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TOXIC AREA DELINEATION BY CANINE OLFACTION

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16. ABSTRACT

The ability of animals to respond to pollutants in their environment is a well-known phenomenon. While this capability has been used to trace people and to find explosives and narcotics, there has been little effort to apply this "talent" to environmental problems. The idea of using dogs to detect or locate sources of pollution was conceived several years ago by one of the authors (H.S. Skovronek). While the use of animals will (probably) never replace sophisticated instrumentation, source monitoring by animals offers a rapid, economical means of screening suspect locations for specific pollutants. Recently, a program was initiated by the U.S. Environmental Protection Agency to explore the application of monitoring by animals to expedite sampling programs at hazardous spills or waste sites.

This paper describes a feasibility study in which a dog/handler team was used to locate low concentrations of a hazardous substance (i.e., trichlorophenol and toluene) hidden in a field, thus suggesting that a dog can be trained to locate such materials on industrial sites, abandoned landfills, etc. The use of a dog/handler team to uncover simulated hazardous wastes infiltrating into buildings such as might be encountered with groundwater leakage, seepage from storage tanks, etc. will also be described. Lastly, the use of dogs to assist workers at a hazardous site in delineating the contaminated area will be discussed.

To a limited extent, the use of state-of-the-art portable gas/vapor detection instruments at waste sites will be compared with the application of this new "instrument". The experience with and the inherent detection potential of canines will be reviewed and new directions explored.

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ABSTRACT

The ability of animals to respond to pollutants in their environment is a well-known phenomenon. While this capability has been used to trace people and to find explosives and narcotics, there has been little effort to apply this "talent" to environmental problems. The idea of using dogs to detect or locate sources of pollution was conceived several years ago by one of the authors (H.S. Skovronek). While the use of animals will (probably) never replace sophisticated instrumentation, source monitoring by animals offers a rapid, economical means of screening suspect locations for specific pollutants. Recently, a program was initiated by the U.S. Environmental Protection Agency to explore the application of monitoring by animals to expedite sampling programs at hazardous spills or waste sites.

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BACKGROUND

With the passage of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, also known as "Superfund"), the nation's attention has shifted strongly to the search for and the cleanup of hazardous waste sites. The location of such sites is, however, far from easy. Many sites evolved over the years as industrial and municipal authorities sought to dispose of their wastes in the safest and most cost-effective manner. Disposal in dumps, landfills, and "the back 40" were all common practices--with no realization that a legacy of toxic wastes was also being left behind to leach into groundwater, surface water, and air. And to such practices, unfortunately, must be added the intentional uncaring disposal of wastes, even those known to be toxic, in blatantly unsuitable sites.

The need for controlled disposal is now better understood, and there is a current appreciation of the risks that such past disposal practices may have created for us and for our progeny. A massive program is underway both by regulatory agencies and by industry to locate and to delineate such sites and, soon, to undertake corrective action where needed and economically achievable.

In addition to the problems created by the inappropriate disposal of wastes now known to be toxic or hazardous, society must also face the consequences of the releases or discharges into the environment that result from transportation and industrial accidents and disasters. A key factor in assessing the impact of such incidents is delineating the dispersal of the contamination quickly so that containment and cleanup operations can be started.

Sophisticated instrumentation continues to be developed to locate and identify pollutants in the environment. These instruments are capable of measuring lower and lower concentrations and of producing reliable results much more rapidly than in past years. The cost, complexity, and very sensitivity of modern instruments often makes them less than ideal for rapid deployment and for use in preliminary field measurements of a "screening" nature. To some extent, industrial health-monitoring instrumentation can fill the gap and provide quick field measurements, although often not at the very low concentrations now demanded to protect field workers and neighboring residents at hazardous waste release and spill sites. The search for techniques and methods to assist field workers in delineating contaminated areas continues.

Another approach has been available for many years--and, indeed, widely used in the environmental area--albeit from a different viewpoint: the responses of animals to pollutants. Much of the biological testing used to evaluate the hazard of wastes and specific compounds depends on the effects on living organisms. All are familiar with LC-50 and LD-50 tests in which the lethality of materials to mice, rats, or other animals is determined. Bacterial and enzyme-inhibitor work has also been undertaken. Another key factor in animal tests is the behavior of the species at lower, non-lethal doses. Over the years, the activity of fish, either in aquaria or in tethered cages in a river, has been extensively used as a measure of water quality. Specific activities such as swimming, coughing, gill movement, etc., have all been monitored. Indeed, there are typical biomonitoring requirements in many National Pollutant Discharge Elimination System (NPDES) permits.

The approaches described above may be considered as "passive" monitoring; the investigator merely observes the behavior of a species in a contaminated environment and compares that behavior to that which would be expected in the creature's normal, uncontaminated environment. The utility of this approach is well-documented. The opportunity now exists to move forward by applying more sophisticated "active" monitoring using higher creatures, specifically, the dog.

Everyone is familiar with the use of the dog in locating explosives, narcotics, lost children, criminals, etc. No instrumental method has approached the olfactory (i.e., sniffing) ability of the canine in these pursuits. For several years, it has been our opinion that a dog could be trained to track and locate specific pollutants or classes of pollutants in a similar manner. Some very encouraging results have been reported by researchers working at the dog training industry interface. For example, using procedures evolved from formalized man-tracking techniques, Glen Johnson used dogs to successfully traverse a 94-mile natural gas pipeline and to uncover 150 leaks, many of which went undetected when sophisticated instrumentation was brought in. Leaks were detected in sections buried 18-ft deep, as well as in 12-ft elevated segments.[1]

In another experiment, dogs were trained to find and to differentiate between nitrogen, helium and Freon 12 with 100% reliability.[2] In a

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[1]Johnson, Glen R. Tracking Dog Theory and Methods. Arner Publications, Inc., Westmoreland, NY, 1977. pp. 15-21.

[2]Johnson, Glen R. Odorless Gas Detection by Domestic Canines. Off-lead 6: 18-19, 1977.

little-known study, Johnson also used dogs to locate leaks of electrical fluid "below 10 in. of concrete covered by 8 in. of asphalt" in New York City's streets.[3]

The little understood olfactory ability of the dog,[4] coupled with its ability to work with man, can be harnessed, by qualified trainers and handlers, and used in the location of hazardous wastes. The overall goal of this program is to demonstrate that dogs, properly trained and properly handled, can be used to assist field respose personnel in several ways. Specifically, the canine's extreme olfactory sensitivity can aid in screening areas, both within and outside of structures, where specific pollutants may be present. For example, the dog's responses may show that a building contains a source of BTX (benzene, toluene, xylenes), such as may leak from storage tanks or arise from the seepage of contaminated groundwater. The trained dog can potentially delineate the perimeter of a site contaminated by hazardous wastes or the area contaminated by movement of spilled material, either in the water, soil, or air. This knowlege will assist field workers in determining where safety equipment must be worn and can also save costs by reducing the number of samples that must be collected and analyzed--often at considerable cost and delay--to define the extent of a contaminated site.

Hypothetically, a trained dog could (at this time), have gone into Times Beach, MO or the Ironbound section of Newark, NJ and quickly outlined the area contaminated with dioxin. Sampling teams would have then taken

[3]Johnson, Glen R. New York Experiment. Off-lead, 10: 10-13, 1981.
[4]McCartney, William. Olfaction and Odours. Springer-Verlag, New York, New York, 1968. pp. 15-70.

samples to confirm and quantify the level of contamination at the sites. This paper covers only the first, or feasibility, phase of a study in which the goal is to demonstrate that the use of dogs to locate pollutants and to define contaminated areas is viable and can be applied to hazardous waste situations.

TECHNICAL PROGRAM

Many aspects of the study cannot currently be approached from a rigid scientific approach since there is no full understanding of the phenomenon of the dog's olfactory ability. Other compromises are also necessary in the interest of speed and economy. To compare canine detection with conventional field methods, demonstrations will be conducted in parallel with rapid on-site methods of chemical analysis that use some of the most sophisticated portable equipment available today.

The goal of this feasibility study is to train dogs to discriminate, above background levels certain hazardous substances. Sensitized specifically to toluene and 2,4,6-trichlorophenol (TCP), a more volatile and a less volatile species, the dog will either move toward the source, presumably along a line of increasing concentration, or will alert his handler that he is at or close to the source. In many ways, this training parallels the work on detection of narcotics or explosives.

In the case of TCP, the dog will be trained NOT to move to the source of an odor but, instead, to stop and alert his handler so that the dog need not approach or enter an area of high pollutant concentration. TCP was selected as an indicator for dioxin since it is usually present in the synthetic scheme that yields dioxin, but does not present the extreme hazards associated with dioxin.

The dog will be trained, or conditioned to move in an indicated direction (toward a suspected source) ONLY until he first detects the specific material (TCP). He will then stop, indicate his observation to the handler, and withdraw. This process should be repeated from several different directions until the perimeter of the contaminated area has been delineated. In a more sophisticated adaptation, the dog will be taught to move along the perimeter of the contaminated area at the distance where he is only able to receive the first olfactory indication of the compound. In this way, the handler or an accompanying observer can actually map the Canine Detection Limit (CDL) perimeter of the source. Once it is established whether the CDL is higher or lower than the detection limit achievable by field instrumentation, samples will be taken or monitors installed at or near this perimeter to protect workers and neighboring residents.

EXPERIMENTAL PROCEDURES

The training of the dogs and the familiarization of the handlers with the dogs' responses is essentially a developmental process. Technically, the dog is sensitized or trained to recognize a specific material or a class of materials using what is called an inductive or positive reinforcement mode in which the dog's natural tendencies are emphasized and allowed to "reinforce" the desired response.

The dog is sensitized by exposure to different materials that have been impregnated with or contain small amounts of toluene or TCP. This technique is used to help the dog "target" on a specific material or chemical while teaching him to ignore all other odors. The dog is then conditioned to select, for example, the toluene-impregnated items from among several different blanks. The amount of chemical used to impregnate the targets can be reduced, but no attempt is made at this stage to achieve the CDL. Once the dog is consistently selecting impregnated targets in a confined area, the dog's prior training in field tracking is brought to bear. (The dogs used for this program all have previously demonstrated a high proficiency in following human tracks through brush, woods, fields, etc.) The dog's purpose for search is now transferred from a person to the chemical and the dog is directed to seek out a planted target. Each time the dog successfully finds the planted target, he is vigorously rewarded.

The training next takes two slightly different directions in order to address interior and exterior searches. Working outside and subject to the weather makes it very difficult to estimate the actual concentration (ppm) that is sufficient to catch the dog's attention. Several experiments will be carried out with the dog approaching fresh sample targets from different wind directions until he indicates discovery and moves toward the source. Measurements using conventional techniques will be made along these same vectors in order to estimate the level at which the dog first responds confidently.

When the dog is consistently able to detect surface samples, samples will be buried to depths of 2 ft. Similar holes will also be dug but refilled to overcome the dog's ability to detect or recognize freshly dug earth. With buried samples, there will be some time delay in the appearance of "peak" sensitivity, which factor results from the gradual diffusion or permeation of the vapor from its initial depth to the surface.

When the dog consistently recovers buried samples from the maximum depth, a demonstration will be arranged for EPA observers. The demonstration will consist of several small targets both located on the surface and buried by EPA personnel at varous depths from zero to 2 ft. In addition, there will be one or more "blank" holes. The dog will be brought to the site approximately 24 hr after emplacement of the samples. The handler will be given only a general direction and a distance limit (ca. 200 ft) within which to search. By allowing the dog to cast about and sniff freely, the dog/handler team will attempt to locate all of the samples without identifying any false targets. Ideally, the test will be carried out early in the day when scent detection seems to be easiest.

The area will immediately be monitored after the dog has completed his test to determine whether conventional instrumentation could have uncovered the samples and to assess the time and effort that such monitoring would require.

Throughout the study and particularly for the demonstrations, records will be maintained of local temperature, relative humidity, approximate wind speed, wind direction, and ground temperature.

At the same time that the field training is proceeding, the interior search program--using toluene as an indicator for BTX, gasoline, etc.--will also be underway. Once the dog has been trained to select the designated chemical and move toward its source, samples will be hidden in buildings and the dog encouraged to find them. As the dog becomes more proficient, the size of the target (i.e., the quantity of toluene) will be reduced until the dog's ability to detect the material fails. By knowing the dimensions of a room in which the sample is placed and adjusting the sample size, an ambient concentration can be approximated--assuming (1) no air exchange and (2) uniform diffusion of the chemical.

When reliability has been established for interior searching, a formal demonstration will also be carried out by having EPA personnel hide various toluene-containing samples in several test rooms of a building. The dog will be brought to each room to (1) determine whether toluene is present by barking or by performing some other means of communication with his handler and (2) finding the source, which may be an open bottle or a spot on the floor that had been impregnated with a small amount of toluene to simulate seepage, as may occur from contaminated groundwater.

The third phase of the study, called the perimeter search, is expected to be the most difficult since it requires the dog to inhibit his natural desire to move from less concentrated material to more concentrated. It will be necessary, instead, to teach the dog to stop as soon as he detects the specific target odor. The handler will have to learn to "read" the rather limited signal that the dog will be giving at first detection. The dog will then withdraw and approach the site repeatedly from different directions until a full perimeter has been delineated, all at the CDL. This methodology was selected for three reasons: (1) if successful, it will allow a contaminated area to be delineated rapidly so that the public can be excluded and field workers can be alerted to the need for protective equipment, (2) it will minimize the number of monitoring stations or screening samples that must be taken to delineate the area quantitatively, and (3) it protects both dog and handler from all but the minimum exposure to the target material, which in practice could be highly toxic or hazardous materials.

A demonstration of the dog's perimeter-delineation ability will be carried out at a well-documented hazardous waste site where conventional instrumental delineation of the perimeter has been conducted. The dog/handler team will know only the general area of contamination and will develop a perimeter on its own. When necessary, the handler will be given the levels found at certain points to assist in planning the approach. Should the dog/handler team stray toward more contaminated areas, it will be warned off. Still and TV film coverage will be obtained to record the team's efforts. When the perimeter derived by the dog/handler team is more remote from the source than the results of the earlier instrumental analyses, additional analyses will be taken by EPA personnel to attempt to correlate the divergent results.

CONCLUSIONS

Carefully selected and trained dogs, together with competent handlers, are capable of following the "scent" of chemicals to their source, even when those chemicals are present at extremely low airborne concentrations, are non-volatile by conventional scientific standards, and are mixed with other chemicals, soils, etc.

The dog's ability to detect and "home in" on chemical scents appears to far exceed the capability of the most sensitive field monitoring equipment, in the areas of sensitivity, speed, and overall cost-effectiveness.

Innovative training coupled with the amazing sensitivity of the dog's olfactory senses allow contaminated areas to be delineated, at least qualitatively, more rapidly and more completely than can be done using existing instrumentation.

This preliminary or feasibility project demonstrates the utility of competently trained dog/handler teams as an adjunct to the Agency's current resources for locating and delineating hazardous wastes in the environment.

Additional work is needed to verify the utility of dog/handler teams for emergency response needs. Regionally located dog/handler teams should be trained and made available to the Agency on an as-needed, contractual basis for response to hazardous site release and spill emergency clean up situations.

There is reason to believe that the dog does quantitate the level of substance reaching his olfactory nerves. Because of changing conditions, it is extremely difficult to quantify the dog's sensing ability under field conditions. More carefully controlled experiments are needed and should be carried out in a regulated environment to determine whether the dog's sensory ability can be quantified so that results obtained using the dog can attain legal credibility.

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