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Using dogs to detect hidden corrosion

Adee Schoon[a,*], Rune Fjellanger[b], Morten Kjeldsen[c], Kai-Uwe Goss[d]

[a] *Animal Detection Consultancy, Vorchten, The Netherlands*
[b] *Fjellanger Dog Training Academy, Bergen, Norway*
[c] *Flow Design Bureau AS, Trondheim, Norway*
[d] *Helmholtz Centre for Environmental Research GmbH – UFZ, Leipzig, Germany*

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ABSTRACT

Dogs used as detectors in remote scent tracing (RST) technology usually detect the presence of explosives or contraband in scent samples collected by sucking air from containers or air freight. In this study, five dogs were trained to detect corrosion under the insulation (CUI) of pipes in scent samples collected at a gas processing plants. CUI is a major problem in oil and gas processing plants, causing safety risks and leading to production loss. Scent samples were made by sucking air through drain plugs in the insulation material surrounding the pipes onto filters. During a two year project, dogs trained to detect corrosion using insulation material collected earlier from other corroded locations at the plant were able to detect corrosion on the filters collected from intact insulated pipes at that plant at the same level of proficiency, detecting corrosion at around 59% while producing on average less than 3% false alarms. The systematic training approach, the integration of field samples into training runs and the use of several dogs to improve the reliability of the system are described. Preliminary results on double blind samples were promising: the sensitivity of the detection of field samples was 92%, and the selectivity 93%. The application of such a system as a tool in a preventive maintenance program at oil and gas processing plants could be useful to determine timing of maintenance, thus allowing a more efficient allocation of costly resources necessary for the customary visual inspection.

1. Introduction

The sense of smell of dogs has been used traditionally by police forces, customs and the military to detect illicit or dangerous substances using "free running" dogs. Dogs are used for detection purposes for two main reasons: their sense of smell and their trainability. The sense of smell is difficult to study because there is no scale to measure "odour". Odour is best defined as the perception of volatile molecules. Key factors in odour perception seem to be the number of different kinds of odour receptors an animal species has available, and the proportion of its brain dedicated to the processing odour information. Dogs and mice both have approximately 1000 different functional odour receptors while humans have less than 400 (Goldblatt et al., 2009). Dogs also have a much larger proportion of their brain dedicated to odour processing. This means that these animals can perceive and discriminate odours that we cannot, simply because we lack the sensors and the processing unit.

Through the years, using dogs for detection purposes has broadened to many other substances, and by many different organisations. Moreover, the traditional "free running" method has been complemented with a "remote scent tracing (RST)" method, as first described for mine detection (Fjellanger, 2001). RST entails collecting scent samples at a location where dogs cannot be deployed efficiently for safety, environmental or logistic reasons. These scent samples are then presented to the dogs in a laboratory-like setting for analysis. For example: heat can

* Corresponding author. Tel.: +31 623972702.
E-mail address: animaldetectionconsultancy@gmail.com (A. Schoon).

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be a reason dogs cannot be deployed for a long period of time, so at the Palestinian border with Israel scent samples are collected from cars analysed by dogs in a cooler environment (Zoodsma, pers.com.). EU regulations allow air freight to be sampled and analysed by dogs elsewhere for the presence of explosives. In this way, a large amount of freight can be checked in a short period of time (EU regulation 573/2010). Cancer detection dogs essentially work in this manner too: samples are collected from potential patients in hospitals or clinics, and analysed elsewhere by dogs (review Moser and McCulloch, 2010).

In this study, RST was used as a technique to locate potential corrosion of pipes in refineries and processing plants. Such pipes are covered with insulation material and a protective cladding to prevent heat loss. However, this means that the pipes cannot be inspected for corrosion easily. Part of plant maintenance involves taking down the cladding, removing the insulation so a "general visual inspection" (GVI) can take place, and then insulating the pipes again with insulation material and cladding. This is a time and cost consuming but necessary process and time and again serious corrosion is discovered in the nick of time. Collecting scent on filters by sampling the air underneath the insulation without having to remove it, and establishing the odour of corrosion on these filters, could help identify corroded areas and guide plant maintenance planning.

A main challenge in RST systems is to train the dogs in such a manner that they easily transfer from filters made for training purposes to those collected in an operational setting. For example, in training cancer detection dogs, training is done first on diagnosed cancer patients as positive stimuli, and healthy controls as negative stimuli. Collecting scent from cancer patients at a clinic and controls at another location may be logistically efficient, but it provides a systematic cue ("clinic odour") the dogs may learn to respond to. Secondly, diagnosed cancer patients have undergone different medical tests that may make them different in more ways from controls than just the cancer, providing another cue the dogs may learn to respond to. The final testing should be done on samples collected from patients and controls at one location and prior to diagnosis, a level that has not really been achieved yet (Moser and McCulloch, 2010). Training dogs to detect explosives in air freight is even more complicated. It is impossible to mimic operational freight since it would entail placing an explosive in freight when it is being packed at a sender location, transporting it to the airport, and sampling it there. Different solutions are sought for this problem: collecting samples from air freight and adding the odour of explosives to them; or introducing explosives temporarily to air freight, sampling and removing the explosives again. Each of these solutions provides cues the dogs may learn to respond to and controls have to be managed carefully to prevent this – and although the dogs are tested, this is not done in a truly realistic manner (EU regulation 573/2010).

Bearing this in mind, this study focused on creating training samples that were as realistic as possible, on devising a method to introduce operational samples and on establishing transfer of stimulus control. Sampling was standardised by using a sampler specially developed to be used in the field that would ensure a constant and predictable airflow both in the laboratory and in the field. Chemical analysis was sought to elucidate systematic differences between "positive" and "negative" stimuli, which would also allow clarification of systematic false alarms. Finally, the study compared the detection rate of a single dog with that of a group of dogs in an effort to optimize the detection process.

2. Material and methods

2.1. Dogs

Five dogs were used in training: 4 Malinois Shepherds (born in 2008) and 1 Springer Spaniel (born in 2007), all females. The dogs were housed in kennels at Fjellanger Hundeskole in Bergen, Norway. Besides the training for this study, the dogs were trained in a variety of obedience exercises and some agility exercises, and used for teaching pupils basic dog handling skills. They were fed daily and exercised regularly. In general the standard was higher than the prescribed Norwegian animal welfare law. The dogs began the first stages of their training in the fall of 2009 and the final sessions conducted as part of this study were conducted in December 2012. They were trained 2–4 times per week depending on the stage of training and availability of resources. Training sessions varied in length from 10 to 20 min. The progression of the training is described in the results section.

2.2. Training filters

Filters used in training were made using mineral wool insulation material collected from heavily corroded pipes as positive stimuli, and from insulation material collected from pipes that were not corroded as negative stimuli. The difference between the two types was easily seen as the mineral wool collected from heavily corroded pipes was stained with a typical orange–brown colour, and sometimes contained flakes of corroded metal, whereas mineral wool used as controls was not discoloured. Both types of material were collected at two plants in Mongstad and in Kårstø, Norway. Within a training session material from a single plant was used.

The batches of insulation material were coded for the pipe location it came from, and divided into two to six 1 L glass jars depending on the amount available. These jars, nicknamed "mother jars", were used to prepare the training filters. They were closed with a plastic lid that had two needles to allow access for the sampling equipment.

The filters were made from white polyethylene/polypropylene (PP/PE) fibres and cylindrical in shape (25 mm diameter, 40 mm long), purchased from Pentok Ltd., UK. These filters were loaded either by allowing them to "soak" up the volatiles by placing them in a mother jar for a designated period of time and then put into filter cartridges, or used to "sample" the air from the mother jar while already in their cartridge, using specially designed sampling equipment. The cartridges were then sealed until training, usually on the same day.