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Research Results

Study the Impacts of Caltrans Thermoplastic Stripe, Markings and Pavement Markers to Microplastic Pollution and Develop Potential Solutions

This task establishes effective control of microplastic particles (MPs) including thermoplastic paint-derived MPs and other microplastics originating from Caltrans sources.

Environmental

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Project Title: Study the Impacts of Caltrans Thermoplastic Stripe, Markings and Pavement Markers to Microplastic Pollution and Develop Potential Solutions

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WHAT WAS THE NEED?

The California Department of Transportation (Caltrans) is taking a proactive approach to understand the factors and processes that lead to microplastics generation from thermoplastic painted surfaces other sources from the state highway system. The pervasive nature of microplastic pollution warrants a critical investigation of the many different potential sources of this emerging contaminant. Thermoplastic paint used in roadway markings and striping has been implicated as one source of microplastic pollution, potentially accounting for up to 7% of the microplastics that end up into our oceans. Its widespread use among our vast network of roads is a potential source of microplastics pollution to our soil and other water environments as well. Current roadway marking alternatives lack the longevity and retroreflectivity performance of thermoplastic paints and are also cost-prohibitive. Therefore, understanding the factors and processes that lead to microplastics generation from thermoplastic painted surfaces could lead to a cost-effective strategy for microplastic hazard mitigation by defining appropriate conditions for the application of thermoplastic stripes and markings that eliminate or minimize the microplastic hazard.

WHAT WAS OUR GOAL?

The primary goal was to quantify and characterize microplastic pollution and its impacts from Caltrans facilities. Secondarily, the study aimed to evaluate treatment solutions. As one area of focus, permeable shoulders are infiltrated by stormwater and may trap microplastics; these shoulders are

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then maintained with vacuum sweepers (already used on many roads) preventing discharge to waters. All thermoplastics require frequent replacement, goal would be to achieve similar life and life cycle costs for the replacement products. Life cycle costs would consider the value of the pollution reduction.

WHAT DID WE DO?

The Research Team designed and built a prototype MP diagnostic and treatment system. Next, the system was calibrated in a laboratory and tested for its functionality and efficiency removing MP from street sweeping materials and stormwater samples. The first street sweeping samples were taken from the southbound side of the 605 Freeway in coordination with Caltrans staff at Long Beach Maintenance Facility on November 14, 2023. Subsequently, the research team sampled stormwater after the first local rain event on February 19, 2024, and March 23, 2024. Each sample was processed in a vortex separator. The data was validated and optimized for the effective use of the newly designed MPs treatment system.

WHAT WAS THE OUTCOME?

Microplastic pollution has emerged as a critical environmental concern due to its pervasive presence and harmful impacts on human and environmental health. MPs, defined as plastic particles ranging from 1 nm to 5 mm, are problematic because of their ability to disperse widely across ecological habitats. Recent studies have illuminated roadways as a significant source of MPs, yet current best management practices for stormwater are not designed to address MP removal. This emphasizes the urgent need for solutions to mitigate MP pollution from transportation activities. Thermoplastic paint used in roadway markings and striping has been known as one source of MP pollution and the primary goal of this study was to quantify and characterize MP pollution from Caltrans facilities using samples of stormwater and roadway sweeping materials. The first street sweeping samples were taken on November 14, 2023, and stormwater samples were collected on February 19, 2024, and March 23, 2024, after the first local rain events. Each sample was deposited into a MPs treatment system's chamber, and then processed in a vortex separator. The results revealed that high number of MP counts were observed in the 45 to 1,000 µm size, and small particles (< 300 µm) were more mobile during storm events. Sweeping samples (11 classes) exhibited greater polymer diversity than stormwater samples (5-6 classes), and a strong correlation ($r = 0.79$, $p < 0.05$) between MPs in sweeping debris and March stormwater confirmed roadway-origin MPs were mobilized during rainfall. MP concentrations in stormwater varied from 83 to 157 MPs/L, which may be influenced by storm patterns, cleaning schedules, and sampling conditions. MPs of concern included polyolefins (polyalkenes), such as polyethylene (PE) and polypropylene (PP), as well as 'other plastics', which were present in large fractions in all environmental samples. The vortex separator achieved a 69.7% MP removal efficiency at 12 gpm, a system capacity, which was close to the MP target removal of 70%. However, the MPs removal efficiency dropped notably for particles in the 45 – 100 µm range, 14.0% ± 12.7%. A multivariable regression analysis for predicting MP removal by vortex separator identified a particle size parameter as the most significant factor influencing MP removal. Also, the settling compartment demonstrated high solids removal, not MP removal, percentage (> 99%) for particles > 100 µm. The solid removal performance of settling compartment declined at higher flow rates and for smaller particles.

WHAT IS THE BENEFIT?

Microplastics are a significant emerging contaminant of concern that can pose significant risks to human and environmental health. This study produced a MP filtration system that allows Caltrans to begin documenting and assessing the scope of MP pollution in the State Highway System. The study

also identified seasonal and spatial variables with MP load in the State Highway system that indicate optimum timing for pollution treatment prior to the first local storm event of the wet season. This provides Caltrans with critically needed information to help reduce microplastic pollution from Caltrans facilities.

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