深海から動物プランクトン消化管へのマイクロプラスチックスの経路

[課程博士・論文博士共通]

博士学位論文内容要旨
Abstract

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論文題目 Title	THE JOURNEY OF MICROPLASTICS FROM THE DEPTH OF THE SEA TO THE GUT OF ZOOPLANKTON		

Since the 1950s, when plastic material was widely included in the market, both the production amount and product variety have increased and enriched. As a result, plastic materials have become an indispensable part of today's lifestyle, with the effect of this increased production and development. The fact that plastic material production is easier and cheaper than recycling encourages the regeneration of plastic material. Thus, constantly newly produced plastic accumulates *in natura*. The difference between plastic accumulation and the accumulation of other pollutants is that plastics cannot dissolve *per se in natura*. Therefore, the volume and scope of plastic pollution are increasing day by day. Another reason that makes this pollution even more serious is the crumbling of plastics, especially from reasons such as UV. Due to this crumbling, regardless of the initial production size, the dimensions of the product may decrease to μm levels over time. Thus, plastic particles can both move more actively and travel more easily inside the food web via the effect of this crumbling. In addition, this crumbling leads to another problem, "increase in surface area." The plastic material itself is not directly harmful, but the additives in its production and the chemicals attached to it from the environment are harmful to organisms. Exactly for this reason, the present study focused on the issue of surface area in the relationship of plastic particles to zooplankton.

The present study, which is presented in six chapters, was built as an inverted pyramid in scope. Although each of these chapters is independent in itself, it also progresses in a successive scenario. The objectives of the present study were (i) observation of plastic pollution amount in the water column, (ii) detection of plastic contamination in zooplankton in the water column, (iii) possible role of marine snow in vertical transport of plastic, (iv) plastic encapsulation capacity of a zooplankter, and (v) the surface area of plastic material encapsulated by zooplankter. In order to achieve these objectives, the six chapters were created as follows.

In the Chapter I, the importance of the material in the development of humanity was stated. How civilizations depend on materials and their periods were conveyed when these were specified. From the stone age to today's silicon age, it has been shown how materials have transformed humanity and how each new material opens new horizons. In this development story, the discovery of plastic and how it has taken over the world until today are shown. Despite all the advantages of plastic, its effects and harms on nature are reflected in a broad perspective. Contamination of plastic to the aquatic system, its distribution and its pressure on the ecosystem were discussed.

In the Chapter II, the observation of plastic pollution in the water column was examined. The samples were collected using a Multiple Opening/Closing Net and Environmental Sensing System (hereinafter MOCNESS) at the Sea of Japan with three stations via T/V Shinyo-Maru (Tokyo University of Marine Science and Technology). The maximum depths of these Stations (hereinafter Stn.)1, 2, and 3 were 100, 400, and 900 m, respectively. Samplings were made by using a 64 μm net instead of a 330 μm net, which is mostly used in plastic studies in aquatic systems. Then, micro-Fourier transform infrared spectroscopy analyzes were performed to determine the type and concentration of plastics from the samples. For example, a total of 280 particles m^{-3} were found at a depth of 500–900 m, the deepest sample of Stn. 3. The dimensioning of plastic particles found and identified were determined with image software. The surface area of the concentration of

plastic due to the depth was calculated by calculating the Equivalent Spherical Diameter with the particle dimensions obtained.

The Chapter III was born from the analysis results of Chapter II. It was stated that 64 µm nets were used during the sampling with MOCNESS. However, most of the plastic samples found were less than 64 µm. For example, 1160 particles m^{-3} were found at the same station and the same depth (500–900 m in Stn. 3), less than 64 µm. Therefore, although it is difficult to reach a definite judgment, my hypothesis is marine snow formation. Therefore, the marine snow formations caught during the sampling were probably plastic-contaminated. In this way, they were involved in sampling via marine snow greater than 64 µm. In addition, the photographs of the suspected marine snow structures obtained from the samples were supported by the hypothesis.

In the Chapter IV, the effect of plastic contamination on zooplankton was studied in the same samples. First, the sub-sampling of the samples reflecting the volume of 10% was divided. Then, all zooplankton individuals who maintain body integrity were examined from these sub-samples. The gut content of members of all zooplankton whose visible gut was controlled by a digital microscope. Particles with plastic suspicion were searched directly in the gut content. When there was a suspicious particle in any individual's gut, the body surface was wholly inspected and washed until it was sure that there was no contamination on it and was re-checked by a digital microscope. Then, plastic identification analysis was performed on suspicious individuals with the same method and instrument as in Chapter II. However, no plastic contamination was found zooplankter. Then, the method was changed, and this time only the body surfaces of the individuals were controlled by plastic identification analysis. However, no plastic-contaminated zooplankter was found again.

The Chapter V was designed as a laboratory experiment, apart from the field sampling. Although I could not find plastic-contaminated zooplankter in the field study, it is a known fact that zooplankton ingest plastic. Considering the increasing plastic pollution, the present chapter studied how many plastics a zooplankter can encapsulate. *Daphnia magna*, a model zooplankton species, was chosen for the study. Polystyrene spheres of 10 µm diameter were used as plastic. After the experiment, the gut volume was measured with a digital microscope. Subsequently, the approximate number of particles in the gut was determined using the Kepler conjecture. The surface area of the plastic particles encapsulated was calculated in the diet range, suggesting that the total surface area of plastic particles in a *Daphnia magna* gut may reach around as much as that of two soccer balls.

In the Chapter VI, the importance of the surface areas of plastics was emphasized with the findings of the thesis. The surface area should not be ignored in studies in the water column and directly on zooplankton. The surface area should not be ignored in studies in the water column and directly on zooplankton. The surface area is of great importance in transmitting both the additives of the plastic and the harmful chemicals that adhere to the plastic from the environment to the organisms.

The perspective on plastic is that we cannot prevent chemicals from the environment from sticking to the plastic, but we can limit the additives used in plastic production. For this issue, of course, additives that provide structural strengthening cannot be prevented, but additives added for cosmetics can be limited.

The perspective on detecting plastic-contaminated zooplankton should focus on a technology that can marry the µ-FTIR system with field-usable instruments such as Underwater Vision Profiler. Zooplankter gut content can be detected instantly *in situ* with such an instrument.