【Grant-in-Aid for Scientific Research (S)】

Broad Section K

Title of Project : Comprehensive studies on the circulation of ocean plastics including very small microplastics

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Research Project Number : 21H05058 Researcher Number : 00281189
Term of Project : FY2021-2025 Budget Allocation : 148,000 Thousand Yen
Keyword : small microplastics, missing plastics, ocean plastic circulation

【Purpose and Background of the Research】

Plastic debris generated mainly in everyday life move to oceans via rivers and are thereafter fragmentized to microplastics (hereinafter, MPs) due to degradation in the nature. Monitoring the microplastics is limited to those with sizes larger than 300 μm due to the mesh opening of surface net towing to collect plastic fragments and subsequent operations in laboratory analyses. A cutting edge of the marine plastic pollution studies at the present time is therefore to monitor and predict the abundance of microplastics smaller than this size (small MPs). Are the small MPs floating in the current (or future) oceans beyond a threshold concentration harmful to marine organisms? Do the oceans have a resilience to remove MPs from biologically productive upper oceans? To date, part of ocean plastics is suggested to be removed by settling into abyssal oceans, absorbed into sandy beaches and marine biota, and fragmentized to small pieces unmonitorable by net sampling. The objective of our research project is to uncover the entire ocean plastic flow worldwide based on a numerical model, which is expected to elucidate the fate of missing plastics in the plastic flow from the emission of plastic debris to the small MPs after fragmentation.

【Research Methods】

Field surveys: We attempt to sample small MPs by field campaigns from the Southern Ocean to the North Pacific Ocean. The MP samplings so far were conducted using surface net towing, while the present surveys adopt seawater samplings potentially including small MPs using a Rosette sampler. Sampling, extracting, and analyzing MPs and small MPs will map the abundance along the survey line.

Generation mechanism: We attempt to uncover the mechanism and quantify the rate of MP generations, which are estimated by comparing plastic samples degraded by UV radiation in a weather meter with samples collected in the oceans. Surface crack patters and carbonyl index of the samples after the oxidation are used for measures of plastic degradation.

Transport to marine biota and its influences: Based on laboratory-based studies, we attempt to establish a model of the MP behavior in bodies of an individual marine organism, food chain, and surroundings to assess the influence of MPs to marine ecosystem. Noted is the complex toxicity of a vector effect and endocytosis, which are incorporated into an ingestion-egestion model of marine organism.

Beach-Nearshore sea exchange: We attempt to estimate an exchange rate of small MPs between beaches and nearshore seas in field experiments, where wood tips with densities adjusted to plastics by painting are spread onto beaches to estimate the average residence time of MPs. In addition, a beach absorption rate is evaluated using a one-dimensional diffusion model of small MPs between beaches and nearshore waters.

Deposition of MPs to the ocean floor: We will conduct core samplings of bottom sediment in Beppu Bay west of the Seto Inland Sea, Japan to compute the deposition rate of MPs and small MPs in the past 70 years with the rapid increase of plastic productions. In addition, we attempt to estimate the deposition rate in the open oceans.

Numerical model approach: We attempt to establish a numerical plastic circulation model incorporating emission, transport, and removal processes, which all quantified in the subprojects mentioned above. The model is expected to uncover the fate of ocean plastics and future MP and small MP abundance in oceans.

【Expected Research Achievements and Scientific Significance】

The challenge of the present research project is to establish a plastic circulation model in the world's oceans by integrating the accomplishments by researchers with the background of oceanography, ecotoxicology, ocean engineering, polymer sciences, and paleoceanography. The Osaka Blue Ocean vision declared in the 2019 G20 summit stated that additional ocean plastic pollution will be reduced to zero by 2050. Our numerical model contributes to make an action plan justified by scientific evidence to materialize this vision.

【Publications Relevant to the Project】

Isobe, A., …H. Hinata, …,K. Uchida, and others "An interlaboratory comparison exercise for the determination of microplastics in standard sample bottles", *Marine Pollution Bulletin*, **146,** 831-837, 2019.

Isobe. A., S. Iwasaki, K. Uchida, and T. Tokai "Abundance of non-conservative microplastics in the upper ocean from 1957 to 2066", *Nature Communications*, **10**, 417, 2019.

【Homepage Address and Other Contact Information】

https://research-project-for-small-microplastics.jimdosite.com