Summary

This volume is the fourth in a series of special technical publications (STPs) sponsored by ASTM Committee D-34 on Waste Disposal. As noted in the Introduction to this volume, the prior volumes$^1$-$^3$ covered a wide variety of topics in solid and hazardous waste management. This STP, and the symposium on which it was based, were intended to provide even greater insight into a number of waste characterization methods and to present state-of-the-art information on land treatment and disposal, incineration, and risk assessment technologies. A special effort was made to include papers in all of these areas which described ongoing research by the U.S. Environmental Protection Agency (EPA).

The papers included herein have undergone peer review and often extensive revision since their presentation at the symposium in Arlington, Virginia, in May 1984. The information discussed can be used to assist the solid waste community in developing better testing and handling methods for industrial and hazardous solid wastes.

Analysis and Characterization of Wastes

The most important factor in determining the proper handling methods for a solid waste is the actual character of the waste. Methods that define the chemical composition and physical characteristics of a waste are essential to ensuring that such materials are treated or disposed of in a manner that is protective of human health and the environment.

The precision and accuracy of the standard Soxhlet extraction method for the determination of oil and grease content in soils was evaluated by Martin and Loehr. They found that the coefficient of variation for five different oil/soil mixtures never exceeded 4%. The authors state that careful adherence to procedural details allows this method to be used to quantity the oil and grease content in soil samples accurately.

Francis et al conducted extensive leaching studies of four different industrial wastes, using batch and column leaching methods and five different


leaching media. This work was performed in part to provide a data base for further development of regulatory testing programs to determine the hazard potential of solid wastes disposed in landfills. Data from large-scale lysimeter tests were compared with the results of 32 different laboratory leaching tests. The authors conclude that a batch leaching test using carbonic acid as the extraction fluid may provide a suitable test for further evaluation, but caution that the selection of the final test conditions may be dependent on the intended use of the test results.

Current EPA plans to use the data presented in the paper by Francis et al are the topic of the next paper by Kimmell and Friedman. The authors describe the testing needs of the agency, explaining how the development of a new generation batch extraction method will be applied in the regulatory framework. The advantages and disadvantages of a batch extraction method are discussed, as well as future EPA research activities in this area. Significant discussion of the technical validity of a short-term extraction procedure versus long-term real-world behavior of landfilled wastes is also included.

The concentrations of specific compounds or classes of chemicals in waste samples are often critical in determining ultimate disposal techniques. Barsotti and Palmer compare the results of two different analytical methods, manual distillation and an automated technique, on the cyanide content of an aqueous waste stream. While both methods show acceptable precision, the automated technique was easier and had a larger sample throughput. Depending on the types of cyanide species present in the sample, the manual distillation method could yield erroneous results when used to measure free cyanides.

Ziegler et al describe a rapid method for determining total organic halogens in industrial wastes. The procedure combusts a waste sample in a Parr combustion bomb, then measures the converted inorganic halides by any of three different methods. A detection limit of 3.5 ppm can be obtained. Actual precision data on a large number of halogenated organics are presented.

Friedman discusses ongoing EPA research activities for a number of specific analytical techniques. The single and multilaboratory programs to evaluate 21 analytical methods included or considered for inclusion in the EPA's Solid Waste Analytical Manual (SW-846) are described. Other primary areas of focus included two different analytical schemes for analyzing hazardous constituents in groundwater; monitoring methods for volatile and nonvolatile organic compounds from incinerators or boilers, as well as volatile compounds from land treatment and disposal facilities; and leaching potential (mobility) of hazardous constituents from solidified wastes and wastes that contain pyritic sulfur.

At times, the ability to characterize a waste properly is limited by the lack of acceptable test methods. Michael et al describe ongoing research to identify a test suitable for quantitatively measuring the ignitability potential of a solid waste. Three different tests—the radiant heat ignition, rate of flame
propagation, and difficulty of extinguishing the waste with water—were evaluated on 26 different waste samples and commonly found materials. The test results were used to determine an "ignitability factor" for each of the materials; the factor takes all of the data into account for determining the overall tendency of a waste to ignite and cause a hazard. The authors note that the results are not conclusive enough to classify materials qualitatively as hazardous or nonhazardous based on the calculated ignitability factor.

The difficulty of determining the amount of hydrogen cyanide or hydrogen sulfide evolved from a waste is discussed in the paper by Handy et al. Their attempts to analyze 16 selected waste streams as part of an interlaboratory testing program show that further work is needed before reliable results can be obtained with the type of testing procedures they evaluated. The procedure showed poor precision for hydrogen cyanide, and the authors recommend that it not be considered further. The hydrogen sulfide results are more encouraging but demonstrate a need for optimizing testing conditions to improve the precision of the method.

Problems associated with the analysis of lead in two different types of soil are presented by Perket and Barsotti. A multilaboratory analysis has revealed that several laboratories consistently generated aberrant data. Statistical evaluation of all laboratories suggests that problems exist with sample preparation as well as actual laboratory analysis. Recommendations for better quality assessment programs for remedial site investigations are presented.

Gurka et al propose the use of a sophisticated instrumental technique for identifying a complex array of organic constituents in environmental samples. The combination of Fourier-transform infrared spectrometry and the more common gas chromatography/mass spectrometry (GC/MS) technique allows a more detailed composition of samples to be obtained. Data on two specific samples are presented to show the utility of such an analysis. The needs for lower-cost, better computer software and for improvements in the infrared techniques are suggested as areas for further evaluation.

Risk Assessment/Biological Test Methods

An area that has been receiving an increasing level of attention in both the public and private sectors is the concept of risk assessment of chemical wastes and various waste management methods. This volume includes a special section on risk assessment. In addition, several papers address the more specific area of biological testing of wastes in order to ascertain the level of risk involved with various management techniques.

Human exposure assessment is discussed in the paper by Dragun and Erler. They describe the various types of environmental releases and exposure routes for chemicals and provide a real-world example calculation for determining exposures during cleanup of a site contaminated by polychlorinated biphenyls (PCBs). In this case, the assessment reveals that greater human
exposure to PCBs would occur if contaminated soil were disposed off-site than if it were simply covered and left at the site.

*Matthews and Bulich* discuss a new method for assessing the suitability of organic wastes for land treatment. The test uses marine luminescent bacteria to measure differences in toxicity before and after a waste is subjected to land treatment. The reduction of the toxicity is regarded as a measure of treatability of that waste. The data can also be used to determine optimum operating criteria (for example, the waste application rate or moisture/nutrient effects).

*Newhauser et al* describe an innovative test using earthworms to determine the biological impact of wastes applied to soil. Data are presented comparing the relative toxicities of a variety of organic chemicals and metals to earthworms under two different test conditions—one using filter paper impregnated with a test solution, the other using an artificial soil mixture. The toxicity results from the earthworm tests were qualitatively similar to published results on rat oral median lethal dose (LD$_{50}$) values for a number of the organic chemicals tested.

*Andon et al* describe several tests using chemical extracts to determine the level of biological activity in a number of industrial waste samples. Samples were extracted with ethanol, dichloromethane, and dimethyl sulfoxide (DMSO); the extracts were tested for toxicity and mutagenicity by using the Chinese hamster ovary and Ames tests. A new procedure utilizing thin-layer chromatography of the pure waste streams is also described. All of the waste samples showed some biological activity, although the tests differed in their ability to detect the toxic or mutagenic properties.

A full toxicological screening program is proposed by *Lewtas and Andon*. Their protocol involves feeding hazardous wastes orally to rats for ten days, followed by a comprehensive battery of tests to identify potential toxic effects of the waste. The testing program is currently being validated by using known toxic compounds. A prescreen test sequence is also being developed to allow prioritization of waste samples for full toxicological screen testing.

**Land Treatment and Disposal Test Methods**

The historical practice of disposing of solid and hazardous wastes in landfills or other land disposal systems has been seriously questioned over the past ten years because of the environmental problems caused by this waste management method. A number of papers address research and testing efforts designed to provide a better technical basis for determining what types of wastes may be best suited for land disposal and how to design such facilities better.

The paper by *Bowders et al* provides an up-to-date description of the types of tests available for predicting leachate effects on natural soil liners. A thorough discussion of the advantages and disadvantages of using different permeability tests is presented. A number of recommendations regarding per-
meameter selection, graphic presentation of the results, and the use of index tests and batch equilibrium tests are presented. Actual test results are included showing the effects of landfill leachates and pure chemicals on clay soils when using the recommended tests.

The current EPA research program in land disposal is described in the paper by Schomaker. Specific programs addressing landfills, surface impoundments, underground storage in mines, and dioxin engineering are discussed as to general approach, study content, and application of the information within the regulatory framework. Most research efforts culminate in the issuance of Technical Resource Documents (TRDs).

Myers describes a test program utilized by the U.S. Department of the Army for determining the adequacy of solidified waste for landfilling. A 15-minute cone index test on compacted samples of freshly solidified waste was shown to be a good indicator of the suitability of the material for landfilling.

The need for proper testing of chemical grouts used as subsurface barriers at hazardous waste sites is described by Malone et al. The standard tests currently in use are discussed, and specific deficiencies in these tests are noted. Procedures for judging the compatibility of grouts with specific groundwater environments and test methods for determining the permeability of the in-situ material are two areas where standardized test methods are needed.

Loehr et al discuss the need for a statistical sampling program to obtain valid data from a land treatment facility. Because of such variables as soil nonhomogeneity, differences in waste application, and uneven mixing characteristics, the coefficients of variation for a number of parameters ranged from 5 to 16%, even for a small pilot-scale land treatment plot. A proposed sampling plan, based on acceptable error in measuring critical parameters, is presented for obtaining valid data on waste constituent concentrations in the zone of incorporation.

Incineration

As regulations and public concern over the effects of landfilling continue to reduce dependency on this method of disposal, particularly for hazardous wastes, an increased emphasis on incineration technology has resulted. Although incineration is a far more desirable technology for managing most organic wastes, there are a number of problems that are deserving of study, including improvement in analytical techniques. This volume has sought to emphasize the importance of incineration by having a special section for this technology.

Lee et al discuss a variety of problems encountered in analyzing complex chemical wastes to determine the characteristics that are important for incineration. Topics covered include GC/MS analysis and data interpretation; chlorine, phosphorus, sulfur, sodium, water, and ash content; and tests for heat of combustion and viscosity. Solutions are offered to a number of the
analytical problems discussed and several areas are suggested for further research. As a general suggestion, a statistical plan for obtaining valid analytical data from complex, nonhomogeneous chemical wastes is proposed that will help minimize the problem of nonrepresentative analysis.

Doucet describes the importance of test burns to assist in the proper design and selection of waste incineration systems. Such testing programs allow the owner to determine the incinerability of a waste under actual operating conditions. Numerous qualitative and quantitative benefits, such as observing flame patterns, ash slagging tendencies, air and fuel requirements, and organic destruction efficiency, are outlined for this approach. The problems of identifying proper facilities and specifying the waste and operating criteria to be used in the test are also discussed.

Santoleri presents a similar paper on the importance of pilot test burns. Data from a real test burn are also presented to demonstrate the value in this approach; an operational method for controlling emissions of oxides of nitrogen while achieving the necessary efficiency in organic destruction was determined as a result of information collected during the test.

As indicated in the previous two papers, a critical aspect in assessing the suitability of an incineration system is organic destruction efficiency. The paper by Johnson describes EPA efforts at developing a volatile organic sampling train (VOST) to use for stack sampling. A summary of some of the laboratory evaluation data using various chlorinated organics is presented. Some of the potential problem areas, such as sample breakthrough and the need for extensive quality assurance/quality control data to validate the data, are reviewed.

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