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2. Il candidato illustri le principali esperienze di studio e/o professionali indicate nel Curriculum vitae et studiorum in formato europeo;

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4. Il candidato illustri le principali caratteristiche del pacchetto Microsoft Office

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Review

Microplastics as contaminants in the marine environment: A review

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ARTICLE INFO

Keywords:
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Plastic debris
Priority pollutant

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Whilst the societal benefits of plastic are far-reaching (Andrady and Neal, 2009), this valuable commodity has been the subject of increasing environmental concern. Primarily, the durability of plastic that makes it such an attractive material to use also makes it highly resistant to degradation, thus disposing of plastic waste is problematic (Barnes et al., 2009; Sivan, 2011). Exacerbated by the copious use of throw-away "user" plastics (e.g. packaging material), the proportion of plastic contributing to municipal waste constitutes 10% of waste generated worldwide (Barnes et al., 2009). While some plastic waste is recycled, the majority ends up in landfill where it may take centuries for such material to breakdown and decompose (Barnes et al., 2009; Moore, 2008). Of particular concern are plastics that, through indiscriminate disposal, are entering the marine environment (Gregory, 2009). Despite plastics being an internationally recognised pollutant with legislation in place aimed to curb the amount of plastic debris entering the marine environment (Gregory, 2009; Lozano and Mouat, 2009), Thompson (2006) estimates up to 10% of plastics produced end up in the oceans, where they may persist and accumulate.

The impact that large plastic debris, known as 'macroplastics', can have on the marine environment has long been the subject of environmental research. The presence of macroplastics in the marine environment presents an aesthetic issue, with economic repercussions for the tourist industry, a hazard for numerous marine-industries (e.g. shipping, fishing, energy production, aquaculture) as plastic may result in entanglement and damage of equipment, and significant environmental concerns (Barnes et al., 2009; Derraik, 2002; Sivan, 2011). The environmental impact of macroplastics include: the injury and death of marine birds, mammals, fish and reptiles resulting from plastic entanglement and ingestion (Derraik, 2002; Gregory, 2009; Lozano and Mouat, 2009), the transport of non-native marine species (e.g. bryozoans) to new habitats on floating plastic debris (Barnes, 2002; Derraik, 2002; Winston, 1982), and the smothering of the seabed, preventing gas-exchange and creating artificial hard-grounds, resulting from sinking plastic debris (Gregory, 2009; Moore, 2008).

In recent years, there has been increasing environmental concern about 'microplastics': tiny plastic granules used as scrubbers in cosmetics and air-blasting, and small plastic fragments derived from the breakdown of macroplastics (Derraik, 2002; Ryan et al., 2009; Thompson et al., 2004). The presence of small plastic fragments in the open ocean was first highlighted in the 1970s (Carpenter and Smith, 1972), and a renewed scientific interest in microplastics over the past decade has revealed that these contaminants are widespread and ubiquitous within the marine environment, with the potential to cause harm to biota (Rands et al., 2010; Sutherland et al., 2010). Owing to their small size, microplastics are considered bioavailable to organisms throughout the food-web. Their composition and relatively large surface area make them prone to adhering waterborne organic pollutants and to the leaching of plasticisers that are considered toxic. Ingestion of microplastics may therefore be introducing toxins to the base of the food chain, from where there is potential for bioaccumulation (Teuten et al., 2009).

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2.1. Primary microplastics

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Microplastic "scrubbers", used in exfoliating hand cleansers and facial scrubs, have replaced traditionally used natural ingredients, including ground almonds, oatmeal and pumice (Derraik, 2002; Fendall and Sewell, 2009). Since the patenting of microplastic scrubbers within cosmetics in the 1980s, the use of exfoliating cleansers containing plastics has risen dramatically (Fendall and Sewell, 2009; Zitko and Hanlon, 1991). Typically marketed as "micro-beads" or "micro-exfoliates", these plastics can vary in shape, size and composition depending upon the product (Fendall and Sewell, 2009). For example, Gregory (1996) reported the presence of polyethylene and polypropylene granules (<5 mm) and polystyrene spheres (<2 mm) in one cosmetic product. More recently, Fendall and Sewell (2009) reported an abundance of irregularly shaped microplastics, typically <0.5 mm in diameter with a mode size <0.1 mm, in another cosmetic product.

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Secondary microplastics describe tiny plastic fragments derived from the breakdown of larger plastic debris, both at sea and on land (Ryan et al., 2009; Thompson et al., 2004). Over time a culmination of physical, biological and chemical processes can reduce the structural integrity of plastic debris, resulting in fragmentation (Browne et al., 2007).

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2.1. Primary microplastics

Plastics that are manufactured to be of a microscopic size are defined as primary microplastics. These plastics are typically used in facial-cleansers and cosmetics (Zitko and Hanlon, 1991), or as air-blasting media (Gregory, 1996), whilst their use in medicine as vectors for drugs is increasingly reported (Patel et al., 2009). Under the broader size definitions of a microplastic, virgin plastic production pellets (typically 2–5 mm in diameter) can also be considered as primary microplastics, although their inclusion within this category has been criticised (Andrady, 2011; Costa et al., 2010).

Microplastic "scrubbers", used in exfoliating hand cleansers and facial scrubs, have replaced traditionally used natural ingredients, including ground almonds, oatmeal and pumice (Derraik, 2002; Fendall and Sewell, 2009). Since the patenting of microplastic scrubbers within cosmetics in the 1980s, the use of exfoliating cleansers containing plastics has risen dramatically (Fendall and Sewell, 2009; Zitko and Hanlon, 1991). Typically marketed as "micro-beads" or "micro-exfoliates", these plastics can vary in shape, size and composition depending upon the product (Fendall and Sewell, 2009). For example, Gregory (1996) reported the presence of polyethylene and polypropylene granules (<5 mm) and polystyrene spheres (<2 mm) in one cosmetic product. More recently, Fendall and Sewell (2009) reported an abundance of irregularly shaped microplastics, typically <0.5 mm in diameter with a mode size <0.1 mm, in another cosmetic product.

Primary microplastics have also been produced for use in air-blasting technology (Derraik, 2002; Gregory, 1996). This process involves blasting acrylic, melamine or polyester microplastic scrubbers at machinery, engines and boat hulls to remove rust and paint (Browne et al., 2007; Derraik, 2002; Gregory, 1996). As these scrubbers are used repeatedly until they diminish in size and their cutting power is lost, they will often become contaminated with heavy metals (e.g. Cadmium, Chromium, Lead) (Derraik, 2002; Gregory, 1996).

2.2. Secondary microplastics

Secondary microplastics describe tiny plastic fragments derived from the breakdown of larger plastic debris, both at sea and on land (Ryan et al., 2009; Thompson et al., 2004). Over time a culmination of physical, biological and chemical processes can reduce the structural integrity of plastic debris, resulting in fragmentation (Browne et al., 2007).

Over prolonged periods, exposure to sunlight can result in photo-degradation of plastics; ultraviolet (UV) radiation in sunlight causes oxidation of the polymer matrix, leading to bond cleavage (Andrady, 2011; Barnes et al., 2009; Browne et al., 2007; Moore, 2008; Rios et al., 2007). Such degradation may result in additives, designed to enhance durability and corrosion resistance, leaching out of the plastics (Talsness et al., 2009). The cold,