microplastics

Article

Comparing Methods for Microplastic Quantification Using the Danube as a Model

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Abstract: This study investigates the impact different mesh-sized filtration methods have on the amount of detected microplastics in the surface water of the Danube River delta. Further, the distribution of microplastics in different size categories (20 µm, 65 µm, 105 µm) and in the water column (0 m, 3 m, 6 m) was analyzed. Our findings show that the Danube River carries 46 p·L^{-1} (microplastic particles per liter) with a size larger than 105 µm, 95 p·L^{-1} larger than 65 µm and 2677 p·L^{-1} that are larger than 20 µm. This suggests a negative logarithmic correlation between mesh size and particle amount. The most abundant polymer throughout all samples was polyethylene terephthalate, followed by polytetrafluorethylene. Overall, the data shows that different sampling methods cannot be compared directly. Further research is needed to find correlations in particle sizes for better comparison between different sampling methods.

Keywords: microplastics; polymers; method comparison; Danube

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Citation: Kiefer, T.; Knoll, M.; Fath, A. Comparing Methods for Microplastic Quantification Using the Danube as a Model. *Microplastics* **2023**, 2, 322–333. https://doi.org/10.3390/microplastics2040025

Academic Editor: Nicolas Kalogerakis

Received: 20 August 2023
Revised: 30 September 2023
Accepted: 12 October 2023
Published: 17 October 2023

1. Introduction

Due to the fact that plastic is relatively cheap, easy to handle during production, and durable, it is the most often used material in our lives [1]. The widespread utilization of plastic compounds the urgency of the emerging challenges linked to it. Plastic is the catch-all term for a wide range of materials made out of different kinds of synthetic or partially synthetic, non-biodegradable polymers [2]. In our mostly noncircular value chain, the only path a plastic product can take, after its use is deemed over, is to end up in landfills, the ecosystem, or an incineration plant. With 31% of all discarded plastic ending up in landfills and 39% being incinerated in Europe, it is estimated that 4.8 to 12.7 million metric tons of plastics are transferred into the oceans each year [2,3]. Further estimations suggest that the amount of plastic waste released on land is 4 to 23 times higher than that released into the oceans [4]. In the last years, attention has turned towards microplastics as one of the biggest but still uncharted dangers of plastic in our environment [3,5,6].

Microplastics is the term for plastic particles with a size less than 5 mm. They are further classified into large microplastics with a size of 1–5 mm and small microplastics with a size smaller than 1 mm [7]. With a size of less than 0.1 µm, they fall in the nanoplastic category [8]. Due to its chemical properties, plastic breaks down into smaller and smaller particle sizes when exposed to sunlight, wind, or other mechanical forces [5]. Studies have shown that today, microplastics have a global distribution, including rivers and deep-sea sediments [4].

The origins of microplastics are diverse, stemming from various sources. These include the shedding of fibers from clothing during washing in household appliances like washing machines, tire wear, industrial processes, agricultural activities [6], and deliberate discharge of waste into waterways [9]. As rivers and freshwater streams constitute a continuous transfer system, they make up one of the biggest pathways of microplastic migration into the oceans [3]. However, investigations of microplastic abundance in terrestrial water and freshwater, as well as in the respective sediments, have only begun relatively recently [4].

Different sampling methods are used by different research groups. For water samples, most often, manta trawls, plankton nets, or neuston nets with pore sizes ranging from 50 μm to 3000 μm are utilized. The most common pore size in use is 300 μm [10,11]. This allows for easier sampling since large, pored nets tend not to get clogged by debris as easily as smaller-sized nets. At the same time, this leads to an underestimation of the extent of the microplastic pollution since smaller plastic particles are much more abundant than larger ones. This will be shown in this paper.

Several studies have been published about microplastic occurrence in water [5,12,13] and sediments [14] of the Danube. Whereas most of these studies involving microplastics in water have been conducted in the upper reaches of the Danube [5,12], only a few have analyzed the amount of microplastic in the Danube Delta [13,15]. Being the second largest stream in Europe, the water in the delta is a mirror of the water and environmental treatment policies of 19 countries [16]. This makes it one of Europe's most interesting rivers concerning water quality. Most studies of microplastics in terrestrial waterways have only analyzed surface or near-surface waters, whereas deeper layers of the water column have only been studied by a small number of research groups [5,17–19]. None of these were conducted in the Danube River. This study aims to further increase the available data on microplastic (with emphasis on small microplastics) carried by water in the Danube Delta area while also drawing attention to the impact of different sampling methods on the respective results and their ability to be compared.

2. Materials and Methods

2.1. Danube River

The Danube River, with a catchment area inhabited by over 80 million people, spans 19 European countries and encompasses an extensive drainage basin of approximately 817,000 square kilometers [16,20]. Originating in the Black Forest of Germany and flowing through a diverse range of landscapes, including alpine regions and lowland floodplains, the river ultimately empties into the Black Sea. With varying elevations along its course, ranging from the source at around 1000 m above sea level to sea level at its mouth, the Danube is a geographically diverse and economically significant waterway [21]. Understanding microplastic abundance in this critical river is imperative for preserving its ecological integrity and safeguarding the well-being of both aquatic ecosystems and the human population relying on it.

2.2. Depth Samples

The sampling location for the depth samples was located upstream from where the Danube River splits into its multiple distributary channels of the delta (Figure 1A). The exact location was at 45.242 latitude, 28.635 longitude.

The sampling spot for the depth samples was chosen to be approximately in the middle of the main channel, slightly to the southern side of the main shipping lane (Figure 1B,C). The depth of the river at the point of sampling was 8.4 m and was determined with the built-in echo-sounding apparatus of the ship (Figure 1C).

To ensure that all samples were taken at the same spot, the location was marked by GPS. For each sample, the ship was steered against the current, stopped, and put into reverse to match the speed of the current. The 2.2 L WILDCO sampling tube was then lowered to the specific depth, sealed, and pulled up. A weight was added to the sampling tube to speed up the sinking process (Figure 2). This method is often referred to as 'grab sampling'. In this paper, the term depth sampling is used.

Three samples were taken at each depth. The depths were 6, 3, and 0 m below the water surface. The 0 m sample was taken as close as possible to the surface while still submerging the whole sampling tube. This effectively resulted in an approximate depth of 10 cm. (Figure 1D).