

Imaging of water samples for the detection and identification of microplastics

Matthieu Roussey^{1,*}, Boniphace Kanyathare¹, Blaž Hrovat², Nikolaos Papamatthaiakis³, Joni Hattuniemi⁴, Benjamin O. Asamoah¹, Antti Haapala³, Arto Koistinen², and Kai-Erik Peiponen¹

¹Department of Physics and Mathematics, Institute of Photonics, University of Eastern Finland, P.O. Box 111, 80101 Joensuu, Finland

²SIB Labs, University of Eastern Finland, P.O. Box 1627, 70211 Kuopio, Finland.

³School of Forest Sciences, University of Eastern Finland, PO Box 111, 80101 Joensuu, Finland.

⁴Valmet Automation Inc., Kehräömöntie 3, 87400 Kajaani, Finland.

Abstract. We demonstrate that direct imaging is a powerful tool for the detection and recognition of microplastics in water, even in case of complex matrices. We use a commercial high-resolution imaging device (Valmet FS5, Valmet Oy.) originally developed for the observation of wood fibres and particles in papermill pulp samples. We show how to discriminate microplastics from other particles in suspension in real water samples. We show differences between several common plastic types in homemade samples.

1 Introduction

Water is the main carrier for vital resources for human and is the most polluted environment. Among the numerous chemical, biological, and physical pollutants, there are micro- and nano-plastics (MP and NP). These particles are of different sizes (MP < 5 mm, NP < 1 μm), of different shapes (spheres, fibers, flakes, arbitrary), of different compositions, and different origin. All types of waters are concerns: open and fresh water, industrial water, wastewater, and tap water. MPs and NPs are vectors for viruses, heavy metal particles, and other bacteria strongly affecting flora and fauna. An abrupt stop of the production of plastics would limit the future number of MPs in NPs but not decrease it rapidly¹. For 70 years, plastic wastes are discarded in oceans, and they slowly degrade forming the vicious particles studied here. No efficient method currently exists to monitor MPs coming out of our industrial world or coming in the pipes feeding the water we drink. Therefore, there is a crucial and urgent need for developing techniques to detect and eventually remove MPs from water.

Water can be a complex matrix. It can contain all kind of particles and materials, which makes the study of MPs in such an environment is extremely challenging. Currently, water samples containing MPs are characterized in laboratory with techniques such as Raman spectroscopy and Fourier Transform Infrared (FTIR) spectroscopy, mainly². These methods are improved by being robust and reliable, providing accurate results. However, they are expensive in cost and time, and they require a high level of expertise. In addition, the sample preparation and sorting are crucial and time demanding, which prevents the analysis of large water volumes, which is an industrially driven need. We recently demonstrated that using a combination of several

optical techniques³, i.e., spectroscopy, speckle, interferometry, and transmission measurements, one can determine many of the key properties of plastics and microplastics in water, even in complex water matrices such as ones coming from sludge samples⁴. These demonstrated photonic-based techniques are fast and relatively easy to implement. However, they still request some sample preparation.

2 Result and discussion



Fig. 1. Valmet Fiber Image Analyzer (Valmet FS5).

In this study, we investigate the possibility of using direct imaging system for the monitoring and identification of microplastics in water. We use the Valmet Fiber Image Analyzer (Valmet FS5, see Fig. 1), which is a device originally developed for the imaging of wood fibers and particles in half a litre water samples. Ultra-high-resolution images can be captured and analysed at high-

* Corresponding author: matthieu.roussey@uef.fi

speed providing an accurate figure of the particles in suspension in the considered water volume.

Besides some minor technical challenges such as the contamination of the sample container with MPs, using such a device is not difficult and provide quickly numerous images of high quality thanks to a transmission imaging system, a precise and stable illumination. The challenges come from the analysis of the collected data, and we expose here our method to recognize plastic particles.

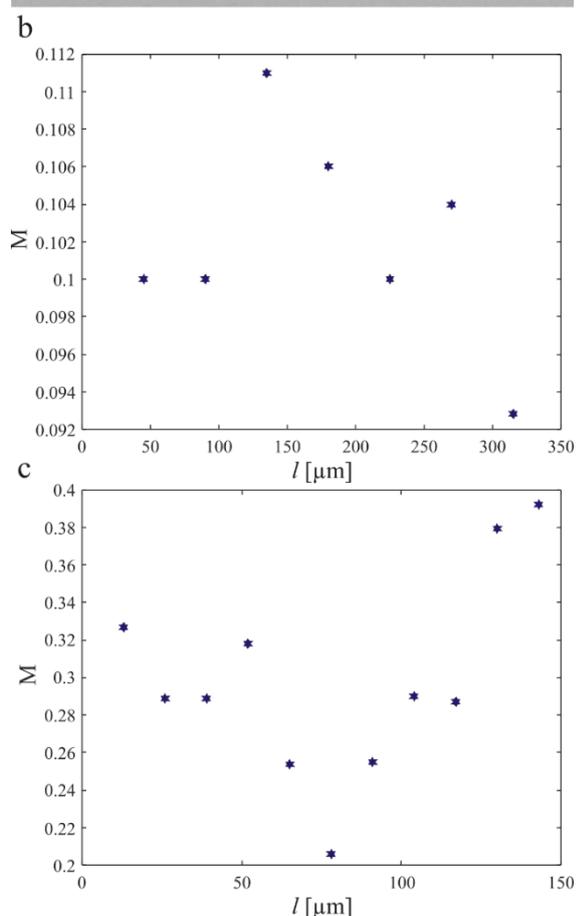
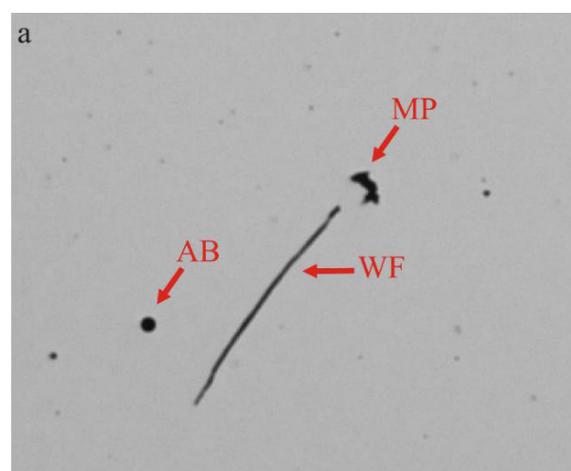


Fig. 2. Imaging of LDPE MP and wood fiber in water. a) High resolution initial image acquired with Valmet FS5 device. Intensity ratios calculated from a) for b) a MP, and c) a wood fiber (WF). AB stands for air bubble.

An example of acquired image is shown in Fig. 2a. One can see several typical compounds of a complex water sample, namely air bubbles coming from the stirring of the water sample during the measurement, microplastics, and wood fiber.

A first visual analysis allows us to discriminate between these different particles. Indeed, the air bubble is perfectly spherical and appear as a black round spot on the image, the wood fiber is elongated and not regular, the microplastics are of complete arbitrary shape. Note that primary plastics used in industry are often microbeads of very regular spherical shape that could be confused with air bubbles, preventing us to use the automatic function implemented in the device to identify the air bubbles and remove them from the figure.

To analyse further the image, we use a fast data processing consisting in calculating a light intensity ratio M defined as the intensity of the image normalized by a reference background image. Although most of the particles appear dark on the image due to scattering mainly, they transmit light. This transmission depends directly on the type and shape of the particles. This affects the ratio M . Some values of M are given in Figs. 2b and 2c for a microplastic particle and a wood fiber, respectively. Using this ratio, it becomes easy to distinguish between both particle since most of the plastics will have an M -value close to 0.1, while wood fibers have M -values ranging from 0.2 to 0.4. Air bubbles have a much lower value of M than MPs.

The analysis software implemented in the FS5 device could be further taught and trained to recognize plastic particles using such a method. An extensive analysis work has been already done on various water samples with known and unknown MP compositions. We will present these results.

Authors acknowledge the financial support of the Academy of Finland through the flagship on “Photonics research and innovation” (PREIN, 320166) and of Business Finland through the project on “Circulating economy of water in industrial processes” (CEIWA, #541/31/2021).

References

1. R. Geyer J. R. Jambeck and K. Lavender Law, *Sci. Adv.* **3**(7) (2017)
2. B. O. Asamoah, E. Uurasjärvi, J. Rätty, A. Koistinen, M. Roussey, K.-E. Peiponen, *Polymers* **13**, 730 (2021).
3. B. O. Asamoah, M. Roussey, and K-E Peiponen, *Chemosphere* **254**, 126789 (2020).
4. B. O. Asamoah, P. Salmi, J. Rätty, K. Ryymin, J. Talvitie, A. K. Karjalainen, J. V. K Kukkonen, M. Roussey, K.-E. Peiponen, *Polymers* **13**, 871 (2021).