Macroplastic

Subjects: Environmental Sciences
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The term macroplastics describes plastic items with a diameter ≥ 5 mm. With this size definition macroplastics can be directly distinguished from microplastics (diameter < 5 mm). Plastic items ≥ 5 mm are commonly considered to be macroplastics once they are released into the environment. Other terminologies used synonymous to macroplastic are “macro litter", “anthropogenic litter”, “plastic litter”, “marine litter”, “marine plastic” and “plastic debris”.

Keywords: Plastic ; Environment ; Anthropogenic Pollution ; Plastic Litter ; Anthropogenic Litter ; Marine Litter ; Macro Litter ; Plastic Debris ; Marine Plastic

1. Introduction

Plastics are synthetic macromolecules consisting of compounds of monomers produced synthetically or by natural product conversion [1]. Due to their high economic and technological importance, they have a larger production volume (in m³) worldwide than steel and aluminium [2]. However, the great advantages of the material—its lightness, durability and low-cost production—are leading to an ever-increasing environmental problem: due to large production values, short product life, and unconscious handling of the material, 3% of the produced plastic leaks into the marine environment and accumulates there due to its persistence [3][4]. So far, the occurrence and accumulation of micro- and macroplastics in the environment has been widely documented although a uniform definition is still lacking.

Definition Macroplastic. While the size of microplastic is defined as particles with a diameter < 5 mm [5], MaP is commonly defined in distinction to microplastics as items with a diameter ≥ 5 mm [6][7][8][9]. However, both size classifications are not internationally standardised. Regarding MaP, other definitions are also published. For example, Barnes et al. (2009) [10] defined macro-debris with a diameter > 20 mm, the European Commission (2013) [11] defined it as items > 25 mm, while other studies define items > 5 cm as MaP [12] or suggested to define MaP as items > 1 cm [13] (Hartmann et al., 2019). Furthermore, the term mesoplastic is also used with a size classification of > 5–25 mm, according to which MaP is defined as a fraction > 25 mm [14]. Due to the large number of publications on microplastic (>4400 papers in Web of Science in August 2020, keyword: *microplastic**), the size definition of MaP ≥ 5 mm is preferable and simplifies the distinction with regard to already present research work on microplastics.

In addition to the unstandardised size definitions, the unclarified terminology is also a problem, as numerous terms are used synonymously beyond the term MaP. The terms “macro litter” [15], “anthropogenic litter” [16], “plastic litter” [17], “marine litter” [18], “marine plastic” [19] and “plastic debris” [20] are most frequently used alongside MaP, and the first publication using “macroplastic” in its headline was only published in 2012 [21]. With this variety of terms, a clear focus on the problem with MaP in the environment is difficult to implement within research. Based on a comprehensive literature review, this study suggests to set a new standard with the size limit of particles with a diameter ≥ 5 mm and the classification with the term “macroplastic”.

2. Production of Macroplastic and Entry into the Environment

In 2018, 359 million tons (Mt) of plastic were produced worldwide with more than half (51%) coming from Asia (30% China, 4% Japan, 17% rest of Asia). In Europe, 61.8 Mt, 17.2% of the global production, were manufactured. Here, the packaging industry is the main user group, accounting for 39.9% of the plastic produced, while the construction industry (19.8%), the automotive industry (9.9%), the electronics industry (6.2%), household and leisure use (4.1%), and agriculture (3.4%) require only comparatively small shares [22] (Figure 1).

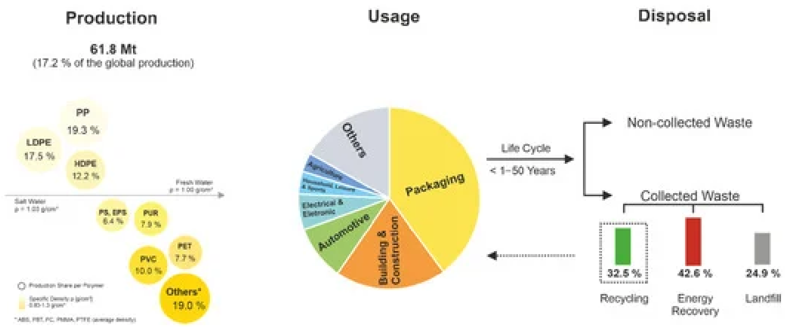

Figure 1. Life cycle of macroplastic with characteristic information on production shares, specific densities, market sectors, and waste treatment in Europe 2016/2017 (data based on [22], layout from [23]).

Polypropylene (PP) accounts for the largest share, followed by low-density polyethylene (LDPE) and high-density polyethylene (HDPE). These three plastics have a lower density than water. The polymers polyvinyl chloride (PVC), polyurethane (PUR), polyethylene terephthalate (PET) and (expanded) polystyrene ((E)PS) have a higher density than water. In Figure 1, five different polymers are covered with the term “Others”, including acrylonitrile–butadiene–styrene (ABS), polybutylene terephthalate (PBT), polycarbonate (PC), polymethyl methacrylate (PMMA), and polytetrafluoroethylene (PTFE), which have densities (ρ) between 1.05 and 2.2 g/cm³.

The mass production of plastics began in 1950, and global plastics production was estimated at 8300 Mt by 2015. Of those, approximately 600 Mt have been recycled into new products. A total of 800 Mt were energetically recovered and 4900 Mt were disposed during this period, which describes both landfilling and improper disposal in the environment [24]. Hoornweg and Bhada-Tata (2012) [25] estimated that while 2.9 billion urban residents generated 0.64 kg of municipal solid waste (MSW) in 2002, it increased to 3 billion residents generating 1.2 kg per person per year in 2012, accumulating to 1.3 billion of tons per year—an increasing trend.

The current literature offers different estimates of the amount of plastic leakage into the environment every year (a):

- 4.8 Mt/a to 12.7 Mt/a [26]: linking data on solid waste, population density, and economic status; land-based, mismanaged plastic waste entering the ocean from the coastline
- 8.28 Mt/a [27]: MaP (fishing nets and related losses, littering, mismanaged waste treatment) and microplastics (plastic production, cosmetics and personal care products, fibers, tire abrasion, road marking, city dust, marine coating weathering); plastic losses to the environment

The calculations are largely based on population figures and the proportion of mismanaged plastic waste.

Generally, MaP is released into the environment following land-based and ocean-based pathways (Figure 2). The land-based entry paths include coastal mismanaged plastic waste (75.5%, 8 Mt/a) and inland mismanaged plastic waste (18.9%, 2 Mt/a), while the ocean-based entry paths include waste from shipping and fishing activities and illegal waste disposal on the open sea (5.6%, 0.6 Mt/a) [4]. The distinction between inland and coastal waste generation is often made, since a large number of people live in coastal areas, and the input paths there are more direct than with inland plastic waste. Coastal is defined here as everything that is at most 50 km away from the coast. This includes residents of 192 countries [4][26].

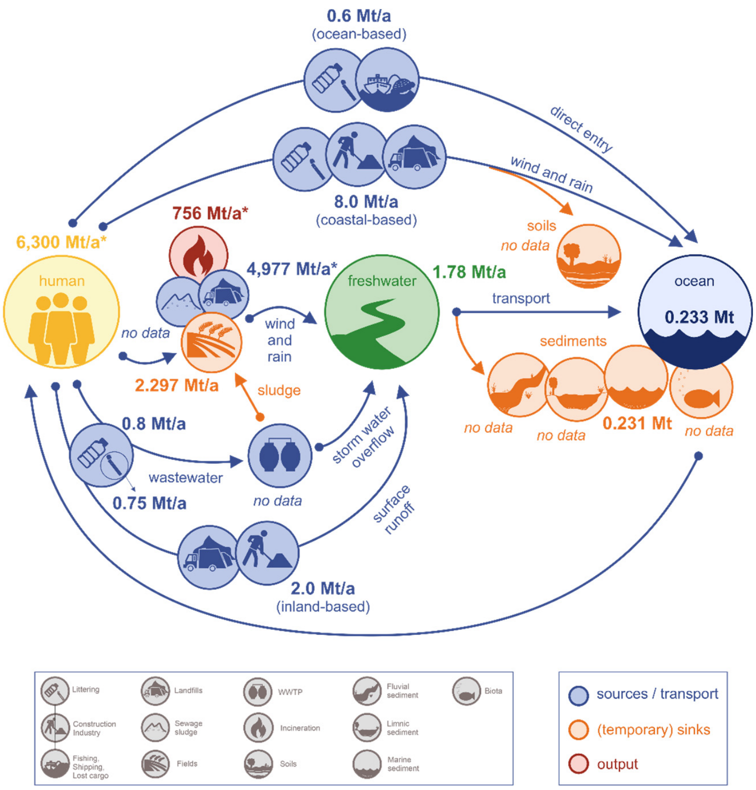

Figure 2. Sources and transport paths of macroplastic with approximate accounting of mass budget if data are available, * data from 2015 (based on [28], data and calculations from [4][22][24][29][30][31][32][33][34][35]).

The sources, entry paths, and pathways as well as sinks of MaP in the environment are shown in Figure 3, giving also information on mass budgets if data are available. With regard to such high volume flows of plastic getting into the environment, it is particularly important to address the issue of macroplastics in the environment and a uniform definition is the basis for further research.

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