The Prevalence of Microplastic Pollution (and How to Find It)

James L. McGrath
University of Rochester
http://nanomembranes.org
jmcgrath@bme.rochester.edu

Biomedical Engineering
Material Science Program
Biochemistry and Biophysics
Environmental Health Sciences Center

Co-Founder:

SiMPore Inc.
Precision Separation Technologies

Parverio
Small Revelations

IRSS: Microplastics and Pulmonary Risk: Environmental prevalence, exposure and mechanisms of pulmonary action. Society of Toxicology.

April 13, 2021

Microplastics @ Rochester

NEWS

Plastic: Study finds tiny synthetic bits in Great Lakes tap water — and beer

Steve Orr Democrat and Chronicle

Published 2:20 p.m. ET Aug. 28, 2018 | **Updated 9:08 p.m. ET Aug. 29, 2018**

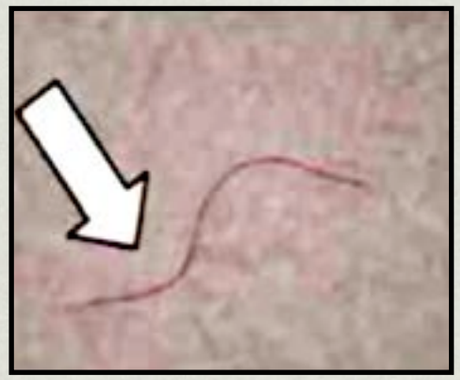
RESEARCH ARTICLE

Anthropogenic contamination of tap water, beer, and sea salt

PLOS ONE

Mary Kosuth[1]*, Sherri A. Mason[2], Elizabeth V. Wattenberg[1]

1 University of Minnesota, School of Public Health, Division of Environmental Health Sciences, Minneapolis, Minnesota, United States of America, **2** State University of New York at Fredonia, Department of Chemistry and Biochemistry, Fredonia, New York, United States of America



Fleece is a major source

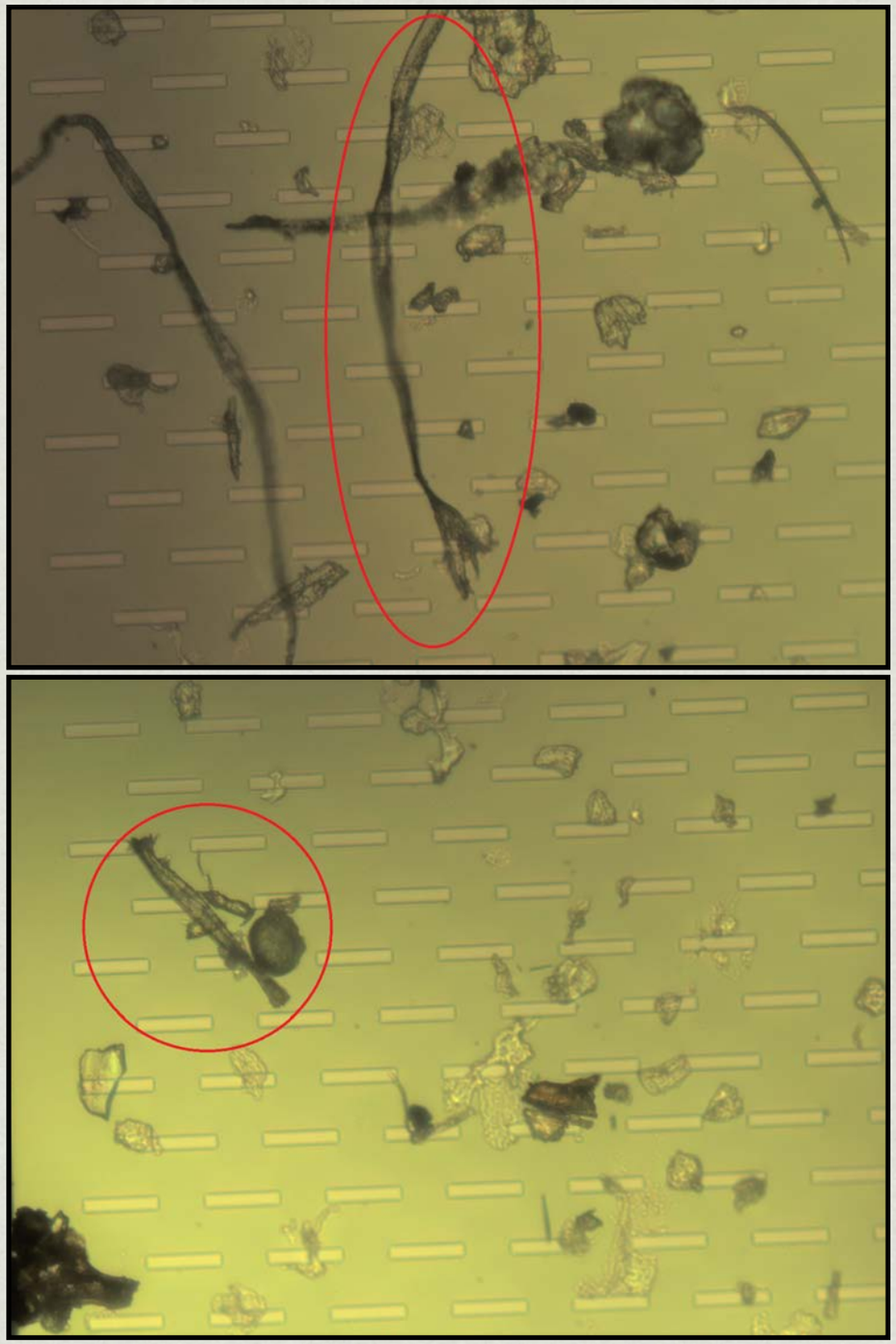
One of the highest concentrations is where Rochester's Genesee River meets Lake Ontario

Wayne's World

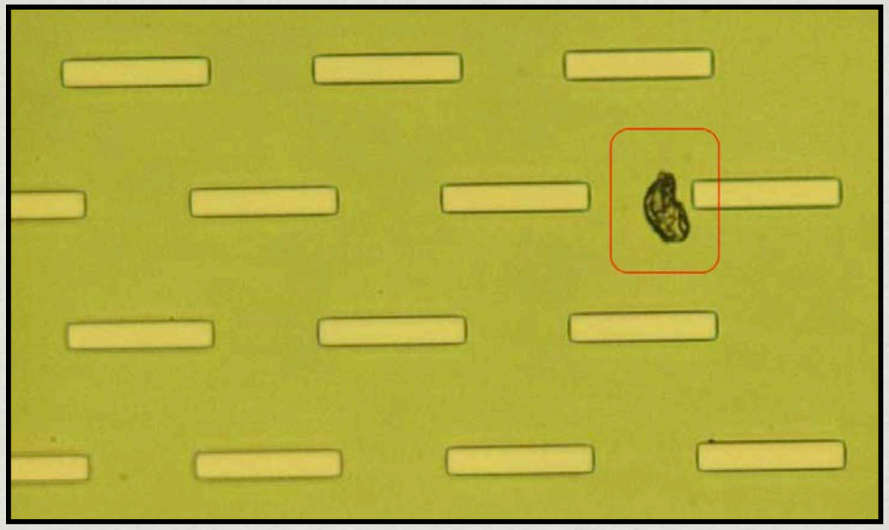
UR Optics Professor Wayne Knox

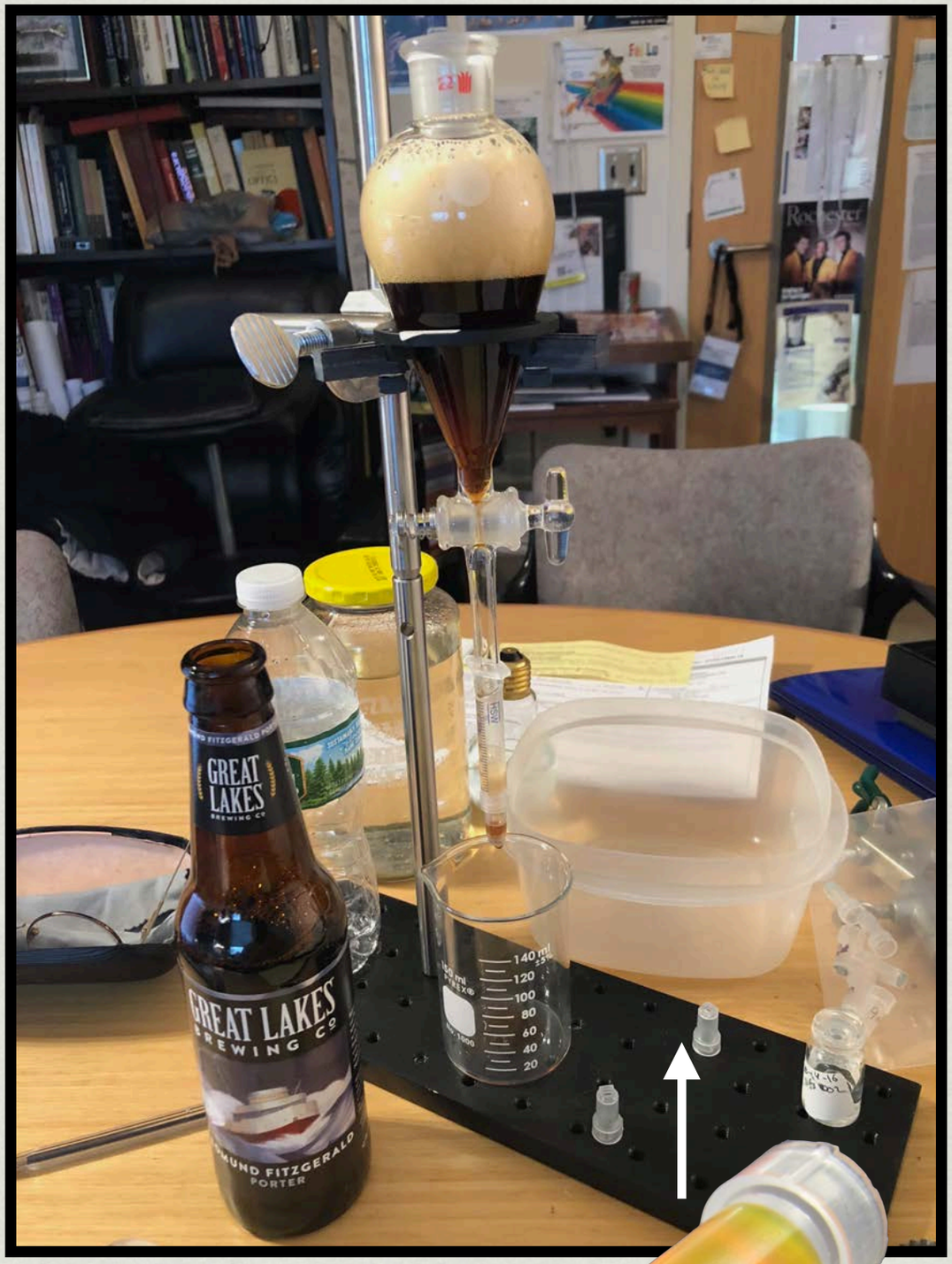
Five foot diameter water pipe sucking in water from the bottom of lake Ontario from 2000 feet away from shore

Monroe County Water Authority
Edgemere Drive Water Pumping Station

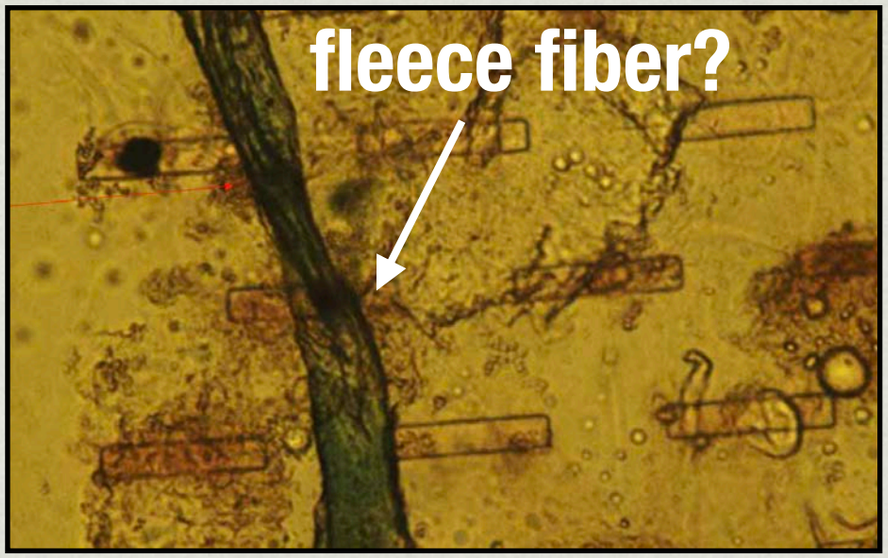



Poland Spring

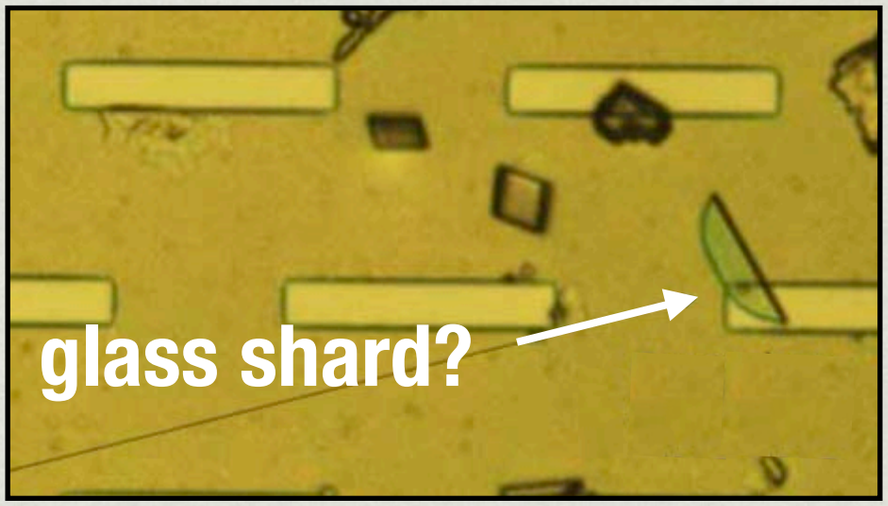



GREAT LAKES
BREWING CO
EDMUND FITZGERALD
PORTER

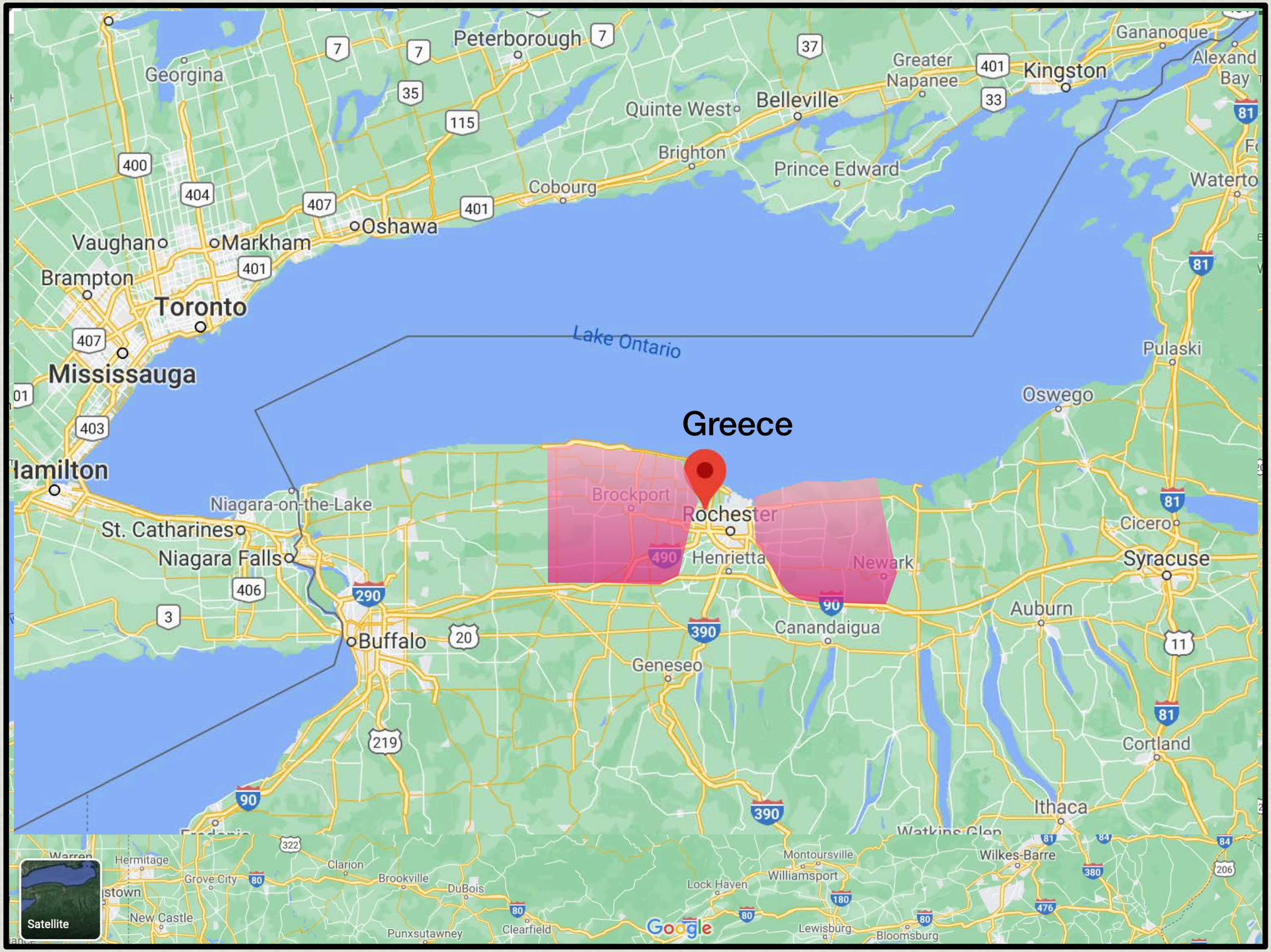

GREAT LAKES
BREWING CO
Edmund Fitzgerald
A Handcrafted Porter
Cleveland, Ohio
12 fl. oz.


fleece fiber?


Perrier


glass shard?

Goergen Hall Tap Water


Greece
Lake Ontario
Peterborough
Georgina
Quinte West
Belleville
Greater Napanee
Kingston
Gananoque
Brighton
Prince Edward
Cobourg
Oshawa
Vaughan
Markham
Brampton
Toronto
Mississauga
Pulaski
Oswego
Brockport
Rochester
Henrietta
Newark
Canandaigua
Geneseo
Auburn
Cicero
Syracuse
Cortland
Ithaca
Niagara-on-the-Lake
St. Catharines
Niagara Falls
Buffalo
Hermitage
Grove City
Clarion
Brookville
DuBois
Clearfield
Punxsutawney
Montoursville
Williamsport
Lock Haven
Lewisburg
Bloomsburg
Wilkes-Barre
Satellite
Google

University of Rochester
Private school known for music program

7.5 miles mixed piping

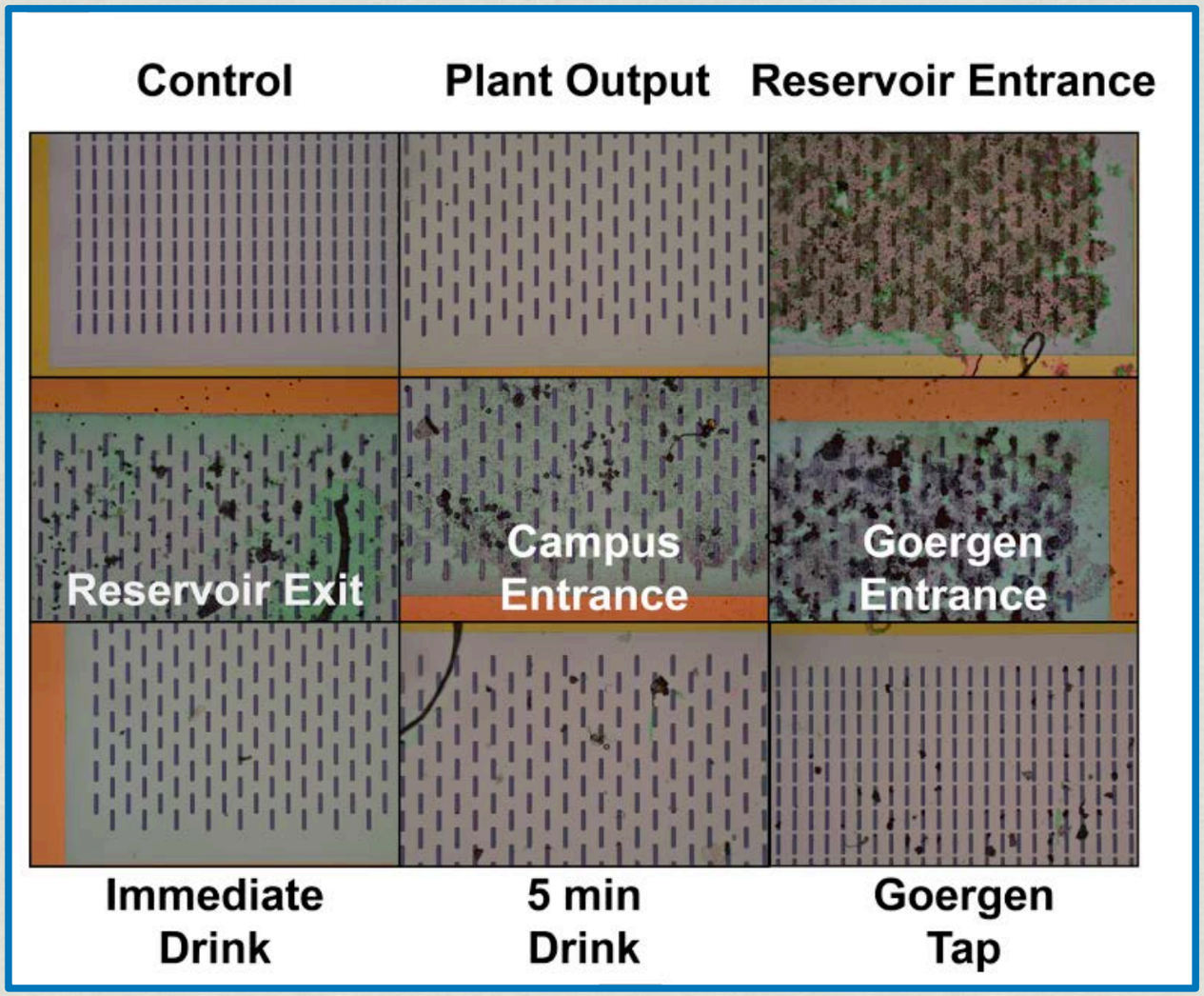
Rush, NY Reservoir (3 days)

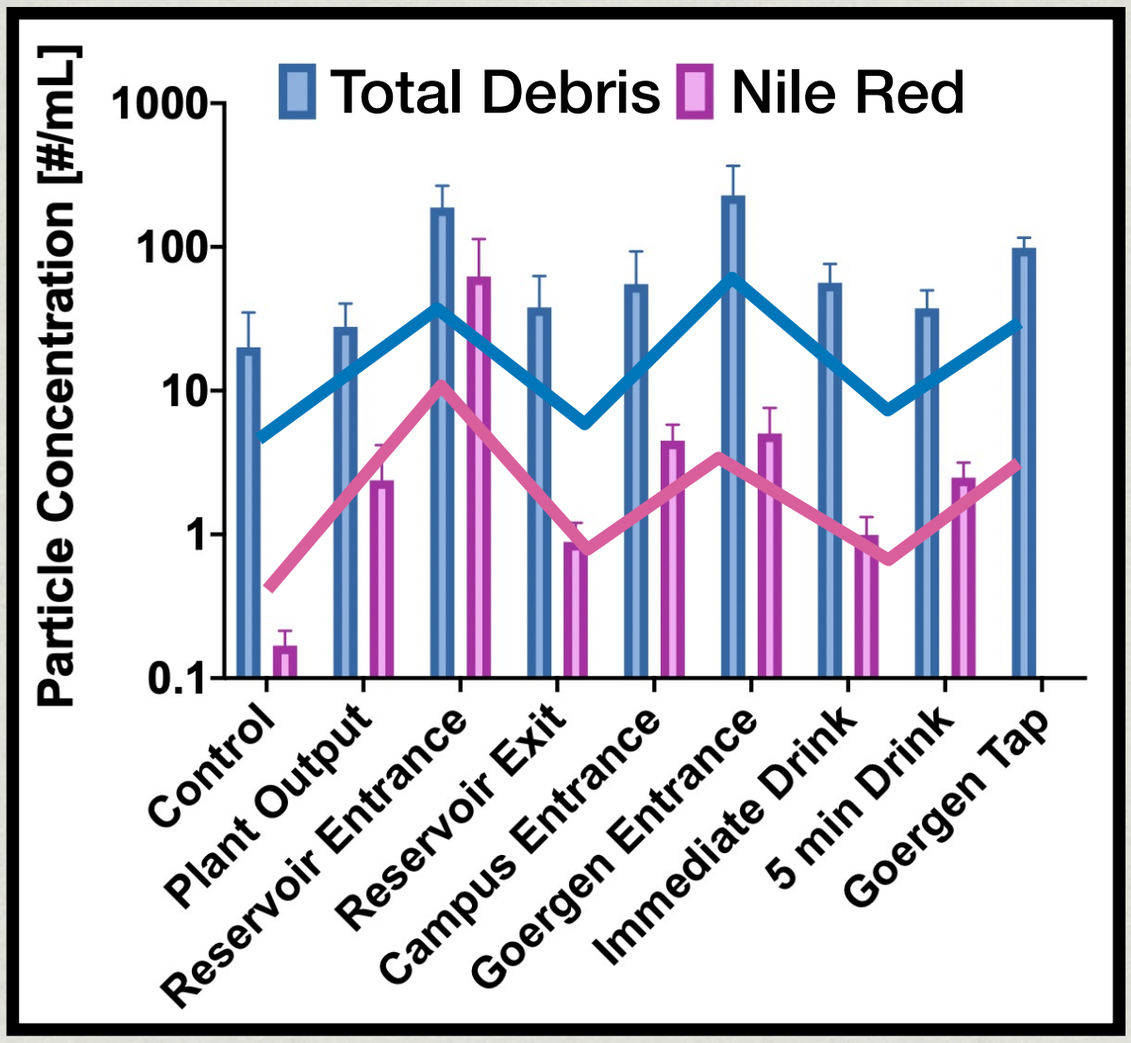
18 miles of 19th century cast-iron pipes

Filtration

- Water plant is the only construction on the lake.
- No recycling. Only natural inputs.
- Filtered through anthracite and sand.
- Gravity driven.

Entrainment of Debris and Plastics *En Route* to Goergen Hall





Madejski et al., 2020 Sustainability 7:44501

Yuck! There's a 90 percent chance your tasty sea salt contains plastic, study says

USA TODAY

ROBBIE GONZALEZ SCIENCE 10.22.18 06:00 PM

YOUR POOP IS PROBABLY FULL OF PLASTIC

WIRED

Pacific Standard

MICROPLASTIC POLLUTION IS AT AN ALL-TIME HIGH IN CYPRUS

TRILOBITES

The New York Times

Microplastics Find Their Way Into Your Gut, a Pilot Study Finds

Researchers looked for microplastics in stool samples of people from eight countries. "The results were astonishing," they said.

Falklands' waters micro-plastics pollution comparable to areas of UK

MercoPress. South Atlantic News Agency

Anthropocene 13 (2016) 4–17

Contents lists available at ScienceDirect

Anthropocene

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

Review

The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene

Jan Zalasiewicz[a,*], Colin N. Waters[b], Juliana A. Ivar do Sul[c], Patricia L. Corcoran[d], Anthony D. Barnosky[e], Alejandro Cearreta[f], Matt Edgeworth[g], Agnieszka Gałuszka[h], Catherine Jeandel[i], Reinhold Leinfelder[j], J.R. McNeill[k], Will Steffen[l], Colin Summerhayes[m], Michael Wagreich[n], Mark Williams[a], Alexander P. Wolfe[o], Yasmin Yonan[a]

Images of microplastics plankton

bing.com/images

See more images of microplastics plankton

Shocking photos reveal plankton consuming microplastics ...

https://www.dailymail.co.uk/sciencetech/article-4420992/Shocking...

Dr Richard Kirby, a plankton scientist from Plymouth, collected a sample of the plankton that are at the bottom of the marine food chain by towing a net through the water off Devon. Home U.K.

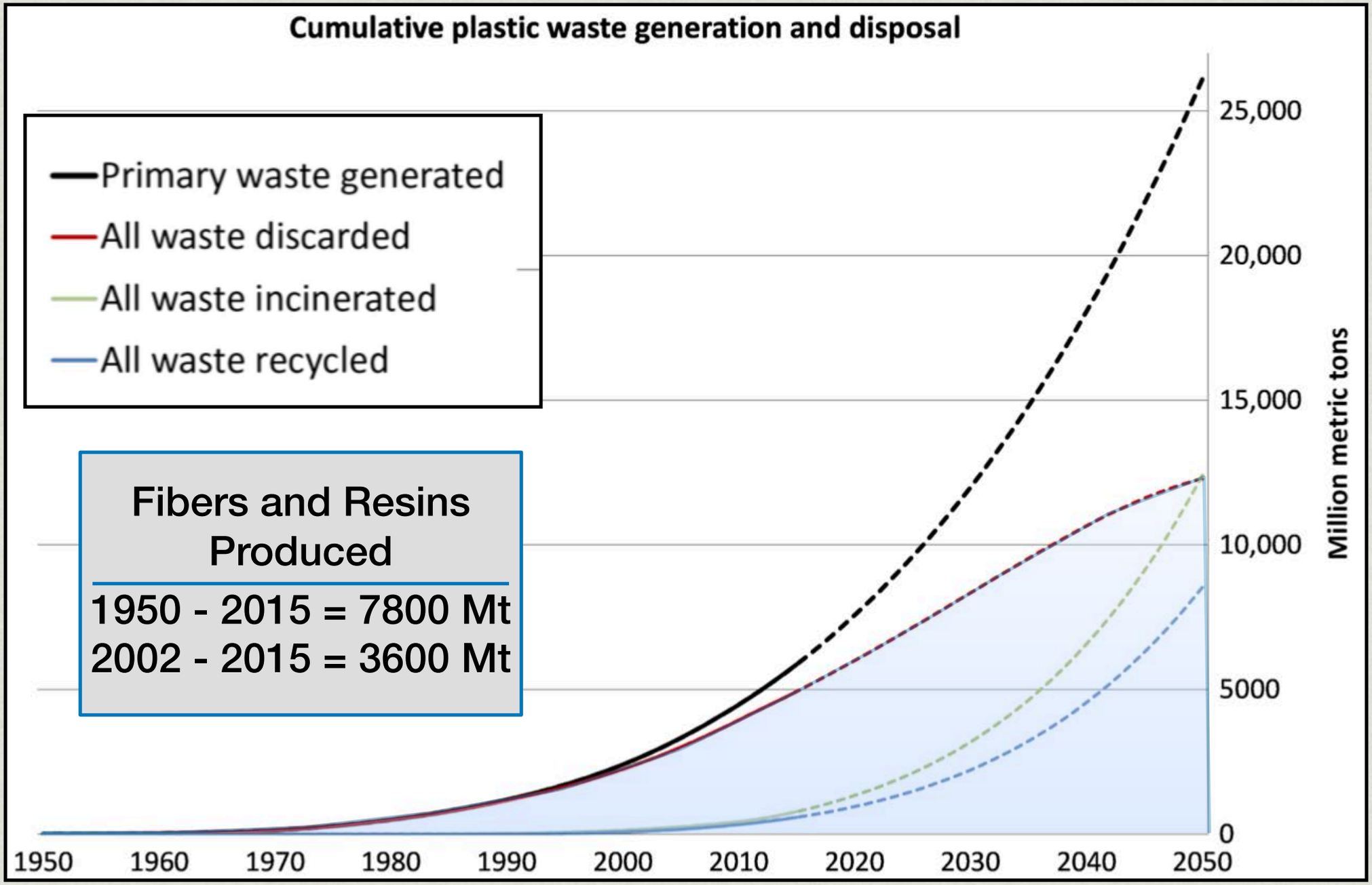
SCIENCE ADVANCES | RESEARCH ARTICLE

PLASTICS

Geyer, Jambeck, Law Sci. Adv. 2017;3: e1700782

Production, use, and fate of all plastics ever made

Roland Geyer,[1]* Jenna R. Jambeck,[2] Kara Lavender Law[3]



SCIENCE ADVANCES | RESEARCH ARTICLE

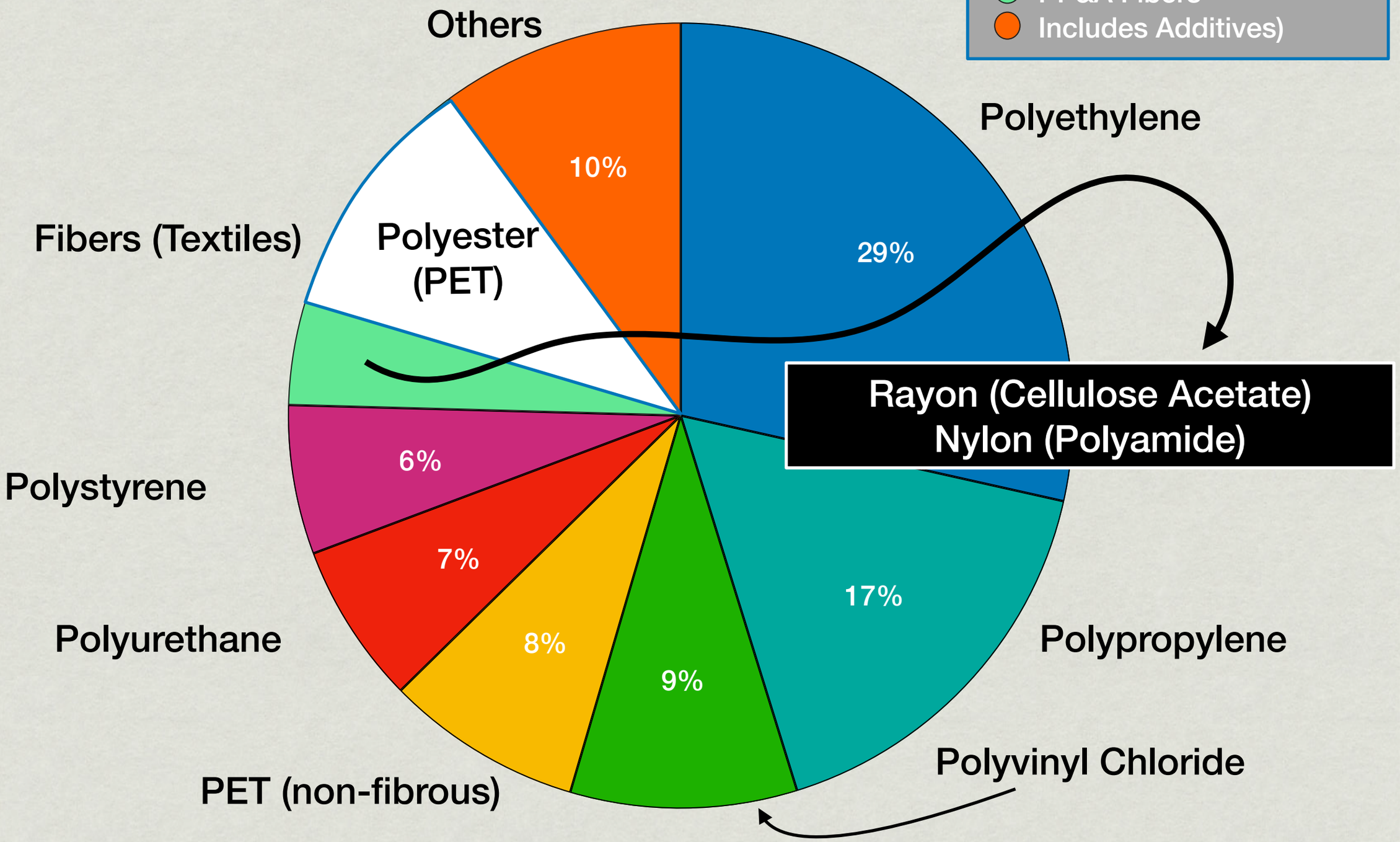
PLASTICS

Geyer, Jambeck, Law Sci. Adv. 2017;3: e1700782

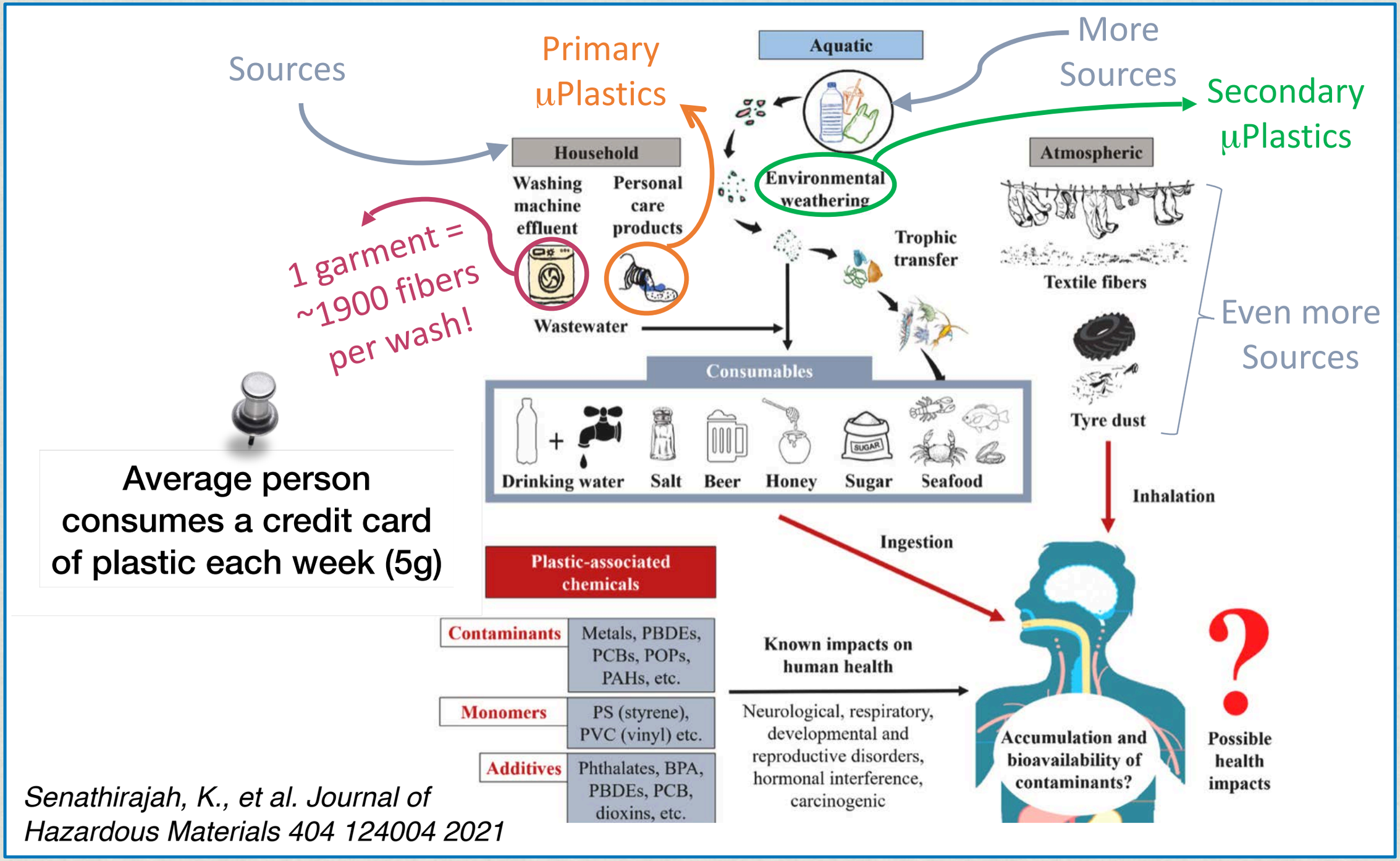
Production, use, and fate of all plastics ever made

Roland Geyer,[1]* Jenna R. Jambeck,[2] Kara Lavender Law[3]

- LD & HD PE
- PP
- PVC
- PET
- PUR
- PS
- PP&A Fibers
- Includes Additives)



How do Plastics Enter the Environment and Enter Us?



Average person consumes a credit card of plastic each week (5g)

Senathirajah, K., et al. Journal of Hazardous Materials 404 124004 2021

SB-1422 California Safe Drinking Water Act: microplastics. (2017-2018)

Text | Votes | History | Bill Analysis | Today's Law As Amended | Compare Versions | Status | Comments To Author

SHARE THIS:

Date Published: 09/28/2018 09:00 PM

Senate Bill No. 1422

CHAPTER 902

An act to add Section 116376 to the Health and Safety Code, relating to drinking water.

[Approved by Governor September 28, 2018. Filed with Secretary of State September 28, 2018.]

THE PEOPLE OF THE STATE OF CALIFORNIA DO ENACT AS FOLLOWS:

SECTION 1. Section 116376 is added to the Health and Safety Code, to read:

116376. (a) The state board, on or before July 1, 2020, shall adopt a definition of microplastics in drinking water.

(b) The state board, on or before July 1, 2021, shall do all of the following:

(1) Adopt a standard methodology to be used in the testing of drinking water for microplastics.

(2) Adopt requirements for four years of testing and reporting of microplastics in drinking water, including public disclosure of those results.

(3) If appropriate, consider issuing a notification level or other guidance to aid consumer interpretations of the results of the testing required pursuant to this section.

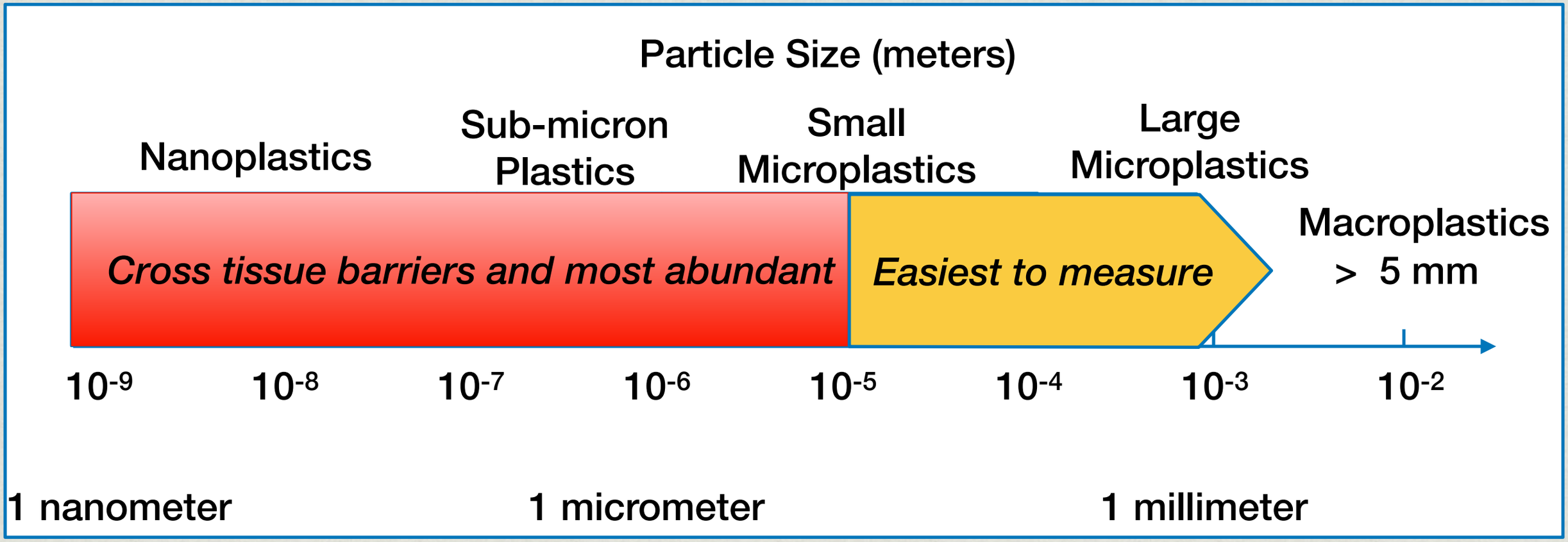
(4) Accredit qualified laboratories in California to analyze microplastics.

(c) The state board may implement this section through the adoption of a policy handbook that is not subject to the requirements of Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code.

Official Definition of ‘Microplastics in Drinking Water)’

“Solid polymeric materials to which chemical additives or substances may have been added, which are particles which have at least three dimensions that are greater than 1 nm and less than 5 mm.”

“Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded”



Environ. Sci. Technol. **2008,** *42,* 5026–5031

Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, *Mytilus edulis* (L.)

MARK A. BROWNE,*,† AWANTHA DISSANAYAKE,† TAMARA S. GALLOWAY,‡ DAVID M. LOWE,§ AND RICHARD C. THOMPSON†

Atlantic over the la
abundance, recent w
microplastic can co
debris (*4*). Large (>5

ENVIRONMENTAL SCIENCE & TECHNOLOGY

Article

pubs.acs.org/est

Uptake and Accumulation of Polystyrene Microplastics in Zebrafish (*Danio rerio*) and Toxic Effects in Liver

Yifeng Lu,† Yan Zhang,*,† Yongfeng Deng,† Wei Jiang,† Yanping Zhao,‡ Jinju Geng,† Lili Ding,† and Hongqiang Ren*,†

ENVIRONMENTAL SCIENCE & TECHNOLOGY

Uptake and Retention of Microplastics by the Shore Crab *Carcinus maenas*

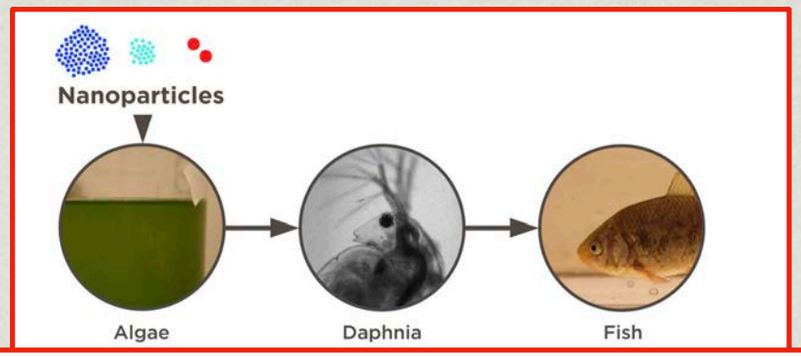
Andrew J. R. Watts,*,† Ceri Lewis,† Rhys M. Goodhead,†,‡ Stephen J. Beckett,§ Julian Moger,‡ Charles R. Tyler,† and Tamara S. Galloway†

SCIENTIFIC REPORTS

OPEN

Brain damage and behavioural disorders in fish induced by plastic nanoparticles delivered through the food chain

eceived: 9 June 2017
ccepted: 14 August 2017



Behavioral Changes for NP < 100 nm

- Longer feeding times
- Lower activity levels

SCIENTIFIC REPORTS

OPEN

Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure

Received: 10 October 2016
Accepted: 27 March 2017

5 μm PS particles

- Found in liver, kidney, deep within intestinal tissue
- Metabolic profiles for oxidative stress and neurotoxicity

10 μm PS particles

- Superficial regions of the gut
- No evidence of neurotoxicity

Microplastics in Human Tissue

Annals of Internal Medicine ORIGINAL RESEARCH

Detection of Various Microplastics in Human Stool

> 50 µm

A Prospective Case Series

Philipp Schwabl, MD; Sebastian Köppel, Dipl-Ing(FH); Philipp Königshofer, DVM; Theresa Bucsics, MD; Michael Trauner, MD; Thomas Reiberger, MD; and Bettina Liebmann, PhD

Environment International 146 (2021) 106274

Contents lists available at ScienceDirect

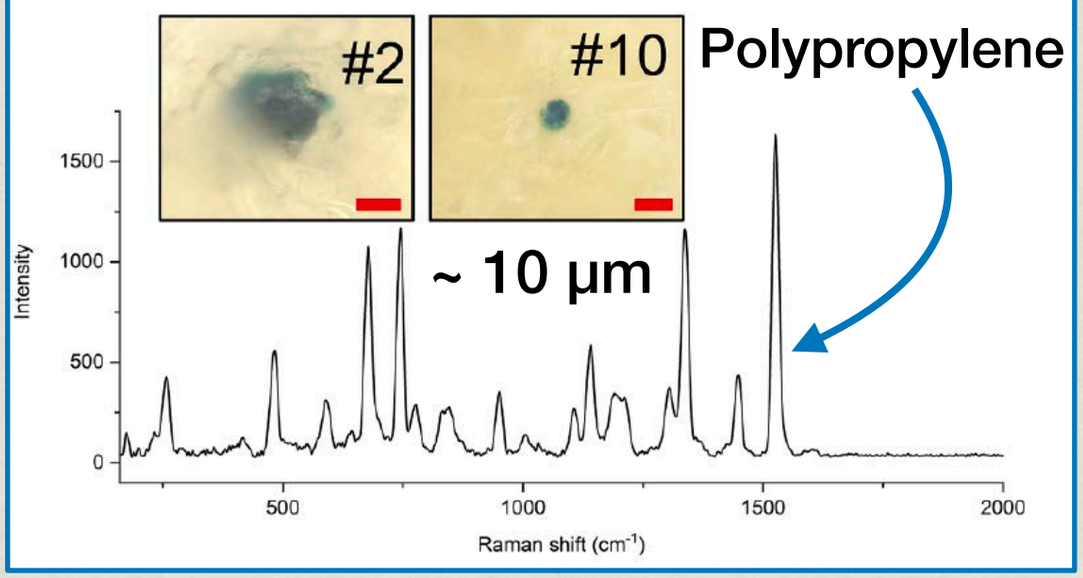
Environment International

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

ELSEVIER

Plasticenta: First evidence of microplastics in human placenta

Antonio Ragusa [a], Alessandro Svelato [a,*], Criselda Santacroce [b], Piera Catalano [b], Valentina Notarstefano [c], Oliana Carnevali [c], Fabrizio Papa [b], Mauro Ciro Antonio Rongioletti [b], Federico Baiocco [a], Simonetta D[illegible]isabetta D'Amore [a], Denise Rinaldo [d], Maria Matta [e], Elisabetta Giorgini [c]



1998

Vol. 7, 419–428, May 1998 Cancer Epidemiology, Biomarkers & Prevention 419

Inhaled Cellulosic and Plastic Fibers Found in Human Lung Tissue[1]

John L. Pauly,[2] Sharon J. Stegmeier, Heather A. Allaart, Richard T. Cheney, Paul J. Zhang, Andrew G. Mayer, and Richard J. Streck

Departments of Molecular Immunology [J. L. P., S. J. S., H. A. A., A. G. M., R. J. S.] and Pathology [R. T. C., P. J. Z.], Roswell Park Cancer Institute, New York State Department of Health, Buffalo, New York 14263

Polarized light

Breathable Plastics

Environmental Pollution 221 (2017) 453–458

Contents lists available at ScienceDirect

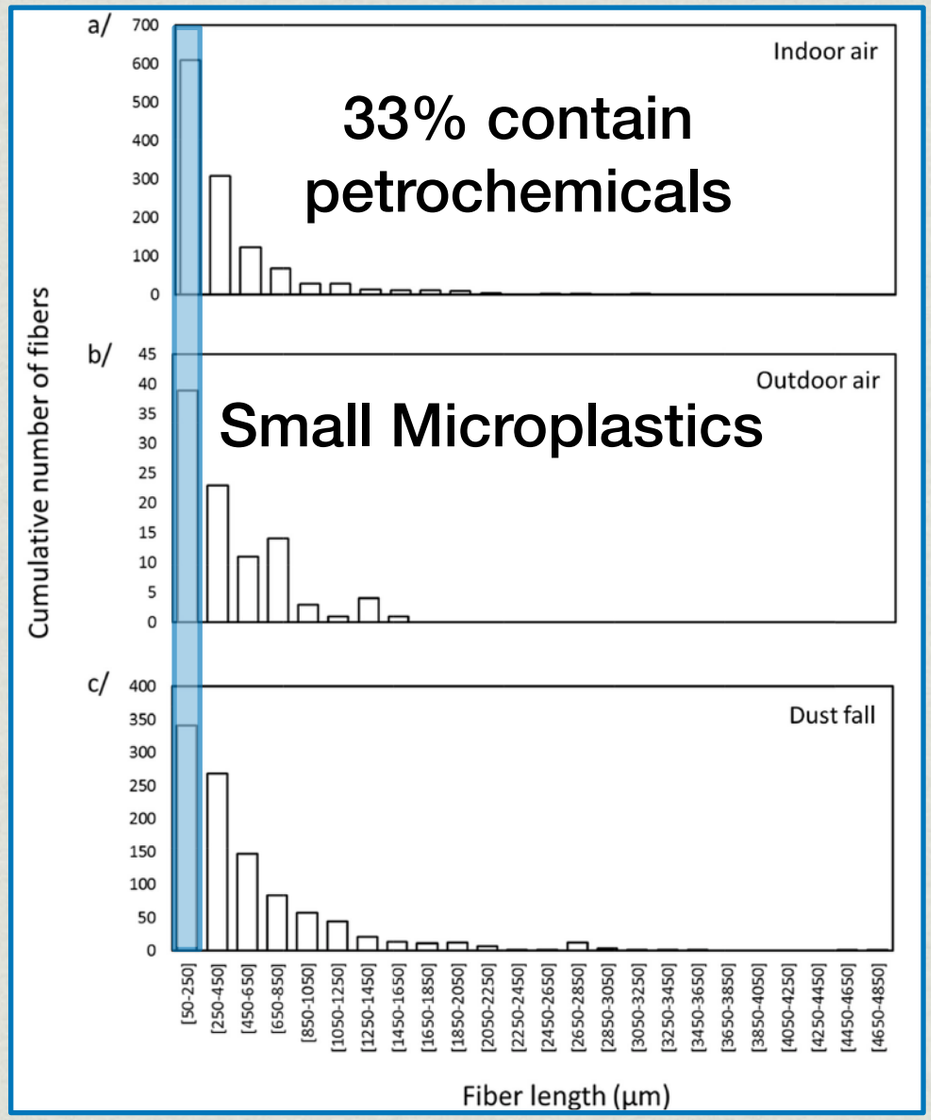
Environmental Pollution

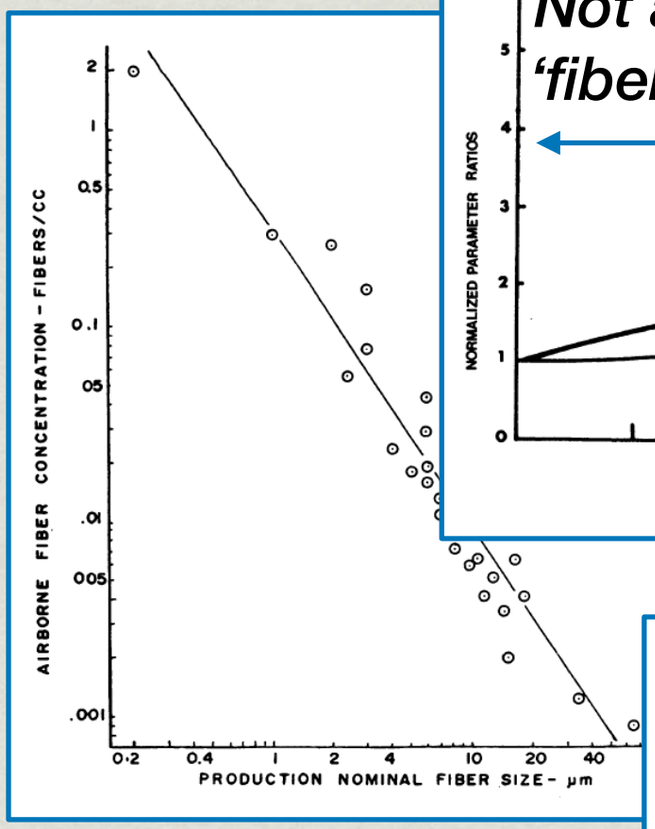
journal homepage: www.elsevier.com/locate/envpol

A first overview of textile fibers, including microplastics, in indoor and outdoor environments☆

Rachid Dris [a, *], Johnny Gasperi [a, **], Cécile Mirande [a], Corinne Mandin [b], Mohamed Guerrouache [c], Valérie Langlois [c], Bruno Tassin [a]

[a] Université Paris-Est, LEESU (laboratoire eau environnement et systèmes urbains), 61 avenue du Général de Gaulle, 94010 Créteil Cedex, France
[b] Université Paris-Est, Centre Scientifique et Technique du Bâtiment (CSTB), 77447 Marne-La-Vallée, France
[c] Institut de Chimie et des Matériaux Paris Est, CNRS





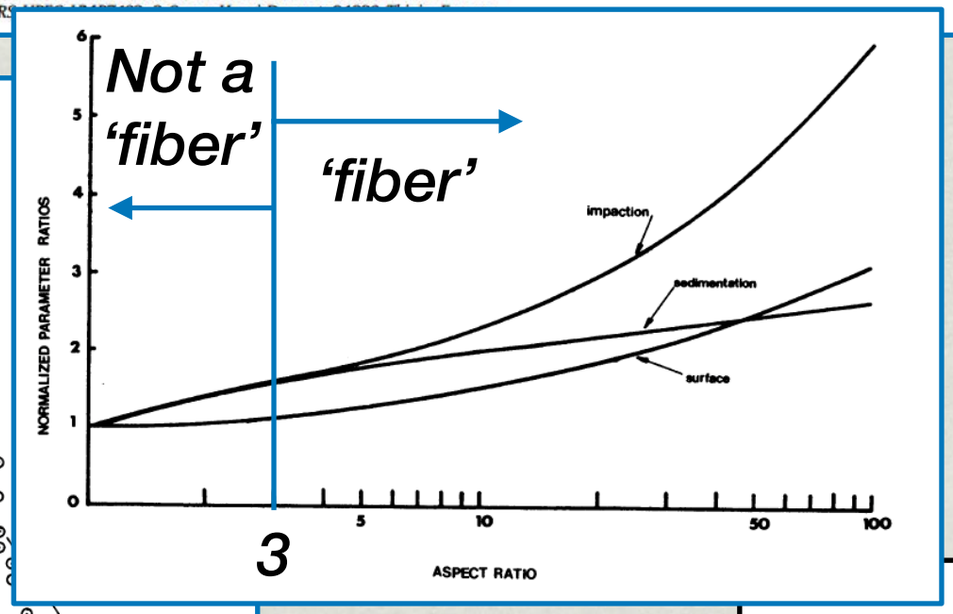


Table 1. Fiber categories as related to fiber dimensions.

Category	Length, µm	Diameter, µm	Comments
Type 0	< 2	—	Fragments
Type 1	> 2	< 3.5	Respirable total
Type 2	> 5	< 0.1	Translocatable
Type 3	> 10	> 0.15	Tracheobronchial
Type 4	> 100	> 8	Extrathoracic

Environmental Health Perspectives
Vol. 88,. pp. 277–286, 1990

n Occupational and Nonoccupational ure to Fibers

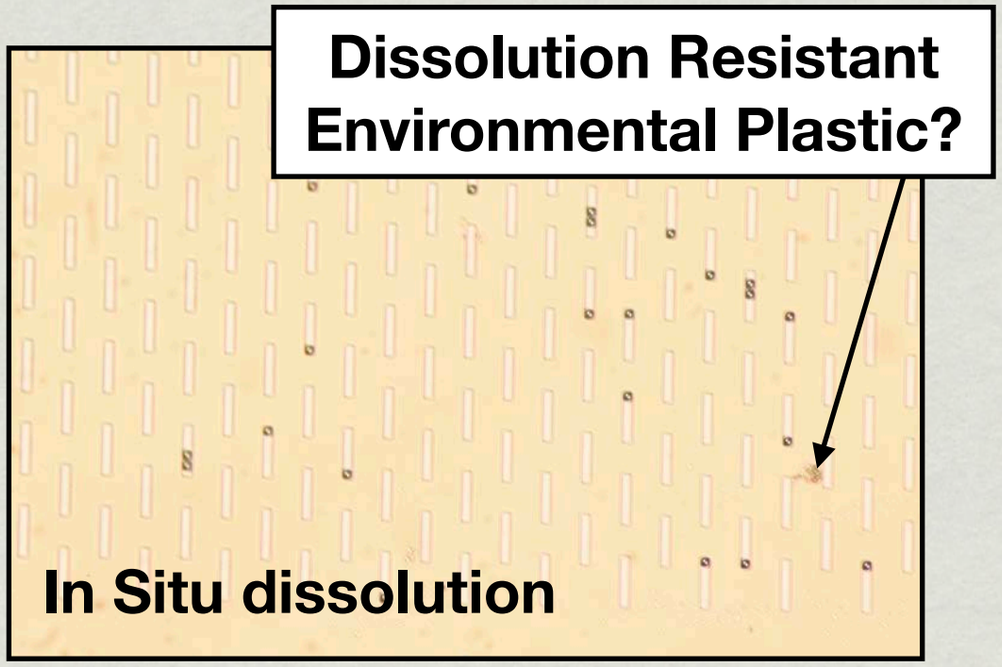
n A. Esmen* and Serap Erdal*

Isolation of Microplastics

Large microplastics captured with a coarse mesh

Madejski et al., 2020 Sustainability 7:44501

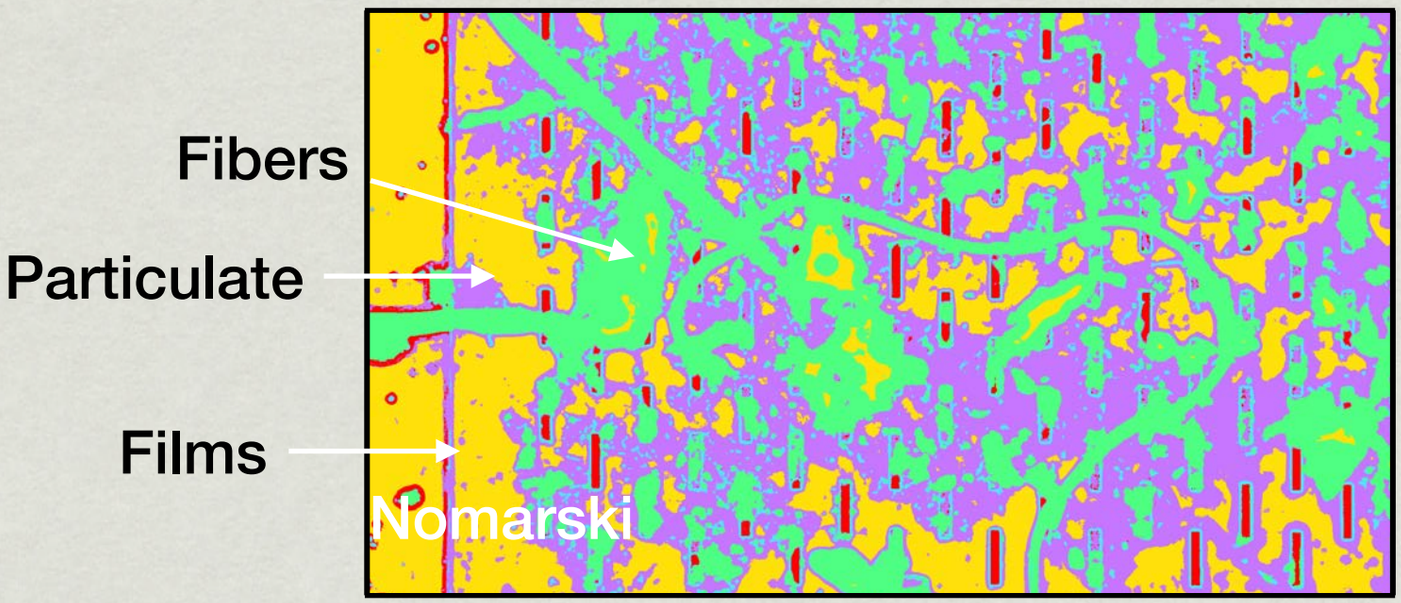
Sample
('Laemmli')
Buffer

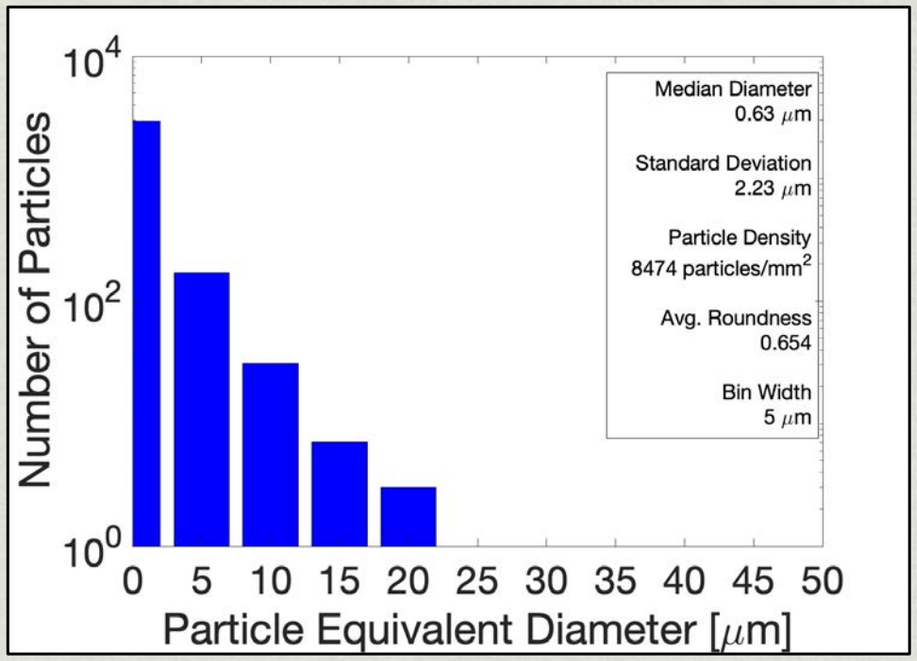


Biological Tissues, Waste-water, River Bottoms require harsh treatments (extended exposure to KOH) and enzymes

Identifying Plastics: Affordable but Low Precision Methods

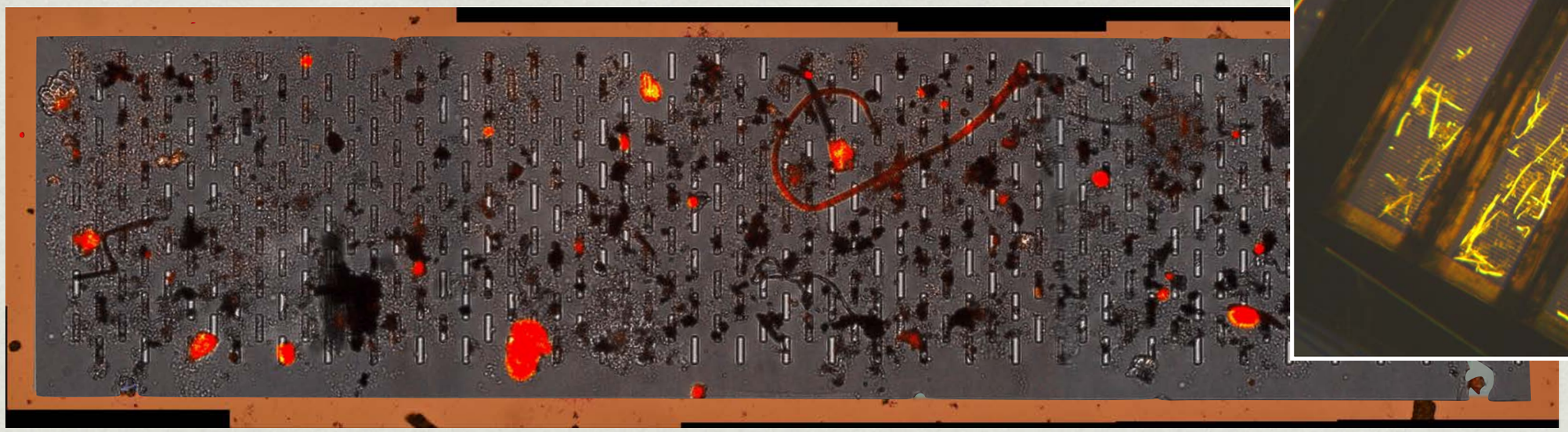
Madejski et al., 2020 Sustainability 7:44501

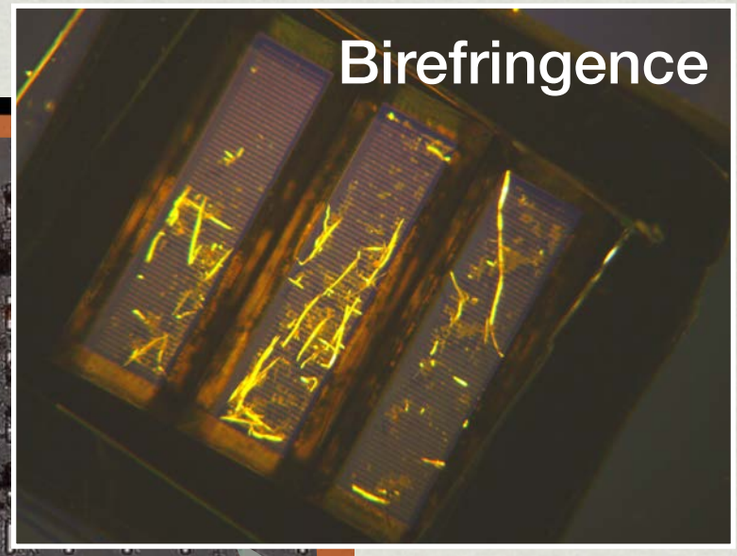




Nile Red Staining

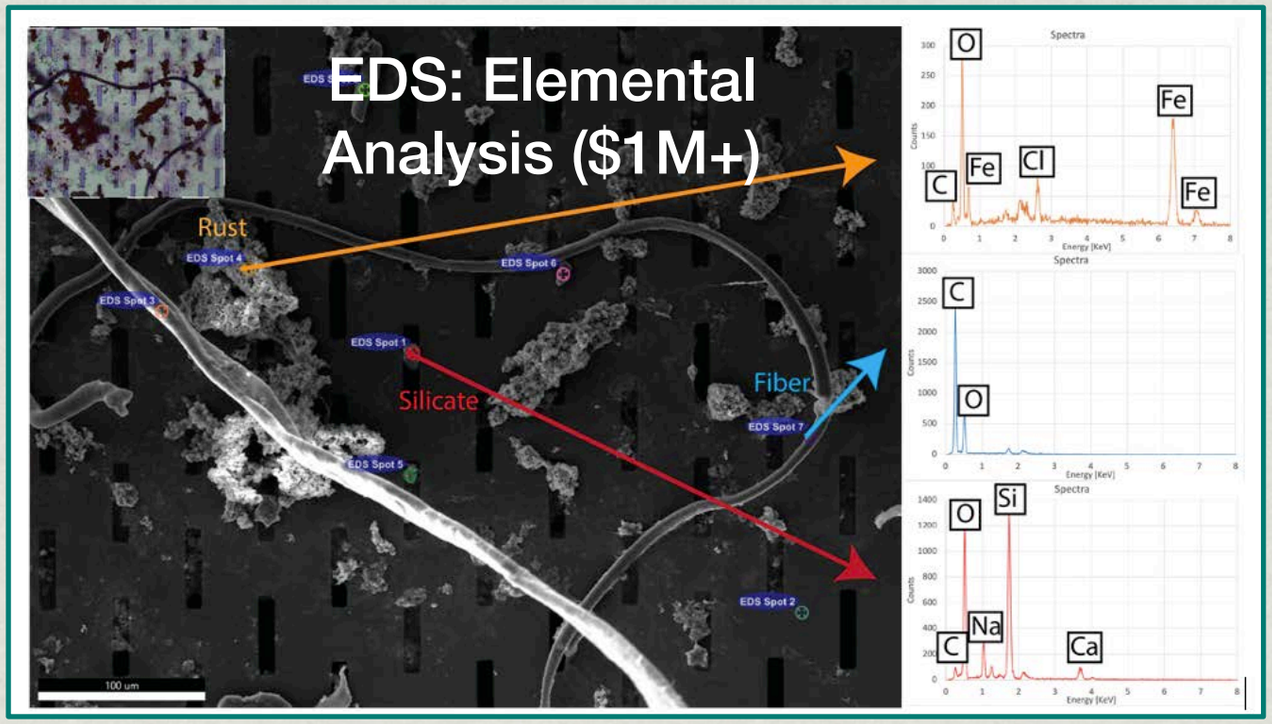
Maes et al., 2017 Scientific Reports 7:44501

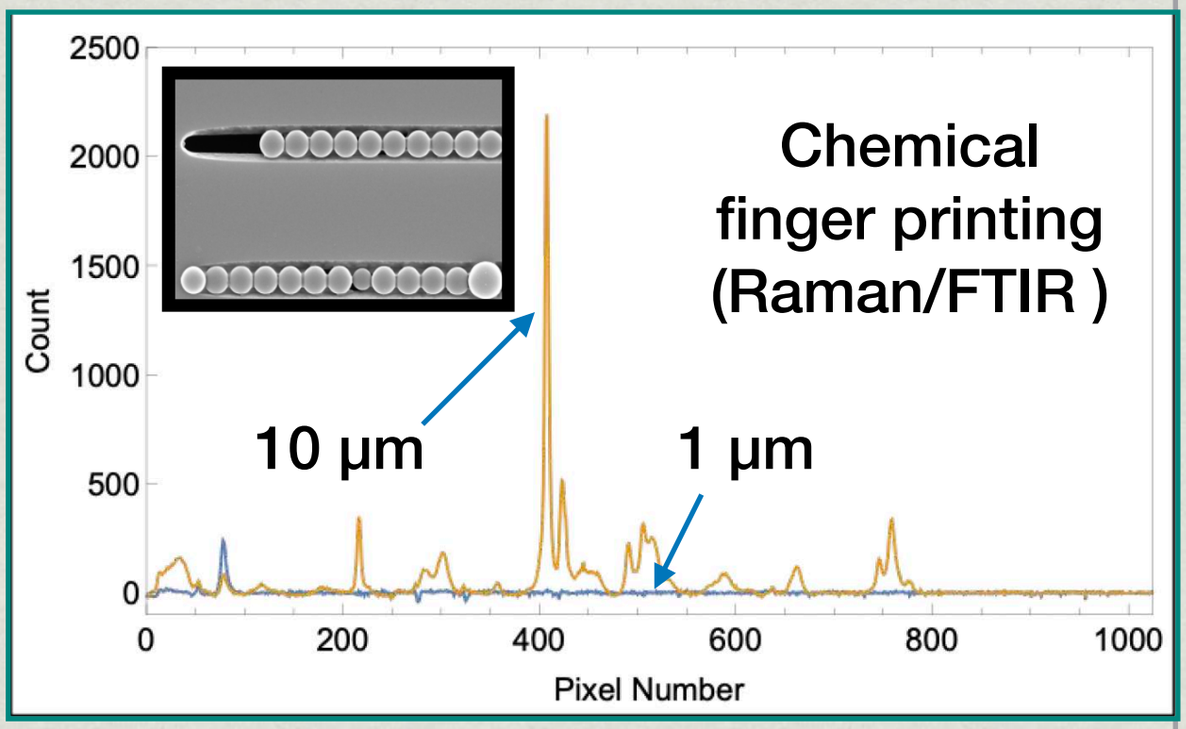




Madejski et al., 2020 Sustainability 7:44501

Identifying Plastics: Precise but Expensive and Slow Methods





Madejski et al., 2020 Sustainability 7:44501

WeTek Confocal Raman ~ $250,000
Material signals gets weak < 10 µm

Agilent FTIR/LDIR > $250,000
Does not resolve < 10 µm

Take Homes

- Microplastics are ubiquitous pollution that is in the air and in our food chain.
- The smallest microplastics are small enough to breach tissue barriers.
- The problem is only going to get worse.
- Solutions to isolating and identifying microplastics need to be affordable and distributable to match the scope of the problem.

Nanomembrane Research Group

Trainees

Sam Walker (Exosome Capture from Biofluids)
Alec Salminen (Vascular Models, μSiM)
Molly McCloskey (Modular μSiM, BBB, iPSCs)
Raquel Ajalik (Modular Devices,Tendon chip)
Michael Klazco (Virus Detection, Surface Coatings)
Bill Houlihan, PhD (High Content Microscopy)
Dan Ahmad (Machine Learning, Transmigration)
Victor Zhang (Tendon Chip Vasculature)
Samantha Romanick, PhD (Microplastics, Lung Barrier)

Collaborators

Knox, Elder, Flax,DeLouise, Korfmacher, Waugh, Kim, Pietropoaili, Johnson, Shestopalov, Abdolrahim, Miller, Schwarz, Awad, Kelly
Gaborski, Abhyankar,
Tabard-Cossa, Godin
(**Clarkson**); Latulippe
Dawson (**UC Dublin**);
(**Chicago**), Singer, Ku

Founding Team

* @ Vanderbilt
** @ RIT *** @ Adarza Inc

Jim McGrath
Philippe Fauchet*
Tom Gaborski**
Chris Striemer***

Alumni

Anant Agrawal (Cell Culture)
Jess Snyder (Diffusion, EO)
Barrett Nehilla (Cell Culture)
Dave Fang (pnc-Si mechanisms)
Maryna Kavalenka (Gas Flow)
Charles Chan (SiMPore - Materials)
Nakul Nataraj (SiMPore - Cell Culture)
Joe Qi (pnc-Si on SiN)
Josh Winans (NPN, Fouling)
Bob Carter (Lift-off)
Tucker Burgin (Dialysis & ECMO)
Karl Smith (Dead End Filtration, Fouling)
Tejas Khire (Vascular Models)
Jirachai Getpreecharsawas (Electrokinetics)
Henry Chung (Microfluidics)
Kayli Hill (Dialysis)
Greg Madejski (Adv. Membranes, Microplastics)
Kilean Lucas (Exosome Capture)

Funding

NSF, NIH, CSTI, UR, J&J, NYSTAR,
CEIS, Coulter Foundation, DOD, EHSC

SiMPore Inc.

Jamie Roussie
Josh Miller
Jared Carter
Rick Richmond
JP Desormeaux
Geoff Rosenberger
Kevin Rogers