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OCCURRENCE AND EFFECT OF MICROPLASTIC IN MARINE ENVIRONMENT

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ABSTRACT

Plastic pollution has numerous negative effects on the aquatic environment, including socioeconomic, physiologic, and ecological effects. Fish, seabirds, whales, and other marine species are particularly susceptible to the effects of plastic pollution. Marine animals can become entangled in plastic waste, which can causing injury, hindering aquatic organisms, ability to swim hunt, and reproduce, and in extreme situations, result in asphyxia or death. Aquatic environments are also chemically vulnerable to plastics. Numerous plastic items have additives like plasticizers and flame retardants that can leak into the water, especially when exposed to sunshine, heat, and saltwater. These substances can interfere with the hormonal processes and reproductive capacity of marine creatures, resulting in aberrant reproduction, stunted growth, and weakened immune systems.

1. INTRODUCTION

Plastic is derived from the Greek word meaning moldable, which are derived by polymerizing monomers made from coal, oil, or gas. The first plastic materials (Celluloid and Bakelite) were invented more than a hundred years ago. The synthesis of microscopic plastic pieces or particles known as "secondary microplastic" is caused by a combination of mechanical abrasion, UV radiation and biological deterioration in the environment, despite the general longevity of synthetic polymers. (do Sul and Costa 2014). Plastic pollution in aquatic environments has become a significant global environmental threat. Plastics known for their durability and affordability persist in the environment for hundreds of years, causing long-lasting effects. The breakdown of plastics into microplastics further exacerbates the problem. Plastic pollution significantly affects the aquatic environment, causing harm to social, economic, physical and ecological system.

Plastic and microplastic Source: © iStock

Sources of plastic pollution in Land based sources:

Littering:

The buildup of plastic pollution in rivers, lakes, and oceans is largely due to littering. Bottles, bags, packaging materials, and other single-use plastic objects are frequently dumped in the street and can easily enter rivers, streams, and storm drains. Sea turtles, seals, dolphins, and seabirds are especially prone to becoming entangled in trash like plastic rings and fishing nets.

Storm water runoff:

When it rains or when there is snowmelt, storm water runoff is the water that flows over the land and eventually enters water bodies like rivers, lakes, and seas. The entry of contaminants, such as plastic waste and microplastics, into rivers can have a substantial negative impact on aquatic habitats. Litter, pesticides, fertilizers, oil, sediment, and other toxins are all picked up by rainwater or melting snow as it flows over the ground. Storm water runoff is created when rainfall or snowmelt exceeds the soil's ability to absorb water.

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Marine based sources-

Shipping and maritime activities

Global trade and transportation are significantly influenced by shipping and marine operations. These actions, however, further exacerbate the problem of plastic contamination in aquatic habitats. The discharge of plastic trash from maritime vessels poses a serious risk to marine ecosystems through the emission of microplastics as well as solid garbage. Another significant source of plastic garbage in maritime environments is fishing equipment, such as nets, lines and traps.

Fishing Activities-

The act of fishing, which is essential to maintaining the world's marine food supply and way of life, can also lead to plastic pollution in aquatic habitats, known as "ghost nets", in discarded, lost Caught or discarded fishing gear pose a serious threat to marine ecosystems by directly harming marine life and accelerating the build-up of plastic waste. Ghost nets are fishing nets, lines, and nets that have been accidentally or intentionally lost in the ocean, resulting in a variety of marine creatures, including fish, turtles, marine mammals, and sea birds, being injured, suffocated, or Even get killed by the ghost's trap.

Aquaculture operations:

Aquaculture operations' use of plastic-based components contributes to the buildup of plastic waste in aquatic ecosystems. These substances can linger in the ecosystem for a very long time, posing dangers to marine organisms such as entanglement and ingestion. Marine species including turtles, marine mammals, and seabirds can become entangled in fishnets, ropes, and buoys, which can result in injuries, malformations, and even death.

2. PLASTIC POLLUTION DISRUPTS AQUATIC SYSTEM

1. **Habitat destruction:**

   Aquatic environments can be physically changed by plastic trash. The growth and survival of coral reefs, seagrass beds, and other vital habitats can be hampered by the entanglement and suffocation of large plastic objects like plastic bags or abandoned fishing gear. Plankton to huge marine mammals, marine creatures frequently mistake plastic particles for food, leading to ingesting them and suffering internal injuries.

2. **Accumulation on microplastic :**

   Microplastics are the potential to accumulate and persist in aquatic environments. As microplastics enter the food chain, they can bioaccumulate in organisms, meaning their concentration increases as they move up the food web. This can result in higher concentrations of microplastics in predators at the top of the food chain, leading to biomagnification of toxins associated with plastics.

3. **Disruption of Nutrient Cycling:**

   Plastic pollution can alter nutrient cycling processes in aquatic ecosystems. The colonization of plastic surfaces by microorganisms can lead to changes in microbial communities and affect nutrient cycling dynamics. This disruption can have far-reaching consequences on the productivity and functioning of aquatic ecosystems**.**

4. **Biodiversity Loss:**

   Plastic pollution can contribute to the loss of biodiversity in aquatic environments. The adverse effects on marine species, including population decline and species extinction, can disrupt the delicate balance of ecosystems, leading to reduced ecological resilience and overall biodiversity loss.

Impact on microplastics in marine organisms-

Entanglement:

Entanglement occurs when marine animals become trapped or entangled in plastic debris, such as fishing nets, lines, and packaging materials. Entangled animals can suffer physical injuries, restricted movement, and impaired feeding abilities. It can lead to drowning, suffocation, amputations, and deformities, ultimately resulting in reduced survival and reproductive success. Marine mammals, sea turtles, seabirds, and fish are particularly vulnerable to entanglement.

Ingestion:

Ingestion occurs when marine organisms mistakenly consume plastic debris, mistaking it for prey or unable to differentiate it from their natural food sources. Plankton, fish, turtles, birds, and marine mammals can all ingest plastics, ranging from macroplastics to microplastics. Plastic debris can also accumulate toxins on its surface, which can transfer to organisms upon ingestion, causing further harm.

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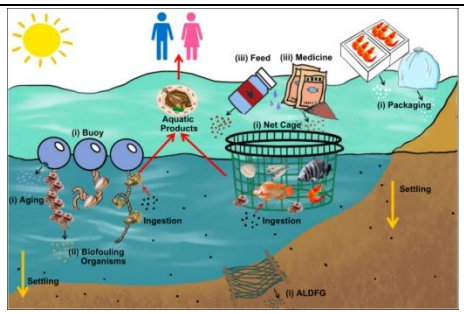

Microplastic in sea water

Source: https://www.frontiersin.org/articles/10.3389/fmars.2022.923471/full

3. RISKS OF PLASTIC POLLUTION TO HUMAN HEALTH

1. **Ingestion of Microplastics:**

   Consuming tainted seafood, such as fish, shellfish, and mollusks, can introduce microplastics into the human food chain. Microplastics have the ability to introduce toxic substances and hazardous compounds into the human body when consumed. These substances could include persistent organic pollutants (POPs), bisphenol A (BPA), phthalates and polychlorinated biphenyls (PCBs).

2. **Inhalation of Microplastics:**

   Microplastics can also be present in the air we breathe, as they are released from various sources, including synthetic textiles, vehicle tires, and the degradation of larger plastic items. Inhalation of microplastics may lead to respiratory issues, inflammation, and respiratory tract irritation. While the long-term health effects of inhaling microplastics are still being studied, there is concern that chronic exposure to these particles could have adverse effects on lung function and respiratory health.

3. **Exposure to Plastic Additives:**

   Plastic products contain additives, such as plasticizers, flame retardants, and UV stabilizers, which are added during manufacturing. These additives can leach out from plastic items and contaminate the environment and consumer products. Some plastic additives have been associated with endocrine disruption, reproductive disorders, developmental issues, and increased cancer risk.

4. **Chemical Transfer via Plastics:**

   Plastic particles can contain high levels of pollutants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs) and pesticides. Prolonged exposure to these pollutants can have detrimental effects on human health, including an increased risk of cancer, hormonal imbalances, and organ damage.

4. MICROPLASTIC IDENTIFICATION

Identification of plastic particles is used to differentiate synthetic polymer particles from natural substances present in the environment. The first method used for separation is by naked eye, if the particles are small then they are identified under a microscope. (J. H. Dekiff, 2014). Several studies have already highlighted the findings of a comparison between optical identification and spectroscopic techniques, such as infrared (IR), Raman microspectroscopy (RM) and energy dispersive X-ray spectroscopy. The two most common methods used for identification of Microplastic.

1. **Fourier transform infrared spectroscopy:**

   The analytical technique known as Fourier Transform-Infrared Spectroscopy (FTIR) is useful and trustworthy for identifying polymers and evaluating the quality of plastic products. The spectrum created when a plastic material absorbs infrared light typically in the mid-infrared region gives a characteristic "fingerprint" that may be used to quickly screen and test samples for a variety of applications.

2. **Raman microspectroscopy:**

   A different and effective technique for microplastic characterization is called Raman spectroscopy (RS). In this method the sample is irradiated with a monochromatic light source, usually a laser. Some photons are scattered in elastically and therefore provide information about molecular vibrations on the sample. The spectra are then compared by references or commercially available databases. Since the light sources used are normally in the visible range, RS is easily coupled to a standard optical microscope, so-called Raman microspectroscopy (RM). The advantages of RM are high spatial resolution (up to 1 μm) and insensitivity to water.

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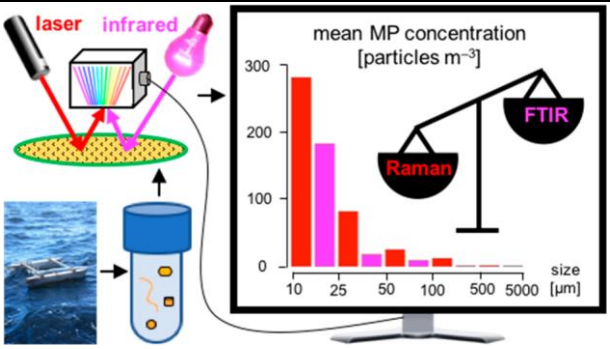

Raman and Fourier Transform Infrared Spectroscopy use of Quantification Source:

https://pubs.acs.org/doi/10.1021/acs.est.8b03438

Global initiatives and solutions on plastic:

International efforts and initiatives to tackle plastic pollution:

1. **United Nations Environment Programme (UNEP) Clean Seas Campaign:**

   The UNEP Clean Seas Campaign aims to combat marine plastic pollution by engaging governments, businesses, and individuals to take action. The campaign encourages countries to establish national strategies to reduce plastic waste, promote sustainable consumption and production, and improve waste management systems. It also supports initiatives such as the Global Partnership on Marine Litter and the Global Plastics Platform to foster collaboration and knowledge sharing.

2. **The Global Plastic Action Partnership (GPAP):**

   GPAP is a World Economic Forum initiative, brings together governments, businesses and civil society organizations to address plastic pollution at a global scale It focuses on driving systemic change by promoting circular economy approaches, innovative business models, and policy reforms. GPAP works with partner countries to develop national roadmaps and action plans for plastic waste reduction and recycling.

3. **International Coastal Cleanup:**

   The International Coastal Cleanup is a global initiative led by the Ocean Conservancy, engaging volunteers in cleaning up coastal areas and collecting data on marine debris.The initiative raises awareness about the impact of plastic pollution, generates data for policy advocacy, and promotes community involvement in coastal conservation.

Policies, regulations, and campaigns aimed at reducing plastic waste:

1. **Single-Use Plastic Bans and Restrictions:**

   Many countries and cities have implemented bans or restrictions on single-use plastics, such as plastic bags, straws, and disposable cutlery. These policies aim to reduce the consumption and disposal of single-use plastics by encouraging the use of reusable alternatives. Examples include the European Union's Single-Use Plastics Directive and the plastic bag bans in countries like Rwanda, Kenya, and Bangladesh.

2. **Extended Producer Responsibility (EPR) Programs:**

   EPR programs shift the responsibility of managing plastic waste from the consumer to the producer. Producers are required to take responsibility for the collection, recycling, or safe disposal of the products they put on the market. Examples include EPR programs for packaging waste in countries like Germany Canada and Japan.

3. **Awareness Campaigns and Education Initiatives:**

   Public awareness campaigns and education initiatives play a crucial role in raising awareness about the impact of plastic waste and promoting behavior change.

   These campaigns often target individuals, communities, and businesses to reduce plastic consumption, promote recycling, and encourage responsible waste management.

Individual actions to reduce plastic pollution:

1. Use Reusable Shopping Bags
2. Carry a Reusable Water Bottle
3. Choose Reusable Food Containers:
4. Avoid Disposable Cutlery and Straws
5. Properly Dispose and Recycle Plastic Waste

5. CONCLUSION

Marine life, aquatic ecosystems, and human health are now seriously threatened from plastic waste. Plastic waste has accumulated in rivers, lakes, oceans, and other bodies of water all over the world as a result of the widespread use and improper disposal of plastic products. International efforts, such as the UNEP Clean Seas Campaign, the Global Plastic Action Partnership, and the Basel Convention, aim to combat plastic pollution through collaborative actions, policy reforms, and knowledge sharing. Additionally, policies, regulations, and campaigns focused on reducing plastic waste, such as single-use plastic bags, extended producer responsibility programs, and awareness campaigns, are being implemented worldwide. Individuals can also contribute to reducing plastic pollution through simple actions. Using reusable shopping bags, water bottles, and coffee cups, choosing plastic-free personal care products, and properly disposing and recycling plastic waste are practical steps that individuals can take to reduce their plastic usage.

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