The Migration of Microplastics: From urban creeks to the Pacific Ocean

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Abstract

Microplastics originate from many urban sources, including the degradation of tires and synthetic fabrics. Our hypothesis is that these plastics wash into storm drains, where they flow into streams and accumulate in lakes and rivers before being deposited into the ocean. The aim of this study is to analyze the microplastic concentrations along an urban stream to determine the degree of plastic accumulation from city streets. Water samples were taken from different locations along Belmont Creek, which receives stormwater runoff from various streets along its three-mile course. These samples were filtered and selectively stained with Nile Red (0.01 mg/mL), which allows for fluorescent microscopy analysis to quantify microplastic concentrations as the creek flows to San Francisco Bay and the Pacific Ocean. Microplastics were found to be at a higher concentration (2.8-4 particles/mL) upstream in comparison to downstream (0.8-2 particles/mL), which indicates that microplastic concentrations decreased as the creek approaches San Francisco Bay. These findings, which were taken during the COVID-19 lockdown, are being validated due to the return of human activity in the area. We are currently investigating the hydrologic factors that might deposit microplastics prior to reaching the ocean and expanding our research to measure microplastics in the gastrointestinal tract (<40 particles/g) and gills (<10 particles/g) of local fish species.

Objective

To study the microplastic pollution from the head of an urban creek into the San Francisco Bay and Pacific Ocean.

Background

- Microplastics are a type of plastic pollution that includes any plastic found to be smaller than 5 mm (2).
- Sources of microplastics include tires, fishing lines, and shedding of synthetic fibers (3, 6).
- Potential problems with microplastics include ingestion of particles by marine animals and humans, however the impact of these plastics is still in its infancy.
- Potential problems have led to looking at contributions of storm drains and road run-off through the analysis of microplastics (1).
- Belmont Creek is an urban creek in the San Francisco Bay Area that flows through densely populated areas. The creek begins with runoff from storm drains into Waterdog Lake. The creek continues through a suburban town, collecting more road runoff. The creek flows into San Francisco Bay, a critically important estuary on the West Coast, through Belmont Slough (**Figure 1**).

Figure 1. Belmont Creek (San Mateo County, California) is fed by storm drains and precipitation. The creek flows through and under an urban area to San Francisco Bay. Water samples were collected along the three-mile creek from the headwaters (lake) to the Bay (slough).

Materials and Methods

Sample Collection

- Water samples were collected in sterile 50-mL centrifuge tubes from five different locations along Belmont Creek (**Figure 1** and **Figure 2**).

Preparation of Nile Red

- Nile red was chosen to visually quantify the microplastic concentration of the samples due to its quick absorption into the plastic particles and the strength of its fluorescence (4, 5).
- Nile red was diluted with acetone from a stock solution (10 mg/mL in acetone) to 0.1 mg/mL.
- For sample preparation, the Nile Red was diluted 10^{-1} in distilled water within 5 minutes of use to avoid coagulation of Nile red in water.

Filtration and Dyeing

- Samples were run through a 6-mm sieve to remove excess debris.
- Each sample was filtered through Whatman 1 filter paper on a Buchner filter to collect particulates. Distilled water was used to rinse both the centrifuge tube and the sides of the Buchner filter.
- The prepared Nile red was then added to the Buchner funnel and incubated for 15-20 min. at room temperature in the dark.
- The Nile red was drained out using vacuum filtration, and 8-10 mL of distilled water was used to rinse the sides of the Buchner filter before draining again.

Analysis

- The filter paper was examined using a Keyence BZ-X710 fluorescent microscope at 440 nm.

Figure 2. Water samples were collected in 50-mL centrifuge tubes. A Nansen bottle was used to collect deep-water samples.

Results

- The microplastic concentration in Belmont Creek decreased gradually as Belmont Creek approached the San Francisco Bay, however, it increased significantly at Oracle Parkway (**Figure 3**).
- The type of microplastics also changed as the location of samples got closer to the Bay, with fibrous and thread-like particles being more common towards Waterdog Lake and smaller fragmented particles being more common in Oracle Parkway (**Figure 4**).

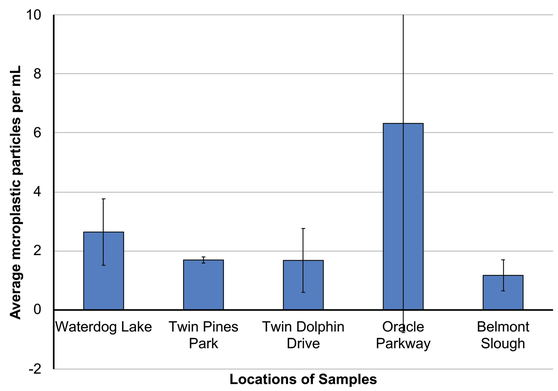

Figure 3. Microplastic concentrations along Belmont Creek from the headwaters (Waterdog Lake) to San Francisco Bay (Belmont Slough). Error bars = 1 S.D.

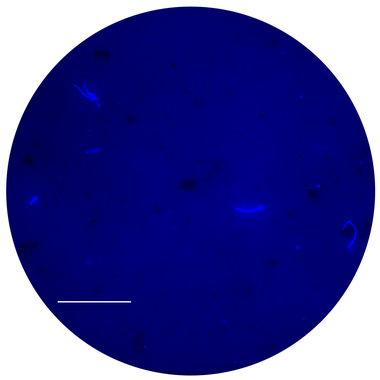

Figure 4. Microplastics at Oracle Parkway made visible with Nile red staining. Scale bar = 1 mm.

Discussion and Conclusion

- On average, microplastics decreased as locations got closer to the Bay, with Oracle Parkway being the only outlier from that trendline.
- The decrease in plastic concentration could be due to plastics being caught on rocks and debris along the creek.
- Smaller, more fragmented particles are more prevalent downstream. This could be due to degradation of larger pieces by rocks and turbulence.
- We hypothesized that Oracle Parkway's high concentration of plastic pollution was caused by the near-constant use of roads and the presence of a major freeway at this location.

Future Studies

- We are currently studying the microplastic concentrations in the gills and gastrointestinal tracts of freshwater animals found in Belmont Creek and marine animals in the Creek estuary.
- Future studies should look to identifying ways to chemically determine the sources of microplastics in order to identify which anthropogenic source contributes the most to plastic pollution.

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