COMPREHENSIVE STREET SWEEPER PICKUP PERFORMANCE TESTING FOR MICROPLASTICS AND PARTICULATE MATERIAL

STORM WATER AWARENESS WEEK
September 22-26, 2025

COMPLIANCE

presentation by:

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WORLD SWEEPER .COM
EARTH'S LARGEST POWER SWEEPING RESOURCE

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CLEAN STREETS, CLEAN SEAS PROJECT: Innovating Public Works to Intercept Microplastics in Urban Runoff

National Sea Grant Infrastructure Investment & Jobs Act
Marine Debris Challenge Competition, NOAA-OAR-SG-2022-2007452

Objective 2: Optimize street sweeper pickup efficiency for interception of microplastics (UCSB, Cascade, and World Sweeper).

THE WORLD HAS A PLASTIC PROBLEM

Humans have produced more than 8 billion tons of plastic since 1950, more than half of which went straight to landfills. Only about 9% was recycled.

Plastic is creating slow-but-certain havoc on our environment in multiple ways, from leaching toxic chemicals into the soil and groundwater to directly choking or poisoning animals that unwittingly ingest it.

The U.S. produces the most plastic waste. According to data from 2016, the U.S. produced over 34 million tons, followed by India (26 million/tons), and China (21.5 million/tons).

THE WORLD HAS A PLASTIC POLLUTION CRISIS

- Most studies report that people eat and drink an estimated 39,000 to 52,000 microplastic particles every year, with the number increasing to 74,000–121,000 when inhalation is included.
- One million marine animals die due to plastic pollution every year.
- 75% of all plastic produced has become waste.
- It takes around 500-1,000 years for plastics to decompose.
- 73% of all litter on beaches worldwide is plastic.
- About 91% of plastic is not recycled.
- Plastic wastage is growing at an annual rate of 9%.
- The Center for Biological Diversity calls the ocean plastic pollution problem: "***a global tragedy for our oceans and sea life. Plastic accumulating in our oceans and on our beaches has become a global crisis. Billions of pounds of plastic can be found in swirling convergences that make up about 40 percent of the world's ocean surfaces. At current rates, plastic is expected to outweigh all the fish in the sea by 2050.***"

WHAT CAN BE DONE ABOUT THIS PROBLEM?

- Street sweeping studies over the last two decades have targeted a variety of pollutants found in our waterways including nutrients like phosphorus and nitrogen; heavy metals like lead, copper, and zinc; and toxics like PAHs, among others.
- We have known since 1972 that the primary source of pollution in stormwater is contaminated street dirt that accumulates on urban streets and parking lots and is easily transported to waterways by urban runoff.
- We now know that sampled street dirt worldwide is contaminated with plastics, and the most damage done by plastics is from the smaller particles of plastic, which are most easily ingested into the food chain. The term "microplastics" has come into widespread usage.
- Microplastics (MPs) are defined as small plastic pieces less than five millimeters long, the size most harmful to the ocean and aquatic life. That said, when allowed to get into waterways, get run over by tires, degrade in the sun, etc., larger plastic litter more easily becomes microplastic particles.
- The study we are about to describe is the first study in the world designed to evaluate how well street sweeping removes microplastics (MPs) and nanoplastics (NPs) that have been scientifically placed within a street dirt simulant that mimics the physical characteristics (i.e., particle size distribution (PSD) and specific gravity) that are found in real street dirt.

Street Sweeping:

Clearly America's *First Line of Defense* for Stormwater Pollution Runoff Abatement

September 2023 CA_SAW workshop by:

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Nationwide Urban Runoff Program (NURP) Test of Old-Style Mechanical Broom Sweepers

- Early 1980s NURP studied the effectiveness of street sweepers in reducing Event Mean Concentrations (EMCs) for five pollutants of interest (i.e., TSS, COD, TP, TKN, and Pb) at ten sites located in four states — North Carolina, Illinois, Washington, and Wisconsin.
- Unexplainable negative results from two sites in N. Carolina and one in Wisconsin resulted in the conclusion that "street sweeping is generally ineffective as a technique for improving the quality of urban runoff" — despite the fact that data showed EMC decreases in 34 of the 50 site/pollutant investigations.
- "Statistically indeterminant" results have hampered sweeping's perceived BMP value for stormwater runoff pollution ever since.

Sweeping Reduces Pollutant Concentrations

City of San Diego: Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment, June 2010 Measured EMCs

Storm Event	Type of Sweeping	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)	TSS (mg/L)
12/07/2009	Unswept	143.0	71.8	1,689.4	703.8
	Mechanical	50.9	30.7	443.6	112.8
	Vacuum	51.2	22.3	362.7	130.2
01/18/2010	Unswept	218.4	234.0	1,210.9	1,719.6
	Mechanical	83.1	77.8	610.1	431.6
	Vacuum	34.1	23.5	307.6	145.2
02/05/2010	Unswept	73.7	59.2	452.1	357.6
	Mechanical	55.4	38.5	353.8	187.1
	Vacuum	39.4	15.2	366.1	132.0
Mean of Three Storms	Unswept	145.0	121.7	1,117.5	927.0
	Mechanical	63.1	49.0	469.2	243.8
	Vacuum	41.6	20.3	345.5	135.8

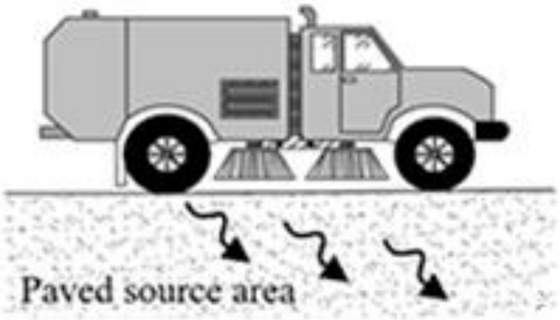
TSS was reduced 74% by mechanical broom sweeping and 85% by vacuum sweeping. Reductions for metals ranged from 56% to 60% for mechanical broom sweeper and 69% to 83% for vacuum sweeper.

2007, 2011 and 2019:

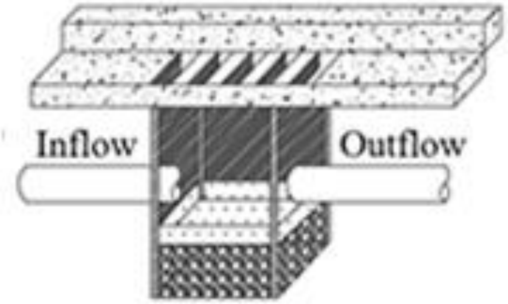
Studies conducted by the U of Florida in association with the Florida Stormwater Association involving 12 to 14 Florida MS4s found street sweeping was the best BMP — *up to almost seven times more cost-effective than next best BMP for TN and TP recovery*.

- Studies measured the amount of material captured by the complete range of all available BMPs — from sweeping to catchbasin cleaning to a variety of structural end-of-the-pipe measures.
- Cost of capturing a pound of nitrogen and/or a pound of phosphorus was calculated for each type of BMP recovery method.
- Sweeping was the lowest cost per pound; catchbasin cleaning was 2nd in all instances.

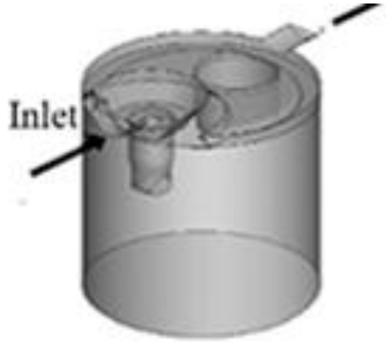
Relative costs of removing Total Nitrogen (TN)



Street Sweeping (SS)



Catch Basin (CB)



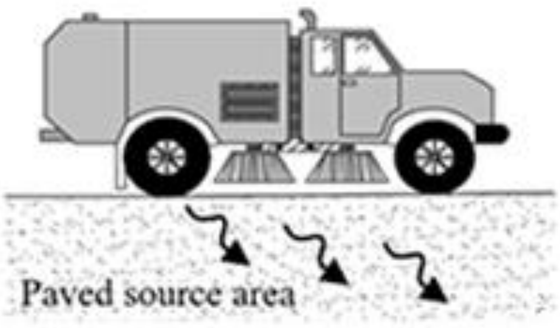
Best Management Practice (BMP)

$189 / lb. $1,162 / lb. $2,173 / lb.

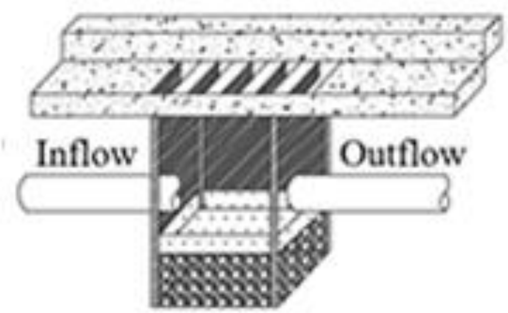
Study data combined broom and air sweeper performance: air sweeper data expected to be better.

Source: www.worldsweeper.com/Street/Studies/UFloridaSansaloneInterview12.19.html

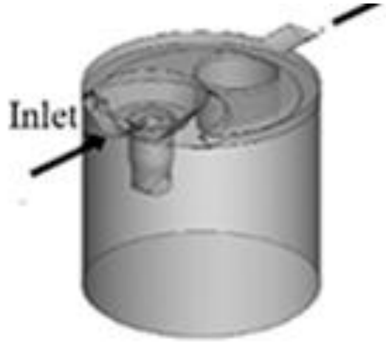
Relative costs of removing Total Phosphorus (TP)



Street Sweeping (SS)



Catch Basin (CB)



Best Management Practice (BMP)

$294 / lb. $1,894 / lb. $12,006 / lb.

Study data combined broom and air sweeper performance: air sweeper data expected to be better.

Source: www.worldsweeper.com/Street/Studies/UFloridaSansaloneInterview12.19.html

Recovery of Particulate Material (PM) Matters
(Proving That Street Dirt Pick-Up Recovery Also Matters!)

The Florida studies found street sweeping to be the most economical and dominant practice that MS4s could implement and optimize in order to maximize nutrient (TN and TP) and particulate matter (PM) recovery benefits to urban drainage systems and their receiving waters. ***This was true even though the study didn't separate broom & air sweeper data!***

The study showed conclusively that the more PM an MS4 recovers, the more pollutants are reduced. The study results are statistically defensible at a 95% confidence level (CL) when combining all 14 MS4s for PM, TN, and TP.

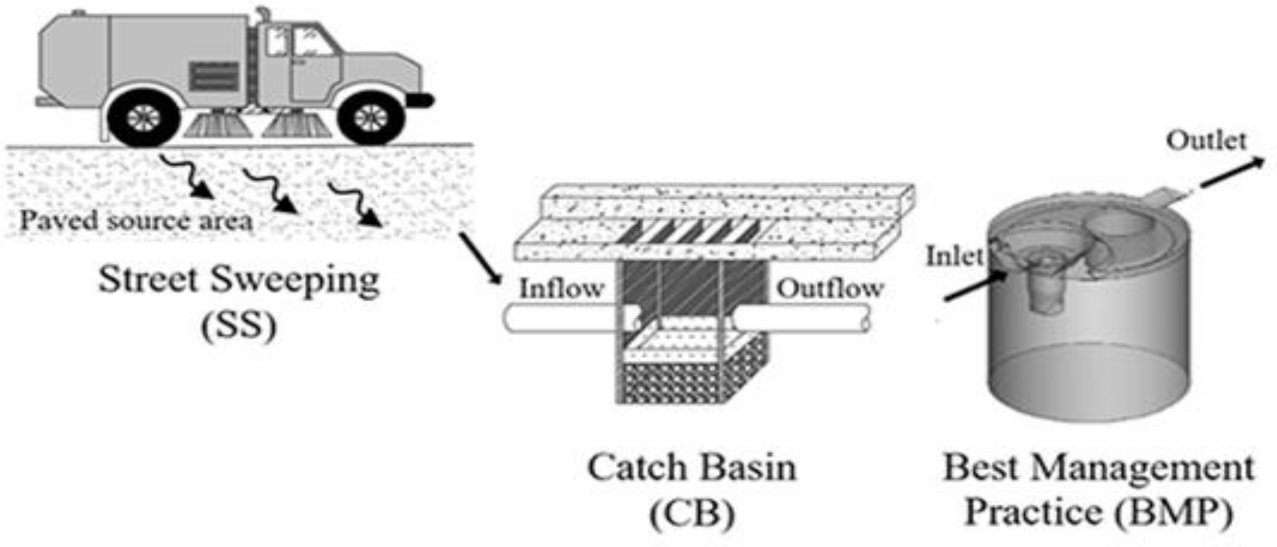


Figure 2 Conceptual illustration of hydrologic functional units (HFUs) sampled in this study.

This info is due to a grant facilitated by

and provided by

with participants including:

concerning the street sweeper tests, thanks to

held July 14—18, 2025 in Van Nuys, CA, at the Donald C. Tillman Water Reclamation Plant

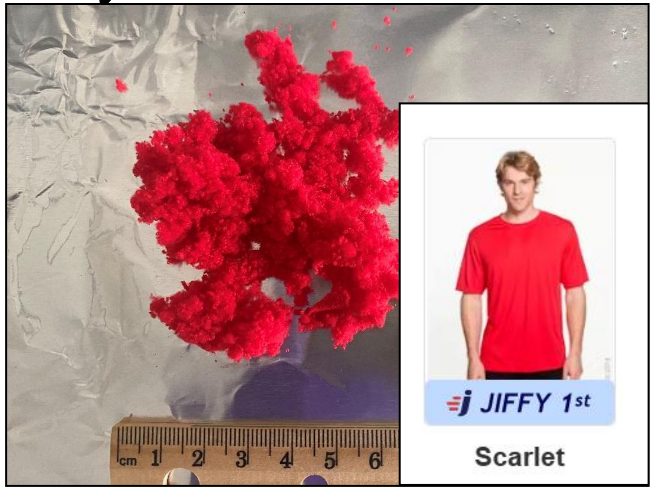
OBJECTIVES OF 2025 STREET SWEEPER TESTING

Overall: How well do street sweepers remove micro- and nano-plastics (MPs and NPs) from the gutters of streets where they are known to accumulate?

1. How does removal vary with sweeper speed (5 or 10 mph)
2. How does removal vary by the different types of sweepers (mechanical, regenerative air, and vacuum) operating at the same speed?
3. How does plastic particle removal vary by plastic materials (e.g., polyester fibers, polyamide fragments, polystyrene beads, polyethylene fragments, crumb rubber [tire-type] particles)?
4. How does removal vary for polystyrene only according to size (micro- versus nano-sized spheres)?

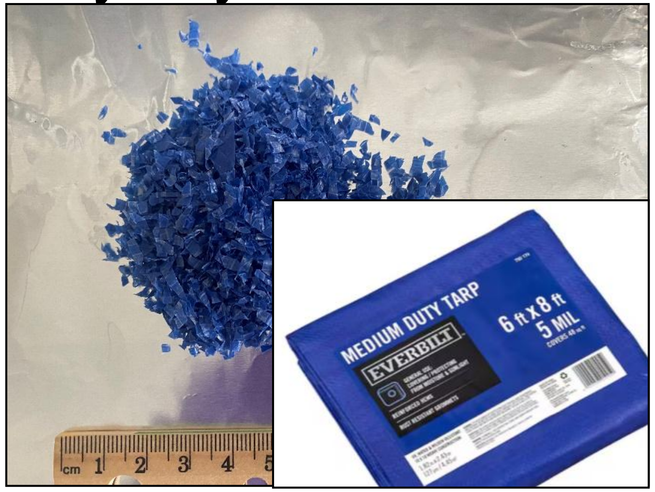
MICROPLASTIC PARTICLES

Polyester

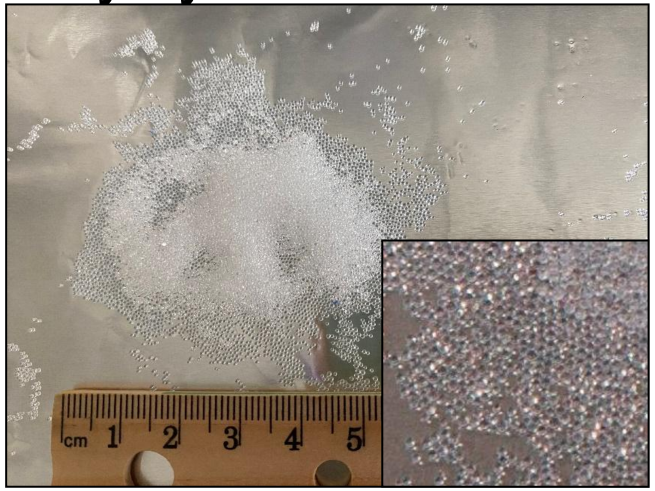


Polyamide

Polyethylene

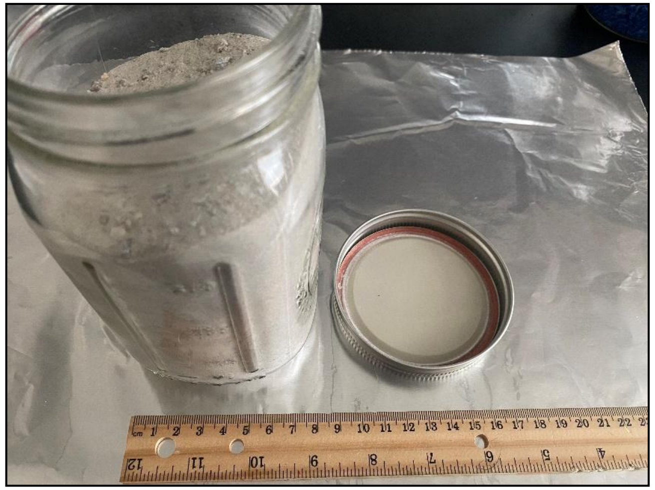


Polystyrene



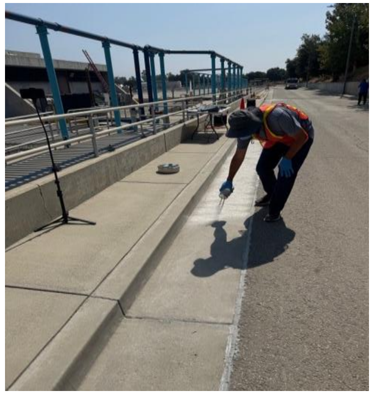
Tire wear particles

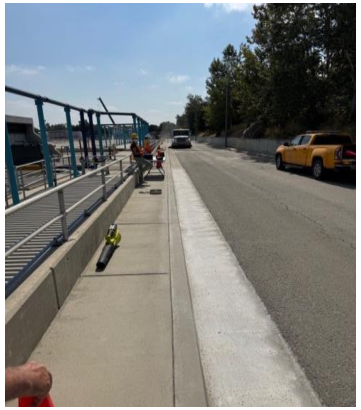
Simulant in Mason Jar



SWEEPER TESTING METHOD

1. Clean test track with sweeper (initially) & high-powered leaf blower to prepare for testing
2. Disperse a known quantity ~6 lbs (~634 lbs/curb mile) of artificial street dirt spiked with microplastics along a 50-ft by 2-ft wide test track by sprinkling by hand directly from a glass jar.
3. Conduct a single pass of a sweeper at a targeted speed (timing sweeper for exact speed) and with an air quality monitor operational & located at the halfway point of the track
4. Vacuum remaining street dirt & microplastics left on test track using a stainless-steel Shop-Vac® with a plastic hose and attachment called a gulper, which was ~6 inches wide.
5. UCSB processes samples for size fractions and recovery of sediment and microplastics.
6. Previously sieved fractions by UCSB are recombined and sent to a commercial soils lab for full-stack sieving analysis





REMAINING MATERIAL ANALYSIS PROCEDURE

Protocol Parameters:

The recovered spiked simulant will be sieved into five size fractions, and the MPs and NPs will be quantified via microscopy for each of the sieved fractions.

The MP and NP quantities in the recovered sieved street dirt will be compared to the known initial amounts applied, which had been previously documented for each test.

Accordingly, different street sweeper types or technologies operating at the two different speeds will be compared for their relative recoveries of both street dirt size fractions and of the various types of plastic particles included in those fractions.

Once the MP and NP analyses are completed, each “remaining material” sample will be recombined and sent to a commercial soils lab for sieve analysis that will result in eight size fractions, which will provide more information on the size fraction pickup of each test, along with a QA/QC check on the shorter-stack sieve analysis conducted by UCSB.

Three samples of the unspiked street dirt simulant will also be submitted to the soils lab for sieving to establish the overall particle size distribution (PSD) of the simulant, which serves as the before-sweeping condition for sweeper pickup performance calculations by size fractions.

SPIKED STREET DIRT SIMULANT

- LA SANITATION recipe and materials for simulant
- No standardized methods or recipes for microplastics
- Pilot study
- Literature review: type, concentration, size classes in street dirt

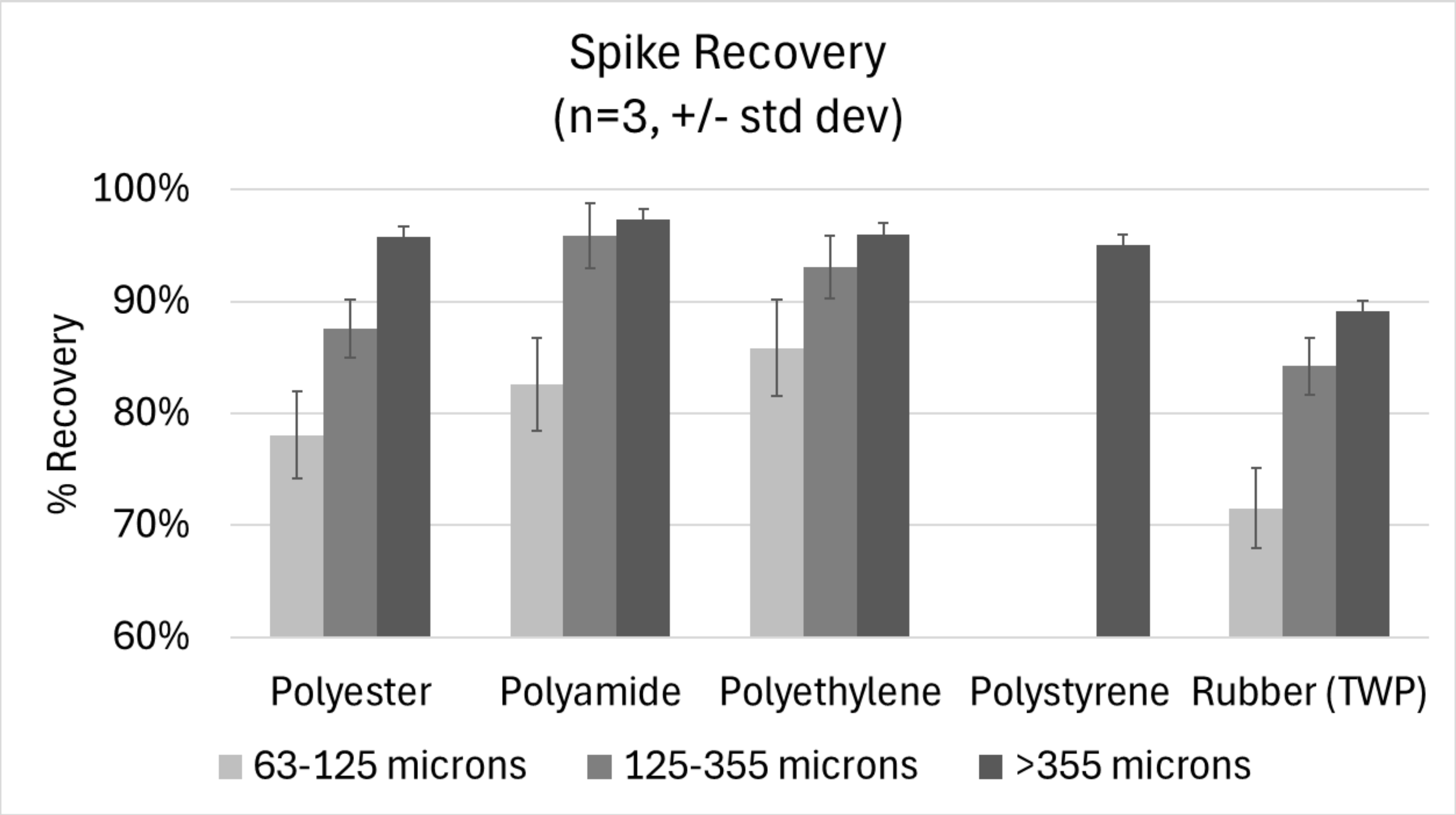
Method Article

Think positive: Proposal of a simple method to create reference materials in the frame of microplastics research

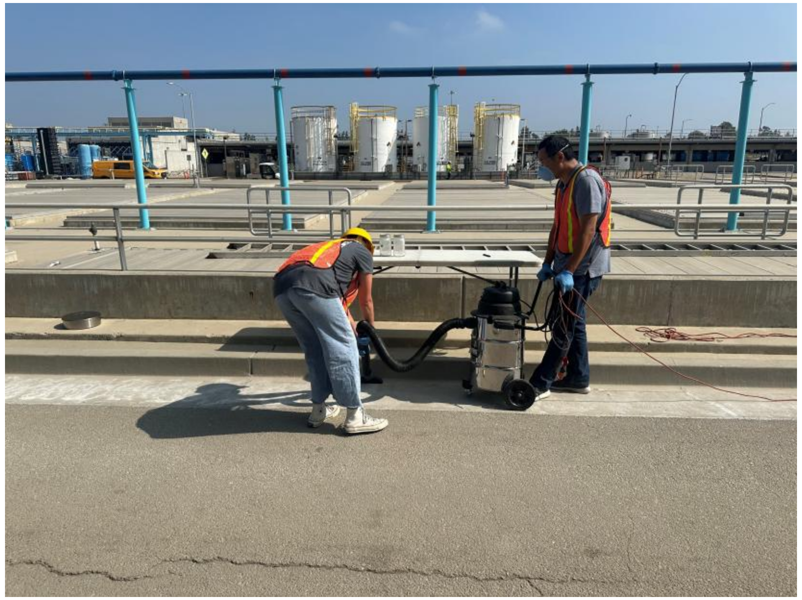
Alexandre Dehaut*, Charlotte Himber, Mathilde Colin, Guillaume Duflos

ANSES – Laboratoire de Sécurité des Aliments, 6 Boulevard du Bassin Napoléon, 62200 Boulogne-sur-Mer, France

SPIKE RECOVERY – POSITIVE CONTROL



FIELD WORK



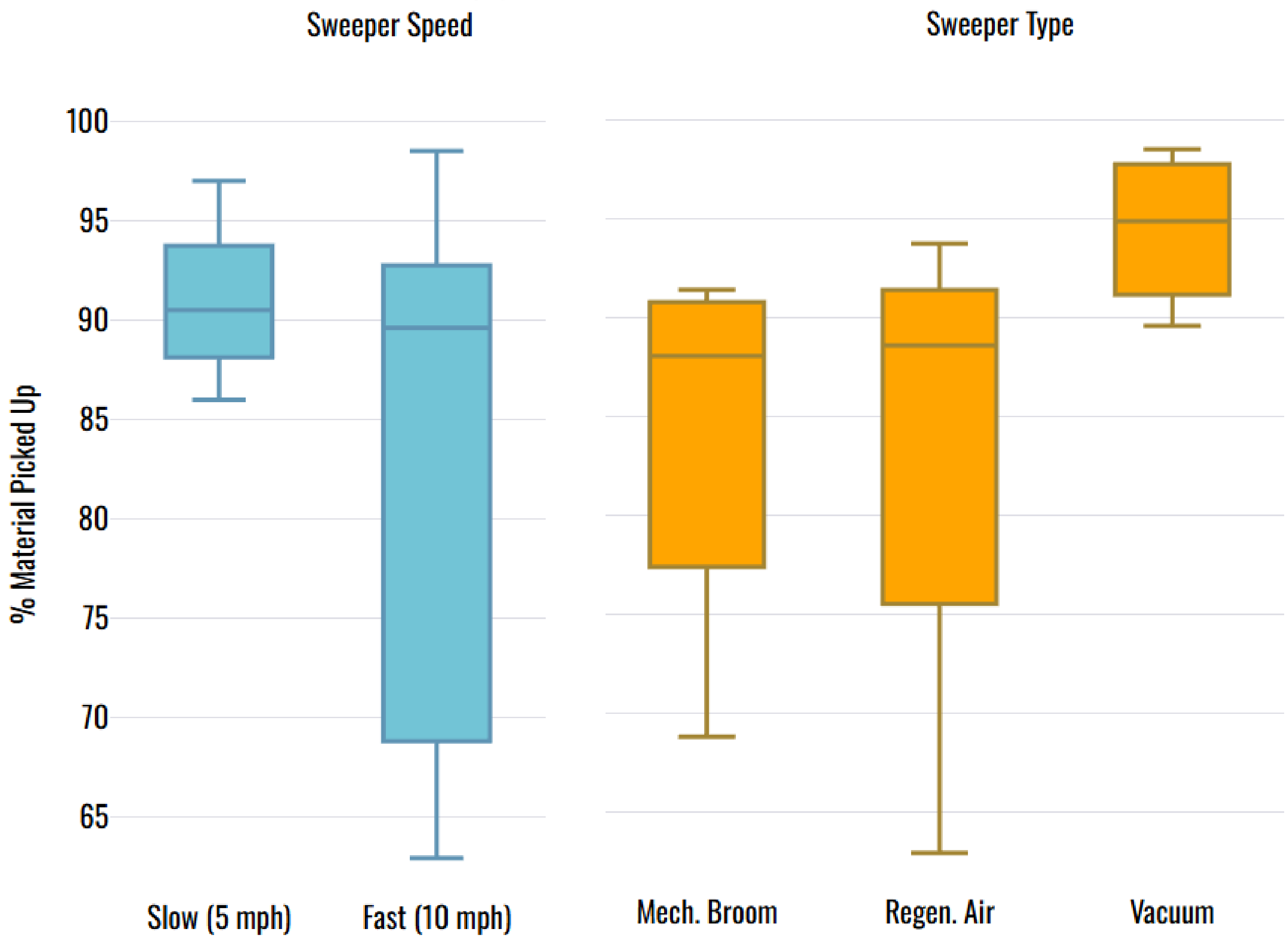
6 Sweepers + 5 Operators

3 Types (mechanical, regenerative air, vacuum)

2 Speeds (5, 10 mph)

RESULTS: PICKUP EFFICIENCY

- Pickup Efficiency (sediment only): 63– 98%
- Multiple operators
- Wide Variations Due to Operator Errors & Machine Age
- Still to Come: Pickup by Size Fractions and Microplastics Pickup



PICKUP PERFORMANCE RESULTS

Test No	Sweeper Model & Type	Target (mph)	Timed (mph)	Diff %	Initial (grams)	Pickup (grams)	Pickup %	Comments
1	SweepRite Isuzu NRR; Mech	5.0	4.4	0.13	2729	382	86.0	Water Used: Full Gulper Width
2	SweepRite Isuzu NRR; Mech	10.0	10.6	-0.06	2730	851	68.8	No Water Used; Full Gulper Width
3	2017 Schwarze A4000; Regen	5.0	4.2	0.16	2714	322	88.1	Water Used: Full Gulper Width
4	2017 Schwarze A4000; Regen	10.0	10.6	-0.06	2710	1004	63.0	Water Used; Gutter Broom Off Gutter~16 ft
5	TYMCO 600; Regen	5.0	3.5	0.30	2726	170	93.8	Water Used; Reduced Gulper Width (~2 inches)
6	TYMCO 600; Regen	10.0	11.0	-0.10	2720	297	89.1	Water Used; Reduced Gulper Width
7	Elgin Broom Bear; Mech	5.0	3.7	0.25	2719	233	91.4	Water Used; Reduced Gulper Width
8	Elgin Broom Bear; Mech	10.0	9.4	0.06	2720	271	90.0	Water Used; Main Broom Off: Reduced Width
9	Ravo; Vac	5.0	4.9	0.01	2721	883	67.6	Reduced Water Used; Reduced Gulper Width
10	Ravo; Vac	10.0	9.2	0.08	2723	197	92.8	Water Used; Reduced Gulper Width
11	Ravo; Vac	5.0	5.3	-0.06	2712	282	89.6	Water Used; Reduced Gulper Width; Redo of 9
12	Scarab Maven; Vac	5.0	5.9	-0.17	2714	81	97.0	Water Used; Reduced Gulper Width
13	Scarab Maven; Vac	10.0	8.7	0.13	2717	40	98.5	Water Used; Reduced Gulper Width
14	Elgin Broom Bear; Mech	10.0	7.4	0.26	2727	268	90.2	Water Used; Reduced Gulper Width; Redo of 8

A BRIEF VIDEO OVERVIEW OF LA TEST

AIR QUALITY TESTING

In order to also gain data about dust output from the sweeper tests, we rented a TSI 8530 DustTrak II machine designed for the purpose of tracking dust content of ambient air.

The values of all the sweepers tested when using water for dust suppression were similarly low. However, **the one sweeper that forgot to turn on its water for the test produced up to 10 times more dust when it passed by the testing unit.**

This underscores the importance of using dust suppression water for any sweeper designed to use it for that purpose!

SOUND LEVEL TESTING

A smart phone decibel app was used to assess the noise when each sweeper passed. The dBA differences between the various sweepers tested ranged from @92dBA to 102dBA.

Such a change of dBA is generally interpreted as a doubling of perceived loudness. For example, permissible exposure duration drops from about 6 hours at 92 dBA to only about 1.5 hours at 102 dBA, illustrating the increased risk of hearing damage.

This much differential in operation output shows that when sweepers are evaluated for purchase the use of a decibel app might make sense to use during the test process for each sweeper being considered.

Key Webinar Takeaways

Operators, Buyers, and Storm Water Professionals Should All Understand:

• Importance of demanding and supporting independent, head-to-head sweeper performance testing as a key way to foster innovation and data-driven purchasing.

• Recognition of the critical role operator experience and training offer, aspects that matter as much as design and specifications.

• Why widespread encouragement and pressure on sweeper manufacturers to participate openly in transparent performance benchmarking will benefit the whole industry as well as improving public health.

• The importance of advocating for regulatory and/or financial incentive programs that reward effective, science-backed pollutant removal practices.

• Discuss why educating the storm water community, especially, via ongoing documentation and continuous improvement is the pathway to cleaner streets, ultimately a key to cleaner waterways, streams and oceans.

ENHANCE YOUR SWEEPING PROGRAM! p1

Develop a street sweeping program that maximizes pollutant removal, improves stormwater quality, and provides additional benefits to the community:

1. Vehicle removal program
    - Implement mandatory removal of parked vehicles during sweeping
    - Use now-available technology for citizen notifications and real-time updates
2. Use appropriate sweeper technology
    - Prioritize regenerative air and/or vacuum sweepers for general city street sweeping
    - Use vacuum sweepers for porous pavements
    - Mechanical broom sweepers only for specific conditions: highways, heavy debris
3. Sweeper maintenance and operation
    - Ensure regular maintenance of equipment
    - Optimize forward speed of sweepers (typically 3- 10 mph)

ENHANCE YOUR SWEEPING PROGRAM! p2

Develop a street sweeping program that maximizes pollutant removal, improves stormwater quality, and provides additional benefits to the community:

3. Optimize sweeping frequency
    - Adjust frequency based on land use and street type
    - Implement more frequent sweeping in high-accumulation areas
4. Pavement condition management
    - Focus on sweeping curbed streets
    - Support repaving projects to improve stormwater quality
    - Seal cracks in poor and fair pavements
5. Monitoring and data collection
    - Implement street dirt accumulation monitoring
    - Conduct sweeper pick-up performance monitoring
    - Use controlled street sweeper pick-up performance testing

ENHANCE YOUR SWEEPING PROGRAM! p3

7. Program optimization
    - Use software like SIMPTM to model pollutant removal
    - Allocate resources based on data-driven insights
8. Integration with stormwater management
    - Consider adding the sweeping program to the stormwater department
    - Combine budgets so as to maximize action to be appropriate after analysis
9. Public education and outreach
    - Educate citizens about sweeping's pollutant removal value
    - Use sweeper hopper graphics for civic messaging
    - Implement school education programs
10. Innovative use of sweepers
    - Outfit sweepers with data collection systems for community issues
    - Use sweeper operators as "eyes of the community"

ENHANCE YOUR SWEEPING PROGRAM! p4

11. Develop a cost-effective ticketing system
    - Implement camera-based ticketing on sweepers
    - Allow immediate re-parking after sweeper passes
12. Regulatory alignment
    - Work towards state-level regulations that credit sweeping for pollutant removal
13. Continuous improvement
    - Stay informed about new technologies and best practices
    - Participate in or follow results of ongoing research and testing

Have questions or want to find out more? The internet's most comprehensive database on street sweeping is online at:

www.worldsweeper.com/Street/

For More Information...

As of 2025, the two presenters had nearly 100 years of experience with street sweeping. For assistance with any aspect of your sweeping program, contact:

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