Marine Pollution Bulletin xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Using a forensic science approach to minimize environmental contamination and to identify microfibres in marine sediments

Lucy C. Woodall [a,*], Claire Gwinnett [b], Margaret Packer [a], Richard C. Thompson [c], Laura F. Robinson [d], Gordon L.J. Paterson [a]

[a] Department of Life Sciences, Natural History Museum, London SW7 5BD, UK
[b] Department of Forensic and Crime Science, Staffordshire University, Stoke-On-Trent ST4 2DF, UK
[c] School of Marine Science and Engineering, Plymouth University, Plymouth, Devon PL4 8AA, UK
[d] School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK

ARTICLE INFO

Article history:
Received 30 January 2015
Revised 20 April 2015
Accepted 21 April 2015
Available online xxxx

Keywords:
Microplastic
Microfibre
Sediment
Deep-sea
Pollution

ABSTRACT

There is growing evidence of extensive pollution of the environment by microplastic, with microfibres representing a large proportion of the microplastics seen in marine sediments. Since microfibres are ubiquitous in the environment, present in the laboratory air and water, evaluating microplastic pollution is difficult. Incidental contamination is highly likely unless strict control measures are employed. Here we describe methods developed to minimize the amount of incidental post-sampling contamination when quantifying marine microfibre pollution. We show that our protocol, adapted from the field of forensic fibre examination, reduces fibre abundance by 90% and enables the quick screening of fibre populations. These methods therefore allow an accurate estimate of microplastics polluting marine sediments. In a case study from a series of samples collected on a research vessel, we use these methods to highlight the prevalence of microfibres as marine microplastics.

1. Introduction

Microplastics have been found in all environments thus far examined (Barnes et al., 2009; Eriksen et al., 2013; Imhof et al., 2013; Obbard et al., 2014; Thompson et al., 2004; Woodall et al., 2014). Microplastics, are <5 mm (Arthur et al., 2009), and are typically reported as fragments and pellets, but recent research has specifically highlighted the predominance of fibrous plastics 'microfibres' (Browne et al., 2011; Ivar do Sul and Costa, 2014). Laboratory studies have shown microplastics may have impacts on marine organisms potentially causing physical effects (Wright et al., 2013) and/or chemical effects (Frias et al., 2010; Holmes et al., 2012). In addition, they can adsorb and concentrate hydrophobic chemicals such as persistent organic pollutants (POPs) which then can be exported away from the source at the water/surface interface (Bakir et al., 2014; Teuten et al., 2009). When microplastics sink to the seabed, any associated pollutants could also be transported to depth (see Woodall et al., 2014 for a discussion on possible mechanisms). Microplastics may also change environmental conditions in sediment, by altering its thermal properties and water permeability (Carson et al., 2011). The quantification of the abundance of microfibres in the marine realm can easily be confounded by contamination of samples during laboratory processing. Fibres are ubiquitous in the everyday environment and have been documented in studies that have focused on diverse substrata from human skin to car seats (Free et al., 2014; Grieve and Biermann, 1997; Liebezit and Liebezit 2014; Marnane et al., 2006; Owen et al., 1992; Palmer and Burch 2009; Roux and Margot, 1997; Was-Gubala, 2004; Zhao et al., 2014), thus the possibility of post-sampling contamination is high. As a result some studies on microplastic pollution (Dekiff et al., 2014; Goldstein and Goodwin, 2013; Van Cauwenberghe et al., 2013) have intentionally excluded this fraction in their analyses. However, when included in studies, fibres are a large proportion of the microplastics recovered from sediment, ice and some subsurface waters (Browne et al., 2011; Claessens et al., 2011; Desforges et al., 2014; Mathalon and Hill, 2014; Obbard et al., 2014; Thompson et al., 2004; Woodall et al., 2014). Excluding microfibres may bias the quantification and interpretation of the effects of marine pollution.

The recovery and identification of microfibres has long been an integral part of forensic investigation (Petraco et al., 1980; Petraco, 1987; Stoeffler, 1996), and are defined in this field as fibres of

* Corresponding author at: Natural History Museum, Department of Life Sciences, Cromwell Road, London SW7 5BD, UK. Tel.: +44 (0)20 7942 6475.
E-mail address: l.woodall@nhm.ac.uk (L.C. Woodall).

http://dx.doi.org/10.1016/j.marpolbul.2015.04.044
0025-326X/

5–10 μm width (De Wael and Gason, 2008). Forensic investigations apply standard techniques to minimize potential contamination and to identify fibres from the same source. The nature of forensic examinations means that they are under scrutiny by the criminal justice system, therefore rigour and validity of approach is fundamental to their design. Studies of marine microfibres have many of the same challenges as forensic investigations, thus the adaption and use of established forensic techniques may be used in their identification.

This paper describes a practical and rigorous methodology to sample sediment, extract and characterize microfibres, while ensuring minimum possible post-sampling contamination. The potential for post-sampling contamination by microplastics has been previously highlighted (Hidalgo-Ruz et al., 2012; Fries et al., 2013). The presence of high background levels of fibres in a working laboratory was demonstrated by Nuelle et al. (2014) who suggest the avoidance of contamination with fibres is vital, but not all studies follow such protocols. We present simple procedures that result in low levels of microfibres in the ambient environment of a working laboratory by using an approach employed in forensic science laboratories that examine fibre evidence (Fig. 1). We also examine the differences in background microfibre levels in three indoor areas. In addition we investigate whether the screening processes used in forensic investigations, in the form of polarized light microscopy, would also be useful in screening for microfibres. Finally we test our procedures in a field study using seabed sediment.

2. Methods

2.1. Minimizing microfibre contamination

Given the ubiquity of microfibres in the environment, important steps to prevent and monitor potential contamination of sediment by microfibres need to be undertaken at every phase of the experimental process. In our study all procedures, both on shore and aboard the research ship, were designed to minimize and monitor potential contaminants following recommendations and procedures made for the forensic investigation of fibres (Moore et al., 1986; Robson and Coyle, 2001; Roux et al., 2001; Wiggins and Nehse, 2001).

All of the materials and fluids used in the processing were controlled and tested for microfibre contamination. In this study, all preservation and processing fluids that were part of the field study (Section 2.4) were sieved at 32 μm using clean metal sieves before being added to the sediment sample. Standard non-plastic equipment i.e. metal and glass, was used as much as possible. Where this was not possible, a sample of the plastic was taken and optical properties assessed under the microscope and then added to a database of identified control plastic samples. Hereafter, the term 'clean' is used when the equipment was cleaned with filtered water then rinsed in 0.22 μm membrane filtered Millipore water, and when possible was checked for any remaining contamination under a microscope.

Clothing made from synthetic fibres such as acrylic, rayon, polyester and nylon are common and therefore potential sources

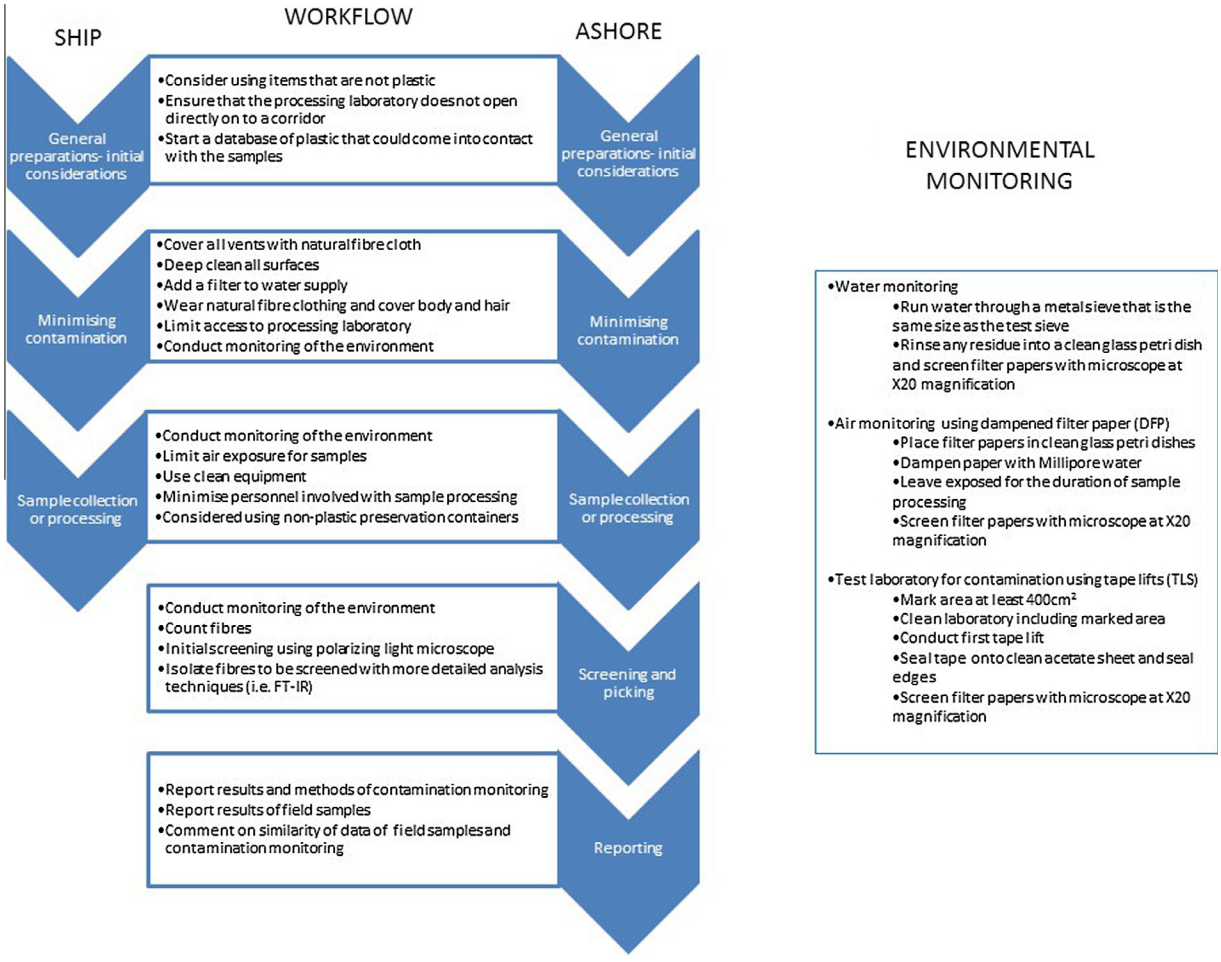

Fig. 1. Flow diagram to show the procedure for microplastic investigation, including the monitoring protocols.

Please cite this article in press as: Woodall, L.C., et al. Using a forensic science approach to minimize environmental contamination and to identify microfibres in marine sediments. Mar. Pollut. Bull. (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.04.044