WRF Webcast

Occurrence of Microplastics in Water…Size Does Matter!

December 13, 2018

Housekeeping Items

- Submit questions through the question box at any time!
- Participate in the Live Poll after the first presenter.
- We will do a Q&A near the end of the webcast.
- Please be sure to take the survey at the end of the webcast.
- Slides and a recording of the webcast will be available at www.waterrf.org within 24 hours.

Agenda

Today, December 13| 3pm - 4:30pm ET

(12pm PT, 1pm MT, 2pm CT, 9pm GMT/UTC+1,)

- Overview
- Microplastics in Aquatic Systems - Size Does Matter! – Dr. Allen Burton, Univ. of Michigan
- Live Polling – Webcast participants
- Current Research Trends and WRF research activities
  - ❖ Biological Nutrient Removal (BNR) facility Ejby Mølle, Denmark - Per Henrik Nielsen, VCS Denmark
  - ❖ Microplastics in Wastewater and Policy Implications – Shelly Walther, Sanitation Districts of Los Angeles County - LACSD
  - ❖ Determining the Fate and Major Removal Mechanisms of Microplastics in Water & Resource Recovery Facilities (WRF-4936) - Dr. Belinda Sturm, Univ. of Kansas (PI)
  - ❖ WRF Research Activities & Collaborations on Microplastics - Lola Olabode, Moderator
- Q & A

Microplastics in Aquatic Systems:
Size Does Matter!

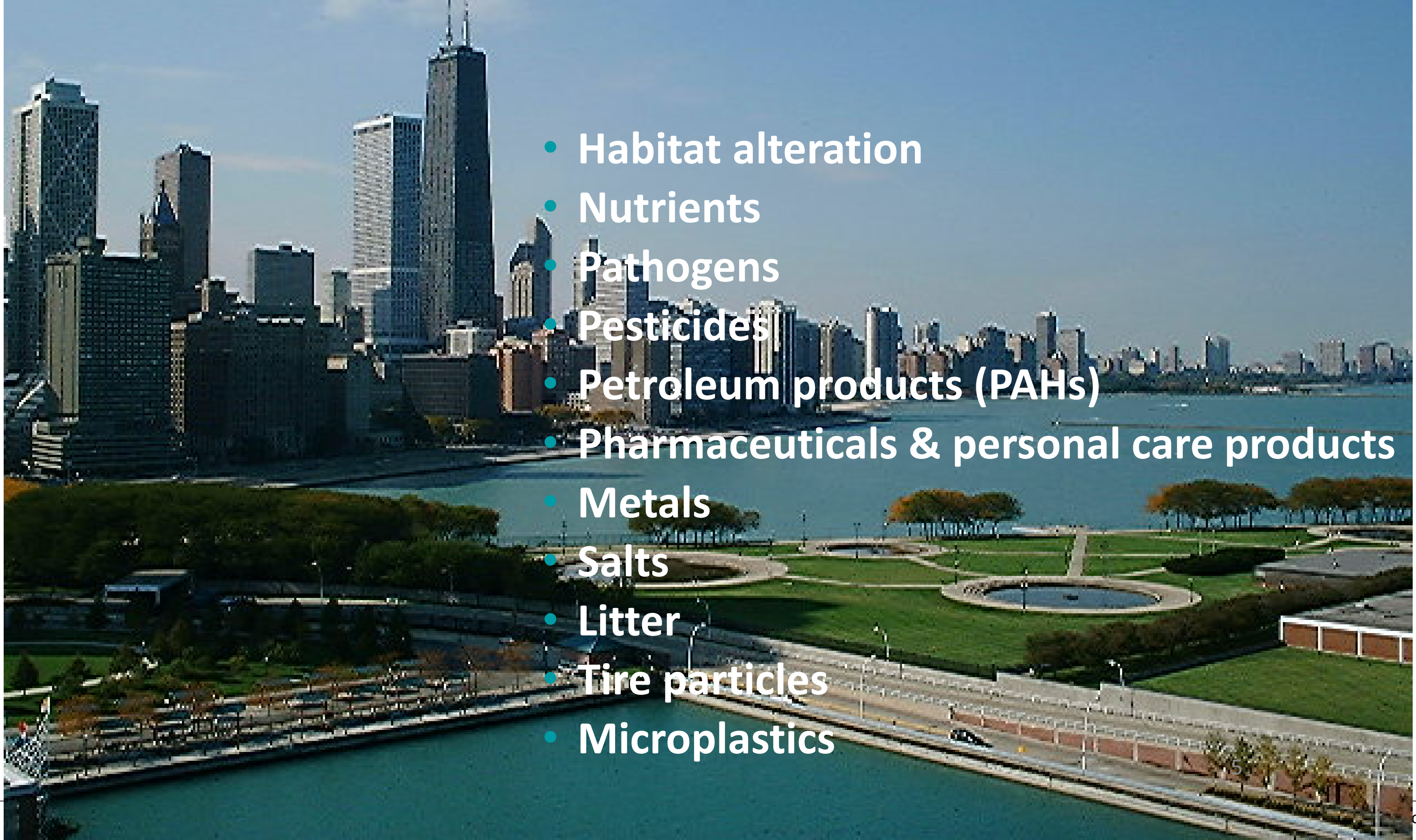
G. Allen Burton, Jr.

University of Michigan

burtonal@umich.edu

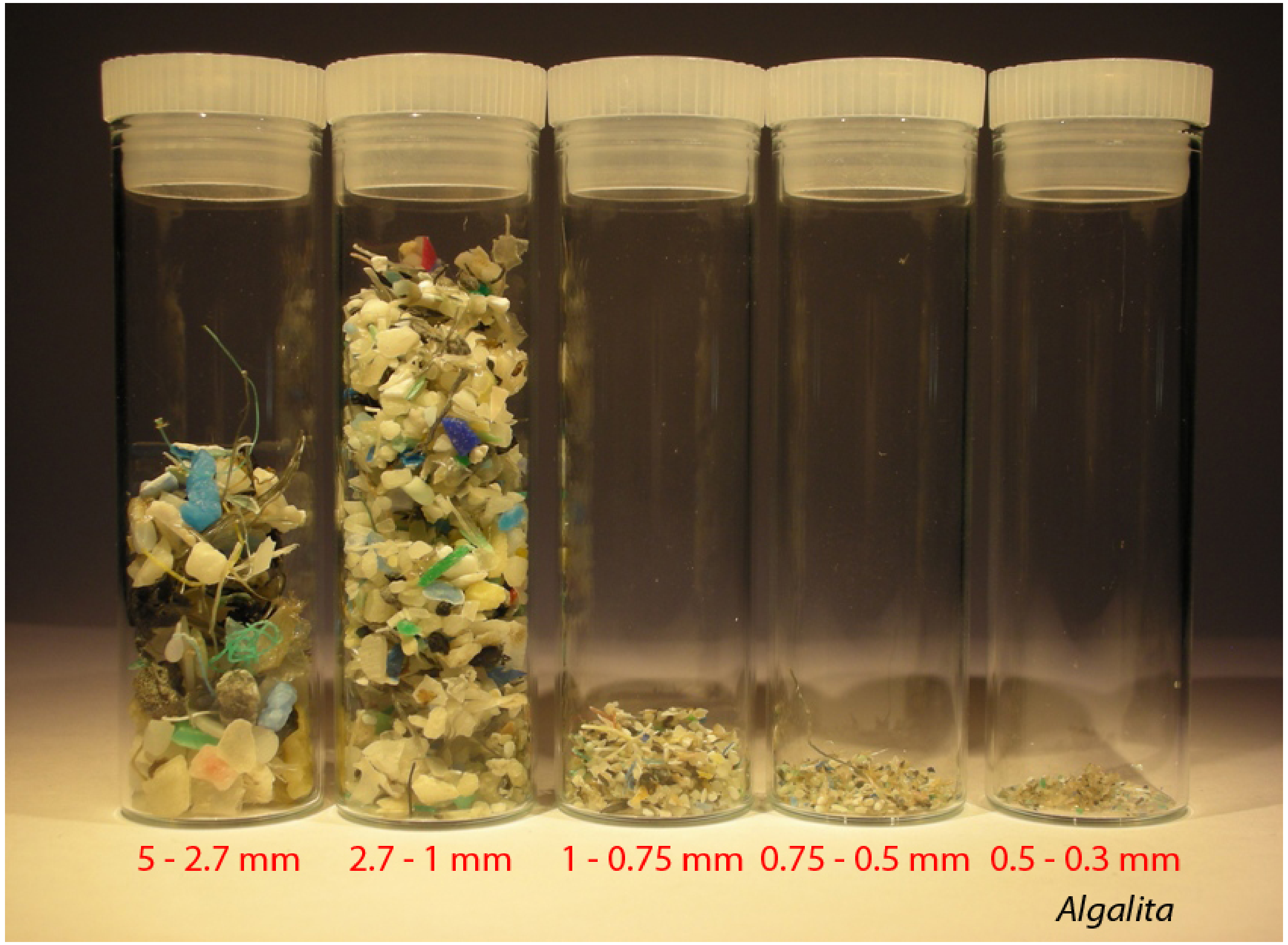
Human Dominated Watersheds

Runoff and Point Source Stressors Impairing Receiving Waters – *sometimes…*



- **Habitat alteration**
- **Nutrients**
- **Pathogens**
- **Pesticides**
- **Petroleum products (PAHs)**
- **Pharmaceuticals & personal care products**
- **Metals**
- **Salts**
- **Litter**
- **Tire particles**
- **Microplastics**

Is the ECOLOGICAL problem "Macroplastics"?



Size distribution plastics from a typical Manta trawl
"Microplastics" measured typically 0.5 – 0.3 mm

Credit: Marcus Eriksen, 5 Gyres Institute

Credit: Claire Johnson/NOAA

Credit: Imhof et al. 2013. *Current Biology*

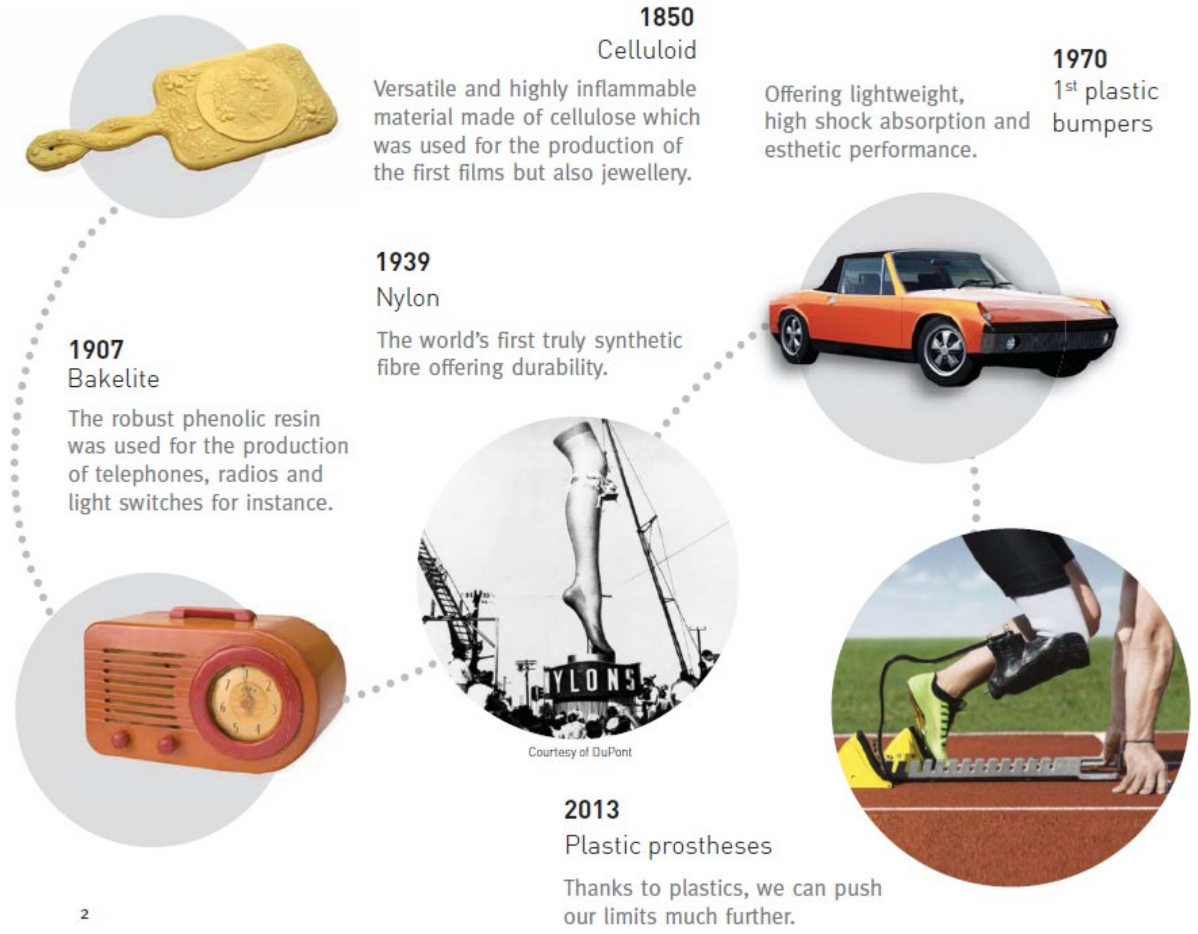
Different Sizes Requires Different Conversations:

Micro - Microplastics, Microbeads, Microfibers; **Nano –** sized? *vs.* **Macro –** Fishing nets/lines, bottles, packaging, bags, etc.

Size Does Matter!

The amount of plastic will continue to rise

Rochman et al. Nature. 2013



Increasing global demand

World Plastics Production, 1950 – 2012. The Facts about Plastic, PlasticsEurope (2013), p. 4.

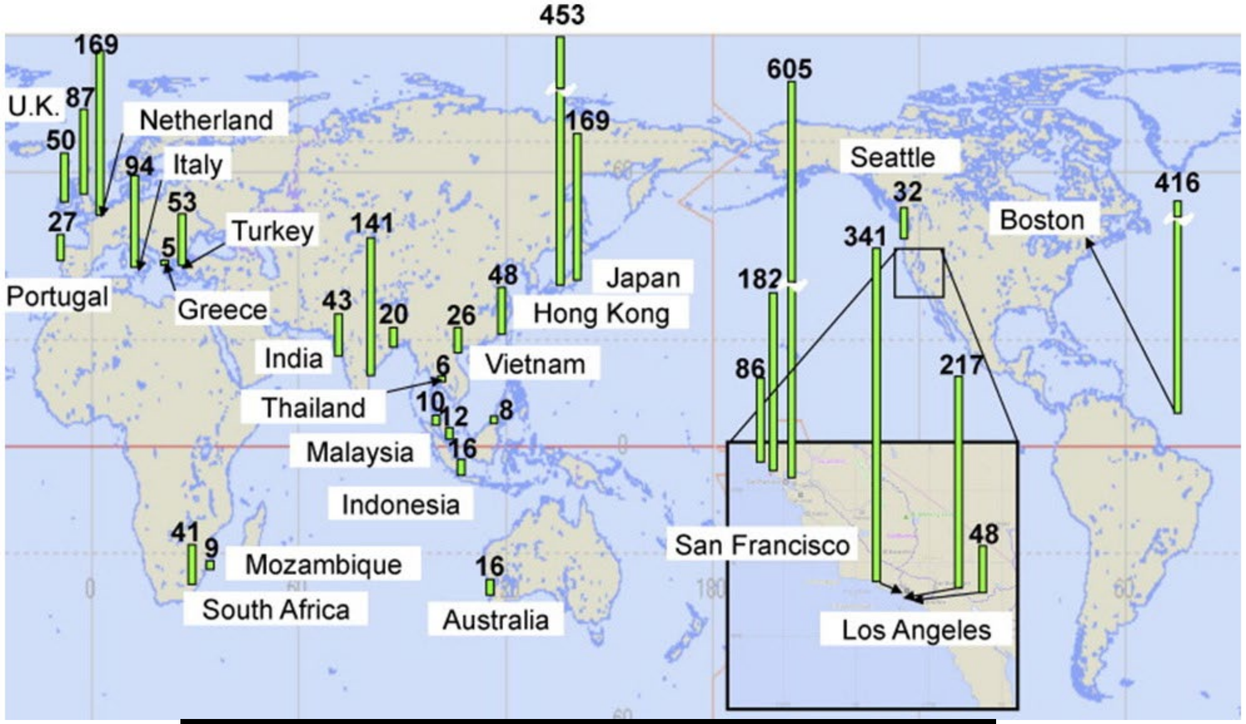
MPs and Adsorbed Pollutants

Plastics can adsorb and concentrate pollutants

- Persistent Organic Pollutants (e.g., PAHs, PCBs, pesticides)
- Metals (e.g., mercury, zinc, cadmium, lead)

Do these represent an ecological threat?

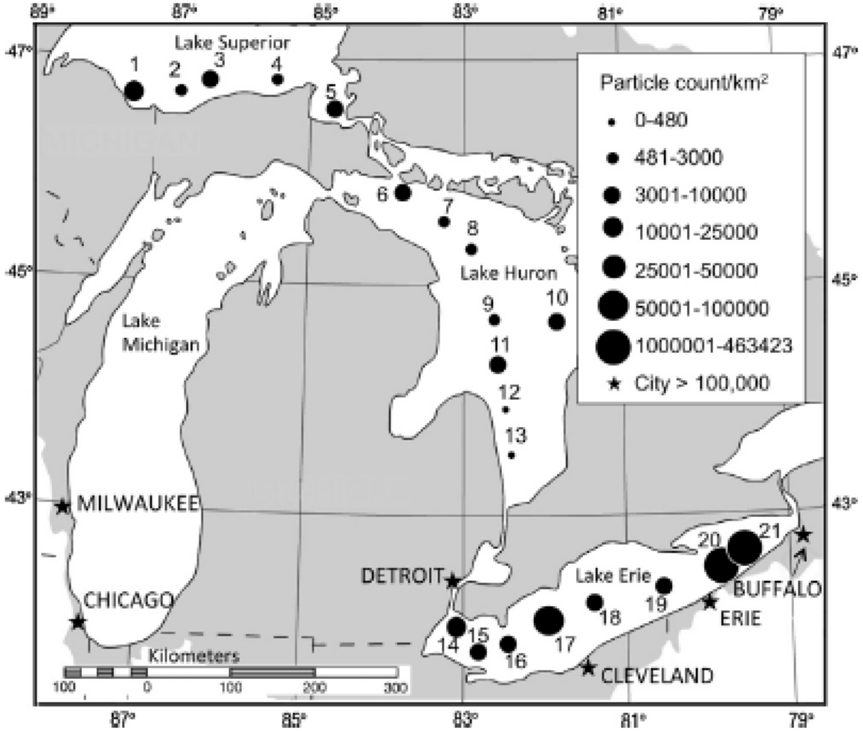
NO - Uptake AND assimilation pale compared to chemical uptake from prey ingestion



PCBs in beached plastic pellets.
Europea EU 2011, data from Teuten et al. 2009 and also International Pellet Watch, Ogata et al. 2011.

MP pollution in surface waters of the Great Lakes

(Eriksen et al. 2013 Marine Pollution Bulletin)

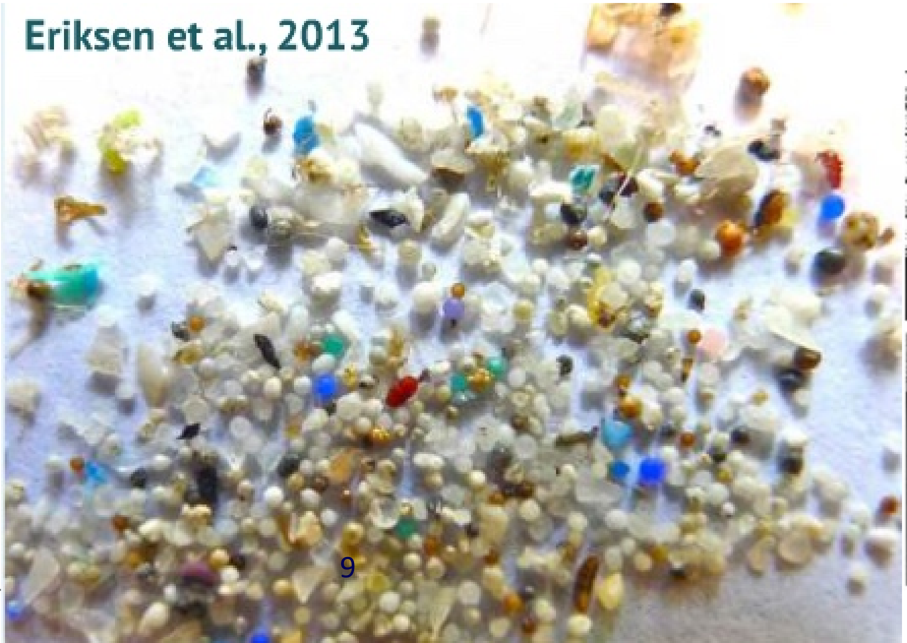


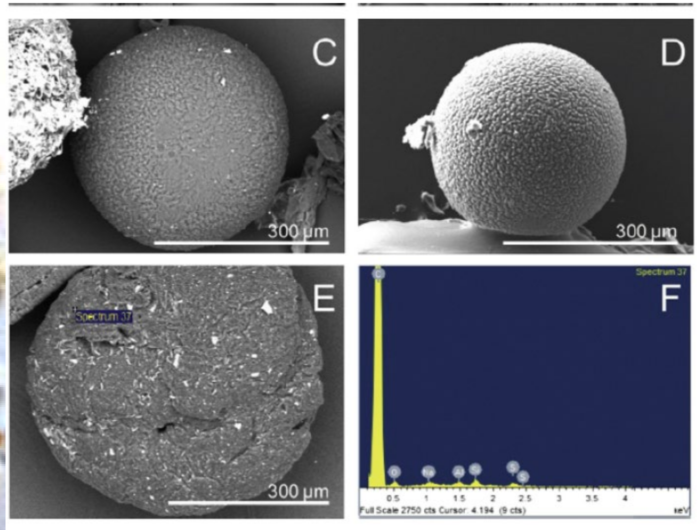
Are these high numbers bad ecologically?

THAT is the important question

Average abundance: ~43,000 microplastic particles / km²

- L. Erie worst > 466,000 to possibly 1 million particles/km²
- Most particles 0.3 – 1 mm "pellets"
  - Microbeads, coal/coal fly ash (Al2O3, SiO2)
  - Wastewater, aeolian (point sources?)





Current Issues

- 150+ MP scientific, peer-reviewed papers per yr. Continuing presence in the popular press
- Peer-review process **varies dramatically** in quality
- Analytical methods - Cannot compare MP studies due to lack of standardized methods, poor QA/QC, 30-70% false +

Accurate monitoring requires advanced instrumentation (usually 2 types) such as:

1) Raman micro- spectroscopy,
2) Fourier transform infrared spectroscopy (FTIR)
3) Focal plane array- based reflection FTIR
4) Combining atomic force microscopy and infrared spectroscopy,
5) Field flow fractionation, or

Optical microscopy prone to error.

Microbeads banned in the US but MPs will not decrease (due to dominating fibers and fragments)

Plastics, plastics, plastics

New life forms discovered on plastics “plastisphere!”

The accumulation of plastic debris in nature is “one of the most ubiquitous and long-lasting recent changes to the surface of our planet” (Barnes et al., 2009)

Increasing amounts of Plastics in Arctic Deep Sea

The “Great” Pacific Garbage Patch

WRF Research Activities and Collaborations on Microplastics

Beauty and the Beads

https://www.wateronline.com/doc/beauty-and-the-beads-0001

Microbeads. Image from 5Gyres

By being aware of what we are using on our bodies and, more importantly, what we are rinsing down the drain, we can be responsible for preventing further accumulation of microbeads in our local waterways.

About the Author:

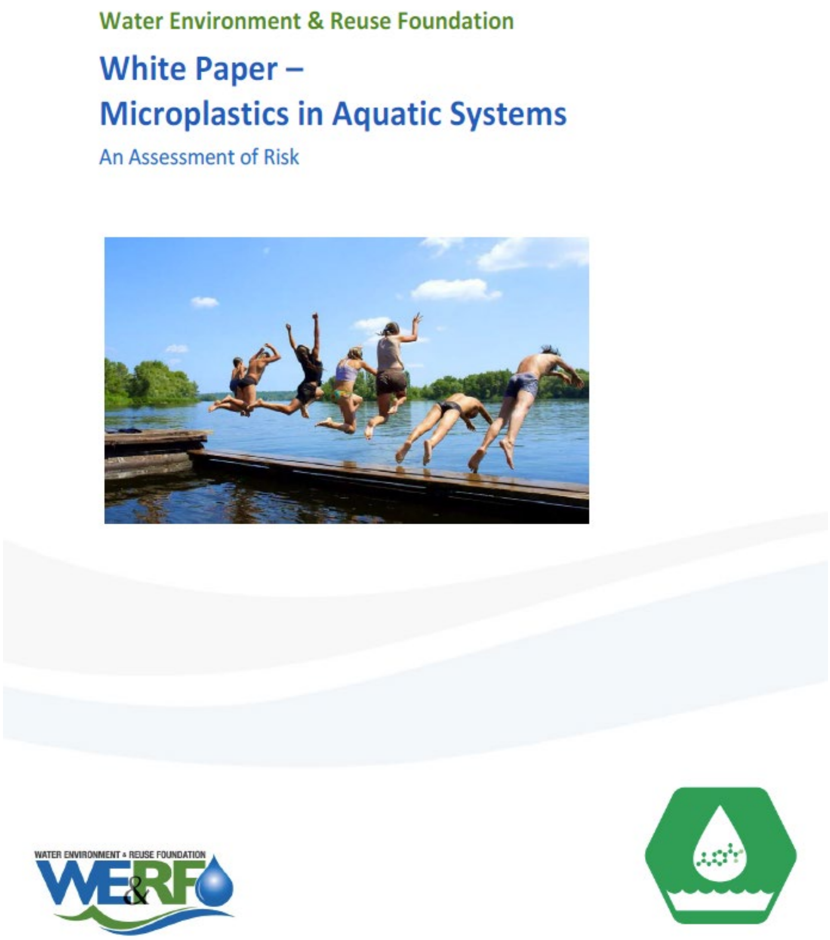
Marcella Capuco is a member of the Key School class of 2015 in Annapolis, MD. In the fall of 2015, she will be attending the Pennsylvania State University, College of Engineering studying Civil Engineering. She is participating in a short internship at the Water Environment Research Foundation (WERF), shadowing Lola Olabode, M.P.H., a research program director for the foundation. WERF is currently tracking and monitoring the issues surrounding microbeads and looking for research opportunities to address microbeads and other emerging contaminants.

[i] Microplastics: Scientific evidence. (2014). Retrieved May 26, 2015, from Beat the Microbead website: http://www.beatthemicrobead.org/en/science

[ii] Types of Rice. (n.d.). Retrieved May 28, 2015, from USA Rice Federation website: http://riceinfo.com/all-about-

WRF Research Activities and Collaborations on Microplastics

White Paper –CEC7R17



Water Environment & Reuse Foundation

White Paper –
Microplastics in Aquatic Systems

An Assessment of Risk

WATER ENVIRONMENT & REUSE FOUNDATION
WE&RF

Fact Sheet

THE Water Research FOUNDATION

Microplastics in Water

What Are Microplastics?

Microplastics (MPs) are plastic particles under 5 mm in size (but seldom sampled <0.3 mm). They enter the environment through human use. Some plastics are manufactured as MPs; however, larger plastic debris can degrade into micro-sized particles over time with exposure to sun and water. The appearance and shape of MPs vary widely, making it difficult to quantify and separate MPs from natural particles. Beauty products with microbeads, synthetic clothing, plastic bags, polystyrene foam, and disposable plastic items can all contribute to microplastic pollution. There are 13 types of MPs—polyethylene, polypropylene, and polystyrene are the most common. There are three primary categories of MPs:

- Microfibers, usually the most common type of microplastics, are derived from synthetic textiles and slough off during daily use and machine washing of clothing (e.g., fleece jackets). Most microfibers released into water are between 0.1–0.8 mm in size. (Hernandez et al. 2017).
- Fragments form as a result of physical breakage of macroplastics.
- Microbeads are common in personal care products.

How Bad Is the Problem and What Can We Do About It?

- The worst MP concentration recorded is 32 per 1,000 liters (Baldwin et al. 2016). Similar-sized algae are thousands to tens of millions per liter higher in concentration (7 to 10 orders of magnitude). This concentration makes ingestion by zooplankton or fish larvae unlikely.
- Lab work using concentrations 2 to 10 orders of magnitude higher than the worst environmental levels shows adverse effects.
- Microplastics have been found to adsorb and transport ambient pollutants such as PCBs (coolants), PBDEs (flame retardants), and other persistent organic pollutants.

Can Microplastics Introduce Compounds of Interest and Pathogens to Aquatic Organisms?

Microfibers have been found in fish and marine animals. However, more research is needed on the toxicology of MPs, including microfibers, and the overall relevance for freshwater resources, drinking water, and human health. There have been no studies to investigate the possible role of MPs on increasing exposure to pathogens. Since biofilms form on most surfaces in shallow waters, it is likely that pathogens are a component of the biofilms in human-dominated watersheds. The increased availability of nutrients on the particles would increase survival of pathogens, just as in sediments (Burton et al. 1987). This should not pose ecological or human health issues due to low concentrations in comparison to natural sediment particles.

How Are Microplastics Monitored?

The numbers and types of MPs measured vary by method, and often two analytical methods are needed. Monitoring for different types of plastic materials requires advanced instrumentation that is not readily available. This instrumentation may include 1) Raman micro-spectroscopy, 2) Fourier transform infrared spectroscopy (FTIR), 3) focal plane array-based reflection FTIR, 4) combining atomic force microscopy-infrared spectroscopy, 5) field flow fractionation, or 6) optical microscopy. Each method has its own unique strengths and limitations. A few limited studies have tried to quantify the various types of MPs occurring in marine and freshwaters; however, none have allowed for site-specific generalizations. It is difficult to compare MP studies due to lack of standardized methods.

What About Microplastics in Treated Municipal Wastewater and Drinking Water?

Municipal wastewater treatment plants (WWTPs) and water resource recovery facilities (WRRFs) are the largest sources of MPs into aquatic systems in the United States, and likely all developed countries (McCormick et al. 2014). Mason et al. (2016) reported widespread MP pollution from WWTP/WRRF effluents, sampling 17 facilities in the

1 OF 4

Wading through the "science"…

- ***Risk = Exposure x Effects. Exposure does not equate to risk***

- Adverse effects being reported from lab studies - Concentrations **1-10 orders of magnitude higher** than worst in nature!

- **Worst MP concentration is 32/1,000 L (median 1.9 in streams receiving WWTP effluent**), while similar-sized algae 1000s to 10s of millions/liter higher (7-10 orders of magnitude). **Highest concentrations reported in China.**

- *Reasonable worst case exposure of MPs virtually impossible for uptake by zooplankton or fish larvae*
- *Benthic organisms accumulate more due to filtering and location near waste outfalls*

- ***No adverse effects on aquatic populations can occur at realistic concentrations – this may not be true with some benthic sites…***

Review by Burns and Boxall

Emily E. Burns and Alistair B.A. Boxall. 2018 (Sept) Microplastics in the Aquatic Environment: Evidence for or Against Adverse Impacts and Major Knowledge Gaps Environmental Toxicology and Chemistry, 37 (11): 2776–2796

- Findings similar to Burton 2017, Koelmans et al., 2016 and 2017, Connors et al. 2017
- Fragments and fibers dominate – not beads
- *In situ* concentrations an order of magnitude or more lower than required to produce any biological endpoint
- Not a vector of POPs to organisms
- MP exposures in lab tests are not like those in nature
- ***Realistic tests and standard methods needed***

Recent lit review take aways…

- MPs not a vector for chemical transfer
- Fibers dominate – are found in fish, mussels and amphibians. PE fleece most common.
- Lab exposures ridiculously high.
- WWTP remove 90-99% of MPs
- Presence of MPs in gut does not equate to adverse effects (give me a straw to eat!) and most egested.
- Statements on MP density must be reviewed with caution if extreme

Worst grad student project ever….

- ***Searching through feces for microplastics…***
- MPs now found in feces, food, bottled water and salt.
- NOT desirable for sure, but how can this be a health risk?

- Highest MP numbers in surface waters are in the China region

Where may MPs be an ecological problem?

Depositional sediments near WWTP outfalls?

- 2-30/250 ml sediment - so 0.5 to 7.5 particles per L which is a low exposure
- San Diego Bay metal on MPs 8 to 150 fold below Sediment Quality Guideline Probable Effect Levels (PELs)

Fibers (>1,900 per wash)?

- Surveyed 150 at risk fish in Lake Erie: Rainbow smelt 30% had 1+ fiber, some 4 to 6. No other MPs

Smaller-sized microplastics and particles (< 300 u)?

- Likely more common – but little known. Difficult to assess.
- Highest MPs likely small antifouling paint chips/fibers from boat hulls in coastal marine areas.

Concluding Perspectives

- Focus on plastic pollution will continue – but ecological risk is from **macroplastics** – not microplastics
- Demonstrate how WWTP MPs rank compare to co-occurring stressors, such as: ***BOD > TSS > Nutrients > Pathogens > Synthetic organics (pesticides to PPCPs) > Metals > MPs***
- Regulators MUST conduct realistic exposures to determine ecological risks in receiving waters

Key needs:

- Difficult or impossible to compare studies due to lack of standardized methods. Numbers and types of MPs vary by method and often two analytical methods needed. Standard methods for collecting, identifying, analyzing + determining toxicity and bioaccumulation (including smaller than 3 mm)
- Microbeads banned in the US but MPs will not decrease (due to fibers and fragments) and likely increase.
- Improved exposure and fate models
- Public and governmental education program

Why are you interested in today's webcast on Microplastics?

- Curious about the topic
- Concerned about possible new regulations
- Actively conducting research, etc.
- We get a lot of inquiries
- Other reasons not listed above

No Lego in my Effluent Please - Danish Perspective on Microplastic

Per Henrik Nielsen VCS Denmark

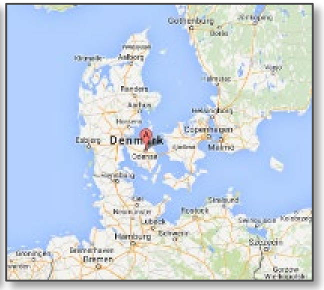
VCS Denmark


DANMARK
Skagerrak
Esbjerg
Århus
Fredericia
Odense
KØBENHAVN
Helsingør
Kattegat
Göteborg
Flensburg
Helsing

Ejby Mølle WWTP

- Ejby Mølle WWTP in Odense, Denmark
- 410,000 PE
- Progressive BNR facility
  TN Limit: 4,2mg/L (average year)
  TP Limit: 0.25 mg/L (average year)
- Ambitious optimization program become energy self-sufficient
- Currently: ~160% heat
  ~115 % electricity

VCS Denmark



No Lego in my Effluent Please - Danish Perspective on Micro plastic

- Why remove micro plastic?
  - Is it dangerous, to us or others?,
  - Seen from a utility perspective
- How do we measure it?
- Can we remove it?


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

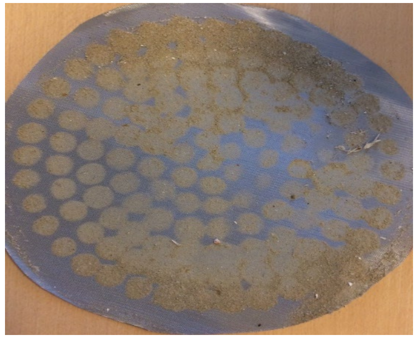
Sampling and sample preparation

Challenges during sample preparation

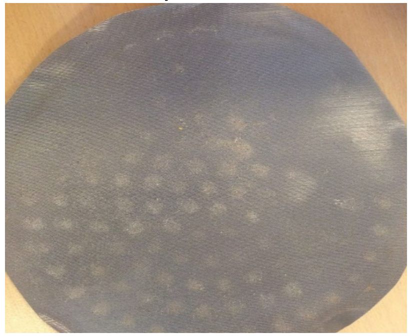
- Inlet 300 ml - Outlet 200 L
- Fragmentation of material during preparation
- Loosing material
- Contamination of samples

H_2O_2

H_2O_2 + enzymer

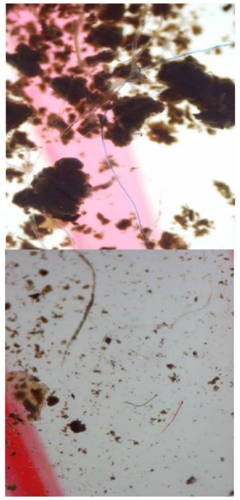


H_2O_2 + enzymer +H_2O_2



Analytic methods

- Detection method
  - Microscope
  - Spectroscopy
    - FTIR (fourier transform infrared spectroscopy)
    - Raman spectroscopy

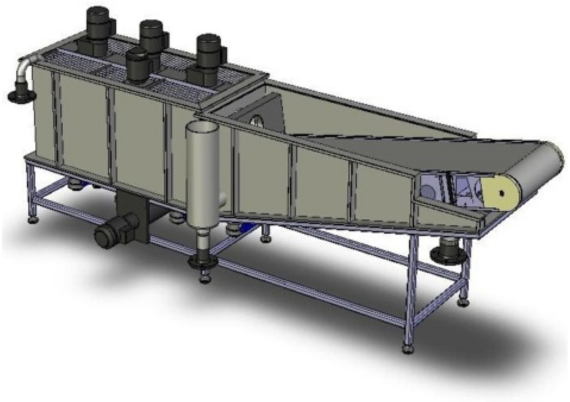


- Less used methods
  - Pyr-GC-MS (gas chromatography – mass spectrometry)
  - SEM (scanning electron microscopy)

Result of initial investigation

- Treatment plants are doing a good job – remove 90-99 % of all micro plastic from the liquid stream
- There is a need for validation of analytic method
- There is a need to make the testing cheaper
- Evaluation of the faith of plastic trough the treatment process
- Micro plastic in CSO and rainwater?
- Micro plastic in biosolids?

Case study - Active removal



- A two in one solution removing both micro plastic and organic matter could be an interesting future technology for wastewater treatment plants.
- A combination of “A-stage” and micro plastic filter
- Spiked test for micro plastic

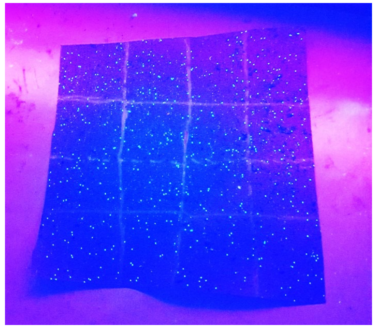
Results of test at two plants

Microplastic particle concentration (m^{-3})

- Inlet: 1- 7.6 x 10^6 particles
- Effluent: 1.8 – 7.6 x 10^3 particles
- Median particle size: 22,4 – 45.1 micro meter
- Types of plastic identified:
  - PE, PET, PMMA, PP, PS, PTFE and PVC

Micro plastics removal

- Three tests were conducted with artificial micro plastics (90 – 106 µm)
- ~ 1 mil particles added with inlet water
- Removal rates: 99.6, 99.5 and 99.7 %




Conclusions from case study

- Micro plastic removal 99.6 %

- COD removal rate: ~80 % total COD, 15 % COD diss.

- Filter cake total solids: 9 - 13 %

Summary

- The sampling is difficult – and important
- Measuring is not easy – costly and not very precise
- Well operated BNR plants does remove most micro plastic from the waterline
- Inlet is a lot higher than outlet - Biosolids?
- CSO might be a bigger problem than wastewater treatment?
- More focus on tracing the source of pollution
  – What about particles less than 10 - 20 µm?

Thanks to:

DANVA
The Danish Water and Wastewater Association

Ministry of Environment and Food of Denmark
Environmental Protection Agency

TEKNOLOGISK INSTITUT

vand og affald

SANITATION DISTRICTS OF LOS ANGELES COUNTY

Microplastics in Wastewater: Policy Perspective

Shelly Walther
Environmental Scientist
Sanitation Districts of Los Angeles County

Water Research Foundation Webcast:

Occurrence of Microplastics in Water…Size Does Matter

December 13, 2018

Are WWTPs Discharging Mass Quantities of Microplastics?

Source: The Story of Stuff Project

Negligible Amounts of Microplastics in WWTPs

Water Research 91 (2016) 174–182

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Transport and fate of microplastic particles in wastewater treatment plants

Steve A. Carr, Jin Liu*, Arnold G. Tesoro

San Jose Creek Water Quality Control Laboratory, Sanitation Districts of Los Angeles County, 1965 South Workman Mill Road, Whittier, CA 90601, USA

A R T I C L E I N F O

Article history:
Received 14 September 2015
Received in revised form
9 November 2015
Accepted 4 January 2016
Available online 7 January 2016

A B S T R A C T

Municipal wastewater treatment plants (WWTPs) are frequently suspected as *significant* point sources or conduits of microplastics to the environment. To directly investigate these suspicions, effluent discharges from seven tertiary plants and one secondary plant in Southern California were studied. The study also looked at influent loads, particle size/type, conveyance, and removal at these wastewater treatment facilities. Over 0.189 million liters of effluent at each of the seven tertiary plants were filtered using an assembled stack of sieves with mesh sizes between 400 and 45 μm. Additionally, the surface of 28.4

No Relationship Between WWTP Location and MP

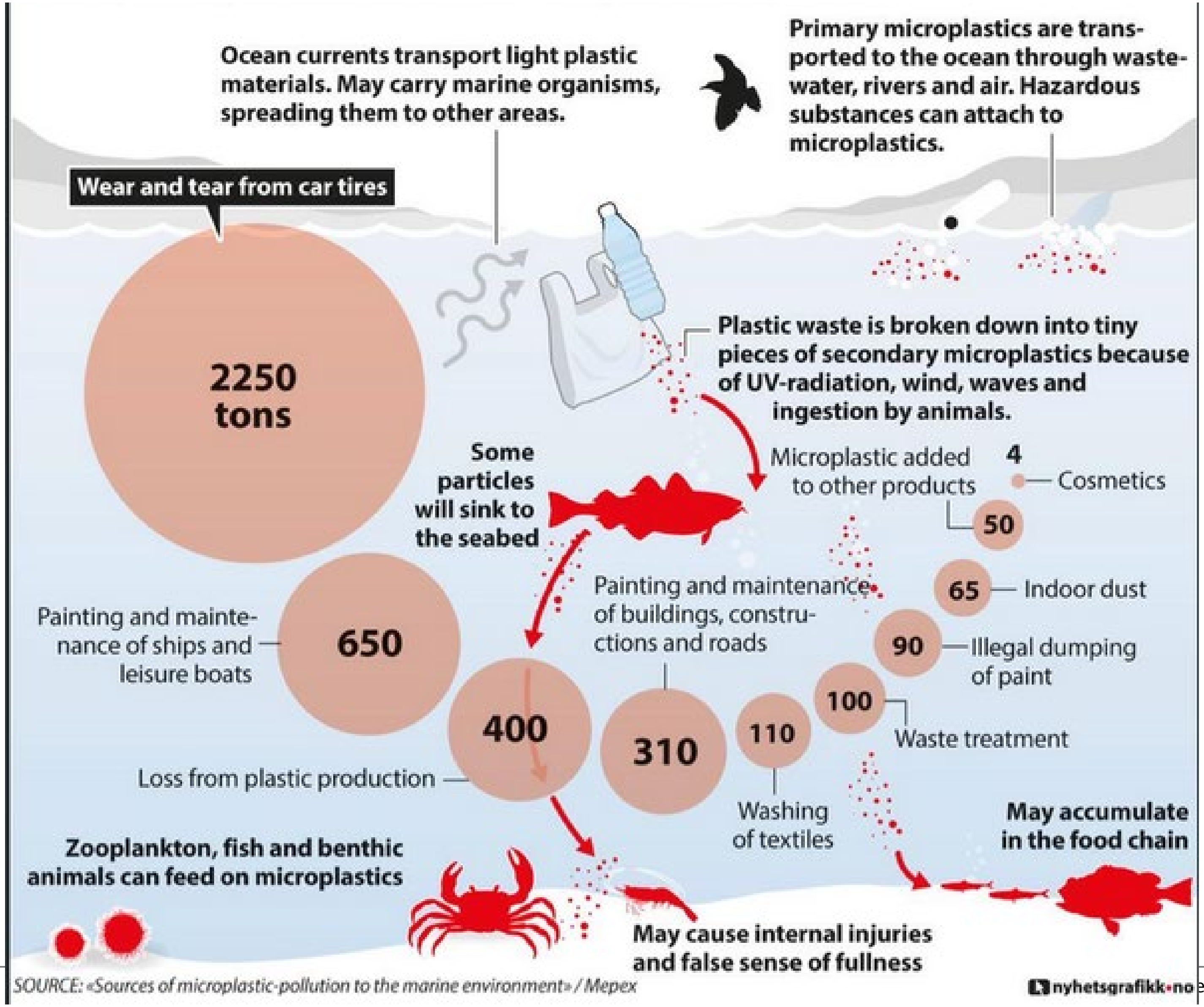
Marine Pollution Bulletin

Volume 124, Issue 1, 15 November 2017, Pages 245-251

Mountains to the sea: River study of plastic and non-plastic microfiber pollution in the northeast USA

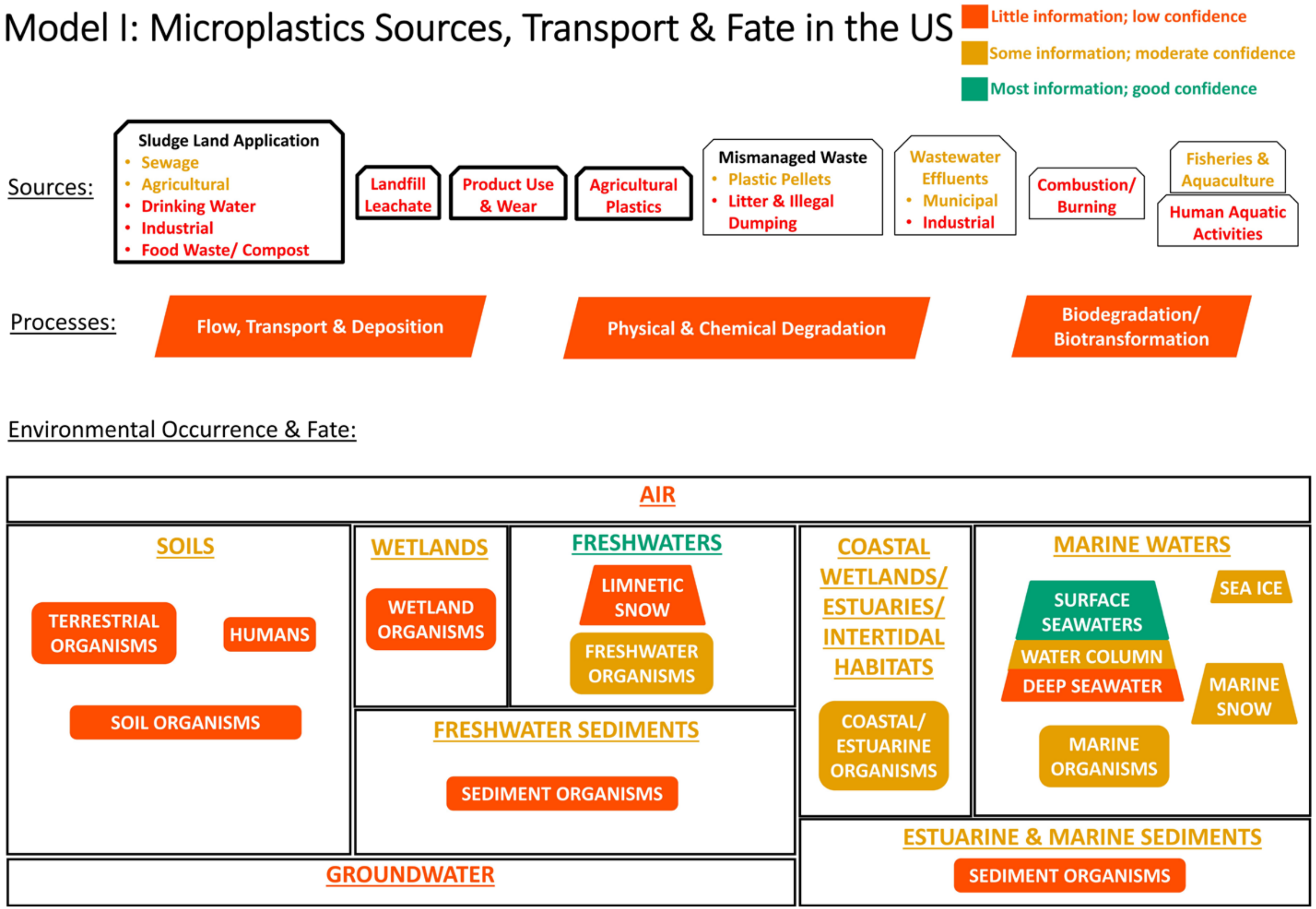
Rachael Z. Miller [a, 1], Andrew J.R. Watts [b, 1], Brooke O. Winslow [a], Tamara S. Galloway [b], Abigail P.W. Barrows

Microplastics Sources and Loadings



Translating Science to Policy:

EPA Expert Panel, Dec 2017



Addressing the Issue: Policy

- CA Plastic Microbeads Nuisance Prevention Law (Oct 2015)
- Federal Law: Microbead-Free Waters Act
  (Dec 2015)

Addressing the Issue: Policy

THE BUSINESS > LEGISLATION & REGULATION

California Legislature Passes Plastic Pollution Reduction Bills

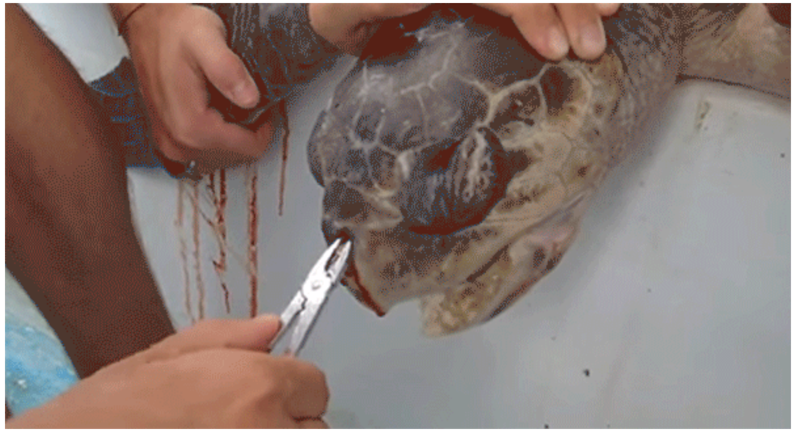
Legislation includes prohibition on unsustainable takeout food packaging, testing for microplastics, straws upon request and funding for recycling centers.

Waste360 Staff | Sep 05, 2018

Addressing the Issue: Policy

Addressing the Issue: Policy

- AB 1884 Restaurants: single-use plastic straws upon request only
  - Takes effect Jan 1, 2019

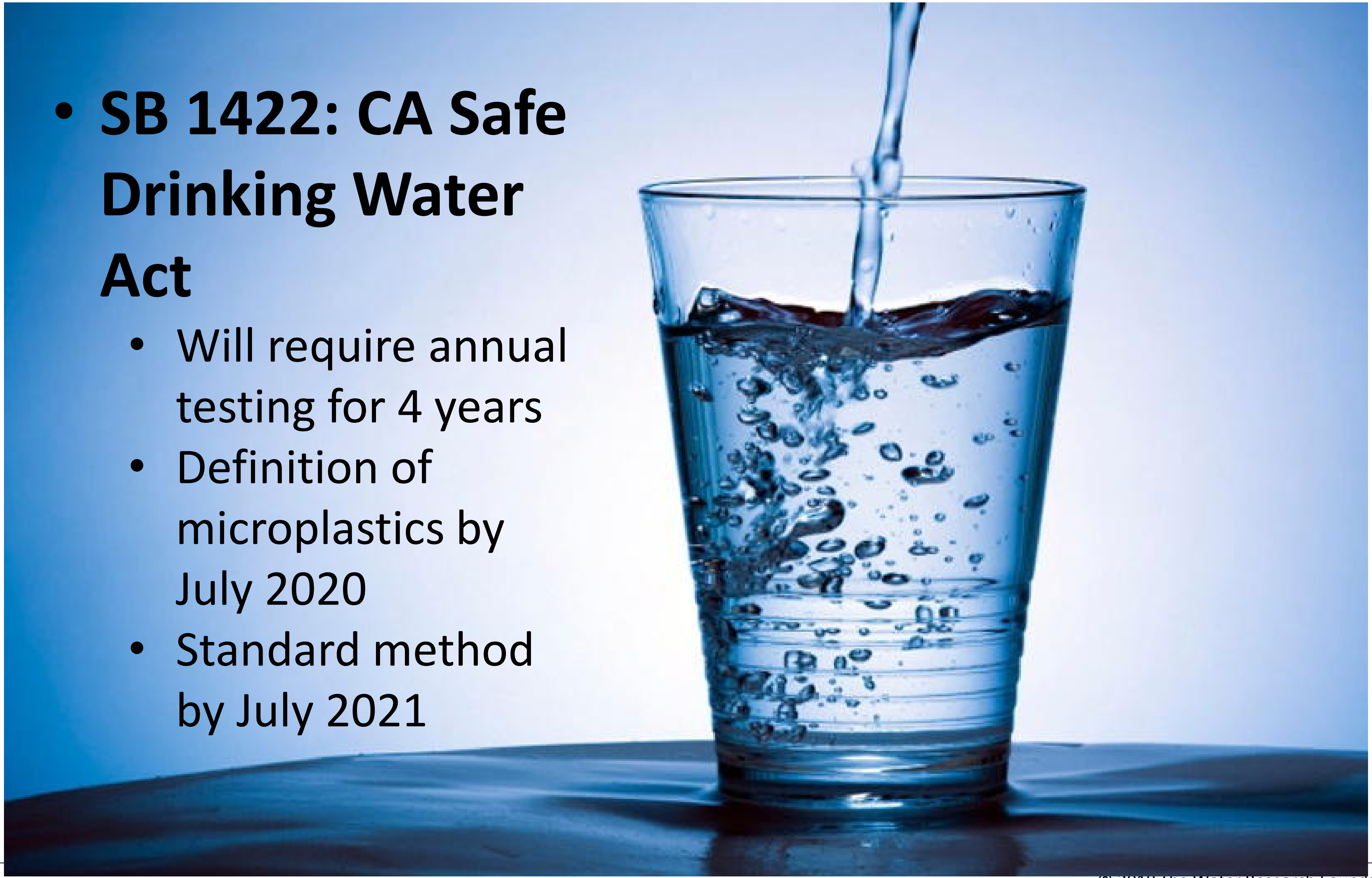


Addressing the Issue: Policy

Related Policy

- **SB 1263 Ocean Protection Council:** Statewide Microplastics Strategy

Addressing the Issue: Policy



- **SB 1422: CA Safe Drinking Water Act**
  - Will require annual testing for 4 years
  - Definition of microplastics by July 2020
  - Standard method by July 2021

Addressing the Issue: Policy

- Additional Efforts in 2018
  - Statewide CA source reduction campaign, #CAMustLead

Addressing the Issue: Policy

- Additional Efforts in 2018
  - In CA:
    - 6th International Marine Debris Conference in San Diego

Addressing the Issue: Policy

- Additional Efforts in 2018
  - In CA:

OCEAN PROTECTION COUNCIL

    - OPC grant opportunity for marine debris research on risk assessment, transport closes Dec 14th
    - OPC-funded research for microplastics as a vector for terrestrial pathogens

Addressing the Issue: Policy

- Additional Efforts in 2018
  - Nationally:
    - Save Our Seas Act

Looking Forward…

- In CA, “expect to see comprehensive microplastic legislation, including microfibers” in 2019
- Effective microplastics policy should be based on sound science, not popular opinion
- Standardized methods & QA for wastewater, and other matrices should be a first step in any policy
- QC review of research is critical
- Pathways: for ALL major sources
- Risk assessment

“You can’t manage what you can’t measure”

Thank you

Challenges and Research Needs for Microplastic Fate and Transport

Belinda Sturm

University of Kansas

Research Needs

- Standard methods for microplastic identification
  - That are also relatively quick
  - And accurate
- How sludge structure and properties affect microplastic fate within treatment plants
- Role of microplastics as a microbial carrier in environment
- Fate of microplastics in biosolids

Literature Review

Author	Mesh Sizes (µm)	Sampling Location	Extraction Processes Used	Measured MP/L	Fibers (%)	Fragments (%)
Mintenig[7]	500, 10	Varied	5+/5	0.01 – 1.00	30-70	30-70
Michielssen[6]	4750, 850, 300, 106, 20	Varied	2/5, SAL* and Subsamples	0.5-5.9	44-83	17-56
Talvitie[12]	300, 100, 20	Tertiary	3/5	13.5	36	64
Ziajahromi[13]	500, 190, 100, 25	Varied	3/5	0.28-1.50	60-93	7-40
Carr[1]	400, 180, 45	Tertiary	3/5, Subsamples	0.0009	0	100
Murphy[8]	500, 65	Tertiary	3/5, Subsamples	0.25	18.5	82.5
Mason[4]	355, 125	Varied	3/5	0.007-0.195	46-80	20-54
Dyachenko[2]	1000, 355, 125	Secondary	3/5	0.02	17	83
McCormick[5]	2000, 330	Secondary	3/5	0.016	58	42

*SAL – Small Anthropogenic Litter

Microplastic Quantification

Visual Detection / Quantification

Visual Identification of Plastics
- User bias
- Human error

Small Anthropogenic Litter (SAL)
- Removes user bias
- True MP loading/impact unknown

Nile Red Staining
- Removes user bias
- More accurate MP loading rates
- Some contaminants are also stained
- Validation by chemical analysis needed for future use

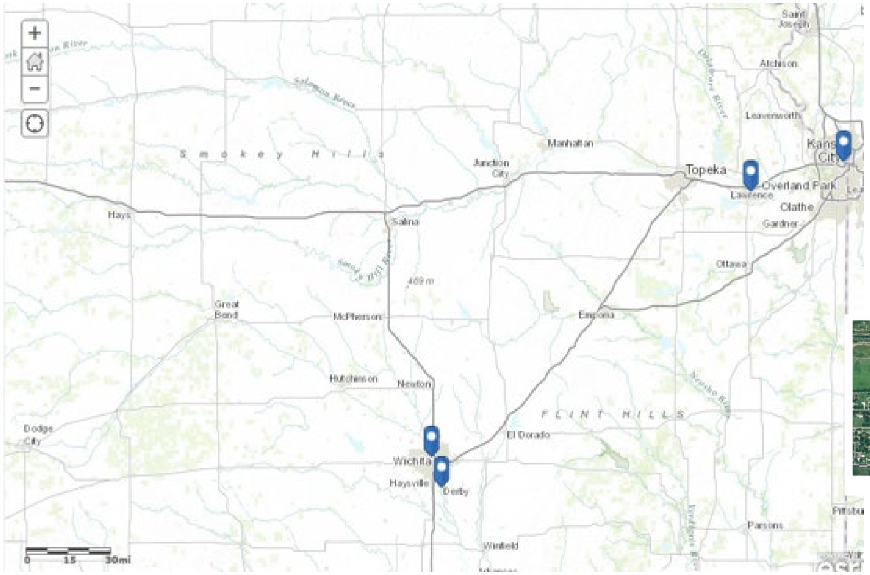
Analytical Chemistry

Fourier Transform Infrared Spectroscopy
- Widely used in microplastics research
- FPA: plane imaging removes bias
- Time consuming
- Largely unavailable to our lab

X-Ray Photoelectron Spectroscopy
- Inexpensive to run & available
- Point imaging introduces user bias
- Uncommon for microplastics

Energy-Dispersive X-Ray Spectroscopy
- Less expensive to run
- Moderate Availability
- Claims of high-throughput capacity
- Uncommon for microplastics

Baseline Sampling Locations: Four Kansas WWTPs



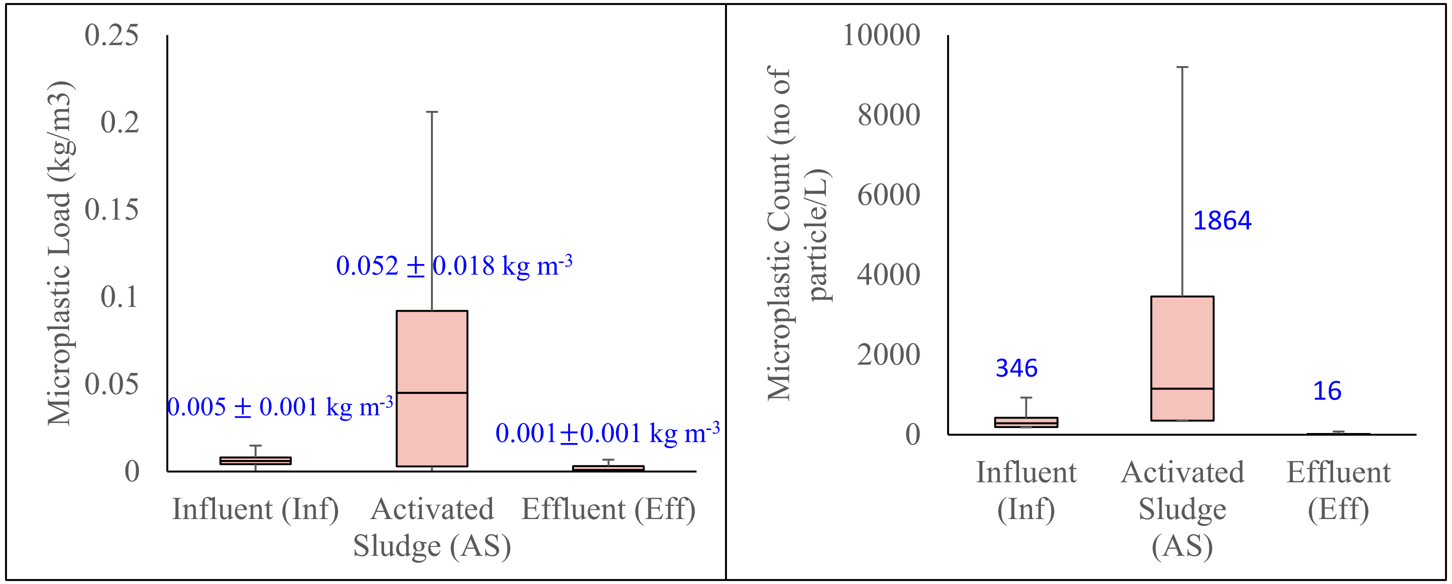

Lawrence WWTP


Kansas City, KS WWTP


Wichita WWTP


Derby WWTP

Microplastic Load in WRRFs

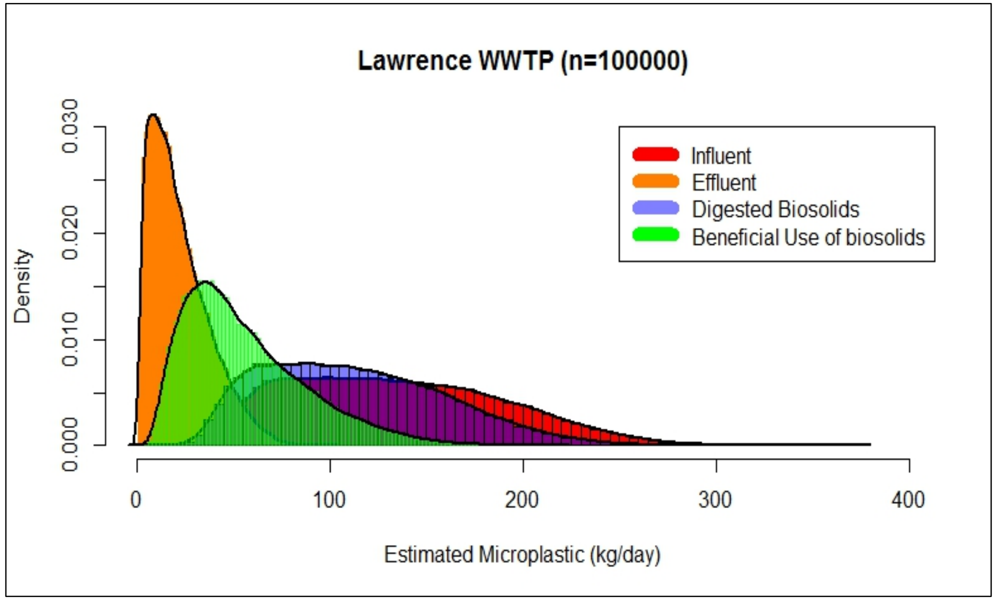


Box plot showing microplastic load (kg m^{-3}) and average microplastic count (no. of particle L^{-1}) in four wastewater treatment plants.

Key points: Microplastics found in all four WRRFs. Microplastics accumulate in activated sludge.

Fate of Microplastics in WRRFs

Monte Carlo simulation showing fate of microplastics from Lawrence WRRF



Key Points:
Effluent has highest percentage of microplastics (18%) to total solids.

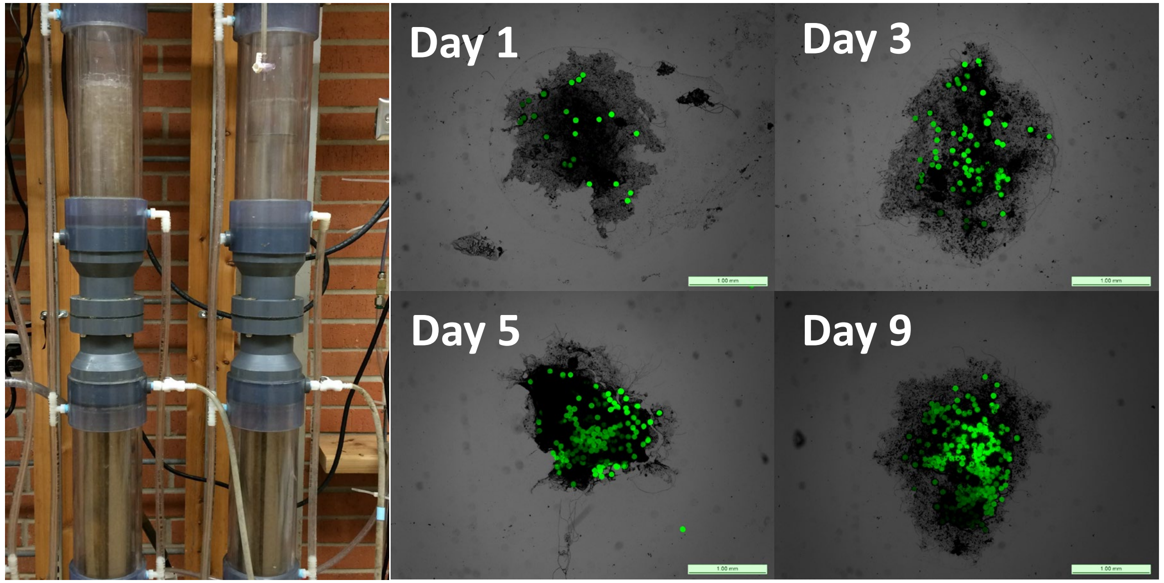
16 plastic particle/ L effluent
* 160 trillion liters of wastewater /day
= **256 trillion plastic particle / day**

WWTPs in the east and west coast will receive the majority of plastic contaminants due to the greater population density in these areas

99.7% of microplastics settled in digested sludge (0.2% of total solid sludge) which would be disposed for beneficial use.

Only 0.02-0.3% of the microplastic entering into effluent.

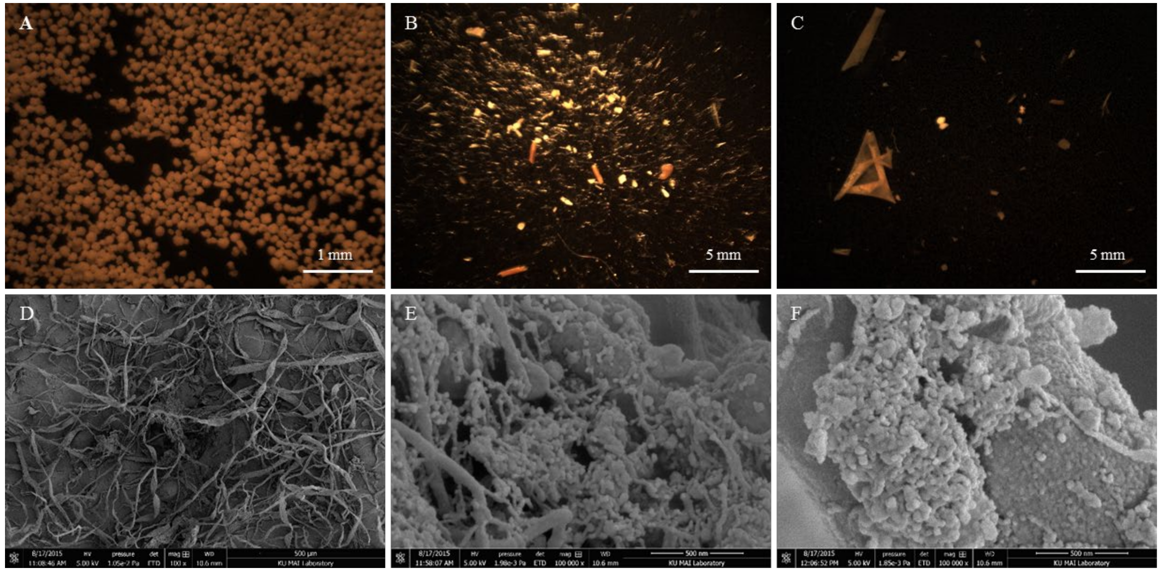
Fate of Microplastics *within* Sludge Particle



Current research: Two bench-scale reactors testing microplastic capture rates after seeding with microplastics

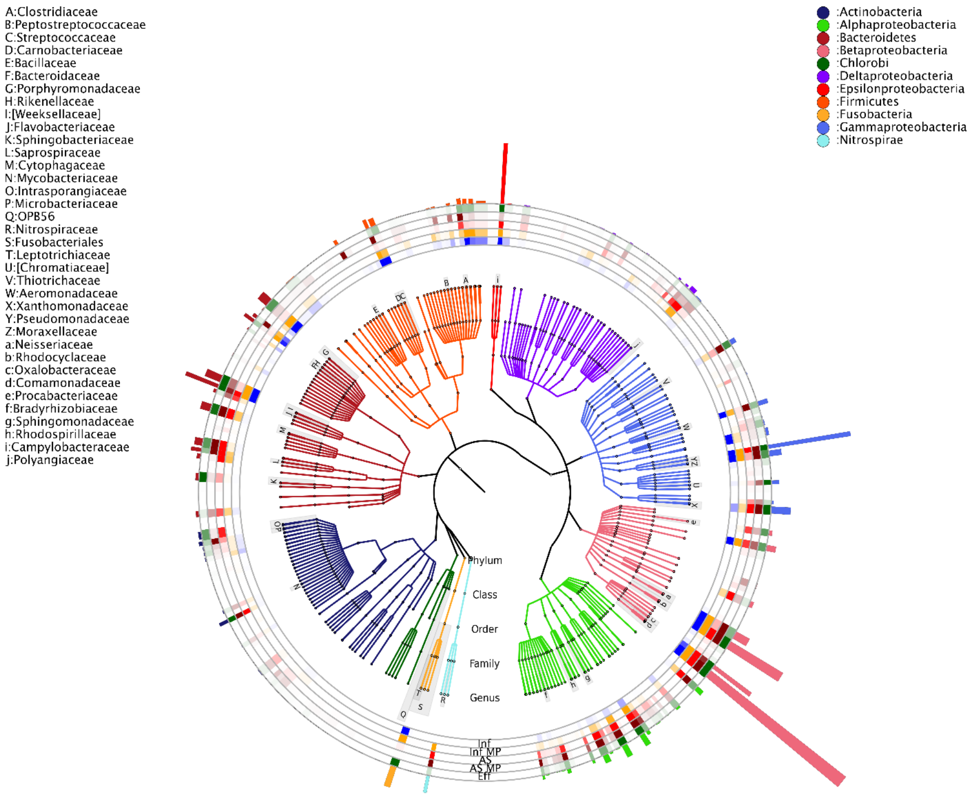
Questions: What sludge properties control capture rates? What is the size dependency?

Microplastics as Carrier Materials



Light microscopic images (top) and scanning electron microscopic images (bottom) of microplastic (A) PVC control pellets (B) Influent (C) Activated sludge (D) microplastic thread like structure and **bacterial biofilm on the plastic surface** in (E) influent and (F) activated sludge samples taken from Lawrence WWTP.

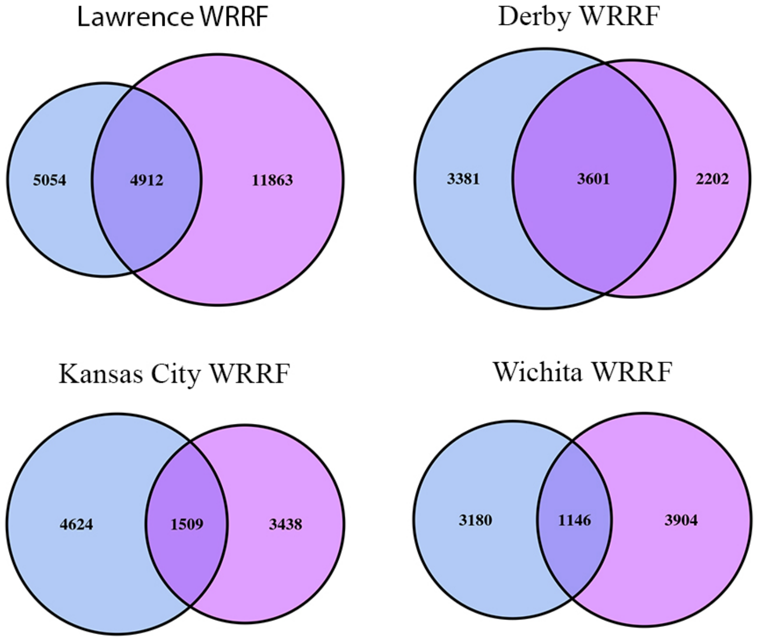
Microbial community composition



Key Points: Proteobacteria was major phyla (23-98% of total bacterial sequences) followed by Bacteroidetes (12.4%). Typical characteristics of WRRFs microbial community.

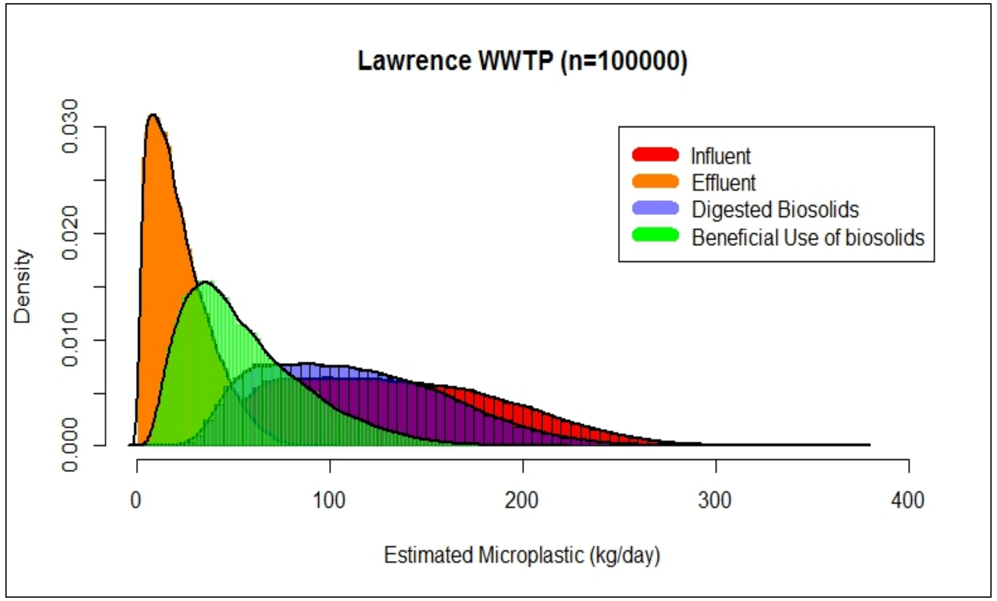
Microbial Community in Sludge vs Plastic Biofilm

Key Points: 22 % of the OTUs (~species) were shared between activated sludge and microplastic biofilm.



Venn diagram showing bacterial OTU overlap between activated sludge (blue) and activated sludge microplastic (purple) in (A) Lawrence WRRF, (B) Derby WRRF, (C) Kansas City WRRF and (D) Wichita WRRF.

Ultimate Fate of Microplastics and Microbial Community in the Environment

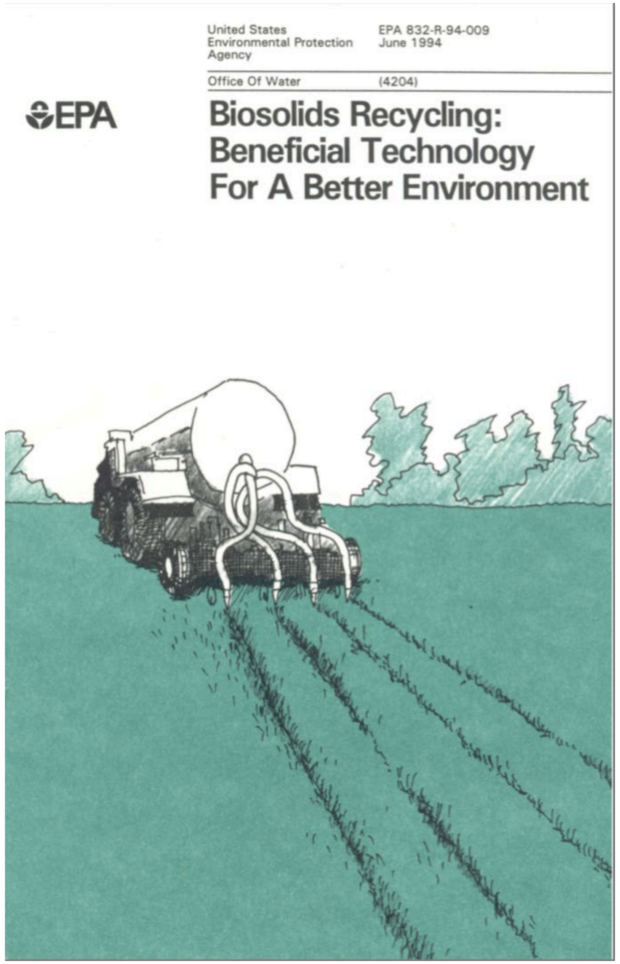


99.7% of microplastics settled in digested sludge which could be disposed for beneficial use.

Only 0.02-0.3% of the microplastic entering into effluent.

What about the Biosolids?

- What is the fate of microplastics through sludge stabilization processes?
- Do microplastics get sequestered in soils or runoff into receiving water bodies?
- Although plastics are stable in ambient conditions, what transformations may occur in thermal processes?



https://www3.epa.gov/npdes/pubs/owm0027.pdf

Thoughts on the Work So far....

- Activated sludge accumulates much of the plastic load.
- Less than 1% of the microplastics entering wastewater treatment plants are discharged to waterbodies... But this small % is a significant # of particles.
- Mass majority of environmental release of microplastics from wastewater treatment plants will occur through land application of stabilized biosolids.
- The bacterial community on the microplastic surface can be transported into waterbodies.

Thanks to....

KU THE UNIVERSITY OF KANSAS

Rock Chalk, JAYHAWK!

WRF Research Activities & Collaborations on Microplastics

Fact Sheet

Microplastics in Water

THE Water Research FOUNDATION

What Are Microplastics?

Microplastics (MPs) are plastic particles under 5 mm in size (but seldom sampled <0.3 mm). They enter the environment through human use. Some plastics are manufactured as MPs; however, larger plastic debris can degrade into micro-sized particles over time with exposure to sun and water. The appearance and shape of MPs vary widely, making it difficult to quantify and separate MPs from natural particles. Beauty products with microbeads, synthetic clothing, plastic bags, polystyrene foam, and disposable plastic items can all contribute to microplastic pollution. There are 13 types of MPs—polyethylene, polypropylene, and polystyrene are the most common. There are three primary categories of MPs:

- Microfibers, usually the most common type of microplastics, are derived from synthetic textiles and slough off during daily use and machine washing of clothing (e.g., fleece jackets). Most microfibers released into water are between 0.1–0.8 mm in size. (Hernandez et al. 2017).
- Fragments form as a result of physical breakage of macroplastics.
- Microbeads are common in personal care products.

How Bad Is the Problem and What Can We Do About It?

- The worst MP concentration recorded is 32 per 1,000 liters (Baldwin et al. 2016). Similar-sized algae are thousands to tens of millions per liter higher in concentration (7 to 10 orders of magnitude). This concentration makes ingestion by zooplankton or fish larvae unlikely.
- Lab work using concentrations 2 to 10 orders of magnitude higher than the worst environmental levels shows adverse effects.
- Microplastics have been found to adsorb and transport ambient pollutants such as PCBs (coolants), PBDEs (flame retardants), and other persistent organic pollutants.

Can Microplastics Introduce Compounds of Interest and Pathogens to Aquatic Organisms?

Microfibers have been found in fish and marine animals. However, more research is needed on the toxicology of MPs, including microfibers, and the overall relevance for freshwater resources, drinking water, and human health. There have been no studies to investigate the possible role of MPs on increasing exposure to pathogens. Since biofilms form on most surfaces in shallow waters, it is likely that pathogens are a component of the biofilms in human-dominated watersheds. The increased availability of nutrients on the particles would increase survival of pathogens, just as in sediments (Burton et al. 1987). This should not pose ecological or human health issues due to low concentrations in comparison to natural sediment particles.

How Are Microplastics Monitored?

The numbers and types of MPs measured vary by method, and often two analytical methods are needed. Monitoring for different types of plastic materials requires advanced instrumentation that is not readily available. This instrumentation may include 1) Raman micro-spectroscopy, 2) Fourier transform infrared spectroscopy (FTIR), 3) focal plane array-based reflection FTIR, 4) combining atomic force microscopy-infrared spectroscopy, 5) field flow fractionation, or 6) optical microscopy. Each method has its own unique strengths and limitations. A few limited studies have tried to quantify the various types of MPs occurring in marine and freshwaters; however, none have allowed for site-specific generalizations. It is difficult to compare MP studies due to lack of standardized methods.

What About Microplastics in Treated Municipal Wastewater and Drinking Water?

Municipal wastewater treatment plants (WWTPs) and water resource recovery facilities (WRRFs) are the largest sources of MPs into aquatic systems in the United States, and likely all developed countries (McCormick et al. 2014). Mason et al. (2016) reported widespread MP pollution from WWTP/WRRF effluents, sampling 17 facilities in the

1 OF 4

White Paper –CEC7R17

Water Environment & Reuse Foundation

White Paper – Microplastics in Aquatic Systems

An Assessment of Risk

WATER ENVIRONMENT + REUSE FOUNDATION WE&RF

Science Brief

Global Water Research Coalition

SCIENCE BRIEF

Microplastics in Fresh Water Resources

Florian R. Storck, TZW Karlsruhe; Stefan. A.E. Kools, KWR Watercycle Research Institute; Stéphanie Rinck-Pfeiffer, GWRC.

Microplastic residues in fresh water resources has become a topic of interest attracting the attention of the public and authorities. Microplastic pollution has been an issue for a number of years in the marine research field[1]. However, investigations on the occurrence in fresh water systems including drinking waters and wastewater treatment is still in an early stage and research, mainly in Europe, has only just commenced. There is currently very little knowledge and expertise on microplastic residues in drinking water and its potential impact. The media has circulated misinformation on the suspected occurrence of microplastic in drinking water which has spread fear and uncertainty amongst the public. This brief compiles the current state of knowledge on the subject of microplastics as currently known by the Global Water Research Coalition (GWRC) members. It includes recent information and grey literature, thus updating and going beyond the information presented in the year 2013 in the STOWA report[2].

Definition

Microplastics are commonly defined as particles or fibers with a diameter < 5 mm consisting of polymers. A lower limit has not yet been defined, but the term "micro" implies 1 µm. However, most studies investigated particles > 300 µm [3]. Currently, the categories "large" (1 mm to 5 mm) and "small" (<1 mm) have been introduced[4,5]. The lower limit is mostly determined by the mesh size of the sieve or net used for sample filtration and by the application of spectral and optical analysis for identification[1,3].

Origin / emission of microplastics to the environment

Global annual plastic production in 2012 was 288 Mega Ton (Mt) (Europe 58 Mt, US 57 Mt) and has strongly increased for the past 60 years (however, European production recently stagnated). The latter numbers include mainly high production volume polymers like polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polyurethane (PU), polystyrene (PS) and polyethylene terephthalate (PET). The overall tonnage is even higher when considering fibers of PET, polyamide (PA) and polyacryl[6]. One source of microplastics are cosmetic and personal care products designed for gentle friction ("Micropearls", "Peeling") such as soap, hand and facial cleansers, tooth paste, shower gels, deodorants and shampoo[7, 8]. These particles are often < 300 µm and may contain additives like dyes (unpublished data TZW). This aspect has been the focus of environmental NGO's in the Netherlands, in the US and in Germany, resulting in increased public awareness at the general public and leading to policies to reduce the use of plastics in cosmetic products.
Sandblasting with microplastic particles[7, 9] and abrasion from plastic articles (tyres) are further sources of microplastics in the environment. Washing clothes made of synthetic fibers can

WRF Research Activities & Collaborations on Microplastics

Collaborative Project NSF-WRF – *ongoing*

Determining the Fate and Major Removal Mechanisms of Microplastics in Water and Resource Recovery Facilities (WRF-4936)

- **PI** - Dr. Belinda Sturm, University of Kansas
- **Duration** - 3 Yrs.
- **Status** – Collecting Survey data of MP fate at four (4) representative full scale WRRF

Collaborative Project GWRC-WRF – *completed*

Method Harmonization and Round Robin Comparison for Microplastics (MicRobin)

- **PI**- Muller et al - TZW Germany
- **Duration** -11 months
- **Status**- Published August 2018
- The data evaluation guideline was inspired by DIN 38405, a German standard for the assessment of round robin tests.

Questions?

Thank You!

Comments or questions, please contact:

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For more information visit:

www.waterrf.org or www.werf.org

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