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Microplastics as Vectors of Contaminants in Aquatic Ecosystems

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Plastic pollution represents one of the most urgent threats of the recent era [1-6]. Evidences of the negative impacts of macroplastics, and their derived microplastics and nanoplastics debris on both aquatic and terrestrial ecosystems, are provided daily by the scientific community. Most of the total litter released in the natural environments belongs to the small size plastic debris (microplastics) which originate from a wide-variety of sources, including clothing, fishing, cosmetics, and industrial processes; their abundance is expected to continue to increase, representing a serious concern for humans and marine wildlife. In this context, it is extremely urgent to activate actions aimed at monitoring the sources, distribution pathways, and effects of marine litter on biota as well as at mitigating or reducing such impacts. Although many Countries have started to undertake measures to counteract plastic pollution, through the activation of research projects regarding this issue, educational programs to increase public awareness of the problem and the set up and development of standardized protocols to recover microplastics from the environment [7], research on marine litter is relatively recent and the actual implications of plastic contaminants on human health are still unpredictable [8]. Limiting attention to the marine ecosystems, more research is needed to focus on the role of plastics as vectors of both biological and chemical contaminants not only within the pelagic compartment, but also within the benthic one; indeed, sediments act as a sink for those contaminants once they have reached the aquatic environment.

With respect to biological contaminants, hydrological forcing such as wind and current can transport plastic-attached organisms over long distances; bryozoans, crustaceans, molluscs, have been found rafting on floating litter across the open sea [9]. Taking in consideration the huge amount of litter and the great persistence of plastic materials in the world's oceans, rafting dispersal can favour the spread of invasive species. At lower size range, interactions of plastic particles with aquatic microbiota are a new research challenge that needs to be elucidated yet, particularly regarding potentially negative effects played by microplastics on microbial structure and metabolism [10]. Indeed, plastic debris may support adhesion and colonization by microbes, that work as pioneering surface colonizers through biofilm production [11] leading to the formation of an attached plastisphere [12] or an ecocorona of macromolecules [13]. Ecological interactions between marine microorganisms and microplastics are now receiving increasing attention [10,14-27].

The impacts of microplastics and plastic co-pollutants on the structure, composition and activities of natural microbiota (bacteria, microalgae) is complex, nevertheless, their study is important to understand the fate of plastic debris in aquatic environments. Some studies [9] have shown that microbial aggregates on microplastics depend on specific characteristics of substrata, such as the type of plastic polymer. Furthermore, the process of plastic colonization can be affected by the surface rugosity and hydrophobicity of litter fragments.

Recent studies have confirmed that microplastics may have a role as vectors for toxic microalgae [28,29] and favour the absorption and accumulation of chemical pollutants [30-32]. Partitioning of chemicals into different plastics has been reported to follow the order of low-density polyethylene ≈ high-density polyethylene ≥ polypropylene>polyvinyl chloride ≈ polystyrene [33].

In addition to plastic pollution, the spread of antibiotic resistances represents another major societal and economic concern. Chemical contaminants, such as antibiotics and heavy metals, which are known to play a role as drivers of Antibiotic Resistance (AR) phenomena [34,35], can absorb to plastic debris, supporting the transmission of antibiotic resistant bacteria (ARB) and/or Antibiotic Resistance Genes (ARG) and making water bodies natural reservoirs of AR. AR-phenomena mediated by plastic contaminants can affect also unexpected regions, such as polar regions, previously considered as pristine environments [36]. A recent study, performed on a macro-plastic fragment of polystyrene retrieved from the King George Islands (South Shetlands, Antarctica) by Laganà et al. [37] has highlighted the occurrence of multiple resistances in the associated bacterial flora. Of a total of 27 bacterial isolates, identified by molecular 16s rRNA gene sequencing, strains were selected and screened for their ability to produce biofilm and antibiotic susceptibility profiles, showing multiple AR resistances against the molecules cefuroxime and cefazolin (belonging to cephalosporins), cinoxacin (belonging to quinolones) and ampicillin, amoxicillin+clavulanic acid, carbenicillin and mezlocillin (belonging to beta-lactams). The results of this study, supported by the Italian National Antarctic Research Program (PNRA) in the framework of the projects PLANET (Plastic in Antartic Environment, PNRA 14_00090) and ANT-BIOFILM ("Microbial colonization of benthic ANTarctic environments: response of microbial abundances, diversity, activities and larval settlement to natural or anthropogenic disturbances and search for secondary metabolites", PNRA 16_00105 [38]) confirmed the role of plastics as vectors for the spread of multiple AR across Antarctic marine environments. A similar result has been reported by Arias-Andres et al. [39] who have reported an increased frequency of plasmid transfer in bacteria associated with microplastics compared to those free-living or present in natural aggregates. All the above-reported observations suggest that microplastics can represent potential carriers for the spread of organic contaminants and marine microbes, including ARB; consequently the spread of microplastics poses a neglected hazard for human health, underlying the relevance of future studies on this emerging research topic.

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