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Determining the Presence of Micro-Particles in Drinking Water in the Czech Republic—An Exploratory Study Focusing on Microplastics and Additives †

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Abstract: With the increasing prevalence of monitored micro-pollutants in the environment, new challenges arise in their determination. Currently, the issue of microplastics in the environment is a highly debated topic. This article focuses on the assessment of micro-particles in drinking water samples collected in the Czech Republic. The samples for analysis were collected at two locations, twice a day. Particle separation was achieved through vacuum filtration, and particle identification was performed using the μ-FTIR method. A total of 40 particles were analyzed, and their shape, color, and material composition were determined. The study results demonstrated the presence of microplastics and additives used in plastic production in the drinking water samples. The findings of this article contribute to understanding the issue of micro-particles in drinking water and raise questions for further research and measures to protect public health and the environment.

Keywords: microplastic; drinking water; FTIR; particles; additives

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1. Introduction

Plastic materials are utilized by humans on a daily basis in nearly all their activities, and without them, we would not know the life we have on this planet. The quantity of produced plastics exhibits a consistently growing trend, with the exception of a stagnation due to the pandemic in 2020, thereby increasing the significance of addressing the issue of plastic waste. In 2021, over 390 million metric tons (Mt) of plastics were produced globally (57.2 Mt in Europe), of which 90% originated from fossil sources and only 8.3% originated from recycled materials [1]. However, the escalating production of plastics also entails serious risks as unprocessed plastic materials often end up in the environment, including water bodies [2]. In 2016, up to 10% of produced plastics found their way into aquatic environments, and by 2030, it is projected to reach as high as 53 Mt annually [3]. Such a quantity currently approaches the amount of plastics produced across Europe. Some plastic materials themselves and the fragments present in the aquatic environment are persistent. However, they are subject to chemical, biological, and mechanical processes and fragment into smaller pieces, such as microplastics [4]. This leads to the formation of microplastics and, further down, nanoplastics. Microplastics are defined in the literature as particles smaller than 5mm [5], although alternative size definitions have also been observed [6], which complicates the interpretation of study results. Microplastics were found in air [7–9], water [10–13], and soil [14–18]. The current climate situation also places significant demands on ensuring an adequate water supply for the population, agriculture, and industry. New sources of drinking water are being sought in various places, including old closed coal mines with excess mine water [19]. However, the presence of micropollutants often causes water quality problems [20]. Moreover, their removal is often technologically challenging, allowing them to permeate into

drinking water during conventional treatment processes. Secondary microplastics, generated from the degradation of larger plastic pieces, sometimes subsequently coexist in water with primary microplastics intentionally manufactured for their specific effects. Nevertheless, legislative measures in some countries already restrict the addition of primary microplastics to products, which should gradually lead to a reduction in their occurrence [21]. However, due to the enormous amount of unprocessed plastic waste, an increase in the amount of mismanaged plastic pieces in aquatic environments is expected [22]. The removal of these particles should be preceded by a standardized methodology for their determination, which is currently lacking and needs to be addressed at the legislative level. Among the various methods currently in use, it is necessary to select one that can be employed in a conventionally equipped water quality laboratory. Based on the obtained data, the actual effectiveness of individual water treatment and purification technologies can then be monitored.

This article focuses on the analysis of four samples of drinking water, which underwent optical analysis to determine their shape and color. Subsequently, the material composition of the particles was identified using the micro-FTIR method. This method is frequently utilized for detecting the presence of microplastics in aquatic environments. As there are still many unanswered questions in this field, further intensive research on microplastics is necessary.

2. Materials and Methods

As mentioned above, the methodology for determining microplastics in aquatic environments suffers from significant shortcomings. There are different procedures for sample collection and handling, diverse instrumental methods for analysis, and inconsistent interpretations of the obtained data.

2.1. Sample Collection

The samples consist of drinking water collected at a sampling point within households (Figure 1). Sampling was conducted twice a day, using a volume of 50 mL. Prior to sampling, the water from the faucet was allowed to run for 10 s. Two samples were collected from the same location, once in the morning and once in the evening, providing insights into potential variations in the presence of microplastics over time. The sampling containers are made of glass with a metal lid to minimize the risk of contamination from the sampling apparatus.

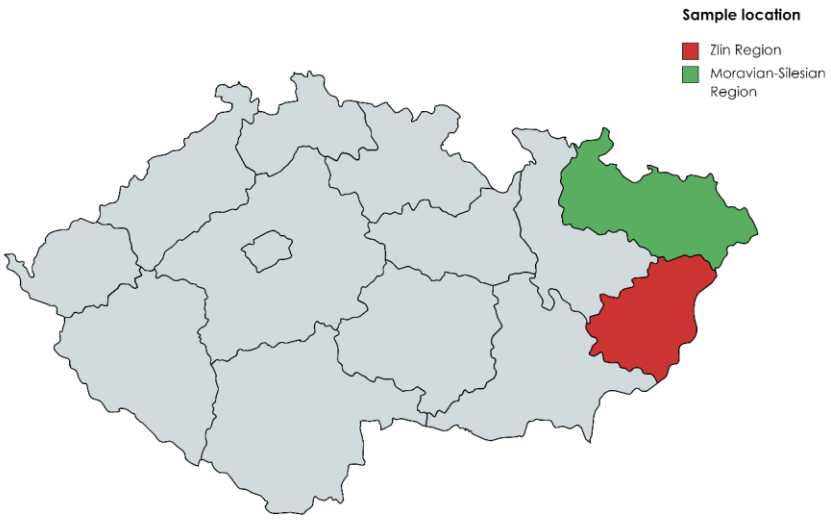

Figure 1. Sampling locations in Czech Republic.

2.2. Optical Analysis

All collected samples of drinking water underwent microscopic analysis, where each filter was examined. The filter was placed in a Petri dish, transferred from the desiccator to the microscope. Preparation and focusing of the microscope were carried out before

opening the Petri dish with the filter to minimize potential contamination. The entire surface of the filter was observed, starting from the upper left corner and progressing across the entire surface until reaching the lower right corner.

This step is also crucial for assessing possible atmospheric contamination. Each blank filter was observed under the microscope, and the particles present on it were counted and subsequently analyzed using micro-FTIR. The number of particles on the blank filters was then subtracted from the total number of microplastics found in the samples for evaluation.

2.3. Infrared Spectroscopy

In order to ascertain the material composition of the particles captured on the filters, an essential analysis is conducted. Micro-FTIR analysis is employed in this particular case, utilizing Fourier-transform infrared spectroscopy in conjunction with a microscope-equipped instrument. This enables the measurement of particles down to a critical size of 10 μm, with the ultimate limit contingent upon their morphological characteristics. The Nicolet iN10 instrument, manufactured by Thermo Fisher Scientific (Waltham, MA, USA), is employed for these analytical investigations. Considering the particle size and the filtration medium employed, reflectance was selected as the optimal measurement mode, employing a liquid nitrogen-cooled mercury cadmium telluride (MCT) detector. The measurement parameters are standardized across all samples, encompassing the acquisition of spectra within the wavenumber range of 650–4000 cm^{-1}.

Prior to the commencement of the measurements, ten particles are meticulously selected through manual manipulation utilizing an optical stereomicroscope, and subsequently, they are transferred onto glass slides employing fine tweezers. The morphology and color of each particle are diligently documented throughout this transfer process. Subsequently, the individual particles undergo thorough analysis, and their visual documentation is duly recorded.

The acquired spectra are processed using Omnic Picta software. These spectra are subsequently subjected to comparison with available spectral databases. If the measured spectrum demonstrates an agreement exceeding 60% with a library entry, the resultant material composition of the particle, the percentage match, and the corresponding library spectra are meticulously documented. In cases where the agreement falls within the range of 50% to 60%, manual identification procedures are employed, entailing the scrutiny of characteristic spectral peaks. However, a careful determination is made regarding the adequacy of the match for accurate material identification, based on a comprehensive comparison with the spectral library.

3. Results and Discussion

A total of 40 particles from four samples of drinking water collected in the Moravian-Silesian and Zlín regions in the Czech Republic were analyzed. Since the presence of microplastics in drinking water has already been confirmed in multiple studies [23,24], they were also detected in the analyzed samples. A total of 17 different types of materials were identified and divided into two categories. The first category includes polymers and materials used in the plastic industry as additives or other substances that influence the properties of plastic products. The second group comprises substances detected in drinking water that are unrelated to plastics. In the first group, there were a total of nine materials with a combined count of 26 particles (Figure 2). The most frequent materials were wood with melamine–formaldehyde resin (eight) and paper with coating (eight), followed by polyethylene terephthalate (PET), polyvinyl alcohol (PVA) and viscose (two). Polyvinyl alcohol, viscose, and polyethylene terephthalate were also identified in the study conducted by Shruti et al. [25]. The second group includes eight materials with 14 particles, with cellulose (three) and cotton + flax (three) being the most prominent ones (Figure 3).

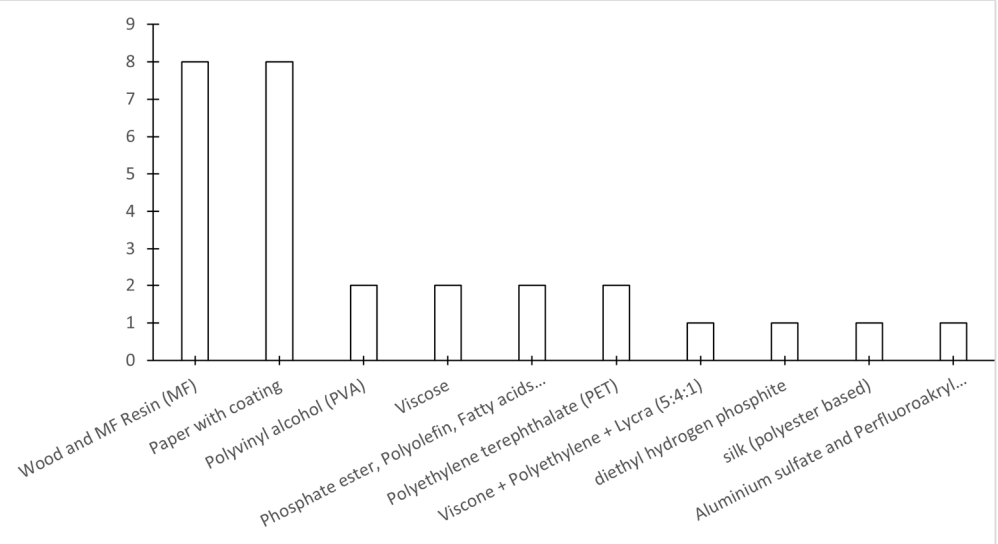

Figure 2. Group 1; number of particles for each material.

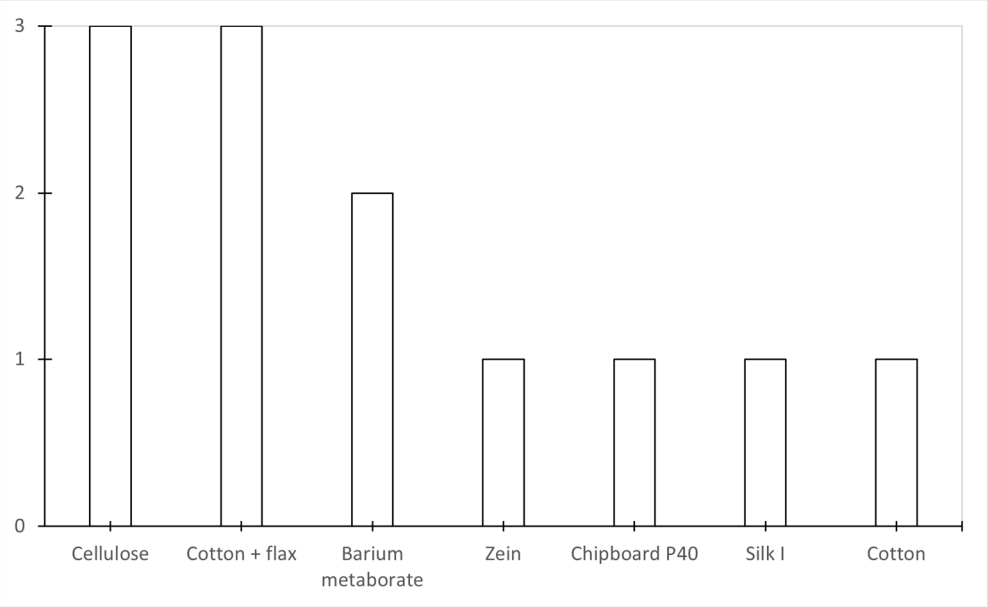

Figure 3. Group 2; number of particles for each material.

In addition to material composition, the shape of individual particles was also determined. They were sorted into four groups using optical analysis, as shown in Figure 4: Fibre (47%; 19 pcs.), Particle (30%; 12 pcs.), Fragment (18%; 7 pcs.), and Film (5%; 2 pcs.).

Similar to this study, Pérez-Guevara et al. also confirmed the most frequent occurrence of fibers in samples of drinking water [26]. The Fibre category included particles with a length at least 3 times greater than their width. The Particle category consisted of particles with regular shapes such as flakes or spheres. Deformed particles were classified as Fragments, while thin particles were categorized as Films. In the analyzed samples of drinking water, fibers were the most prevalent, followed by particles, fragments, and films.

All analyzed particles were also recorded for their color. A total of 11 different colors were observed, with the highest frequency being brown (9), followed by red (5), blue (5), white (5), and transparent (5). All colors, along with the respective particle counts, are presented in Figure 5.

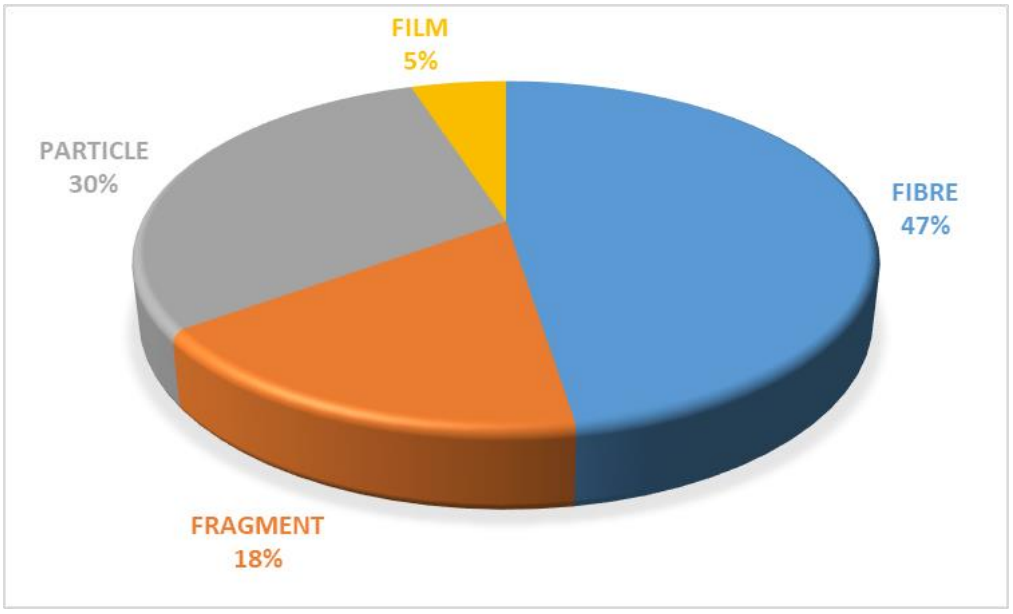

Figure 4. Particles sorted by shape.

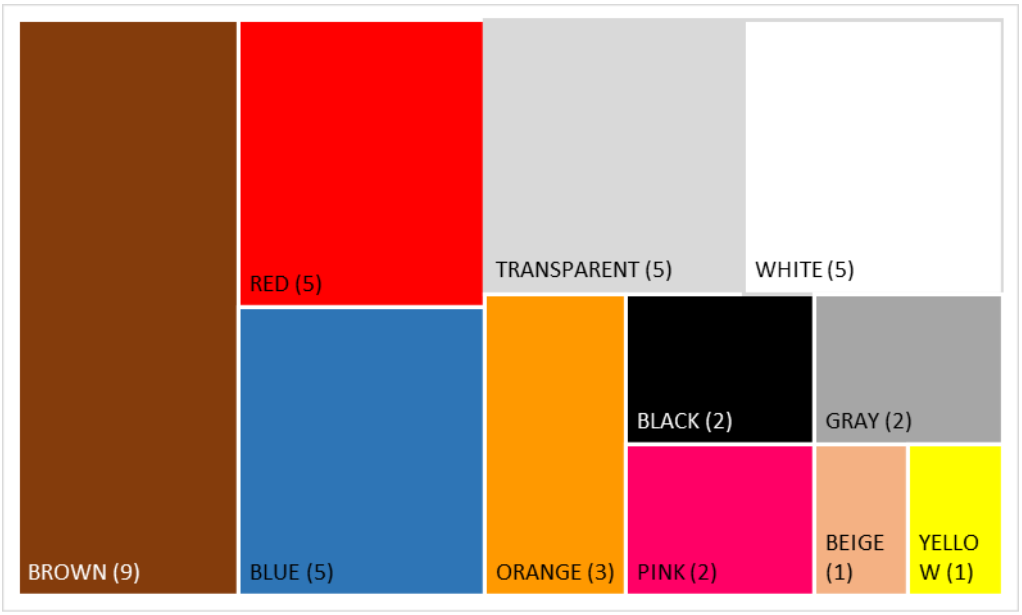

Figure 5. Particles sorted by color.

The escalating production of plastics and their accumulation in the environment will inevitably lead to a rising prevalence of microplastics in the future. Addressing this issue requires exploring strategies to mitigate the potential proliferation of microplastics. One effective approach involves the reutilization of macroplastics, wherein products can be meticulously recycled and upcycled. As an example, tires, which contribute significantly to secondary microplastic sources, could potentially find application in the production of cement composites [26,27]. This innovative reimagining of tire usage presents a promising avenue for curtailing the microplastic menace.

4. Conclusions

This study presents an initial analysis of particles in four samples of drinking water collected from the territory of the Czech Republic. The selected analytical methodology demonstrates its suitability and allows for the examination of a larger number of samples.

A pivotal step involved a systematic reduction in contamination influence, enabling the verification of proper timing for particle introduction during analysis. However, in light of impending legislative changes concerning microplastics, there emerges a pressing need to refine and standardize the methodology for their determination. The objective is to achieve the feasibility of conducting such analyses with optimal time and financial investment, while adhering to stringent result quality requirements and minimizing potential contamination. Nevertheless, the issue of microplastics' presence in drinking water remains a complex challenge, necessitating further comprehensive research for its resolution.

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