海洋マイクロプラスチックの劣化の時空間動態に関する研究

［過程博士・論文博士共通］

博士学位論文内容要旨
Abstract

専　攻 Major	Applied Marine Environmental Studies	氏 名 Name	CELIK MURAT
論文題目 Title	Studies on spatio-temporal dynamics of marine microplastic degradation		

Plastic production in the world has exceeded 400 million tons in recent years. They reach to the sea area through rivers. It has been estimated that the plastic amount floating on the sea surface is 0.27 million tons. It is assumed that large amount of plastics are moving to seawater and seabed. Plastic leaked into the sea area degrades due to the effects of UV, temperature change, and waves, and becomes gradually smaller. The distribution of microplastics concentration is becoming clear, and it has not been grasped the change or behavior of its concentration. In order to correctly understand the fluctuation of microplastic concentration in the sea area, the formation process and movement of microplastics due to plastic degradation and miniaturization must be elucidated. To do this, it is necessary to know how long plastic deteriorates in the marine environment. It is important to consider the degradation of MPs on the sea surface in considering the behavior of MPs in the ocean. The degree of degradation due to plastic oxidation can be evaluated by carbonyl index (CI). The CI is widely known as an index of oxidative degradation of plastics. The 'Specified Area Under Band' (SAUB) technique for use with attenuated total reflection (ATR)-FTIR spectroscopy was applied in this study. According to this method, the CI was calculated from the ratio between the integrated band absorbance of the carbonyl (C=O) peak from 1,850 to 1,650 cm^{-1} and that of the methylene (CH_2) scissoring peak from 1,500 to 1,420 cm^{-1}. Therefore, the purpose of this study was to calculate the CI of several MPs sampled from various sea areas around Japan with an examination of the relationship with the properties of MPs, and clarify the state of deterioration and the fate of plastic in the sea area.

In Chapter 1, explained the background of the present condition and degradation process of microplastics with expressed the purpose of this study.

In Chapter 2, the purpose of this study is to calculate the CI of numerous MPs as well as to examine the relationship between the properties of the MPs and clarify the state of plastic deterioration in the sea area. In order to determine the CI, neuston net surveys (350-μm mesh size) were conducted in July August 2017 and August 2018 from seven stations around the Japan coast. The carbonyl index (CI) of polyethylene and polypropylene microplastics (MPs) collected in coastal waters around Japan was investigated. The CI of MPs

was calculated by the specified area under band technique (SAUB). It was found that the mean MP CI in all samples (regardless of shape and color) was 0.69 and 0.70 for polyethylene and polypropylene, respectively, and there was no significant difference in the color or shape of the MPs. The polyethylene MPs CI was negatively ($p < 0.05$) correlated with the major length of the MPs. Large MPs with relatively little deterioration were distributed off Shimane Pref. (west coast of the Sea of Japan), and small MPs were distributed off of Ibaraki Pref. on the Pacific Ocean and off of Toyama Pref. (east coast of the Sea of Japan). Thus, the CI and size of MPs in the sea area corresponded to the degree of degradation of the MPs.

In Chapter 3, the study aimed to calculate the CI values of the most used polymers PE and PP particles between 50 µm and 350 µm to determine the degradation behavior of MPs smaller than 350 µm and their degradation processes in the environment. A double neuston net was used to collect the small MPs small from Tokai offshore and Tokyo Bay, Japan. A total of 59 SMPs were investigated, and among them, 49 particles were identified as PE, and 10 particles were identified as PP, respectively. According to measurements, the mean length was recorded as 65.06 µm and 94.91 µm for PE and PP, respectively. The mean value of CI of PE was 2.58. On the other hand, the mean value of CI was found as 2.52 for PP. On the contrary, CI values of PE have a slightly bigger distribution range between 2.1-3.1. A moderate but statistically significant correlation ($p < 0.05$) was found between length and CI for PE ($r^2 = 0.087$) and weak correlation ($p < 0.05$) PP ($r^2 = 0.149$), respectively. From the result of chapters 2 and 3, it can be concluded that the CI value of SMPs is higher than that of LMPs, i.e., the smaller the particle size, the higher the CI value.

In Chapter 4, using these results, the final discussion was held. The CI of MPs was obtained by the SAUB method for 2950 (PE and PP) samples obtained from seven stations in the sea around Japan. I found that a negative correlation between the length and CI of MPs when expressed as mean values for each station. Furthermore, the small MPs (50-350 µm) CI was significantly larger than the large MPs CI. Thus, MPs are degraded at the sea surface and become many small MPs. Accordingly, the CI and length of MPs are indicators of the degree of degradation of MPs in the area. The standard deviation of the small MPs CI was smaller than that of large MPs. This was thought to indicate that the MPs on sea surface has deteriorated and that it is sinking in the seawater from the sea surface when it becomes fine particles. In the future, the MPs CI on the sea surface of other sea areas and the MPs CI sinking in the seawater should be examined to clarify the behavior of MPs.