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"Sampling of micro(nano)plastics in environmental compartments: How to define standard procedures?"

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Abstract

Microplastics, plastic particles smaller than <5 mm, are a worldwide environmental concern and the current realisation of the scale of the problem made the quest for methodological consensus in sampling, sample treatment, data handling, and reporting central to the scientific community. The need for spatio-temporal comparisons and multiple-scale surveys have pressed the development and sharing of methods and techniques. Determining the amounts of microplastics at sea, variation patterns and ongoing ecological processes are objectives of studies with effect on society and environmental management. The rising issue of microplastics in food and their possible role in the register, description, and quantification of anthropogenic interference in the environment opens a new philosophical and working front for science, decision makers, and citizens alike.

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Introduction

Sampling strategies are crucial when answering scientific questions relevant to society [1,2]. It evolves into a virtuous cycle towards pollution sources control and mitigation of environmental passives [3]. In the case of microplastics, science has been challenged to deal with an ever increasing problem around which discoveries of important and unpredicted consequences to society and nature are described at an accelerated pace [4].

Studies of microplastics pollution flourished since the turn of the 21st century, helped by efficient science communication [5]. In result, questions diversified and their answers gained an important depth, until the issue reached policy/decision makers. Techniques to sample and characterize these pollutants in all environmental compartments have also developed rapidly [6–9].

Size of particles studied decreased to the nanoplastics scale [10,11] and issues as detection of samples contamination also helped pushing research to the forefront of marine science. Citizen science also played a role in studies of microplastics in the environment [12,13], which requires special attention regarding quality checks as calibration, standards and quality control of analytical measurements.

However, it is still difficult to establish a unique and standardized operation protocols [8]. For example, the variety of reporting units hampers comparisons and the formation of ocean-scale pictures of microplastics pollution. Therefore, conservative approaches [14] of though organization help guarantee good quality sampling and subsequent research steps at the foundation of microplastics research.

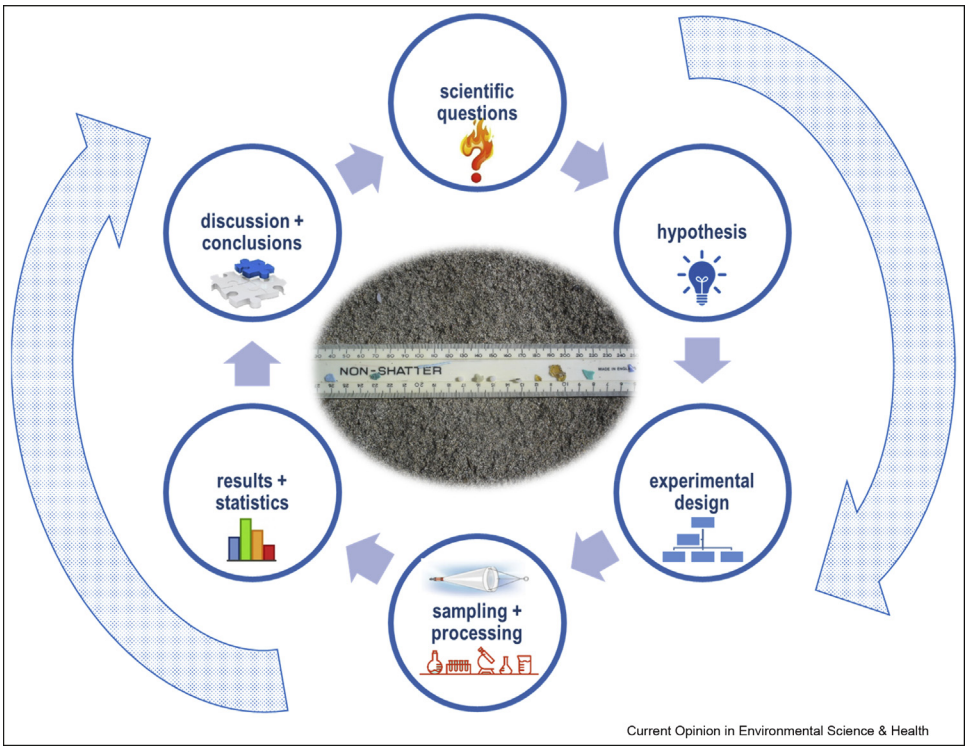
Microplastics are present in soils, forest litter, sewage sludge, effluents, and all environmental compartments on the continents [15,16], which through aquatic environments are sources to the sea [17,18]. Delay in linking such issues will have consequences for society and nature conservation [19].

Plastics pollution at sea is a demographic, societal and economic problem. We will not give up on excess plastics unless consistent evidence of its harm to the aquatic biota [20,21], especially food resources [22] emerges in a scientifically proven and consistent way.

Contribution for setting up standard procedures

In Science, observations take place after questions emerged in their simplest and clearer form. In the marine environment, factors vary in cyclical ways (ex. tide, seasons, and El Niño) or along ecoclines (ex. estuaries, depth, and thermocline) that need to be considered in the development of sample design (Fig. 1). Microplastics sampling seldom considers seasonal [23,24] or inter-annual variations of environmental parameters. On the other hand, short scale temporal and

Fig. 1



Sampling, characterizing and reporting microplastics pollution is part of a greater aim of revealing the real extent of the problem to society and decision makers, as well as suggesting possible solutions for a ubiquitous environmental problem. Centre photograph by MFC, 2008: virgin plastic resin pellets on the strandline of Leão Beach – Fernando de Noronha, Brazil. Scale in cm. Figure re-drawn from Ref. [1].

spatial variations (hours, days; meters) are not considered either, despite their importance for benthic ecology, for instance, and as a result, for sampling protocols. To reverse this trend, it is necessary to couple studies that investigate ecological gradients along different time frames. However, comparing microplastics from different space and time sampling efforts is difficult face the variety of objectives, methods and techniques and reporting units that result in different data quality and resolution [6,14].

Sampling captures microplastics that afterwards are isolated from their matrix (water, sediment, and stomach contents) and sorted to be confirmed by chemical characterization [6], making analytical standards and quality control checks a pressing issue [6,14].

Size range depends on sampling gear and procedures adopted. Microplastics (<5 mm) is an almost consensus size fraction, but there is still discussion on the cut-off point that retain ecological and technological meanings [14]. Nanoplastics are within the nanometre size range [10,11], but a bulk mass of fragments and primary plastics still remains between them. Therefore, it remains difficult to gain ecological meaning regarding size classes while ingestion by fauna remains poorly understood.

In the laboratory, microplastics quali-quantification risk being under or overestimated due to the ubiquity of synthetic polymers in the environment, which includes those present in boats, the lab and operator clothing [24]. Avoiding contamination should become a regular feature in quality control and quality assessments reported. Storage and preservation can be achieved by drying ~40 °C or freeze-dying (sediments), or cooling/freezing (water; organic-rich) samples. Multi-purpose samples preserved in formalin or alcohol can be useful for analysis of stomach contents.

A cleaning step [25] before analysis [7] without destroying or mischaracterizing the analyte is another important challenge, since most wet-chemistry methods alter the microplastics themselves and impair the determination of physical (*e.g.*, shape and colour) and chemical (polymer and adsorbed pollutants) variables [26].

Plankton and neuston tows allow surveys made at the same oceanic regions being compared to determine a