Race for Water Odyssey: Tonga to Fiji Microplastic Analysis Summary

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Introduction

Since the invention of plastics, the past half a century has seen its proliferation with associated economic, environmental and social benefits. The increased consumption of plastics coupled with improper management of plastic wastes has caused significant social and environmental impacts (Jambeck *et al*., 2015; Plastics Europe, 2018). One considerable impact is microplastics (MPs) which have been detected across the entire spectrum of habitats that comprise our marine environment, from rivers and streams to the deepest parts of the ocean (Browne *et al*., 2007; Wright *et al.*, 2013; Chen *et al.*, 2018). The ubiquitous nature of MPs is a cause for growing concerns especially threats pertaining to the health of marine habitats, marine species and consequently humans.

Presently, the bulk of microplastics studies have centered on developed countries with South Pacific based studies lagging at a considerable rate (Forrest and Hindall, 2018). Research being conducted at the University of the South Pacific's School of Marine Studies indicate the presence of MPs in all near-shore water samples from Fiji (Ferreira *et al*.,in review). There have been no studies previously done on MPs in offshore waters between Fiji and Tonga waters and consequently the quantity of MPs which is generated locally as well as the amount which is brought in from other places by prevailing winds and surface water currents. High levels of MPs in the marine environment will impact significantly on the health and vitality of marine resources and marine ecosystem services (Barnes *et al.*, 2009). Pacific islanders who depend heavily on the marine environment are expected to be disproportionately affected by plastic waste.

This study was conducted as a component of the Master's thesis titled **The Abundance and Distribution of Microplastics in Surface Waters Around Fiji** that aims to quantify the abundance, distribution, morphology and composition of microplastics in surface waters between Tonga and Fiji.

Methodology

Water samples were collected at ten sites along a Tonga to Fiji transect from the 16th to the 20th of December 2018. Surface water samples were collected by towing a framed plankton net, mesh size of 63 μm, and mouth diameter 500 mm between 4 and 5 knots for five minutes. The net was maintained just below the surface of the water throughout the transect and rinsed with seawater after every tow to ensure that all material collected in the net was completely transferred into the cod end for retrieval. MP extraction from water followed the method described by the National Oceanic and Atmospheric Administration (Masura *et al*., 2015) The processed samples were examined using an Olympus dissecting microscope fitted with a camera to measure and catalogue identified MPs. MPs identified in samples were categorized into four main types; fragments, films, fibres and fibre bundles. Polymer analyses were conducted to determine polymer types with attenuated total reflectance Fourier transform infrared (ATR-FTIR). Polymer identification was carried out following the criterion set by Jung *et al*. (2018). Differences between sites were analysed by means of ANOVA, followed by Tukey post hoc test at a significance of 5%. Some of the data had to be log transformed to fit ANOVA assumptions.

Results

MPs were found throughout the Tonga-Fiji transect with at least six MPs present in the samples. A total of 120 individual MPs were collected and MP concentrations ranged from 0.04 MP per M^3 to 0.16 MP per M^3 with a mean value of 0.087±0.012 MPs per M^3. An observable pattern of MP concentration was noticed between samples near shore (within 200 kilometers) and offshore (more than 200 kilometers from the island archipelagos) (Figure 2). MP concentrations were significantly higher ($p<0.05$) toward the larger islands and reduces in concentration farther away.

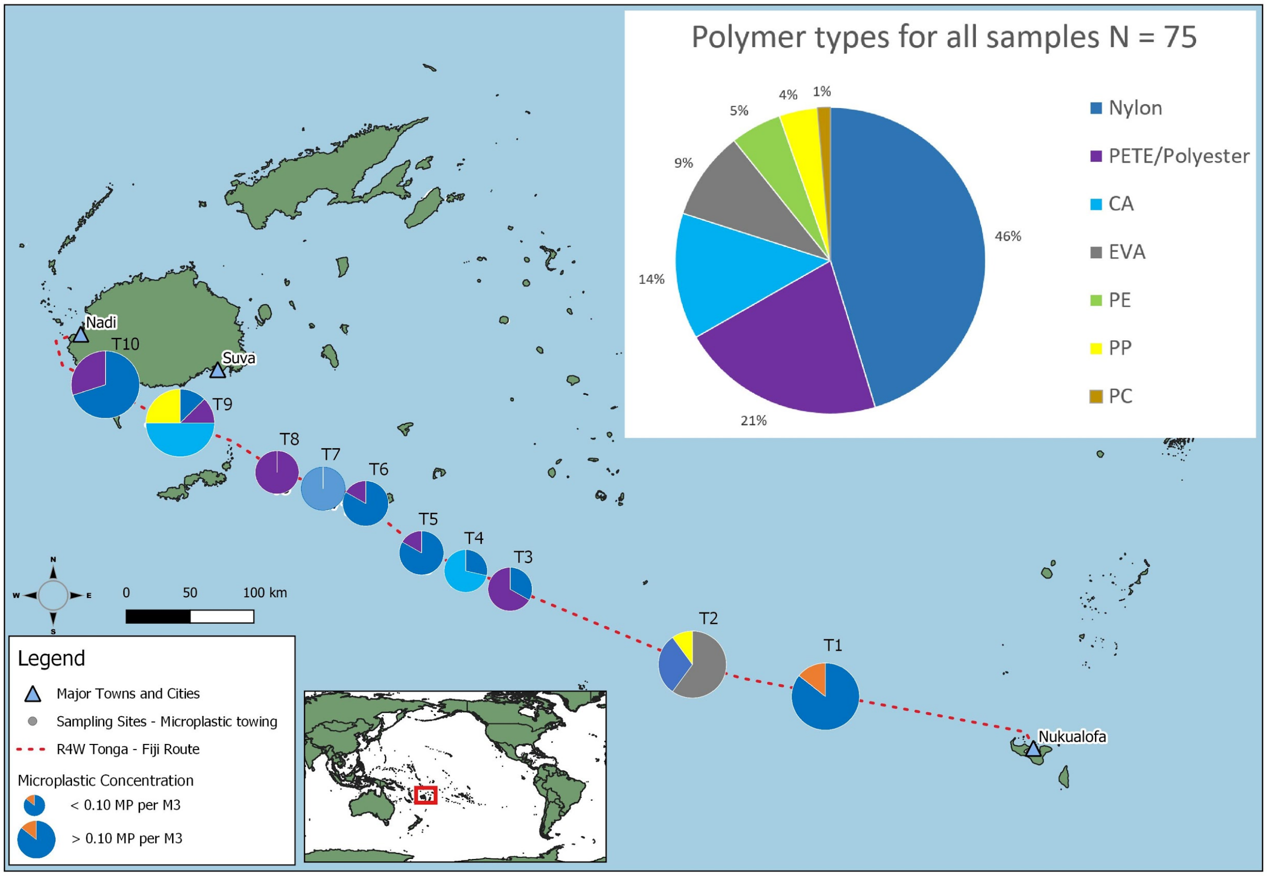

Figure 1: Profile of microplastic abundances and compositions between Tongatapu, Tonga and Viti Levu, Fiji. Inset: Chart showing polymer types for subset of total MPs cataloged (n=75). Polymer list: nylon, polyester (PETE), cellulose acetate (CA), ethylene vinyl acetate (EVA), polyethylene (PE), polypropylene (PP) and polycarbonate (PC). Individual sampling sites are denoted by pie charts of polymer type percentages. Acknowledgement to Jasha Dehm who developed the map using QGIS software (version 2.18.28)

Fibres were found to be the most common MP morphology (78%) followed by fragments (10%), films (8%) and fibre bundles (4%) (Figure 2).

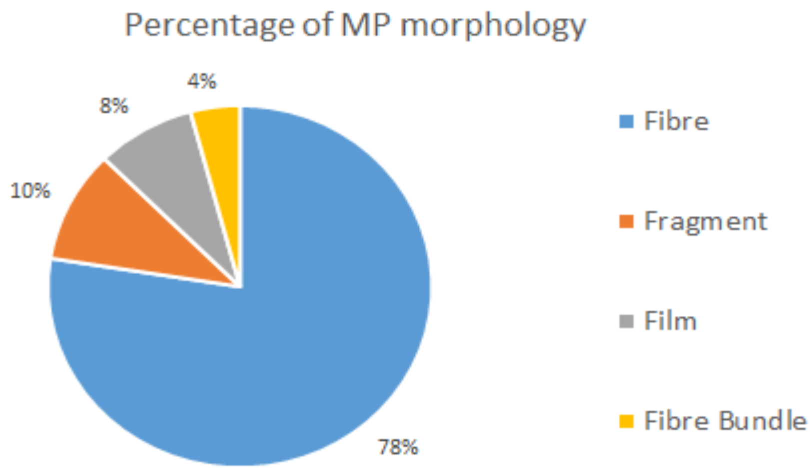

Figure 2: Microplastic morphology percentages for all samples (fibres, fragments, films, fibre bundles).

A minimum of half the sample number per site was set aside for FTIR analysis with a total of 75 MPs. A total of 7 polymer types were detected; nylon, polyester/polyethylene terephthalate (PETE), cellulose acetate (CA), ethylene vinyl acetate (EVA), polyethylene (PE), polypropylene (PP) and polycarbonate (PC). Overall the most common polymer types were nylon (46%), polyester/PETE (21%), CA (14%), EVA (9%), PE (5%), PP (4%), PC (1%) (Figure 1). No major differences were observed with polymer type distribution although a slightly higher diversity of polymer types was noted for sites that were closer to the larger islands (not significantly different; $p>0.05$)

Discussion

The results present a first MP analysis between waters from Tonga to Fiji. MP concentrations ranged from 0.04 MP per M^3 to 0.16 MP per M^3 with a mean value of 0.087±0.035 MPs per M^3 across the 10 sites. The 10 samples were placed in two categories; near shore, within 200 kilometers of Viti Levu and Tongatapu and offshore samples further than 200 kilometers from these islands. Near islands samples were found to be significantly higher ($p<0.05$) than offshore samples, with means of 0.13±0.012 MPs per M^3 and 0.06±0.002 MPs per M^3 respectively. Near shore samples were similar to concentrations found in a study by Ferreira *et al*. (in review) of Suva Harbour water samples 0.10±0.02 MPs per M^3. MP concentrations were comparable to studies done in the Mediterranean (de Lucia et al., 2014), the Ross Seas (Antarctica) (Cincinelli et al., 2017). Offshore sample concentrations were relatively low and this is to be expected with higher concentrations often associated with areas of heavy anthropogenic pressures.

Microfibres were found to be the most prevalent MP morphology at 78% of all MPs analysed followed by fragments at 10%. Microfibres are known to enter the marine environment as both primary sources liberated during production and use of textiles and secondary sources involving fragmentation of larger items such as discarded clothing (Henry *et al*., 2019). Fibres have been found to be the dominant type of MP in surface water (Frias *et al*., 2016) followed by fragments (Burns and Boxall, 2018) and this holds true for the study.

Prevalent polymer types identified in this study were nylon, polyester (PETE), cellulose acetate (CA), ethylene vinyl acetate (EVA), polyethylene (PE), polypropylene (PP) and polycarbonate (PC). A meta-analysis of previous studies of polymer types in sea water by Erni-Cassola *et al*. (2019) has shown that PE, PP, polyamides (nylon) and polyester were among the most abundant polymer types in aquatic environments with these plastics accounting for 74% of global production of plastics in 2015. Most of these plastics are commonly encountered in Pacific islands such as; nylon, a common component of fishing lines and nets, cellulose acetate, a low density plastic found in cigarette butts, ethylene vinyl acetate, which is used for the manufacture of floats for commercial fishing gear and polyethylene, the polymer used for most plastic bags.

Conclusion

The study presents a first analysis of microplastic distribution and composition for surface waters between Fiji and Tonga. The concentration of microplastics are considered low, however a distinct pattern was observed for near-shore and offshore samples with the latter found to be significantly lower. The prevalent microplastic types were fibres and fragments with the polymers identified directly related to globally mass produced plastics as well as plastic products commonly used in the Pacific islands. The dominant plastic morphologies and polymers found highlight the importance of improving land based waste management in developing countries to reduce the levels of secondary microplastics in marine environments

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