

“Magnetic Cleansing” for the Provision of a ‘Quick Clean’ to Oiled Wildlife

Lawrence N. Ngeh, John D. Orbell, Stephen W. Bigger, Kasup Munaweera, and Peter Dann

Abstract—This research is part of a broad program aimed at advancing the science and technology involved in the rescue and rehabilitation of oiled wildlife. One aspect of this research involves the use of oil-sequestering magnetic particles for the removal of contaminants from plumage – so-called “magnetic cleansing”. This treatment offers a number of advantages over conventional detergent-based methods including portability - which offers the possibility of providing a “quick clean” to the animal upon first encounter in the field. This could be particularly advantageous when the contaminant is toxic and/or corrosive and/or where there is a delay in transporting the victim to a treatment centre. The method could also be useful as part of a stabilization protocol when large numbers of affected animals are awaiting treatment. This presentation describes the design, development and testing of a prototype field kit for providing a “quick clean” to contaminated wildlife in the field.

Keywords—Magnetic Particles, Oiled Wildlife, Quick Clean, Wildlife Rehabilitation.

I. INTRODUCTION

FOR almost a decade, scientists at Victoria University and the Phillip Island Nature Park have been engaged in a collaborative program aimed at advancing the science and technology involved in the rescue and rehabilitation of oiled wildlife.

A promising development involves the use of oil-sequestering magnetic particles for the removal of contaminants from plumage [1], [2]. This is effectively a benign dry cleansing process - with minimal feather damage compared to detergent-based cleansing. Being inherently portable, the application of magnetic particle technology (MPT) to the removal of oil contamination from plumage (and fur) also offers a number of other advantages over conventional detergent-based methods, such as the possibility of providing a “quick clean” to the animal upon first encounter. This could be particularly advantageous when the contaminant is toxic and/or corrosive or where there is a delay in transporting the victim to a treatment centre. The method could also be useful as part of a stabilization protocol when large numbers of affected animals are awaiting treatment.

The “magnetic cleansing” technique requires the development and optimization, not only of the particles themselves, but also of the equipment and protocols that are appropriate for application in the field. With respect to the development of the oil-sequestering magnetic particles themselves, various approaches have been under

investigation, ranging from the coating of iron particles with hydrophobic (or super-hydrophobic) surfaces, Fig. 1(a), to the identification and characterization of highly absorbent grades of iron powder, Fig. 1(b). Regarding the latter, it has been demonstrated that certain grades of finely divided iron powder are highly effective for the removal (via “magnetic harvesting”) of a range of different oil types and oil/seawater emulsions from both feather clusters and from the plumage of whole birds [3]. More recently, this technique has been demonstrated to be capable of achieving 100% removal within experimental error [4] and has also been demonstrated to be effective with respect to weathered/tarry contamination [5], [6].

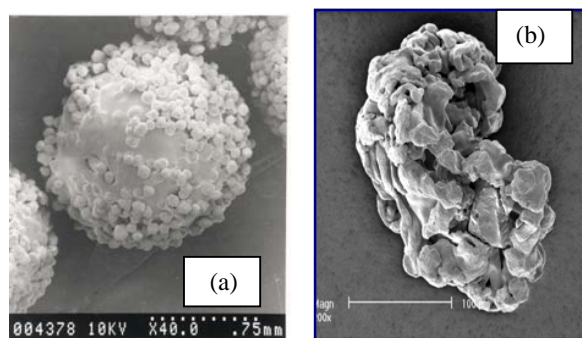


Fig. 1 Electron micrographs of oil sequestering particles (a) polymer-coated and (b) finely divided iron powder

II. THE DEVELOPMENT OF MAGNETIC DEVICES

The development of appropriate equipment is also ongoing and includes the design and testing of a portable, hand-held, magnetic device (the “magnetic harvester”) that can safely and efficiently strip the oil-laden magnetic particles from the animal and which can allow the waste to be disposed off in a controlled way. The development of such devices within our research group is represented in Fig. 2.

The device shown in Fig. 2(a) is a standard “magnetic tester” the magnetic field of which may be turned on and off mechanically by operating the plunger. Although suitable for routine laboratory experiments, this device requires two hands to operate and is not considered practical for “field” work. Fig. 2(b) is a one-handed magnetic harvester with the mechanical on-off switch operated by compressed air. Although effective, this device is considered to be too cumbersome for field work. Fig. 2(c) depicts an electromagnetic device that has since proven to be unsuitable due an inability to achieve a magnetic field strength within the desired range of 5,000 – 10,000 Gauss. The device in Fig. 2(d), dubbed the “magnetic wand”, has been developed with a “quick clean” in mind. It is based on a carefully designed array of rare earth magnets within a stainless steel tube (100 mm), the tip (35 mm) of which has been made to be non-magnetic. This device generates a

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strong, highly localized, magnetic field and the magnetic tip allows oil-laden particles to be readily wiped off into a waste container.

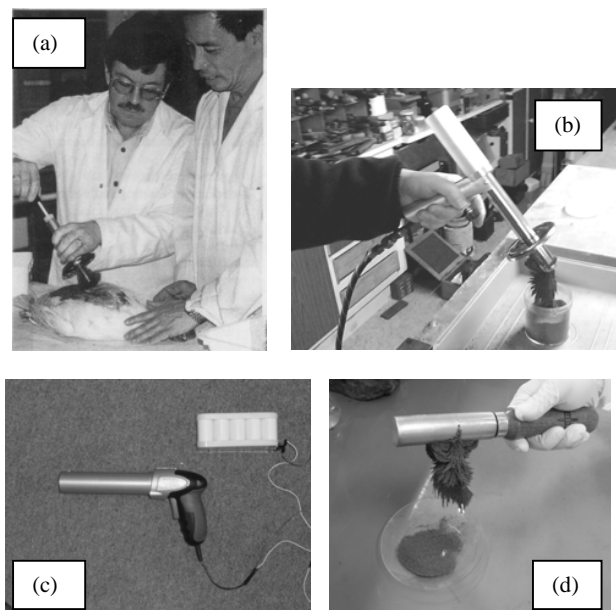


Fig. 2 (a) Magnetic "tester" (b) Compressed air device (c) Electromagnetic device (d) Magnetic "wand"

III. REMOVAL OF CONTAMINANTS FROM WHOLE BIRD MODELS

Concomitant with the development of the above technology, an experimental program has been conducted into the removal of different coverage (% by mass) of various oil types from the plumage of Little Penguin (*Eudyptula minor*) in order to investigate the feasibility of applying MPT to the cleansing of oiled wildlife in the field [7]. As well as establishing important methodologies for conducting complex experiments of this kind, these continuing investigations have attempted to estimate the logistical requirements for such potential operations - such as the time taken, the mass of particles required per bird, the mass of waste per bird and the costs relating to materials, waste disposal and personnel. Other factors such as the use of pre-treatment agents have also been addressed [8].

Fig. 3 depicts a typical set of data. These initial investigations were carried out using the laboratory magnetic tester shown in Fig. 1(a) and indicate that a high percentage removal of contaminant can eventually be achieved. However, at this stage, the most exciting finding is that a significant fraction of contaminant can be removed after only one or two treatments (taking only 5 – 10 minutes). This observation gives rise to the possibility that MPT could be applied to providing a "quick clean" upon first encounter.

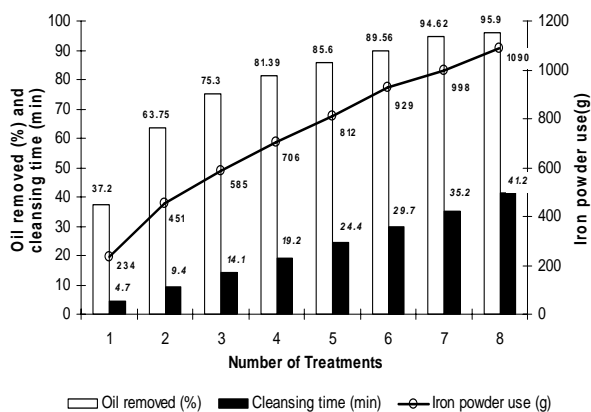


Fig. 3 A representation of the removal of Diesel oil (100% coverage – a worst case scenario) from a Little Penguin carcass. Note that in this experiment, the "first generation" magnetic tester was used and that 37% removal may be achieved in 4.7 minutes and 64% in 9.4 minutes

Accordingly, with the subsequent development of the magnetic wand device, Fig. 2(d), a program has commenced to develop a prototype set of equipment to enable a quick wash to be trialled in the field. Such experiments are depicted in Fig. 4.

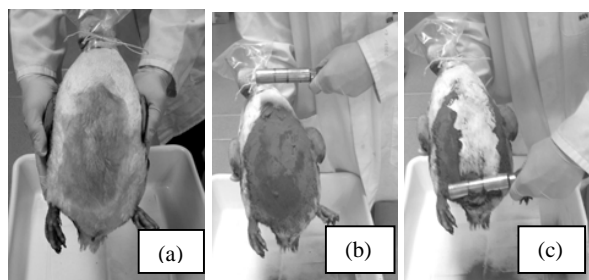


Fig. 4 Simulating a "quick wash" for a Little Penguin carcass contaminated with (a) 20% coverage (by mass) of engine oil (b) after application of magnetic particles (c) 82% removal is achieved after one treatment. Two persons would be required for this procedure to be carried out on live animals

Further analysis of the data obtained from such experiments shows that the initial removal increases as the percentage coverage decreases. Our more recent experiments have also shown that use of the magnetic wand device, rather than the magnetic tester, further enhances the initial removal. Some representative data is presented in Fig. 5. Notably, for 20% coverage (by mass) of Diesel oil and engine oil respectively, 85% and 93% removal of these contaminants can be achieved after two treatments - taking approximately 5 minutes in each case.

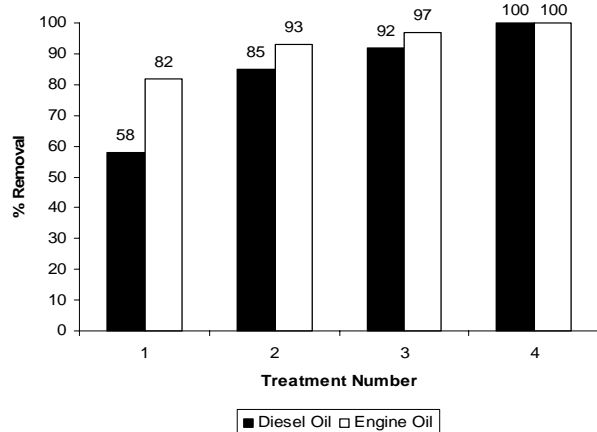


Fig. 5 “Magnetic wand” removal of 20% coverage (by mass) of Diesel oil and engine oil from the plumage of Little Penguin

Work is continuing to further develop this method with respect to improving the magnetic particles and optimizing the equipment (such as the magnetic harvester). Studies are also continuing into the development and use of pre-treatment agents in conjunction with magnetic cleansing and to tailor the method for different scenarios.

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REFERENCES

- [1] J. D. Orbell, J.D, E. K. Tan, M. C. Coutts, S. W. Bigger, and L.N. Ngeh, “Cleansing oiled feathers – magnetically”, *Marine Pollution Bulletin*, 38, pp. 219-221, 1999.
- [2] J. D. Orbell, H. V. Dao, L. N. Ngeh, L.N, and S.W. Bigger, “Magnetic particle technology in environmental remediation and wildlife rehabilitation”, *Environmentalist*, 27, no.1, pp. 175-182, 2007.
- [3] J. D. Orbell, H. V. Dao, L. N. Ngeh, L.N, and S.W. Bigger, M. Zabinskas, M., Zheng, M., Healy, R., Jessop, and P. Dann, “Whole-bird models for the magnetic cleansing of oiled feathers”, *Marine Pollution Bulletin*, 48, pp. 336-340, 2004.
- [4] H. V. Dao, L. N. Ngeh, S. W. Bigger, and J. D. Orbell, “The achievement of 100% removal of oil from feathers employing magnetic particle technology”, *Journal of Environmental Engineering*, no. 5, pp. 555-559, 2006.
- [5] J. D. Orbell, H. V. Dao, L. N. Ngeh, S. W. Bigger, M. Healy, R. Jessop, and P. Dann, “Acute temperature dependency in the cleansing of tarry feathers utilizing magnetic particles”, *Environmental Chemistry Letters*, 3, pp. 25-27, 2005.
- [6] H. V. Dao, L. A. Maher, L. N. Ngeh, S. W. Bigger, J. D. Orbell, M. Healy, R. Jessop, and P. Dann, “Removal of petroleum tar from bird feathers utilizing magnetic particles”, *Environmental Chemistry Letters*, 4, pp. 111-113, 2006.
- [7] J. D. Orbell, H. V. Dao, L. N. Ngeh, and S.W. Bigger, “An investigation into the feasibility of applying magnetic particle technology to the cleansing of oiled wildlife in the field”. 75 page report prepared for the Australian Maritime Safety Authority (National Plan Environment Working Group) and the Phillip Island Nature Park, 2008.
- [8] H.V. Dao, L. N. Ngeh, S.W. Bigger, J.D. Orbell, M. Healy, R. Jessop, and P. Dann, “Magnetic cleansing of weathered/tarry oiled feathers - the role of pre-conditioners”, *Marine Pollution Bulletin*, 52, no. 12, pp. 1591-1594, 2006.