Title of Research:

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Constructing a model for estimating a vector effect of microplastics using an artificial bioconcentration device and predicting impact in the real environment

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Summary of Research:

Plastic has extensive use in daily life due to its low cost, lightweight, and rigid decomposing. Due to their high production and slow degradation, plastic pollution has expanded worldwide in aquatic environments. Plastic pollution from large items to small particles (microscopic plastic MP, < 5mm) emerged. The effect of MP and its vector effect on pollutants are of concern. Many studies have examined these topics. However, most of the study were used pristine MPs. Thus, a study on the effect of aging on the vector effect of MP is required.

This fiscal year, freshwater and marine medaka were co-exposed to microplastics (MP) with chlorobenzenes (CBs) and anthracene (ANT) under various conditions, and vector effects were investigated. No vector effect could be observed in CBs (logPow 4.19-5.73). However, a vector effect was confirmed with anthracene (logPow4.45). Therefore, it was concluded that the vector effect differs greatly depending on the character of the chemicals, even if the LogPow is close. Further studies may be required on PAHs, POPs, etc., concerned about the influence of vector effects. The details are described below.

1) Freshwater medaka-CBs + degraded crushed PE-MP 3-day co-exposure experiment: CBs group (CBs; TriCB: 10 μg/L, TetCB: 10 μg/L, PentCB: 10 μg/L, HexCB: 8 μg/L), CBs + aged fragmented PE-MP (1 mg/L) co-exposure group, CBs + unaged fragmented PE-MP (1 mg/L) co-exposure group were set, and after equilibrating with MP for one day, medaka (3 fish/group) were exposed for 3 days. As a result of the analysis, CBs in the unaged group was 1.6 times higher than in the CBs group. Moreover, there was no effect on aging.

2) 7-day co-exposure experiment with different concentrations of freshwater medaka-CBs+PE-MP : CBs group (CBs; TriCB: 10 μg/L, TetCB: 10 μg/L, PenCB: 10 μg/L, HexCB:

8 μg/L), CBs + low-concentration fragmented PE-MP (0.1 mg/L) Co-exposure group, and CBs+ high-concentration crushed PE-MP (1.0 mg/L) group were set. They were exposed to Japanese medaka (33 fish/section) for 7 days and excreted for 5 days. Sampling was performed on the 3rd, 5th, 7th, 9th, and 12th days. The water exchange was semi-static (once a day, full exchange). There was no significant difference in CBs concentrations compared with the water-exposed group, indicating no vector effect.

3) Freshwater medaka-CBs + PS-MP co-exposure experiment with different particle sizes: CBs (CBs; TriCB: 10 μg/L, TetCB: 10 μg/L, PenCB: 10 μg/L, HexCB: 8 μg/L) exposure group, CBs+10-μm PS-MP co-exposure group,and a CBs+45-μm PS-MP co-exposure group were set.. After 7 days of exposure, they were excreted for 5 days and sampled on the 7th, 8th, 9th, 10th, and 12th days. The water exchange was semi-static (once a day, full exchange). As a result, the CBs concentration in the co-exposed groups did not differ from that in the CBs-exposed group and somewhat decreased, indicating no vector effect.

4) Freshwater medaka-ANT+58-μm PE-MP co-exposure experiment with different MP concentrations: ANT (200 μg/L) group, ANT+ low-concentration PE-MP (0.6 mg/L) co-exposure group, ANT+ middle-concentration PE-MP (6 mg/L) co-exposure group, and ANT+ high-concentration PE-MP (60 mg/L) co-exposure group were set. After 10 days of exposure, fish were excreted for 4 days and sampled on the 10th, 11th, 12th, 13th, and 14th days. The water exchange was semi-static (once a day, full exchange). The vector effect was confirmed from the obtained concentrations of ANT in the medaka. A twin-compartment vector model was used to analyze the effect of MP concentration, and as a result, the vector coefficient decreased as the MP concentration increased.

5) Prediction of ANT-MP vector effect in the real environment: The data set (Takai, PhD. thesis, Kyushu University, 2023.3) was used obtained from marine Java medaka-anthracene (ANT) + different size (2, 10-μm) polystyrene MP (PS-MP) exposure studies. As a result of evaluating the vector effect from the different concentrations of PS-MP using a twin-compartment vector model, it was estimated that the vector effect would hardly occur in the real environment.

6) Effect of PS-MP particle size on ANT adsorption: As a result of examining the adsorption of ANT to PS-MP with particle sizes of 10, 45, and 90 μm. The smaller the particle size PS-MP show a larger surface area and adsorption potency to ANT, suggesting a vector effect. However, it was expected that the larger the particle size PS-MP has minor adsorption potency and the weaker the vector effect.

Timeline:

March 1, 2022- Feb28, 2023

Topics:

Publications:

1. Takai Y., Tokusumi, H., Sato, M., Inoue D., Chen K., Takamura T., Enoki S., Ueno Y., Kang I. J., Shimasaki Y., Qiu X., Oshima Y., Combined effect of diazepam and polystyrene microplastics on the social behavior of medaka (*Oryzias latipes*), Chemosphere, 299 134403-134403.

2. Takai Y., Tokunaga M., Honda M., Qiu X, Shimasaki Y., Kang I.J., Oshima Y., Size effect of polystyrene microplastics on the accumulation of anthracene for Java medaka (*Oryzias javanicus*). Chemosphere (Under reviewing)

3. Takai Y., Tominaga A., Honda M, Qiu X., Shimasaki Y., Kang I.J, Oshima Y., Combined effect of anthracene and polyethylene microplastics on Java medaka (*Oryzias javanicus*). Ecotoxicology. (2023.3.31, submit)

4. Takai Y., Honda M., Qiu X., Shimasaki Y., Kang I.J., Oshima Y., Concentration effect of polystyrene microplastics on the accumulation of anthracene for Java medaka (*Oryzias javanicus*). Mar poll bull (2023.4, submit)