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Microplastics' Effects on Marine Biology

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Introduction

Large concentrations of plastic debris are growing in our seawaters and negatively affecting various important marine life. It is a widely known fact that plastic is everywhere: it is in the air we breathe, in the tap water we drink, on beaches, in oceans, and more. Since plastic is used so much due to its durability, versatility, and inexpensiveness, plastic garbage has become a global environmental issue, with an estimated 5 to 13 million tons of plastic debris being released into the aquatic environments each year (Blankson et al. 2022). Also, plastic doesn't just disappear, even when we recycle it. Instead, plastics disintegrate into smaller particles known as microplastics which are less than 5 mm, the size of sesame seeds. Unfortunately, concentrations of microplastic debris are growing in our seawaters and impacting our marine life. A noted concern known as the ‘missing plastic phenomenon’ is beginning to appear and it is the observation that there are lower amounts of microplastics accounted for, compared to the suggested plastic amounts entering the water. This begs the question: “where are these microplastics going?” The answer is varied but nonetheless affects marine life in damaging ways. Reichert et al. (2021), suggests previous findings show that some microplastics are being deposited into permanent and/or temporary sinks such as the arctic sea ice, deep-sea and coastal sediments, with some clusters found in marine snow or organisms; yet other studies propose another detrimental potential sink for microplastics: living coral structures. This can be especially concerning when we consider the effects of microplastic pollution on worldwide reef-building coral colonies, which protect our shorelines and serve as a habitat for various organisms. Researchers note studies that show evidence of microplastics being found in the digestive tract of corals, resulting in the coral’s growing plastic particles. Furthermore, considering that many microplastics also end up in rivers and oceans, microplastics are very easily ingested into other marine organisms such as fish. Two such fish are the Bagrid Catfish and Black-chinned Tilapia of the Densu River in Ghana, two vastly important organisms for the economy of the region. The examination of ingested microplastics within these fish will not only tell us how often these species of fish are exposed to microplastics but will also inform us on how polluted the river is, whilst also shedding light on the potential threat to other marine life forms that microplastic pollution has. In addition, Humans lack a comprehensive understanding on what happens to the microplastics within the marine ecosystem. The microplastic problem has been growing so much to the point that microplastics are now present in our food chain in the form of fragmentized nanoplastics. Large concentrations of plastic debris are growing in our seawaters and negatively affecting various marine life. Living Coral Structures are being inundated by plastic micro-waste so much so that they've begun growing plastic particles. In the Ghana region, two economically important fish, the Bagrid Catfish, and the Black-chinned Tilapia are suffering population losses as a result of ingesting microplastics. Lastly, deep open marine ecosystems are growing evidence of the presence of microplastics within the animals, bottom floors sediments and trenches of the deep waters, Anela Choy et al. (2019).All of this represents the growing pollution and dangerous impact of microplastics on our marine life.

Methodology

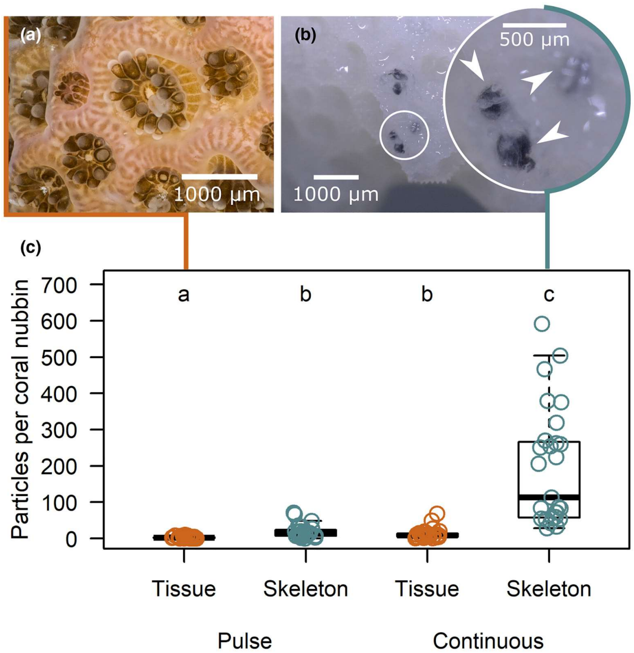
As observed and noted by past research and studies, microplastics are being found in all aspects of our environment and have shown to have detrimental effects on our marine life. This can be especially concerning when we consider the effects of microplastic pollution on worldwide reef-building coral colonies, which protect our shorelines and serve as a habitat for various organisms. Reichert et al. (2021) explore the “missing plastic” phenomenon and attempt to make sense of where the missing microplastics may be accumulating. Reichert et al., utilize black PE microplastic particles, which are one of the most common polymers in the marine environment, to study the deposition patterns in reef-building corals. The black color of the PE would assist in the visual identification of the particles in various structures of the coral reefs. The coral species utilized in the study are known as *Acropora Mucricata, Pocillopora Verrucose, Porites Lutea,* as well as *Heliopora Coerulea.* The species selected allow for a wider range of morphologies and rates of growth. Two different time frames were used, one of which was during 18 months of continuous exposure, and one was during a singular 24-hour period. This approach allows for observation of time frames for deposition, as well as whether the short-term experiments would appropriately mirror the results of the long-term studies. Nubbins in the long-term study were continuously exposed for 18 months, and nubbins in the short-term study were left in microplastic free control conditions for 17 months, before being exposed to microplastics for 24 hours. Nubbins were then either left to recover in microplastic-free conditions or re-exposed to microplastic particles for an additional month. Nubbins were analyzed throughout all conditions. The amounts of microplastics in exposure varied depending on realistic values as well as estimated values that align with future predictions of microplastics in our waters by the year 2100. All tanks were supplied with water from a close recirculation system that mimicked artificial seawater at a rate of 120 L a day. The coral species were all maintained under controlled laboratory conditions and temperature for 6 months before the experiment. Three nubbins from each colony were exposed to each tank condition; Long-term, Short-term, and Controlled microplastic-free, except the *Heliopora* nubbins, which only 1 for each condition was extracted due to the lack of more colonies. This resulted in a total of 9 nubbins for the *Acropora*, *Pocillopora*, and *Porites* colonies, and a total of 3 nubbins for the *Heliopora* colony. The *Pocillopora* nubbins experience high mortality so it was excluded from the analysis, giving a total of 27 nubbins to analyze. To analyze the coral tissue, the colony samples were dissolved in 7% sodium hypochlorite (NaClO) for 24 hours, whilst their remaining skeletons were rinsed in distilled water and put into a beaker. The remnants of the NaClO solution were then filtered through a 50 µm stainless steel sieve to remove the solution. The coral skeletons were dissolved in a hydrochloric solution (HCI) and then also filtered through a sieve. The particles were evaluated through a digital microscope.

With consideration of our various bodies of water, researchers begin to examine rivers and shorelines that are useful to aquatic ecosystems and devise an informative experimental design. Blankson et al. 's (2022) study includes the study area, which is the 116 km long Densu River in the Eastern Region of Ghana. Between February and April 2021, fish samples were bought from fishermen at Weija Dam and Densu Delta in the Densu River. The 48 fish specimens (24 specimens of Black-chinned Tilapia and 24 specimens of Bagrid Catfish) were obtained using a random sampling method, in which the fishermen were chosen at random and a maximum of two fishes were purchased from each of them. The specimens were then transferred on ice to the University of Ghana's Department of Animal Biology and Conservation Science, where they were stored frozen until they could be analyzed. Surface water samples were collected in acid-washed glass jars from three distinct places in each of the study habitats and kept at 4°C until analysis. Each 10 ml subsample taken from the glass jars of water, was later mixed with Potassium hydroxide (KOH) at 60℃ for 24 hours and then the mixed materials were filtered through 1.2 µm Whatman GF/C microfiber filter papers and residues dried at 60℃ for 24 hours. The sediment samples were individually wrapped in aluminum foil and transferred to the laboratory, where they were oven-dried to a consistent weight at 60℃. Dried sediment samples were homogenized with a ceramic pestle and mortar and approximately 10g each was weighed into a beaker and mixed with a NaCl solution (density ρ = 1.2 g/mL), containing a drop of olive oil to allow microplastics to collect rather than stick to the glass wall. Each mixture was stirred for 10 minutes and left for 4 hours after which the supernatant was slowly poured into tubes and mixed with potassium hydroxide (KOH) at 60℃ for 24 hours. Microplastics were seen using a Leica EZ4 HD stereo microscope and a Leica IC80 HD camera for image analysis.

In continuation of the different experimental designs used, other researchers, Anela Choy et al. (2019), expanded on our knowledge of microplastic pollution in marine environments through their meticulous design of their research that was conducted between January, february and april 2017 in the monterey bay pelagic ecosystem off the central california coast. A total of two collection sites were used, a series of remote operated vehicles were used to get the sample in the needed dept (epipelagic, 0-200m and mesopelagic, 200-1000m). Water samples were filtered in situ by samplers and coupled pumps on the vehicle. Particles larger than 100-µm were collected in a sterile mesh. An integrated flowmeter in the vehicle recorded the water levels from each depth. Strict measures were taken as to not provoke any contamination in the fragments of plastic. The authors also collected giant larvacean particle filtering houses, also known as sinkers. The eight individual sinkers were collected using detritus samplers on ROVs ventana and doc riketts across the depth range of 251 to 2,967 meters. Sinkers were then filtered using a sterile mesh with a vacuum pump system in a controlled shipboard environment. Freshly deceased crabs were also selected for the analysis.

Data & Results

In continuation of the studies completed, the results extracted are analyzed carefully and will allow us to have more insight into how microplastics are affecting our marine life. In the research conducted on the missing plastic phenomenon by Reichert et al. (2021), microplastics were observed in all studied nubbins, and in both the long-term and short-term nubbins. Higher amounts of particles were found in the long-term nubbins as opposed to the short-term nubbins. As seen in *Figure 1* below, microplastic particles in the coral and skeletal tissue are significantly gathered in the skeleton of the long-term nubbins. All four experiment conditions are depicted in box-and-whisker plots. *Figure 2* shows a more detailed analysis of the gathering of microplastic particles in all four conditions within each of the colonies. Particles gathered in the skeleton were a higher amount than in the tissue, in both time-frames of exposure and for all colonies.



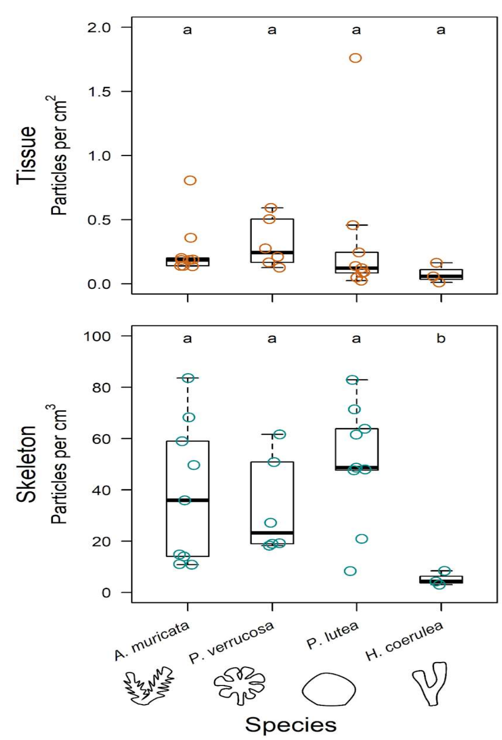


Figure 1 ***Figure 2***

Thus far, more significant results were gathered on behalf of the other experiments in regard to microplastic pollution. Blankson et al.'s (2022) study concluded that there was extensive pollution of microplastics in the Densu River. The Bagrid Catfish consumed a similar amount of microplastics as the Black-chinned Tilapia, however, both species ingested fewer plastics than marine fish species in Ghana's coastal waters. In addition, the Weija Dam's static water system facilitates the flotation of larger microplastics while the flowing waters of the Densu Delta are not selective in depositing microplastics between the sediments and the water column. As you can see from *Figure 1*, the number of microplastics was high in the gut of Bagrid Catfish from Densu Delta and in the gut of Black-chinned Tilapia in Weija Dam.

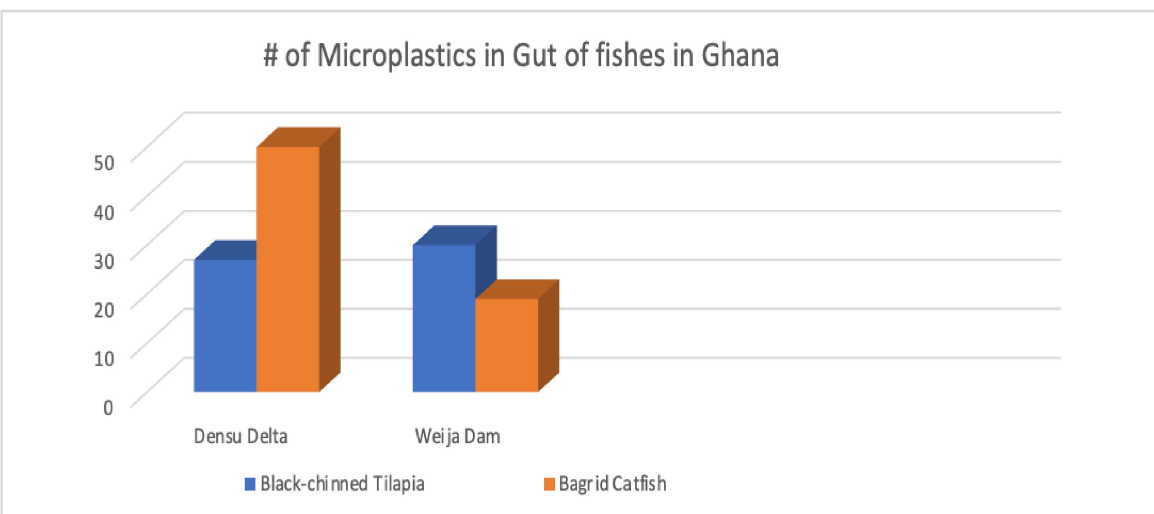


Figure 1

A closer look into the details of the following study is reported. A significantly big number of plastic polymers were found in the studies conducted in 2017. Microplastics concentration was higher in water samples collected below the mixed layer (15 particles m^{-3} at 200 m). Areas near the sea surface were low on microplastics concentration, but still had microplastics in them (median 2.9 particles L^{-1}). The concentration was higher in the mesopelagic zone. After analyzing bothe the offshores and near shores location it was found that microplastic concentration are higher at the offshore locations. Microplastics were more likely carried there by the wind or the current of that area. Plastics were also present in all pelagic red crab and giant larvacean sinker samples that were examined. The plastics in each sinker individual ranged from 3 to 17 particles per specimen while the red crab samples contained fewer than 5 particles per specimen, however, 3 individual crabs contained greater numbers than 10 microplastic particles each.

Discussion/Conclusion

A growing trend in global concerns is identifying plastic pollutants being released into the environment by humans and potentially creating a catastrophic issue to many ecosystems and our earth as we know it. As noted in the reviewed research, various reef-building coral species could have the potential to be a long-term sink for microplastics in the marine environment and is a leading factor in the missing plastic phenomenon. The short-term studies did not mirror the results of the long-term study, but this benefits us in the newfound knowledge that there is still time to prevent further contamination of our microplastics in our marine environment. Furthermore, as we have gathered from the studies above, two economically important species of fish in Densu River(Ghana): Bagrid Catfish and Black-chinned Tilapia are also ingesting high amounts of microplastics. To be more precise, there were more microplastics present in Densu Delta than the Weija Dam of the Densu River. These concerns should be at the forefront of our agenda as a species, to combat them before it is too late. The Monterey Bay marine ecosystem is part of a marine protected area, it was found that the marine concentrations match and exceed the records of other microplastics fragments found in other aquatic ecosystems. As some of the studies above are rather recent, the rapid spread of microplastics in our marine ecosystems is ongoing and very current. Further research could lead us towards more effective methods to prevent and stop the rapid pollution of microplastics.

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