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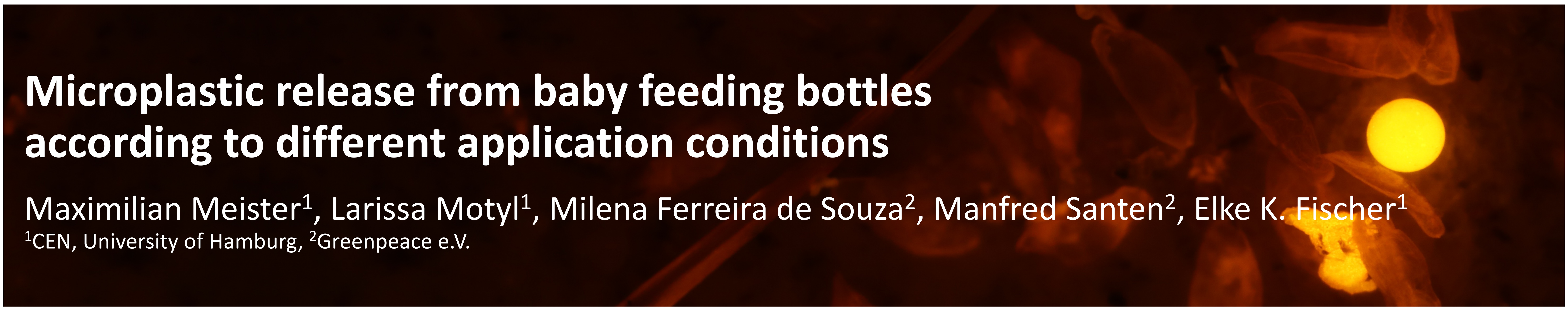

Microplastic release from baby feeding bottles according to different application conditions

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Introduction

Previous studies on the release of microplastic particles from baby feeding bottles revealed contradicting results and high variations in particle numbers. To further investigate and contribute to this issue and to gain additional insight on the release of microplastics from baby feeding bottles we conducted this study in conjunction with the German Midwifery Association (DHV) and Greenpeace e.V.

The overall objective was to evaluate whether different bottle materials and different brands release different number of microplastic particles. Common use scenarios should be simulated revealing particle emissions from initial bottle sterilization, preparation temperatures, duration of use and physical stress.

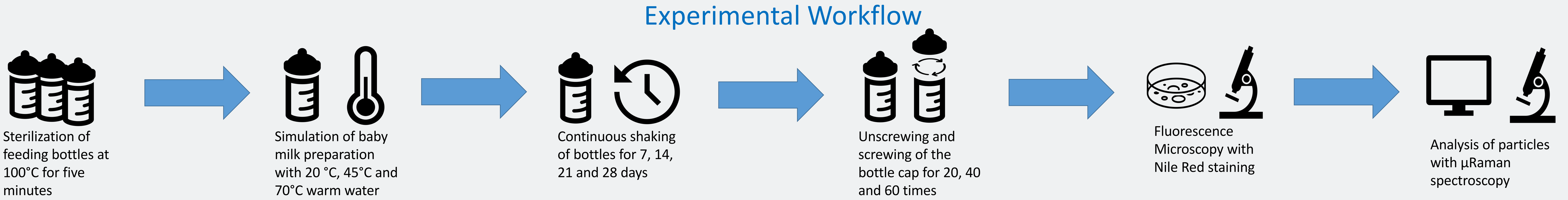
Material & Methods

We tested eleven different models of baby bottles from 6 brands. These included bottles made of plastics (n=5), glass (n=5) and metal (n=1). All bottles were equipped with caps made of polypropylene and silicone nipples. All experiments were conducted in triplicates (n=3) and included blank samples within all tests. The following test scenarios were applied:

- Sterilization of all bottle parts
- Manual shaking at three different temperatures: room temperature (20 °C), preparation temperature at 45 °C and 70 °C (according to recommendation of the Food and Agricultural Organisation) → temperature
- Continuous automated shaking for 7, 14, 21 and 28 days → time
- Screwing and unscrewing of the bottle cap for 20, 40 and 60 times → physical stress

Within these scenarios we prepared particle suspensions that were transferred onto cellulose filters that subsequently underwent Nile red staining, fluorescent microscopy (Axioscope 5, ZEISS) and automated imagery (ZEN Blue Intellisis, ZEISS).

Experimental Workflow



Results & Discussion

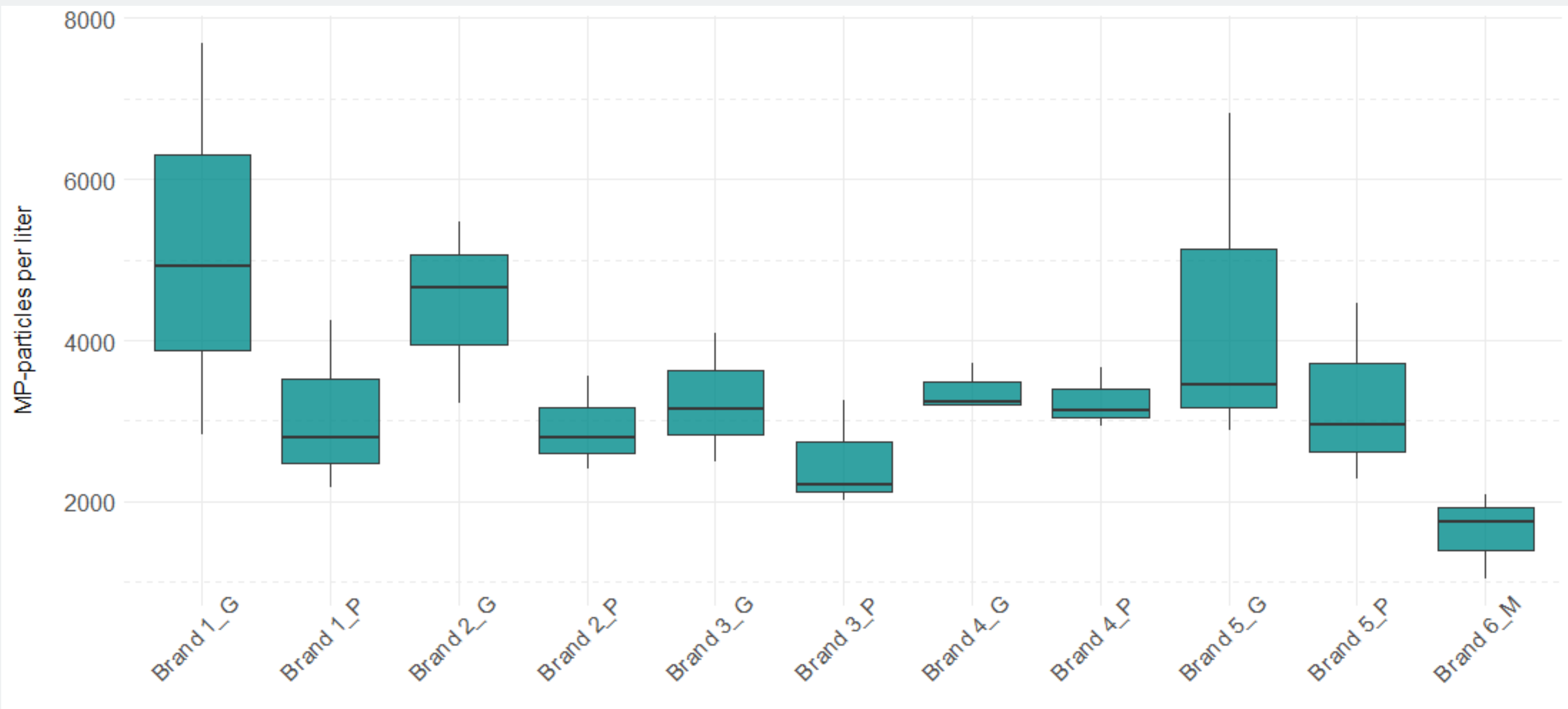


Fig. 1: Microplastic abundance after the sterilization of the bottles.

The test on sterilization of the bottles reveals that glass bottles have a slight tendency to a higher release of microplastics, whereas the lowest abundance is significantly found for the stainless steel bottle (p=0.001, α=0.05). However, test results mostly refer to different packaging and potentially storing and might also be attributed to production residues.

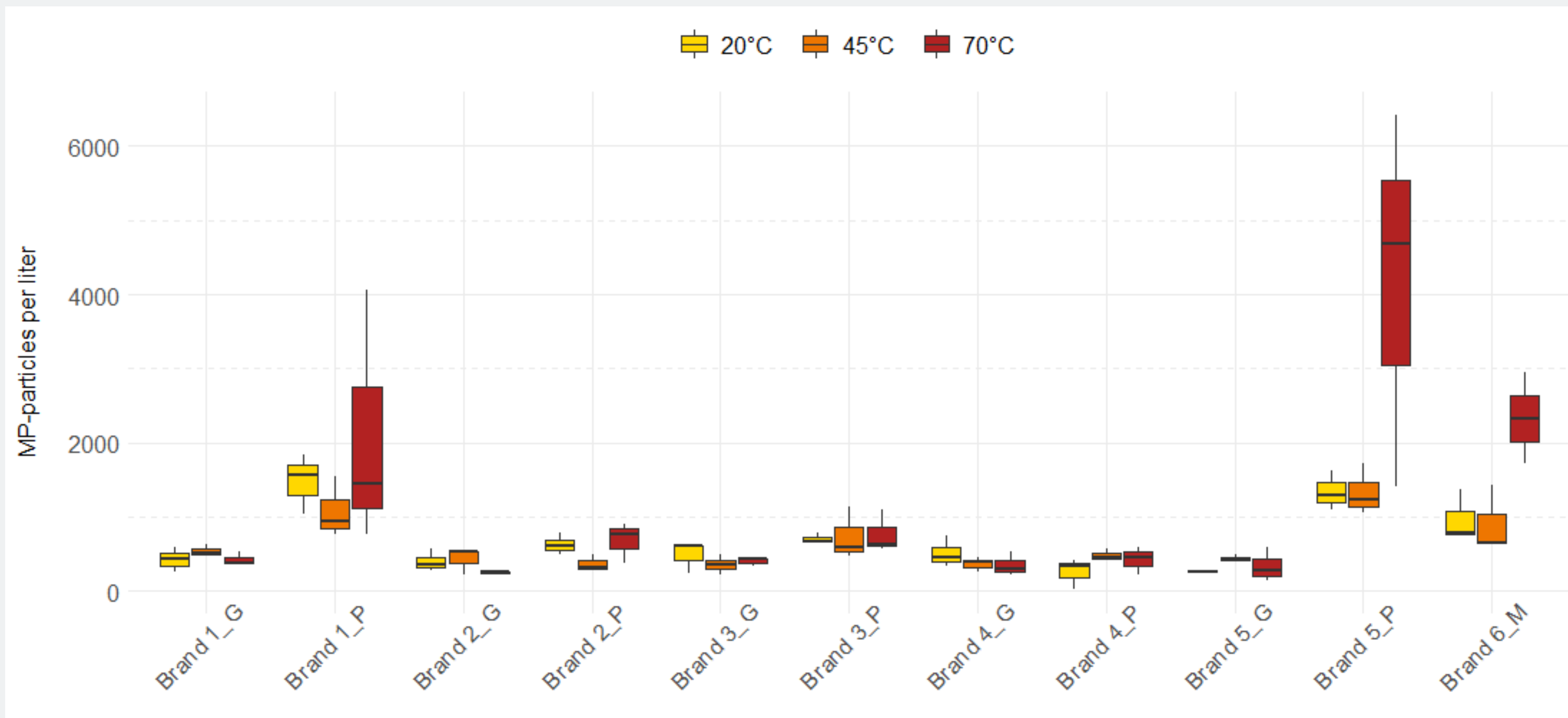


Fig. 2: Microplastic release from different preparation temperatures.

Simulated shaking at room temperature, a preparation temperature of 45 °C and 70 °C leads to significantly higher release from plastic bottles of brands one and five (p=0.001-0.043, α=0.05). The increase of temperature comparing the findings within the respective models reveal that especially the metal bottle model is prone to MP release when the temperature is elevated to 70°C (p=0.025, α=0.05) which might be attributed to higher thermal conductivity of the material. Comparing glass versus plastic bottles of all brands reveals that glass bottles release significantly fewer microplastics than the other materials (ρ<0.001, α=0.05). Particle sizes (median) differ significantly between bottle material with plastic (18 µm) > glass (14 µm) > metal (10 µm) (p<0.001, α=0.05).

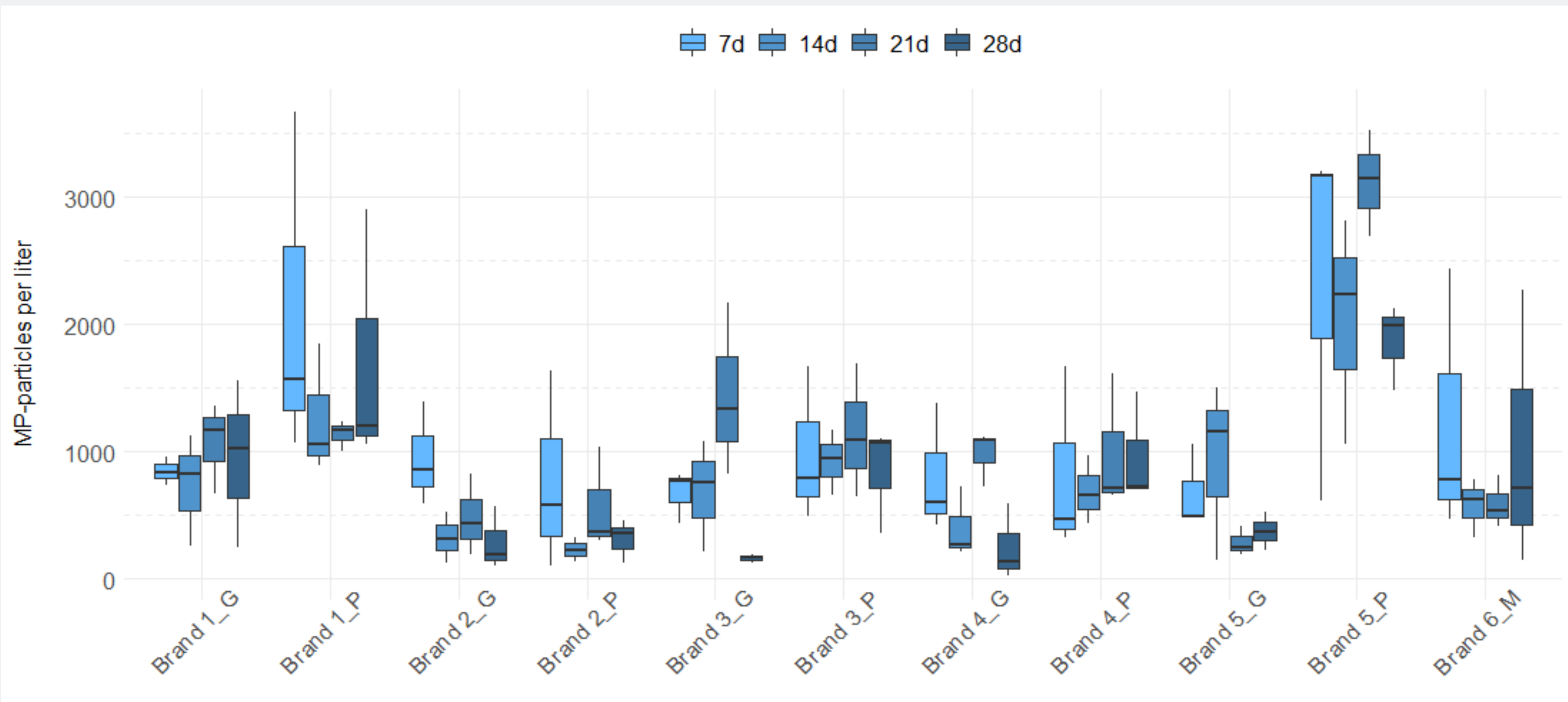


Fig. 3: Microplastic release after different periods of exposure to continuous shaking.

Tests on continuous shaking over 7, 14, 21 and 28 days reveal no distinct patterns of microplastic release over time. In total the plastic bottles of brand 1 and 5 show highest concentrations but due to the high variability the differences between bottles and brands are not significant. However when comparing the results according to bottle material over all bottles and brands, significant lower concentrations are detected for glass compared to plastic bottles (ρ<0.001, α=0.05). In terms of particle sizes, glass bottles release smaller particles (median 21 µm) than plastic bottles (23 µm). This difference is very small though significant (p=0.004, α=0.05).

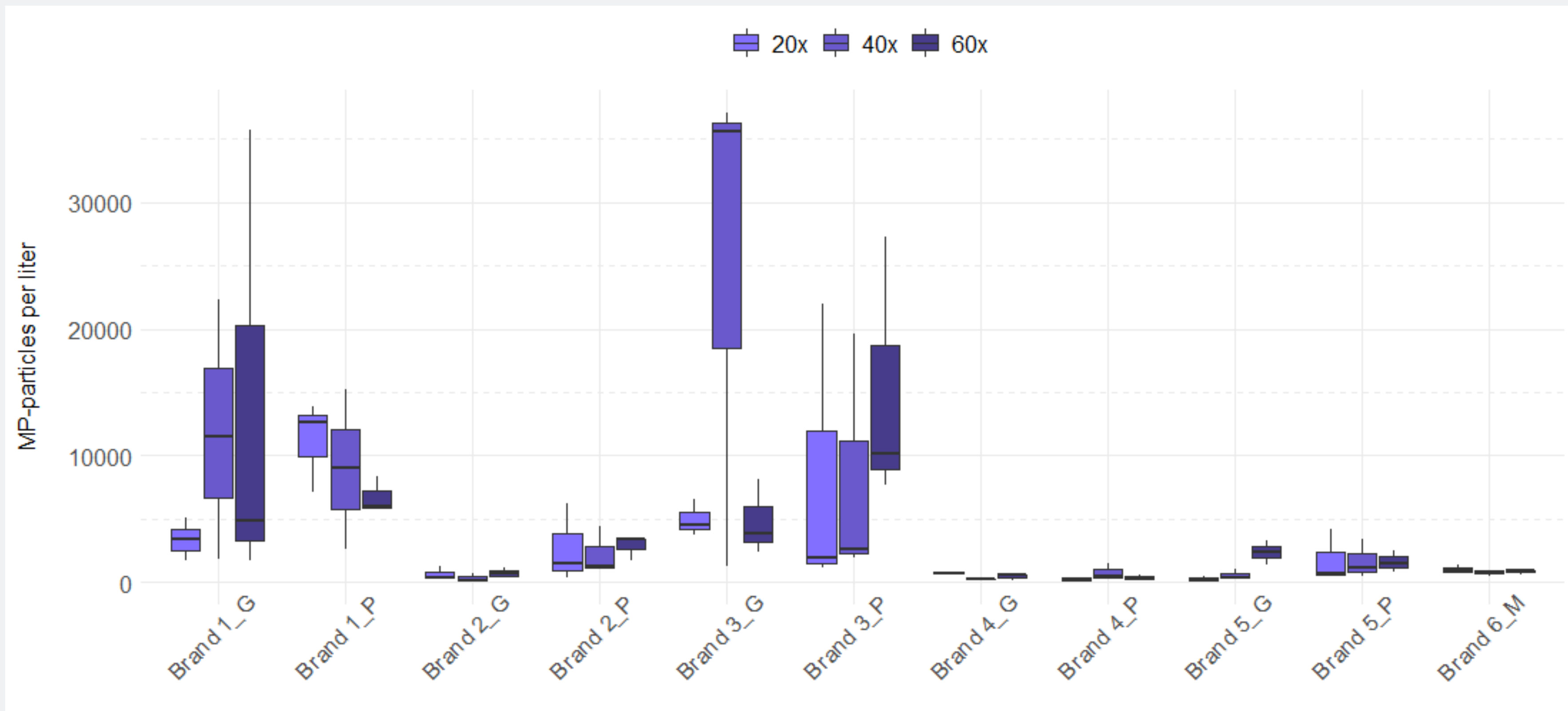


Fig. 4: Microplastic release from screwing and unscrewing of the bottle caps.

The physical stress test from repeated unscrewing and screwing the bottle caps reveals comparably low releases of microplastics for the majority of the bottles except for brands one and three which are significantly higher (ρ<0.001-0.035, α=0.05). However, no significant increase of MP concentrations with increasing repetitions is found indicating that there is only a limited potential of physical abrasion. In terms of bottle material lower abundances are detected for glass compared to plastic bottles (ρ<0.001, α=0.05). Furthermore, particle sizes (median) significantly decline from 23 µm (plastic bottles) > 18 µm (glass bottles) > 16 µm (metal bottles) (ρ<0.001, α=0.05).

Conclusion

Our results suggest that the release of microplastic is not only related to the material of the bottle but more depending on the manufacturer. The different test scenarios applied the influence of temperature, and the increase of temperature has the greatest impact compared to the factors time and physical stress.
The release over time simulated by continuous shaking of the bottles suggests that the duration of use has no signficant influence and that there is rather a steady release of microplastics over time. The physical stress to the bottles tested within the screwing and unscrewing of the bottle caps did not show a higher release with higher repetitions.

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