NTP Board of Scientific Counselors Meeting

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U.S. FOOD & DRUG ADMINISTRATION

Understanding Human Exposure to Nanoplastics/Microplastics: Novel Agents Bring Novel Challenges

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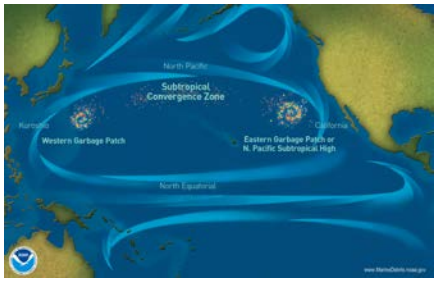
Disclaimer: The views expressed are of the presenter and should not be considered as the official position or policy of U.S. FDA

Overview

- Plastic Waste: A Global Challenge
- What are micro nanoplastics
- Human exposure
- Domestic efforts and interest from US Government Agencies
- International efforts
- Knowledge gaps
- NTP-FDA collaboration

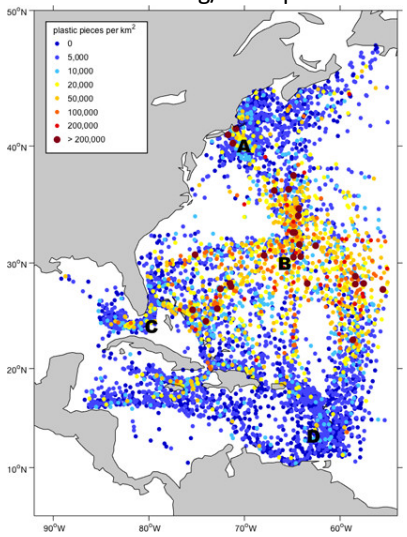
Plastic Waste: A Global Challenge

- Worldwide annual production of plastics is estimated to be >300 Million Tons
- World Economic Forum estimates accumulation of 50 million tons of plastic in Oceans and 90% of plastic ends up in Oceans through rivers
- Plastic debris in aquatic environment can degrade into micro/nanoplastics, leading to biopersistence, bioaccumulation, and toxicity
- A large variety of plastics sources exist including paints, food packaging, consumer products, personal care products, medical products & devices, diagnostics, and electronics.
- Compared to microplastics, nanoplastics have significantly higher surface area, penetrate through barriers and adsorb to metals and chemicals including PNAHCs, pesticides, and other persistent organic pollutants (POPs) resulting in potential hazard.
- Human exposure can occur through inhalation, ingestion and dermal routes
- Significant knowledge gaps exist, especially for nanoplastics for the identification, detection, quantitation to conduct exposure and risk assessment



www.marinedebris.noaa.gov

https://www.adventurescientists.org/microplastics.html#



C. Wilcox et. al., Environ. Sci. Technol. 2020, 54, 2, 790-796

What are Micro and Nanoplastics

- Micro and nanoplastics can be engineered particles or generated from bulk plastics through degradation
  - **Primary particles:**
    Particle made commercially in micron or nano size range
  - **Secondary particles:**
    Particles from degradation of bulk plastics/primary particles

K.L. Law et. al., *Science*, **345**, 6193 (2014)

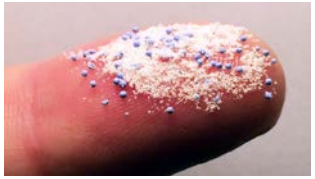
Micro plastics 0.1 µm – 5 mm	Nanoplastics 1 nm-100 nm

Fragments, Fibers, Spheroids, Granules, Pellets, Flakes, Beads

- No standard definitions exists
- Diversity of compositions, shapes, sizes
- Proprietary additives
- Chemicals bound to the micro- nanoplastics from waste streams

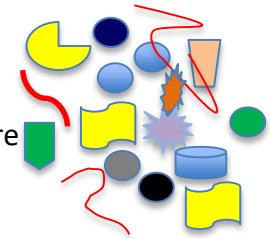
Public Concerns and Actions

- Very costly to clean up environment of accumulating plastics
- Solution to this problem is to reduce, recycle, reuse & upcycle
- US banned the microbeads use ‘Microbead-Free Waters Act of 2015’ – banned manufacturing of cosmetics with added microbeads from Jan 1, 2018
- European Parliament approved ban on single use plastics (25 October 2018)



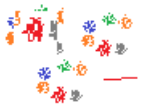
Micro Nanoplastics degradation

UV, Temp,
Agitation, pressure



Microplastics
0.1 µm – 5 mm

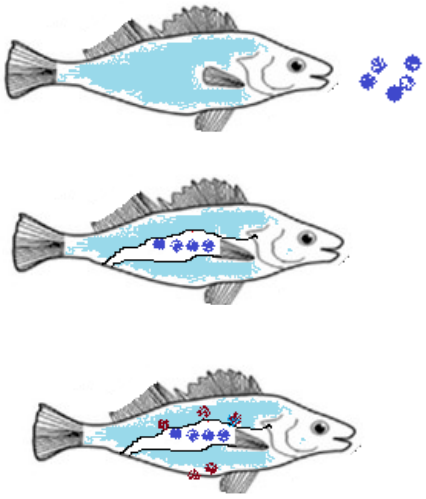
Further
Degradation



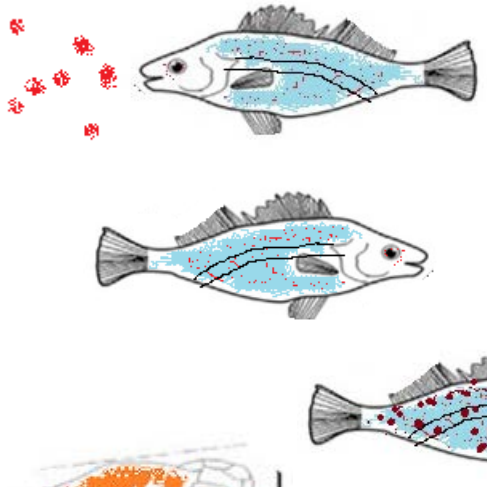
Nanoplastics
1-100 nm

Chemicals

Nanoplastics adsorbed to chemicals & pollutants

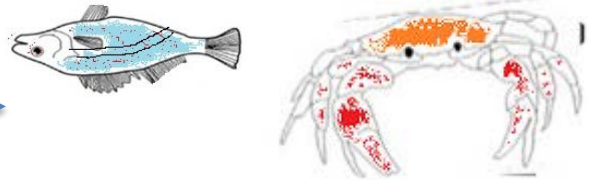


Micro



Nano

Food Chain

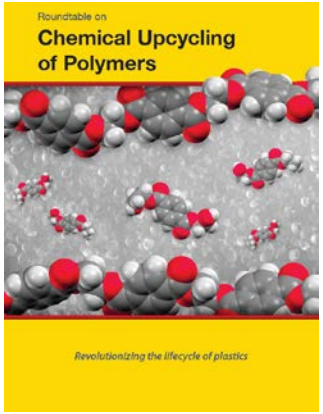


Domestic US Government Interest

Nanoplastics Interest Group

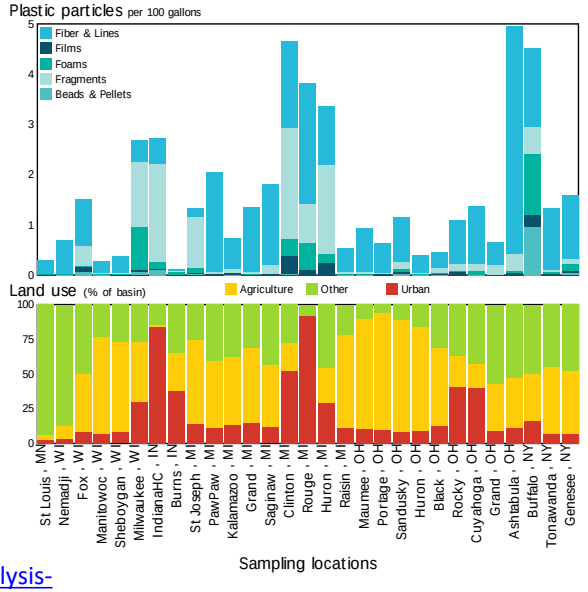
- Environmental Protection Agency (EPA)
  - Several workshops; research on microplastics
- US Geological Survey (USGS)
  - Water ways
- DOE Basic Energy Sciences
  - Upcycling
- National Institute of Standards and Technology (NIST)
  - Characterization
- Centers for Disease Control (ATSDR)
  - Risk assessment
- National Institute of Occupational Safety and Health (NIOSH)
- Consumers Products Safety Commission (CPSC)
- Department of Defense (DoD)
  - Exposure assessment
- US Department of Agriculture (USDA/NIFA)
- NOAA Marine Debris Program
- National Science Foundation
  - External grants
- Department of State (DOS)
  - International coordination
- Food and Drug Administration
  - Detection, Identification and Quantitation

https://www.epa.gov/trash-free-waters



https://www.ameslab.gov/cbs/fwp/catalysis-the-upcycling-polymers

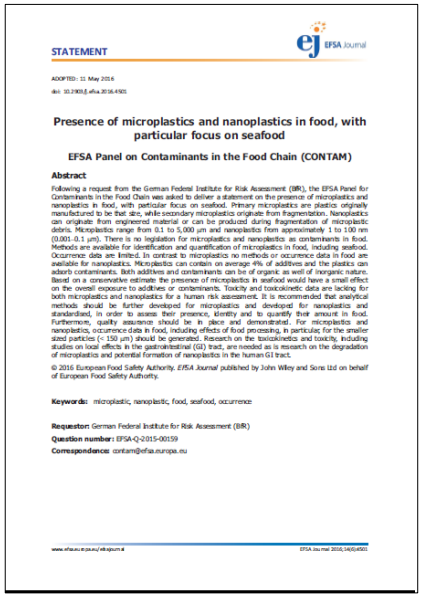
https://science.osti.gov/bes/Community-Resources/Overview-Brochures



https://owi.usgs.gov/vizlab/microplastics/

International Interest

- European Food Safety Authority (EFSA)
  - EFSA Panel on Contaminants in Food Chain
  - Workshops on microplastics
- Canadian Food Inspection Agency (CFIA)
  - Nanoplastics in the aquatic environment
- Joint Research Center (JRC/EC)
  - Microplastics/reference material
  - Standard methods, interlab studies
- Scientific Advice on Policy by European Academies (SAPEA) Report
- World Health Organization
  - Microplastics in drinking-water
- World Wildlife Fund
- Global Summit on Regulatory Science 2019 Nanotechnology and Nanoplastics
- National Academy of Sciences Emerging Technologies to Advance Research and Decisions on the Environmental Health Effects of Microplastics 2020



STATEMENT

EFSA Journal

Presence of microplastics and nanoplastics in food, with particular focus on seafood

EFSA Panel on Contaminants in the Food Chain (CONTAM)

Abstract

Following a request from the German Federal Institute for Risk Assessment (BfR), the EFSA Panel for Contaminants in the Food Chain was asked to deliver a statement on the presence of microplastics and nanoplastics in food, with particular focus on seafood. Primary microplastics are plastics originally manufactured to be that size, while secondary microplastics originate from fragmentation. Nanoplastics can originate from engineered material or can be produced during fragmentation of microplastic debris. Microplastics range from 0.1 to 5,000 μm and nanoplastics from approximately 1 to 100 nm (0.001–0.1 μm). There is no legislation for microplastics and nanoplastics as contaminants in food. Methods are available for identification and quantification of microplastics in food, including seafood. Occurrence data are limited. In contrast to microplastics no methods or occurrence data in food are available for nanoplastics. Microplastics can contain on average 4% of additives and the plastics can adsorb contaminants. Both additives and contaminants can be of organic as well of inorganic nature. Based on a conservative estimate the presence of microplastics in seafood would have a small effect on the overall exposure to additives or contaminants. Toxicity and toxicokinetic data are lacking for both microplastics and nanoplastics for a human risk assessment. It is recommended that analytical methods should be further developed for microplastics and developed for nanoplastics and standardised, in order to assess their presence, identity and to quantify their amount in food. Furthermore, quality assurance should be in place and demonstrated. For microplastics and nanoplastics, occurrence data in food, including effects of food processing, in particular for the smaller sized particles (< 150 μm) should be generated. Research on the toxicokinetics and toxicity, including studies on local effects in the gastrointestinal (GI) tract, are needed as is research on the degradation of microplastics and potential formation of nanoplastics in the human GI tract.

Keywords: microplastic, nanoplastic, food, seafood, occurrence

Requestor: German Federal Institute for Risk Assessment (BfR)
Question number: EFSA-Q-2015-00159
Correspondence: contam@efsa.europa.eu

https://efsa.onlinelibrary.wiley.com/doi/full/10.2903/j.efsa.2016.4501

https://www.sapea.info/
https://www.who.int/water_sanitation_health/publications/microplastics-in-drinking-water/en/

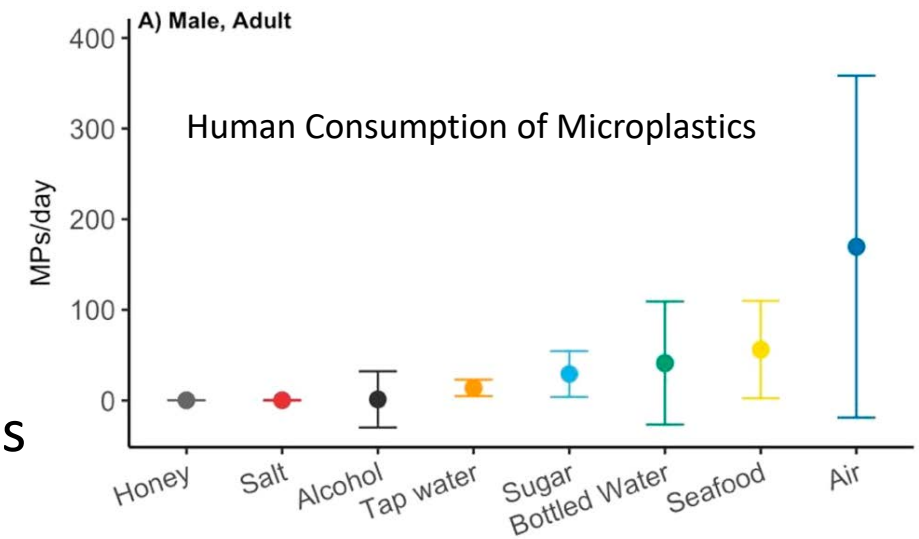
https://ec.europa.eu/jrc/en/event/conference/gsrs19-global-summit-regulatory-science-2019-nanotechnology-and-nanoplastics

Studies relevant to human exposure

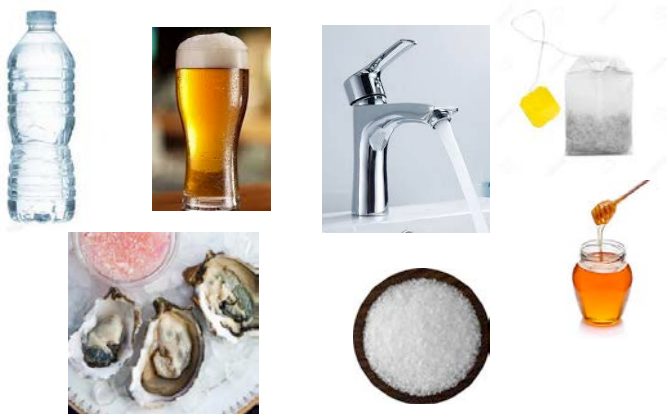
- Varying data and opinion on major sources of potential human exposures
- Focused on microplastics in marine environment
- Plastic fragments found in 1/3rd of all fish studied from Pacific Gyre and English Channel
- 50% of coastal fish from Northeast Atlantic area are found to contain microplastics
- Most studies found macro and micro plastics in GI tract while some studies found micro plastics in fish liver
- Shell fish and mussels contain higher concentrations of microplastics
- Studies estimated European consumer consumption of 10,000 microparticles per year
- Microplastics were found in honey, beer, poultry, sea food, salt, sugar, water
- Controlled laboratory experiments
  - Used higher concentrations
  - Zebra fish models
- Nanoplastics (50 nm, 100 nm) study in zebra fish: Taken up all over the body
- So far, no scientific evidence exist to support human harm
- Overall, very few studies exist on nanoplastics and lack of appropriate methods for their detection in natural environment
- A lot of unanswered questions and knowledge gaps exist both for micro and nanoplastics

Potential human exposure

- Direct particle-mediated effects
  - Inhalation
  - Oral uptake
  - Dermal route
- Effects of Chemical Additives
- Effects due to adsorbed chemicals
  - PCBs
  - POPs
  - PAHs



Cox, K.D. et. al., Environ. Sci. Technol. 2019, 53, 7068−7074

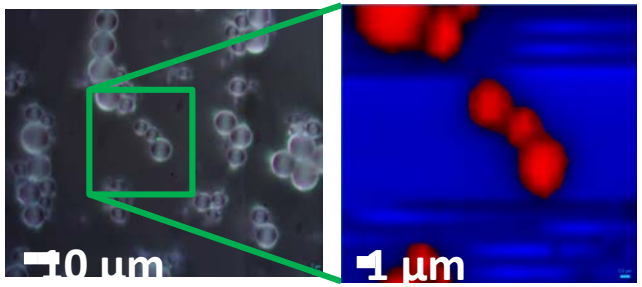


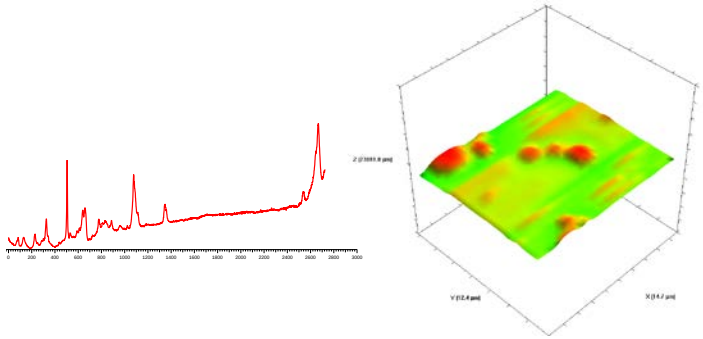
Key knowledge gaps

- Lack of robust, rigorous, reproducible science and standardized methods for the collection, isolation, separation, identification, and quantitation of micro- nanoplastics, additives and bound chemicals from complex mixtures for real-world sample analysis
- Methods for micro- nanoplastics mixtures in complex matrices such as food and sea food.
- Lack of performance standards, reference material standards and test methods
- Lack of quality controls
- Challenges in methodological gaps for nanoplastics
- Systematic studies on hazard, exposure, risk assessment of micro- nanoplastics mixtures

Methods currently used for analysis

- Most studies used fluorescent micro particles to track particles in zebra fish models
- Sampling and sample processing (i.e. size- and density separation)
- Extraction of plastic from biota by degradation of organic matter
- Detection and Quantification (enumeration – visual, optical)
- Characterization/ Identification of the polymer
- Other analytical methods: EM, Optical microscopy, Infrared, pyrolysis GC-MS, TGA-IR-GCMS
- Limitations for nanoplastics





Reviews on the topic: Hidalgo-Ruz et al. 2012, Cauwenberghe et al. 2015, Shim et al. 2017

Potential studies between NTP & FDA

- Horizon scanning on the extent of the problem, learn about research within USG and abroad, identify knowledge gaps to conduct complimentary research to minimize redundancies
- Work with groups that collect samples from various sources of potential human exposure
- Utilize existing knowledge with nanomaterial characterization to develop novel methods that are applicable to mixtures of nanoplastics
- Develop validated methods for detection, identification and quantitation of various mixtures of nanoplastics in food chain
- *In vitro* & Air Liquid Interface (ALI) models & studies
- Zebra fish models to investigate penetration of real world nanoplastics and adsorbed chemicals

Understanding exposure & hazard

BSC Questions

- Are we asking the right questions? What might be missing?
- Based on the questions, what other routes of exposures or materials of exposure should be considered?
- Are there technical capabilities that we need to develop to be successful?

Acknowledgment

NTP & NIEHS
NNCO/NSET/NEHI
Nanoplastics Interest Group
Global Coalition for Regulatory Science Research
Nanotechnology Task Force/OCS/OC
NCTR-ORA Nanocore

Thank you