

THE IMPACTS OF MICROPLASTIC POLLUTION ON FRESHWATER FISHES IN JAPAN'S KOMAOI RIVER AND TAMA RIVER

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ABSTRACT

In recent years, environmental pollution caused by microplastics (MP) has become a global issue, yet only a few studies have considered MP pollution of freshwater fish, in contrast to the substantial research done on seawater fish. Thus, the purpose of this study is to examine MP pollution of river fish. To this end, we obtained Ayu (*Plecoglossus altivelis*) from Tama River Tokyo and Ugui (*Tribolodon Hakonensis*) from Komaoi River, Hokkaido. We also collected MP samples from the river water in both locations in order to examine the relationships of MP pollution between fishes and river water. Our findings were as follows. In the Komaoi River, MPs were detected in 2 out of 8 Ugui with 0.25 particles on average and up to 1 particle per individual. In the Tama River, MPs were detected in 2 out of 2 Ayu with 4 particles on average and up to 4 particles per individual. Thus, the MP pollution in the Ayu was higher than in the Ugui. In addition, the MP numerical concentrations in the Tama and Komaoi Rivers were 3.75 and 0.50 particles/m³, respectively. Together, these facts show that the MP pollution in the Tama River was greater than that in the Komaoi River and consequently had a greater tendency within its fish.

Keywords: microplastics, river, fish, Ugui, Ayu

1. INTRODUCTION

Plastics production grew exponentially after the 1950s, and microplastics (MPs), defined as plastic particles less than 5 mm in length, began appearing in the oceans as early as the 1960s (Carpenter and Smith, 1972). Since then, MP pollution in the oceans has been an environmental problem on a global scale. Within the past decade, Eriksen et al. (2014) revealed that the number of MPs in the oceans has risen to 5.25 trillion (0.27 million ton), with most of these MPs originating from land (Pruter, 1987; Gregory, 1991; Jambeck et al., 2015). Due to this growth, many surveys on MP pollution in the ocean and rivers have been conducted. The findings show that MP pollution in Japan and overseas is progressing not only in the oceans, but also in rivers (*e.g.*, Yonkos et al., 2014; Kataoka et al., 2019).

Additional studies have specifically looked at MP pollution in seawater fishes. Boerger et al. (2010) showed that MPs were found in 35% of all samples of fishes in the North Pacific Ocean, and the average concentration of MPs was 2.1 particles per individual. Lusher et al. (2013) found MPs in 36.5% of the gastrointestinal tracts extracted from 10 kinds of fish, and the average concentration of MPs was 1.90 particles per individual. Neves et al. (2015) examined MP pollution in 26 kinds of fish in Portugal and observed that 19.8% of all samples had more than 1 MP in the gastrointestinal tracts. Also, MP pollution has been reported in about 40% of freshwater fish on average (Collard et al., 2019).

MP pollution in seawater fishes has also been reported in Japan. Tanaka and Takada (2016) found MPs in 49 out of 64 (77%) Japanese anchovies sampled from Tokyo Bay. Ushijima et al. (2018) observed MPs in 9 out of 31 (29%) samples from Lake Biwa. These findings suggest that MP pollution has spread widely throughout Japan, as it has in the rest of the world.

However, scant information has been gathered on MP pollution in freshwater fishes when compared to the research on seawater fishes. In addition, only minimal data has been collected on the relationships of MPs, between the fishes and the fishes' surrounding environment, such as the river water and sediment. Thus, the purposes of this study are to examine MP pollution impacts on river fish. To this end, we obtained Ayu (*Plecoglossus altivelis*) from Tama River in Tokyo and Ugui (*Tribolodon Hakonensis*) from the Komaioi River, a branch of the Abashiri River in Hokkaido. We also collected MP samples of river water from both locations in order to examine the relationships of MP pollution between fishes and river water. The watersheds in the Tama and Komaioi River regions are primarily an urban area and forest, respectively. Thus, the environmental impacts in the two locations present different factors for consideration. The parts of the fish targeted to find the MPs were the esophagus, stomach, and intestines. The analysis covered 8 samples of Ugui from the Komaioi River and 2 samples of Ayu from the Tama River. We then examined the amount (number and mass) and quality (size, shape, or material) of the MPs.

2. METHODS

2.1 Study sites

Figure 1 includes maps of the study sites for the Komaioi River and Tama River. The Komaioi River is a branch of the Bihoro River and Abashiri River in Hokkaido and flows into Lake Abashiri and the Sea of Okhotsk. The Abashiri River is a first-class river with an area of 1,380 km² and a river length of 115 km. Most of the basin area of the Abashiri River is mountainous forest. The Tama River flows mainly down in the western part of Tokyo. It is a first-class river flowing into Tokyo Bay, with a river length of 138 km and a basin area of 1,240 km². The middle and downstream parts of the Tama River are widely urbanized. Thus, the social environment is different between the Komaioi River and Tama River.

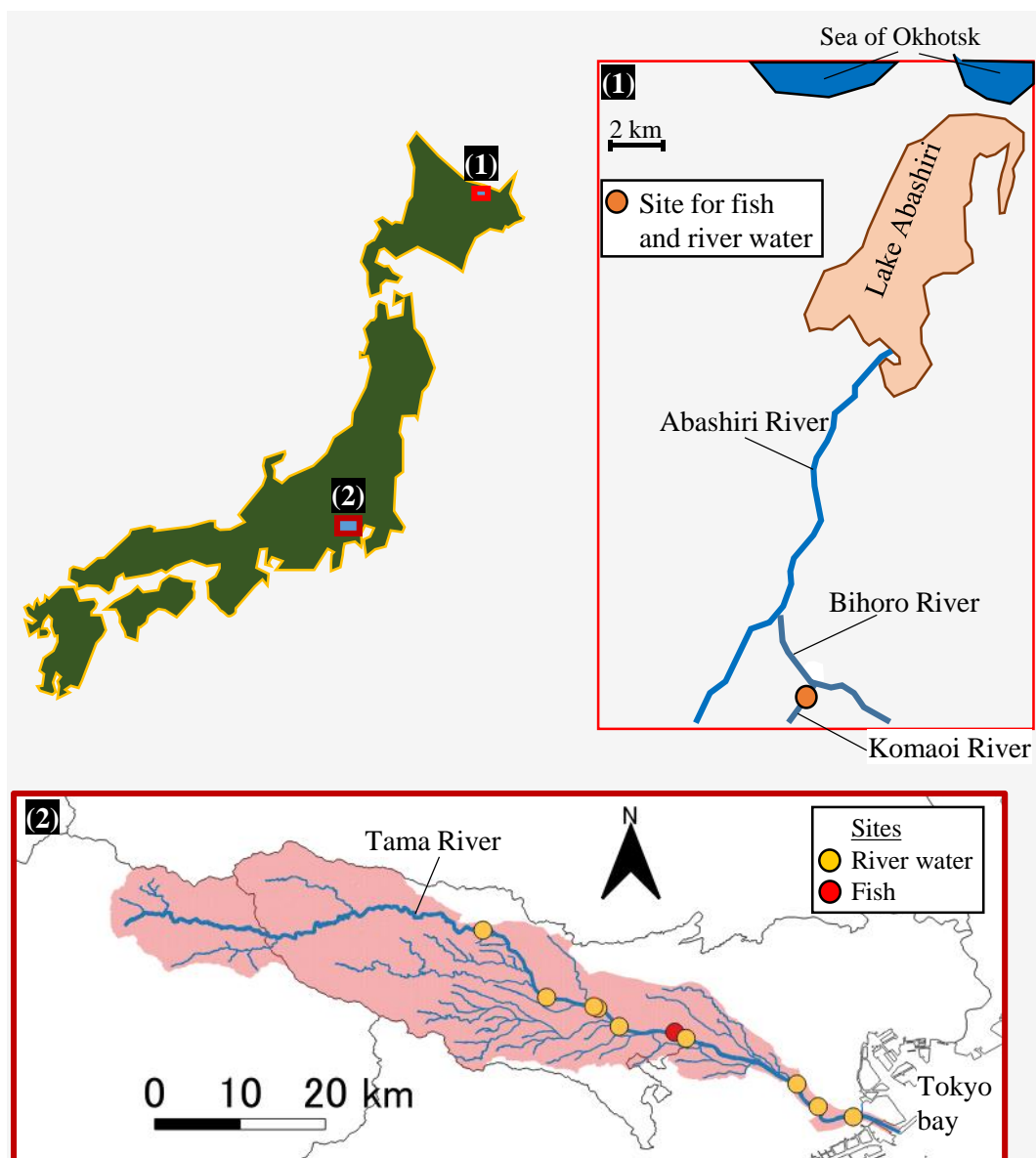


Figure 1 Field sites for MP pollution in the Komaioi River and Tama River.

2.2 Field measurements and analysis of the fish samples

On Oct. 11, 2019, MP samples from the river water and fish were collected at the downstream point of the Komaio River (43.819748N, 144.1280753E), which is shown in **Fig. 1**. At the Tama River, the measurement sites included 8 stations for river water and 1 station for fish on August 5 and July 23, 2019, respectively. At present, 8 samples of Ugui in the Komaio River and 2 samples of Ayu in the Tama River have been analyzed. The methods for collecting and analyzing MPs in the river water were almost the same as those used by Kataoka et al. (2019).

The process for analyzing MP pollution in the fish samples required several steps. First, we carefully extracted a gastrointestinal tract from each fish sample, which was then soaked in hydrogen peroxide with a concentration of 30% for one week to dissolve the organic matter. Next, the sample was filtered through a 0.1-mm net and the residue was dried for 24 hours in a 60°C incubator. Finally, the MP candidate particles were detected by eye from the dried sample and analyzed. The mass and size of the MP candidates were measured by an ultra-micro balance (XPR2UV, Mettler Toledo) and a stereoscopic microscope (SZX7, Olympus Corp.) with a charge-coupled device (CCD) camera (HDCE-20C, AS ONE Corp.). MPs were identified using a Fourier Transform Infrared Spectrophotometer (FTIR, IRAffinity-1S, Shimadzu Corp.).

3. RESULTS AND DISCUSSION

3.1 MP pollution in fishes

Figure 2 shows the MP pollution present in the Ugui from the Komaio River and the Ayu from the Tama River. In this figure, the number and mass of MPs per individual are depicted. In the Komaio River, MPs were detected in 2 out of 8 Ugui (25%) with 0.25 particles on average and up to 1 particle per individual. In the Tama River, MPs were detected in 2 out of 2 Ayu (100%) with 4 particles on average and up to 4 particles per individual. The average mass per individuals was 0.00029 and 0.0258 [mg/individual] for the Ugui and Ayu, respectively. Thus, the MP pollution of the Ayu in the Tama River was greater than that of the Ugui in the Komaio River.

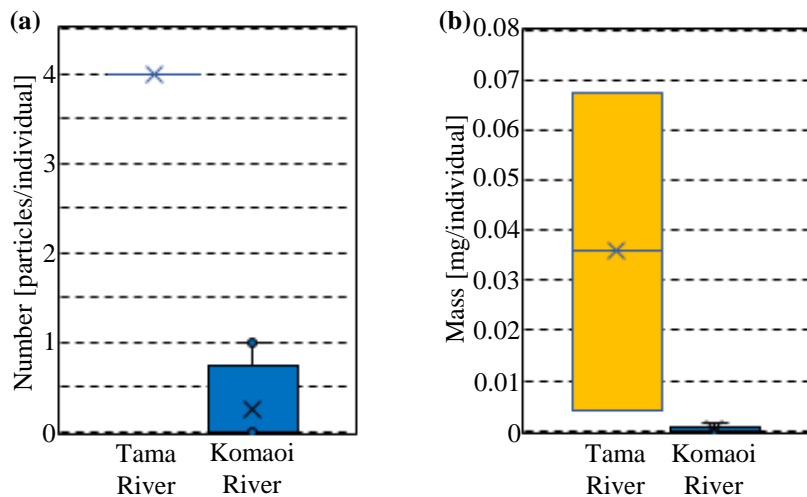


Figure 2 MP pollution of fish for number (a) and mass (b) per individual.

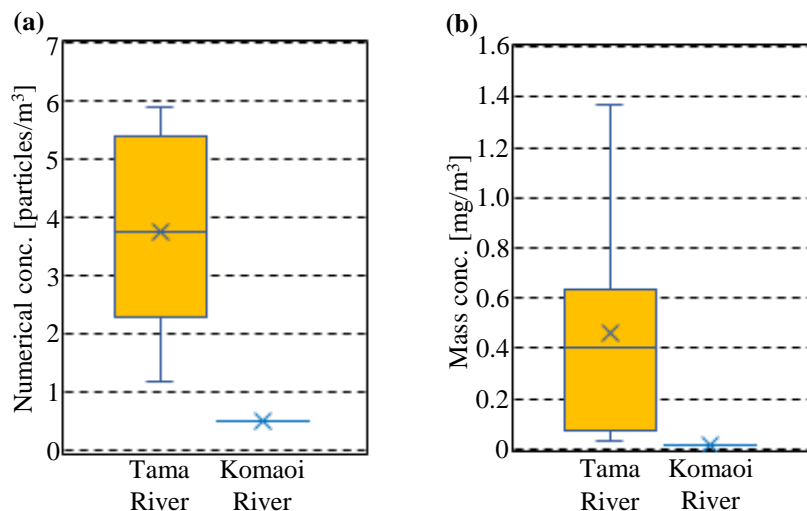


Figure 3 Comparison of MP numerical concentration (a) and mass concentration (b) of the river water.

3.2 River water

Figure 3 indicates the MP numerical and mass concentrations of the river water in the Komaioi and Tama Rivers. The concentration in the Tama River was the average of the observed data at 8 stations. The numerical (mass) concentrations of the river waters were 0.50 and 3.75 [particles/m³] (0.01 and 0.46 [mg/m³]) in the Komaioi River and Tama River, respectively. Thus, the MP pollution was significantly higher in the Tama River than in the Komaioi River, corresponding with the higher tendency of MP pollution in the Tama River's fish. This fact suggests that the difference in MP pollution between the fish from these rivers was mainly caused by the MP pollution in the river waters.

Also of note, the primary shape of the MPs in the river waters of the Tama and Komaioi Rivers were fragments, whereas the detected MP shapes within the fish were fibrous. This difference in dominant MP shape may be caused by the retention time of each shape in the fish.

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