Microplastics in Dredged Material: Nature & Extent, Effects, and Risk

David W. Moore, Burton Suedel, Andrew McQueen, Justin Wilkens, and Mark Ballentine

ERDC
Engineer Research and Development Center

Innovative solutions for a safer, better world

US Army Corps of Engineers®

U.S.ARMY

Microplastics

What are they?

Small plastic particles. Some debate as to size; the US National Oceanic and Atmospheric Administration (NOAA) has established a <5mm threshold.

Where do they come from?

Primary microplastics are manufactured for specific applications (e.g., micro-beads used in cosmetics, cleansers, and air blasting technology, etc.). These are often uniform in shape and size.

Secondary microplastics are fragments that arise from the breakdown of larger plastic containing materials (e.g., fibers in grey water from laundering of polyester clothing). Tend to be irregular shapes and sizes; can be particle or fiber.

Characteristics

- Ubiquitous.
- Persistent.
- Sediments serving as a sink.

Context for Dredging Operations

- As MPs are ubiquitous dredging operations are not expected to affect distribution.
- Sediment associated MPs have physical properties that will cause them to behave as other "natural" sediment particles in the environment, re: transport and physical behavior.
- Current DM assessment approaches account for biological effects as well potential of MPs to serve as vectors for contaminant uptake.
- At this time, MP in sediments is a topic of research interest only (i.e., not for regulatory purposes).

Approach

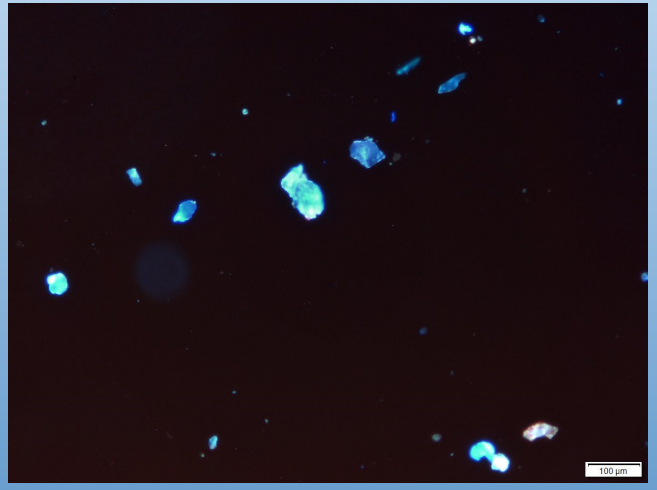
Review of relevant literature (MP in sediments).

Selection and refinement of analytical methodologies.

Preliminary survey of representative US sediments.

Literature Review: MP in Sediment

- > 50 publications reviewed
- >75% focused on presence of MP in beach sediment and relied on visual analytical techniques
- Fewer papers (<25%) examined MP in finer grained sediments typical of most dredging projects.
- Conkle et al. (2018) found that 80% of surveys conducted to date have focused on particles ≥ 300µm while their survey of 770 personal care products found >95% had particles < 300µm.
- Limited effects data, no clear mode of action, primarily physical direct/indirect effects.
- No clear spatial trends - some indication of higher MP levels near heavily industrialized areas, water treatment outfalls, or large urban areas; some indication of higher prevalence of fibers in coastal areas relative to particles.



Challenges

- Measurement of MP in finer grain sediments is challenging (i.e., Most of the work to date on MP has focused on water column and beach sediments which are more amenable to visual techniques [microscopy]).
- Results of Conkle et al suggests importance of looking for particles < 300µm
- Need for other analytical methodologies to identify MP in fine grain sediment and segregate by type (e.g., fiber, particle, material type).

Methods Development and Validation

Approach:

Adapted methods from Maes et al. (2017) of the UK Centre for Environment, Fisheries, and Aquaculture Science.

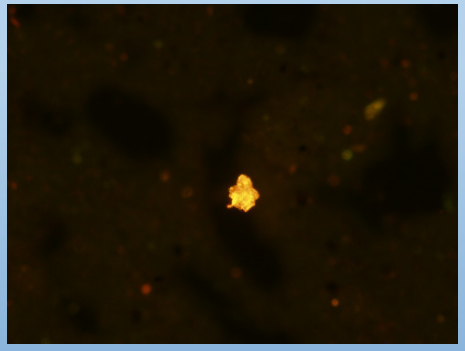
- Nile Red was used in both acetone and chloroform as a diluent
- ZnCl2 is added to change the density and allow the MPs to float
- Detection with fluorescent microscope and fluorometer

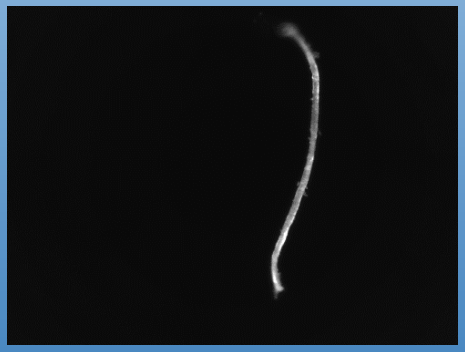
Microscopy:

- Three dye concentrations in two solvents under two different filters were tested

Spectroscopy:

- Two dye concentrations in two solvents (chloroform and acetone) and no differences were found, but lower dye concentration was harder to work with
- Non specific binding was observed with the dye, and verification of plastics was not possible without Raman spectroscopy or FTIR





Methods Development and Validation

Approach Cont.

Initial survey of representative geo-regions within the US (freshwater and marine).

10 of 20 samples analyzed.

Methods Development and Validation

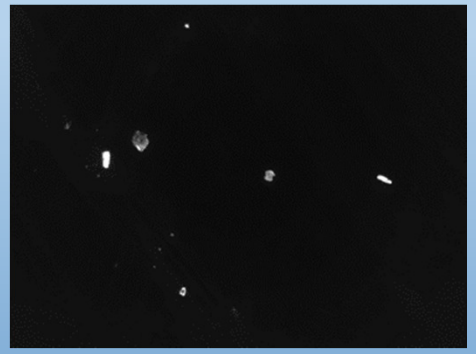
Results:

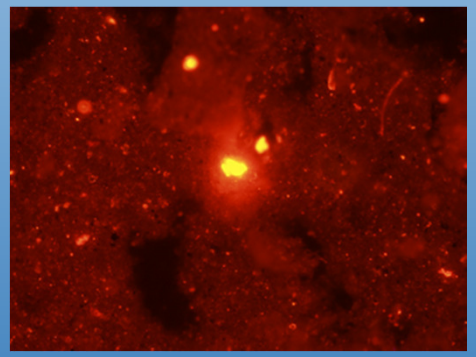
Microscopy:

- False positives challenging – need for standard reference materials and/or positive controls (known concentration and types of plastics) to calibrate method.

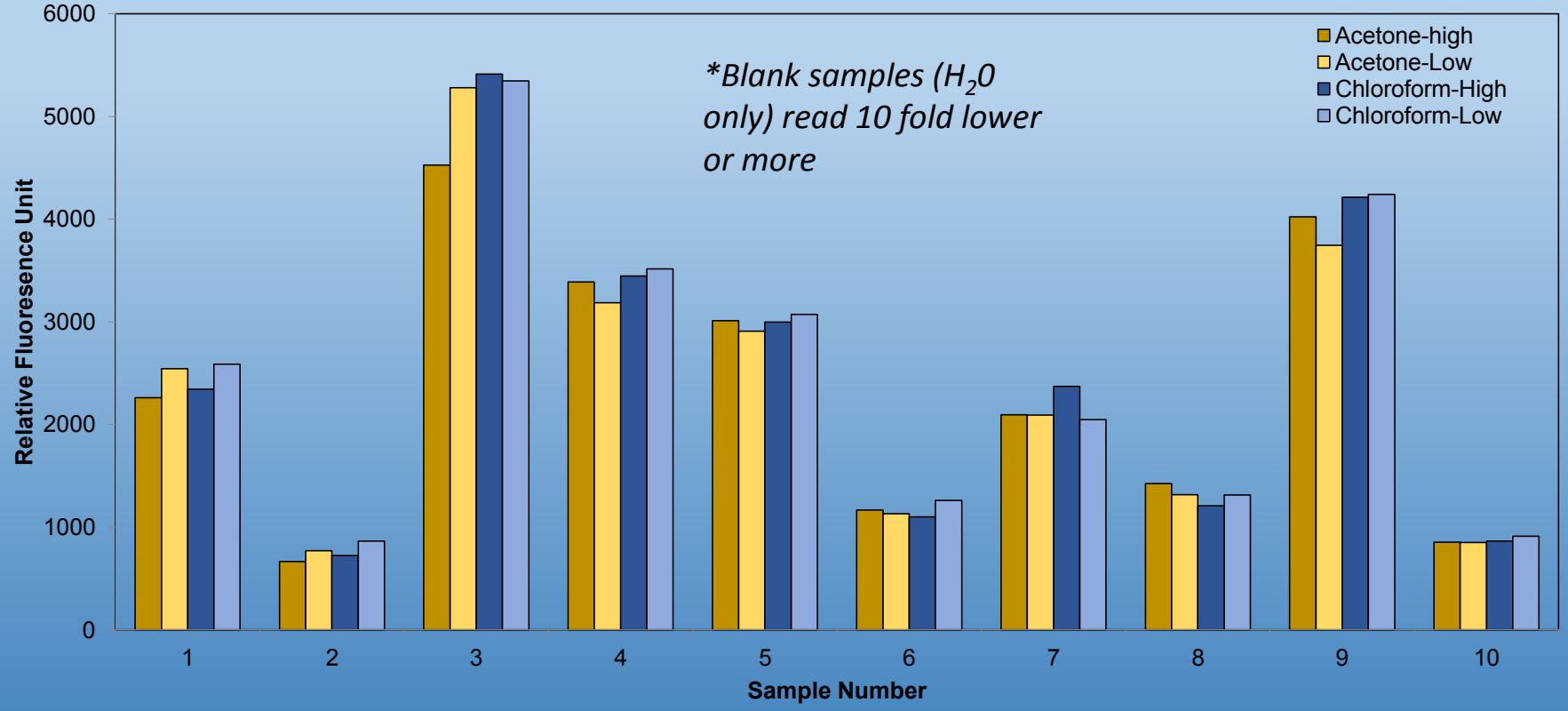
Spectroscopy:

- no differences between solvents but lower dye concentration harder to work with
- Non specific binding was observed with the dye, and verification of plastics was not possible without Raman spectroscopy or FTIR.
- Need for standard reference materials to calibrate.





Results: Fluorometer



Preliminary Conclusions

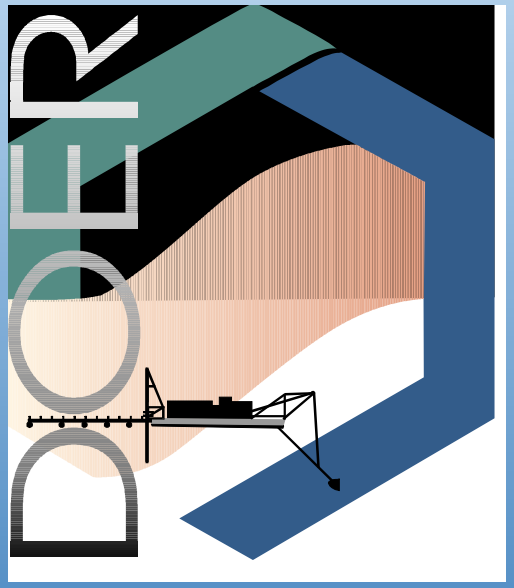
- Most MP survey work conducted to date has focused on larger particles in coarser sediments.
- Recent work of Conkle et al. (2018) suggest large fraction of MP maybe less than 300µm.
- Spectroscopic methods show promise for evaluation of MP in finer grain sediments but there is a need for reference standards.
- Initial survey across a large spectrum of representative U.S. sediments(freshwater and marine) confirm ubiquitous distribution of MP.

Next Steps

- Evaluation of additional representative inland and coastal sediments.
- Further refinement of analytical methodologies to measure smaller particles in fine grain sediments.

Acknowledgements

This project is funded through the USACE Dredging Operations Environment Research Program (DOER).



Contacts

David Moore (DOER Program Risk Management Lead)

E-mail: david.w.moore@usace.army.mil

Phone: 601-634-4199

Burton Suedel (Principal Investigator)

E-mail: burton.suedel@usace.army.mil

Phone: 601-634-4578