FORENSIC SCIENCE MEETS ARTIFICIAL INTELLIGENCE TO HELP IN THE BATTLE AGAINST PLASTIC POLLUTION

The Plastic Problem

As exemplified by the December 2017 United Nations conference on plastic pollution, there is increasing global recognition that marine litter is a problem. It has been shown to be a threat to wildlife, ecosystems and economies, and a potential risk to human health. It can be transported by ocean currents over long distances and is found in all marine environments. This issue can affect organisms and habitats through ingestion of litter items (e.g. microplastics) or entanglement, resulting in death and/or severe suffering or by acting as a vector for transport and thereby facilitating invasion by alien species. It also carries significant implications for human welfare, making it a complex multidisciplinary problem. It impacts negatively on vital economic sectors such as tourism, fisheries, aquaculture and energy supply, bringing economic losses to individuals, enterprises and communities. Despite this there is currently no standardised and cost-effective way of monitoring and quantifying the scale of this global concern.

It is now known that microplastics (defined as being <5mm in size) in the form of synthetic fibres are a significant form of marine litter pollution. Fibres are the building blocks from which textile fabrics are made. They are readily dislodged from clothing and slow to degrade. When textiles are washed, huge numbers of fibres enter the water, find their way through sewage works, down rivers and into the sea, where they are ingested by fish and other animals [http://go.nature.com/2zA3JuC]. Fibres are also lost from items of clothing when brought into contact with other objects. Forensic scientists have taken advantage of this fact for more than 50 years and have developed methods for the analysis and interpretation of fibres that can be readily used in microplastic work.

Marine litter on a coastal beach

Forensic Fibres Analysis

Forensic fibres examination has been a fundamental part of criminal investigations for decades. This is due to the ubiquity of fibres, their ability to be readily transferred during a crime, and the fact that some fibres are uncommon and others are rare when found in combination. Fibres found at crime scenes are either natural, e.g. cotton, or man-made, e.g. polyester, and are typically <5mm in length. The forensic examination of fibres is mainly a comparative science: the properties of a sample from an unknown origin are determined and compared with those of a sample from a known source. From such information, the case context and knowledge of the frequency of occurrence, a fibre analyst may be able to infer the unknown fibres' source(s), their possible end-use(s) or even actions of those involved in the crime.

The fact that forensic science is used to inform decisions made by the courts means that the techniques it uses for both analysis and interpretation must be robust. The need to characterise fibres, to infer their prevalence and source, whilst minimising the chance for contamination is common to both forensic analysis and microplastic pollution work. Figure 1 outlines five key areas where forensic fibres expertise can be applied to the benefit of microplastic pollution studies. This includes: the use of robust contamination prevention procedures; methods that allow for greater characterization of fibres thereby improving the inference of source; research into the transfer and persistence of fibres to help understand how fibres are shed from fabrics and how long they will be retained in different environments; the development of analysis protocols to expedite identification; and the generation of large datasets to be used to interpret and evaluate fibre samples.

Unlike in many microplastic pollution studies, forensic fibres analysis is not solely focussed on the use of Fourier Transform Infrared Spectroscopy (FTIR). Instead, it uses a series of observations to categorise and characterise the fibres. In forensic examinations 'layers of information' are sought to produce reliable inference of source. This is done in the knowledge that not all fibres of a particular polymer type are the same.

Plastic litter found on Northumbrian beaches, UK being documented in the forensic laboratory

As outlined above, many aspects of forensic fibre analysis and research overlap with the needs of microfibre pollution analysis, such that techniques, protocols and developing technologies designed for forensic application could be employed in microplastic work. Contamination prevention procedures, better understanding of source level and transfer and prevalence, faster and more effective quantification and improved interpretation and evaluation are all priorities in forensic fibre examinations which would also benefit microplastic pollution analysis, quantification and interpretation. Some of this forensic knowhow has already been employed successfully in the context of marine microfibre pollution

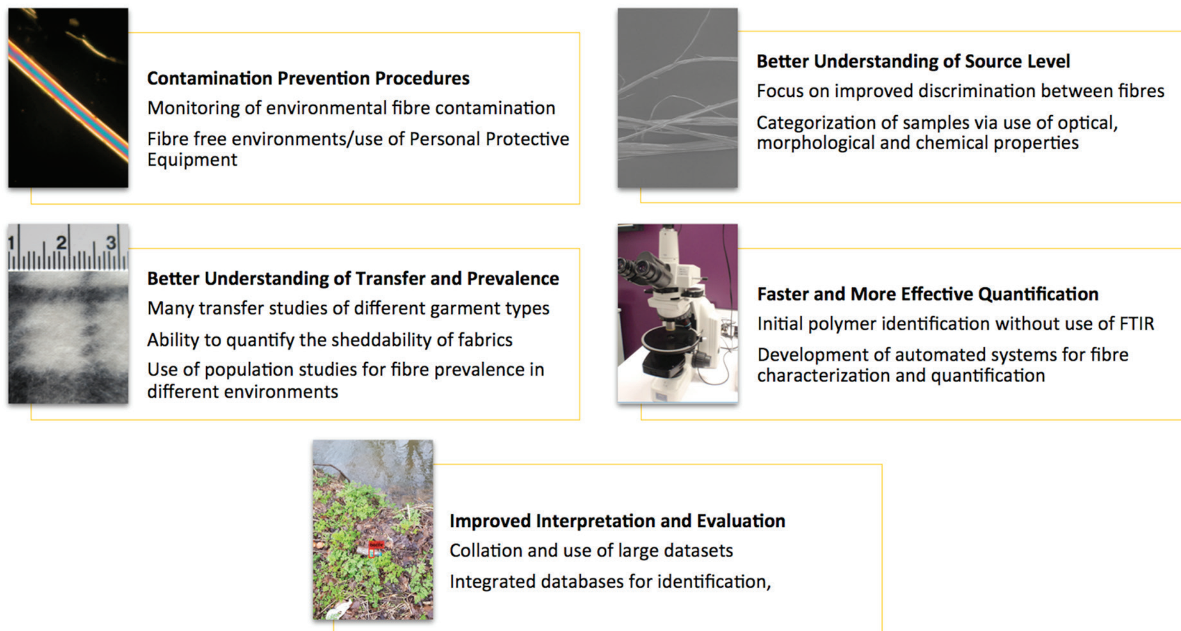


Figure 1: Forensic fibre examination processes and ideas that can benefit microplastic pollution work.

studies [http://bit.ly/L-Woodall2015] demonstrating the potential of a collaborative approach.

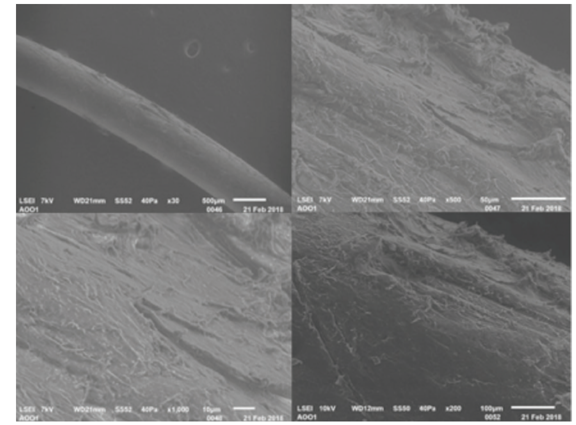
There are also common drivers for technological advancement in both forensic fibres and microplastic pollution analysis techniques. These include the need to improve both:

- the discrimination between similar fibre types to help infer source.
- their cost effectiveness to allow greater quantities of samples to be processed.

This has led to a multi-disciplinary project at Staffordshire University which draws upon knowhow in forensic analysis, computer vision, machine learning, environmental science, data analytics, plastics analysis and evidence evaluation to aid in the battle against plastic pollution.

The New Project: Machine Learning Meets Forensic Science for Plastic Pollution Monitoring

Machine learning (also known as artificial intelligence, AI) allows the development of complex models that can adapt with the addition of new data to provide reliable results and predictions. The ability to automate the accurate categorisation of thousands of objects via machine learning is an important step in improving plastic pollution monitoring. To achieve this automation, computer vision techniques are required; this is where large datasets of images of both macro and micro plastics can be used to develop training sets for the automated characterisation of these samples. But this is not without its issues. Taking images of microplastics which may be bio-fouled or of macro-plastics in different lighting conditions in the marine environment can cause problems in categorisation unless new technological approaches are employed.



Degradation of the surface of plastics found in the marine environment using Scanning Electron

This project is utilising existing patented technology [http://bit.ly/spectral360] developed at Staffordshire University, to overcome these issues to create the first automated system for the characterisation, quantification and modelling of macro-litter and microplastic aquatic pollutants.

This project is using machine learning and computer vision for the monitoring and quantification of macro-litter in coastal regions and marine environments and developing predictive models of the amounts and movement of such litter. This is to be followed by the creation of a machine learning enabled platform that will harness the power of proven technologies to allow standardised and automated means of microfibre pollution monitoring and modelling. In this, machine learning will be used to automate the identification and characterisation of microfibres and, via a database, allow new insights to be gained by cross-comparison of location, time and fibre type data. It will allow fibre categorisation based on a range of features such as polymer type, cross-sectional shape, colour, width and the presence or absence of inclusions. The monitoring of features indicating degradation or presence of biofouling will also be facilitated which can help identify how long these samples have been in the marine environment. Ultimately this approach promises the ability to build models to better understand the sources, movement and impact of marine litter as well as the likely efficacy of strategies proposed to abate this pollution.

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