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Short communication

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# Marine Pollution: The Problematic of Microplastics

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Throughout the history of mankind and the of conquest of the seas and oceans these water masses were always seen as unlimited sinks of wastes since they were assumed as being able to disperse, dilute and redistribute natural and synthetic substances. However, in the last few decades we have finally realized that this capacity is not unlimited [1,2]. According to literature about 6.4 millions of tons of litter are deposited in oceans and seas. Per year, there are about 8 millions of daily sewages together to 5 million tons of solid residues thrown into the marine environment by boats. Moreover, it was estimated that more than 13,000 plastic pieces are floating per each square kilometer of ocean [3]. The marine litter is a great and crescent environmental threat since it can be found in all oceans and seas even in remote places far away from obvious source of pollution. Marine litter can migrate long distances through oceans currents and winds being observed in marine and coastal environments, from poles to equator, from continental littorals to small remote islands. Islands completely made of litter already exist and the slow degradation process litter aggravates this problem [4].

The concern about the presence of plastics in marine environments comes from many years ago. Actually, in 1972 Carpenter et al. [5] warned about the increase of plastic production, which could lead to greater concentrations of plastics on sea surface. Only few months later it was reported the first case of plastics ingestion by fishes [5]. Nowadays, it is known that several million tons of plastics have been produced ever since [6,7,8] leading to the need to deal with this contamination, especially in oceans where they suffer degradation and fragmentation [6,8]. Their main sources are beach litter (contributing to about 80% of plastic debris), fishing industry (about 18%) and aquaculture [8,9]. Coastal tourism, recreational and commercial fishing and marine vessels may also be in the origin of plastic pollution [10]. Plastics debris migrates through the oceans being transformed into small fragments forming microplastics. Microplastics receive this designation due to their size smaller than 5 mm [11].

The impacts of microplastics still remains unclear nevertheless some conclusions and suspicions were already raised by recent studies. In fact, the evidences of exposure of several marine organisms enlarge, although being difficult to quantify such exposures and to establish dose/effect relationships required for setting risk limits (as PNEC values - predicted no effect concentrations), as we intended to demonstrate. Table 1 summarizes some of the studies that were performed mainly aimed in detecting exposures to microplastics and in evaluating resulting effects on different species, both under natural and laboratorial conditions. Some review papers also summarize much more information analyzing data with different points of view [12-14]. However, all the existing data suggests that for assessing the risks of microplastics, dose response curves have to be established under laboratorial conditions, and for being representative of field situations, such doses for different species have likely to be established at least based on the size, concentration of particles and on the chemical composition of the microplastics. These seems to be the most relevant factors determining their bioavailability, chemical versus physical effects and potential for transference through trophic chains [12].

Neverthless, the contamination of marine environments by microplastics may have other types of impacts, indirectly affecting organisms. The ingestion of microplastics by small animals may cause a decrease in food consumption due to satiation feeling and/or intestinal blockage leading to death [15]. These compounds can accumulate in the gut of filter-feeding mussels persisting for more than 48 day [16].

It is known, for example, that the presence of small plastics debris in beach sand slows the heating of the sediments [17]. The resulting reduction in temperature of sand can impact organisms with temperature-depending sex-determination, like turtles that can be affected even by a low concentration of plastic (1.5%) [18]. Further, the permeability of the sand increases with the presence of microplastics [17]. This change combined with grain size increase and desiccation stress could negatively affect the embryonic development of eggs of several organisms like crustaceans [19], mollusks [20], polychaetes [21] and fishes [22]. Permeability increase also leads to a change in trace element cycling in beach sediments. When sands have a higher permeability more water is flushed through the beaches giving more oxygen and organic matter to the small interstitial organisms. More oxygen and organic matter causes an increase in the abundance of such organisms, which, in turn, will release a higher amount of compounds resulting from their metabolism in water. More metabolites lead to changes in oxygen gradients and redox conditions impacting those environments [17,23].

Besides all the efforts applied at regional, national and international levels, marine litter continues to increase. Delays in the application and fulfillment of the already existent regulations, or either the lack of supervision or of specific regulations in several parts of the world are contributing for such increasing problem. More awareness and outreaching activities to general public are also required, to promote new behaviors related with plastics use and disposal. Such actions are of particular importance, since the effects of marine pollution

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| Local | Species | Goals | Main results | References |
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| Laboratorial exposure | Lytechinus variegatus (sea urchin) | Compare the effects of plastic pellets (virgin and beach stranded) on Lytechinus variegatus embryos development. | A 58.1 and 66.5% increase of anomalies in embryonic development were recorded for beach stranded and virgin pellets, respectively. The pellets were tested in a proportion of 1:4 (pellet:seawater) | [24] |
| Laboratorial exposure | Mytilus edulis (mussel) | Assess the uptake and translocation of microplastics (10-30-90 mm) under laboratorial conditions and the effects on energy metabolism | Organisms exposed to a high concentration of polystyrene microspheres (110 particles/ mL-1 sea water). Microplastics were present in all organisms collected (0.2 ± 0.3 particles/g body weight). Ingestion and translocation of microplastics in the gut didi not affect the cellular energy allocation. | [25] |
| Laboratorial exposure | | Assess effects of polyethylene ingestion at cellular and subcellular levels. | After intake of particles with 0-80 µm, the following effects were observed: strong inflammatory response; granulocytomas formation after lysosomal membrane destabilization in connective tissue of digestive gland. Microplastic uptake into the gills and stomach with transport to digestive gland where they accumulated in lysosomal system in 3 h. | [26] |
| Laboratorial exposure | | Assess the effects of 30 nm polystyrene particles (0, 0.1, 0.2, and 0.3 g/L) on the feeding behavior. | Filtering activity was reduced in presence of polystyrene. Production of pseudo-feces when exposed to 0.1 g/L. The polystyrene was recognized as a low nutritional food by mussels. | [27] |
| Laboratorial exposure | | Evaluation of the Ingestion, translocation and accumulation of microplastics debris (3.0 or 9.6 µm). | Microplastics accumulation in gut. Microplastics capture in hemolymph. Microplastics translocation from gut to circulatory system during 48 days. | [28] |
| Laboratorial exposure | | Assess the presence of microplastics in soft tissues (whole body except the shell). | 0.36 ± 0.07 particles/g (wet weight). | [29] |
| Laboratorial exposure | Mytilus galloprovincialis (mussel) | Evaluate the effects of pyrene in presence of polyethylene and polystyrene microplastics. | Presence of microplastics in hemolymph, gills and in digestive glands. Microplastics caused DNA strand breaks in haemocytes at 20 g/L. Pyrene effects were emphaticized by microplastics because they adsorb pyrene increasing its uptake and bioavailability. | [30] |
| Laboratorial exposure | Crassostrea gigas (oyster) | Assess the presence of microplastics in soft tissues (whole body except the shell). | 0.47 ± 0.16 particles/g (wet weight). | [29] |
| Laboratorial exposure | Arenicola marina (annelid) | Assess the uptake and translocation of microplastics (10-30-90 mm) under laboratorial conditions and the effects on energy metabolism | Organisms exposed to a high concentration of polystyrene microspheres (110 particles/g-1 sediment). Microplastics were present in all organisms collected in the field; on average 1.2 ± 2.8 particles/g body weight. Ingestion and translocation of microplastics in the gut did not affect the cellular energy allocation. | [25] |
| Laboratorial exposure | Arenicola marina (annelid) | Assess the bioaccumulation of polystyrene and polychlorinated biphenyl. | A low polystyrene dose increased bioaccumulation of PCBs by a factor of 1.1−3.6. Polysterene did not accumulate in A. marina but it can be ingested by its predators while in the gut of A. marina. | [31] |

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| Laboratorial exposure | | Evaluation of the effects of microscopic unplasticised polyvinylchloride (UPVC) | Energy reserves depletion after a chronic exposure to a dose of UPVC corresponding to 5% of sediment weight. Accumulation of UPVC in longer gut and inflammation with an enhanced phagocytic response after a chronic exposure. | [32] |
| Laboratorial exposure | Pomatoschistus microps (common goby fish) | Assess the predatory behavior of juveniles in the presence of microplastics. | Microplastics (420-500 μm size) were ingested suggesting confusion with food. Such confusion was dependent from the color of the microplastics and from the conditions of the fish juveniles. | [33] |
| Laboratorial exposure | Pomatoschistus microps (common goby fish) | Assess the Influence of microplastics on chromium toxicity in juveniles. | In presence of microplastics (0.216 mg/L), chromium (1.8 – 28.4 mg/L inhibited acetycholinesterase activity. | [34] |
| North Western Mediterranean basin | Zooplankton | Evaluation of the ratio of microplastic to zooplankton in neustonic waters collected in 40 sampling stations | Presence of microplastics of different types (filaments, polystyrene, thin plastic films) in 90% of the sampling stations with sizes ranging 0.3-0.5 mm and an average weight of 1.81 mg/particle. A ratio of 1:5 (microplastic/ zooplankton) was recorded in neustonic water samples thus representing a high risk to filter feeding organisms. | [35] |
| Cepola macrophthalma (bandfish) | Southwest of Plymouth, United Kingdom | Assessment of plastic ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (<40 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Southwest of Plymouth, United Kingdom | Callionymus lyra (common dragonet fish) | Assessment of plastic ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (< 50 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Southwest of Plymouth, United Kingdom | Buglossisium luteum (yellow sole) | Assessment of plastic ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (< 20 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Southwest of Plymouth, United Kingdom | Microchirus variegatus (sole) | Assessment of plastic ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (< 20 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Southwest of Plymouth, United Kingdom | Aspitrigla cuculus (red gurnard fish) | Assessment of plastics ingestion. (The study documents microplastics in 10 species of fish from the English Channel). | Microplastics ingestion (< 70 pieces). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Mediterranean Sea (Pelagos Sanctuary) | Balaenoptera physalus (fin whale) | Detection of MP and phthalates in surface neustonic/planktonic samples. Detection of phthalates in stranded fin whales. | 56% of the surface neustonic/ planktonic samples contained microplastic particles. Portofino MPA (Ligurian Sea) with the highest abundance of microplastics (9.67 items/ m3). High concentrations of phthalates (1.00 – 4.32 ng/g fw) were detected in the neustonic/ planktonic samples. Phthalates were in bubbler of stranded fin whales suggesting that they can be used as a tracer of the intake of microplastics. | [37] |

with microplastics still few evident for the society, thus resulting, for example, in misinterpretations of the taxes applied to plastic bags. Nevertheless, there is still hope that, as it happened with other dangerous contaminants such as tributyltin [23], the legislation will contribute to prevent the catastrophe presently envisaged to the marine environment due to pollution with microplastics.

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| Mediterranean Sea | | Evaluation of phthalate levels in this species. | Presence of phthalates in bubbler (1.48 – 377.82 ng/g lipid basis). This species can be a potential bioindicator of the presence of microplastics in pelagic environments. | [38] |
| Ireland | Mesoplodon mirus (beaked whale) | Evaluation of exposures trough the analysis of stomach and gut contents. | Presence of microplastics in stomachs. Top oceanic predatory species are exposed to plastics; exposure pathways still unclear. | [39] |
| Mediterranean Sea | Cetorhinus maximus (basking shark) | Evaluation of the exposure to phthalates. | High concentrations of phthalates in muscle (11.17 – 156.67 ng/g lipid basis). This species can be a potential bioindicator of microplastics in pelagic environments. | [38] |
| Southwest of Plymouth, United Kingdom | Merlangius merlangus (whiting fish) | Assessment of plastic ingestion. (Study documents microplastics in 10 species of fish from the English Channel). | Microplastics ingestion (< 30 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Southwest of Plymouth, United Kingdom | Micromesistius poutassou (blue whiting fish) | Assessment of plastic ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (~ 30 pieces). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Southwest of Plymouth, United Kingdom | Trisopterus minutus (poor cod fish) | Assessment of plastic ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (~ 40 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |
| Central Mediterranean Sea | Xiphias gladius (swordfish), Thunnus alalunga (tuna albacore) and Thunnus thynnus (tuna fish) | Evaluation of the presence of plastic debris in stomach. | Microplastics ingestion: 29 particles were found in the stomach of 22 fish. Plastic fragments with different colors and shapes. Swordfish: dominance of mesoplastics (44.4%); Albacore: dominance of microplastics (75%); Tuna fish: meso and macroplastics ingested in the same proportion. A relation between fish size and plastic size was found. | [40] |
| Southwest of Plymouth, United Kingdom | Zeus faber (fish) | Assessment of plastics ingestion. (The study documents microplastics in 10 species of fish from the English Channel.) | Microplastics ingestion (< 60 pieces/particles). Presence of polyamide, semi-synthetic cellulosic material and rayon in gastrointestinal tracts).* | [36] |

**Table 1:** Collection of some microplastics exposure and effects in animal species under both natural and laboratorial conditions.

## References

1. Baptista Neto JA, Wallner-Kersanach M, Patchineelam SM (2008) Poluição Marinha. Ed. Interferência, Rio de Janeiro, Brazil.
2. Clark BR (1997) Marine Pollution. Claredon Press, United Kingdom.
3. UNEP (2005) Marine Litter, An Analytical Overview.
4. Kennish JM (1997) Practical Handbook of Estuarine and Marine Pollution. Ed. Boca Raton CRC Press. 524.
5. Carpenter EJ, Anderson SJ, Harvey GR, Miklas HP, Peck BB (1972) Polystyrene spherules in coastal waters. Science 178: 749-750.
6. Barnes DKA, Galgani F, Thompson RC, Barlaz M (2009) Environmental accumulation and fragmentation of plastic debris in global. Phil TR Soc B 364: 1985-1998.
7. Thompson RC, Swan SH, Moore CJ, vom Saal FS (2009) Our plastic age. Phil TR Soc B 364: 1973-1976.
8. Andrady AL (2011) Microplastics in the marine environment. Mar Pollut Bull 62: 1596-1605.
9. Hinojosa I, Thiel M (2009) Floating marine debris in fjords, gulfs and channels of southern Chile. Mar Pollut Bull 58: 341-350.
10. Cole M, Lindeque P, Halsband C, Galloway TS (2011) Microplastics as contaminants in the marine environment: A review. Mar Pollut Bull 62: 2588-2597.
11. Bakir A, Rowland SJ, Thompson RC (2012) Competitive sorption of persistent organic pollutants onto microplastics in the marine environment. Mar Pollut Bull 64: 2782-2789.
12. Wright SL, Thompson RC, Gallowaya TS (2013) The physical impacts of microplastics on marine organisms: A review. Environmental Pollution 178: 483-492.
13. Ivar do Sul JA, Costa MF (2014) The present and future of microplastic pollution in the marine environment. Environmental Pollution 185: 352-364.
14. Cauwenberghe LV, Devriese L, Galgani F, Robbens J, Janssen CR (2015) Microplastics in sediments: A review of techniques, occurrence and effects. Mar Environ Res 1-13.
15. Derraik JGB (2002) The pollution of the marine environment by plastic debris: a review. Mar Pollut Bull 44: 842-852.
16. Browne MA, Dissanayake A, Galloway TS, Lowe DM, Thompson RC (2008) Ingested microscopic plastic translocates to the circulatory system of the mussel Mytilus edulis (L.). Environmental Science and Technology 42: 5026–5031.

17. Carson HS, Colbert SL, Kaylor MJ, McDermid KJ (2011) Small plastic debris changes water movement and heat transfer through beach sediments. Mar Pollut Bull 62: 1708-1713.

18. Yntema CL, Mrosovsky N (1982) Critical periods and pivotal temperatures for sexual differentiation in loggerhead sea turtles. Canadian Journal of Zoology 60: 1012-1016.

19. Penn D, Brockmann HJ (1994) Nest-site selection in the horseshoe-crab, Limulus polyphemus. Biological Bulletin 187: 373-384.

20. D'avila S, Bessa ECD (2005) Influence of moisture on growth and egg production by *Subulina octona* (Bruguiere) (Mollusca, Subulinidae), reared in different substrates, under laboratorial conditions. Rev Bras Zool 22: 349-353.

21. Di Domenico M, Lana PD, Garraffoni ARS (2009) Distribution patterns of interstitial polychaetes in sandy beaches of southern Brazil. Marine Ecology an Evolutionary Perspective 30: 47-62.

22. Quinn T (1999) Habitat characteristics of an intertidal aggregation of Pacific sandlance (Ammodytes hexapterus) at a North Puget Sound Beach in Washington. Northwest Science 73: 44-49.

23. Evans SM (1999) Tributyltin pollution: the catastrophe that never happened. Mar Pollut Bullet 38: 629-636.

24. Collignon A, Hecq JH, Glagani F, Voisin P, Collard F, Goffart A (2012) Neustonic microplastic and zooplankton in the North Western Mediterranean Sea. Mar Pollut Bullet 64: 861-864.

25. Nobre CR, Santana MFM, Maluf A, Cortez FS, Cesar A, Pereira CDS, Turra A (2015) Assessment of microplastic toxicity to embryonic development of the sea urchin Lytechinus variegatus (Echinodermata: Echinoidea). Mar Pollut Bullet 92: 99-104.

26. van Cauwenberghe L, Claessens M, Vandegehuchte MB, Janssen CR (2015) Microplastics are taken up by mussels (Mytilus edulis) and lugworms (Arenicola marina) living in natural habitats. Environmental Pollution 199: 10-17.

27. Moos NV, Burkhardt-Holm P, Köhler A (2012) Uptake and effects of microplastics on cells and tissue of the blue mussel Mytilus edulis L. after an experimental exposure. Environ Sci and Technol 46: 11327-11335.

28. Wegner A, Besseling E, Foekema EM, Kamermans P, Koelmans AA (2012) Effects of nanopolystyrene on the feeding behavior of the blue mussel (Mytilus edulis L.). Environ Toxicol and Chem 31: 2490-2497.

29. Browne M, Dissanayake AD, Galloway TS, Lowe DM, Thompson RC (2008) Ingested microscopic plastic translocates to the circulatory system of the mussel, Mytilus edulis (L.). Environ Sci and Technol 42: 5026-5031.

30. van Cauwenberghe L, Janssen CR (2014) Microplastics in bivalves cultured for human consumption. Environmental Pollution 193: 65-70.

31. Avio CG, Gorbi E, Milan M, Benedetti M, Fattorini D, et al. (2015) Pollutants bioavailability and toxicological risk from microplastics to marine mussels. Environmental Pollution 198: 211-222.

32. Besseling E, Wegner A, Foekema EM, Martine J, van den Heuvel-Greve, Koelmans AA (2013) Effects of microplastic on fitness and PCB bioaccumulation by the lugworm Arenicola marina (L.). Environ Sci Technol 2: 593-600.

33. Wright SL, Rowe D, Thompson RC, Galloway TS (2013) Microplastic ingestion decreases energy reserves in marine worms. Current Biology 23: 1031-1033.

34. Lusher AL, McHugh M, Thompson RC (2013) Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. Mar Pollut Bullet 67: 94-99.

35. Carlos de Sá L, Luís LG, Guilhermino L (2015) Effects of microplastics on juveniles of the common goby (Pomatoschistus microps): confusion with prey, reduction of the predatory performance and efficiency, and possible influence of developmental conditions. Environ Pollut 196: 359-362.

36. Luís LG, Ferreira P, Fonte E, Oliveira M, Guilhermino L (2015) Does the presence of microplastics influence the acute toxicity of chromium (VI) to early juveniles of the common goby (Pomatoschistus microps)? A study with juveniles from two wild estuarine populations. Aquat Toxicol 164: 163-174.

37. Fossi MC, Panti C, Guerranti C, Coppola D, Giannetti M, et al. (2012) Are baleen whales exposed to the threat of microplastics? A case study of the Mediterranean fin whale (Balaenoptera physalus). Mar Pollut Bullet 64: 2374-2379.

38. Fossi MC, Coppola D, Baini M, Giannetti M, Guerranti C, et al. (2014) Large filter feeding marine organisms as indicators of microplastic in the pelagic environment: the case studies of the mediterranean basking shark (Cetorhinus maximus) and fin whale (Balaenoptera physalus). Mar Environ Res 100: 17-24.

39. Lusher AL, Hernandez-Milian G, O'Brien J, Berrow S, O'Connor I, et al. (2015) Microplastic and macroplastic ingestion by a deep diving, oceanic cetacean: the true's beaked whale Mesoplodon mirus. Environ Pollut 199: 185-191.

40. Romeo T, Pietro B, Peda C, Consoli P, Andaloro F, et al. (2015) First evidence of presence of plastic debris in stomach of large pelagic fish in the Mediterranean Sea. Mar Pollut Bullet 95: 358-361.