# Microplastics pathway in sea cucumbers: A perspective

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Plastics have become a major component of our life, mainly due to their durability (Thompson et al. 2009). Plastic production increased rapidly from the 1950s onward, with global production reaching about 368 million metric tons in 2019 (Shanmugam et al. 2020). The mismanagement of plastic waste has resulted in the accumulation of plastics in the ocean (Eriksen et al. 2014). Plastics degrade over time, resulting in the formation of tiny plastic particles called microplastics (5 mm–1μm) and nanoplastics (less than 1 μm) (Wayman and Niemann 2021). Microplastics can also be purposefully manufactured, such as microbeads, which are used for personal care products, and have been named as primary microplastics (Rochman 2018).

Marine microplastics are distributed throughout the ocean, from the Arctic to the Antarctic (Rochman 2018). These microplastics can have a significant ecological impact not only because of their original structure but also because of the chemicals applied to their final product, such as dibutyl phthalate and phthalates (Zimmermann et al. 2020). Furthermore, microplastics have raised concern because of the adsorbed chemicals and colonised microbes on their surface in the ocean (Barboza et al. 2018). The transport of microplastics in the ocean is dependent on their properties, among which the density, shape and size are considered to be major factors (Khatmullina and Chubarenko 2019). Microplastics may be ingested by marine organisms intentionally or unintentionally, according to an organism's feeding habits (Egbeocha et al. 2018).

Sea cucumbers are exposed to microplastics in water and sediment according to their behaviour. Deposit- and suspension-feeding sea cucumbers can ingest microplastics through the mouth (Graham and Thompson 2009). Sea cucumbers likely ingest microplastics unintentionally when they brush the surfaces to collect particles into their mouth. Microplastics with shapes that the tentacles can trap are likely to have the highest proportion of being ingested by sea cucumbers. It has been shown that dietary-ingested microplastics can be excreted from sea cucumbers through their faeces without evidence of transferring these microplastics through the intestinal epithelium (Fig. 1), as has been shown in the sea cucumber *Apostichopus japonicus* (Mohsen et al. 2020b). However, nanoplastics have been observed to cross the intestinal barrier in fish (Clark et al. 2022; Vagner et al. 2022), which is worthy of investigation in sea cucumbers (Fig. 1).

Microplastics are ubiquitous in seawater, and fresh water sea cucumbers can uptake microplastics during suspension feeding (Iwalaye et al. 2020; Mohsen et al. 2020a) or respiration (Mohsen et al. 2022b, 2020b). Microplastics in inhaled water can reach the perivisceral coelomic fluid of sea cucumbers and even breach the tissues of the respiratory tree (Mohsen et al. 2020b). However, these microplastics are excreted again by sea cucumbers when they are placed in clean seawater (i.e. sand-filtered seawater) (Fig. 1) (Mohsen et al. 2023). It is worth investigating whether these microplastics can be a vector for pollutants (e.g. heavy metals) or pathogens, and passed on to sea cucumbers (Fig. 1) because

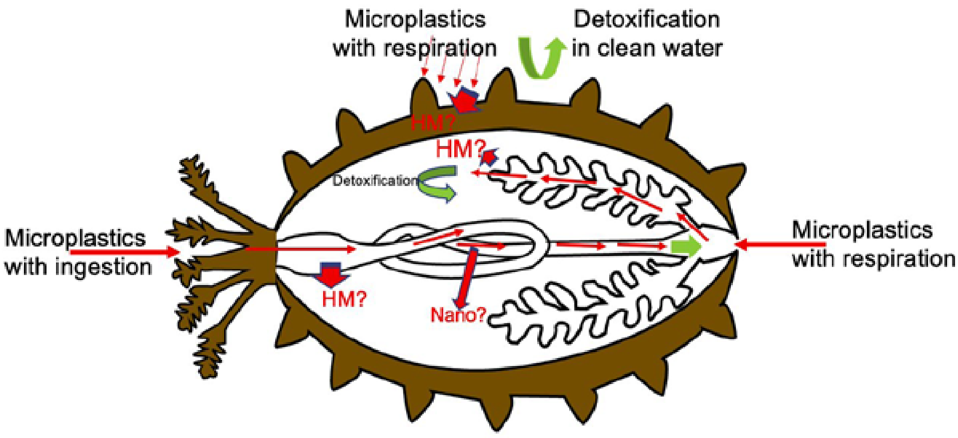


**Figure 1.** Microplastics pathway in sea cucumbers. Microplastics are taken up by sea cucumbers during feeding and respiration. These microplastics decrease in abundance when the sea cucumbers are transferred to clean seawater (i.e. filtered seawater). Polluted microplastics moving inside sea cucumbers can be vectors for transferring heavy metals (HM) or pathogens, which is worth future investigation. Also, the possibility of nanoplastics being transferred through the intestinal epithelium is worth investigating.

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microplastics adsorb a wide range of heavy metals (Mohsen et al. 2019) and potential pathogens (Mohsen et al. 2022a). Furthermore, microplastic transfer during the respiration of sea cucumbers can disturb their growth. Mohsen et al. (2023) showed in laboratory experiments that sea cucumbers exposed to microplastics two times and three times per week (thus had microplastics transferred in their coelomic fluid), had significantly affected growth rates over 60 days. It has been suggested that sea cucumbers should be farmed in areas where microplastic concentrations are low (Mohsen et al. 2023). Accordingly, microplastic abundance in the water should be added to water quality parameters for the healthy farming of high-quality sea cucumbers.

Although the microplastic pathway has been revealed in adult sea cucumbers, research on the microplastics and nanoplastics pathway in the larvae of sea cucumbers has not gained much attention. The uptake of 20-µm nanoplastics by larvae of the sea cucumber *Parastichopus californicus* has been demonstrated, and the uptake rate has been calculated (Hart 1991). However, the uptake and toxicity mechanism of nanoplastics is still not well understood, including the effect of different nanoplastic characteristics and their adsorbed pollutants or attached biofilm. Because sea cucumber larvae are useful in ecotoxicology and environmental risk assessment (Rakaj et al. 2021), microplastics and nanoplastics uptake and toxicology research on larvae is of potential value. The uptake and pathway research of microplastics and nanoplastics in sea cucumbers not only can clarify the fate and effects of emerging contaminants on these endangered species and echinoderms, but can also provide useful information about the physiology of sea cucumbers. For instance, when the deposit-feeding sea cucumber *Apostichopus japonicus* is exposed to microplastics in the water, it exhibits suspension-feeding behaviour (Mohsen et al. 2020a).

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## References

Barboza L.G.A., Vethaak A.D., Lavorante B.R., Lundebye A.K. and Guilhermino L. 2018. Marine microplastic debris: An emerging issue for food security, food safety and human health. Marine Pollution Bulletin 133:336–348.

Clark N.J., Khan F.R., Mitrano D.M., Boyle D. and Thompson R.C. 2022. Demonstrating the translocation of nanoplastics across the fish intestine using palladium-doped polystyrene in a salmon gut-sac. Environment International 159:106994. https://doi.org/10.1016/j.envint.2021.106994

Egbeocha C.O., Malek S., Emenike C.U. and Milow P. 2018. Feasting on microplastics: Ingestion by and effects on marine organisms. Aquatic Biology 27:93–106. https://doi.org/10.3354/ab00701

Eriksen M., Lebreton L.C., Carson H.S., Thiel M., Moore C.J., Borerro J.C., Galgani F., Ryan P.G. and Reisser J. 2014. Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PloS One 9 :e111913.

Graham E.R. and Thompson J.T. 2009. Deposit- and suspension-feeding sea cucumbers (Echinodermata) ingest plastic fragments. Journal of Experimental Marine Biology and Ecology 368 :22–29. https://doi.org/10.1016/j.jembe.2008.09.007

Hart M.W. 1991. Particle captures and the method of suspension feeding by echinoderm larvae. Biology Bulletin 180:12–27.

Iwalaye O.A., Moodley G.K. and Robertson-Andersson D.V. 2020. The possible routes of microplastics uptake in sea cucumber *Holothuria cinerascens* (Brandt, 1835). Environmental Pollution 264:114644. https://doi.org/10.1016/j.envpol.2020.114644

Khatmullina L. and Chubarenko I. 2019. Transport of marine microplastic particles: Why is it so difficult to predict? Anthropocene Coasts 2:293–305. https://doi.org/10.1139/anc-2018-0024

Mohsen M., Wang Q., Zhang L., Sun L., Lin C. and Yang H. 2019. Heavy metals in sediment, microplastic and sea cucumber *Apostichopus japonicus* from farms in China. Marine Pollution Bulletin 143 :42–49. https://doi.org/10.1016/j.marpolbul.2019.04.025

Mohsen M., Zhang L., Sun L., Lin C., Liu S., Wang Q. and Yang H. 2020a. A deposit-feeder sea cucumber also ingests suspended particles through the mouth. Journal of Experimental Biology 223(24):jeb.230508. https://doi.org/10.1242/jeb.230508

Mohsen M., Zhang L., Sun L., Lin C., Wang Q. and Yang H. 2020b. Microplastic fibers transfer from the water to the internal fluid of the sea cucumber *Apostichopus japonicus*. Environmental Pollution 257:113606. https://doi.org/10.1016/j.envpol.2019.113606

Mohsen M., Lin C., Hamouda H.I., Al-Zayat A.M. and Yang H. 2022a. Plastic-associated microbial communities in aquaculture areas. Frontiers in Marine Science 9.

Mohsen M., Lin C., Liu S. and Yang H. 2022b. Existence of microplastics in the edible part of the sea cucumber *Apostichopus japonicus*. Chemosphere 287:132062. https://doi.org/10.1016/j.chemosphere.2021.132062

Mohsen M., Chenggang L., Sui Y. and Yang H. 2023. Fate of microplastic fibers in the coelomic fluid of the sea cucumber A*postichopus japonicus*. Environmental Toxicology and Chemistry 42:205–212. https://doi.org/10.1002/etc.5513

Rakaj A., Morroni L., Grosso L., Fianchini A., Pensa D., Pellegrini D. and Regoli F. 2021. Towards sea cucumbers as a new model in embryo-larval bioassays: *Holothuria tubulosa* as test species for the assessment of marine pollution. Science of the Total Environment 787:147593. https://doi.org/10.1016/j.scitotenv.2021.147593

Rochman C.M. 2018. Microplastics research – from sink to source. Science 360:28–29. https://doi.org/10.1126/science.aar7734

Shanmugam V., Das O., Neisiany R.E., Babu K., Singh S., Hedenqvist M.S., Berto F. and Ramakrishna S. 2020. Polymer recycling in additive manufacturing: an opportunity for the circular economy. Materials Circular Economy 2:1–11.

Thompson R.C., Swan S.H., Moore C.J. and vom Saal F.S. 2009. Our plastic age. Philosophical Transactions of the Royal Society B: Biological Sciences 364:1973–1976. https://doi.org/10.1098/rstb.2009.0054

Vagner M., Boudry G., Courcot L., Vincent D., Dehaut A., Duflos G., Huvet A., Tallec K. and Zambonino-Infante J.-L. 2022. Experimental evidence that polystyrene nanoplastics cross the intestinal barrier of European seabass. Environment International 166:107340. https://doi.org/10.1016/j.envint.2022.107340

Wayman C. and Niemann H. 2021. The fate of plastic in the ocean environment – a minireview. Environmental Science: Processes and Impacts 23:198–212. https://doi.org/10.1039/D0EM00446D

Zimmermann L., Göttlich S., Oehlmann J., Wagner M. and Völker C. 2020. What are the drivers of microplastic toxicity? Comparing the toxicity of plastic chemicals and particles to *Daphnia magna*. Environmental Pollution 267:115392. https://doi.org/10.1016/j.envpol.2020.115392