

# Microplastics Removal Through Water Treatment Plants- Current Knowledge and Future Directions

A Presentation by:

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# Microplastics in the News



HEALTH

Do you have plastic in your blood? 80% of people do, study shows

**PLASTIC IN YOUR BLOOD?**

**STUDY: MICROPLASTICS FOUND IN HUMAN BLOOD**

RUSH HOUR

45 RUSSIANS SUSPECTED OF SPYING | SOME PROMINENT RUSSI | LATEST HEADLINES | NEWSNATION | 2:41 PM

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**Plastic fibres found in tap water around the world, study reveals**

Exclusive: Tests show billions of people globally are drinking water contaminated by plastic particles, with 83% of samples found to be polluted

We are living on a plastic planet. What does it mean for our health?

72,462 1,619

**BBC NEWS**

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Science & Environment

## Plastic from tyres 'major source' of ocean pollution

By Helen Briggs  
BBC News

22 February 2017 | Science & Environment



Tyres can give off plastic particles, that can end up in the ocean

Particles of debris from car tyres are ending up in the ocean as "plastic soup", conservationists warn.

Microplastics from tyres and textiles are a bigger source of marine pollution than the breakdown of household waste, says a new study.

**Los Angeles Times**

HOUSE ISSUES THREATS, TRUMP RAGES

**L.A. vows to void 2 million court citations and warrants**

**Cars pollute the sea too, with tire rubber**

California's waters are awash in microplastics, and automobiles may be the primary source

**A test-optional route into UC?**

**The Mercury News**

**Plastic tide: 7 trillion bits wash into bay every year**

New study reveals that storm drains are the largest source of the toxic cocktail

**Pompeo, House chairmen clash**

Secretary of state rejects House demands to depose State Department officials

**Excusal of black jurors ruled legal**

**San Francisco Chronicle**

**Huge amounts of plastic, much of it from car tires, washing into SF Bay, study finds**

Trash gathers on the shoreline of San Francisco Bay at the Berkeley Marina

More than 7 trillion tiny pieces of plastic wash from city streets into San Francisco Bay each year, a new study finds, a staggering amount of pollution that researchers weren't entirely aware of and aren't prepared to stop.

The microplastic, defined as plastic particles smaller than 5 millimeters, are the remnants of bottles, cigarettes, clothing fibers and a seemingly endless list of plastic products. They're pushed by rain into storm drains and carried through rivers and creeks into the bay.

Nearly half of this pollution, according to the report, consists of black rubbery fragments that the study's authors believe are from worn tires.

"These urban stormwater findings really surprised us," said Rebecca Sutton, lead author of the study and senior scientist for the San Francisco Estuary Institute, a research center in Richmond. "We were not anticipating such high levels."

The study represents the most comprehensive look at microplastics in California. The work is unique in quantifying just how much plastic pollution comes from stormwater runoff. The researchers estimate that rain is washing 100 times more plastic into the water than what enters through sewers and sewage treatment plants.

# Today's Topic

Overview: Microplastics in Water Treatment Plants

Removal with Conventional Water Treatment Technologies

Removal with Emerging Treatment Technologies

Management of Water Treatment Wastes

Challenges and Data Gaps

Conclusions and Future Research

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Management of Water Treatment Wastes

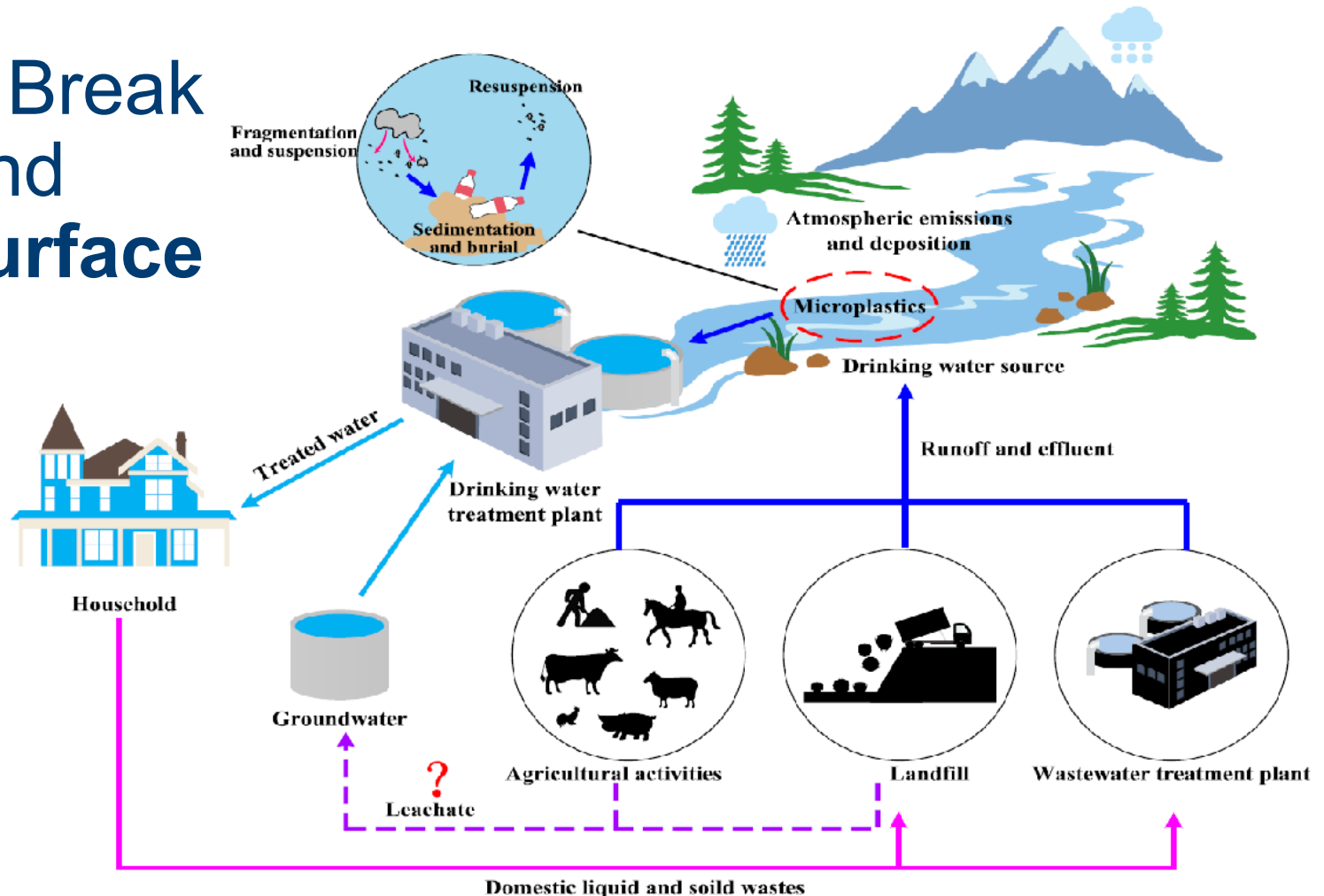
Challenges and Data Gaps

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# How Do Microplastics Enter Water Treatment Plants?

## Plastics Break Down and Enter Surface Waters



Overview: Microplastics in Water Treatment Plants

**Removal with Conventional Treatment Technologies**

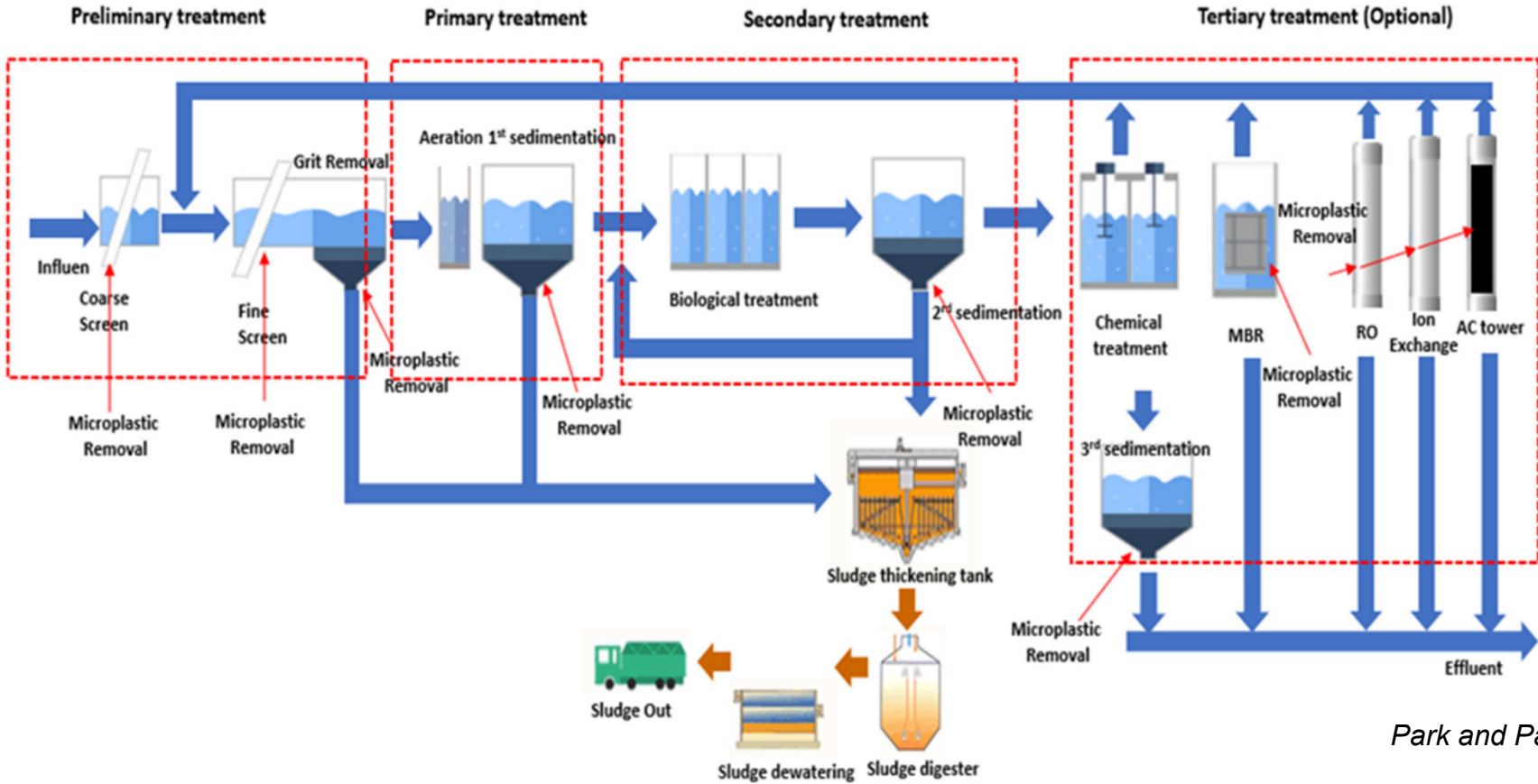
Removal with Emerging Technologies

Management of Water Treatment Systems

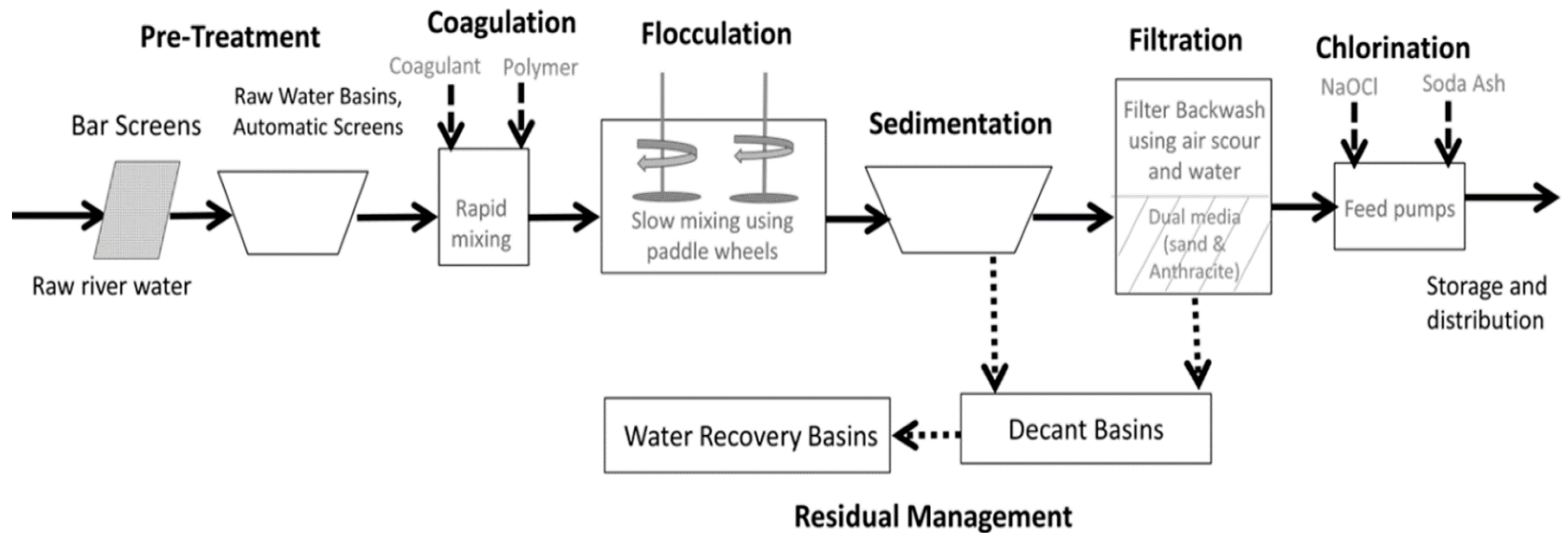
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# Conventional Wastewater Treatment Plants

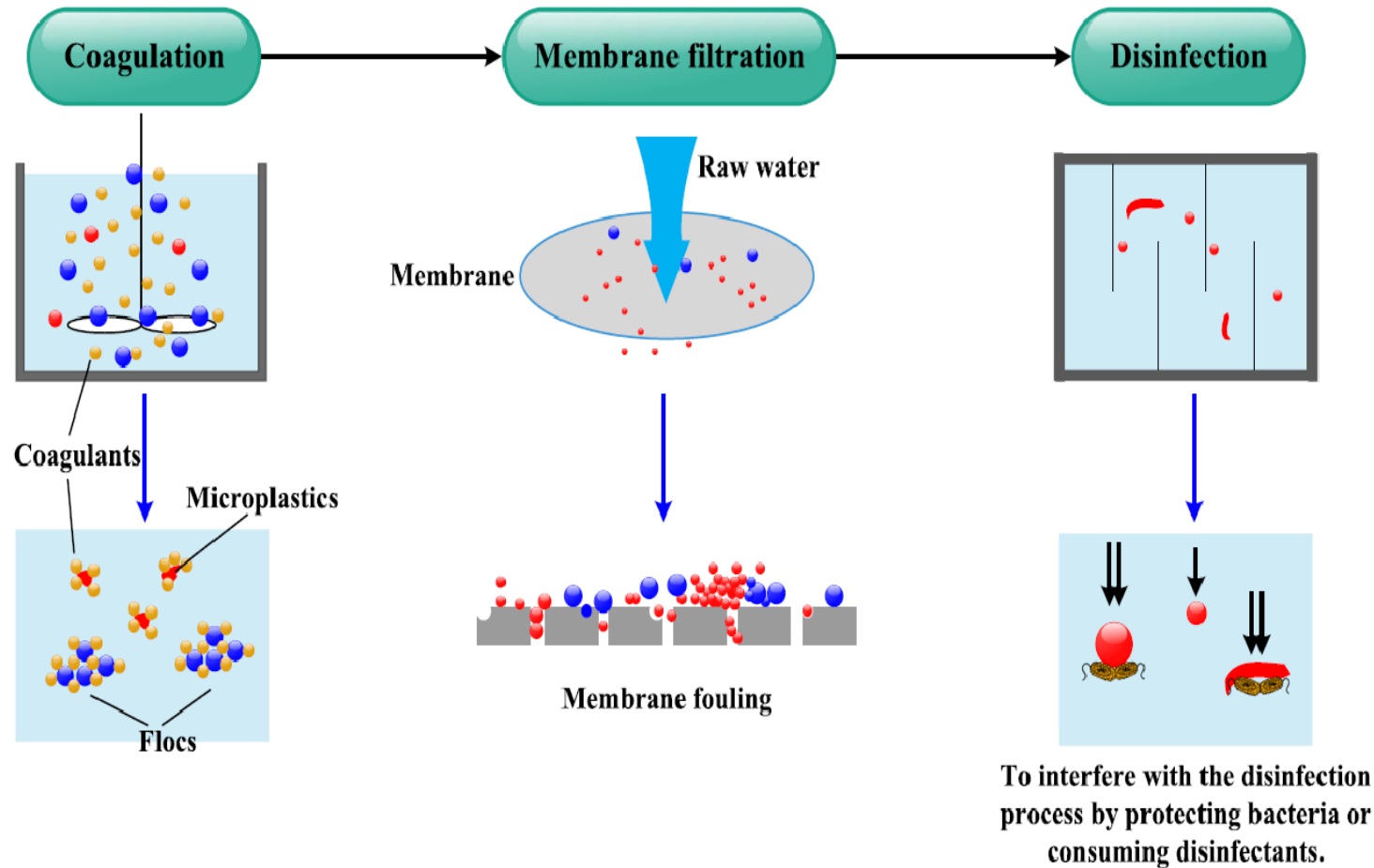


# Conventional Drinking Water Treatment Plants

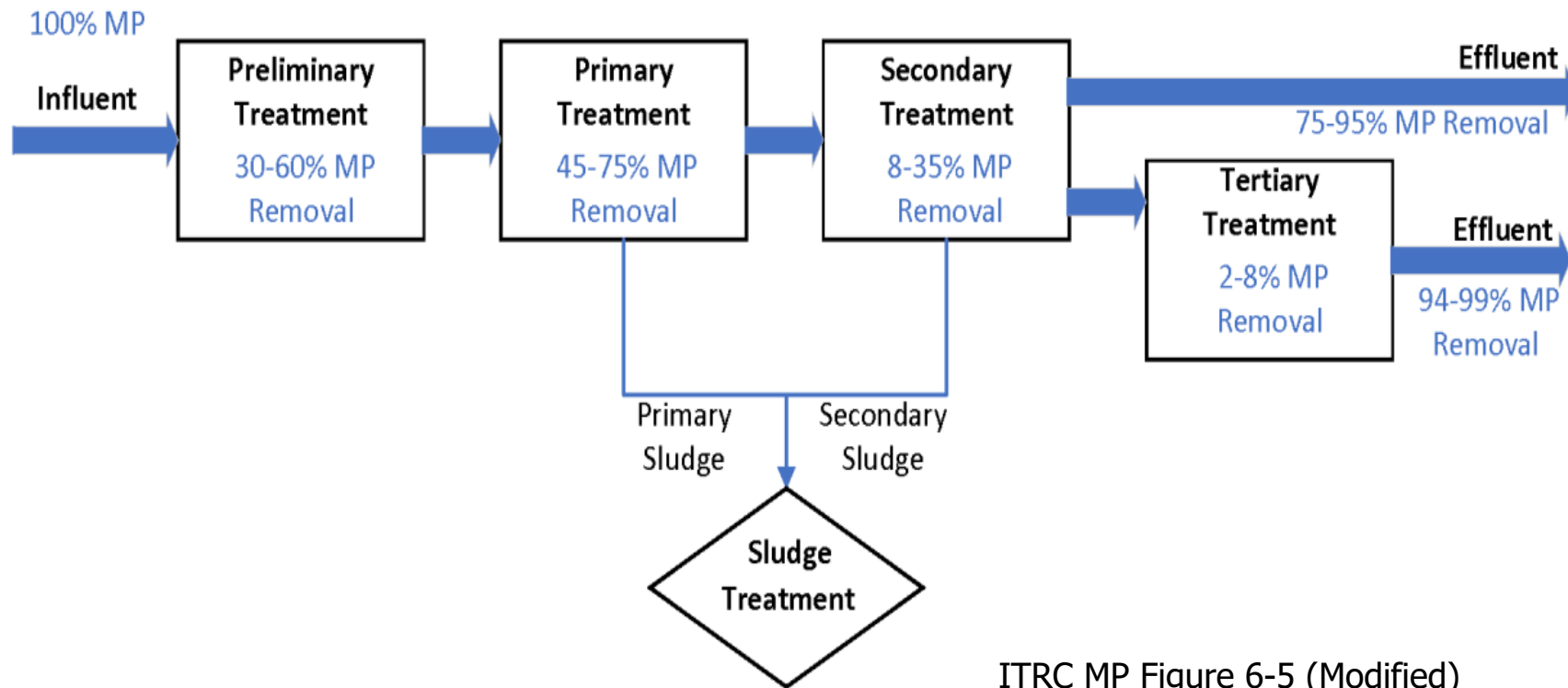




# Challenges Encountered



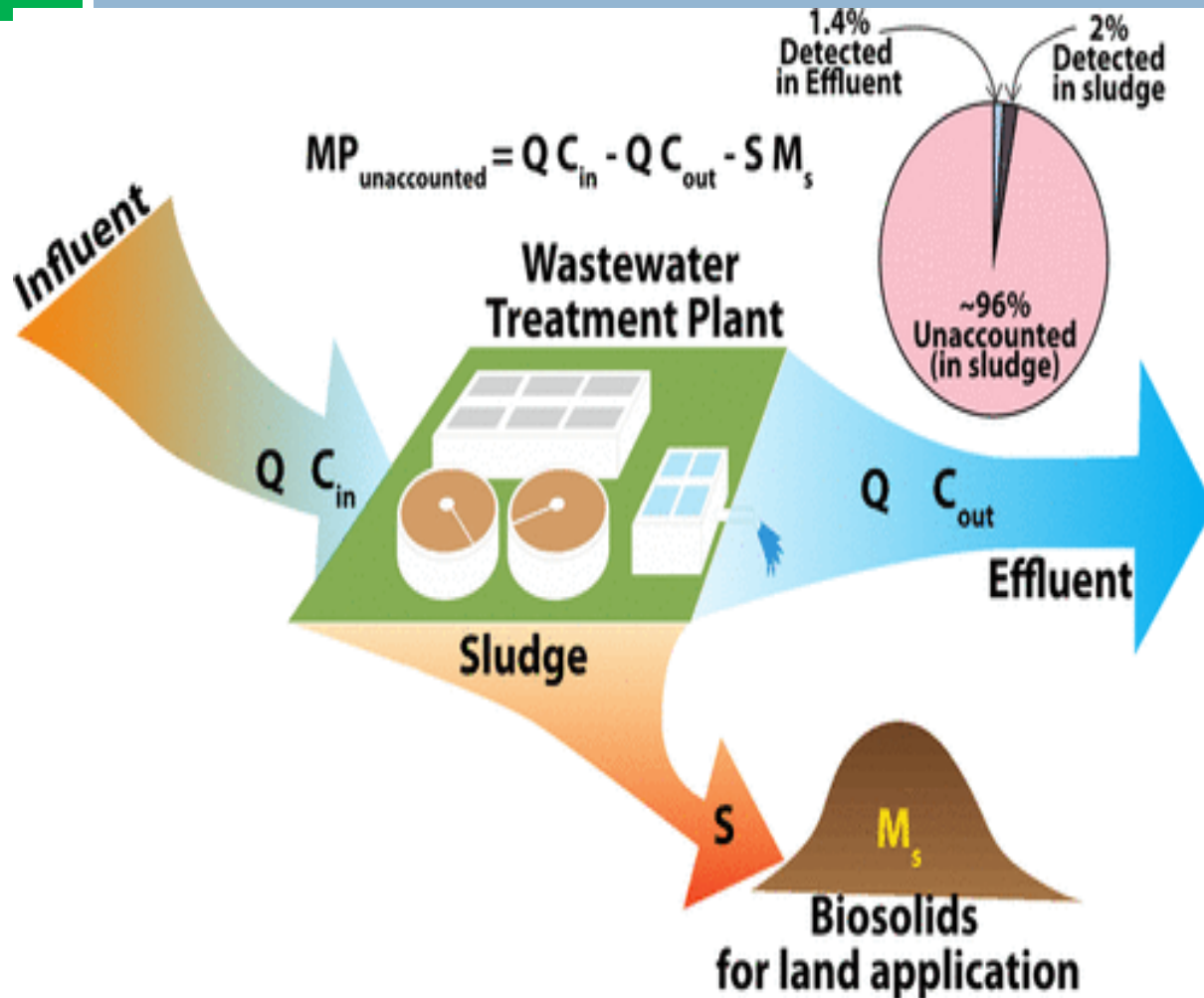
# Microplastics Removal in Wastewater Treatment Plants



ITRC MP Figure 6-5 (Modified)

Source: Renee Lu, modified from Ali et al. (2021)

# Unaccounted Microplastics in Wastewater Sludge: *Where Do They Go?*



Sampling Artifacts and Detection Limits

- A lack of uniform protocols in sampling and analysis

Fragmentation of plastics during wastewater treatment

- Heat and Physical stress

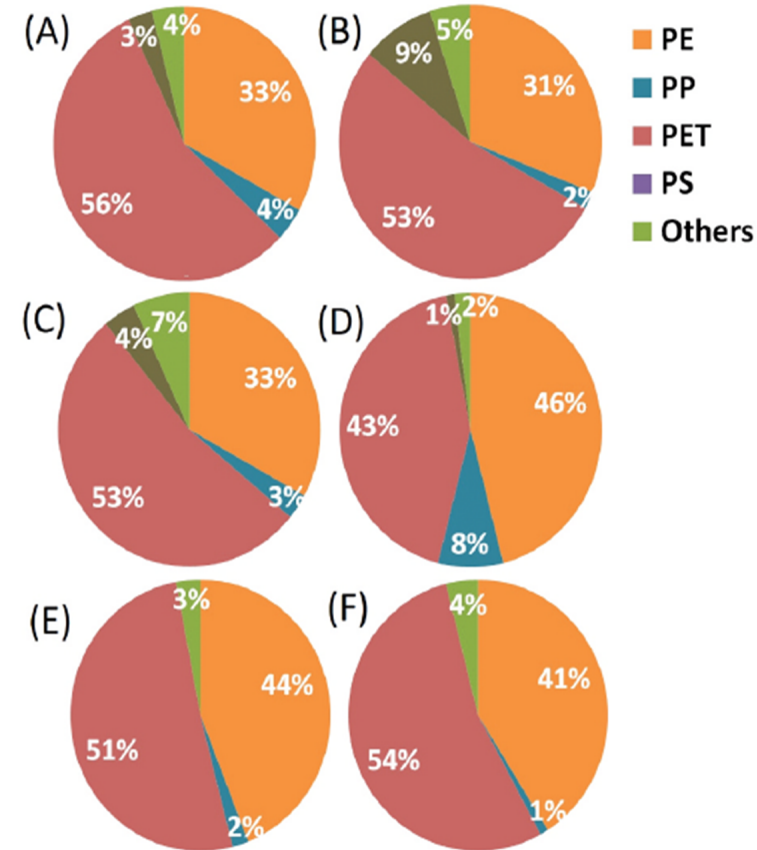
Biodegradation of MPs at WWTPs

- Fragmentation, heat, carbon source

# Microplastic Removal in Drinking Water Treatment Plants

Comparison of microplastics removal efficiency with other studies.

Country	Raw water	System steps	MP size	MP (items/L)		Removal efficiency (%)	Reference
				Raw water	Treated water		
Czech Republic	Large reservoir	Coagulation/flocculation and sand filtration	0.2-100 µm	1473 ± 34	443 ± 10	70	Pivokon et al. (2020)
Czech Republic	Small reservoir	Coagulation/flocculation, sedimentation, sand and GAC filtration	do	1812 ± 35	338 ± 76	81	Pivokon et al. (2020)
Czech Republic	River	Coagulation-flocculation, flotation, sand filtration and GAC filtration	do	3605 ± 497	628 ± 28	83	Pivokon et al. (2020)
Germany	Ground water	Aeration and filtration	>20 µm	0-7 items/m <sup>3</sup>	0-3 items/m <sup>3</sup>	-	Minteniş (2019)
Czech Republic	Úhlava River at Milence	Coagulation, flocculation, sand filtration, CO <sub>2</sub> lime and ClO <sub>2</sub> treatment	1-100 µm	23 ± 2	14 ± 1	39.13	Pivokon et al. (2020)
Czech Republic	Úhlava River at Plzeň	Lime milk, coagulation, flocculation, sedimentation, KMO <sub>4</sub> oxidation, sand filtration, ozonation, GAC filtration, UV treatment, CO <sub>2</sub> lime and chlorine treatment	do	1296 ± 35	151 ± 4	88.34	Pivokon et al. (2020)
China	Yangtze River	Coagulation/flocculation, sedimentation, sand filtration, ozonation combined with GAC filtration	1-100 µm	6614 ± 1132	930 ± 72	82.1-88.6	Wang et al. (2020)
India	Ganga River	Chlorination, coagulation, pulse clarification and sand filtration	25-100 µm	17.86 ± 2.66	2.75 ± 0.92	85.39	Present study



Percentage distribution of plastic types (PE, PP, PET, PS and others) at the different water treatment steps (A. Raw water; B. Pre-disinfection; C. Flocculation; D. Pulse clarification; E. above Sand filtration

Overview: Microplastics in Water Treatment Plants

Removal with Conventional Technologies

**Removal with Emerging Technologies**

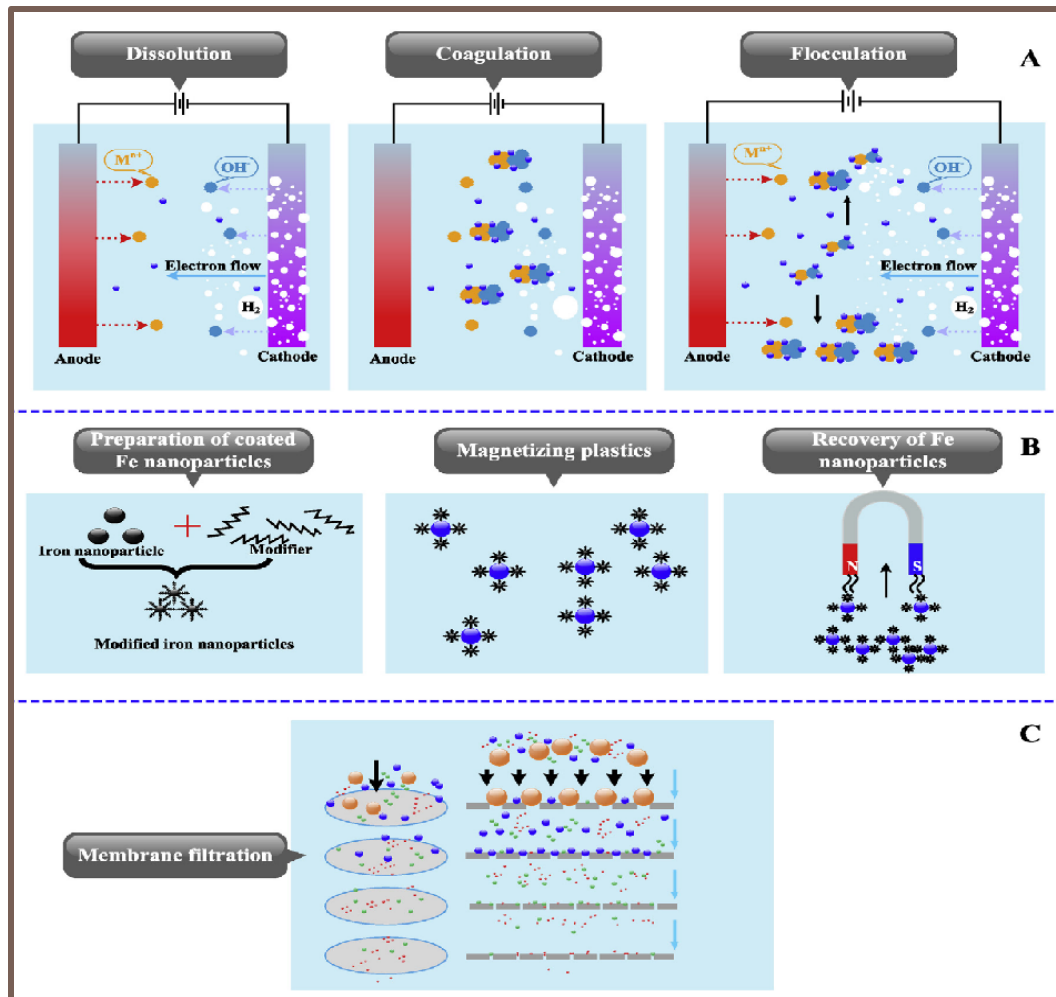
Management of Water Treatment Systems

Challenges and Data Gaps

Conclusions and Future Research



# Selected Emerging Technologies



Shen et al., 2020

## A. Electrocoagulation

- i. Laboratory Scale
- ii. Optimum removal efficiency ~99.24% (Perren et al., 2018)

## B. Magnetic Extraction

- i. Better removal of small MPs (<20  $\mu\text{m}$ )
- ii. Suitable for drinking water treatment and not preferred for sediment

## C. Membrane Separation

- i. Fouling

## D. Sol-Gel Method

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# Management of Water Treatment Wastes

## Sludge

- Landfill
- Incineration
- Agriculture
- Cement, glazed tiles and ceramic<sup>1,2,3</sup>
- Lime stabilization
- Composting
- Anaerobic digestion
- Thermal drying

## Membranes

- Reusing ROs for NF and UF<sup>4</sup>
- As geotextile for stabilizing rocks and retarding grass
- No studies available prior to their reuse and recycling

## Filtration Concentrate

- Electrodialysis and shear enhanced NF/RO to remove nutrients<sup>5</sup>
- UV and TiO<sub>2</sub> in photo-oxidative removal of diclofenac ( > 95%), ibuprofen ( > 95%) and naproxen ( < 65%) from the concentrate of a nanofiltration
- No studies available targeting the microplastics

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# Key Challenges and Knowledge Gaps

- No two WWTPs are identical:
  - Connectivity of wastewater system
  - Wastewater treatment processes
  - Sludge treatment process
- Sources of microplastics to WWTPs
- Effect of different wastewater and sludge treatment processes
- Lacking standardized methodologies
- A full-size distribution of plastic particles in sludge





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# Conclusions and Future Research

- Efficiency of microplastics removal
- Range of compositions in the effluent of WWTPs
- Gaps related to the efficiency of treatment technologies
- More research related to the fate of MPs in the WTPs as well as technologies removing MPs



# What do all these things have in common?



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