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REVIEW PAPER

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HIDDEN PART OF ICEBERG ABOUT PLASTIC POLLUTION: LEAKAGES AND PLANKTON, A CRITICAL PERSPECTIVE

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Abstract
Over the last decade, plastic became a symbol of threats for humanity today. The big pluses in its preference, such as its robustness and cheapness, can also be cited as reason for the ecological crisis. The leaching of the additives used during the production of this robust material into the water over time creates severe pressure on aquatic organisms. The present review reflects the potential impacts from plastic leaching on the primary producers and consumers of the aquatic ecosystem. For this reason, it is shown that the additives used during the production of plastics are released to the environment for some reasons. The ecological risks that these additives may pose are briefly explained in the present study.

Keywords: Plastic pollution, leakage, phytoplankton, zooplankton

Introduction
Materials have always been decisive and essential to the way of life for humanity. In fact, this relationship is so strong that the ages of humanity are classified according to the material that the human being have used (Wilson, 1851). From stone to metal and even plastic, these are impressive materials. However, the products that can change the way of life have burden on nature. Plastic, which is one of the symbol products of today's civilization, has also created a pressure on the environment and nature. The mismanaged waste of this product, which is not only limited by visual pollution, also affects the living organisms in the environment. Since the first record on its physical effect on *Laysan albatross* (*Phoebastria immutabilis*) by the 1960s in Hawaiian Islands (Kenyon & Kridler, 1969), it has been reported to be seen in many living organisms from zooplankton to sea mammals (Lusher et al., 2017). On the other hand, the chemical effects of plastics are a file that has not yet been fully elucidated. During the manufacturing process of plastics, many chemical materials are added to the structure of the product with cosmetic concerns or customizing the structure of the product. These substances,

called additives, are chemicals such as endocrine-disrupting chemicals (hereinafter EDCs) and heavy metals, that can be dangerous for the aquatic live. These EDCs can cause metabolic disorders, reproductive disorders, neurodevelopmental conditions, asthma, and cancers (Cingotti & Jensen, 2019). Heavy metals, which are other additives, are included in the structure of the plastic as a colorant as well as their biocide effect and stabilizer effects against physical wear such as UV. These added heavy metals (for example: As, Pb, Hg, Cr, Cd) can cause various cancers (Tchounwou et al., 2012). In addition to these, plastics can also absorb chemicals in their environment on their surfaces and carry them to organisms. Since the leachate of both additives and absorbed chemicals is related to the surface area of the plastic material, it can be assumed that the harm to the plastic increases as the surface area increases (Rochman, 2015).

Perhaps the most important issue in plastic pollution, which the human beings face more and more, is this leakage situation. The present article focused on the possible effects of;

(i) leakage to the water column,
(ii) leakage not only on zooplankton groups that can ingest plastics, but also on phytoplankton groups
(iii) exposing structures such as marine snow to leakage

These focused points have been visualized in Figure 1.

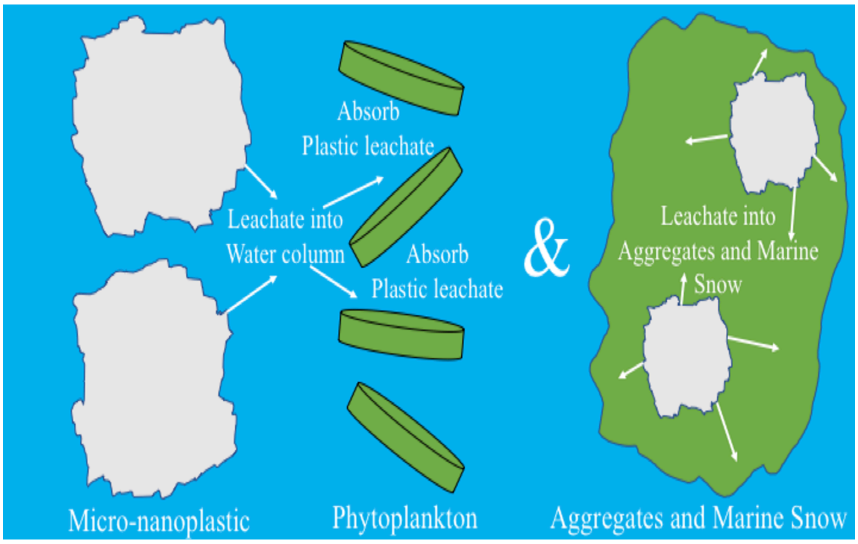

Figure 1. Graphical representation of the absorption of plastic leakage by phytoplankton and its leakages into aggregates and marine snow.

Water

The invisible significant effect of this pollution is that plastics release additives or re-release chemicals into the water column that they have already absorbed into their structure. *In-situ* experiments performed by Collins et al. (2023), showed that the plastic leakage into the water environment is affected by UV, and proved that plastics aged by force of UV and leakage to water. Further evidence was noted that some types of plastics did this process faster than others. This situation shows that toxic substances leaking from plastics can pass to living organisms such as phytoplankton which are not capable to intake particles. However, living organisms such as zooplankton can realize intakes which not only passes through the digestive system, but also through the respiratory system, via the skin.

Phytoplankton

Most of the phytoplankton and plastic leakage studies are conducted with *in-situ* experiments, mainly on growth rate of algae. In studies conducted in media with both direct plastic and only plastic additives, a negative effect on algae was found (Amaneesh et al., 2022). Although studies continue in this area, these studies, which were developed in a laboratory environment for a period of up to a few days and did not follow a fixed protocol, may not adequately reflect in peril that can be experienced in nature.

Aggregates and Marine Snow

For aggregates and marine snow, this leakage situation is slightly different. Not only is the leakage to the nature effective, but also there may be some disadvantages in building a structure together with plastic. This structure can be formed in several different ways., Biofouling formation is also valid for plastics as it is for almost every material in aquatic systems (Fazey & Ryan, 2016). Plastics that are primarily covered by bacteria (Wright et al., 2020) can also be coated with other biofouling levels, depending on their size. Even a plastic particle can be completely covered with organic material and turn into a structure called eco-corona (Galloway et al., 2017). In this case, the possibility of being consumed by both zooplankton and other intake-able creatures may increase. In addition, it becomes inevitable for these creatures that cover the surface of plastic to be affected by plastic leakage (Galloway et al., 2017). Another effect may be coincidental capture to aggregates or marine snow structures already in the water column. In this case, it may leak into the organic material, which is directly proportional to the time it is in the structure of which it has become a part. Yet another way of attaching to aggregate is faecal pellets. In this case, the fact that an organism that can produce faecal pellets already has plastic in its structure is another way for the formation (Shore et al., 2021). Considering that only a single zooplankter can encapsulate 17.81×10^4 microplastic spheres (10 µm *Ø*) in its gut (Gürses et al., 2022), this is a notable effect. In this case, it is possible to make an addition load on the organic material in the aggregate structure. In addition to all these, even if a low-density plastic included in aggregate or marine snow, it could become sinkable by gaining vertical mobility in the water column as it will move with the density of the structure (Kooi et al., 2017). This may extend its influences to a wider range of living organisms at greater depths in long run.

Conclusion

The present review article briefly explained the relationship between plankton and plastic leaching. Although there is increasing interest in plastic pollution, clarifying the ring of primary producers and consumers is essential for the understanding of their bioaccumulation in the ecosystem. For this purpose, besides focusing on zooplankton, it is important to understand the pressure that phytoplankton face in this plastic pollution. An ecotoxicology protocol should be determined especially for phytoplankton experiments. Further, interdisciplinary studies are encouraged in. future investigations in order to figure out the level of effects on the nature. Also, realistic steps need to be taken as soon as possible by international organizations to slow down the increasing threat of plastic pollution.

Ethical approval
No ethical approval needed for this study.

Informed consent
Not available

Conflicts of interest
There is no conflict of interests for publishing this study.

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Contribution of authors
Rıdvan Kaan Gürses: conceptualization, writing original draft, investigation, methodology, resources, validation, visualization, and finalizing paper.

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