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Future Aspects of Micro-Plastics and their Management

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ABSTRACT

Plastics are versatile materials of synthetic long-chain polymers with low cost, lightweight, recalcitrant properties. The market is mostly dominated by 6 classes of plastics: Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC), Polystyrene (PS), Poly-Urethane (PUR), and Polyethylene Terephthalate (PET). Micro-particles as being in the size range <5 mm (recognizing 333 µm as a practical lower limit when neuston nets are used for sampling. Micro-plastic pollution has been a particular concern in recent years because of its prevalence in the ocean and potential ingestion by marine organisms. A sustainable approach to both production and consumption of plastic materials with global efforts has been geared towards the management of marine debris *via* prevention. Recycling and reusing plastic products are some of the most effective actions to reduce the volumes of plastic wastes that must be flushed into the ocean. Finally, with the increase in micro-plastics and its effects on marine ecosystems, it is suggested that community and public vanguards could be initiated to develop a feasible platform for micro-plastics' mitigation and ecosystem balance.

Keywords: Plastics; Micro-plastics; Polymers; Pollution

INTRODUCTION

Plastics

Plastics are versatile materials of synthetic long-chain polymers with low cost, lightweight, recalcitrant properties, which bring numerous social benefits and become an indispensable component of daily life, driving the annual demand for world production on a substantial scale [1]. Table 1 shows the timeline of plastics over the years to the 21st century.

Table 1: Shows the timeline of plastics over the years to the 21st century.

Year	Event
1284	First recorded mention of The Horners Company of London, with horn and tortoiseshell as the predominant early natural plastic.
1820	Vulcanised rubber, gutta percha, parkesine, cellulose
1823	Macintosh uses rubber gum to waterproof cotton and the 'mac' is born
1845	Bewley designs extruder for gutta-percha
1850	First submarine telegraph cable in gutta-percha laid between Dover and Calais
1862	Display of Parkesine, predecessor of celluloid (cellulose nitrate), at the 1862 Great International Exhibition in London
1872	Hyatt brothers patented first plastics injection moulding machine
1885	George Eastman Kodak patents machine for producing continuous photographic film based on cellulose nitrate

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1880	Fashion for long hair leads to cellulose nitrate replacing horn as the preferred material for combs
1890	Thermoforming introduced and used to make babies rattles from cellulose nitrate
1892	Viscose silk (rayon) developed by Cross and Bevan (Chardonnet Silk)
1898	Beginning of mass production of rpm gramophone records from shellac
1899	Krische and Spittler in Germany awarded patent for Casein Plastic from milk. Artefacts introduced at the Plastics Universal Exhibition in 1900
1909	Casein plastics, derived from milk, developed by Erinoid
1910	Stockings made of viscose (CA) begin to be manufactured in Germany
1915	Queen Mary sees casein products at the British Industries Fair and orders several pieces of jewellery made from it
1916	Rolls Royce begins to use phenol formaldehyde in its car interiors and boasts about it
1919	Eichengrun produce first cellulose acetate moulding powder
1921	Beginning of rapid growth of phenolic

Micro-plastics

The term 'micro-plastics' and 'micro-litter' has been defined differently by various researchers defined micro-litters as the barely visible particles that pass through a 500 µm sieve but retained by a 67 µm sieve (0.06 mm-0.5 mm in diameter) while particles larger than this were called meso-litter. Others, including a recent workshop on the topic defined the micro-particles as being in the size range <5 mm (recognizing 333 µm as a practical lower limit when neuston nets are used for sampling.) Particles of plastics that have dimensions ranging from a few µm to 500 µm (5 mm) are commonly present in seawater. For clarity, this size range alone is referred to as 'micro-plastics' here; the larger particles such as virgin resin pellets are referred to as 'meso-plastics'. Persistent Organic Pollutants (POPs) that occur universally in seawater at very low concentrations are picked up by meso micro-plastics *via* partitioning. It is the hydrophobicity of POPs that facilitates their concentration in the meso micro-plastic litter at a level that is several orders of magnitude higher than that in seawater. These contaminated plastics when ingested by marine species present a credible route by which the POPs can enter the marine food web. The extent of bio-availability of POPs dissolved in the micro-plastics to the biota and their potential bio-magnification in the food web has not been studied in detail [2-7].

Micro-plastic (less than 5 mm was commonly defined) pollution, identified as an important emerging threat by a horizon scan of global conservation issues for 2010, has been a particularly concern in recent years because of its prevalence in the ocean and potential ingestion by marine organisms [8].

The occurrence and distribution of micro-plastics to the global marine environment include both primary sources (derived from hand and facial cleansers, cosmetic preparations, scrubbers in air-blasting, and production waste from plastic processing plants) and secondary sources (derived from fragmentation of larger plastics as a result of physical and chemical effects) [9].

Micro-plastics are compositional complex containing a wide range of additives such as plasticizers, fillers and stabilizers. They also provide the surface area for the adsorption of various chemicals in the environment including drugs and hydrocarbons, which complicate their eco-toxicological effects. Together with nano-plastics which have the potential to enter cells and disrupt cellular functions, their removal from the environment has been a primary concern. As long-term solutions to micro-plastics elimination from the environment have yet to be framed, water and provide an immediate and feasible means of micro-plastic removal. Micro-plastics can be transported by the hydrodynamic process, winds, and ocean currents, and have been found abundant in almost every corner of our oceans over the past few years, ranging from the coastline, the Irish continental shelf, the Atlantic Ocean, the Pacifiic Ocean, European coastal areas and the Indian Ocean, even to the polar regions and the deep-sea. As pointed out by the G20 Action Plan on, it is an arduous task to reverse the far-reaching impact of marine pollution, which will take 67 ships one year to clean up less than 1% of the garbage in the North Pacifiic Ocean. Tracks of micro-plastics even extend to terrestrial environments inland, threatening access to clean water and the sustainable management of water in freshwater systems [10-20].

CATEGORIES OF MICRO-PLASTICS

Micro-plastics encountered in the marine matrices are broadly classified into 2 types:

1) Primary Micro-plastics and

2) Secondary Micro-plastics.

- Primary micro-plastics are originally and intentionally manufactured in the size range of 1 nm to 5 mm and have applications in personal care products like toothpaste, shower gel, scrubs, cosmetics, and air-blasting [2].
- Secondary micro-plastics result from the breakdown of large plastic items, e.g from fishing gears, ships, aquaculture, recreational activities, and transport of plastic products into finer particles [2,21,22].

THE FORMATION OF MICRO-PLASTICS IN THE OCEAN

Management of micro-plastics in the marine environment; Micro-plastics in marine waters and their adverse effects have been reported since the early 1970s, giving rise to research based on micro-plastics in aqueous environments. A sustainable approach to both production and consumption of plastic materials with global efforts has been geared towards the management of marine debris *via* prevention. The upstream measures of preventing the sources of plastic materials in the marine environment are more cost-effective than the focus on downstream clean up exercises. Risk assessments of various regions can be used to predict global hot-spots of plastic/micro-plastics' prevalence in the marine environment, and well-defined protection goals can be meted out, especially for the sustenance of biodiversity [23-25].

DISCUSSION

The social slogan of "3Rs: Reduce, reuse, and recycle", used in the management of most wastes found in the environments, has continuously been implemented in the case of plastic wastes, more so to traditional plastics, whose long carbon chains make them difficult to degrade or be broken down by microorganisms. The 3Rs are what reported as a circular economy approach, as a means of a sustainable long-term solution, from the existing linear economy. Up-cycling (reuse), which is the art of recycling to improve a material's value, and redesigning of products to make them less hazardous, as well as improved producer responsibility, are also means of sustainable management of plastic waste. Open landfills and dumpsites seat a considerable amount of plastic waste that is often flushed into the ocean during rains. Recycling and reusing plastic products are some of the most effective actions to reduce the volumes of plastic wastes that must be flushed into the ocean. In improving recyclable plastic material wastes, chemical recycling has been considered as a sustainable alternative in the past decade, i.e., the collection of used plastics and chemically recycling them into raw materials for brand-new plastic production of the same properties as the original, and avoiding the incidence of new monomer feed-stock [19,26-28].

The quest for (marine) environment-friendly plastics gave rise to green plastics (green chemistry). Green plastics involve the use of biodegradable plastics. Among the considered perspectives toward sustainable plastic production and curbing plastic wastes, commodity polymers can be made through the use of monomers from plant sources or by producing an alternative to fuel-based products from plant based polymers [28].

RECOMMENDATIONS AND CONCLUSION

Recommendations

- Realistic discussions should be proposed to ensure a significant change in policies and implementation of existing ones.
- Existing laws on environmental pollution and the development of stringent plastic discharge regulations need to be strengthened.
- Plastic industries and firms responsible for production should be monitored or sanctioned where necessary.

Conclusion

The absence of statutory law formulations, as well as being weak and poorly enforced with inadequate compliance in most developing countries, contributes to the continuous discharge of plastics and micro-plastics into the coastal waters. As there exist environmental regulations to monitor different environmental pollution, there should be specific environmental guidelines and standards that would guide plastic discharge and non-compliance of policies in countries. Therefore, in-depth knowledge of the environmental fate and potential adverse effects of micro-plastics in aquatic environments is needed. With the increase in micro-plastics and its effects on marine ecosystems, it is suggested that community and public vanguards could be initiated to develop a feasible platform for micro-plastics' mitigation and ecosystem balance.

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CONFLICTS OF INTEREST

None.

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