Chapter 5
Plastic Pollution and the Ecological Impact on the Aquatic Ecosystem

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ABSTRACT

Plastic pollution in the environment is currently receiving worldwide attention. Improper dumping of disused or abandoned plastic wastes leads to contamination of the environment. Contamination by bulk plastics and plastic debris is currently the one of the most serious problems in aquatic ecosystems. In particular, small-scale plastic debris such as microplastics and nanoplastics has become a leading contributor to the pollution of marine and freshwater ecosystems. Over 300 million tons of plastic is produced annually, and around 75% of all marine litter is plastic. Plastic litter is widespread in aquatic ecosystems and comes from a variety of sources. The abundance of plastics, combined with their small size and subsequent association with plankton in the water column, allows for direct ingestion by aquatic biota at different trophic levels.

INTRODUCTION

Plastics are ubiquitous materials and find applications in all parts of our life and economy. They are lightweight (energy saving) and low cost, and exhibit unique and versatile properties. They find use in agriculture, aviation, railways, telecommunication, building construction, electrical, electronics,

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medicine and health, automotive, packaging, thermal insulation, household, furniture, toys, and others. The usage of plastic packaging's and products has increased multifold in the last one decade due to its low price and convenience. However, general public is not aware of its impact on the human and environment on littering or dumping. In India, approximately 12 million tonnes plastic products are consumed every year (2012), which is expected to rise further. It is also known that about 50 to 60% of its consumption is converted into waste. Main usage of plastics is in the form of carry bags, packaging films, wrappingmaterials, fluid containers, clothing, toys, household applications, industrial products, engineering applications, building materials, etc. It is true that conventional (petro-based) plastic waste is non-biodegradable and remains on landscape for several years polluting the environment. It is also well established that all types of plastic wastes cannot be recycled and therefore, it gets accumulated in open drains, low-lying areas, river banks, coastal areas, sea beaches, etc. Further, recycling of a virgin plastic product can be done 3 to 4 times only by mixing with virgin plastics granules. Therefore, after every recycling, its tensile strength and quality of plastic product gets deteriorated. Besides, recycled plastic materials are more harmful to the health and environment than the virgin products due to mixing of color, additives, stabilizers, flame retardants, etc.

By 2014 the top three global producers of plastics were China, Europe and North America at 26%, 20% and 19%, respectively.337 Five countries accounted for 63.9% of the total European demand for plastics: Germany (24.9%), Italy (14.3%), France (9.6%), the United Kingdom (7.7%) and Spain (7.4%).337 The plastics in most demand worldwide were polyethylene and polypropylene, and the packaging industry was by far the biggest consumer of these materials. By 2015 the worldwide consumption of plastic materials was almost 300 million tonnes.

The presence of small plastic pieces in the oceans was first noted by scientists in the early1970s (Carpenter et al., 1972). Since that time, many scientists have studied the potential problems associated with what we now term "microplastics." Microplastic debris in aquatic ecosystems is currently considered one of the most important global pollution problems of our time.

The majority of synthetic plastics polluting the aquatic environment include polyethyleneterephthalate (PET), low- and high-density polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), and polystyrene (PS). Microplastics are categorized as primary or secondary and then further classified as fragments, pellets, fibers, film, or foam for further study. The term "microplastic" generally refers to plastic particles that are<5 mm, with the term "nanoplastic" being used to describe a plastic particle that is<1 μm in at least one of its dimensions (da Costa et al., 2016).

Primary microplastics are those plastic particles intentionally manufactured in sizes<5 mm for use in personal care products or industrial applications, such as blasting scrubbers. Plastic microbeads have become common components in consumer products such as toothpastes, body washes, and facial cleansers. As such, they frequently flush into municipal wastewater treatment facilities (Fendall and Sewell, 2009). While wastewater treatment processes remove much of this material, a certain portion bypasses the treatment process to be discharged into the aquatic environment (Carr et al., 2016;Talvitie et al., 2015). Mason et al. (2016a) estimate that an average of 13 billion microbeads is released each day into waterways of the United States alone.

Secondary microplastics are the degraded fragments of larger plastic debris that have made their way into the environment. In the environment, plastic items degrade through photo-oxidative pathways (Singh and Sharma, 2008) that make the plastic brittle enough to break into pieces that become increasingly smaller over time. The formation of secondary microplastics from plastic debris depends upon a number of exposure factors including ultraviolet exposure, oxygen concentrations, temperature,