Microplastics in Mountain Ecosystems of the Colorado Front Range

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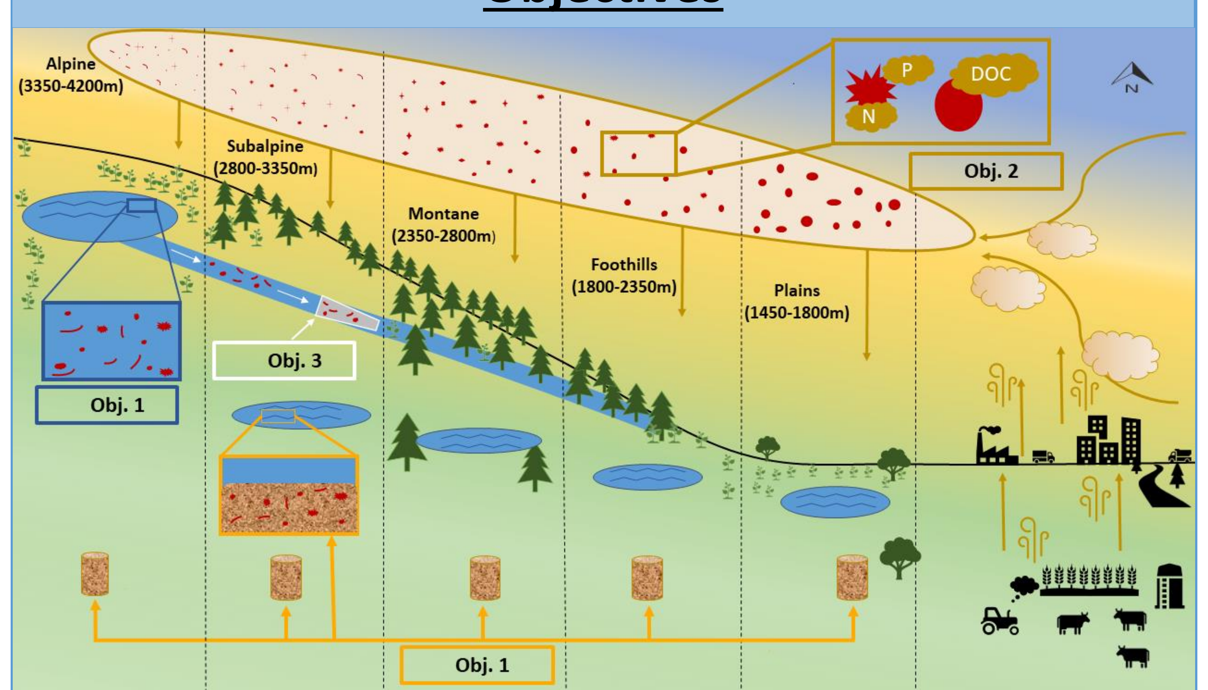
Introduction

The field of microplastic research in marine settings has made considerable advances, however, there is limited research investigating the impacts of microplastics in sensitive mountain ecosystems. High microplastic deposition rates in the Colorado Front Range (9.6 Mt yr^{-1}) make it an ideal study system for investigating the ecological impacts of microplastics in mountain ecosystems. With worldwide and local plastic use projected to increase, now is a critical time to investigate how microplastics impact the Rocky Mountains and their natural resources. My research focuses on developing methods for isolating microplastics from environmental matrices (e.g., benthic sediments, creek waters, lake waters, and soils) to explore how microplastics are distributed across the elevation gradient of the Colorado Front Range, estimate toxicity in biota most at-risk to microplastic contamination, and investigate how microplastics impact biogeochemical processes. This poster outlines research efforts starting Summer 2023 where I will be conducting modified isolation methods established by the National Ocean and Atmospheric Administration for soil and sediments samples, a microplastic collection net for creek waters, and a peristaltic pump-and-filter method for lake waters. In acquiring microplastic concentrations and characteristics (e.g., polymer composition, morphology, and size) critical in estimating toxicity, testable hypotheses can be made to determine the potential impacts of microplastics in mountain ecosystems.

Objectives



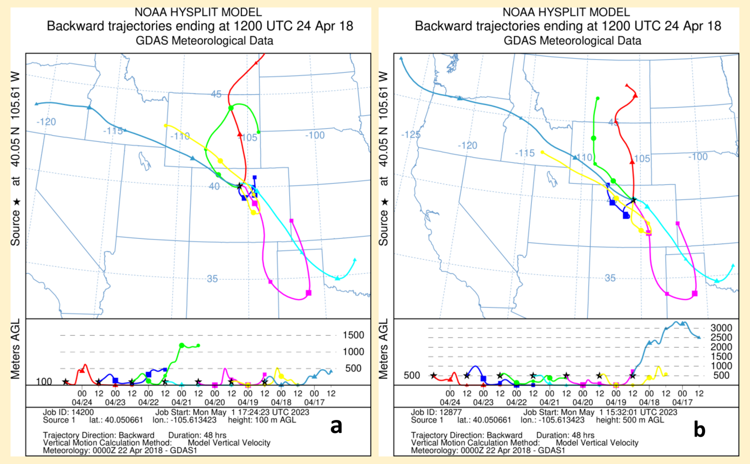
Microplastics Are Not a Micro Problem

Past research demonstrated that microplastics have adverse consequences (e.g., reproductive abnormalities, feeding impairment, and oxidative stress) for aquatic and terrestrial biota.[1,2] Moreover, additives applied to plastics (e.g., plasticizers, flame retardants, and surfactants) improve plastic functionality, but also serve as sources of heavy metals, toxic organic compounds, and dissolved organic carbon (an energy source for microbes).[3] Shifts in biotic health and labile nutrient sources can lead to reduced ecosystem function with consequences to biogeochemical cycling.[4] To understand how these novel contaminants impact the Colorado Front Range, their ecosystem interactions must be understood. Therefore, objectives for this research are to:

1) Determine how aquatic and terrestrial systems are compromised by microplastic pollution.
2) Investigate biogeochemical sources derived from microplastic leachates and sorbates.
3) Investigate ecosystem sinks and sources of microplastics and their temporal cycling.

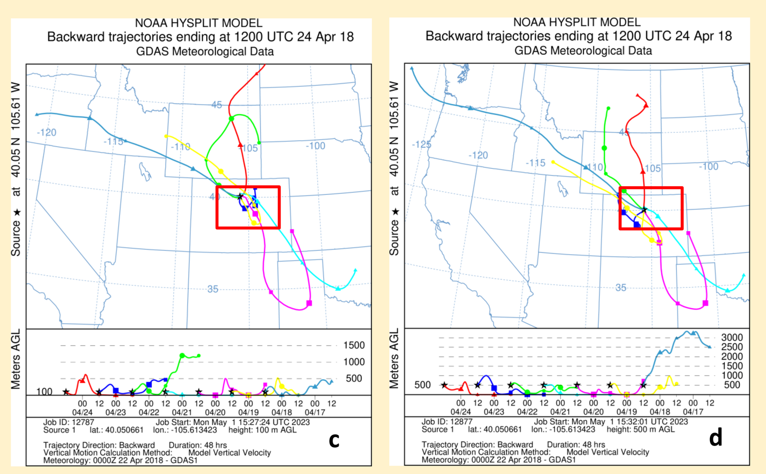
Contamination in the Colorado Front Range

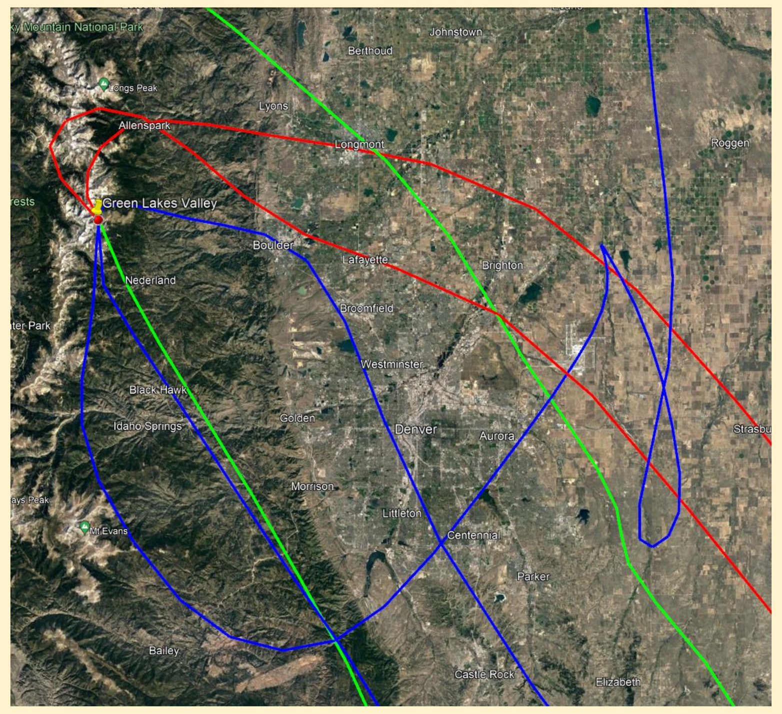
Drivers for Plastic Deposition: Air Transport and Population Centers



Figures a and b: HYSPLIT back-trajectory models for RMNP performed by Brahney et al. (2016) found a strong correlation of days with high microplastic deposition rates (325 particles m^{-2} day^{-1}) with long-range transport and local air parcels intersecting with population centers.[5]

Plastic Deposition in the Green Lakes Valley and Niwot LTER



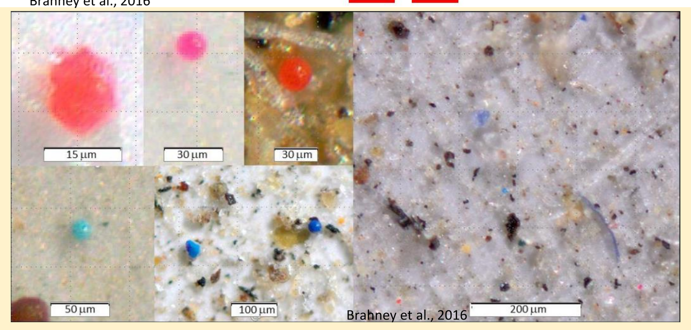


Figures c and d: HYSPLIT back-trajectories for Green Lakes Valley in the Niwot LTER show similar air-parcel trajectories at 100 m and 500 m above ground that correlate to high microplastic deposition rates.

Plastic Trait Distribution

Sample ID	ID03	NV05	CA67	CO98	CO10	AZ03	UT09	UT95	UT99	WY06	CO02	Total
Total number of particles analyzed (above 20um)	713	665	538	639	660	633	676	695	591	663	626	7099
Total number of particles used for spectra analysis	437	411	374	434	398	469	379	478	384	404	412	4580
Organic (cellulose, other biological)	202	217	154	235	217	237	166	235	176	245	196	2280
Inorganic (silicate, minerals)	216	178	204	181	171	209	199	221	192	143	207	2121
Polymeric total	**19**	**16**	**16**	**18**	**10**	**23**	**14**	**22**	**16**	**16**	**9**	179
polyester PET	4	2	3	5	3	5	3	5	3	3	3	39
polystyrene	2	3	2	3	1	3	0	1	2	3	0	20
polyethylene	3	1	1	2	1	2	1	2	1	2	0	16
acrylates	2	2	3	1	2	1	2	4	4	3	1	25
polypropylene	2	2	2	1	1	3	1	1	2	1	1	17
PVC/similar	3	2	2	2	1	4	4	4	2	2	2	28
PTFE/teflon	1	1	1	2	1	2	1	2	2	1	2	16
Other (nylon/etheramide, pvdf)	2	3	2	2	0	3	2	3	0	1	0	18
Fraction of all partciles	**0.027**	**0.024**	**0.030**	**0.028**	**0.015**	**0.036**	**0.021**	**0.032**	**0.027**	**0.024**	**0.014**	**0.025**
Fraction of particles identified	**0.043**	**0.039**	**0.043**	**0.041**	**0.025**	**0.049**	**0.037**	**0.046**	**0.042**	**0.040**	**0.022**	**0.039**

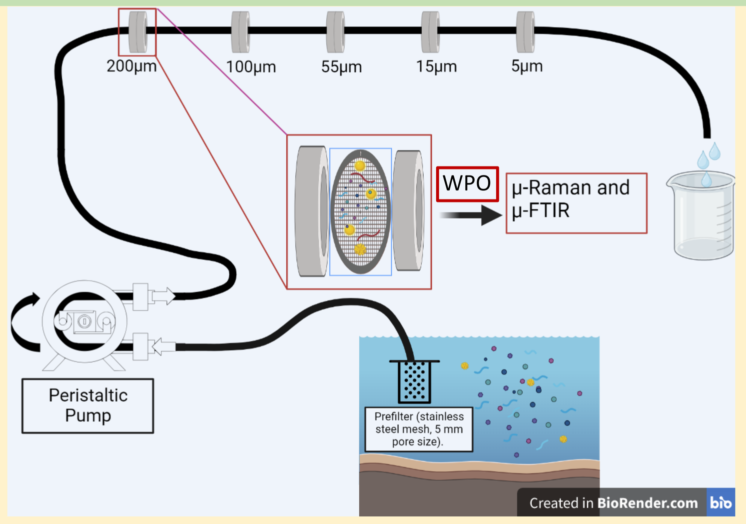
Brahney et al., 2016



Plastic characterization by Brahney et al. (2016) depicts the diversity of polymer composition, morphology, and size. An array of physicochemical traits implies a wide range of toxicological and biogeochemical implications.

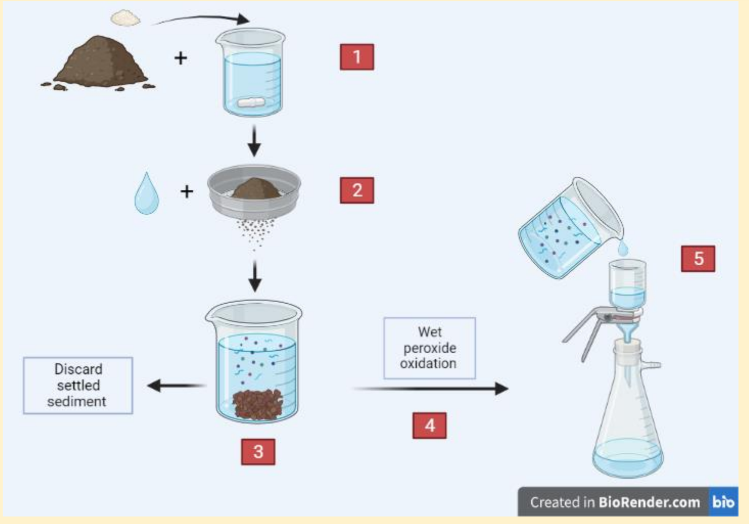
Materials and Methods

Peristaltic Pump-and-Filter Water Sampling



- A stainless steel prefilter will prevent the passing of particles over 5 mm.
- A peristaltic pump and shed-resistant silicon tubing will pump water to five in-line mesh filters at sizes 200 µm, 100 µm, 55 µm, 15 µm, and 5 µm to capture plastic particles.
- Filters will go through wet peroxide oxidation to digest organic matter prior to µ-FTIR and µ-Raman spectroscopy.
- Filters may be replaced as needed once they are saturated with particles.
- At the outlet, a flow rate can be taken to ensure an appropriate water volume is filtered per lake. This water can be collected for 1 µm filtration in the lab.

Density Separation for Soil and Sediment Samples



1. Sample disaggregated with stir bar and sodium metaphosphate.
2. Wet sieving will remove particles over 5 mm.
3. Density separation using solutions of Li_2WO_4 and NaCl to separate plastic particles from sediments.
4. Wet peroxide oxidation using 30% H_2O_2 and Fe(II) to digest organic matter in supernatant.
5. Supernatant filtered using a series of 200 µm, 100 µm, 55 µm, 15 µm, and 1 µm stainless steel mesh filters.

Microplastic net sampler

- The USGS survey recorded substantial plastic concentrations in snow samples.[6]
- Como Creek hydrology is primarily driven by snowmelt.
- A Hydro-Bios microplastic collection net (left) will be installed in Como Creek downstream of the NEON sensor array (right).
- Quantifying microplastic output from alpine and subalpine snowmelt can give insight into understanding temporal MP outflux during baseflow and peak snowmelt.

Expected Results

Environmental Sinks of Plastic Particles

- Benthic sediments are expected to hold the highest concentrations of microplastics driven by settleability and nonpolar polymer surfaces.

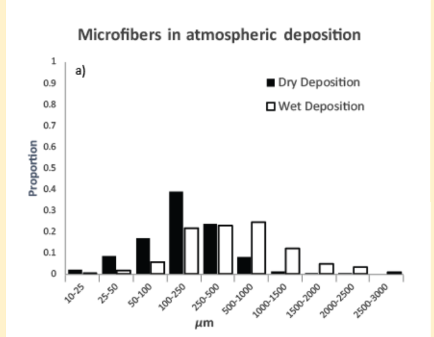


Figure a: Size distribution expected in alpine and subalpine benthic sediments due to the efficacy of fiber vertical transport and lower density.

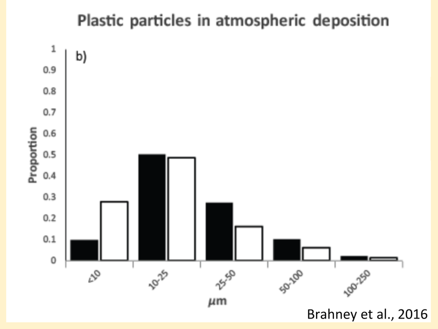


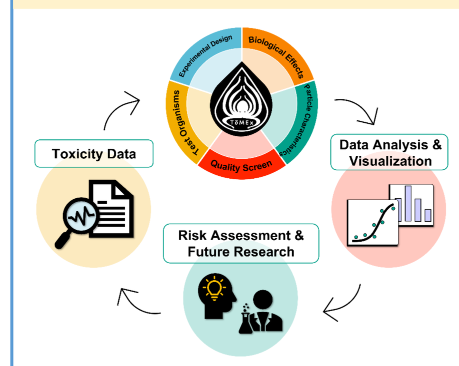
Figure b: Size distribution expected from regions montane and below.

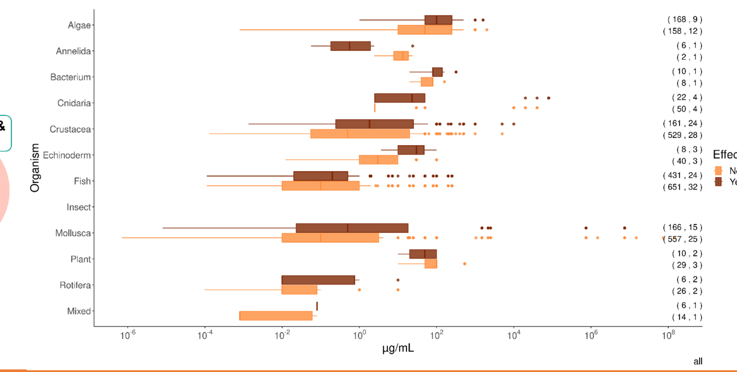
Snowmelt Expected to Drive Microplastic Outflux

- Snow serves as sources of microplastics and their large surface area act as large atmospheric bulk deposition collectors.
- Coupled with lake turnover which suspends benthic plastic particles, snowmelt will drive the output of plastic particles from alpine and subalpine terrain.

Microplastics as drivers for ecotoxicity

- With high resolution data of microplastic trait distribution relevant to estimating toxicity (e.g., morphology, polymer composition, and size), biologically critical endpoints can be determined by utilizing the Toxicity of Microplastics Explorer (ToMEx).
- ToMEx is a R Shiny modeling interface with a repository of published aquatic ecotoxicological data to assist in determining and visualizing biologically critical endpoints of microplastic toxicity.
- Model organisms most at-risk can be identified to inform research approaches for conducting microplastic exposure assays and microcosm studies for biota in the Colorado Front Range.





Microplastics as vectors for biogeochemical inputs

- Determine environmentally relevant concentrations of extractable plastic-derived nutrients.
- Investigate biotic assimilation of carbon, nitrogen, and phosphorous from microplastic-derived sorbates and leachates.

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