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ScienceDirect
Marine Pollution Bulletin 52 (2006) 1591–1594
MARINE POLLUTION BULLETIN
www.elsevier.com/locate/marpolbul

Magnetic cleansing of weathered/tarry oiled feathers – The role of pre-conditioners

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Abstract

Iron powder has previously been demonstrated to be effective in the removal, via magnetic harvesting, of a wide variety of oil contaminants from feathers and plumage. This study investigates the efficacy of magnetic cleansing for the removal from feathers of tarry contamination that has been allowed to weather. Clusters of feathers from Mallard duck (*Anas platyrhnchos*) and Little Penguin (*Eudyptula minor*) were completely immersed in a tarry contaminant and allowed to weather from one to fourteen days. The contaminant was removed using a magnetic cleansing protocol and the removal efficacy assessed gravimetrically. For one, seven and fourteen days of weathering, a final removal (after fourteen treatments) of more than 99% and 97% was achieved for duck feathers and penguin feathers, respectively. Repeating the experiments (for a seven-day weathering period) for both duck and penguin feathers, with the *judicious* application of a pre-conditioner (olive oil), further improved removal efficacy. A convenient method to screen for improved pre-conditioning agents is suggested.

Keywords: Iron powder; Magnetic; Oil removal; Weathered contamination; Feather; Pre-conditioner

1. Introduction

The weathered and/or tarry nature of many oil deposits in the environment presents a challenge to environmental remediation and wildlife rehabilitation. Thus when exposed to the environment, oil undergoes a process whereby its chemical composition and physical properties change over time (Leighton, 2000). When oil becomes weathered, it often forms a tarry deposit that complicates remediation (EPA, 1997). This is of particular concern when oil weathers on the fur or feathers of wildlife (Oiled Wildlife Care Network, 2003; Bryndza, 2005). This is not an uncommon scenario, since it may take days or even weeks for affected animals to be discovered by rescuers. For example, following the *Sea Empress* oil spill on 15 February 1996 off the coast of south west Wales (UK), the first oiled birds came ashore on 17 February and the last ones were collected on 8 March 1996 (Clark et al., 1997). A recent oil spill in Ventura County, California (USA) is believed to have killed or injured around 3000–5000 seabirds, some of which were coated with heavily weathered/tarry oil (Mecoy, 2005).

To date, there have been only a limited number of studies on the removal of weathered/tarry contamination from feathers (Holcom and Russell, 1999; Hill, 1999; Oiled Wildlife Care Network, 1999, 2003; US Fish and Wildlife Service, 2002). The standard technique for the removal of this kind of contamination involves the use of detergents and a large amount of warm water, together with pre-conditioning agents (Oiled Wildlife Care Network, 1999; US Fish and Wildlife Service, 2002). Although these techniques are sometimes successful, they are time-consuming and labour-intensive. The use of pre-conditioning agents can

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0025-326X/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2006.04.017

also be problematic since they too need to be removed during the cleaning process (Frink and Crozer-Jones, 1986; US Fish and Wildlife Service, 2002).

In previous studies, magnetic cleansing has been shown to be effective in removing up to ca. 100% of various fresh (non weathered/tarry) contaminants from different substrates (Orbell et al., 1999, 2004; Dao et al., 2006). More recently, it has been demonstrated (Orbell et al., 2005) that magnetic cleansing may also be applied to the removal of non-weathered tarry oil from feathers. The present study investigates the efficacy of magnetic cleansing in the removal from duck and penguin feathers of tarry contamination that has been allowed to weather over time. This is likely to be more representative of the situation in the field. The use of olive oil as a pre-conditioner has also been investigated and, in this regard, we have previously demonstrated a removal of 100% of the olive oil itself by this method (unpublished data).

2. Materials and method

2.1. Materials

Shell crude oil (viscosity, 3000–4000 cSt, at 100 °C) was used as the tarry contaminant. This oil was chosen to represent a "worst-case scenario". The magnetic particles, supplied by Höganas AB, Sweden, were described by the manufacturer as "superfine spongy" iron powder (Grade MH300.29). This grade has previously been shown to be capable of achieving ca. 100% removal from duck and penguin feathers for various unweathered non-tarry oils (Dao et al., 2006) and for the present unweathered tarry oil (Orbell et al., 2005). The feathers used in the present work are clusters of breast/contour feathers from the Mallard duck (*Anas platyrhnchos*) and the Little Penguin (*Eudyptula minor*). Commercially available olive oil has been used as the pre-conditioning agent. This is based on the reported effective use of olive oil as a pre-conditioner for the removal of weathered/tarry contamination by traditional surfactant-based methods (Oiled Wildlife Care Network, 1999, 2003).

2.2. Methods

For these experiments, weathering is considered to be simply the loss of the lighter fractions of the contaminant over time, up to approximately fourteen days. It is appreciated that, for longer periods, other factors such as oxidation also contribute to the weathering process. However, for wildlife contamination, it is not necessary for long-term, non-evaporative weathering processes to be considered since these would extend beyond the survival time of the animal. Therefore, the weathering of the tarry oil was simulated *in vitro* as follows: a cluster of feathers was immersed in a melt of the oil that was then allowed to solidify to a tarry deposit. The resultant tarry feathers were left to hang in the air at ambient temperature for up to fourteen days. The weight of the oiled feathers was monitored over time and this was taken to be a measure of the degree of weathering. After seven days it was found that the weight had essentially stabilized with full weathering being considered to have occurred after fourteen days. Therefore, experiments were conducted on the removal of the contaminant after a period of one day (minimal weathering), seven days (significant weathering) and fourteen days (full weathering).

The oil removal experiments at different stages of weathering were carried out in five-fold replicate according to a previously described gravimetric procedure (Orbell et al., 1999). Since the contamination is tarry it was necessary to maintain a temperature (295 K) above that previously shown to be required for removal to occur (Orbell et al., 2005). Experiments that were conducted using olive oil as a pre-conditioner, involved seven-day weathering only.

3. Results and discussion

Initial experiments were directed at comparing the removal of significantly weathered tarry oil from widely different feather types, namely duck and penguin. Thus Fig. 1 depicts the removal of tarry oil, weathered for seven days, from clusters of duck and penguin feathers.

Overall, it can be seen that penguin feathers are significantly less responsive to treatment than duck feathers for this contaminant, although the final removal achieved is high in both cases, being ~99.4% and 97.5%, respectively after 14 treatments. In particular, it should be noted that the initial removal for duck feathers was double (37.7%) that for penguin feathers (16.9%).

In order to ascertain the effect of weathering time on removal efficacy for both types of feather, experiments were also conducted after one and fourteen days. These data (together with the individual seven-day data) are presented in Figs. 2a and 2b.

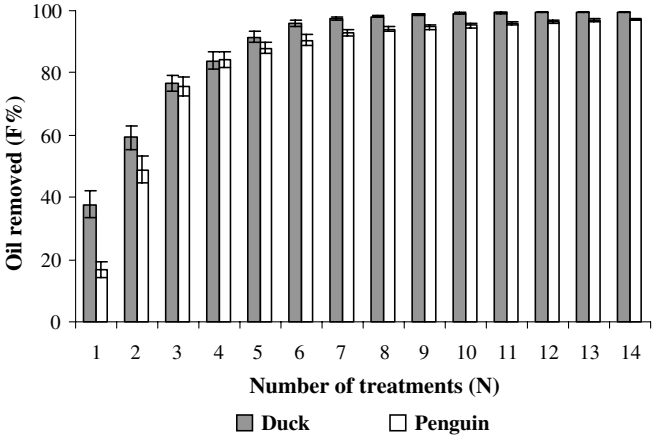

Fig. 1. Removal of the seven-day weathered oil from duck and penguin feathers. Error bars represent SE for five replicates.