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RESEARCH ARTICLE

The Effects of Plastic and Microplastic Waste on the Marine Environment and the Ocean

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ABSTRACT

Globally, plastic pollution is acknowledged as a serious human-caused problem for marine and coastal ecosystems. The main sources of these pollutants in the many ways they enter the ocean are land-based and sea-based. Megaplastic, mesoplastic, macroplastic, and microplastic are among the various sizes and kinds of plastic pollutants that are found in ecosystems. The water, sediment, and biota of marine and coastal environments are widely distributed with primary and secondary microplastics. The vast majority of consumer goods in use today are made of plastic. Every year, almost 280 million tons of plastic are manufactured worldwide, most of which wind up in landfills or the ocean. Plastics can be made from primary chemicals, usually coal, oil, or natural gas, or they can be made by converting natural resources. At least 267 species are impacted by plastic and microplastic globally, including 44% of all seabird species, 43% of all marine mammal species, and 86% of all sea turtle species. Through detrimental effects on human health, shipping, and fishing, this new pollutant has an impact on socioeconomic factors. At the international, regional, and national levels, current and enacted laws, policies, rules, and programs are essential to lowering the amount of plastic waste in the world's oceans. Last but not least, the plastics industry should implement plastic recycling or upgrading programs to assume global responsibility for the end-of-life of their goods. The main objective of this paper is to show the impact of plastic and microplastic waste on the marine environment and oceans, and some ways to solve this problem.

Keywords: Marine environment, microplastic waste, ocean pollution, plastic waste.

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1. Introduction

Global warming has negative impacts on the climate and is currently a contentious issue. Global warming is causing a rapid change in the climate [1]. Despite being one of the most widely used materials worldwide, plastic is regarded as one of the most dangerous compounds for the environment [2]. Plastic is inexpensive, robust, lightweight, and incredibly resilient. Half of the plastic manufactured is made to be used just once and then discarded. Polyethylene (PE), polyurethane (PUR), polypropylene (PP), polyvinyl chloride (PVC), polyterephthalate (PET), and polystyrene (PS) are the six main plastic polymers that dominate the market and the litter found in the marine environment. These six substances together account for about 80% of the total production of plastics [3], [4]. Half of the manufactured plastic is made to be used just once and discarded after each usage. Waste travels from the wild to rivers, streams, and the marine environment due to human carelessness and a lack of adequate recycling techniques. Floods are another type of natural calamity that contributes to the spread of plastic debris into the ocean [5]. The population density, the nation's economic status, and the extensive waste management system all affect how much waste enters the maritime environment. Eight major rivers in Asia and two in Africa account for approximately 90% of the total riverine input, supporting the claim that rivers are the primary source of land-based plastics entering the sea. Additionally, estimates from 2015 show that over 50% of marine plastic waste originates from poorly managed plastic waste in five East Asian countries. By 2050, scientists estimate that the entire weight of plastic debris in the ocean will surpass the weight of all the fish [6]. This leads us to conclude that the vast amount of plastic floating on the ocean's surface constitutes the seventh continent. Since most wavelengths are easily absorbed by water, the breakdown of negatively buoyant polymers relies on extremely slow thermal oxidation, or hydrolysis. As a result, plastics that live in marine environments break down far more slowly than those that live on land. Any physical or chemical alterations brought on by environmental elements such as moisture, light, chemical conditions, heat, and biological activity can be classified as polymer degradation.

2. Literature Review

Every year, more than 300 million tons of plastic are manufactured for a wide range of uses [7], [8]. Every day, huge amounts of carbon and other toxic chemicals are released into the environment [9]. Marine life consumes or becomes entangled in plastic trash, which can lead to serious harm or even death. Plastic accounts for 80% of all marine garbage found in surface waters and deep-sea sediments, with at least 14 million tons of plastic entering the ocean annually.

Plastic waste entangles or is consumed by marine life, resulting in serious harm or even death. Human health, coastal tourism, food safety and quality, and climate change are all under risk due to plastic pollution. Half of the more than 300 million tons of plastic manufactured annually is used to make single-use products like straws, cups, and shopping bags. Plastic garbage can damage biodiversity and the environment if it is improperly disposed of. The primary land-based contributors of plastic debris in the ocean include storm water and urban runoff, sewer overflows, littering, improper waste management and disposal, industrial operations, tire abrasion, construction, and unlawful dumping. The fishing industry, nautical operations, and aquaculture are the main sources of plastic pollution in the ocean. Under the action of solar UV radiation, currents, wind, and other natural elements, plastic degrades into tiny particles known as nanoplastics (particles smaller than 100 nm) or microplastics (particles smaller than 5 mm). Marine life can easily inadvertently consume them due to their small size. Plastics made to have a microscopic size are known as primary microplastics. Products used in air blasting media [10], cosmetics and face cleansers, and pharmaceuticals as drug vectors are the main sources of the majority of primary microplastics in the environment. The sheer volume of microplastics released through effluents makes them noteworthy even though up to 99% of them may be removed by contemporary wastewater treatment plants [11]. Accordingly, microplastics can easily penetrate the marine environment and build up in freshwater and ocean environments. Scrubbers, which are found in exfoliating hand cleansers and facial scrubs, are among the most frequently mentioned categories of main microplastics. Large plastics break down into smaller detritus both on land and at sea, producing secondary microplastics [12].

All garbage is especially dangerous and will affect the environment if not disposed of properly [13]. The lifespan of plastics is thought to vary from months to thousands of years; however, since typical plastics have only been mass-produced for about 60 years, this number is still ambiguous. According to numerous research, however, the environmental fragmentation of plastic products is caused by a variety of physical, biological, and chemical processes that weaken the structural integrity of plastic waste [14]. Numerous factors contribute to the direct and indirect accumulation of plastic debris in aquatic habitats. Through both in-situ and ex-situ channels, plastic pollution from land-based and ocean-based sources is a major concern for coastal and marine ecosystems. Micro plastics are produced by the secondary breakdown of plastics, which occurs as a result of weathering and fragmentation due to their resilience and relatively low rate of disintegration. The distribution of micro plastics found in marine samples is consistent with the distribution of plastic types and their uses. However, it is usually impossible to identify where these micro plastics come from.

3. Materials and Methods

The Scopus Index, PubMed, Academia, Research Gate, and Google Scholar were used to search the literature, and the results of that search and any related ones were taken into account. Secondary data was gathered by doing an extensive online and offline literature review. To identify solutions to the impact of plastic and microplastic waste on the ocean, various research papers, news, global reports, books, and journals are considered.

4. Effect of Plastic Pollution on the Marine Environment

The United Nations Development Programme (UNDP) states that coral reefs are an important source of life for many marine creatures in the marine system, in addition to its aesthetic value [15]. Even yet, it only makes up a tiny portion of the world's oceans—more than 0.1% of their total surface. It is the primary source of all forms of life for 25% of marine animals, though, and it also serves as a natural barrier to protect coastal areas from rising sea levels and hurricanes [16]. More than a quarter of marine fish and many other animals live in coral reefs, which are home to the highest biodiversity and offer a variety of ecosystem services like food, flood prevention, and risk reduction, according to the International Union for Conservation of Nature (IUCN) [17]. As a result, numerous environmental, health, and economic issues are brought on by the loss of coral reefs. Since coral reefs are a significant supply of nitrogen and other nutrients required by seafood chains, they are extremely important to the ecosystem. In the marine environment, it plays a significant role in fixing carbon and nitrogen and recycling nutrients. The health of the ecosystem depends on the coral reefs since they are a vital source of food, medicine, and services that the marine environment offers, such as air purification, nutrient-rich soil, and pollution reduction [18].

Sea turtles are essential to healthy oceans because they are important elements that greatly influence all nearby animals; their demise will have an impact on both marine and terrestrial ecosystems. Sea turtles' environment is destroyed by plastic pollution, and beaches frequently drain of plastic garbage. As a result, female turtles find it difficult to deposit their eggs, and material prevents snails from hatching. Furthermore, the physical characteristics of beaches are altered by plastic waste, including changes in permeability and temperature. The rate at which sea turtles reproduce is influenced by each of these factors [19]. These sea turtles serve a variety of vital tasks, thus we must endeavor to reduce plastic pollution, which is one of the primary causes of the rise in turtle mortality and also leads to several digestive issues and organ damage. By affecting the marine and terrestrial food chain and creating several issues for the terrestrial and marine ecology, the extinction of these turtles can be seen to have a huge influence.

5. Potential Effects of Microplastics on Marine Ecosystems

Marine organisms that consume microplastics may experience a variety of consequences, such as intestinal tract blockage, inflammation, oxidative stress, hormone disruption, reproductive effects, and changes in metabolism and behavior, according to research on the subject. Nonetheless, new studies indicate that exposure to nanoplastic particles, which are smaller, is more likely to have negative effects. Two opposing viewpoints dominate current research, despite some research suggesting that microplastics may have serious effects: microplastics affect marine ecosystems [20], and the risks associated with microplastics have not yet been established [21].

Nonetheless, a large number of commonly used chemical additives in plastic products have been discovered in marine environments, and these chemicals induce reproductive abnormalities, developmental disorders, and endocrine disruption in a variety of vertebrate species, including fish and marine mammals [22].

6. The Effects of Plastic Waste on Aquatic Ecosystem Biodiversity

Because organisms entangle themselves in plastic nets or consume plastic items when they mistake plastic waste for food, plastic pollution affects a wide variety of species [23]. The fact that plastic pollution makes it easier for species to spread to other areas is another issue; alien species invade new ecosystems by hitching a ride on floating garbage, changing the species composition or possibly leading to the extinction of other species. Additionally, when plastics are consumed, they can release pollutants into the environment or living things. According to a scientific analysis examining the effects of marine waste on biodiversity, plastic was linked to more than 80% of all contacts between creatures and marine debris, whereas microplastics accounted for 11% of all reported encounters. The plastic sheets may function as a blanket, preventing gas exchange and resulting in anoxia or hypoxia (low oxygen levels), according to Goldberg [24]. Additionally, plastic garbage could lead to issues, particularly for burying species, and produce artificial hand grounds.

Plastics are becoming more and more prevalent in the marine environment as a result of their increased use. Plastic waste can harm marine industry in addition to having an effect on the environment and life. The Asia-Pacific region's marine industry is thought to suffer $1.26 billion in damages each year as a result of marine debris.

Eventually, plastic garbage in the oceans may fragment so much that it resembles tiny grains of sand, a phenomenon known as microplastics. These tiny pieces, which have a diameter of around 20 µm, have been found in ocean waters and marine sediments. Numerous studies have shown that plastic makes up the majority of marine garbage, which is present all around the world. Table I provides a summary of reports from a few of these investigations. Even though the methodologies were not evaluated to guarantee that the outcomes were equivalent, Table I makes it abundantly evident that plastics make up the majority of marine litter, with their share continuously fluctuating between 60% and 80% of all marine debris [25].

7. Faunal Communities Affected by Plastic and Microplastic Waste

Plastics in the environment can entangle or be consumed by wildlife, causing harm. Research has demonstrated that at least 267 marine species globally experience entanglement and ingestion of plastic trash. Such touch has a profound effect on organisms, often leading to their death. Since it cannot be immediately viewed, it is extremely challenging to calculate the overall impact of plastic garbage in the water or to forecast the outcomes for creatures that consume or otherwise come into contact with it.

Death from entanglement may result from strangling, asphyxia, drowning, or hunger. Birds, tiny whales, and seals frequently perish in ghost nets. Due to their entanglement, they can also become less able to dodge predators or lose their capacity to capture food [26]. Frequently, fish, turtles, mammals, and marine birds consume plastic garbage that contaminates the marine ecosystem. The most common way that plastics are consumed is when they are mistaken for food, however, accidental ingestion is also possible. The materials that are ingested frequently contain shards of micro and meso-debris sizes, which can occasionally pass through the gut without harming the organisms.

7.1. Fish

Intestinal blockage, internal damage, development retardation, and decreased stomach capacity have all been linked to ingested plastic waste. For fisheries, ghost fishing may result in financial losses [27]. In the Cantabrian Sea in northern Spain, for instance, an experimental research on ghost fishing of monkfish from lost nets calculated that 18.1 tons of monkfish are caught by abandoned nets per year. This accounted for 1.46% of the Cantabrian Sea's monkfish landings for commercial purposes. Potential losses to the brown crab fishery due to ghost fishing could be significant, according to a study on lost pot ghost fishing off the UK's Wales coast. Ghost fishing is thought to cost the United States $250 million in marketable lobster each year [28].

TABLE I: Global Percentage of Plastics in Marine Debris (*per number of items*)

Place in the globe	Type of litter	Plastics as a representation of trash things
United States National Parks	Beach	88%
Georgia, USA	Beach	57%
Mexico	Beach	60%
The Mediterranean Coast of France	Deep Sea Floor	>70%
International Coastal Cleanups in 1992	Shoreline	59%
Mediterranean Sea	Surface waters	60%–70%
Japan's Tokyo Bay	Seabed	80%–85%
Argentina	Beach	37%–72%
88 locations in Tasmania	Beach	65%
USA's four North Atlantic harbors	Harbor	73%–92%
Coasts of Europe	Sea Floor	>70%
Ocean of the North Pacific	Surface Waters	86%
South Australia	Beach	62%
Caribbean island of St. Lucia	Beach	51%
Cape Cod, USA	Beach/harbor	90%
Transkei, South Africa	Beach	83%
Alaska's Kodiak Islands	Seabed	47%–56%
9 Islands in the Sub-Antarctic	Beach	51%–88%
South Wales, UK	Beach	63%
New Zealand	Beach	75%
Halifax Harbor, Canada	Beach	54%
Is. Beach State Park, USA, in New Jersey	Beach	73%
Australia's Fog Bay, Northern	Beach	32%
South German Bight	Beach	75%
Caribbean island of Dominica	Beach	36%
Southern Ocean, Bird Island, South Georgia	Beach	88%
Southern Ocean, Prince Edward Island	Beach	88%
Southern Ocean, Macquire Island	Beach	71%
Southern Ocean, Gough Island	Beach	84%
The Two gulfs in Western Greece	Seabed	79%–83%
Southern Ocean, Heard Island	Beach	51%
Five beaches in the Mediterranean	Beach	60%–80%
Caribbean island of Curacao	Beach	40%–64%
Northwest Mediterranean	Seabed	77%
Panama's Caribbean coast	Shoreline	82%
Fifty beaches in South Africa	Beach	>90%
Sea of Biscay, Northeast Atlantic	Seabed	92%

7.2. *Reptiles*

The polythene bags floating in the ocean currents resemble the prey items that turtles hunt. Young sea turtles are especially at risk of dying as a result of plastic waste, according to data. A turtle discovered in New York that had ingested 540 meters of fishing line was mentioned by O'Hara *et al*. [29], while Balazs [30] reported 79 instances of turtles whose stomachs were filled with different types of plastic garbage. Marine reptiles face a major risk of becoming entangled in plastic waste, particularly from abandoned fishing equipment. Given that they are endangered; it also has an impact on sea turtle survival.

7.3. *Seabirds and Coastal Birds*

Weight loss is one negative consequence of birds consuming plastic, for instance, because of a falsely satisfied hunger and an inability to accumulate enough fat for migration and reproduction. Plastics may already be in the intestines of their prey or be transferred from adult to chick through regurgitation feeding, even though birds mostly consume them because they are mistaken for food. Certain species only consume pieces of plastic with a particular shape or color.

Eight of the eleven seabird species that were caught as bycatch in the North Pacific had plastic particles in their stomachs, according to a research by Blight and Burger [31]. Reproductive failure, reduced feeding stimulus, delayed ovulation, decreased steroid hormone levels, and obstruction of stomach enzyme release are among the negative consequences of consuming plastics. Internal injury and death due to intestinal tract blockage are caused by food intake, albeit the severity of the damage varies by species.

However, the damage caused by plastic consumption is not limited to seabirds. Seabirds frequently confuse little plastics, like bottle tops, for food. Diving birds that consumed fish from the water column had fewer plastic particles in their stomachs than those that consumed fish from the surface, according to multiple studies. Ingesting plastics may lower seabirds' fitness, growth rate, and food intake, according to Ryan. The quantity of plastic consumed by various bird species may serve as a gauge of the buildup of plastics in a given area, according to the findings of a study conducted with domestic chickens. Further details on the documented global impact of plastic on a wider range of marine species, including seabirds, can be found in Table II.

7.4. *Invertebrates*

Microplastics are mostly responsible for the plastic effects on invertebrates. Microplastics have a number of negative effects on aquatic invertebrates, such as abrasions from sharp objects or blockages throughout the digestive system that cause injuries, a blockage of enzyme production, decreased feeding stimulus, nutrient dilution, decreased growth rates, lowered steroid hormone levels, delayed ovulation and reproductive failure, and toxin absorption. Microplastics can lodge themselves in tissues or obstruct marine creatures' feeding tentacles.

7.5. *Mammals*

According to estimates, entanglement has impacted 58% of seal and sea lion species, including Hawaiian monk seals, Southern Ocean species, New Zealand fur seals, and Australian sea lions. Marine debris can also entangle whales. Even though some whale species drown because they are unable to free themselves, larger whales frequently take fishing gear with them. It has been reported that at least 26 different species of cetaceans consume plastic garbage. Eleven days after becoming stranded alive in Texas, a juvenile male pygmy sperm whale perished in a holding tank. Plastic detritus, such as a garbage can, liner, bread wrapper, corn chip bag, and two additional pieces of plastic sheeting, totally obscured the stomach compartments [32].

Most likely, ingestion occurred because the debris was combined with the food that was intended. In 2008, two sperm whales were discovered off the northern California coast, their digestive tracts full of fishing gear. A rupture in the stomach region of one of the sperm whales was brought on by nylon netting. However, fishing line, plastic bags, and netting obstruct the passage of food from the intestines to the stomach [33]. When plastic becomes tangled with nets or other materials, it can cause strangulation, decreased feeding efficiency, and occasionally drowning. Pinnipeds frequently interact with marine life trash out of natural curiosity [34].

8. Effects on Floral Communities

Naturally occurring flotsam, which is referred to as "the wrack" at high tidal strandlines, is composed of jetsam from unknown sources as well as flotsam from marine and terrestrial sources, such as plants and seaweeds. In addition to being ephemeral, dynamic, and seasonal, these places frequently gather large amounts of manufactured items, particularly those composed of plastic and additional non-destructible substances.

Microplastics, on the other hand, have the greatest effects on floral communities. Due to their easy ingestion by small organisms like plankton species and their ability to create a channel for toxins to enter the food web, recent studies like have highlighted the critical significance of microplastics.

9. Effect on Species that are Invasive

Plastic can act as a method for encrusting and contaminating organisms to spread over long distances, just like any other floating debris, whether it be man-made or natural. Since logs, pumice, and other flotsam have been moving across the ocean for thousands of years, the addition of hard plastic waste to the marine environment can provide some opportunistic colonists a different and more alluring substrate. According to estimates, biotic mixing might result in a 58% reduction in the diversity of marine organisms worldwide.

Plastics' hard surfaces give opportunistic colonists the perfect substrate. Though bacteria, diatoms, algae, and barnacles are also encrusting organisms, bivalve mollusks are the most frequent colonizers of pelagic plastics. Native species may be eliminated as a result of plastic garbage encouraging the invasion of hard-surfaced species, especially those that favor sandy and muddy environments. Beach clean-ups are a good technique to get rid of plastic debris, however, after the cleanup is finished, it's usually anticipated that the beach will be in its original condition [35].

10. Ecotoxicology

Since plastic's macromolecules do not react with or pass through an organism's cell membrane, they are regarded as biochemically inert. Most polymers aren't pure, though. They are made up of a number of other compounds in addition to their polymeric structure, each of which adds to a particular attribute of the plastics they are made of. Numerous hydrophobic pollutants are drawn to the hydrophobic surface of plastics and are absorbed from

TABLE II: The Quantity and Proportion of Marine Species with Entanglement and Ingestion Records that have been Documented Globally

The species group	Total number of species in the globe	Number and percentage of species having entanglement records	Number and percentage of species with records of ingestion
Seabirds	312	51 (16%)	111 (36%)
Sea Turtles	7	6 (86%)	6 (86%)
Grebes	19	2 (10%)	0
Penguins	16	6 (38%)	1 (6%)
Shearwaters, Albatrosses, and Petrels	99	10 (10%)	62 (63%)
Boobies, Gannets, Frigate birds, Pelicans, Cormorants and Tropicbirds	51	11 (22%)	8 (16%)
Gulls, Terns, Shorebirds, Skuas, Auks	122	22 (18%)	40 (33%)
Baleen Whales	10	6 (60%)	2 (20%)
Ocean Animals	115	32 (28%)	26 (23%)
Different Birds	0	5	0
Toothed Whales	65	5 (8%)	21 (32%)
Crustaceans	0	8	0
True Seals	19	8 (42%)	1 (5%)
Manatees and Dugongs	4	1 (25%)	1 (25%)
Sea Otter	1	1 (100%)	0
Sea Lions and Fur Seals	14	11 (79%)	1 (7%)
Fish	0	34	33
Squid	0	0	1
Species Total	–	136	137

the surrounding water to build up on and in the plastic debris. Due to their ease of ingestion by living things and their role as a conduit for chemicals to enter an organism, this process is given a lot of attention when it comes to microplastics or trash.

Two categories of potentially harmful contaminants, additives, and hydrophobic compounds that are absorbed from the surrounding water can be found in plastic debris in the marine ecosystem. Flame retirements have been incorporated into numerous everyday products and are also found as additives in polymers. Because they have a negligible impact on material properties and are highly effective at avoiding ignition, the majority of flame retardants (BFFS) BFF are used extensively in plastics production. They are found in the air, rivers, and waterways up to the Arctic, but they are also contaminants in practically every part of the world's ecology.

Fish and seabirds may bio-accumulate heavy metals, dichlorodiphenyltrichloroethane (DDT), PCBs, and other pollutants by the ingestion of plastic particles. Reproductive issues, illness, changed hormone levels, or mortality at more advanced trophic levels can result from these substances being absorbed and transferred by filter-feeding creatures and invertebrates [36].

11. Initiatives to Prevent and Regulate Ocean Pollution from Plastic and Microplastics

Numerous approaches have been found to deal with the problem of plastic pollution. Participation at the institutional level is one of the main tactics employed to address the current issue. Institutions at the national, regional, and international levels are crucial to limiting and averting the buildup of plastic waste in coastal and marine areas.

11.1. Scientific Research and Observation

Research and scientific studies are additional methods for addressing the problem of plastic contamination in a methodical manner [37]. However, there are still gaps in our understanding of several elements of plastic pollution, including its sources, fate, transportation, effects, and solutions in the environment. When it comes to implementing the best behavioral, technological, and policy solutions to effectively address the problem of marine plastics, stakeholders (such as the local community, legislators, politicians, consumers, and suppliers) would benefit greatly from scientific knowledge and evidence of all facets of plastic pollution. Frequent monitoring combined with ongoing scientific study is an important strategy for managing plastic pollution [38].

11.2. Campaigns to Increase Awareness

One of the most effective ways to improve the condition of marine and coastal ecosystems is to shift public perceptions toward environmental conservation and sustainable management. One way to change attitudes in local communities is to raise public understanding of litter generation, removal, and its effects on the marine and coastal environment. One such global initiative, Blue Flag, is carried out in Europe to lessen the buildup of marine and coastal garbage [39].

To raise local community knowledge and capability for this new issue, beach cleaning and rubbish disposal programs are also carried out with the involvement of stakeholders. The local community's participation is necessary for these cleaning and debris removal initiatives to be successful and effective.

11.3. Initiatives at the Global Scale

The Law of the Sea and the United Nations General Assembly on Oceans are two instances of international activities that help resolve this problem. Controlling plastic pollution is made possible by an international legal framework established by the UN Convention on the Law of the Sea (UNCLOS). Important statements to improve the cleanliness of the maritime environment have also been made by the UN General Assembly. This includes a decision to establish a partnership to raise public and private sector awareness of the negative impacts of plastic pollution on social, ecological, and economic facets as well as the explicit integration of measures to address the problems caused by plastic debris contamination by a national framework for strategy [40]–[42].

In 2012, the Manila Declaration, which examines the success of the UNEP Global Program for the control of waste sources from land-based activities, was approved by the European Commission and sixty-four government agencies. To manage pollution, particularly the buildup of marine debris that damages marine ecosystems, the members of the Manila Declaration also decided to develop pertinent national-level regulations. Under the direction of the Honolulu Strategy, parties in the Manila declaration also agreed to implement the Global Partnership on Marine Litter (GPML). Reducing contamination from ocean-based sources also included the following objectives: (i) reducing contamination levels and potential impacts from ocean-based sources that contribute to the buildup of plastics and other debris in aquatic systems; (ii) lowering the amounts and impacts of marine plastics and other marine debris on coastlines, aquatic habitats, and biodiversity; and (iii) limiting the accumulation levels and impacts of solid waste and land-based litter debris in aquatic ecosystems.

11.4. Cooperation to Create Plastic-free Areas: Interaction with Commercial Enterprises

The American Chemistry Council has run awareness campaigns about recycling and reusing plastic bottles in the United States. One such globally renowned organization is Plastic Europe, which runs some initiatives aimed at managing and preventing the buildup of marine litter [43]. This study suggests the creation of strong Public-Private Partnerships (PPPs) with joint participation from government agencies and the private sector for extensive scientific research projects aimed at reducing plastic pollution as well as waste management at the national level because there is a dearth of additional information.

11.5. Initiatives at the Regional Level

Thirteen regional seas—the South Asian, Mediterranean, Baltic, Black, Gulf of Aden, East Asian, Red, Eastern African, Northeast Atlantic, Northwest Pacific, Caspian, Wider Caribbean, and Southeast Pacific-were the focus of pertinent regional activities suggested by UNEP's Regional Seas Program. Programs for coastal cleanup have been finished worldwide in each of the aforementioned areas.

Through NOAA/MDP, a regional initiative to collect abandoned fishing gear was put into place along the coasts of South Africa and Hawaii. Furthermore, to develop efficient management strategies, scientific research is advised to determine the distribution pattern of plastic pollution in South American estuarine ecosystems. To address the new problems related to pollution, Barletta *et al*. [44] also suggested that conservation plans for South American estuaries concentrate on yearly changes in eco line, retention reuse and recycling cycles, flushing of environmental indicators, and impacts on trophic webs across the entire coverage of variations of estuary ecosystems.

11.6. Sustainable Ideas for Reducing Ocean Plastic Pollution

Enhancing recycling capabilities and reducing packaging are necessary for green procurement. To reduce the buildup of plastic waste, some plastic products may also be packaged using biodegradable plastic components [45]. However, encouraging the collection and recycling of plastics can be achieved through positive incentives, whether they be monetary or tangible. More economic advantages to society will result from these projects if they are promoted at the regional, national, and international levels. They will also stop plastics from building up in marine and coastal environments.

12. Remedial Methods for Marine Environmental Plastic Pollution

In 2017, 335 million metric tons of plastic were manufactured, contributing to the growing problem of plastic contamination of the marine environment. By 2050, it is anticipated that this quantity would have increased to 1100 million metric tons. To date, over 8300 million tons of plastic have been manufactured. Of these, 79% were buried or ended up in the marine environment, while just 9% were recycled and 12% were burned [46]. One of the biggest issues affecting marine life is rubbish entering the ecosystem; it is estimated that between 4.8 and 12.7 million metric tons of plastic waste enter the environment annually [47].

One strategy to reduce the amount of plastic waste that enters the environment is to try to limit the amount of disposable plastic that we use daily, such as cups, water bottles, bags, and other products that are used just once before being thrown away. Steer clear of items that include microbeads, which are tiny plastic particles that are present in various toothpastes, body washes, and face exfoliators. These molecules can readily infiltrate the marine environment and then infect hundreds of marine species [48]. To dispose of plastic trash and lessen its introduction into the aquatic environment, the IUCN states that recycling, reusing, and producing ecologically friendly polymers are crucial. These procedures contribute to a mostly plastic-waste-free environment.

13. Conclusion

Estuaries are one of the main coastal ecosystems impacted by plastic pollution. Currently, primary and secondary sources of plastic pollution have terrestrial or ocean-based origins, and because microplastics are similar in size to the food particles that are consumed by the majority of marine and coastal organisms in lower trophic levels, these micro-contaminants are highly susceptible to accumulation in such biota through ingestion with harmful impacts. It is widely acknowledged that plastic pollution in marine and coastal environments needs to be mitigated and managed at the global, regional, and national levels. Due to its long lifespan and resilience to corrosion, plastic waste lingers in the environment since it is tough to biodegrade after it has entered there and merely breaks up into tiny bits. Numerous creatures are negatively impacted by the presence of plastic waste in the environment, primarily by plastic entanglement or ingestion. Ingested plastic, which is frequently linked to hydrophobic pollutants, can collect in the bodies of certain marine animals, including fish, seabirds, and sea lions. These creatures could also get entangled in the plastic, which can be dangerous.

Plastics do not go away; they will always be present in our surroundings and will continue to harm aquatic life until pollution levels are decreased. Without water, none of the living things on Earth could survive. It is not appropriate for us to contaminate this resource if it is so valuable that life cannot live without it. Chemicals found in plastics have the potential to harm marine life. Education is especially crucial because it serves as the foundation for educating the next generation about the negative effects of throwing plastics and other waste into the world's oceans. More than 270 species, including fish, turtles, seabirds, and mammals, have suffered from impeded movement, hunger, or even death as a result of ingesting or being entangled in plastic garbage. Banning the introduction of plastics into the ocean or marine environment is the most crucial step in addressing the impact of plastics on aquatic ecosystems. Plastics should not be allowed to enter the ocean to save certain marine creatures. It is necessary to design a strategy to guarantee that materials are recycled or disposed of appropriately.

14. Recommendation

The following are suggestions for reducing plastic, microplastic, and nano-plastic contamination in aquatic areas:

- Enforcement of bylaws about the management of plastic garbage is necessary.
- As much as possible, foil-coated paper should be used in place of plastic packaging materials.
- The health and safety implications of recycling plastic garbage at all levels should be communicated to the local community.
- Creation of domestic and native solutions for managing plastic trash.
- Plastics should be properly handled and kept apart from other waste while being disposed of.

- The needs of the community at all levels should be taken into account when developing and implementing policies for the management of plastic trash. At every stage of our educational system, starting with primary school, the social responsibility for managing plastic trash should be instilled.
- Creating and enforcing quality requirements for all recycled plastic items.
- Continuous sharing of knowledge about the best technology and techniques available.
- Because microplastics are so common in the world's seas, cleaning them up is either impossible or very difficult. Laws to regulate the contamination caused by microplastics are still lacking, though. Governments should so work together, either domestically or internationally, to control the main sources of microplastics, which are household and industrial goods.
- Increasing funding for the creation of technologies for collecting plastic is necessary.
- Standard or non-biodegradable materials should be substituted with materials that have a high rate of biodegradation, like pullulan or starch.
- Plastic waste from industries should be upgraded or recycled.

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Conflict of Interest

No conflicts of interest have been disclosed by the paper's author.

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