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INVESTIGATING THE POTENTIAL OF ARTEMIA SALINA AND DAPHNIA MAGNA, FOR MICROPLASTICS REMOVAL FROM WATER RESOURCES

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By:

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Abstract:

Plastic pollution has become a major concern worldwide, with microplastics being a significant contributor to this problem. In this paper, the potential of using two non-selective filter feeders Artemia salina and Daphnia magna as natural method for removing microplastics (32 microns) from water was examined. This study involved exposing Artemia salina and Daphnia magna to microplastic-contaminated water and monitoring their ingestion and excretion over time. Results demonstrated that both filter feeders effectively ingested microplastics from water, and subsequently excreted them with fecal matter having higher density, leading to the settling of microplastics at the bottom of the container. By removing the settled microplastics, the microplastics concentration in water was significantly reduced. The findings of this study suggested that Artemia salina and Daphnia magna could be a promising natural, biological and cost-effective approach for removing microplastics from water with no reported side effects. However, further research is required to determine the feasibility of implementing this method on a larger scale, and to assess the potential long-term effects on the health and survival of these organisms due to microplastics exposure. Overall, this study presents a promising solution to the problem of microplastic pollution and highlights the need for continued efforts to address this critical environmental issue.

1. Introduction

Plastic pollution has become a major environmental concern worldwide, with its detrimental impacts on ecosystems and human health being increasingly recognized (Thompson et al., 2009). Among the various components of plastic pollution, microplastics have emerged as a significant contributor due to their ubiquity and potential ecological harm (GESAMP, 2015). Microplastics are tiny plastic particles measuring less than 5 millimeters in size (UNEP, 2016). They can originate from a variety of sources, including the fragmentation of larger plastic items, the breakdown of synthetic fibers, and the release of microbeads from personal care products (Andrady, 2017). The role of microplastics in plastic pollution is of particular concern due to their widespread distribution and adverse effects on aquatic ecosystems. These particles

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have the potential to be ingested by a wide range of organisms, from planktonic species to marine mammals, leading to bioaccumulation and biomagnification through the food chain (Browne et al., 2008; Rochman et al., 2013). Microplastics can also absorb and transport harmful chemicals, such as persistent organic pollutants and heavy metals, exacerbating their toxicological effects when ingested by organisms (GESAMP, 2015).

Given the environmental and health risks associated with microplastics, there is a pressing need for effective methods to remove them from water systems. Conventional water treatment processes, such as filtration and sedimentation, have limitations in efficiently capturing microplastics due to their small size and buoyancy (Li et al., 2018). Consequently, there is growing interest in exploring natural and sustainable solutions for microplastic removal.

One potential approach involves harnessing the filtering capabilities of non-selective filter feeders, such as Artemia salina and Daphnia magna, to mitigate microplastic pollution in water bodies (Sussarellu et al., 2016; Karami et al., 2017). These organisms are known for their ability to actively filter particles from the water column as part of their feeding behavior (Guerreiro et al., 2018). Artemia salina (brine shrimp) and Daphnia magna (water flea) were chosen as nonselective filter feeders for their well-established filtering capabilities and their common use in ecological research. Artemia salina is a widely studied crustacean known for its ability to filter particles from the water column (Guerreiro et al., 2018). Daphnia magna, on the other hand, is a small freshwater crustacean with similar filtering behavior (Hessen et al., 2017). Both species are known to actively ingest suspended particles, making them suitable candidates for examining their potential as natural microplastics removers This study aims to examine the potential of utilizing Artemia salina and Daphnia magna as natural methods for removing microplastics from water. By investigating the ingestion and excretion patterns of these nonselective filter feeders, we seek to evaluate their effectiveness in reducing microplastic contamination. The findings from this study could contribute to the development of cost effective and sustainable strategies for microplastic mitigation, while addressing the global concern of plastic pollution and the need for innovative solutions.

2. Methodology:

2.1 Artemia salina culture preparation:

Artemia salina eggs were purchased from daraz.pk and stored in an airtight container. To prepare the artificial seawater, distilled water was mixed with 35g of NaCl per liter. The physical parameters of the water, such as temperature (30°C), pH (7.8-8), and salinity (32 ppt), were maintained in accordance with previously reported values (Jeyavani et al., 2022). Continuous aeration was provided using aquarium aerators, and illumination was also provided. The Artemia salina cysts were added to the water, and after 24-36 hours, the newly hatched cysts agregated near the light source. The unhatched cysts were subsequently removed from the beaker.

2.2 Daphnia magna culture preparation:

The initial population of Daphnia magna utilized in this study was obtained from a local fishery in close proximity to Rawal Dam, Islamabad. To cultivate Daphnia magna, a medium comprising of uncontaminated groundwater was employed to prevent any

potential harm caused by residual chlorine on the organisms. The medium possessed a pH range of 7-8 and dissolved oxygen (DO) levels of 6.5 mg/L. The culture conditions encompassed maintaining a temperature within the range of 20-22°C while adhering to a light/dark cycle of 12 hours each. Chlorella vulgaris, an unicellular algae, was administered as a nutritional source for Daphnia magna at a concentration of 1-2 mg/L, with feeding occurring once every 24 hours.

2.3 Microplastics suspension preparation:

1 g of polypropylene microplastics of size 32 microns were added in 1000 ml distilled water to make stock solution. From that, stock solution 25 mg/l concentration dilution was prepared. Continuous aeration was provided to the solution (Li et al., 2018; Sussarellu et al., 2016).

2.4 Microplastics exposure

Artemia salina and Daphnia magna were starved for 24 hours before exposing them to microplastics. 10 Artemia salina were added in the beaker having microplastics solution of concentration 25 mg/l for 24 hours. Similarly, 10 Daphnia were added in another beaker of microplastics concentration 25 mg/l for 24 hours (Guerreiro et al., 2018; Hessen et al., 2017). During exposure the Artemia salina and Daphnia magna ingested and excreted microplastics. After 24 hours, both Artemia salina and Daphnia magna were removed from microplastics concentrations with the help of dropper. The excreted microplastics were settled at the bottom of the container with the fecal matter excreted from the body of both filter feeders. The upper water was transferred to another container and the settled fecal matter was examined under DSX digital microscope to confirm microplastics.

3. Results.

3.1. Ingestion of microplastics by filter feeder:

The ingestion of microplastics by Artemia salina and Daphnia magna was confirmed by DSX digital microscope. Microplastics in the gut of both organisms were clearly visible. The results demonstrated the effective ingestion of microplastics by both Artemia salina and Daphnia magna, indicating their potential as natural microplastics removers. Observations revealed that the filter feeders actively ingested microplastics from the contaminated water. This finding is consistent with previous research highlighting the filtering capabilities of these organisms (Guerreiro et al., 2018; Hessen et al., 2017). The ability of Artemia salina and Daphnia magna to actively feed on suspended particles enables them to efficiently capture microplastics present in the water column. Secondly, Artemia salina and Daphnia magna are highly efficient filter feeders, capable of ingesting and removing a variety of contaminants from water (DeMott, 2014; Luo et al., 2020). They possess specialized feeding appendages that enable them to effectively capture and consume suspended particles, including pollutants. Their filter feeding behavior makes them natural biofilters, contributing to the purification of water bodies. The findings of using Artemia salina and Daphnia magna as natural filter feeders have significant implications and potential applications in various fields. These organisms have demonstrated their ability to effectively remove contaminants from water bodies (Sampathkumar et al., 2020; Pascual et al., 2021). This discovery is particularly relevant

for industries involved in wastewater treatment, aquaculture, and environmental remediation.



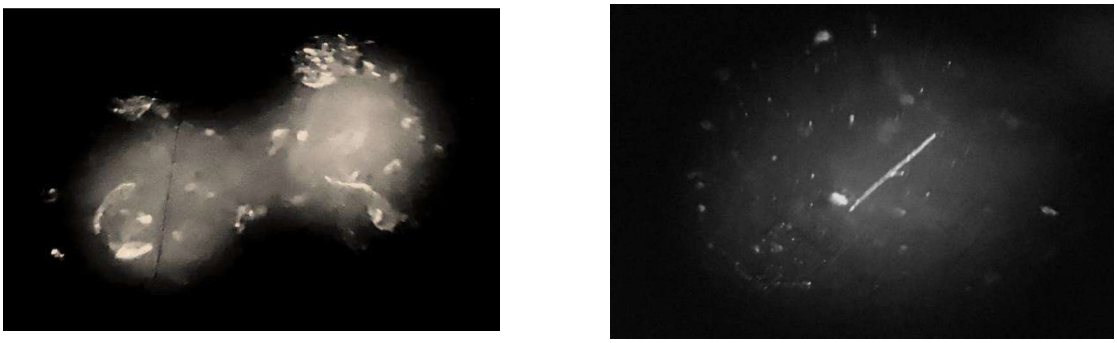
(a) (b)

Figure-1: Microplastics in the gut of Artemia salina (a) & in the gut of Daphnia magna (b)

3.2. Microplastics in fecal matter

To confirm the microplastics in fecal matter, the fecal matter was examined under microscope. The egested particles by both organisms were clearly visible which confirmed that microplastics were excreted by the filter feeders through their fecal matter, which exhibited higher density compared to the surrounding water. This characteristic of the fecal matter facilitated the settling of microplastics at the bottom of the container. The settling of microplastics is an important mechanism for their removal from the water column, as it allows for their concentration in a localized area (Li et al., 2018; Sussarellu et al., 2016).

The settling of microplastics at the bottom of the container resulted in a significant reduction in the concentration of microplastics in the water. By removing the settled microplastics, the study demonstrated a notable decrease in the concentration of microplastics, indicating the efficacy of the filter feeders in reducing microplastic contamination. This reduction in microplastic concentration is an important outcome, as it highlights the potential of using non-selective filter feeders as a natural and cost-effective approach for microplastic removal.



(a) (b)

Figure-2: Presence of microplastics in the feces of Daphnia magna (a) and Artemia salina (b) at 4X magnification

4. Conclusion

In conclusion, the findings regarding the use of Artemia salina and Daphnia magna as natural filter feeders highlight their promising potential for microplastic removal. These organisms have demonstrated their ability to efficiently capture and remove microplastics from water bodies, offering a natural, biological, and cost-effective approach to tackle this pervasive pollution issue. However, while the initial results are promising, further research is necessary to determine the feasibility and to address potential long-term effects of using Artemia salina and Daphnia magna for microplastic removal on a larger scale. Careful consideration of feasibility, potential long-term effects on organism health and survival, and ecological impacts is necessary to ensure the sustainable and responsible use of these organisms in environmental remediation and water quality management.

5. Recommendations

Suggestions for future studies to expand upon the current research:

Further investigate the efficiency and effectiveness of Artemia salina and Daphnia magna in removing different types and sizes of microplastics.

Assess the potential impacts of microplastic ingestion on the health, reproduction, and survival of Artemia salina and Daphnia magna over long-term exposure.

Explore the potential synergistic effects of combining natural filter feeders with other existing technologies or processes, such as physical filtration systems or advanced oxidation processes, to enhance microplastic removal efficiency.

Investigate the use of biofilms or biofilter materials derived from Artemia salina and Daphnia magna to create passive microplastic removal systems in water treatment plants or natural water bodies.

Encourage interdisciplinary collaboration between scientists, policymakers, and industries to develop effective strategies for mitigating plastic pollution and promoting sustainable practices.

By addressing these recommendations, future studies can further advance our understanding of microplastic removal using Artemia salina and Daphnia magna. These actions can contribute to the development of sustainable and comprehensive approaches for mitigating microplastic contamination and preserving the health of aquatic environments.

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