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(DE95000049)

Road Transportable Analytical Laboratory (RTAL) System

Topical Report

December 1994

Work Performed Under Contract No.: DE-AC21-92MC29109

For

U.S. Department of Energy
Office of Environmental Management
Office of Technology Development
Washington, DC

U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
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Annapolis, Maryland

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ABSTRACT

The problem of groundwater contamination at a large number of industrial facilities is well known. Many U.S. Army and Department of Energy (DOE)facilities share this problem of potentially contaminated water as a result of past disposal practices associated with military and energy source development activities. A wide range of contaminants are found at certain installations encompassing industrial pollutants and military-unique materials.

The U.S. Army Biomedical Research and Development Laboratory (USABRDL) has been conducting research for a number of years on developing better means to determine the hazards associated with exposure to these types of complex mixtures. The methods involve the use of aquatic organisms together with <u>in vitro</u> mutagenicity assays and analytical chemistry in an integrated biological assessment of a specific site.

Integrated Biological Assessment is an important development in the Army's continuing efforts to locate, clean and monitor sites contaminated as a result of military operations. This method provides meaningful hazard data regarding whether a test medium contains low levels of industrial or military-unique contaminants. This is an important advance in determining which sites are clean and which require remediation. It also provides a direct measure of health and ecological hazard posed by contaminated waters to logically prioritize remediation efforts. And, finally, it provides continuing monitoring of the effectiveness of remediation operations and aids in answering the frequently asked question, "How clean is clean?"

Engineering Computer Optecnomics (ECO), Inc. was tasked, in a collaborative Army and DOE effort, to develop a transportable Integrated Biological Assessment Laboratory Complex. This multi-modular Complex is designed to be taken into remote areas to provide the necessary long-term on-site research for determining hazards from low levels of contamination in the environment.

Each module of the Complex is designed to be self-sufficient, to provide a safe environment for the operators, and a controlled environment for the test organisms and related critical chemical and biological analyses.

ADMINISTRATIVE INFORMATION

The development of the Integrated Biological Assessment Complex was conducted as part of the development of the Road Transportable Analytical Laboratory (RTAL) System by Engineering Computer Optecnomics (ECO), Inc. for the Morgantown Energy Technology Center (METC) of the U.S. Department of Energy under Contract No. DE-AC21-92MC29109. The METC Contracting Officer's Representative (COR) is Mr. Jagdish L. Malhotra. The METC Contracting Specialist is Mr. Ronald Roth. The ECO Principal Investigator is Dr. Stanley M. Finger, Vice-President and Director of Environmental Programs. The ECO Project Director is Mr. Virgil F. Keith, President.

INTRODUCTION

The U.S. Army operates a number of industrial-type facilities around the country conducting a wide range of development, testing, and field operations. Many of these operations involve the use of materials which have been determined to be hazardous and which, despite the Army's best efforts to perform operations in an environmentally acceptable manner, may have entered the environment around the bases. For example, the Army is engaged in extensive monitoring of the groundwater at its facilities to locate contaminated areas and to remediate these waters. The most significant problems in this endeavor have been the difficulties in the timely and cost-effective analysis of groundwaters.

The U.S. Department of Energy is facing many of the same problems of site characterization, particularly groundwater, as the Army. For this reason, the development of the Integrated Biological Assessment complex was undertaken as a collaboration between the two agencies.

There are two components of groundwater contamination assessment which are critical in assessing governmental sites. First, potential contaminants encompass not only standard industrial pollutants but also a rather wide range of military-unique materials and their breakdown products. Allowable concentrations of these military-unique contaminants in groundwater have been set at exceedingly low levels to ensure the safety of any receiving populations. However, standard analytical methods are often strained and are sometimes incapable of achieving the low detection levels required.

To address this problem, the U.S. Army Biomedical Research and Development Laboratory (USABRDL) has developed sensitive integrated methods for assessing the hazards from low levels of hazardous materials in groundwaters. These methods combine (a) exposure of aquatic organisms to the test waters under controlled conditions with (b) in vitro mutagenicity assays and (c) analytical chemistry.

Aquatic organisms are sensitive to aqueous contaminants and therefore are relatively rapid indicators of low level hazards. While these methods do not always identify the specific contaminant present, they are very effective in (a) detecting low levels of contamination, (b) corroborating the lack of any contamination, and (c) monitoring the effectiveness of remediation operations.

A second problem unique to the military is the remote location and large size of many of the facilities involved. In some cases, the potential for groundwater contamination exists in areas far from laboratories and other support services. While it could be done, there are several reasons why transporting large volumes of groundwater to central laboratories for testing is undesirable. First, significant amounts of volatile contaminants may be lost before the waters are tested. This would make the water appear cleaner than it is. At the same time, the water may pick up additional contaminants through contact with container materials during transportation and storage. This may make the water incorrectly appear to have high levels of contamination. Also, the expense and time involved in transporting large quantities of water from a remote location to a central laboratory may be prohibitive.

OBJECTIVE

To overcome the problems of groundwater contamination assessment discussed above, Engineering Computer Optecnomics (ECO), Inc. was tasked to develop a self-sufficient, transportable Integrated Biological Assessment Laboratory Complex for conducting integrated studies of organisms and related test under carefully controlled conditions on-site. This Complex eliminates the potential errors, expense and time associated with transporting groundwater to a central laboratory for evaluation.

INTEGRATED BIOLOGICAL ASSESSMENT

The concept of Integrated Biological Assessment involves the examination of environmental samples using a variety of bioassays coupled with the analytical determination of chemical contaminants present in the media from a given site. These bioassays include both well-accepted tests, such as the ecological assays for acute toxicity using the Fathead Minnow and Ceriodaphnia, as well as new assays developed to determine the presence of hazards to both ecological and human receptors from complex chemical contamination which may be present at a military site. Accepted techniques to determine the mutagenic potential of a test substance, e.g. the Ames test and the Chinese Hamster Ovary (CHO) chromosomal aberration assay, are accomplished on materials taken from the site. New assays being developed include a non-mammalian vertebrate cancer assessment model to evaluate chronic toxicity and the Frog Embryo Teratogenicity Assay Xenopus (FETAX) which assists in the determination of the presence of potential developmental toxins.

The use of the mobile, on-site laboratory complex enables research to be conducted on assays which can subsequently be incorporated into a site-specific suite of integrated bioassays and analytical chemistry techniques. Other new methods in the research phase of development include assays for the presence of immunotoxins, a near real-time acute toxicity monitor, and new analytical chemistry techniques to determine the potential for bioaccumulation of chemicals at a site. As these methods are transitioned from basic through applied research to a technique to be incorporated into an installation's remediation package, auditable quality assurance Standard Operating Procedures (SOP) are developed for the proper conduct of the tests when they are performed by the installation's contractors.

Research is also being pursued which will develop enhanced risk characterization approaches for the presentation of the results of the integrated assessment. The risk characterization will provide a useful tool for risk managers, demonstrating where risk may exist and providing insight into the uncertainty surrounding the determination of this risk. The use of these biological techniques coupled with better tools for exposure assessment should assist program managers in focusing resources on areas posing the greatest risk, provide useful tools for demonstrating remediation efficacy, and establish baselines for long-term monitoring of contaminated sites.

INTEGRATED BIOLOGICAL ASSESSMENT LABORATORY COMPLEX

The Integrated Biological Assessment Laboratory Complex is designed to provide a controlled environment for conducting, on-site, the studies of organisms and related chemical and biological tests described above. The Laboratory Complex currently consists of the following modules:

- Aquatic Biomonitoring Laboratory
- Chemical Analysis Laboratory
- Research Support Module

Each laboratory module is contained in a 48 foot long trailer with its own electrical generation system; heating, ventilation and air conditioning (HVAC) system; fuel tank; and wastewater holding tank. Each module rests on hydraulically operated levelling legs to provide a stable, horizontal platform on uneven terrain. Each module has two large double doors to facilitate the movement of equipment into or out of the system. A standard 3 foot wide doorway for personnel entry and exit is incorporated into one of the larger doors. Communications among the laboratory modules are maintained through (1) telephone connections directly between the modules, (2) cellular telephones in each module, and (3) a Local Area Network integrating all the computers in the Laboratory Complex. Each module is also equipped with a Citizens Band (CB) radio.

The Aquatic Biomonitoring Laboratory is divided into three work rooms. The entry doors lead into the Analytical/Operational Control Room. This space contains the analytical equipment necessary to support the experiments, computers to record all data, and operational controls for all laboratory systems.

A doorway from the Analytical/Operational Control Room leads to the Main Diluter Room. This room contains two banks of test animal tanks arranged along the walls. These banks are fed from two wall-hung diluters, one for each set of tanks. This room also contains the diluter used to feed the set of tanks in the Ventilatory Monitor Room.

The Ventilatory Monitor Room is entered through a doorway from the Main Diluter Room. In addition to another set of test tanks, this room also contains equipment to aerate, filter and control the temperature of the entering test waters. It also contains an autosampler connected to the test water feed lines.

Air is fed into the laboratory in the Analytical/Operational Control Room. It then flows through the Main Diluter Room and, finally, into the Ventilatory Monitor Room. The air from the Ventilatory Monitor Room is either discharged or it can be recycled through carbon filters to remove any volatile contaminants.

The laboratory has external connections to accept three water sources as feeds to the diluters. Two of these sources are normally test waters, e.g. groundwater before treatment and groundwater which has been treated to remove contamination. This allows for parallel experiments to determine the effectiveness of alternative remediation treatments. The third water source would normally be "clean" water used for diluting the test waters.

The Chemical Analysis Laboratory is divided into two work spaces. The entry doors lead into the Analytical Preparation Room, outfitted with a fume hood, sink, acid and solvent storage cabinets, and drying oven. Samples are prepared in this room for the instrumental analyses conducted in the Analytical Instrumentation Room. Instrumentation include Purge and Trap Gas Chromatograph/Mass Spectrometer, High Performance Liquid Chromatograph, and Inductively Coupled Plasma Spectrometer. These instruments are coupled directly to computers for test condition control and data storage. The Chemical Analysis Laboratory also has a separate room for storage of compressed gas cylinders. This room has a separate door to the outside and an overhead crane to facilitate resupply of the compressed gas cylinders.

The Research Support Module is divided into an office area with built-in desks, each with its own computer connections, a conference room, a toilet, and storage closets. All the computers in the Laboratory Complex are integrated into a Local Area Network. This allows the operators in the Research Support Module to maintain constant oversight and control over all the experiments and studies in the other laboratory modules at all times.

Each laboratory module in the Integrated Biological Assessment Laboratory Complex is designed to be self-sufficient. Each module contains integral electrical generation equipment to generate its own electricity or it can be run off available external power sources. The internal electrical generation systems in the Aquatic Biomonitoring Laboratory and the Administration Module each provide 25 kVA of power. The Chemical Analysis Laboratory, with its higher power consumption and cooling requirements (primarily due to the Inductively Coupled Plasma Spectrometer), provides 100 kVA of onboard power; 10 kVA is fed through an uninterruptible power supply to ensure the reliability of the sensitive analytical equipment.

Each laboratory module is equipped with a set of two parallel heat pumps to maintain interior temperature within tight tolerances, e.g. 70° ±2° F in the Aquatic Biomonitoring Research Laboratory, over a wide range of outside temperatures. The use of two heat pumps provides a number of special advantages. First, in moderate temperatures, only one heat pump is required. The use of a single smaller heat pump prevents frequent on-off cycling which shortens the life of the system and can contribute to vibration problems. In more extreme outside temperature conditions, both heat pumps operate in parallel, providing fine temperature control.

The mechanical equipment, e.g. electrical generators, in each module are mounted for maximum vibration isolation. The laboratory benches are also vibration isolated. Minimizing vibration was a special concern in the design and construction of the Aquatic Biomonitoring Laboratory. One of the test parameters measured in this laboratory is the activity of fish in specialized test chambers.

Each module is contained in standard trailers to facilitate transport to test sites. The use of a separate truck to move the modules results in higher system reliability and lower cost compared to the use of dedicated prime movers.

The Integrated Biological Assessment Complex was completed, delivered to USABRDL and demonstrated in July 1994.

CONCLUSION

Integrated Biological Assessment research in an on-site, self-sufficient, transportable laboratory complex is an important development in the Government's continuing efforts to develop better methods to locate, clean and monitor sites contaminated as a result of military operations. The Laboratory Complex will provide meaningful hazard data related to low levels of industrial or military-unique contaminants. This is an important advance in determining, for example, which water sources are clean and which require remediation. It also provides a direct measure of health and ecological hazard posed by contaminated environmental media to logically prioritize remediation efforts. And, finally, it provides continuing monitoring of the effectiveness of remediation operations and aids in answering the frequently asked question, "How clean is clean?"

DISCLAIMER

The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as official Department of the Army position, policy, or decision, unless so designated by other official documentation.

Research was conducted in compliance with the Animal Welfare Act, and other Federal statutes and regulations relating to animals and experiments involving animals and adheres to principles stated in the Guide for the Care and Use of Laboratory Animals, NIH Publication 86-23, 1985 edition.