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It is Raining Plastic.

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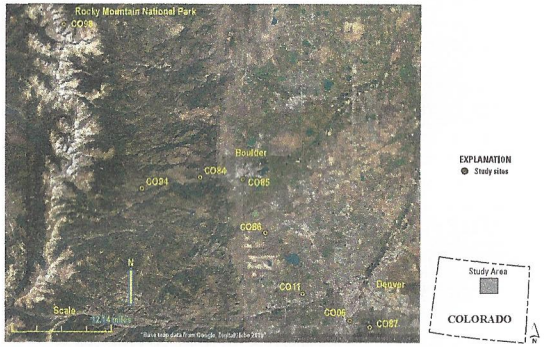
Overview

Atmospheric wet deposition samples were collected using the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) at eight sites (see map) in the Colorado Front Range. Plastics were identified in more than 90 percent of the samples. The plastic materials were mostly fibers that were only visible with magnification, approximately 20–40 times (X). Fibers were present in a variety of colors; the most frequently observed color was blue followed by red>silver>purple>green> yellow>other colors. Plastic particles such as beads and shards were also observed with magnification. More plastic fibers were observed in samples from urban sites than from remote, mountainous sites. However, frequent observation of plastic fibers in washout samples from the remote site CO98 at Loch Vale in Rocky Mountain National Park (elevation 3,159 meters) suggests that wet deposition of plastic is ubiquitous and not just an urban condition.



Sampling Network

The Network for Urban Atmospheric Nitrogen Chemistry (NUANC) is an NTN subnetwork of five sites in the Denver and Boulder, Colorado urban corridor. An additional urban site (CO84) is located outside Boulder, Colorado. Rural and remote montane NTN sites are nearby and form a southeast-trending transect of NTN sites with the NUANC.

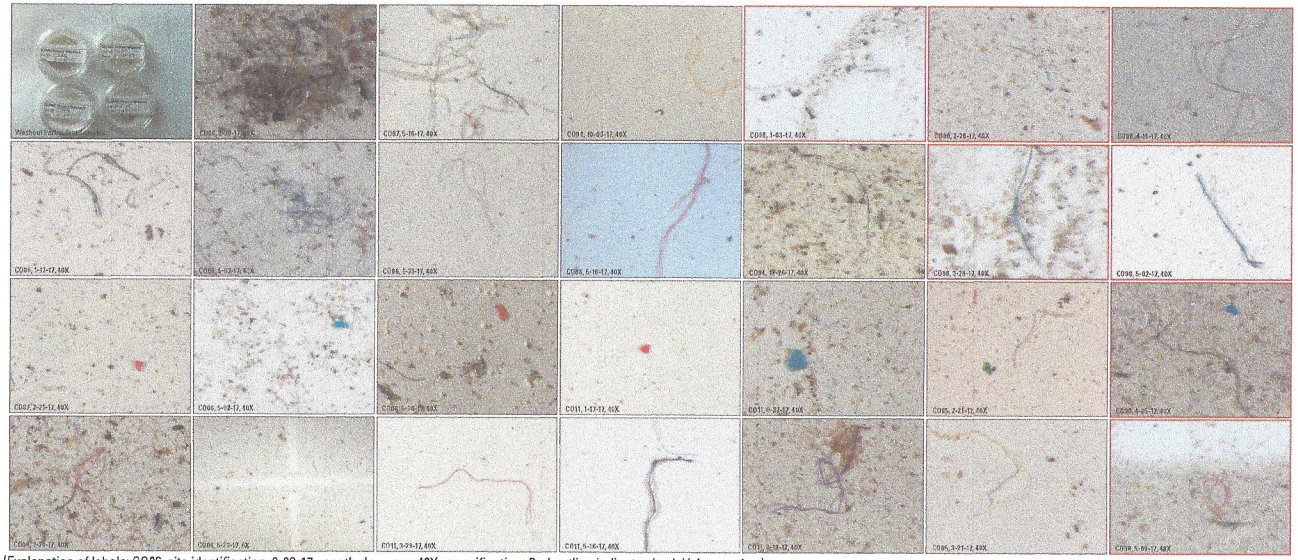
Methods

NUANC samples were collected in plastic bag-lined buckets. Sites CO84, CO94, and CO98 used standard, unlined NTN buckets. The entire volumes of each sample submitted to the NADP Central Analytical Laboratory were filtered (0.45 micrometer, polyethersulfone) to obtain particulates assumed to be washed from the atmosphere (washout). The filters were dried, weighed, and manually analyzed with a binocular microscope fitted with a digital camera (see photomicrographs). Four deionized water rinses of the sampling system were analyzed as blanks. This study was not designed for collecting and analyzing samples for plastic particles. The results are unanticipated and opportune.

Results

General types of particles were classified in the observations (see table). Air mass back-trajectory analysis for site CO98 samples was completed using the HYSPLIT model for 24 hours prior to each sample collection at 500-, 750-, and 1,000-meter altitudes. (National Oceanic and Atmospheric Administration, https://ready.arl.noaa.gov/HYSPLIT.php) Urban areas are southeast (approximately 140°) of site CO98, but plastic deposition was more positively identified for westerly storms than easterly storms. In the four blank samples, there was one small translucent fiber observed that might have been plastic. Translucent and white materials, which are the colors of the sampling apparatus, were disregarded in the analyses.

Photomicrographs of plastics collected at the NUANC NTN subnetwork, Sugarloaf, and Loch Vale sites in Colorado



(Explanation of labels: CO06, site identification; 2-28-17, month-day-year; 40X, magnification; Red outline indicates Loch Vale samples.)

Data for washout particles collected at site CO98, Loch Vale, Rocky Mountain National Park.

[Bold values indicate easterly air mass back trajectories]

Site identification	Weekly sample collection date (month/day/year)	Sample volume (milliliters)	Estimated solids concentration (mg/L)	Identified materials: Mineral	Soil	Plant	Insects	Microplastic	Amorphous carbon	Notes	Back trajectory (degrees from north)
No plastic positively identified											
CO98	1/24/17	337.0	11.4	Yes	Yes	Yes	Possibly	Possibly	Yes		227
CO98	2/14/17	746.4	1.1	Yes	Yes	Yes	Possibly	Possibly	Yes	Egg-shaped particle might be plastic	235
CO98	3/28/17	1,417.3	1.9	Yes	Yes	Yes	No	Possibly	Possibly	Possible blue fiber	**150**
CO98	4/4/17	1,837.1	0.1	Yes	Yes	Yes	No	No	Possibly		**160**
CO98	5/16/17	881.7	4.5	Yes	Yes	Yes	Possibly	Possibly	Yes	Possible black plastic fiber	**62**
CO98	5/22/17	2,856.3	1.0	Yes	Yes	Yes	Yes	No	Yes		**62**
CO98	7/18/17	320.9	3.8	Yes	Yes	Yes	Yes	No	Yes		291
CO98	7/25/17	1,522.5	0.7	Yes	Yes	Yes	Yes	Possibly	Yes		252
CO98	8/1/17	1,897.1	0.2	Yes	Yes	Yes	Yes	Possibly	Yes		213
CO98	8/8/17	2,746.3	0.6	Yes	Yes	Yes	Yes	Possibly	Yes		**176**
CO98	12/19/17	446.2	<2.2	Yes	No	Yes	No	No	Yes		260
Plastic identified											
CO98	1/3/2017	530.5	7.5	Yes	Yes	Yes	Yes	Yes	Yes	Blue fiber	225
CO98	2/28/2017	1,381.2	2.3	Yes	Yes	Yes	No	Yes	Yes	Blue fiber	216
CO98	4/11/2017	918.7	6.1	Yes	Yes	Yes	Yes	Yes	Yes	Blue, green fibers, 2-3	240
CO98	4/25/2017	1,552.8	3.1	Yes	Yes	Yes	No	Yes	Yes	Blue chunk	201
CO98	5/2/2017	1,533.7	0.1	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fibers times 3	266
CO98	5/9/2017	857.1	5.3	Yes	Yes	Yes	No	Yes	Yes	Red fiber	205
CO98	5/30/2017	2,095.2	1.0	Yes	Yes	Yes	Possibly	Yes	Yes	Blue fiber	266
CO98	6/6/2017	557.9	1.7	Yes	Yes	Yes	No	Yes	Yes	White, blue plastic	254
CO98	8/15/2017	2,981.0	0.1	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber	275
CO98	8/29/2017	516.4	3.3	Yes	Yes	Yes	Yes	Yes	Yes	Plastic fiber	266

Discussion

The mass of plastic in even the most concentrated samples was not large enough to weigh or reliably estimate. Developing a routine capability to calculate plastic wet-deposition loads is not possible with current (2019) technology. Methods for more accurate estimation of plastic loads are needed.

Better quality control to limit cross contamination and methods for estimation of percent recovery of the plastic materials from NADP samples are needed. Retaining NADP filters for subsequent analysis would make a washout deposition network possible with very little added expense.

How these plastic materials are accumulating and being assimilated in the environment and biota is unclear. Moreover, the potential effects of these materials on biota is not understood.

Conclusions

It is raining plastic. Better methods for sampling, identification, and quantification of plastic deposition along with assessment of potential ecological effects are needed.

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