Polymer Identification of Plastic Marine Debris on Beaches and Sea Surface in the Hawaiian Archipelago by FTIR to Determine Sources

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OBJECTIVES

1. Verify plastic marine debris abundance throughout the Hawaiian archipelago.8
2. Identify the polymer composition of beach and sea surface plastic debris.
3. Use the polymer composition to deduce the chemical density, relative to seawater, and determine which sites are dominated by floating or sinking plastics.
4. Determine which sites are dominated by more weathered plastics.
5. Determine if land use contributes to debris abundance on beaches.
6. Infer offshore vs. onshore sources of debris on windward and leeward beaches based on objectives 1-5 to inform policy.

INTRODUCTION

Fig. 1: Sampling site located in Kahuku, Oahu, HI.

The Hawaiian archipelago is prone to marine debris accumulation due to oceanic and wind-driven currents.9

Marine debris has been quantified throughout the Hawaiian archipelago, but not identified for its polymer composition.5

DIFFERENT POLYMER TYPES HAVE VARYING DEGRADATION PROCESSES AND ABSORBANCE RATES OF OTHER POLLUTANTS, THUS IDENTIFICATION HELPS US UNDERSTAND THEIR BEHAVIOR IN THE ENVIRONMENT.7

IDENTIFYING THE POLYMERS COMPRISING PLASTIC MARINE DEBRIS CAN ASSIST IN THE ESTABLISHMENT OF EFFECTIVE POLICY THAT REGULATES MATERIAL MANUFACTURING, PROCESSING, DISTRIBUTION, USE, RECYCLING, AND DISPOSAL. THIS IS PARTICULARLY IMPORTANT FOR THE HAWAIIAN ISLANDS DUE TO LIMITED RESOURCES AND GEOGRAPHIC ISOLATION.1

RESULTS

Fig. 5 Map7: Nautical miles from Kahuku to Waikiki.

Fig. 6: Amount of plastic shown by both total pieces and total mass per transect vs. urbanization calculated by % land developed.

Methods

Fig. 3: Weathering intensity code based on physical fracturing.

Samples were collected in 2017:

- Pieces >1cm from the sand surface using measured triplicate transects from 11 Main Hawaiian Island beaches.
- Representative pieces from debris transported from Midway and Kure Atolls to Oahu.
- Sea surface debris sighted by boat transects between Maui and Lanai.
- Three sea surface transects.

Beach (n=3929) and sea surface (n=314) plastic samples were weighed and categorized by type, color, opacity, and weathering intensity (Fig. 3).

Samples (n=4513) were analyzed using Attenuated Total Reflectance Fourier Transform Infrared (FTIR) spectroscopy (Fig. 4).4

ANOVA, MRPP with ISA, and Spearman correlation tests determined differences in debris abundance, polymer composition across sites, and relation between abundance and % land developed, respectively.

RESULTS & CONCLUSIONS

Fig. 5 Map7: Date of each station.

1. Windward beaches had more debris than leeward beaches (Fig. 5 Map).5
2. Predominant polymers were LDPE (24%) and PP (23%), which are commonly used but rarely recycled in Hawaii. These results could help inform policy makers and focus reduction strategies.
3. Windward beaches were dominated by less dense, floating polymers with similar composition to sea surface sites, whereas leeward beaches were dominated by more dense, sinking polymers (Fig. 5 Map).
4. Windward beach and sea surface plastics were more weathered than leeward beach plastics, suggesting longer duration in the environment (Fig. 5 Map).
5. Beaches with more land development (i.e., Waikiki) had less debris (marginally significant correlation, Fig. 6).
6. Windward and leeward beaches are dominated by offshore and onshore sources of debris, respectively, which needs to be addressed by policy mitigation strategies.

REFERENCES