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Editorial

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Microplastics in Marine Environments: Possible Interactions with the Microbial Assemblage

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Litter represents one of the most important problems threatening all the marine environments [1,2]. Among litter, 40-80% is represented by plastics, whose amount has significantly increased in the last years [3,4]. The global annual production of plastics is estimated to be around 280 million tons, the vast majority being for disposable use. The main sources of plastics are land or marine-based (i.e. fishing nets) and the highest pollution levels are generally reached close to heavy urbanized areas, from which plastic debris are dispersed depending on hydrodynamic patterns [3,5].

In the marine environment, plastics undergo a process of weathering and fragmentation of macrodebris into smaller micro- and nano-plastic debris [3,5], made of polypropylene, polyethylene, polystyrene, polyethylene terephthalate, and polyvinylchloride. Both micro- and nanoplastics may accumulate on the sea surface and their concentrations are reported to increase in the world's oceans [6-9]. Due to the long stability of plastic particles in water column, buoyant plastics can, over a timescale of weeks to months, sink and accumulate in sediments; consequently, deep environments are recognized to be a sink for marine debris [10]. Plastics play not only negative effects on marine environments from the aestethic point of view; they also have severe consequences on the marine animals in relation to the ingestion of debris [11,12]. Nano- and microplastics can be ingested and accumulated along trophic webs until top predators. The presence and persistence of microplastics along the marine trophic webs represents an early warning signal of the health status of fish resources [12]. Moreover, phthalates, which are commonly used as plastic additives to increase plastic performance, may act as toxic compounds compromising the reproductive functions [13]. In addition, micro and nanoplastics might have a role in spreading invasive species (i.e. as settlement of planktonic larvae) and may work as carriers of toxic compounds like Persistent Organic Pollutants (POPs) which are endocrine disruptors and may alter organisms viability [14-16]. Attention to the problem of plastics has been addressed by several Organizations working in the field of environmental protection, including US EPA and UNEP [17,18], who have recognized that it is more and more urgent to develop sound environmental policies for micro and nanoplastics risk assessment and marine ecosystems conservation.

On April 28, 2015, the European Parliament has voted to limit the use of plastic bags that are thinner than 0.05mm and often pollute seas and rivers. In the future, EU Countries could reduce annual average consumption to 90 lightweight bags per citizen by the end of 2019, and 40 by the end of 2025, or ensure that no more light plastic bags are handed out free of charge to shoppers by 2018.

In the framework of the recent Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC of the European Parliament, Marine Litter is the Descriptor 10 [19]. The MSFD states that "Properties and quantities of marine litter do not have to cause harm to the coastal and marine environment". Since it is recognized that plastics pose a serious concern for the status of such fragile ecosystems, the composition of micro-particles (in particular micro plastics) has to be characterized in marine and coastal environments and, for the litter in biota, trends in the amount and composition of litter ingested by marine animals require further investigations in some sub-regions, including the Mediterranean Sea [20]. However, there are still severe gaps in establishing the presence and effects of marine litter in Mediterranean marine organisms; therefore, sentinel species should be used to determine the effects and implement future mitigation actions [21]. In marine ecosystems, the surface of plastic debris is colonized by a complex microbial community, indicated with the name of "plastisphere", which has recently been reviewed [22]. The composition of microbial populations associated to these particles has been reported to vary depending on the nature of the plastic substrate and the geographical area, as well as on the sampling season [23]. Nevertheless, specific knowledge is still lacking on the effects of micro and nanoplastics on both structure and function of bacterioplankton. Compared to organisms at the highest levels of marine food webs, relatively little attention has been addressed to the interactions between microorganisms and marine micro plastics [24,25]. This particular topic deserves to be better focused, since plastics may facilitate microbial adhesion and colonization through biofilm formation [2,26] and consequently work as potential carriers for the spread of bacterial pathogens through the sea [9]. For example, Quilliam et al. [27] have suggested that plastic debris can influence the survival of faecal indicator organisms in beach environments. In rivers it has been shown that microplastic in rivers are a distinct microbial habitat and may be a novel vector for the transport of unique bacterial assemblages [28,29]. As reported by Carson et al. [30], species identification could also allow the assessment of some direct impacts of plastic microorganisms, such those related to the transport of potential invaders, harmful algal species, or disease vectors.

Another interesting feature in the microbial interactions with plastic debris regards the possible negative effects played by micro- and nanoplastics on the structure and metabolic profiles of the microbial assemblage in terms of proteolytic, lipolytic and glycolytic abilities, with detrimental consequences on the biogeochemical processes that drive ecosystem functioning.

On the other hand, bacteria/Archaea/fungi have the capacity to degrade various types of plastics through the secretion of specific extracellular enzymes (i.e. oxygenases, lipases and esterases) [9,31]. However, the relative importance of these microroganisms in plastic biodegradation in the environment is still unknown [9], since most of the knowledge on plastic biodegradation processes comes from culture-

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based approaches which take into account less than 0.1% of the total bacterial diversity. The use of molecular and biochemical methods, complementary to culture ones, is, therefore, suggested in future studies to shed lights on the metabolism of the" plastisphere" members. Moreover, a better knowledge of the environmental parameters, such as light, nutrient or carbon limitation, is needed to optimize plastic biodegradation.

Microbial degradation of polymers increases their surface for adsorption, so improving their capacity to carry pollutants [9]. Microorganisms attached to the plastic surface form a biofilm, which modifies the interaction of microplastics with metals and organic compounds and further complicates the relation between pollutants in the water and those adsorbed to or leached from plastics.

In the light of the above reported considerations, it is evident that microplastics in oceans are causing rising concern**;** since they may represent carriers for microbial pathogens and favour the absorption and accumulation of chemical pollutants**,** it is recommended that monitoring plans for plastic debris should take into account also their possible interactions with the microbial assemblage. Particularly, "in situ" monitoring as well as experiments in microcosms should focus on the study of both structure (taxonomic composition) and function (metabolic profiles) of the microflora associated to micro- and nano-plastics. Attention should be addressed to both quantitative and qualitative variations of the microbes attached to micro and nanoplastics.

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