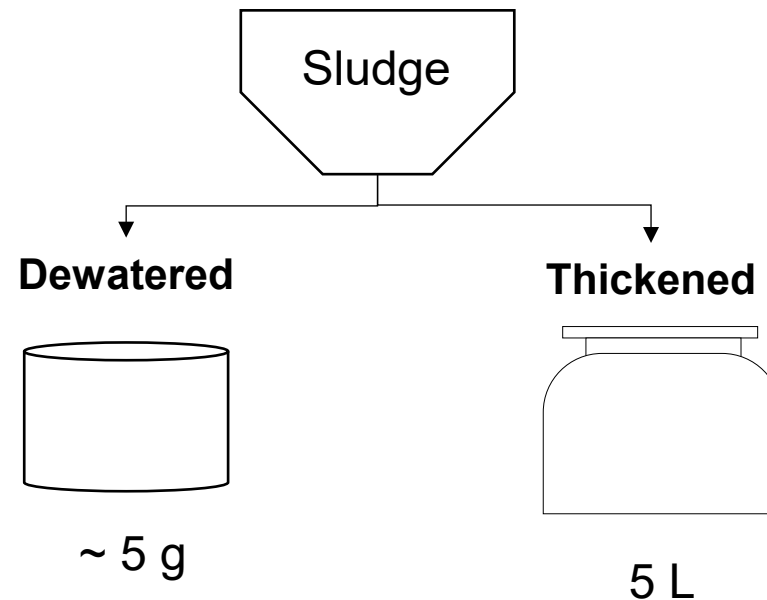
- Average daily flow rate = ~5.5 MGD^[2,3]
- Domestic wastewater source^[2]

WWTP (B)

- Average daily flow rate = ~100 MGD^[4, 5]
- 30%^[6]-50%^[7] of influent from industrial sources



Dewatered sludge samples



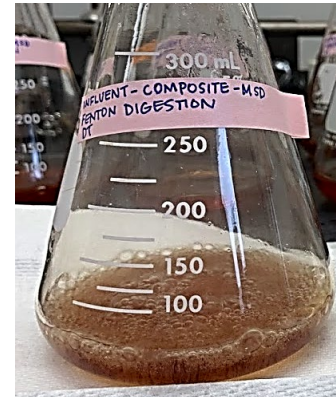
Thickened sludge
Source: Sludge Processing

Laboratory approach

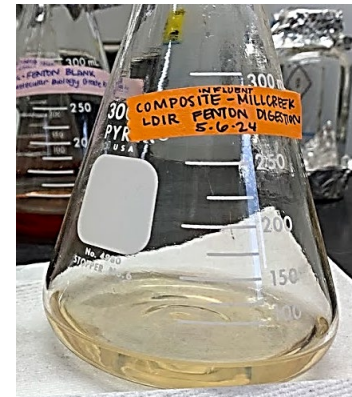
- Controls
 - Cotton lab coats
 - Laminar flow hood and fume hoods
 - Non – plastic equipment and supplies
 - Sample storage in 4°C
- Sample pretreatment
 - LDIR and Particle Analyzer (MS4e)
 - Fenton digestion
 - Density separation with NaBr
 - NTA
 - Filtration through 1 µm glass fiber syringe filter

Fenton digestion with $\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}_2$

Start of reaction



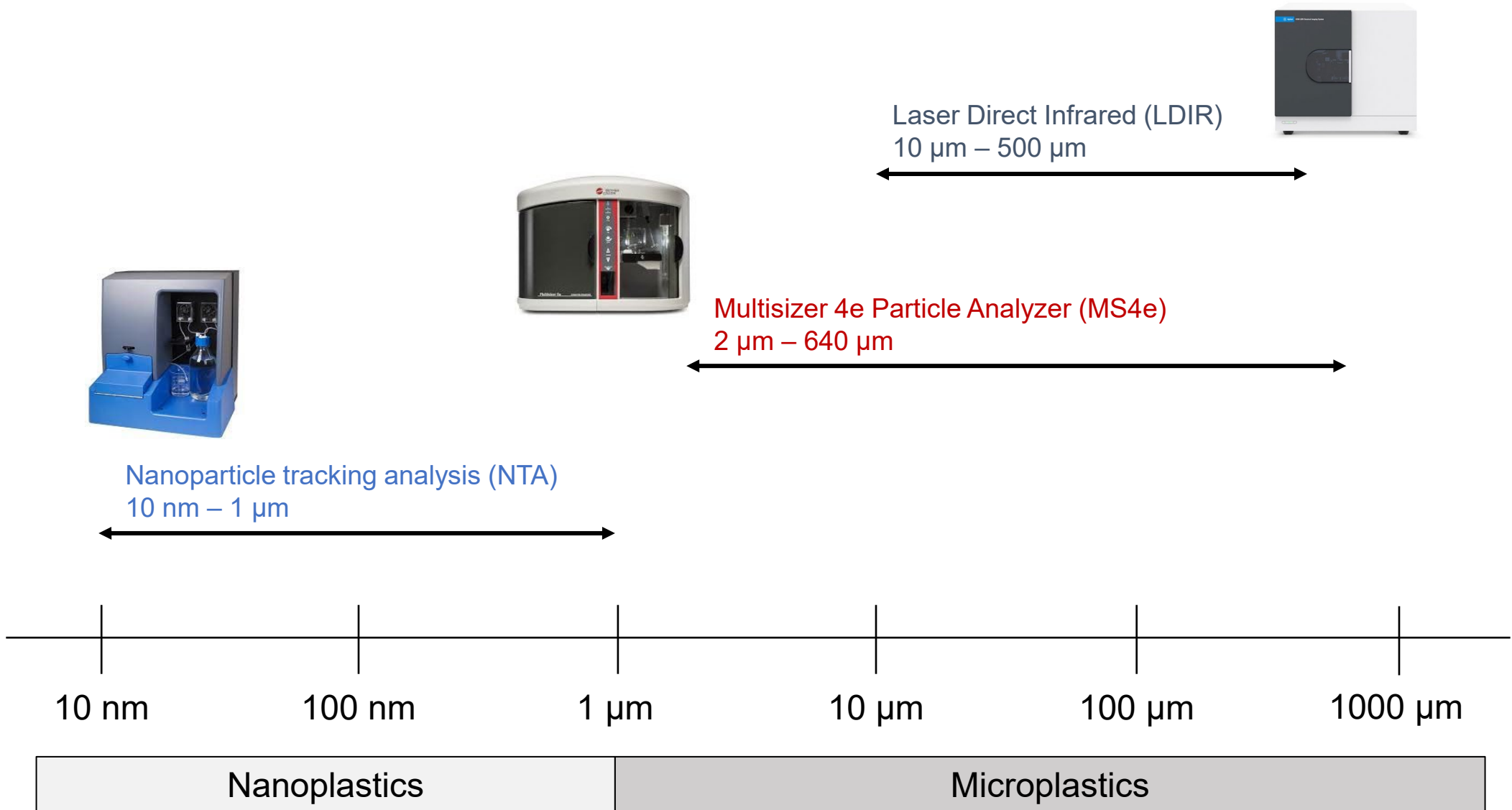
Completed reaction



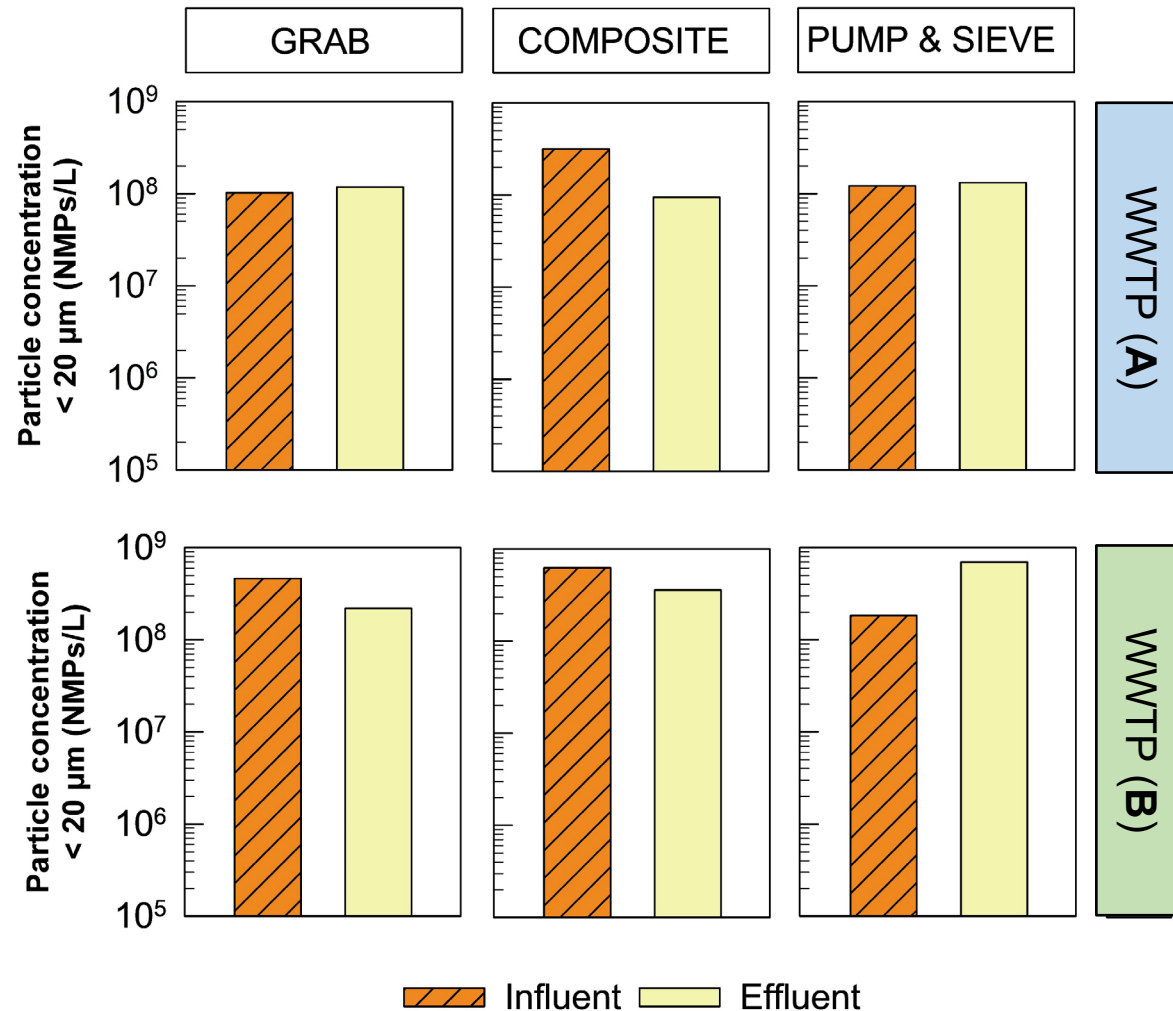
Density separation unit



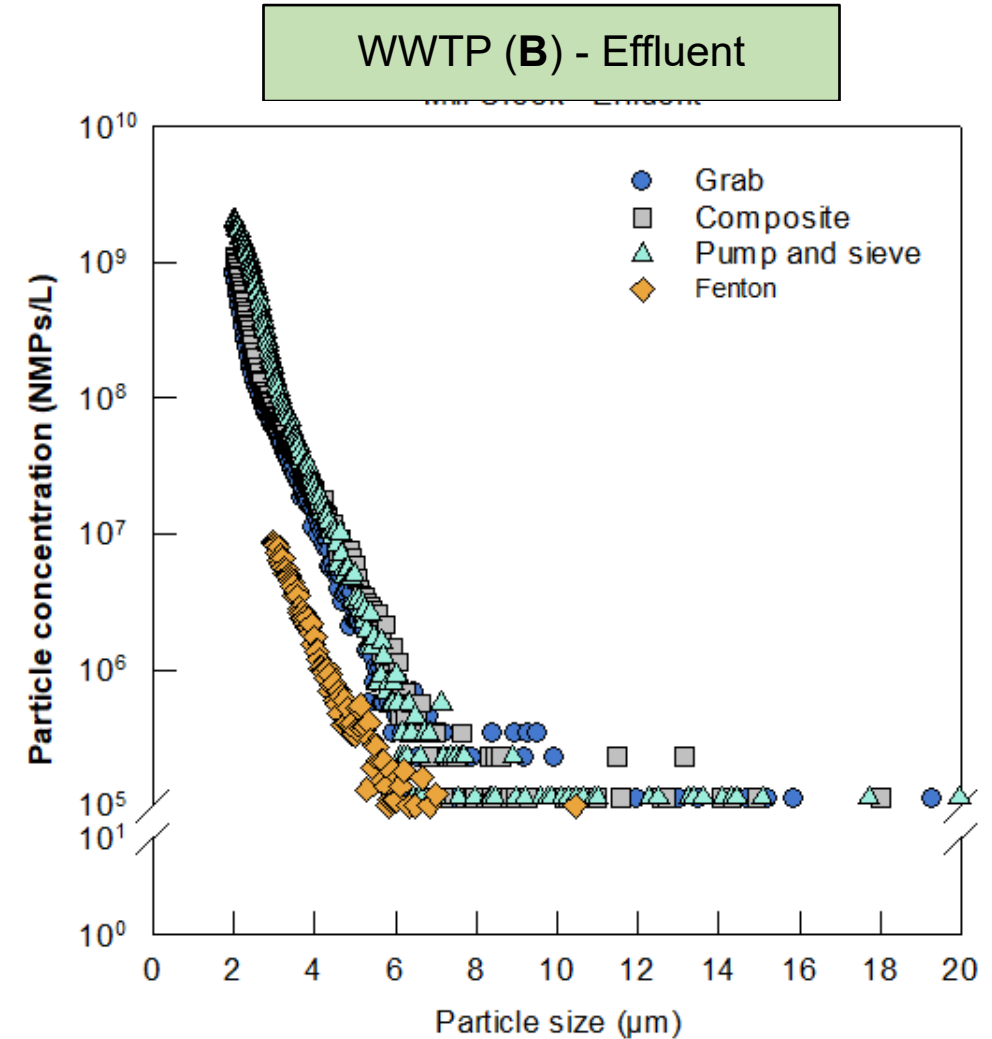
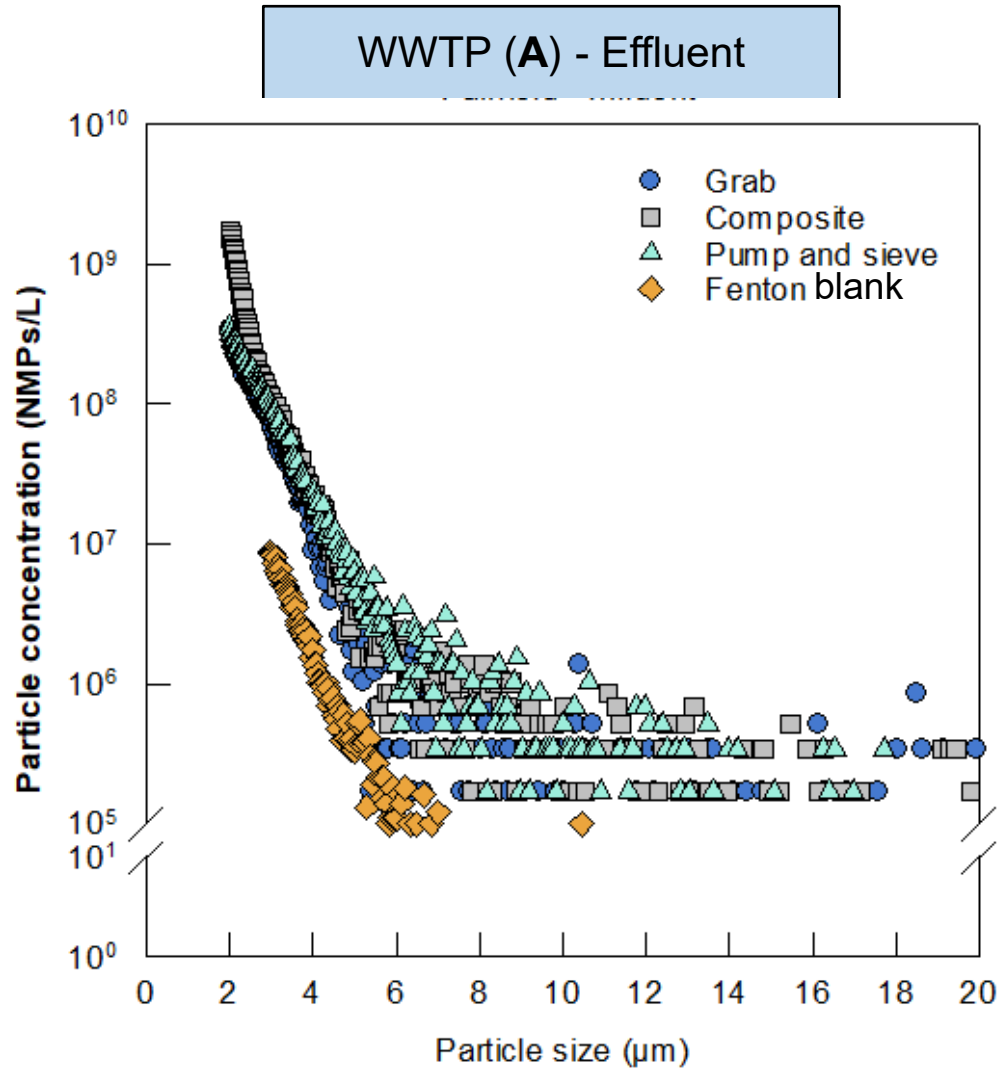
Laboratory approach



Similar particle counts (size < 20 μm) among sampling methods



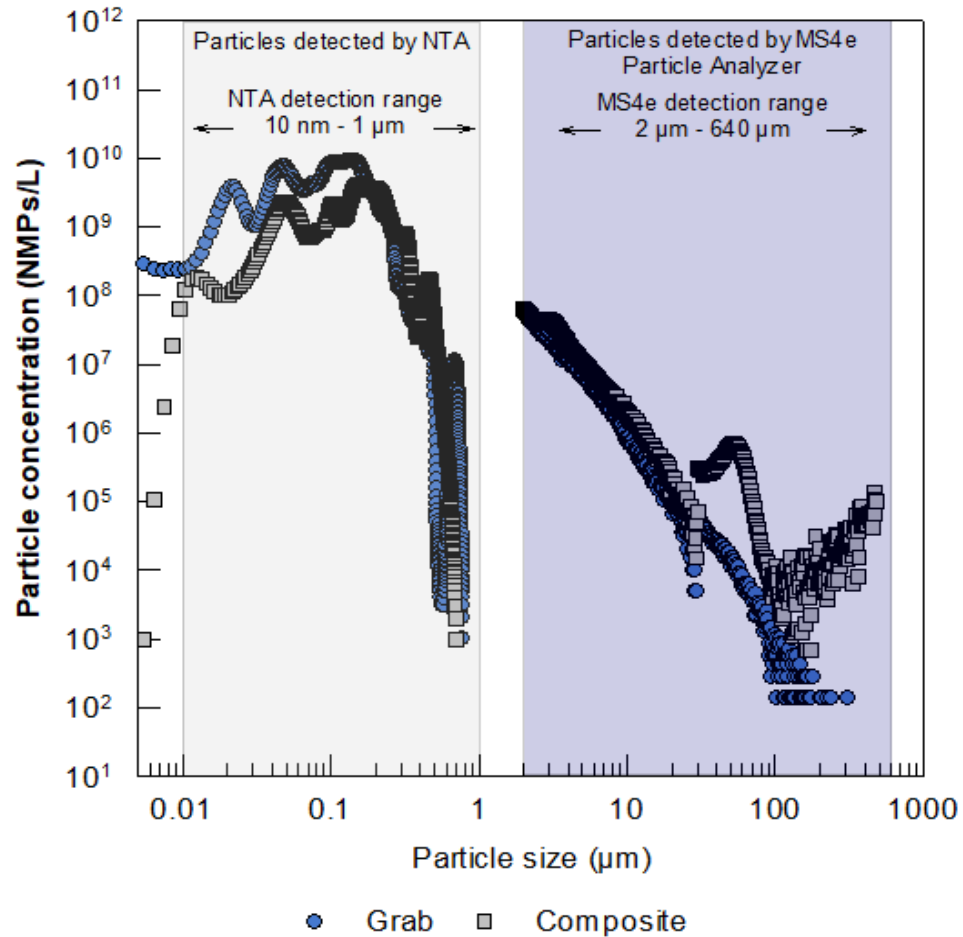
Similar particle distributions (size < 20 μm) among sampling methods



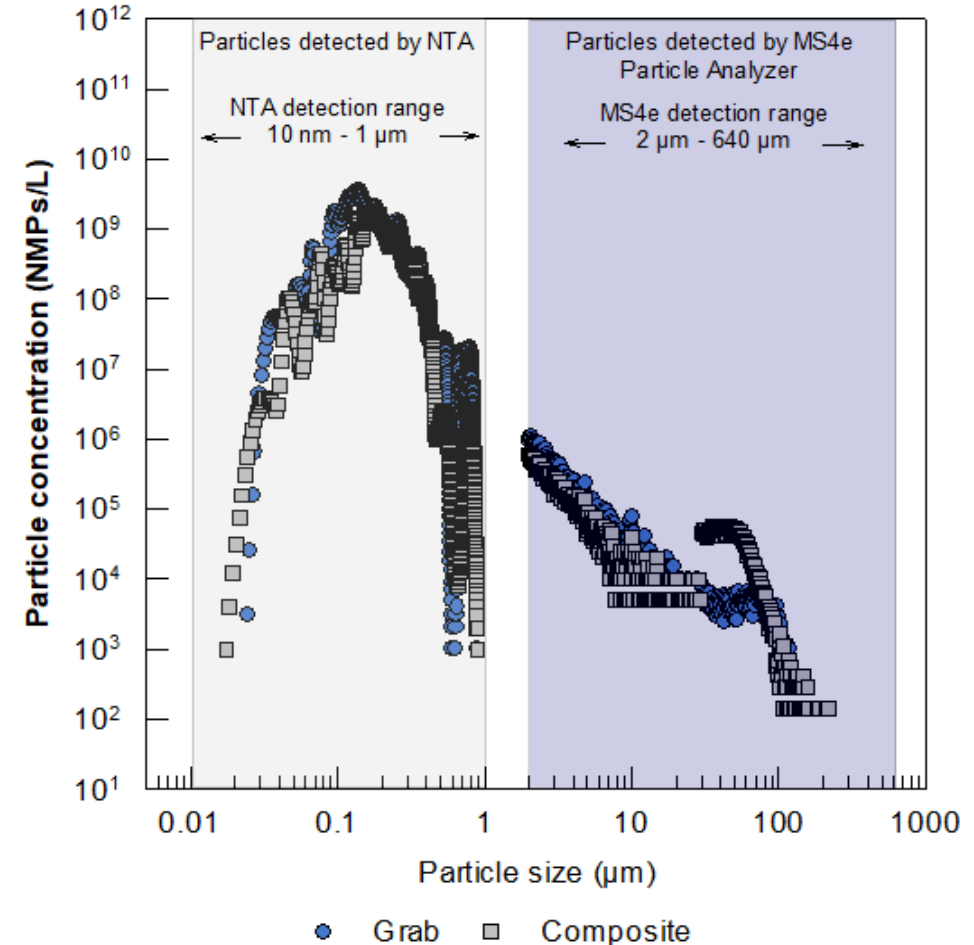
Large concentration of nano-sized particles

Inter – instrument agreement

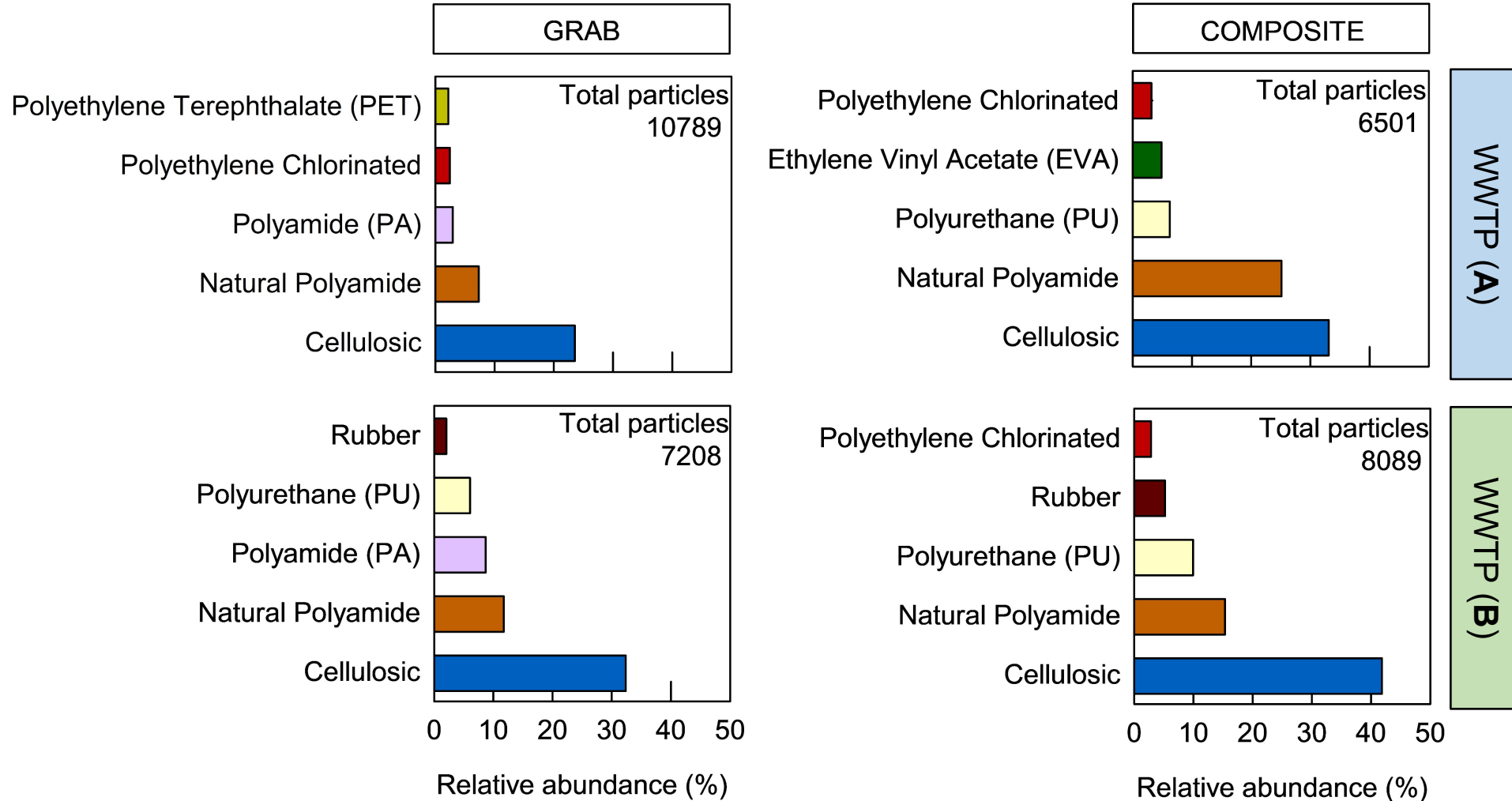
WWTP (A) - Influent



WWTP (A) - Effluent

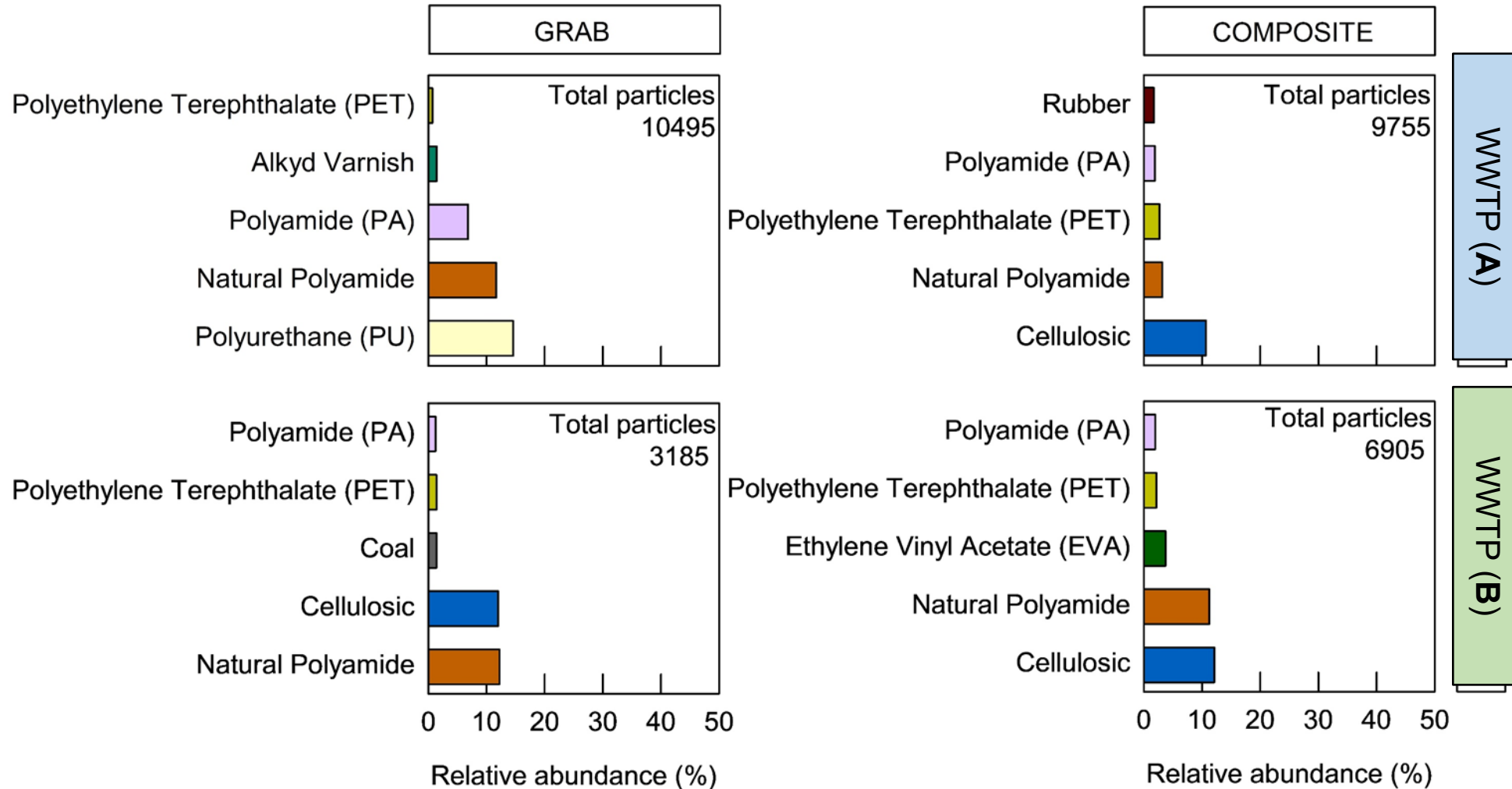


Comparison of top 5 plastic types *Influent*



D. Duvvuru. Sample preparation for LDIR, sample analysis by LDIR, LDIR data analysis.

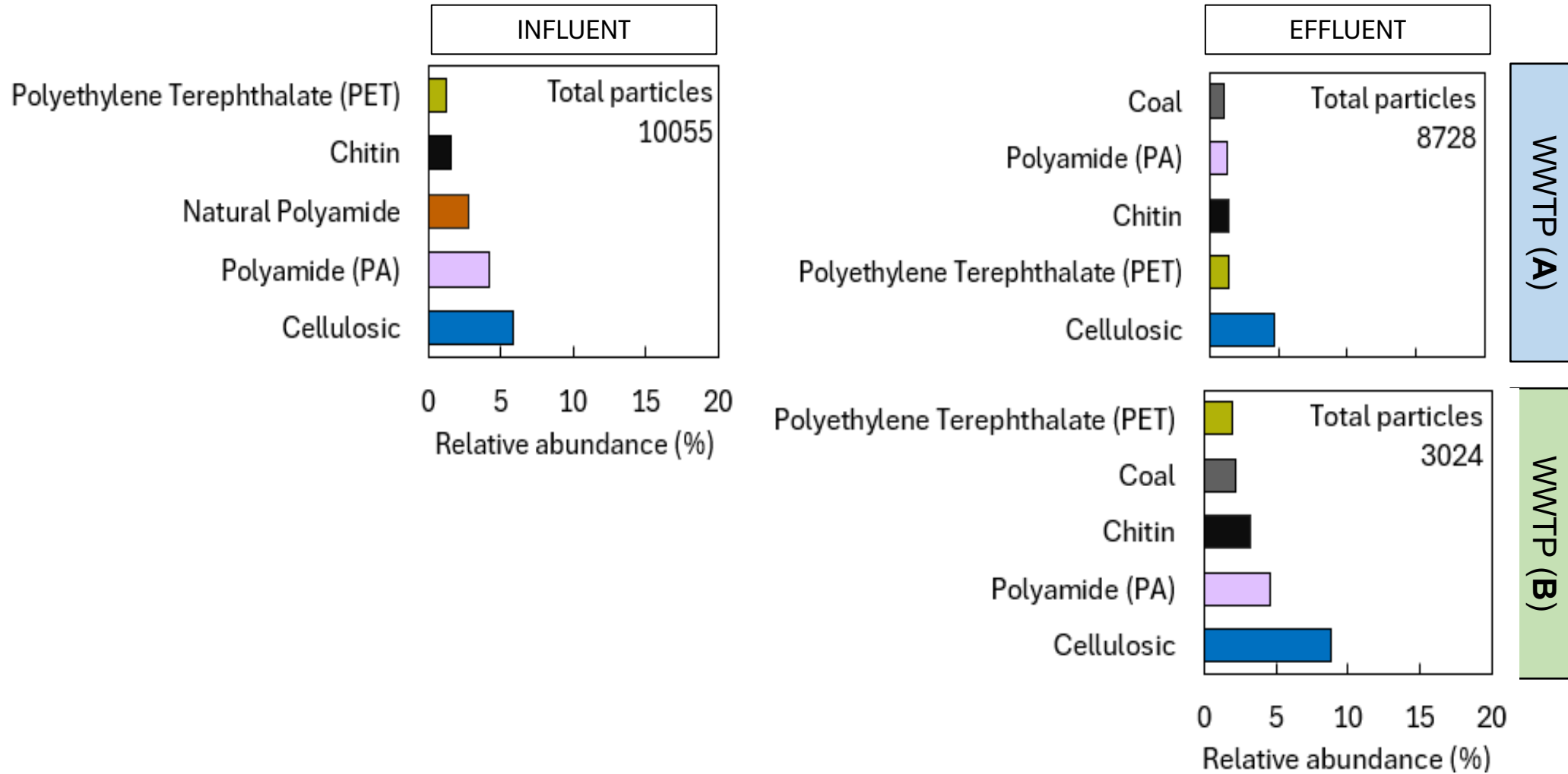
Comparison of top 5 plastic types *Effluent*



D. Duvvuru. Sample preparation for LDIR, sample analysis by LDIR, LDIR data analysis.

Comparison of top 5 plastic types

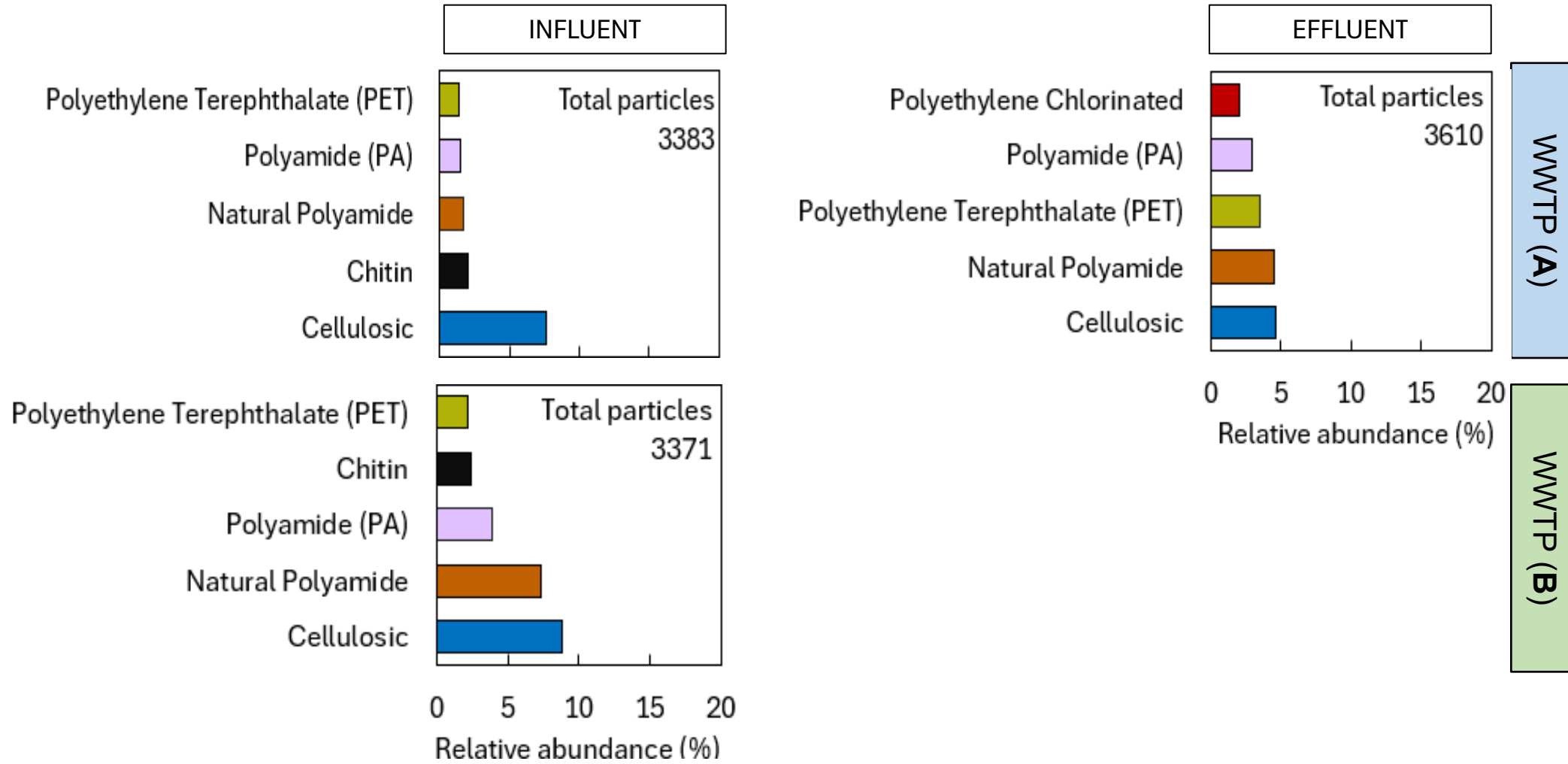
Composite Sample – August 2024



D. Duvvuru. Sample preparation for LDIR, sample analysis by LDIR, LDIR data analysis.

Comparison of top 5 plastic types

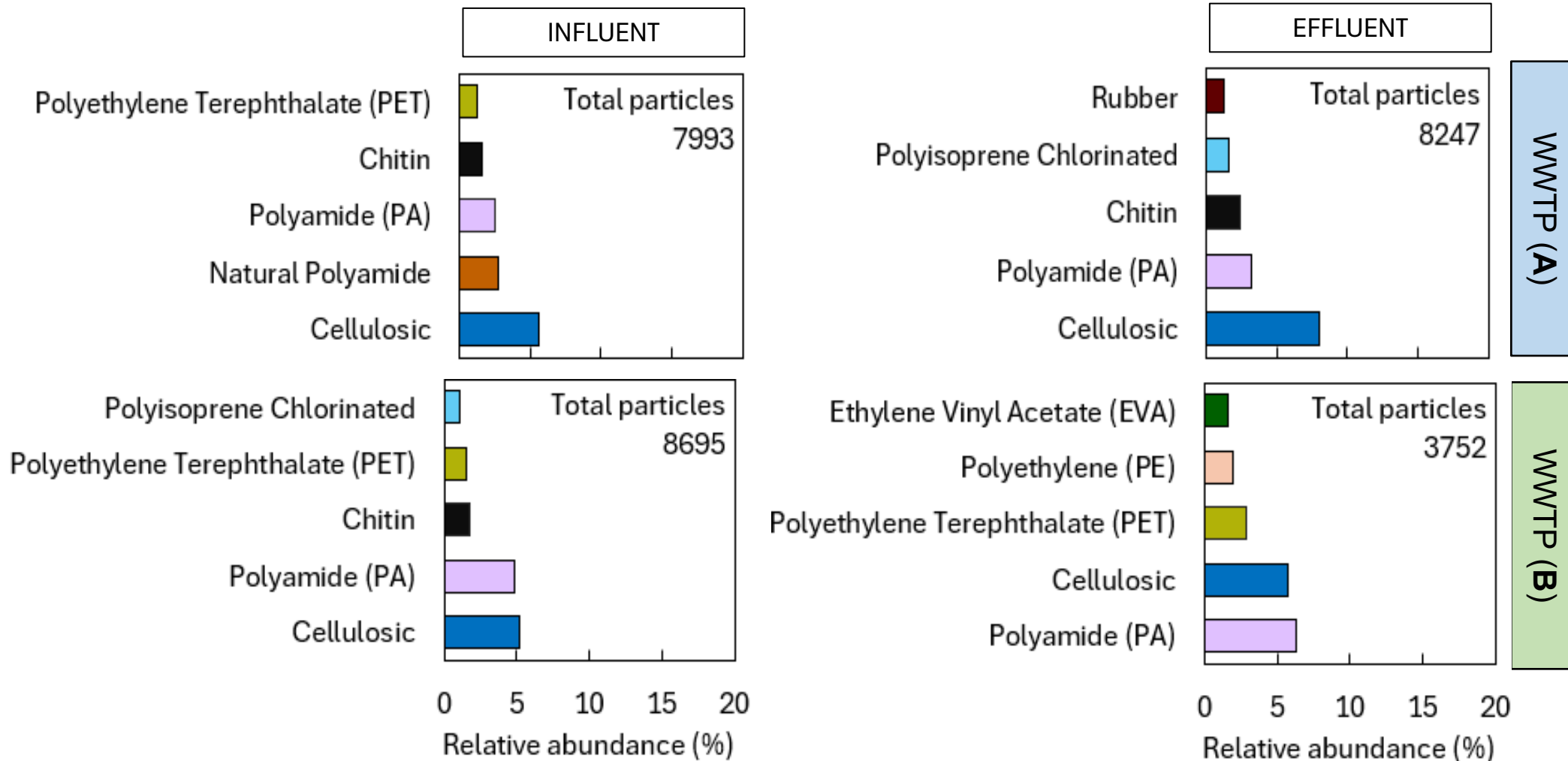
Composite Sample – November 2024



D. Duvvuru. Sample preparation for LDIR, sample analysis by LDIR, LDIR data analysis.

Comparison of top 5 plastic types

Composite Sample – December 2024



D. Duvvuru. Sample preparation for LDIR, sample analysis by LDIR, LDIR data analysis.

Ongoing research efforts

- Long term NMP behavior in both wastewater treatment plants
 - Seasonality
 - Diurnal fluctuations in flow rate
- Correlations between NMP behavior and wastewater treatment characteristics (e.g., NTU)



Acknowledgments

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 - T&E Facility – APTIM
 - City of Fairfield Wastewater Treatment Plant
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 - Adam Balz, U.S. EPA

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