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EPA Project Summary

Delineating Toxic Areas by Canine Olfaction

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A research project was undertaken to learn how the highly acute olfactory sensitivity of the canine could be applied with advantage to environmental problems. The objectives were to determine how dogs could be trained to detect hazardous and toxic pollutants in the environment and how the dogs' responses could be used by environmental workers to improve sampling efficiency and to help delineate contaminated sites that might be encountered in spills and improper disposal incidents.

Three dogs were trained to recognize and locate chemicals selected from the toxic and hazardous chemical lists. One of these dogs was trained to respond upon detection of chemical scents at extremely low airborne concentrations such as those that might exist at the outer perimeter of a disposal site. Throughout the project, the safety and health of both dog and handler were carefully considered.

Over a relatively short period, two dogs were successfully trained to recognize toluene, and 2,4,5- and 2,4,6-trichlorophenol at levels that could not be detected as quickly or efficiently using conventional field instrumentation. These dogs were trained to seek out and retrieve chemically contaminated articles or to dig at the site of a simulated ground contamination. In a field experiment, both dogs successfully demonstrated their ability by locating as little as 0.2 g of chemical from distances as great as 50 ft.

A third dog was acclimated to another chemical, 1,2,3-trichloropropane, to prepare for a field test at a nearby Superfund site contaminated with this material. This dog was trained to sit immediately when he detected the specified odor. This technique allows a dog to delineate the perimeter of a contaminated area without entering the dangerous zone defined by conventional instrumentation. A field experiment at the Superfund site was carried out under extremely adverse weather conditions; it provided encouraging but inconclusive results.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Containment and cleanup of hazardous materials at disposal and spill sites re-

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quire some determination of the presence and extent of the pollutant beyond ground zero. Such a project often calls for extensive air, water, and soil sampling followed by costly and time-consuming analyses. Such data are needed to delineate the cleanup area and to determine which areas require protective gear for workers and exclusion or evacuation of neighbors.

Even with the most sophisticated equipment and the most skilled personnel, characterization of such sites is often a tedious and costly process. In addition, the lack of information concerning a suspect site or the location of wastes within a particular site makes it necessary to take a large number of samples, often on a random basis, before the scope of the problem can be defined. Depending on the nature of the material under investigation, the analytical procedures may be so complex that the results are generated too slowly to be of much help in defining the site. Certainly the large number of contaminant-free samples required contributes to the slowness of this site characterization process. For example, dioxin testing in one Missouri program required more than 10,000 samples. Of these, approximately 8000 were found to be negative. Unfortunately, with the current state-of-the-art in site evaluation, such testing has been unavoidable.

When a site is known to be heavily and widely contaminated (such as at a spill or well-documented disposal site) it is often necessary to know whether constituents are leaving the site as dust or vapors and if so, how far they are travelling and in which directions. Current procedures call for environmental workers to establish sampling stations (e.g., high-volume air monitors) at various distances and in various directions to evaluate the movement of the pollutants. The results of these tests can be affected by weather and again introduce an undesirable time lag between occurrence and availability of data.

Environmental researchers have made extensive passive use of animals in various forms of biomonitoring. Ranging from the well known LD_{50} test with fish, flies, etc. to the use of free-swimming and caged fish as an indicator of water quality, these tests have well-established credibility in the environmental research community.

Surprisingly, the sensitivity of such species have yet to be put to more active use in environmental programs. The dog, with his acute scenting ability, his high trainability, and his history of working closely with man, is uniquely suited for such an innovative approach. Canines have already demonstrated the desired scenting ability in many areas akin to environmental programs. Explosives and narcotics discovery and the tracking of people are fully recognized, daily uses of the dog. However, applying the dog's scenting prowess to environmental problems remains to be developed.

The current project applies to olfactory acuity of the dog to environmental areas where it offers time or cost benefits. Specifically, the project seeks to determine (1) whether trained dogs can assist environmental workers in locating specific chemical contaminants in the environment, thereby reducing the need for random sampling of suspect areas, and concurrently (2) whether the dog's response can help delineate the perimeter of known contaminated areas, thereby helping to distinguish areas where protective gear must be worn from those areas safe for nearby residents.

Search and Retrieval Program

Training

Two dog/handler teams with extensive backgrounds in scent work were selected for this phase of the program to save time and resources. Toluene was selected to represent a volatile hydrocarbon that might be found at industrial sites and gasoline storage tanks. The dogs were taught to recognize about 0.5 g of toluene, which was somewhat higher than the 0.1 g level planned for eventual use. The chemical was placed on a cotton ball in a wooden dowel or a perforated 35-mm film canister (see Figure 1). This method

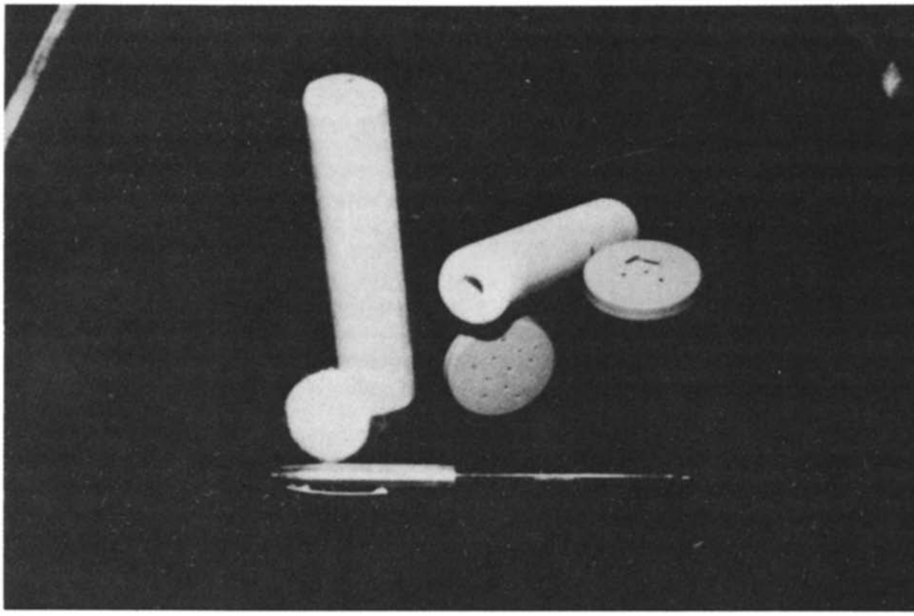

Figure 1. Articles used for training dogs.

gave the dogs something to retrieve, yet protected them from direct contact with the chemical. The dogs quickly learned to recognize the odor, and the quantity was reduced progressively but quickly to the target level of 0.1 g. The dogs were also trained simultaneously to locate airborne vapors of the chemical from greater and greater distances, both indoors and in the field, and even after the chemically-scented articles had been allowed to age for up to 24 hrs. (when the toluene would presumably have evaporated). The dogs exhibited no reluctance in finding and retrieving the articles, even from distances of as much as 50 ft. Presumably they accomplished these feats by detecting the movement of minor vapor components in the air reaching them. In addition to learning the target odor, the dogs also had to be taught to disregard other distracting odors such as those of the articles themselves and the handlers.

When the dogs had achieved the basic objective, a second chemical, 2,4,6-trichlorophenol, was introduced. This material was chosen as a potential indicator or simulator for the dioxin class of compounds. Later, 2,4,5-trichlorophenol, the isomer commonly associated with the most common dioxin isomer (2,3,7,8-TCDD) was obtained and also located successfully in a series of tests. These results suggested that the dogs either did not differentiate the two isomers, made an association between the two compounds, or understood that their task was to find the new chemical. Since both of these compounds are solids, they were applied to the cotton as a 10% solution in methanol and allowed to air dry before the dogs were asked to seek them. The dogs were also taught to ignore methanol.

The protocol used for the training is essentially that used in training dogs for narcotics or explosives detection. The dogs learn to recognize airborne vapors of the target material and follow them back along a concentration gradient (presumably) to the source. The protocol, called operant conditioning, relies on positive reinforcement with food and/or praise for all successes (even very minor ones) and negative reinforcement, through withholding of the reward and/or praise for incorrect decisions. Discipline is not normally part of this protocol.

Field Tests

Once the dogs were trained, a simulated field search was carried out at EPA's Edison, New Jersey area facilities. An outdoor test was conducted on a half acre area where various obstacles were placed in the field to simulate an actual site. To simulate an indoor search, an area inside a warehouse was equipped with 55-gal drums, wooden pallets, tires, concrete rubble, etc. About 3 hr before the test was to begin, both areas were planted with several dowels and film canisters containing 0.25 g toluene or 2,4,6-trichlorophenol, unscented articles, and several ground impregnations with both chemicals.

Results

The outdoor test used one dog, who almost immediately located a toluene-scented article hidden at the support jack of a trailer from about 50 ft away (see Figure 2). From this area, the dog/handler team moved quickly to a ground impregnation of toluene and then to a series of tires on the ground where the dog indicated one of the tires but did not retrieve an article. Her handler investigated and found a film canister (toluene) partially submerged in water in the tire. Finally, working in a small depression where several unscented articles were planted, the dog retrieved a blank dowel after much investigation. This article had been disturbed during a 3-hr delay period and covered with a rock to prevent visual detection. New odor may have been introduced at that time.

The indoor test differed primarily in that there was essentially no air movement in the large building. The second dog was used here, and he also uncovered several toluene-scented articles and a concrete block impregnated with a drop of 2,4,6-trichlorophenol before ending with a blank article that was only about 1 ft away from a scented one.

No trichlorophenol-scented articles

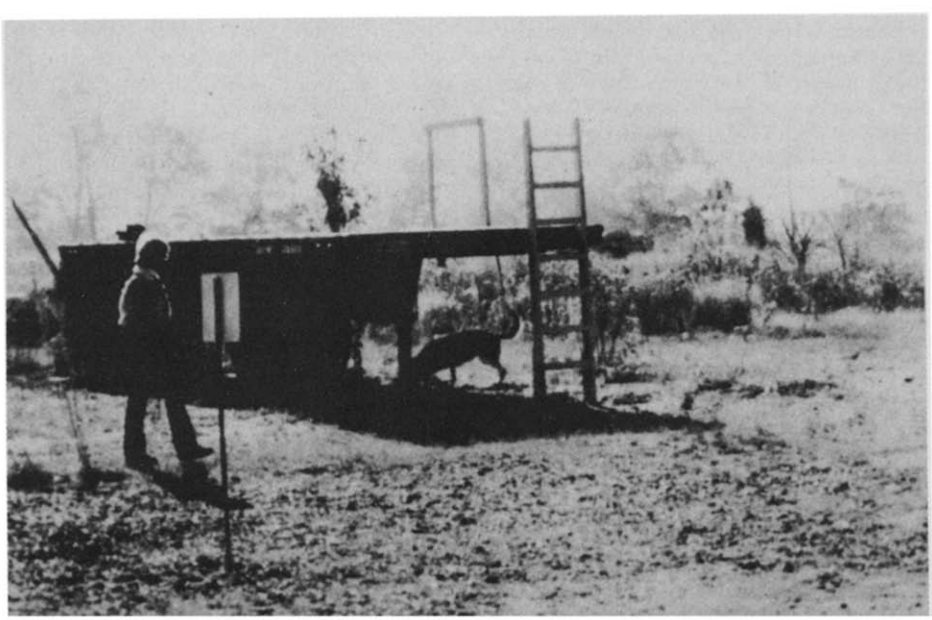

Figure 2. Dog locating toluene-scented article hidden at the support jack of a trailer.

were retrieved during the tests. Since this result was inconsistent with the training, the procedures were reexamined and it was found that all the 2,4,6-trichlorophenol articles had been prepared with only 0.05 g of the chemical, or 25% of the expected amount. Nevertheless, the results still raise some questions, since the dogs consistently retrieved aged 2,4,6-trichlorophenol articles that probably contained no more than this amount of the compound.

Attempts to measure airborne levels of toluene using a Foxboro Century 128 Organic Vapor Analyzer (gas chromatograph) were largely unsuccessful, both at the field test and in laboratory experiments. No instrument readings were obtained in the field or the laboratory unless the probe was adjacent to the sample or unless very large samples were used and a draft was induced with a fan.

Perimeter Delineation

The second goal of the project was to learn whether a dog could indicate the presence of chemical odors at a distance from a source while NOT moving forward to the source. Since the two dogs used in the earlier work had been trained to locate the source, another untrained dog was used for this work. To prepare for a field test at an actual Superfund site, this test used a chemical expected at that site—1,2,3-trichloropropane.

Training

The initial training of the dog followed the protocol described earlier. The dog was trained to recognize and distinguish the 1,2,3-trichloropropane odor with as little as 0.1 g. Because the chemical was expected to have a continuous source at the field site, the training did not incorporate an aging period beyond about 1 hr. Once the dog understood that he was to search for 1,2,3-trichloropropane, he was required to sit immediately on detecting the odor to receive his reward, which was food. Because the instinct to move to the source is so strong and so useful in reinforcing the training, and because the handler often needed some confirmation that the dog had really detected the chemical, the dog was occasionally allowed to move further into the scent cone. This step increased the dog's confidence and also helped the handler to understand or "read" the dog.

A larger, nonpoint source was then simulated by replacing the small samples of pure compound with 8 in. diameter pans containing a layer of dilute (25 ppm) aqueous solution of 1,2,3-trichloropropane. With practice, the dog could detect such scented "puddles" from as far as 25 ft and immediately alert his handler by sitting. The odor dissipated from such sources in 0.5 to 1 hr, and the dog could no longer locate the pans reliably.

Field Test

The field experiment took place on March 28, 1984, at the Tyson's Wastesite near King of Prussia, Pennsylvania. As a result of cleanup work, run-off was now channeled through an activated carbon treatment unit before it was discharged to the nearby Schuylkill River. The site consisted of a narrow (100- to 200-ft) strip of brush- and tree-covered lowland between the river and a railroad right-of-way. Beyond the railroad tracks, the land rose sharply to a ridge that was perhaps 200 ft high.

The weather on the test day was extremely poor, with heavy rain, strong gusty winds, and a temperature near 40°F. Though the team was concerned that the dog might be able to detect the target odor even far downwind under these conditions, access problems forced entry from that direction and about 0.25 to 0.5 mile from the treatment plant. Immediately upon initiating the test, the dog appeared to be tracking enthusiastically into the wind and toward the treatment plant. As the team moved forward on the track right-of-way at the edge of the undergrowth, which was too thick to follow the dog into, the dog's interest appeared to diminish, although he continued to lead the team forward. Some renewed interest occurred when the dog and handler came upon the treatment plant. After passing the plant, the dog changed direction for the first time and returned to the fencing surrounding the facility. The dog was then taken to the outfall pipe and several ground seeps in the area where the trichloropropane was expected to be present, based on an analyses made several months ago. The dog showed no interest or response until he was brought to one of the major seeps—a puddle about 3 ft across, where he finally did sit for the first time. His handler asked for and received a confirmatory sit before rewarding the dog. Additional searching of the area failed to elicit any further response from the dog.

An organic vapor analyzer had been brought along for this trial and was occasionally used to sample the air and the surface of puddles. Though readings of as much as 5 ppm of organic vapor (not necessarily 1,2,3-trichloropropane) were observed, these results did not coincide with the dog's reactions or with the team's own fleeting detection of gas-like odor. No positive readings were obtained at the outfall or at the seep where the dog had sat.

The results of this test are, at best, ambiguous. Perhaps the dog was always in the presence of the chemical, even as the test started, 0.25 mile or more from the source. If so, he may not have known how to respond to this new situation, he may not have been able to get the needed ON-OFF stimulus for a reaction, or he may simply have become desensitized by continued low-level exposure as the team moved forward. Other possibilities include (a) inadequate training of the dog to cope with very adverse weather conditions, (b) masking of the chemical odor by other air constituents, (c) inadequate airborne concentration because of high winds, or (d) disappearance of detectable levels of the chemical in the surface waters in the months since the site cleanup had been completed. Other than samples taken with the organic vapor analyzer, no air or water samples were taken on the test day to determine the presence or absence of the chemical.

Conclusions

This project demonstrates the feasibility of using trained dog/handler teams to locate small quantities (i.e., pockets) of pollutant sources or low-level discharges (airborne or waterborne) from toxic or hazardous sites. The work also indicates that such olfactory detection can assist environmental workers in the early characterization of such sites.

The dog can detect and locate very small quantities of chemicals from considerable distances, even where instruments are unable to detect residual vapors.

Once a dog has been trained in the general protocols of search and retrieval, he can be trained to locate a specific pollutant in the environment with relative ease and speed.

Because of the dog's ability to move about an area and find and follow scents carried by the wind at concentrations not detectable by instruments, the dog and his handler can be used to search large areas more quickly and more efficiently than a person with a portable instrument. Consequently, the dog can localize pockets of pollutants for more effective use of subsequent sampling and analytical procedures.

Considering the extremely low levels detectable by the trained dog (probably far below those usually defined as toxic or hazardous), the dog/handler team can carry out screening programs with minimal risk, even while free of cumbersome protective gear.

Indications are that under certain conditions, a dog can indicate the presence of toxic or hazardous material vapors emanating from a disposal site or an accident at quite a distance. By interpreting the dog's behavior and the weather conditions, the handler can quickly estimate the direction and distance such pollutants have traveled.

Recommendations

Though this project has established the preliminary feasibility of using dog/handler teams to locate pollutants in the environment and to define an outer, safe perimeter for contaminated areas, considerably more work is needed to make this knowledge a practical tool that environmental workers can use in emergency situations.

Clearly, a great deal more must be learned about the range of the dog's abilities in terms of acuity, uniformity (from dog to dog and day to day), sensitivity to different chemicals, and selectivity. A key question is whether the dog can recognize and associate classes of compounds (e.g., chlorinated hydrocarbons). Another great need is to determine whether the dog can be trained to react to levels other than his minimum detection level. In other words, there is a need to know whether the dog's olfactory ability can be made more quantitative, as suggested by some of the results observed in this study.

A variety of field situations need to be considered as potential applications for the dog. In this way, the scope of the dog's abilities and applications can be better defined. Specific areas to consider include using dogs to test the decontamination of equipment and personnel at cleanup sites, and to locate pockets of specific pollutants at or near suspect sites. Detection of dioxins (or trichlorinated phenols) near manufacturing sites, polychlorinated biphenyls (PCBs) in the vicinity of damaged or leaking transformers, and gasoline leaking from underground storage tanks are three situations in which dogs could effect large savings in time and analytical costs.

Careful and extensive analytical support should be provided in parallel with future canine programs, both to provide information on the levels being tested and to provide workers with insight into the relative time and cost factors involved with the two approaches.

The use of the dog should also be considered in areas other than that of hazardous and toxic materials. For example, it should be feasible to use dogs to locate fugitive volatile organic carbon emissions from valves, fittings, pumps, etc. at manufacturing facilities. Similarly, dogs may be able to track the contamination of surface waters back to their sources and thus assist enforcement personnel in locating illegal discharges.

Though the dog is ideally suited for working with man on environmental problems, the concept of using other animals (whales, dolphins, seals, birds) should also be considered as innovative means of tracking contamination of the oceans or the atmosphere.

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The complete report, entitled "Delineating Toxic Areas by Canine Olfaction," (Order No. PB 85-235 596/AS; Cost: $8.50, subject to change) will be available only from:

National Technical Information Service
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