Using a Scanning Electron Microscope to Identify Microplastics in Cumbrian Water Sources

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Keswick School   Lola, Vivien, Lola, Eli, Alistair, William

Introduction

Microplastics are extremely small pieces of broken down plastic debris in the environment (National Geographic, 2022). They have been found in water sources all over the world and can pass through filtration systems. They can be ingested by animals such as fish which is harmful to them and us when we consume them, as microplastics can cause conditions from inflammation to cancer. A study in Cumbria on the River Keekle reported that it could be England's most plastic polluted stretch of river, due to the plastic lining underneath it (Bawden, 2020). The river lining had shed 16 tonnes of plastic over the past three decades before the lining was removed!

The research presented here investigates microplastics in Cumbrian water sources as they are becoming increasingly prevalent in the environment (see Figure 1). In order to collect evidence of their presence in Cumbrian water sources, a Scanning Electron Microscope (SEM) was used to image particles isolated from water samples and identify microplastics.

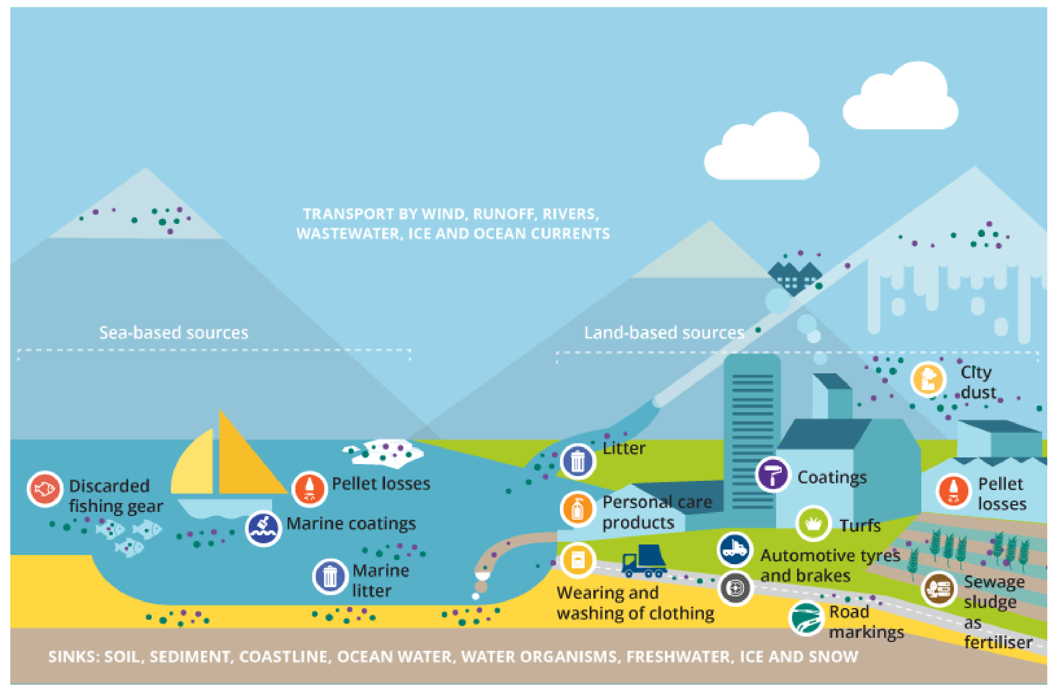

Figure 1: An illustration showing different sources of microplastic pollution (European Environment Agency, 2022).

Research Aims

The main research goal was to identify microplastics from water sources in the local area and capture detailed images using an SEM. The high resolution and magnification of an SEM would allow the particulate matter to be analysed in order to evaluate whether it was a microplastic or another material. The aims were to:

- Collect samples of water from different bodies of water, such as rivers, lakes, and the sea to image the particles they contained to search for microplastics (see Figure 6).
- Bring more awareness about microplastics in water sources and the environment to the public in order to encourage positive environmental changes.

Experimental Method

For this research, a Hitachi TM 4000 Plus Tabletop Microscope was used using backscattered electron (BSE) and secondary electron (SE) imaging. Water samples were collected from the local area and solid particles were separated from the water before imaging as the SEM used a vacuum when looking at samples. Two methods were trialled to isolate the solid particles.

Figure 2: Parton Beach sample using x250 magnification. Potential microplastic specimen highlighted in blue box.

Method 1 - vacuum filtration:

1. The sample was poured into a Büchner funnel containing filter paper and the water was sucked into the Büchner flask using a vacuum.
2. The solid particles remained on the filter paper.
3. The filter paper was removed from the funnel and placed in an incubator to dry.
4. Once dry, small circles were cut out of the filter paper and placed onto SEM stubs using carbon sticky tabs.

Method 2 - evaporation:

1. The sample was poured into an evaporating basin above a Bunsen burner.
2. The Bunsen burner was lit and turned onto the roaring flame.
3. The Bunsen burner was removed once the water had evaporated.
4. The evaporating basin was left to cool.
5. Then, an SEM stub with a carbon sticky tab was pressed against the interior of the evaporating basin to collect the particles inside.

Analysis

Visual analysis was used to evaluate the identity of the photographed specimens. They were compared to known microplastics and also other common materials likely to be found in water sources such as sand, soil, plant material and rock. Microplastics fall into different categories of shapes which are fragments, foams, fibres, beads and pellets and this can be used to help identify them (Lise *et al*, 2017).

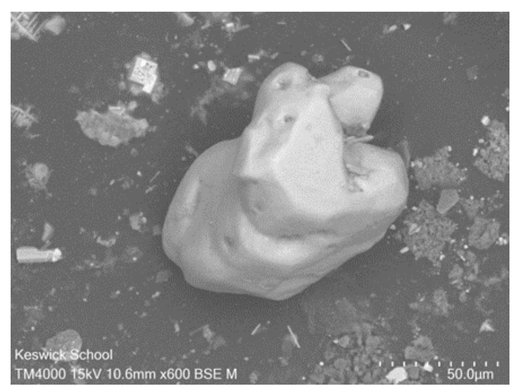

Figure 3: Bleaberry Tarn sample using x600 magnification.

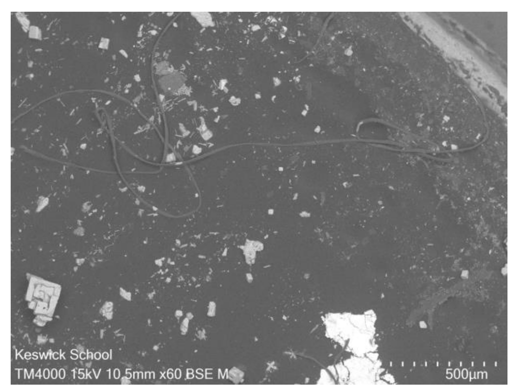

Figure 4: Bleaberry Tarn sample using x60 magnification.

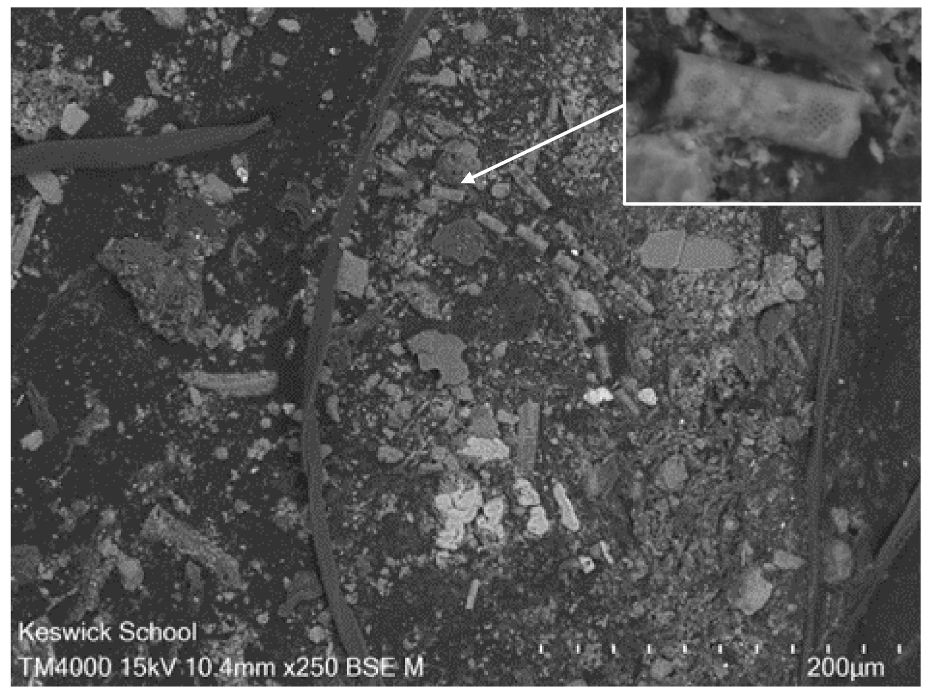

Figure 5: Derwent Water sample using x250 magnification. Inserted image uses x1800 magnification.

Figure 2 shows a specimen from Parton Beach (see Figure 6) that is suspected to be a microplastic because it has an unnatural shape. Due to its fragmented shape, it may be a type of microplastic known as a fragment (a small piece of a larger piece of plastic).

Figure 3 shows a smooth specimen with indents from Bleaberry Tarn (see Figure 6). It seems to be a bead or a weathered pellet as it would be unnaturally smooth for a rock at this magnification.

Figure 4 shows a long looped specimen from Bleaberry Tarn. It may be a fibre as it is clearly a strand or thread and the textile industry is a large source of microplastics polluting our environment (which adds credibility to this judgement.)

Figure 5 shows cylindrical specimens that were discovered in a sample taken from Derwent Water (see Figure 6). They may be a type of microplastic known as pellets due to their shape and the quantity discovered with the same shape and dimpled surface, which suggests they are artificial.

Figure 7 shows a granular specimen from Parton Beach. This specimen appears to be composed of a variety of materials that may include microplastics.

Figure 8 shows a fabric-like specimen with surrounding salt crystals from Bleaberry Tarn. It is potentially a fibrous microplastic due to its overall shape and slightly wrinkled texture. The shape may be similar to part of a leaf but no stomata or other clear indicators of plant material are visible.

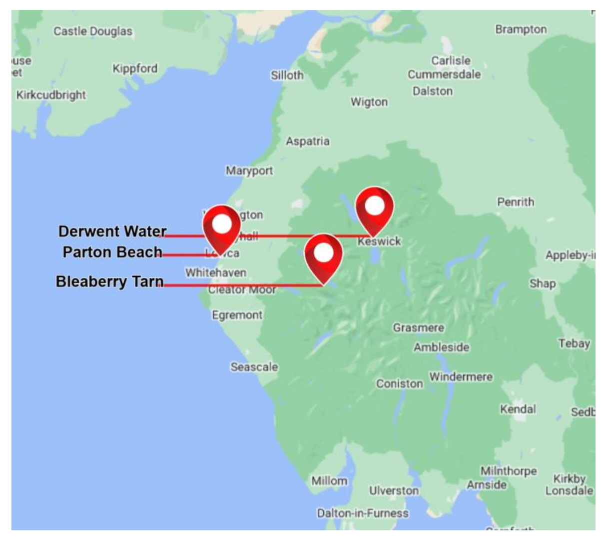

Figure 6: Locations of water sources sampled.

Limitations

One of the greatest limitations to this research was the lack of technologies (such as energy-dispersive X-ray spectroscopy) that could be used to identify the elemental composition of the specimens and obtain evidence supporting the identification of a microplastic.

Also, the sample preparation methods had flaws:

- Although vacuum filtration was simple and effective, the strands of filter paper had to be taken into consideration when viewing the images.
- Evaporation removed the need for filter paper however dissolved salts in the samples crystallised making it harder to view the particles from water with a high salt concentration, especially sea water samples.
- Also, evaporation meant it was not possible to collect all particles from the evaporating basin as to collect them a carbon sticky tab was dabbed on its interior. Therefore, microplastic specimens may have been missed.

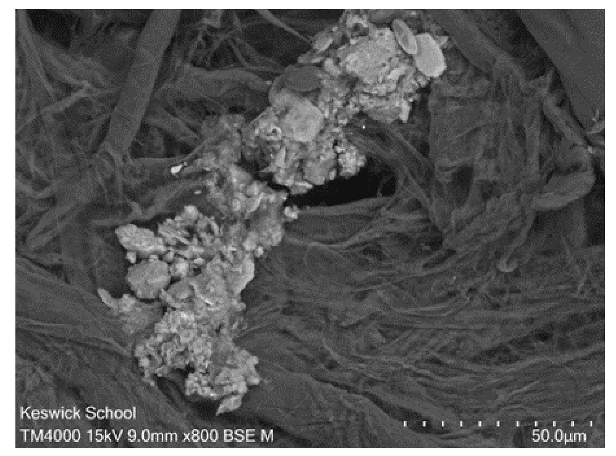

Figure 7: Parton Beach sample using x800 magnification.

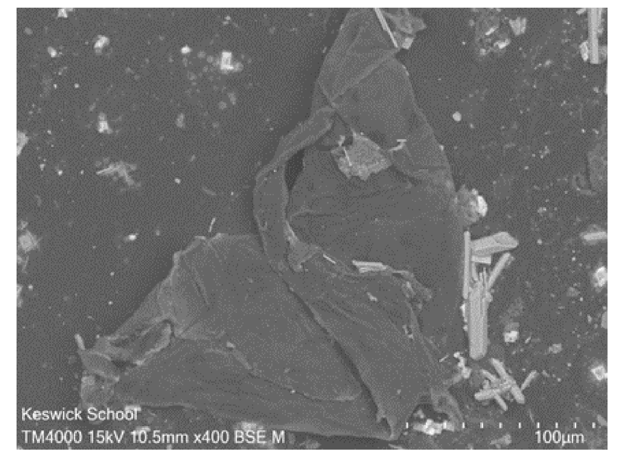

Figure 8: Bleaberry Tarn sample using x400 magnification.

Conclusions

The aim was to find microplastics in Cumbrian waters and the analysis shows that some of the particles that were analysed had similarities to known microplastics and differences to other particles commonly found in water sources such as rock, salt and plant material. This research contributes to other evidence that microplastics are very prevalent in water sources and other places in the environment.

To help prevent the increase in microplastics in the environment:

- SEMs could be used to investigate different areas of water sources to locate sources of microplastic pollution and further investigate the concentration of microplastics in different places.
- Research could be done about how plastic could be made more biodegradable.
- Plastic use could be decreased where possible.
- Research like this could be used to raise awareness in schools, online, and to the public.

Acknowledgements

The authors gratefully thank Mrs S. McDonald for training and support in use of the SEM and the Keswick School Science Department for providing equipment.

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