Journal of Tropical Diversity
eISSN: 3090-3769, pISSN: 3090-4536

(Review)

Hubungan antara Kelimpahan Mikroplastik dan Keanekaragaman Jenis Plankton

The Relationship between Microplastic Abundance and Plankton Type Diversity

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Abstrak: Penelitian ini bertujuan untuk mengevaluasi hubungan antara kelimpahan mikroplastik dengan keanekaragaman jenis plankton. Mikroplastik sebagai salah satu polutan baru yang semakin meresahkan dapat mempengaruhi kualitas ekosistem perairan, termasuk komunitas plankton. Pengambilan sampel air dilakukan di beberapa titik perairan Kwatisore untuk mengukur konsentrasi mikroplastik, sekaligus untuk mengidentifikasi dan menghitung jenis plankton yang ada. Hasil analisis nantinya akan menunjukkan bahwa terdapat hubungan yang negatif antara kelimpahan mikroplastik dengan keanekaragaman jenis plankton. Meningkatnya konsentrasi mikroplastik akan menyebabkan menurunnya jumlah dan keanekaragaman jenis plankton yang dapat berdampak pada kestabilan ekosistem perairan. Temuan ini menggarisbawahi pentingnya pengelolaan dan mitigasi pencemaran plastik untuk menjaga kesehatan ekosistem perairan. Penelitian lebih lanjut diperlukan untuk memahami mekanisme dampak mikroplastik secara lebih mendalam dan menyusun strategi konservasi yang efektif.

Kata kunci: Keragaman, mikroplastik, plankton

Abstract: This paper aims to evaluate the relationship between microplastic abundance and plankton species diversity. Microplastics, as a new and increasingly disturbing pollutant, can affect the quality of aquatic ecosystems, including plankton communities. Water samples were taken from several points in Kwatisore waters to measure microplastic concentrations, as well as to identify and count the types of plankton present. The results of the analysis will later show that there is a negative relationship between the abundance of microplastics and the diversity of plankton types. An increase in microplastic concentrations is associated with a decrease in the amount and diversity of plankton, which can impact the stability of aquatic ecosystems. These findings underscore the importance of managing and mitigating plastic pollution to maintain healthy aquatic ecosystems. Further research is needed to understand the impact mechanisms of microplastics in more depth and to develop effective conservation strategies.

Keywords: Diversity, Microplastics, Plankton

PEER Review Process
Submitted: 16/12/2024
Reviewed: 29/01/2025
Revised: 12/02/2025
Received: 20/02/2025
Published: 28/02/2025

Doi: 10.64283/jotdiverse.2025.1(1):6

Citations: Astricyah, I., Leuwakabessy, J., and Toha, A.H.A. (2025). The Relationship between Microplastic Abundance and Plankton Type Diversity. Journal of Tropical Diversity. 1(1): 43-55, doi: https://doi.org/10.64283/jotdiverse.2025.1(1):6

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1. Introduction

The waters of Kwatisore in Umar Bay were chosen as the research location because of their biodiversity and the potential impact of microplastic pollution that threatens the ecosystem, according to Hamberi et al. (2022). These waters not only provide vital fish resources, but also support various economic and cultural activities of the community (Siboro, 2019). This area is known for its high diversity of marine life and is an important part of the coastal ecosystem (Vatria, 2013; Baransano, et al., 2011). However, increasing human activities around these waters, such as fishing and shipping activities, have the potential to increase the concentration of microplastics in the area (Shafani, et al., 2022; Millenia, 2023). By understanding the impact of microplastic pollution in locations with high biodiversity, we can get a clearer picture of its effects on this vital aquatic ecosystem (Sulistyowati, et al., 2023; Hertika, et al; 2019; Jaya, et al., 2024).

Microplastics are plastic particles less than 5 mm in size, which have become a global concern because of their impact on aquatic ecosystems (Castileon, et al., 2024; Octarianita, 2021). Microplastic pollution can disrupt the balance of aquatic ecosystems, especially in interactions with microscopic organisms such as plankton (Jamalia, 2023). Plankton, which is made up of phytoplankton and zooplankton, play an important role in the aquatic food chain and contribute to primary productivity (Alianto, 2024; Cahyanurani, 2024). This study aims to examine the relationship between the abundance of microplastics and the diversity of plankton species in the waters of Kwatiosore Umar Bay. The presence of microplastics in the waters is suspected to affect the life of aquatic organisms, one of which is plankton. Plankton in the waters plays a role in the food chain, where phytoplankton is the main producer so that it becomes the link between primary producers and larger biota. The adverse impact of microplastic pollution in the ocean molecularly to physiological processes includes the potential for declining organism health (Fath, 2019).

Microplastics cannot be easily removed from the marine environment and plastic is a very persistent material. Microplastic particles are found in almost 85% of the sea. Microplastics with a particle size of < 5 mm have been widely detected in many waters around the world (Permatasari & Radityaningrum, 2020). The diversity of plankton species in Indonesian waters is very important to maintain the balance of the ecosystem and support the life of fish and other organisms in it" (Saputra, 2022). They play a key role in the food chain and biochemical processes of waters. On the other hand, microplastics, which are often invisible to the naked eye, can have a significant impact on plankton organisms through various mechanisms. Measuring the abundance of microplastics and plankton diversity provides insight into how plastic pollution affects the structure of plankton communities and the overall health of the ecosystem.

Examining the relationship between microplastic abundance and plankton diversity is important to understand the impact of microplastics on aquatic ecosystems. Previously, research by Zhang et al. (2019) showed that increasing the concentration of microplastics could decrease the diversity of plankton in coastal waters in China. Another study by Lusher et al. (2017) found that microplastics can interfere with the feeding process and growth of plankton in North Atlantic waters. This study aims to explore how the abundance of microplastics affects the diversity of plankton species in the Kwatisore Waters, Umar Bay, and provide information that can be used for the management and conservation of these aquatic ecosystems.

2. Material and Methods

In a comparative analysis of ten journal research results that examined the abundance of microplastics and plankton diversity, several patterns and variations were found based on the method, research location, and results obtained. In general, research on microplastics shows a wide distribution in various aquatic ecosystems in Indonesia, with the main factors affecting abundance being human activities, such as tourism, ports, and household pollution. Forexample, the research of Ayuingtyas et al. (2019) in the waters of Banyuurip, Gresik found an abundance of microplastics of 57.11 x 10^2 particles/m^3, with fragments being the most dominant type. Another study in the Karimunjawa Islands by Seprandita et al. (2022) also found a high abundance around Syahbandar Port, with the dominance of fragments, fiber, film, and pellet microplastics. These findings are consistent with research by Muchlissin et al. (2020) in Karimunjawa which reported higher abundance in areas with intense human activity, such as tourism and ports.

In the study of aquatic biota, Sandra and Radityaningrum (2021) showed that the Broom-Broom fish has the highest concentration of microplastics, with polyethylene (PE) as the dominant polymer in surface aquatic biota. On the other hand, Tobing et al. (2020), who researched fish for consumption in Bali, found that 43.82% of the fish sampled contained microplastics, which have the potential to harm human health through the food chain. In studies related to microplastics in sediments, variations in microplastic abundance were also found depending on environmental conditions. Research by Ningrum et al. (2022) in Gili Ketapang, Probolinggo, revealed that film is a type of microplastic that ismostly found in sediments, while in Bokori Island, Southeast Sulawesi, Riska et al. (2022) reported that fiber is the most dominant type of microplastic in sediments. The study showed that the abundance and type of macroplastics varied depending on local factors such as ocean currents and human activity around the study site. Here we attach a table from 10 previous studies on the abundance of microplastics and planton diversity.

Table 1. Literature Studies

No	Journal Identity	Journal Type	Method	Result
1.	The abundance of microplastics in the waters of Banyuurip, Gresik, East Java. Ayuingtyas, W. C., Yona, D., Julinda, S. H., & Iranawati, F. (2019).	JFMR (Journal of Fisheries and Marine Research)	ANOVA one way test	The total abundance of microplastics in the waters of Banyuurip reached 57.11 x 10^2 particles/m^3, with the most dominant type of fragment, especially in mangroves (22.89 x 10^2 particles/m^3). The source of fragment pollution comes from household waste and anthropogenic activities, and the accumulation in mangrove roots is higher than in other locations.
2.	Abundance of microplastics in reef ecosystem sediments in Karimunjawa Marine National Park. Muchlissin, S. I., Abi Widyananto, P., Sabdono, A., & Radjasa, O. K. (2020).	Journal of Tropical Oceans	Microplastic extraction method by Cordova et al., 2018.	Research shows that the abundance of microplastics in areas with human activities such as tourism, ports, and shipping routes has a high abundance compared to conservation areas or areas with little human activity.
3.	Study on the abundance of microplastics in aquatic biota. Sandra, S. W., & Radityaningrum, A. D. (2021)	Journal of Environmental Science	Literature Study on Articles Published in the Last 10 Years	The study showed that the abundance of microplastics (MP) was highest in Sapu-Sapu fish (468 particles/individual), with the dominant MP measuring 20-50 µm, fibrous, and black in color. Polyethylene (PE) is dominant in surface aquatic biota, while polyprophylene (PP) and PE are found in marine aquatic biota.
4.	The abundance of microplastics in the waters of residential zones, tourism zones and protection zones of the Karimunjawa Islands, Jepara. Seprandita, C. W., Suprijanto, J., & Ridlo, A. (2022)	Marina Oceanography Bulletin	The microplastics obtained were analyzed for their shape, color, and abundance using an electron microscope with a magnification of 100 times	The study showed the highest abundance of microplastics in the waters of Syahbandar Port (19.98 particles/m^3), followed by Menjangan Kecil Island (17.21 particles/m^3) and Cemara Kecil Island (14.8 particles/m^3). Microplastics are in the form of fragments, fibers, films, and pellets, with types such as HDPE, LDPE, PS, PP, PVC, Nitrile, Nylon, and CA.
5.	Types and Abundance of Microplastics in Sediment in Gili Ketapang, Probolinggo.	Journal of Marine Research	The method used begins with water sampling by purposive random sampling	In sediment, several colors were found for fibers, namely blue, green and red, for the type of fragments yellow, blue, red, and green, while in the type of filament only one color was found, namely clear white. The size of microplastics in sediments is 0.025–2.975 mm. The

	Ningrum, I. P., Sa'adah, N., & Mahmiah, M. (2022)			abundance of microplastics in sediments at 3 stations was the most in the film type as much as 1635 particles/kg and the least was 1180 particles/kg with the type of fiber microplastics.
6.	Characteristics of Microplastics in Marine Fish Consumption Landed in Bali. Tobing, S. J. B. L., Hendrawan, I. G., & Faiqoh, E. (2020).	Journal of Marine Research and Technology	Interviews and Quality control & quality assurance	This study reveals the characteristics of microplastics in fish for consumption in Bali. Of the 89 fish studied, 39 were contaminated with 69 microplastics (fibers, fragments, films) and 1 mesoplastic. Plastic size 0.32 to 22 mm with an abundance of 0.78 particles/fish. These microplastics have the potential to harm marine organisms and humans through bioaccumulation.
7.	Abundance of Microplastics in the Waters of Temajo Island, Mempawah, West Kalimantan. Fadhilah, W., Sofiana, M. S. J., Safitri, I., & Kushadiwijayanto, A. A. (2023)	Equatorial Sea Journal	The identification of the type of microplastic was carried out using a microscope, and the identification of the type of microplastic polymer was carried out using FTIR spectrophotometry	The results showed that station I had a higher total abundance of microplastics (6823.30 particles/L) compared to station II (4766.38 particles/L), with the percentage of film (66.53%), fragments (7.28%), fiber (25.36%), and pellets (0.83%). The types of polymers identified are High-Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Polypropylene (PP), Polyvinyl Chloride (PVC) and Poly Methyl Methacrylate (PMMA).
8.	Abundance of Microplastics in Coral Reef Ecosystem Sediments on Bokori Island, Southeast Sulawesi. Riska, R., Tasabaramo, I. A., Lalang, L., Muchtar, M., & Asni, A. (2022).	Journal of Indopacific Aquatic Resources	The environmental quality parameters measured were temperature, dissolved oxygen, pH, salinity, water brightness, current velocity, nitrates and phosphates. Sampling using the purposive sampling method	Research in the waters of Bokori Island found four types of microplastics in sediments: fiber, foam, film, and fragments. Fiber is the most dominant with 41,564 particles/kg of dry sediment, while foam is the lowest with 9,379 particles/kg. The difference in abundance between locations is due to the varied environmental characteristics.
9.	Plankton Diversity on Jeranjang Beach, West Lombok Regency for the preparation of animal ecology modules. Safnowandi, S. (2019).	JUPE: Mandala Education Journal	Plankton sampling was taken at three stations, each of which was taken at three points (plots) carried out during the day, by filtering 50 L of seawater using plankton nets	Based on the results of the study, 21 species from four classes were obtained, namely, Bacillariophyceae, Dynophyceae, Haptophyceae, and Crutaceae. The results of this research are then compiled into modules to be used as a source of information to students.
10.	Plankton Diversity in the Komering River, Serdang Menang Village, Sirah District, Padang Island, OKI Regency.	Science: Scientific Journal of Mathematics and Natural Sciences	The sampling method uses Purposive Random Sampling which consists of 3 observation stations	Research in the Komering River found three classes of phytoplankton (Bacillariophyceae, Chlorophyceae, Cyanophyceae) and four classes of zooplankton (Mastigophora, Monogononta, Crustacea, Ciliophora). The highest phytoplankton diversity index was at station 1 (1.39) and zooplankton at station 3 (0.33), while the

Febrianto, M. T., Yusanti, I. A., & Anwar, S. (2020).		dominance index showed no plankton genus predominated.

Research on plankton diversity also shows variations in species composition and distribution across different aquatic locations. Safnowandi (2019) found a fairly high diversity of plankton on Jeranjang Beach, with 21 species from four classes arranged into animal ecology modules. Meanwhile, Febrianto et al. (2020) reported the existence of three classes of phytoplankton and four classes of zooplankton in the Komering River, with the highest diversity index for phytoplankton at station 1. Overall, the results of this study highlight the importance of understanding the impact of microplastics on aquatic ecosystems and the organisms living in them, as well as the importance of mitigation efforts to reduce microplastic pollution, especially in areas with high human activity. The variation of the results of microplastics research on waters, sediments, and biota shows that the type and abundance of microplastics is highly dependent on the characteristics of the local environment as well as the type of human activities around it. Likewise in plankton diversity studies, the results are greatly influenced by different local environmental factors, such as water quality and water currents.

3. Results and Discussions

3.1 Diversity of Plankton

Rahmatiza, et al. (2020) stated that plankton comes from the Greek word which means floating. Plankton usually flows with ocean currents. Plankton are also commonly called biota that live in pelagic mintakat and float, drift or swim very agile, meaning they cannot go against the current. Plankton are any drifting organisms (animals, plants, archaea, or bacteria) that occupy oceanic, oceanal, or freshwater pelagic zones. They are divided into two main categories: phytoplankton (plant plankton) and zooplankton (animal plankton). Phytoplankton, like microalgae, perform photosynthesis and produce oxygen, and are an important part of the aquatic food chain. Zooplankton, on the other hand, are consumers who feed on phytoplankton and other plankton organisms. Plankton play a crucial role in aquatic ecosystems, including in nutrient cycles, ecosystem community structures, and ecosystem balance.

Plankton are organisms that are very sensitive to changes in the surrounding environment, so they are able to determine life in waters and can be used to determine the condition or quality of waters. The existence of plankton in an aquatic ecosystem can provide information about the condition of the waters through the diversity of plankton types in it. Plankton play a role as a producer in the aquatic ecosystem. Plankton can be used as one of the bioindicators to determine the primary productivity of aquatic waters because it has a role as a producer (Nurmalitasari & Sudarsono, 2023). The scientific findings referred to here are not the data obtained from the research results.

3.2 Diversity of Species

Species diversity is a community trait that shows the level of diversity of the types of organisms present in it. To obtain this type diversity, it is quite necessary to have the ability to recognize and distinguish types even though they cannot identify the types of Microorganisms. Species diversity refers to the variation or difference in species that exist in a community or ecosystem. In the context of aquatic ecosystems, this includes the number of different species as well as the genetic and functional diversity of those species. Species diversity is important for ecosystem stability because diverse species can provide a variety of ecosystem functions and increase resilience to environmental changes and disturbances (Tolangara, 2020).

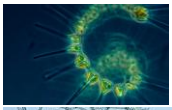
According to Sipahelut, et al. (2019) species diversity can indicate species in the entire ecosystem and species diversity can also be the number of species and the number of individuals in one community. So species diversity is the number of types and the number of individuals of each type. Type wealth can be calculated by the type or area index, which is the number of types per unit area. Equality or acculturability is the equal division of individuals among the types. However, in reality, each type has a different number of individuals. Equality is maximum when all species have the same or equal number of individuals, a simple way to measure species diversity is to count the number of types (S) or species.

3.3 Diversity of Plankton Types

Plankton can be divided into 2 types, namely zooplankton and phytoplankton. Phytoplankton, also called vegetable plankton, are plants whose lives float or float in the sea. It is so small that it cannot be seen by the naked eye. Generally, phytoplankton are 2 – 200µm in size (1 µm = 0.001mm). Phytoplankton are generally single-celled individuals, but there are also chain-shaped. Phytoplankton are the main autotrophic organisms in marine life. Through the photosynthesis process carried out, phytoplankton are able to become an energy source for all marine life through the food chain mechanism (Evita, et al. 2021).

Zooplankton, also called animal plankton, are animals whose lives float, or float in the sea. Zooplankton are heterotrophic, which means they cannot produce their own organic matter from inorganic materials. Plankton have a very important ecological role in supporting life in the waters, but if their growth is not controlled, it will be detrimental even though they are relatively small (Rahmatiza, et al. 2020).

Table 2. Diversity of Plankton Types

It	Genus	Kind		Numbe r of Species	Photograph	Source
		Fito plankton	Zoo plankton			
1	Bacillariophyceae	√		100.000		https://www.forestdigest.com/detail/1716/apa-itu-fitoplankton
2.	Cyanobacteria	√		2.000		https://en.wikipedia.org/wiki/Cyanobacteria
3.	Kopepoda		√	13.000		https://id.wikipedia.org/wiki/Kopepoda
4.	Krill		√	80		https://id.wikipedia.org/wiki/Kril

3.3 Abundance of Microplastics

Microplastics are a type of plastic waste that is smaller than 5 mm in size and is grouped into 2 types, namely primary and secondary microplastics. Primary microplastics are defined as microparticles that are deliberately produced such as for cosmetic needs or synthetic clothing fibers, while secondary microplastics are the result of fragmentation or change to a smaller size physically but the molecules remain the same in the form of polymers. Microplastics come in various types and shapes, varying including in terms of size, shape, color, composition, density, and other properties.

Microplastics are in the ocean in several ways: (1) plastic fragmentation in the sea, (2) microplastics directly reach the sea, (3) microplastics that are accidentally lost in the processing process, (4) waste treatment products that are dumped into the environment (Kershaw, 2015). Microplastics are usually in the form of fragments, films, and fibers. This type of microplastic fiber is commonly found in coastal areas, because this microplastic waste comes from residential areas where people have jobs as fishermen Microplastic fiber has characteristics that resemble fibers or fishermen's nets and when exposed to ultraviolet lights it will be blue. The type of microplastic film has a characteristic

characteristic, which is shaped like a sheet or plastic fragment. Film is a secondary plastic polymer that comes from the fragmentation of plastic bags or packaging plastics and has a low density. Fragment microplastics are characterized by the shape of plastic fragments, unlike the type of film microplastics which are in the form of sheets and the type of microplastics in the form of fibers. The process of plastic degradation is caused by UV radiation which triggers oxidative degradation of polymers. During the degradation stage, plastic waste has characteristics such as discolor, becoming softer and easily destroyed over time. Other mechanical influences are wind, ocean waves, animal bites and human activities that can break plastic into fragments.

Microplastics that enter the water will enter the water body and will eventually settle in the sediment. Microplastics are more commonly found in sediment than in estuarine or sandy beach habitats, beaches and habitats are dynamic so that sediment erosion can occur which causes plastic particles to increase in density. Microplastics that settle in sediments and occur continuously will cause the accumulation of microplastics in the deeper layers of sediment. The properties of these microplastics can undergo changes such as their density, which is caused by prolonged exposure to sunlight in the sea, weathering, and biofouling (Azizah, et al. 2020).

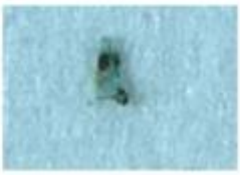
3.4 Microplastics can be divided into two main categories based on their origin

Primary Microplastics: Plastic particles produced in small sizes for a specific purpose, such as in cosmetic products (scrubs) or lubricants. They are already in microform when released into the environment. Secondary Microplastics: Formed from larger plastic fragments, such as plastic bottles or bags, that degrade due to exposure to sunlight, oxidation, and other environmental factors. This process produces small particles that can pollute the waters (Laila, et al. 2020).

3.5 Types of Microplastics

Plastic Seeds (Nurdles): Round or oval in shape, often used as industrial raw materials. Plastic Fibers: Usually derived from synthetic clothing and textile products that are discarded through washing. Microplastic granules: Derived from consumer products such as facial scrubs and toothpastes (Sugandi, et al. 2021).

Table 3. MP Shape: 1. Fiber; 2. Fragment; 3. Sheet; 4. Film; 5. Granule; 6. Pellets.

No	Genus	Number of Species	Photograph	Source
1	Fiber	5,78%		(Sandra & Radityaningrum, 2021)
2	Fragment	5,98%		(Sandra & Radityaningrum, 2021)
3	Sheet	5,1%		(Sandra & Radityaningrum, 2021)

4	Movie	1,3%		(Sandra & Radityaningrum, 2021)
5	Granule	5%		(Sandra & Radityaningrum, 2021)
6	Pellet	1,89%		(Sandra & Radityaningrum, 2021)

3.6 Color Characteristics of Microplastics

MP has different color characteristics. Based on the color, MP can be categorized into six categories: blue, black, yellow, transparent, white and red. The blue category includes blue, dark blue, light blue, dark green and light green (Salsabila, et al. 2023).

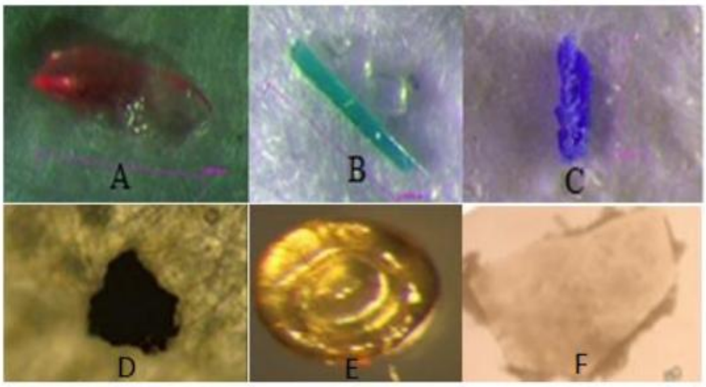


Figure 1. MP color: A. Red; B. Green; C. Blue; D. Black; E. Yellow; F. White/transparent.

3.7 Abundance of Microplastics

The existence of plastic waste in the sea is found in different abundance on the surface, middle and bottom of the sea. Different types of plastics with different densities affect their abundance in ocean waters. The abundance of microplastics refers to the concentration and distribution of microplastic particles in an environment (Haji, et al. 2021).

3.8 Concentration Qualification

Increased concentrations of microplastics in aquatic bodies can reduce the ability of plankton, such as phytoplankton, to process photosynthesis and growth, as well as disrupt zooplankton metabolism. Microplastic concentrations are measured through water filtration or sediment analysis, where the number of microplastic particles is calculated per volume of water or sediment mass, providing an overview of their impact on aquatic organisms. High concentrations of microplastics are often associated with a decrease in plankton diversity, causing certain species to dominate, while the more sensitive ones decrease.

3.9 Geographical and Temporal Distribution

The abundance of microplastics varies geographically, with higher concentrations found in areas near settlements, ports, and industrial areas, where human activity is more intensive. Microplastic concentrations can change over time, for example increasing during the rainy season when river flows carry more plastic waste into the ocean. Microplastics are often distributed at sea level, but they can sink to the seafloor due to biofouling, which also affects the distribution of plankton in various layers of water.

3.10 Sources and Transportation Routes

Microplastics enter the waters through several pathways, such as greater plastic fragmentation, industrial waste, cosmetics, and synthetic clothing fibers. These pollutants are carried by water currents and dispersed to various aquatic ecosystems, including plankton habitats. Ocean currents play a major role in the spread of microplastics. These particles can be carried away from their original source and spread to coastal areas as well as open waters, where plankton live. Microplastics can also settle on the seafloor, where plankton approach or carry out daily activities, magnifying the potential for contamination.

The abundance of microplastics can vary significantly depending on geographic location, human activity, and environmental factors. In areas with high industrial activity or dense populations, the abundance of microplastics tends to be higher compared to more remote or protected areas. Monitoring the abundance of microplastics is important to understand their impact on the environment and ecosystem health, as well as to design effective mitigation strategies (Kapo, et al. 2020).

3.11 The Relationship between Microplastic Abundance and Plankton Type Diversity

The abundance of microplastics in the waters of Kwatiosore Umar Bay has the potential to significantly affect the diversity of plankton species. Microplastics, which often resemble food for plankton, can be consumed by these microscopic organisms and interfere with their biological functions. The immediate impact is a decrease in the growth and reproduction rate of plankton, which leads to a decline in the population of some species. Research shows that high concentrations of microplastics can lead to changes in the composition of plankton communities, where species that are more resistant to environmental changes tend to dominate, while more sensitive species experience a decrease in numbers (Laksono, et al. 2021).

In addition, the presence of microplastics in the aquatic food chain can exacerbate pollution at higher trophic levels, as plankton is a staple food for many other marine organisms. The negative relationship between microplastic abundance and plankton diversity in the region suggests that aquatic ecosystems face serious threats, especially related to the overall health of the ecosystem. With reduced plankton diversity, the balance of the food chain can be disrupted, ultimately affecting fisheries productivity and the sustainability of marine resources in Umar Bay (Ambarsari & Anggiani, 2022). Here's an explanation of how the two are related:

3.12 The Impact of Microplastics on Plankton

Ismi, et al. (2019) The existence of MP in marine waters will have a negative impact on biota, both directly and indirectly. Smaller plastic waste, such as bottle caps, matches, and plastic pellets, can be ingested by aquatic organisms and cause intestinal blockages and potential chemical poisoning. Consumption of plastic by aquatic biota can cause internal bleeding and ulcers, as well as blockages in the digestive tract. MP particles also have the potential to be toxic to fish, namely physical and chemical toxicity, because basically MP absorbs addictive substances and other monomers that are toxic.

Hanif, et al. (2021) stated that the direct impact of MP entering the body of marine organisms can interfere with the work of the digestive tract, as a vector/carrier of additional materials, and also other organic pollutants that are adsorbed in MP. Aquatic biota that ingests can indirectly be consumed by MP-contaminated prey. Plastic also has the potential to absorb and release harmful chemicals into the waters so that it has a bad impact on the food chain system, resulting in biomagnification. MP waste can enter aquatic biota, which has the potential to interfere with human health if consumed through the food chain. The small size of microplastics will make plankton identify these microplastics as food.

- Physiological Disorders: Microplastics can disrupt the physiological processes of plankton through various mechanisms. For example, phytoplankton exposed to microplastics may experience photosynthesis disruption because plastic particles block light penetration. Zooplankton that consume microplastics can experience indigestion and decreased growth.
- Contamination and Accumulation: Microplastics often bind to pollutants such as heavy metals and other harmful chemicals. When plankton consume contaminated microplastics, these pollutants can enter their bodies, potentially affecting the health of plankton and the food chain throughout the ecosystem.
- Habitat Change: The accumulation of microplastics in waters can alter the structure of habitats, for example by forming layers that cover the bottom of the waters or altering the quality of the water. These changes can affect plankton diversity that depends on stable habitat conditions.

Microplastics that contaminate marine life have the potential to enter the body of microplastics so that they have the potential to endanger the health of people living on the coast and people who consume various types of contaminated marine fish. Various potential health risks that can arise from exposure to microplastics are gastrointestinal disorders, liver function disorders, reproductive disorders, cancer, kidney function disorders, metabolic disorders and disorders in thinking or forgetfulness easily (Aulia, et al. 2023).

3.13 Effect on Plankton Type Diversity

Microplastics (MP) have a significant influence on the diversity of plankton species in aquatic ecosystems. Microplastic particles scattered in the ocean are often thought to be food by plankton, both phytoplankton and zooplankton, which are important components in the marine food chain. When plankton consume microplastics, their digestive system can be disrupted, leading to decreased nutrient intake and metabolic function. This can result in a decline in the population of certain plankton species, especially those that are more susceptible to environmental changes.

In addition, microplastics contain harmful chemicals adsorbed from seawater, such as heavy metals and organic pollutants, which further worsen the conditions of the exposed plankton. The presence of microplastics can alter the composition of plankton communities, where some of the more resistant species may dominate, while the more sensitive species decline drastically. This decreases the diversity of plankton species and disrupts the balance of aquatic ecosystems.

The decline in plankton diversity has a direct impact on the health of the seafood chain, as plankton is a major food source for many marine organisms, such as fish. If plankton diversity is disturbed, the productivity of marine ecosystems can also decline, resulting in broader problems for the ecological balance and sustainability of marine resources.

- Decreased Diversity: Increased abundance of microplastics is often associated with decreased diversity of plankton species. Microplastics can cause environmental stress that results in some plankton species not being able to survive, thus reducing species diversity.
- Changes in Community Composition: Microplastics can alter the composition of plankton communities by affecting certain species more than others. Plankton species that are more tolerant of disturbed conditions may become dominant, while more sensitive species may decline or disappear.
- Competitive Interactions and Predation: The presence of microplastics can influence competitive and predatory interactions between plankton. For example, if microplastics affect the availability of food or habitat, this can alter predator-prey dynamics and competition among plankton species.

3.15 Case Studies

The research conducted by Millenia (2023) with the title Composition of Phytoplankton and Microplastics in the Waters of Whale Sharks (*Rhincodon typus*), Kwatisore, Teluk Cendrawasih National Park, West Papua aims to analyze the composition of phytoplankton and microplastics, as well as determine the quality of the water based on the value of the saprophytic index in the waters of Kwatisore, Teluk Cendrawasih National Park. Sampling was carried out in Bagan Cahaya Pinrang at a surface and depth of 40 meters. The results showed that the abundance of phytoplankton on the surface was 1250 Ind/L and 40 meters was 1875 Ind/L. The phytoplankton composition obtained was 2 individuals *of Nitzschia* spp. and 3 individuals *of Amphora* spp. The results of the Diversity Index (H'), Evenness (E), and Dominance (D) were 0.68, 0.96, 0.52 respectively which showed low, even and nothing dominant. Sequentially. The abundance of microplastics on the surface was 36.5 particles/L and 40 meters was 17.5 particles/L with the types of microplastics found consisting of 67 pellets, 39 fragments, and 2 fibers. The number of microplastic colors from high to low was found to be black, clear, yellow, red, and blue. A saprobic index value of 1 indicates that waters including the β-Mesosaprobic phase are classified as lightly polluted. The ratio of phytoplankton abundance and microplastic abundance of 57.87:1 indicates that the abundance of microplastics is lower than that of phytoplankton. The phytoplankton composition in the Kwatisore Waters is low and light pollution has occurred based on the calculation of the saprobic index. This is suspected to be due to the entry of microplastics in Kwatisore Waters. Phytoplankton as the main consumption of whale sharks (*Rhincodon typus*) needs to be improved, one of which is by reducing plastic waste, so that the existence of whale sharks (*Rhincodon typus*) in Kwatisore Waters is not extinct

4. Conclusion

The paper on the impact of microplastics on plankton diversity shows significant results related to the relationship between microplastics and the health of marine ecosystems. Microplastics, which are made up of particles less than 5 mm in size, have accumulated in these waters, potentially disrupting the life of plankton that are vital components in the aquatic food chain. The results showed a low abundance of phytoplankton and indications of light pollution based on the saprobic index, reflecting that although the abundance of microplastics is lower than that of phytoplankton, the impact on ecosystem health still needs to be watched out. The abundance of detected microplastics can affect the growth, reproduction, and diversity of plankton, potentially lowering species diversity and affecting organisms higher up in the food chain. Plankton's dependence on microplastics as food can lead to the accumulation of harmful contaminants in ecosystems, worsening ocean health conditions. With the presence of microplastics in almost all Indonesian aquatic ecosystems, it is important for the authorities to monitor and take mitigation measures against plastic pollution to maintain the sustainability of the ecosystem.

To address microplastic pollution and improve plankton diversity, several suggestive steps can be proposed. First, it is important to raise public awareness about the impact of microplastics through environmental education. The community needs to be empowered to reduce the use of single-use plastics and improve environmentally friendly waste management practices.

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