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Agro-ecological microplastics enriching the antibiotic resistance in aquatic environment

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Abstract

Agricultural and allied sector constitute one of the greatest plastic consumers/users. Plastic undergoes fragmentation in these setups generating micro-/nanoplastics (MPs/NPs), where they share the environment with many toxic/hazardous chemicals and considerable quantities of antibiotics. MPs are contaminants of high priority and are often accompanied by biological contaminants in the form of antibiotic-resistance (ABR) genes (ARGs). Recent reports confirm that the MPs can carry and enrich the ARGs in the environment. However, the information on the spread and persistence of MPs-driven ARGs in aquatic ecosystems associated with agricultural sectors is limited. Due to the heavy MP-inflow, diverse kinds of ARGs are anticipated to be present in agricultural water resources and may therefore be the cause of the ABR. The ecological and health risks associated with the MPs and the related ARGs require genuine consideration and further in-depth investigations for effective and sustainable solutions.

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Microplastics, Antibiotic resistance genes, Agriculture, Aquatic ecosystem, Aquatic plastisphere.

Introduction

The durability, superior performance and cost-effectiveness of plastic make it the substance of choice in the majority of the industrial, agricultural and allied sectors as well as in daily human life [1]. Despite the increased global awareness of plastic over-utilization and efforts to regulate and minimize plastic waste output, 26,000 Mt of plastic waste generation is projected by the mid-21st century [2]. Even after recycling, re-purposing, or incinerating a large chunk of plastic waste, around 32 % re-enters the environment [3,4]. The terrestrial and aquatic ecosystems are major reservoirs of such plastic waste and the over-accumulation of the plastic in these ecosystems confirms the long-term presence (due to the durable nature and resilience to biodegradation) and hence long-term hazards to the terrestrial/aquatic communities [4–6]. Over the course of time, the plastic material disintegrates into various sizes including macroplastic (>2.5 cm), mesoplastic (0.5–2.5 cm), microplastic (MPs, <5 mm) as well as nanoplastics (NPs, <100 nm) due to physical abrasion, weathering, ultraviolet radiation, thermal oxidation, and microbial activities [4,7,8]. These particles (especially the MPs) harbor unique characteristics such as smaller size, larger surface, and hydrophobicity and hence possess an ability to serve as the vector for other contaminants (heavy metals, organic, and inorganic pollutants) present in the ecosystem [8–13]. Due to their abundance, highly reactive nature, and ability to reach the remotest possible location, the NPs are potentially more dangerous than the MPs [14].

The existence of the agricultural and allied sectors is totally dependent on the terrestrial and aquatic ecosystems and hence the interaction of the MPs and NPs with the biological and non-biological elements of these sectors is inevitable. The unfortunate consequence of this fact is the occurrence of MPs/NPs in the core agricultural soils [15,16] as well as in the allied agri-sectors such as dairy industry [17], livestock production [18], poultry [19], meat industry [20,21], and aquaculture [22,23]. The presence of MPs/NPs in these systems impacts the biological entities via immunotoxicity, generation of hazardous reactive species, and growth inhibition [24–26]. However, one of the most vital yet unexplored implications of the heavy occurrence of MPs/NPs in the ecosystems is their influence on conjugative gene transfer, the most efficient way of spreading antibiotic resistance genes (ARGs) [27]. The ARGs are responsible for conferring resistance to the microbes against most of the antibiotics in use, making them antibiotic-resistant bacteria (ARBs). The ARGs mainly include the genes encoding proteins responsible