SPILL TECHNOLOGY

NEWSLETTER

ISSN 0381-4459

VOLUME 19 (3)
July-Sept. 1994

OIL SPILL RESEARCH PROJECTS OF THE EMERGENCIES SCIENCE DIVISION

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Introduction

About 60 oil-spill related projects are now underway, ranging in size from short-term to multi-year projects. These projects focus on oil properties and behaviour and most are conducted in cooperation with other agencies such as the United States Minerals Management Service, United States Coast Guard, and the Canadian oil industry. New projects are continually being added, as ongoing projects are completed.

Projects are conducted in 11 major fields:

1. Oil fate and behaviour;
2. Oil properties and properties measurement techniques;
3. Oil behaviour and spill modelling;
4. *In-situ* spill countermeasures;
5. Remote sensing;
6. Oil analysis;
7. Spill treating agents;
8. Oil environmental fate and effects;
9. Biodegradation studies;
10. Personnel safety at spill sites; and
11. Development of technical information packages.

Three international committees set priorities for the projects and meet annually with Environment Canada to discuss priorities and ideas for projects.

These committees are: the Committee on the Physical Properties and Behaviour of Oil Spills (COPPBOS); the

The Emergencies Science Division (ESD) is an arm of the Canadian government responsible for research into and development of the scientific aspects of oil and chemical spills. In addition to conducting research, the Division provides advice in the event of major spills and conducts on-scene research and assistance. This article focusses on projects related to oil spill research and operations. Work is also underway on chemical spill research, although these projects are not as numerous as the oil spill research projects. This reflects the relative abundance of oil spills compared to chemical spills (about 10:1).

Canada

Environment Canada Environnement Canada

Committee on Countermeasures and Effects (COCE); and the Committee on Surveillance and Monitoring of Oil Spills (SMOOS). Committee members come from various government and industry groups and are primarily 'funders' of research rather than users.

Oil Fate and Behaviour Projects

Fate and behaviour studies are fundamental to oil spill research and their results are important in determining operational response. Decisions concerning countermeasures should be based on a knowledge of the ultimate fate and behaviour of oil. While research is being conducted around the world on oil fate and behaviour, it is not as focussed as it should be, primarily because research funding for oil spills is not consistent. As fate and behaviour studies require a long, concerted effort to yield valuable results, they have suffered much more than others from funding 'spurts'. Little research has been maintained at universities because of the lack of sustained funding. Few other research organizations have the facilities, equipment, and expertise to carry out fundamental studies. A second difficulty in the field has been the tendency to fund one-year studies. Typically, little can be determined in a year. Specialized apparatus require 6 to12 months to build or to acquire, leaving little time for operation. The learning curve is also a factor. It is generally accepted that in a specialized field, a new scientist takes six months to produce any useful work, two years to become productive, and five years to be fully productive. Hopefully, future efforts will allow for longer-term studies on fate and behaviour.

The state of the art in the field of oil fate, behaviour, weathering, and modelling could be summarized as variable. There are many deficiencies in our knowledge about the fate, weathering, and modelling of oil spills. The fate, behaviour, and transformation of oil are dominated by the reality that oil is a varying mixture of hundreds of compounds. Many laws of chemistry and physics do not apply to oil because they assume ideal liquid or gas behaviour and much of the knowledge gained by chemists over the years is difficult to apply in the oil spill field. Examples of this include even standard physical measurements such as pour point. Strictly speaking, there is no single pour point value for a mixture like oil. The current state of the art for pour-point measurement is poor and reproducibility depends largely on the perceptions of the operators, despite very well-defined ASTM standards. In the same way, oil does not have a single boiling point, melting point, or evaporation rate.

The various components of oil have their own well-defined physical parameters, but these are modified and obscured by the bulk behaviour factors. In the place of these 'pure' chemical parameters, bulk parameters have been developed to describe oil properties and behaviour. These have relevance and definition only for mixtures. Examples of these include initial boiling point and percent residuum.

The following projects are underway at the Emergencies Science Division in the field of oil spill behaviour.

Emulsion Stability - Emulsion formation is a major complicating factor in oil spill cleanup. The study of water-in-oil emulsions is proceeding on several fronts in co-operation with the U.S. Minerals Management Service. A key study on the stability of water-in-oil emulsions is attempting to classify emulsions into at least two types: stable and unstable. Studies in the past year have shown that a class of 'very stable' emulsions exists, characterized by their persistence over several days. These stable emulsions, which actually increase in viscosity over time, have been monitored for over five weeks and new studies are being conducted over much longer times. 'Unstable' emulsions do not show this viscosity increase over time. Their initial viscosity is less than two orders-of-magnitude from that of the starting oil. The increase in viscosity for stable emulsions is at least three orders-of-magnitude. New research shows that there may actually be several classes of stability which may be distinguished by

rheological and other measurements.

An ancillary study is the development of several emulsion-formation techniques. A number of apparatuses have been tested and procedures developed for using them in making emulsions.

Emulsion-formation Chemistry - Studies continue on the mechanism of water-in-oil emulsion formation. One study has shown that asphaltenes and resins precipitate and can then act as surfactants to stabilize water droplets in oil. It is thought that approximately 3% of asphaltenes and waxes is required to perform this function. Further study on this factor is warranted because data were limited at the time of this study. The asphaltenes and waxes are stabilized in the oil by BTEX (Benzene, Toluene, Ethylbenzene, and Xylenes). After these weather sufficiently, asphaltenes and resins are no longer solubilized and can precipitate to stabilize emulsions. The solubility factor requires further investigation, as do the amounts of energy, and water droplet sizes, particularly because accurate measurement techniques are lacking.

Oil Evaporation - 'Classic' oil evaporation equations use water evaporation equations and boundary-layer regulation data. Extensive studies on oil evaporation have found that oil is not necessarily boundary-layer regulated, which has profound implications for most oils that are not light, or when boundary-layer regulation is not important. Most implications relate to an understanding of how factors such as wind affect evaporation. Other important implications include: a wider spread of oil does not increase evaporation, wind does not affect the overall time of evaporation, and only very thick oil slicks show boundary-layer regulation. Benefits of this research include the development of simplified equations that can accurately predict evaporative loss.

Natural Dispersion - The natural dispersion process for oil has been studied in conjunction with chemical dispersion studies. Results show that there is an energy threshold at which natural dispersion occurs and that this threshold is higher for oil dispersion than for chemical dispersion. The increase in dispersion with increasing energy is much less than when dispersants are used.

Study of Spreading and Thickness - Some study has been conducted on the thickness achieved by oil spills and a method is being developed for measuring oil thickness in the laboratory. This is a difficult study because oil sheen separates from the main spreading oil mass.

BOSS - Behaviour of Oil SpillS - The BOSS project is designed to provide a comprehensive collection and review of data and concepts related to oil spill behaviour. Topics include behaviour of oil spilled at sea as well as the lesser-documented topics of oil on land, oil on freshwater, and oil-in-ground. The initial topics chosen for the project include:

1. evaporation
2. water-in-oil emulsification
3. dissolution
4. natural dispersion
5. sedimentation
6. chemical dispersion (only as it affects oil fate and properties)
7. shoreline adhesion
8. spreading
9. drift with wind and coriolis affect
10. biodegradation (only as it affects oil properties and behaviour)
11. submergence and over-washing
12. photooxidation and photolysis

Behaviour and fate in specific situations

13. oil with ice
    - oil under ice
    - oil amongst ice
    - oil in ice
    - oil under or with snow but on ice
14. oil with or under snow
15. oil on land
16. oil in soil

Ancillary topics

17. oil analysis summary

The literature on each topic is collected, reviewed, and analyzed in detail, and summaries are prepared and reviewed. These literature summaries are intended to be comprehensive so that the original literature is not required

for further applications. Critiques of each paper are prepared.

A second version of the Oil-In-Ice BOSS project is being prepared which is far more technical and detailed than the draft version.

Oil Properties and Properties Measurement

The measurement of oil and petroleum properties is dominated by the fact that oil is a mixture. Almost all measurement standards are developed for petroleum refining, in which important factors relate to distillation properties and not environmental behaviour. Less work has been done on measurement techniques and standards relating to oil fate and behaviour in the environment. This is probably because the oil spill and oil pollution industry is small and there is little demand for specialized measurement techniques. The following are projects on measurement techniques and standards.

"Catalogue of Oil Properties" - The oil properties catalogue was first compiled by Environment Canada in 1984 and the project has been jointly funded by the United States Minerals Management Service since 1989. The catalogue was started to provide physical and chemical data relevant to oil spills as no catalogue of this type existed and data could be found only by random searching of the literature. In compiling data for the first catalogue, it became apparent that very few data actually existed. The 1992 edition of the catalogue is available on diskette and through SPILLS, an on-line electronic bulletin board, as well as in its traditioinal paper format.

The oil database includes more than 380 oils or groups and contains up to 60 data points on some oils. Extensive activity is underway in the Emergencies Science Division to measure new oil properties and to develop new measurement techniques.

Future work related to the oil properties catalogue will include developing new or improved protocols for hydrocarbon group analysis, chemical dispersibility, emulsion formation and stability, and total oil analysis by GC/MS. More useful equations will be developed that relate the physical-chemical properties to weathering at sea. Data will also be added on common industrial and domestic oil products. Quality assurance procedures for all analyses done in-house are being reviewed.

New Measurement Techniques - A new technique is being developed for group or bulk analysis. Oils can be fractionated into different hydrocarbon groups based on solubility and adsorption characteristics. A common protocol consisting of a sequence of separations using dilute solutions (in appropriate solvents) and adsorption columns is known by the acronym SARA: saturates, aromatics, resins, asphaltenes. For all of these fractions, the definition of the separated material is a blend of chemistry and technique. Each group is defined mainly by the procedures followed in its isolation. For example, asphaltenes precipitated from n-pentane are not the same as asphaltenes precipitated from n-heptane. In spite of this, hydrocarbon group analysis may correlate usefully with other oil properties such as chemical dispersibility or emulsion-formation tendency and stability.

The original methods for preparing these fractions involved simple precipitation and chromatography on large open columns at low pressure. Recent adaptations of these methods include high-performance liquid chromatography (HPLC) using high-pressure columns, and automated chromatography and detection using silica rods and flame ionization detection (Iatroscan). Further work on hydrocarbon group analysis is required to develop a reliable method.

Work also continues on several fronts to develop and standardize other oil measurement procedures.

Environmental Behaviour Measures - In addition to developing new physical methods, ways to measure the ultimate behaviour of spills in the environment are also being developed. Methods under development include: chemical dispersability, natural dispersability, adhesion to

surfaces, spreading, evaporation, and emulsion formation. Interim methods are already being used to measure data for the "Catalogue of Oil Properties".

Field Analytical Kits - A portable field kit was developed in 1993 for performing on-site analysis at oil spills. Methods were based on standard laboratory techniques and results were equivalent to those obtained in the laboratory. The kit consists of four cases, each of which is a "self-contained" unit. The kits have been successfully used on a regular basis over the past two years. The field work has provided valuable operational information which has subsequently been incorporated into the kit.

A smaller, "person-portable", on-site analysis kit was also developed for use by first response personnel to provide general information on the properties of the oil while on site. This kit, which is contained in one case weighing less than 12 kg, is capable of measuring density, viscosity, water content, and effectiveness of dispersants and emulsion breakers. These properties can be determined with common laboratory equipment which costs less than $1000.

Oil Behaviour and Spill Modelling

The knowledge of oil fate and behaviour may be applied in modelling oil spill fate and behaviour which is important for predicting where oil will go once spilled and what its condition will be. Studies on oil behaviour and spill modelling include the following.

Re-examination of Algorithms - This study is a review of the behavioural algorithms used in spill models. Reviews of evaporation and emulsification have been completed and submitted for publication. New algorithms are being developed.

World Oil Spill Model (WOSM) - A partnership has been formed to fund development of a state-of-the-art oil spill model system. Partners are: Applied Science Associates, Inc., Aramco Oil Field Services, the Canadian Petroleum Association, Chevron Oil Field Research Company, Environment Canada, Exxon Production Research Company, Mobil Research and Development Corporation, and the United States Army Corps of Engineers.

The main project has been completed and an operational version of the model is available. The consortium has been extended into a second phase which will consist of adding several features such as a three-dimensional component, a riverine-linking system, and data-import functions.

Modification of the WOSM for Canadian Sites - Environment Canada is pursuing the task further by adding several geographic areas and data sets to render the model operational.

Testing of SEASONDE data for the WOSM Application - SEASONDE is a low-frequency radar system for measuring surface currents on water. It operates by measuring Bragg scattering from wave tops from two separate sites. Aggregated data give accurate surface current data at approximately 1.5-km intervals up to 60 km from shore. Several sites, including the Straits of Juan de Fuca, Georgia Straits, and Lake Erie, have been measured for surface currents in co-operation with Imperial Oil. Further research on freshwater application is necessary, however, because return signals could not be obtained on Lake Erie.

Comparison of SEASONDE and Buoys - Several studies on surface drifter devices have been conducted in conjunction with SEASONDE tests. Devices included three types of Orion buoys, several types of wood chips, and some newer radio-tracking buoys. The Orion buoys and wood chips consistently moved along the same trajectory as that measured by SEASONDE. The newer radio-tracking buoys, however, did not follow the same trajectory as the other devices in all tests. Over the past 20 years, several buoys have been tested and results published.

In-situ Spill Countermeasures

The Emergencies Science Division also works on *in-situ* countermeasures focussing on *in-situ* burning, chemical spill treatment, and shoreline countermeasures. Testing of spill treating agents is another

aspect of *in-situ* countermeasures which is discussed in a separate section. Countermeasures that are not *in-situ* are developed by the Emergencies Engineering Division.

Burning - Newfoundland Test - In 1993, a major experiment known as the Newfoundland Offshore Burn Experiment (NOBE) was conducted. The quantitative analytical data from NOBE clearly show that emissions from this *in-situ* oil fire were less than expected. All compounds and parameters measured beyond about 150 m from the fire were below health concerns and very low emissions were detected beyond 500 m. Pollutants were found to be at lower values in the Newfoundland Offshore burn than in previous pan tests. The reasons for this are not fully understood, but it appears that the offshore test resulted in more efficient combustion.

Burning - Meso-scale Testing - Environment Canada and the United States Environmental Protection Agency (U.S. EPA) jointly measured emissions from three diesel fuel burns conducted at the Mobile facility in October. Analysis of the results continues, but some of the results show that diesel fires produce much more soot than other fuels. The reasons for this are still not clear.

Burning - Aquatic Toxicity - Chemical analysis and multi-species toxicity testing were performed on samples from both lab- and full-scale burning of oil-on-water. The results indicate that *in-situ* burning did not adversely affect the underlying water column beyond those effects already associated with the unburned oil.

Dispersion and Biodegradation - Several studies on dispersion and biodegradation are underway. These will be discussed further in the sections entitled "Spill Treating Agents" and "Biodegradation Studies".

Shoreline Countermeasures - Subsurface Oil - Laboratory column testing is being used to determine retentivity and residual capacity measures of a range of oil types/viscosities, in different grain-sized sediments. The data will be used to enhance the capability to predict oil removal/persistence.

Shoreline Countermeasures - Natural Removal Rates - A model was developed to predict natural rates of removal of stranded oil on coarse sediments shorelines (SOCS). A mesoscale project is planned to monitor removal rates in coarse sediments by passive (non-wave action) processes. In partnership with Imperial Oil, investigations continue of the fine-particle and oil interaction removal process (clay-scavenging).

Shoreline Countermeasures - Hydraulic Washing - A series of mesoscale and full field-scale trials are planned to determine the intertidal biological effects associated with hydraulic cleanup technique operation variables of water pressure, water temperature, and exposure time.

Shoreline Countermeasures - Manuals - In conjunction with other regional operational arms, a variety of activities continue with respect to the development of shoreline cleanup assessment procedures and manuals.

Remote Sensing

The ability to remotely detect and quantify oil slicks is important when dealing with oil spills, especially under certain conditions. Remote sensing is particularly useful for visually detecting spills at night or in fog, or against backgrounds such as ice, weeds, or on darkly-coloured shorelines.

Fluorosensors - In cooperation with the U.S. Minerals Management Service and the U.S. Coast Guard, Environment Canada completed the construction of a prototype laser fluorosensor for testing purposes. The unit has been tested very successfully over oil-on-water and oil-on-land scenes and has often exceeded expectations. The prototype unit, however, suffers from the fact that it is a profiling instrument with a footprint of about 0.3 m, and it has no form of display to provide real-time or map-like information. A new prototype unit is under construction to incorporate these features and to demonstrate the usefulness of such units. The first prototype unit is known as the LEAF (Laser Environmental Airborne Fluorosensor) and the new prototype unit is called SLEAF (Scanning Laser Environmental

Airborne Fluorosensor). This is a large and highly technical project. Fluorosensors are the only sensors capable of positively identifying oil-on-water, on shorelines, and among ice, weeds, or debris.

Thickness Sensor - In cooperation with the U.S. Minerals Management Service, Imperial Oil, and the Industrial Material Institute, Environment Canada has developed a proof-of-concept sensor for remotely measuring oil thickness. The unit operates as a three-laser system that generates an acoustic pulse in oil and measures the acoustic pulse's time of travel through the oil. This is a positive measurement and does not depend on external factors. A lab unit has been constructed and tested to distances up to 90 m and with waves. Operation on an aircraft was unsuccessful because certain components are sensitive to vibration and noise. Work continues on the solutions to these difficulties.

Tests of Sensors - Environment Canada conducts tests of remote sensors in conjunction with other agencies such as the U.S. Minerals Management Service and the U.S. Coast Guard. Several major tests have been conducted over specially-constructed tanks or artificial shorelines. These tests aid in the development of remote sensors because the ground-truthing is very good and the signals can therefore be assigned to the specific oil condition.

Development of an Operational Remote Sensing System - Environment Canada is developing an operational remote sensing system. The system is being developed in a generic mode when possible, so that information on development can be used by others wishing to construct a similar system. The ESD owns and operates a DC-3 aircraft which is being used as the test bed for new developments.

Oil Analysis

As already noted, there is a pronounced lack of work on measurement techniques and standards as these relate to oil fate and behaviour in the environment. This is probably because the oil spill and oil pollution industry is small and does not create the demand for specialized measurement techniques. A number of analytical techniques are needed both for conducting further research and for operational purposes. In future, more research will be based on careful chemical analysis.

'Total' Oil Analysis - A method for fractionation of crude oil, weathered oil, and oil-spill-related samples has been developed in ESD's laboratory using silica gel glass columns. Using this method, oils are fractionated into aliphatic and polyaromatic hydrocarbons. Individual aliphatic, aromatic, and biomarker compounds (triterpanes and steranes) are characterized and identified using capillary GC/FID and GC/MS. Two hundred and seventy compounds (101 aliphatic, 125 PAH, and 44 biomarker compounds) were identified in ASMB oil. The identification is based on mass spectral data, comparison of GC retention data with authentic standards, and calculation of retention index (RI) values and comparison with authentic literature RI values.

BTEX Measurement - A rapid, reliable, and effective method for directly determining BTEX and alkyl-substituted benzene components in oil has been developed in ESD's laboratory using GC/MS in selected ion monitoring (SIM) mode. Using this method, 58 alkyl-substituted benzene components (6 BTEX compounds, 8 isomers in C_3-benzene family, 19 isomers in C_4-benzene family, 16 isomers in C_5-benzene family, 7 isomers in C_6-benzene family, 1 C_7-benzene compound, and 1 C_8-benzene compound) were identified and characterized in a light crude oil, Alberta Sweet Mixed Blend (ASMB).

Biodegradation Methodologies - A "complete chemical analysis method for biodegradation oil product by GC/MS and GC/FID" was developed and is now being modified. The analytes include biodegradable saturate compounds (n-alkanes and isoprenoids), polycyclic aromatic hydrocarbons (PAHs) and their alkylated homologues, and highly biodegradation-resistant biomarker compounds (triterpanes and steranes). So far, several hundred

biodegradation oil samples have been analyzed. For each sample, three analyses are performed on its fraction 1 to determine the concentration of the total saturates and to quantify the distributions of n-alkanes and biomarker compounds; two analyses using GC/MS are performed on fraction 2 to quantify the target PAHs and their homologues; and one run is done for the fraction 3 by GC/FID to determine the total petroleum hydrocarbon (TPH) value.

Weathering Measurement - The key to understanding oil weathering is precise quantitation of compounds in the oil. Using GC/FID and GC/MS, the weathering effects of a light crude oil can be studied and a "weathering index" concept calculated to quantify the weathering degree of oil with the short-term weathering processes dominated by evaporation. The equations and data are used to describe the weathering behaviour and to estimate the evaporation extent of oil.

Polars Methodology - Oils contain a significant amount of polar compounds, none of which is analyzed by current methods. New development focuses on finding a method to separate, analyze, and quantify these compounds. Trial runs have been successful and a tentative method should be available within a year.

Spill-Treating Agents

The testing and approval of chemical spill-treating agents is another aspect of ESD's involvement with *in-situ* countermeasures.

Dispersants

Testing New Products - Testing of new commercial and experimental dispersants continues. The swirling flask test was modified and a new test procedure was drafted with improvements, most of which related to the analytical methods. The most significant advance is the movement away from visible measurement techniques to a GC technique which, in the case of light and waxy oils, improves accuracy by several orders.

Developing New Agents - Testing new experimental dispersants continues and results are very promising and have confirmed hypotheses on the effectiveness of dispersants.

Study of Physics - It has been found that the effectiveness of dispersants is affected by a number of interrelated factors, principally oil composition, dispersant quantity, sea surface turbulence, and dispersant formulation. Sea turbulence strongly affects the effectivenesss of dispersants. Tests show that effectiveness rises with increasing turbulence and then stays constant at a level determined by oil composition and type of dispersant. The quantity of dispersant used is also a critical factor, with peak effectiveness achieved at very high quantities - at a ratio of 1:5, dispersant-to-oil volume.

Studies continue on developing a complete model for dispersant effectiveness.

New Laboratory Techniques - The swirling flask test is being improved and a new test procedure has been drafted. The analytical techniques have also been significantly improved, especially those for waxy oils. Visible measurement techniques are being replaced by a GC technique.

Partitioning into Water - A study has been initiated to investigate the fate of dispersants. Focus is on the partitioning of dispersants into the oil rather than into the water. Analytical techniques have been developed for measuring surfactants in oil and in water. These are being used to examine the ultimate fate of the dispersants.

Biodegradation Agents

These agents will be covered under Biodegradation Studies.

Surface Washing Agents

Surface washing agents are defined as those surfactant-containing agents that are used to clean beaches or man-made shore structures. A test for these agents has been developed and used to test over 80 commercial products.

Emulsion Breaking and Inhibition Agents

Work continues on developing a test for effectiveness of these agents. Four tests are now in hand. Due to the complexities of emulsions, these tests have been very difficult to develop

with work going on for the past five years. Work continues on defining a test for emulsion stability. In the new tests, effectiveness in closed and open systems and effectiveness for inhibition or breaking are tested separately.

Solidifiers

A test has been developed for the effectiveness of solidifiers and used to test over 25 commercial products.

Test Development for New Agents

New agents of types not noted above continually arrive and effectiveness tests for these agents are developed. Frequently, only one commercial product of these agents is proposed and therefore it is not feasible to develop and publish a standard method.

Development of Guidelines

Acceptability guidelines and standards are being drafted for all the types of agents noted above.

Toxicity Testing and Methodology Development

When effectiveness tests are developed, aquatic toxicity methodologies and tests are developed and implemented at the same time. Several standards have been developed and a protocol for sorbent toxicity testing is now being developed. Three tests are being evaluated to determine the most appropriate organism(s). The tests under consideration are Rainbow Trout Acute Lethality Test, the Echinoderm Fertilization Assay, and the Threespine Stickleback Acute Lethality Test.

Oil Environmental Fate and Effects

The study of the fate and biological effects of oil is an important part of oil spill studies. In fact, countermeasures decisions should be based on the effects aspect of oil spills. Increasingly, however, emphasis is placed on countermeasures that reduce the overall environmental impact of spills.

Studies of Old Spills - Studies of old spill sites provide 'real' information on the long-term fate and effects of oil spills. Recently, studies of the 24-year-old *ARROW* spill and the 10-year-old Baffin Island Oil Spill (BIOS) experimental spill have shown that persistent oil remains in low energy sites.

Water Accommodated Fraction - A partnership has been formed with the Marine Spill Response Corporation (MSRC) in the United States to develop a standard method for preparing water accommodated fractions. A method incorporating the knowledge acquired during this extensive study will be complete within a year.

Spill Treating Agent Toxicity - Concurrent with the development of effectiveness tests for spill treating agents, aquatic toxicity methodologies and tests are developed and implemented. Several standards have been developed.

Toxicity of Oils - New data on oils are added to the oil properties catalogue and data base every year. Most of the testing used water soluble fractions of the oils against the test species *Artemia* spp. (brine shrimp) and *Daphnia magna* (water flea). Because sample preparation can influence the outcome of toxicity tests, further testing of oils has been halted until a standard protocol has been developed for preparing water accommodated fractions (WAFs) from oil.

Biodegradation Studies

Biodegradation of oil spills has been studied for many years, but has recently become popular as it is perceived as the most environmentally acceptable means to remove oil spills. The fact remains, however, that technology is available to degrade only a small portion of most oils over a long time period.

Laboratory Studies - Work has gone on for two years to develop a standard laboratory test for evaluating the biodegradation efficacy of oil spill bioremediation agents under freshwater and saltwater conditions. This study is being conducted under contract to the University of Alberta, which has extensive expertise in the microbiology of hydrocarbon degradation. The freshwater protocol has been completed and the saltwater test protocol will be completed this year. To date, 13 commercial products have been tested in order to design and evaluate the

protocols. A sophisticated chemical technique has been developed to analyze oils for degradation.

Examination of Old Spill Sites - In conjunction with studies to examine the long-term fate and effects of oil at old spill sites, samples of oil were taken to examine the extent of biodegradation. Findings to date have shown variable degradation at these sites.

Personnel Safety at Spill Sites

Examination of VOC Data - Volatile Organic Compounds (VOC) data are being taken at several sites to examine the level of these compounds compared to standards. Fresh crude oil evaporates rapidly and releases enough VOCs to cause health concerns a significant distance away from the site (perhaps one kilometre). Study continues to determine how these conditions vary with different spill scenarios.

Verification of Respirators and Protection Methods - Environment Canada has started a program of analyzing sorbents and filters in cartridges used at spill sites. The objective of the research is to determine how close the sorbents are to saturation and whether the contamination could pass through the respirators. This research is continuing.

Development of Technical Information Packages

Manuals - Environment Canada is completing a new spill manual that includes many oils and petroleum products. New simplified prediction and assessment methods are being developed.

Electronic Bulletin Board - SPILLS (SPill Information Library Link System) has been developed to provide technical information and data bases to the world at large. The oil properties catalogue and five other data bases are available. Capabilities and information packages are continually being developed for this media.

Seminars - Every year, Environment Canada sponsors a technical seminar on oil spills known as the AMOP Technical Seminar. The eighteenth annual seminar is now being sponsored. The seminar has grown to include over 100 papers in two concurrent sessions and one poster session. Over half of the papers are from scientists outside Canada.

Other Publications - Results from research programs are published in a variety of ways and over 50 publications are released each year. Special publications and overviews are also occasionally prepared.

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum for the exchange of information on spill countermeasures and other related matters. We now have more than 2000 subscribers in over 40 countries.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

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