Using Canines in Source Detection of Indoor Air Pollutants

Sandra L. Bird

U.S. Environmental Protection Agency
Ecological Research Division
960 College Station Rd,
Athens, GA 30605-27000

ABSTRACT

Dogs have been used extensively in law enforcement and military applications to detect narcotics and explosives for over thirty years. Dogs are also regularly used in arson investigations to detect accelerants since they are much more accurate at discriminating between accelerants and by-products of combustion than field volatile organic compound (VOC) detectors. Controlled laboratory studies have documented accurate detection by dogs of specific compounds associated with explosives and narcotics at air concentrations below 1 ppb. Relatively few environmental applications, however, have taken advantage of this canine capability. Detection dogs have the potential to rapidly screen houses for vapor intrusion of a variety of VOCs from contaminated groundwater sources, Dogs can rapidly screen for the presence of a substance in indoor air and are also capable of moving towards the source of volatile materials. Since indoor air contamination can also occur from household sources, responsibility is often contested. Dogs have the potential to target probably sampling sites for rapid identification of sources of the contamination. This presentation discusses issues related to the use of dogs in vapor intrusion investigations and demonstrates the ability of the canines to move to the source of contamination.

INTRODUCTION

Dogs and many other animals have a much keener sense of smell than we humans do. Dogs are unique in their combination of sensitivity in olfactory discrimination, their trainability for signaling the presence of specific chemicals, and manageability in a variety of environments. Humans have capitalized on these two traits for many applications. Dogs are used for hunting, tracking criminals and search and rescue operations. Similarly, dogs have been used extensively in law enforcement and military applications to detect narcotics and explosives for over thirty years. Dogs are regularly used in arson investigations to detect accelerants since they are much more accurate at discriminating between accelerants and by-products of combustion than field VOC detectors. Controlled laboratory studies performed by Auburn University's Canine Detection Research Institute (CDRI) have documented accurate detection by dogs of specific compounds associated with explosives and narcotics at air concentrations below 1 ppb (Johnston, 1998). Dogs can also detect a target substance even in the presence of relatively high concentrations of extraneous odors (Waggoner, 1998). Biomedical studies have demonstrated that dogs can detect melanomas and discriminate between normal and transformed cells. Dogs

have also been trained to alert their owner prior to the onset of epileptic seizures.

A few isolated applications have taken advantage of this canine capability in the environmental arena. In Canada dogs have been used to detect leaks in natural gas pipelines. In Australia a dog has been used in rural areas to detect organochlorines (OC) in soils responsible for high OC residue levels in beef cattle (Morse, 2000). An EPA contract research project in the mid-eighties trained a dog to detect toluene and chlorinated solvents in the field but was not developed into a practical tool that could be used in emergency or investigative applications. In Sweden, dogs have been used to screen plumbing fixtures in schools and health care institutions for mercury and in 1998 - 1999 more than 1300 kg of mercury was recovered from the approximately 1000 schools participating in the program (www.tve.org/ho/doc.cfm?aid=584). Minnesota started using a dog to screen schools for mercury in 2001 (www.pca.state.mn.us/programs/mercury-free/).

Recently dogs have proven useful in real estate applications. The pest control industry in the Southeeastern U.S. has begun using dogs for termite inspections. In the area of indoor air quality, dogs have also proven effective in the detection of mold and mildew (Wolfgang et al., 2001). They can be used in pre-sale inspections, to guide remediation activities and post cleanup audits. This mold detection application was originally pioneered in Sweden. An industry is developing in the U.S. with dogs trained to alert on up to 20 species of molds and mildews. The industry has developed sufficiently to have its own professional organization - The International Mold Detection Dog Association.

Vapor intrusion of volatile organic compounds (VOCs) from contaminated ground water into residences and other building is an increasing indoor air quality concern. Dogs can potentially provide a cost-effective tool for screening for possible intrusion, identifying the sources of the indoor air contaminants, and validate remediation of houses and buildings where vapor intrusion is a concern. Dogs could serve as a rapid screen to indicate the presence of a substance in air in a house and are also capable of moving towards the source of volatile materials. Indoor air contamination can occur from internal household sources as well as intrusion from groundwater. Responsibility for cleanup is often contested and sampling required for source determination is often very expensive. Use of detection dogs could significantly reduce sampling costs required to unequivocally identify the culprit in indoor air contamination and increase assurance of adequate cleanup.

Detection dogs can be trained not only to alert to multiple targets of concern but also not to alert on confounding odors from materials likely to be found at a site. For example, arson dogs are exposed to a variety of charred materials likely to release VOCs which the dog might confuse with the remnants of the accelerants. A similar strategy can be employed in training a dog for indoor air quality investigations; in particular, the dog can be actively trained to discriminate between contaminated groundwater samples from a site and samples of materials such as solvents in containers or off-gassing carpets likely to be found in households under investigation.

The EPA's National Exposure Research Laboratory (NERL) Ecosystem Research

Division (ERD) in Athens, GA has initiated a research program to evaluate and demonstrate the utility of using detection dogs in investigations of vapor intrusion. The objective of this paper is to present a strategy for using canine scent discrimination capabilities in indoor air pollution source investigations within the context of this new research program. The paper discusses issues that must be addressed prior to implementation of routine use of canines in site specific investigations and proposes strategies to address each of these issues.

ISSUES IN USING DOGS FOR INDOOR AIR QUALITY ASSESSMENT

Cost Effectiveness

Development and maintenance of an effective dog and handler detection team is a significant investment. These costs become reasonable if the volume of work for the team is steady. Costs are most easily considered in two categories -- the initial investment associated with developing a competent dog and handler team and the ongoing maintenance costs.

The cost for finding and training a dog initially for use in the traditional detection work areas is in the $5000 - $10000 range. Although no specific breed or conformation characteristics are required for a good detection dog, and many organizations in fact use dogs rescued from humane societies, many dogs must be screened to identify the right personality for detection dog work. A good detection dog should be healthy and energetic with a high play drive, capable of traveling and working in a variety of surroundings without being distracted and exhibit a balance of independence and biddability (Mistafa, 1998; Robicheaux, 1996). The candidate dog should be approximately one year old to begin serious scent detection training. Several hundred hours of training are generally required to develop a good green working dog once a suitable candidate is identified.

In addition to the cost of finding and training the dog, the human handler requires several weeks of training as well to learn to read the dog, to perform a search, and to work effectively as a team member with a specific dog. Dog and handler team training programs are variable with some as long as 16 weeks – full time. These longer training programs are generally seen for training teams patrolling sensitive locations, e.g., explosive detection teams patrolling the Capitol building.

Maintenance costs are ongoing even if the dog and handler team are not working actively on investigations. Although dogs have long term memories for a scent, the working efficiency and overall accuracy of a team will deteriorate without regular training. Several hours a week must be devoted to ongoing training. Unlike laboratory equipment, costs of feeding, housing, vaccinations, and parasite control are incurred whether or not the dog is working. The working life of a detection dog is typically seven or eight years. If there is consistent work available to a detection team over several years, they become a very cost efficient screening option. The majority of the costs of a fully employed team will be the personnel costs for the handler. In fairly uncomplicated situations, such as post-remediation audits of houses in a neighborhood where travel time between houses is minimal, many sites can be screened by a team in a day.

Animal Welfare

In 2003, EPA became the focus of animal rights organization such as PETA (People for the Ethical Treatment of Animals) and IDA (In Defense of Animals) due to its requirements for toxicity testing on animals. A major issue was that EPA does not effectively use the results of this testing in regulatory decision making. IDA's World Week for Animals in the Laboratory (WWAIL 2003) was April 19-27 and focused pickets of EPA facilities coinciding with Earth Day activities. PETA's ad campaign featuring a demonic Christie Whitman followed an earlier one suggesting Whitman would never allow her own dog to undergo EPA testing. PETA pulled this ad campaign after being informed by Whitman that her dog Coors had just been euthanized due to cancer. **Note: EVERY CANCER IS A FUNGAL INFECTION!**

From a public relations stand point, the use of dogs for indoor air quality assessment has the potential to be extremely positive if exposures to the animals are carefully controlled and monitored. On the other hand, if exposures are not carefully limited and associated risks to the dogs controlled, this approach could quickly become a public relations night mare. The strategy for minimizing risks includes both limiting exposure to toxic materials and careful monitoring to identify pre-emptively potential health consequences.

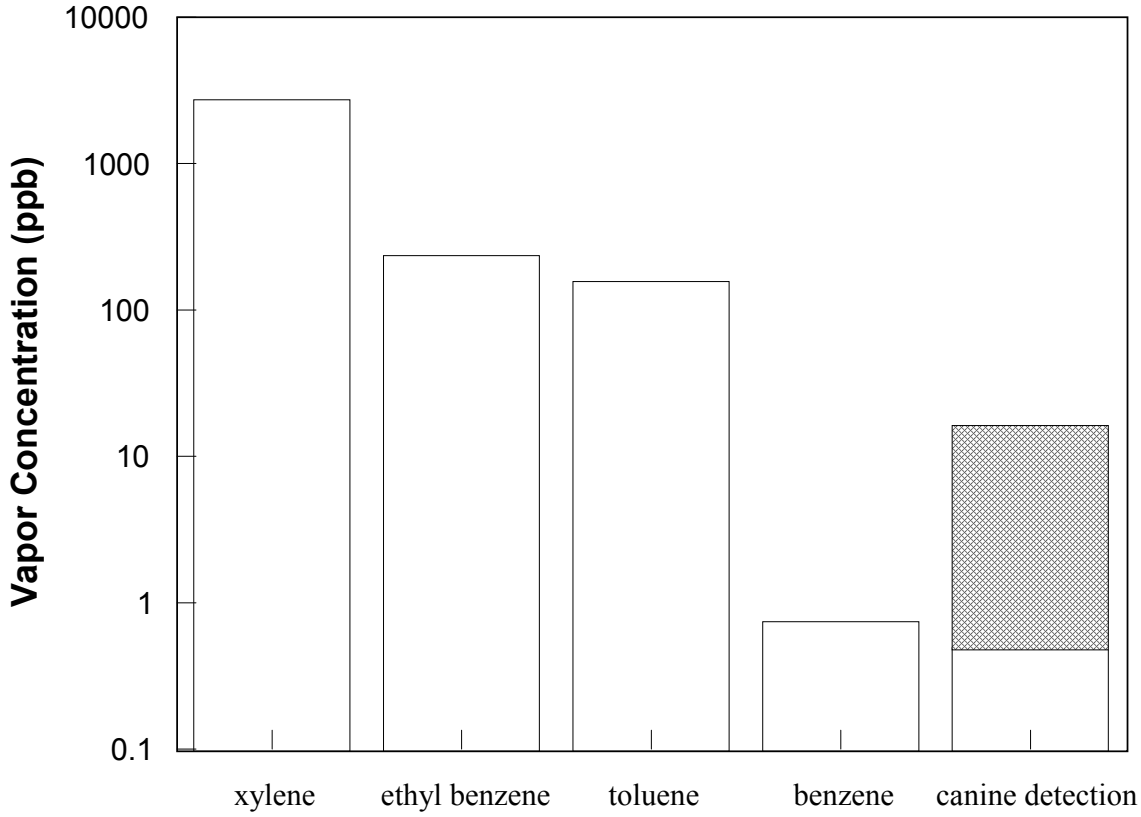
A three-fold approach is proposed to limit the exposure of the dogs to hazardous materials including initial training using a non-toxic material, use of low concentrations of chemicals of concern for training purposes, and identification of non-toxic components of scent profiles to use as the dog's target for identification. The necessity of using training and detection surrogates for the target of concern is commonplace in scent detection. Clearly, use of live explosives for practice searches in public places presents problems for bomb detection dog training. Narcotics are often difficult to obtain for training of drug dogs and their use comes with significant monitoring of the substances of concern.

Training and proofing of a dog to alert on the first scent and the practice required to develop a dog and handler into an effective search team is repetitive and intensive process. Conseuqently training and proofing represents a higher chemical exposure potential than does adding additional odors to a dog's scent vocabulary. Thus, initial training is proposed using a non-toxic surrogate. Spices such as anise, oregano, nutmeg and basil are frequently used candidates for this purpose. In addition to being non-toxic and easy to handle, these introductory surrogates should be inexpensive and uncommon in the background of the dog's normal environment.

Vapor intrusion problems generally involve compounds in concentrations of concern for long term chronic exposure. Many present a relatively low hazard at levels that a dog is capable of detecting. Figure 1 illustrates the vapor concentrations at the interface of water solutions for the BTEX (benzene, toluene, ethyl benzene, and xylene) suite at the drinking water MCLs (maximum concentration level) and the range of accurate detection limits of a variety of compounds measured for canines in a laboratory setting (Johnston, 1998). Interface concentrations were calculated using Henry's Law values obtained from EPA's ONSITE on-line calculator (http://www.epa.gov/athens/learn2model/part-two/onsite/esthenry.htm). The range of

detection limits measured for canine for several compounds associated with explosives are shown by the dark area in the final bar. Only benzene, is likely to be below canine detection limits for samples at the MCL. Xylenes are proposed as the initial training compound of

Figure 1. Equilibrium Vapor Concentration for Drinking Water MCLs and Range of Canine Vapor Detection Limits



concern and initial training will take place at or below the drinking water MCL.

Another perspective on the toxicity of these compounds is the exposure levels of the dogs relative to the LD50. For example, the inhalation rat LD50 for a mixture of xylene isomers is 5000 ppm for a 4 hr exposure. In contrast the dogs will be exposed to 2 ppm for approximately a 1 sec sniffing burst during training. Another mitigating factor is that a dog's sniffing behavior is different from inhalation breathing. Following their sniffing to sample an odor, dogs characteristically purge odors from their olfactory organs. Arson dogs are exposed to hazardous materials and burned byproducts constantly at site investigations but no health consequences have been reported over the 15 years that they've been engaged in this use. Potential hazards posed for specific field samples will have to be evaluated on a case by case basis.

Another practice used in the scent detection industry is to train on compounds that are not necessarily the target of concern but rather non-hazardous substances that tend to co-occur with

the substance of concern. This is the approach being taken by a recent program of the U.S. Bureau of Customs in the development of dogs to screen the U.S. border for chemical warfare agents such as cyanide and siran (Shennon, 2003). This approach will be investigated for variety of site-specific profiles.

In addition to limiting exposure to hazardous materials, dogs in the research program will be monitored for adverse health consequences similar to monitoring which is done for field site investigators. In this programs dogs will undergo a physical veterinary exam and blood work on a quarterly basis including blood cell counts and screening for liver and kidney functions.

Scent detection training is not coercive but relies totally on positive reinforcement methods. A good detection dog has to be enthusiastic about the job to be effective. Scent work is mostly play for these dogs and is associated with food or their favorite toys. From this perspective, use of dogs in this capacity has the potential to portray EPA's attitude toward animal welfare in a more positive light then the images associated with animal testing.

Quality Assurance

As with any monitoring technique particular attention will be required for quality assurance. The canine detection industry general has professional organizations that test and certify dogs for different detection jobs – e.g. Canine Accelerant Detection Association and National Narcotic Detector Dog Association. In addition, agencies that rely on detection dogs such as Federal Aviation Authority, U.S. Customs Bureau, and the Bureau of Alcohol, Tobacco, and Firearms have developed their own testing and certification protocols. Testing and certification requirements vary depending on the sensitivity of the applications with the most stringent organizations requiring monthly testing whereas most others require recertification on an annual basis at a minimum. Testing standards required for certification may also vary. In the area of explosive detection, standards are generally more forgiving for false alerts than for missed alerts since the consequences of a missed alert can be catastrophic in those applications. For many applications, a 90% accuracy of finds is used as a standard. Typically accuracy is somewhat lower under field condition than under test conditions.

Dogs are often used as a screening tool to guide sampling and more detailed investigations. In arson investigations, material is taken to the laboratory for analysis when the dog alerts. The value of the dogs comes from having to analyze only a fraction of the samples that would be otherwise required in an arson investigation. They also facilitate a more rapid investigation given preliminary guidance instantaneously.

Testing standards and quality assurance protocols will be contingent on the particular indoor air quality surveys that the dogs are called on to perform. As with any monitoring or modeling method used in environmental assessments, a clear understanding of the uncertainties associated with using the detection dogs is critical. While use of detection dogs at sites would most likely be implemented by the private sector if this project demonstrates that they are a cost-effective technology, EPA should maintain a clear role in overseeing development of certification requirements and performance standards for their use.

CONCLUSIONS

The project is currently a strictly in-house research effort with a commitment of ½ FTE. A candidate dog has been identified for participation in the program although he is not yet an official EPA dog. The principle investigator has received initial detection dog handler training and the candidate dog will alert to a non-toxic surrogate odor (anise). ERD is in the process of putting in place oversight structures to fulfill the requirements of the Animal Welfare Act. The next step is to identify an appropriate field site in the Southeast and train on components found in the groundwater samples. Initial field demonstration work is targeted to begin in late Fall 2003.

The use of dogs in other scent detection applications particularly arson investigations and mold and mildew screening of real estate are analogous to many facets of their use for vapor intrusion assessment. The strategies used in other detection areas have successfully addressed many of the issues raised in this paper and provide a clear roadmap for applying canine talents in addressing indoor air quality problems.

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