

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:

In the current fiscal year, we first established the passive dosing method. Ant adsorption from the Ant-adsorbed O-ring to MP was more than twice as high as that of the conventional method, which involved dissolving Ant in a solvent and adsorbing it onto MP. Consequently, with the Ant-adsorbed MP created using this method, in vitro tests simulating the gastrointestinal environment became possible.

Next, we investigated the cause of the vector effect of MP using simulated intestinal in vitro tests. As a result, the concentration and proportion of Ant eluted from MP in the intestinal washout fluid were approximately three times higher in the High_conc group compared to the control group. In simulated intestinal fluid containing taurocholic acid, the concentration of Ant eluted from MP was about 10 times higher than in the control. This mechanism is attributed to the surface-active properties of taurocholic acid, a major component of bile, which led to significant adsorption and desorption of Ant on MP. Therefore, the vector effect of MP on Ant is explained by the enhanced desorption due to the surface activity of bile in the gastrointestinal tract, resulting in increased absorption of Ant.

In the Phe+PE-MP co-exposure test, the aqueous-phase Phe concentration in the Phe+MP group was approximately 30% lower than in the Phe group, while there was no difference in Phe concentrations between the fish body Phe group and the Phe+MP group. Analyzing the

results, the elimination rate constants (k_2) were 0.133 and 0.136, showing no significant difference between the two groups. The bioconcentration factor (BCF) was calculated to 2823, and the uptake clearance (k_1) was determined to be 375. We estimated the internal concentration using a one-compartment model using these values and the aqueous-phase Phe concentration in the Phe+MP group (average = 0.102 mg/L). As a result, the Phe taken up from the aqueous phase in the fish body in the Phe+MP group contributed only about two-thirds of the internal concentration, demonstrating the vector effect. Considering that Phe adsorbed to MP at a concentration of 2.63 mg/g MP, the desorption (vector effect) of Phe adsorbed to MP is possible. The results of the 5.3 PaHs exposure experiment also suggest a vector effect for Phe.

In the preliminary experiment of the one-day co-exposure of Japanese medaka (Himedaka) with PaHs+PE-MP, none of the PaHs showed good dissolution in water due to the absence of surfactant additives. However, we performed calculations. In the Acy, Ace, Phe, and Ant MP co-exposure groups, an increase in the internal concentration of each PaH was observed, indicating a strong vector effect for these PaHs. However, Flu, Flt, Pyr, BaA, Chr, BbF, BkF, BaP, BghiP, Da, and IP were not detected in the fish body, likely due to their high log Kow, making desorption from MP difficult and resulting in no vector effect.

In future work, we will verify the vector effect using Japanese medaka exposed to MP and different PaHs or CBs with significantly different log Kow values for 10 days. Simultaneously, we will conduct in vitro desorption tests simulating the intestinal tract to investigate the vector effect further.

Timeline:

March 1, 2023- Feb28, 2024

Topics:

Publications:

1. Takai, Y., Tominaga, A., Honda, M., Qiu, X., Shimasaki, Y., Kang, I.J., Oshima, Y., 2023. Combined effect of anthracene and polyethylene microplastics on swimming speed and cytochrome P4501A monooxygenase expression of Java medaka (*Oryzias javanicus*). *Ecotoxicology*. <https://doi.org/10.1007/s10646-023-02700-4>
2. Takai, Y., Tominaga, A., Uchida, Y., Honda, M., Qiu, X., Shimasaki, Y., Oshima, Y., 2023. Size effect of polystyrene microplastics on the accumulation of anthracene for Java medaka (*Oryzias javanicus*). *Chemosphere* 338, 139543. <https://doi.org/10.1016/j.chemosphere.2023.139543>

Assessment on the effects on ecosystems and the environment

3. Takai et al., Concentration effect of polystyrene microplastics on the accumulation of anthracene for Java medaka (*Oryzias javanicus*). *Chemosphere* (2024.4, 投稿予定)
4. Md Al-Emran et al., No vector effects of polystyrene microplastics (PS-MP) on the accumulation chlorobenzenes (CBs) in Japanese Medaka (*Oryzias latipes*). *Chemosphere* (2024.4, 投稿予定)
5. Md Al-Emran et al., Effect of polyethylene microplastics concentration on the accumulation of co-exposed anthracene for Japanese medaka, *Oryzias latipes*. *Chemosphere*. (2024.5, 投稿予定)