A study of 'new plastic formations' found in the Seto Inland Sea, Japan

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Abstract- In the Anthropocene, the occurrence of 'new plastic formations' is being reported at locations around the globe, but there have been few reports from coasts along the Asian side of the Pacific Ocean. In this study, the cases of 'new plastic formations', consisting mainly of 'pyroplastics', which are drifted on the northwestern coast of Japan's Seto Inland Sea, were described. In Japan, the problem of harmful substances caused by '*hamayaki*' (burning of drifted coastal debris at the shore) has been studied from an early stage as the problem of coastal marine plastic pollution. In addition, in the Japan Sea and Yellow Sea, drifting marine litter created via combustion has been studied, and potential amounts of 'pyroplastic' were suggested. 'Pyroplastics' has been identified as the source of microplastics due to those vulnerabilities, and easy degradation into smaller particles was verified in the 'pyroplastic' collected. The potential amounts of microplastics from 'pyroplastics' and their toxicity are not yet clarified. In addition, it is possible that the 'new plastic formation' found in estuary, with plastics stuck to a pebble, may be incorporated into the stratum due to river sedimentation.

Index Terms- Plastic debris, Microplastics, Pyroplastic, New plastic formation, Seto Inland Sea, Japan.

I. INTRODUCTION

The present age, in which humanity is heavily impacting the earth's environment, is called the Anthropocene (Crutzen and Stoermer, 2000), and increasingly serious marine plastic pollution can be seen as one piece of evidence for this label (Zalasiewicz et al., 2016). There are concerns that this marine plastic litter is impacting wildlife in the hydrosphere (Gregory, 2009). Small plastic particles (<5mm) in the environment, particularly those known as microplastics (Wright et al., 2013), have dispersed widely throughout the oceans (Barnes et al., 2009), and it has been shown that they are being ingested by many species (De Sá et al., 2018). Marine plastic pollution, including the problem of microplastics has become one of many problems from Sustainable Development Goal (SDGs) 14. In addition, recently 'new plastic formations' caused by human activity have been confirmed (De-la-Torre et al., 2021). 'Pyroplastics', plastics similar to small stones that are formed by the combustion of plastic litter from manufactured goods, are now receiving attention as the new marine plastic litter pollution problem (Turner et al., 2019). 'Pyroplastics' drifting has been confirmed on the North American and European Atlantic coasts, including the southwestern coast of England, the North American Pacific coast (Turner et al., 2019), and even on the coast of the Mediterranean Sea (Ehlers and Ellrich, 2020). 'Plastiglomerates', composites formed by mixing plastic with stone when it is burned, has been confirmed in the Hawaiian islands in the North-Central Pacific Ocean (Corcoran et al., 2014), and many coastal locations including Indonesia (Corcoran and Jazvac, 2020). 'Plasticrusts', plastic debris embedded in rock, have been confirmed in volcanic islands in the Atlantic Ocean (Gestoso et al., 2019). Rocks with types of metal or plastic mixed in, called 'anthropoquinas', have been confirmed in the South American Atlantic (Fernandino et al., 2020). From the preceding reports, the occurrence of these 'new plastic formations' is considered to be global. However, although there is one report of 'plastiglomerates' (Corcoran and Jazvac, 2020), there have been few reports from coastal areas on the Asian side of the Pacific Ocean, so there was a lack of information concerning the distribution of 'new plastic formations' in these areas. In this study, 'new plastic formations', consisting mainly of 'pyroplastics', which were confirmed to have drifted on the coast of the Suo-Nada in Yamaguchi Prefecture, located at the northwestern tip of the Seto Inland Sea, Japan, were described. In addition, discussions related past research conducted in Japan were taken into.

II. MATERIALS AND METHODS

The 'new plastic formations' in this study were collected during surveys of organisms that drifted on the estuary coast along the right bank of the Ariho River (33° 59' N, 131° 9' E) in Sanyo-Onoda City, Yamaguchi Prefecture, located on the Seto Inland Sea, Japan. The survey site is a slightly rocky natural coast. As the primary collection method, the top layer of floating debris deposited along the high tide line was observed and collected. A total of 3 'pyroplastics' were collected during surveys in March and May 2020 (Fig.1). Furthermore, to confirm whether the collected 'pyroplastics' were floating plastics, it was observed whether or not they floated on water. In addition, in a survey in April 2021, a 'new plastic formation' of the type where plastics strongly stuck to a rounded pebble was collected rather than at the high tide line, in the intertidal zone at the survey location (Fig.2).

III. RESULTS AND DISCUSSION

The 'pyroplastics' collected in March 2020 (specimen No.1, Fig.1a; specimen No.2, Fig.1b) both had an indeterminate shape.

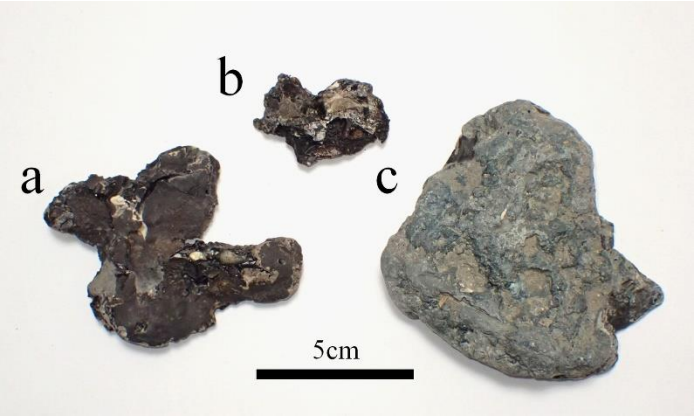

Figure 1. Photograph of 'pyroplastics' collected at the survey site. a. specimen No.1, b. specimen No.2, c. specimen No.3

Figure 2. Photograph of 'new plastic formation' collected at the survey site, plastics stuck to a pebble (specimen No.4).

Both specimens were black across the entire surface due to combustion, and at a glance appeared to be black stones (shale, for example). However, a few white or translucent spots can be identified that appear to be the original plastic. In addition, the thin section of specimen No.2 was soft and elastic. Both specimens were observed floating in freshwater, and their specific gravity was confirmed to be lower than that of water (Fig.3). The 'pyroplastic' collected in May 2020 (specimen No.3, Fig.1c) had an uneven surface, and mimicked the green rock. This specimen also floated in freshwater, confirming that it has a lower specific gravity than water. Polyethylene and polypropylene are plastics with a specific gravity of less than 1, and account for approximately half of all plastic products manufactured worldwide (Geyer et al., 2017). The original plastic material of these specimens can be thought to be Polyethylene or polypropylene. The black-colored specimens have very little wear by waves or weathering by wind and rain, and the corners have not been rounded like the 'pyroplastics' shown in Turner et al. (2019). For that reason, they are thought to have been formed locally and recently, perhaps by combustion residue carried to the shore by the wind. Despite currently being regulated or prohibited by various laws and regulations in Japan, small-scale remains of litter that had been artificially combusted were confirmed near collection points along the shore in the survey in March 2020. The 'new plastic formation' collected in April 2021 (specimen No.4, Fig.2) was the formation of green plastics stuck to a rounded pebble. The host rock surface on which the plastics were stuck was relatively smooth, and the stuck plastics were several centimeters in size, so this specimen is thought not to have been embedded via wave power, like 'plasticrusts' (Gestoso et al., 2019), but rather formed by the once-molten plastics strongly sticking to the host rock.

In Japan, environmental pollution by harmful substances like heavy metals and dioxins, originating from the '*hamayaki*' (the Japanese name of the act of burning of drifted coastal debris at the shore) of drifting litter that includes high amounts of plastic waste, is seen as the serious problem, and has been reported earlier (Yamaguchi, 2002; Yamaguchi, 2007; Okano et al., 2011). A series of reports of 'new plastic formations', such as 'pyroplastics', have focused on the state of environmental plastics formed via combustion on the problem of '*hamayaki*', and it can be said that they have re-focused attention on the issue of marine plastic litter globally. Heavy metals such as lead and chrome have been detected in 'pyroplastics' (Turner et al., 2019), and the similar problem has already been pointed out in the research in Japan, in which heavy metals leach from '*hamayaki-suna*' (beach sand mixed with incineration ash of plastics), which is sand mixed with incinerated ash from '*hamayaki*' (Yamaguchi, 2007).

In the research of drifting marine litter by the Northwest Pacific Region Environmental Cooperation Center (NPEC), 'pyroplastics' are included under the category "Burnt residue" under "Other" in "Plastics," and monitoring surveys are being conducted. In the 2004 survey of drifting marine litter on the Japan Sea and Yellow Sea by the four countries facing these bodies of water (Japan, Russia, South Korea and China), it was reported that the "Other" category of "Plastics" included 0.3% of the total amount of plastics, and "burnt residue" was included in that breakdown (NPEC, 2005). In addition, in recent years it has been reported that '*hamayaki*' of drifting litter is still being done in various places in Japan (Yamaguchi, 2015). Considering the information above, it can be said that 'pyroplastics', the potential source of harmful substances, is widely scattered along Japan coast. The specimens shown in this study are just one example.

It has been pointed out that 'pyroplastics' are the source of small plastic particles (microplastics) because it is made physically fragile by combustion (Turner et al., 2019), and it has

Figure 3. Collected 'pyroplastics' that floats in water.

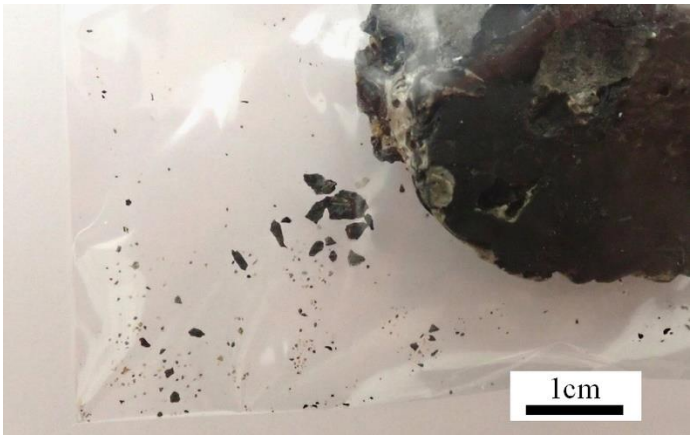

Figure 4. Degradation of 'pyroplastic' (into microplastics).

been verified that the collected specimens shown this study easily degrade (Fig.4). Because microplastics are very small, there are concerns about biological impacts if they are ingested by various species (Wright et al., 2013; De Sá et al., 2018)—even at a cellular level, eluates derived from microplastics are known to exhibit cytotoxicity and genotoxicity (Furukuma and Fujii, 2016; Furukuma, 2020). Microplastics formed from 'pyroplastics' are predicted to have an even stronger toxicity, and may have already come back into our living environments. It has already been reported that microplastics also exist in the Seto Inland Sea (Kabir et al., 2020), but the potential amounts of microplastics from 'pyroplastics' has not yet been clarified. Because they visually resemble rocks and gravel, microplastics from 'pyroplastics' have stealth property. For that reason, those microplastics may be overlooked in the visual sorting process, and ascertaining those abundances is predicted to be difficult. Further progress depends on future research into the amounts and environmental impacts of these combustion-derived plastics, a negative legacy of the Anthropocene. In addition, since this survey was done at the estuary, it is presumed that 'new plastic formations' in which combustion-derived plastics is stuck to rounded pebbles, as in specimen No.4, will almost certainly be incorporated into the strata via river sedimentation. Although it is an inference from the situation, this river-mouth sedimentation activity suggests one typical and important model for the mechanism by which 'new plastic formations' compounded with rocks become geological records.

IV. CONCLUSION

In this study, the cases of 'new plastic formations', consisting mainly of 'pyroplastics', which are drifted on the northwestern coast of Japan's Seto Inland Sea, were described. This is the first detailed report of 'new plastic formations' at coastal areas on the Asian side of the Pacific Ocean. It was observed that the collected 'pyroplastics' are easily partially crushed and became microplastics. It is possible that the 'new plastic formation' found in estuary, with plastics strongly stuck to a pebble, may be incorporated into the stratum due to river sedimentation.

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In the modern, as science has become more advanced and institutionalized, there are many restrictions on an unaffiliated individual carrying out scientific activities—and even making an announcement presents difficulties. However, even given these facts, it is also true that any scientific knowledge acquired by an individual, no matter how small, will be useful for the next, new research. This is even more true for understanding the environmental problems that become ever more serious, day by day. I would like to thank this journal.

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