STUDIES FOR DESIGN OF A SOLID WASTE MANAGEMENT PROGRAM *

H. T. Jones

Division of Coal Conversion, Department of Energy
Washington, D.C.

H. M. Braunstein and W. J. Boegly, Jr.

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

ABSTRACT

Passage of the Resource Conservation and Recovery Act (PL 94-580) in October 1976 will have far-reaching consequences for many solid-waste producing industries including future coal conversion facilities. Since little is known about the potential environmental problems from conversion wastes, a study is under way to evaluate landfill methods for disposal of these wastes. Residues from pilot plant and commercial processes are being characterized in a 3-tiered testing program which incorporates initial laboratory leaching studies, field-scale lysimeter testing and a full-scale landfill experiment. The information will lead to engineering design of safe economical solid-waste landfills for demonstration plants.

INTRODUCTION

In October 1976, the U.S. Congress passed the Resource Conservation and Recovery Act which provides for federal regulation of the treatment and disposal of solid wastes that represent a danger to the environment or to health. This Act is to solid wastes what the Clean Air Act Amendments of 1970 are to airborne wastes and the Federal Water Pollution Control Act Amendments of 1972 are to waterborne wastes. Compliance with this law may have far-reaching consequences for all coal-utilizing systems, especially those necessary for the demonstration of advanced fossil fuel technologies. Since near-commercial demonstration of coal conversion processes in the private sector is important for meeting our national energy objectives and since these technologies produce a voluminous solid waste with components that may possibly be classified as hazardous, a research program was undertaken to determine whether a problem exists. Management of the wastes from demonstration plants can be an important factor in demonstrating both the environmental acceptability and economic feasibility of a given alternative.

FOSSIL ENERGY DEMONSTRATION PROGRAM

In order to appreciate the role of environmental performance in the demonstration of advanced fossil energy technologies, it is helpful to understand the program's objectives, strategy, and structure. The objectives of the fossil energy demonstration program are shown in Fig. 1.

---

* Research sponsored by the Department of Energy under contract with the Union Carbide Corporation.

Environmentally, demonstration plants are unlike pilot plants. The latter are normally concerned only with process development whereas a demonstration plant has many areas of concern. The industrial partner in a demonstration project must show that his process is economically feasible, technically sound, and environmentally acceptable on a near-commercial scale. Not only is he challenged by an emerging technology, he must keep abreast of ever-changing environmental obligations. He must meet the NEPA requirement; he must address New Source Performance Standards; and he must remain alert to new regulations stemming from the Resource Conservation and Recovery Act. Figure 2 is a list of current planned demonstration plants.

In recognition of and to help alleviate the stresses, the government stands ready to support the early phases of demonstration with ample guidance to the industrial partner and with necessary research to develop information needed to respond quickly to crucial questions. The research discussed in this paper was an outgrowth of this information need.

THE SOLID WASTE PROBLEM

It was recognized even before enactment of the Resource Conservation and Recovery Act that solid wastes from coal conversion had the potential for causing adverse environmental impacts. What may not have been recognized was that virtually all wastes from coal conversion facilities will be solid wastes. Air and water quality are closely regulated. This means little if any waste will be allowed discharge into these media,. Consequently, air and water emissions will need to be converted into solids (Fig. 3). Thus, what would have been an air and water emissions problem becomes a solid-waste land-disposal problem.

Figure 4 shows the solid wastes associated with some of the unit operations in a gasification process stream. These cover a wide variety of materials, properties, and potentials for environmental effects. The studies to be discussed are presently directed at the wastes that are unique to coal conversion, those in the dashed circles. Our aim is to identify possible contaminants, to isolate the process parameters with which they are associated and to produce engineering designs that incorporate effective treatment or control schemes. By studying processes in operation, and by examining the wastes they produce, we plan to develop information about the environmental consequences of land disposal of coal conversion solid wastes.

LANDFILL DISPOSAL

Solid wastes from conversion processes must be disposed of. A plant processing 3000 tpd of coal with a 10% ash content will require disposal facilities for at least 300 tpd of solids. Landfilling is a readily available disposal technique. But little is known about landfilling of coal conversion wastes, and data from landfilling of other wastes indicate the possibilities for environmental disruption (Fig. 5).

Although surface runoff can transport contaminants, the primary environmental impact from a landfill would occur by transport of precipitation-generated waste leachate into groundwater through the subsoil. It is not yet known whether leachate from coal conversion wastes will be a problem, but in the event that it is, control of subsurface movement of the leachate will be the best means for protecting the groundwater. By studying the soils that comprise this subsurface environment, by identifying and utilizing their absorption and exchange properties, we hope to come up with an effective economical landfill design.

WASTE MANAGEMENT RESEARCH

The problem is being investigated at the Oak Ridge National Laboratory as part of an ongoing study now in its second year. The first segment of the program was to draw together a wide variety of relevant information, to assess that information and to provide an environmental source book on solid waste disposal as it bears on coal conversion.[1] The document addresses the environmental, ecological and biological aspects of coal conversion solid wastes. It was concluded that definitive studies were needed if the wastes were to be deposited safely, economically, and permanently by landfilling. The experimental study, which is the main subject of this paper, was undertaken to address this need.

OBJECTIVES

To meet the objective of the program, which is to develop engineering designs for safe economical disposal of conversion solid wastes from demonstration plants, the project is structured around a real-world situation. Process wastes will be obtained from pilot and commercial plants and they will be examined in a natural setting, in contact with normal soils especially those from demonstration sites. Process wastes to be studied include: (1) Slagging Lurgi, (2) COGAS, (3) HYGAS, (4) CO_2 Acceptor, (5) Synthane, (6) BI-GAS, (7) Battelle Agglomerating Burner, and (8) Westinghouse/Walz Mills.

SCOPE

The program incorporates three main levels of testing (Fig. 6). Each level of data collection will support the next such that as information accumulates it should be possible to evaluate and predict not only the short-term but also the long-term behavior of buried wastes.

METHODS

Laboratory studies

For coal conversion wastes, laboratory experiments are especially important. Not only is the composition of the wastes variable and process related, they contain an abundance and wide variety of trace element and organic materials. Also, since little is known about their leaching behavior, controlled laboratory leaching studies are needed to identify the effluents for the more comprehensive surrogate landfill studies.

Solids characterization. Each residue will be characterized physically and chemically and the properties will be compared with those of the feed coal from which it was derived. Properties such as solubility, density, porosity, compactibility and particle size distribution will be determined. Chemical analyses of the solids will include major components, trace elements and organic content, if any. Coals will be ashed under standard laboratory conditions to compare the physical and chemical properties with those of the process-derived residues.

Soils characterization. Soils can act as a large interactive medium for many toxic leachate effluents which can be either absorbed or precipitated by soil components. Like coal, the physical, chemical and mineralogical composition of soil varies widely and consequently its capacity to retain toxic effluents varies also. Soils will be characterized for their pH, buffer capacity, ion-exchange capacity, lime equivalent, and mineralogical composition. The absorption — desorption behavior of soils will be examined with the aim of characterizing the persistence of leachate components in a landfill environment.

Batch leaching tests. Leaching under laboratory conditions will be conducted both in the batch mode and by use of leaching columns. Emphasis will be on eluting trace elements and organic compounds. Batch sampling is fast and simple. It simulates natural flooding conditions or submergence of landfill materials as when mounding of a shallow groundwater table occurs. Analyses of the batch effluents will indicate not only the inherent solubilities of trace substances in the wastes, but varying the pH of the effluent will provide data on waste behavior under neutral, dilute acidic or dilute alkali conditions. Batch leaching will be examined also for mixtures of residues with soils to determine the direct effect of soils of leachate quality.

Column leaching tests. Leaching in columns (Fig. 7) allows control of conditions to more closely simulate the natural movement of soluble constituents. The apparatus is simple, quickly assembled, and gives readily reproducible results. The leaching solution will be varied between weakly acidic and weakly alkaline, and fractions will be collected as functions of time and volume throughput. Samples, which will be compared with background-level blanks, will be analyzed by suitable methods to obtain accurate qualitative and quantitative characterization of the constituents. Multielement methods such as neutron activation analysis, atomic absorption spectrometry and isotope dilution mass spectrometry will be examined. If indicated, organic materials will be separated chromatographically and analyzed by mass spectrometry. As with the batch tests, column leaching will be performed using representative soil and residue combinations.

Standardization of procedures. Standard leaching procedures have not been established for coal conversion wastes. Therefore, while collecting leaching data, methods will be studied with the aim of recommending standard procedures. Since leaching behavior of waste materials depends not only on the nature of the wastes but also on soil type and constitution, these considerations will be incorporated in the recommended protocols.

Field-scale lysimeter studies

As soon as laboratory experiments are well under way, field studies will be initiated. Field-size lysimeters have been used in conventional sanitary landfill studies as well as for examining burial ground behavior of radioactive solid wastes. Figure 8 shows the typical lysimeter which will be exposed to natural weather conditions during field studies.

Use of field-scale lysimeters as a transition between laboratory and demonstration-size experiments has several advantages. They:

(1) require less waste

(2) prevent leachate escape

(3) eliminate wall effects, and

(4) cost less.

Whereas the lysimeters will be large enough to prevent wall effects, the amount of waste needed to simulate a loaded landfill is orders of magnitude less than a normal burial site. Nonetheless, large volumes of leachate can be generated and collected without risking discharge of leachate to the environment. But the primary advantage is the small capital investment not only for the data obtained but for the experiential information needed to establish design criteria for the landfill burial studies.

The lysimeters will be loaded with soil and waste to simulate a vertical cross section of a landfill trench, and will be designed to prevent escape of leachate into the environment. Both soil and leachate will be sampled frequently and analyzed to determine the extent of trace element and organic compound attenuation. Analytical methods, developed during the laboratory phase, will be applied to both the solids and leachates.

As a first step toward predicting long-term effects, data gathered during the lysimeter phase will be used to test and modify in-house transport models for substrate behavior of trace contaminants. Results will be used in designing and establishing the field burial studies. Modeling studies are an ongoing activity at ORNL having been initiated to characterize movements of low-level radioactive wastes from burial grounds.

Landfill burial studies

Currently, disposal of coal conversion solid wastes is assumed to be performed using landfill methods similar to those used for conventional municipal or industrial solid wastes. Results of the laboratory- and field-scale lysimeter tests when completed, will indicate whether this conventional method of solid waste disposal will be environmentally acceptable or whether unconventional designs will be required for disposal at conversion facilities.

Burial studies will be conducted at the demonstration site. Landfill designs, developed during the lysimeter stage of the program, will be implemented in full-scale field studies after characterizing the subsurface hydrogeology of the proposed burial area. A monitoring plan will be established at the landfill site to sample both the landfill and subsurface soils, and to monitor groundwater movement and quality. Data obtained from the preliminary modeling studies will help establish both the site and the monitoring plan.

Full-scale modeling studies will be conducted concurrently with the burial work. The rationale for modeling comes from the need to predict possible long-term, long-distance environmental impacts. Most incidents of groundwater contamination are found to occur not only 20 to 30 years after burial but often long distances from the burial site. Mathematical models simulate both the spatial and temporal components of trace contaminant mobilization. The movement of contaminants will be described in terms of hydrogeologic parameters such as subsurface lithology, mineral constituents, texture and stratigraphic structure, and aquifer geometrical properties. Scenarios for transport will be developed and tested using data collected in the field monitoring operations.

As indicated by the experimental results, mitigating measures will be developed to be commensurate with both the probability of escape of contaminants and with the estimated risk associated with their possible escape.

Research on this program has been ongoing for the past year and a half. The status of the experimental studies will be discussed and results of data collected during this period will be presented.

REFERENCES

1. H. M. Braunstein, Ed., *Environmental and Health Aspects of Disposal of Solid Wastes from Coal Conversion: An Information Assessment*, ORNL-6157, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1978.

ORNL–DWG 77-21325

DEMONSTRATION PROGRAM OBJECTIVES

- TO INDICATE TECHNICAL AND ECONOMIC VIABILITY OF NEAR-COMMERCIAL SCALE PROCESSES
- TO SPREAD THE DEMONSTRATED TECHNOLOGY QUICKLY TO PRIVATE INDUSTRY
- TO ENCOURAGE INDUSTRY PARTICIPATION BY PROVIDING PARTIAL FUNDING TO MINIMIZE THE RISK
- TO VERIFY THE ENVIRONMENTAL ACCEPTABILITY OF PROCESSES PRIOR TO FULL-SCALE COMMERCIALIZATION

Fig. 1. Demonstration program objectives.

ORNL–DWG 77-21324

DEMONSTRATION PLANTS

PROCESS	INDUSTRY PARTNER
SLAGGING LURGI	CONOCO COAL DEVLOPMENT CO.
COGAS	ILLINOIS COAL GASIFICATION GROUP
TEXACO GASIFIER (FOR NH_3)	WR GRACE
U GAS	MEMPHIS, LIGHT, GAS, AND WATER
WOODAL-DUCKHAM	ERIE MINING
HYGAS	(DESIGN PHASE ONLY)
SOLVENT REFINED COAL	(PLANNING)

Fig. 2. Demonstration plants.

ORNL–DWG 77-21323

EXAMPLES OF EMISSIONS DISPOSITION

MEDIUM	EMISSION	CONVERTED TO	FINAL DISPOSITION
AIR	SO_2	FLUE GAS DESULFURIZATION SLUDGE	LANDFILL
	PARTICULATES	PRECIPITATES	
WATER	DISSOLVED MINERALS	PRECIPITATES OR SOLIDIFIED PRODUCTS	LANDFILL
	SUSPENDED PARTICLES	SETTLED SLUDGES	
LAND	FLY ASH SLURRY	ASH SOLIDS	LANDFILL
	SLAG OR BOTTOM ASH SLURRIES	SOLIDS	

Fig. 3. Examples of emissions disposition.

ORNL–DWG 77-21322

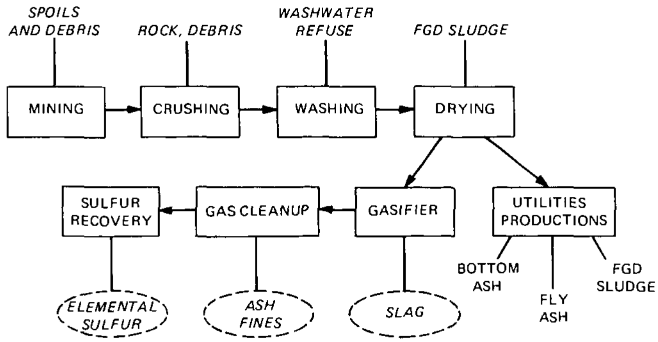


Fig. 4. Waste solids produced in a gasification facility.

ORNL DWG 77-14942

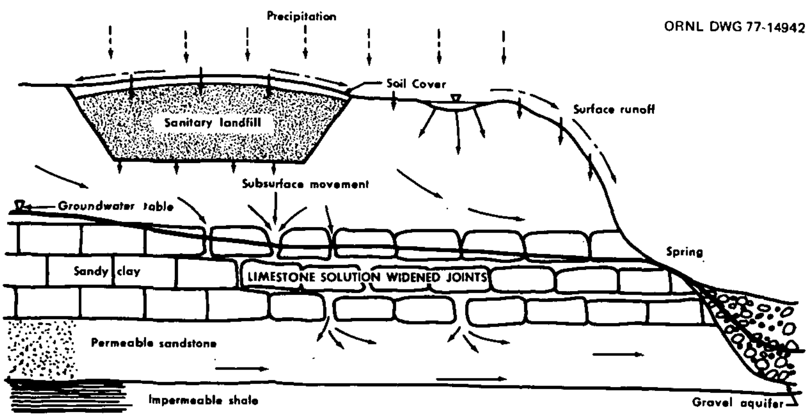


Fig. 5. Leachate formation and movement. Source: D. R. Brunner and D. S. Keller, "Sanitary landfill design and operation," EPA SW-65ts, 1972.

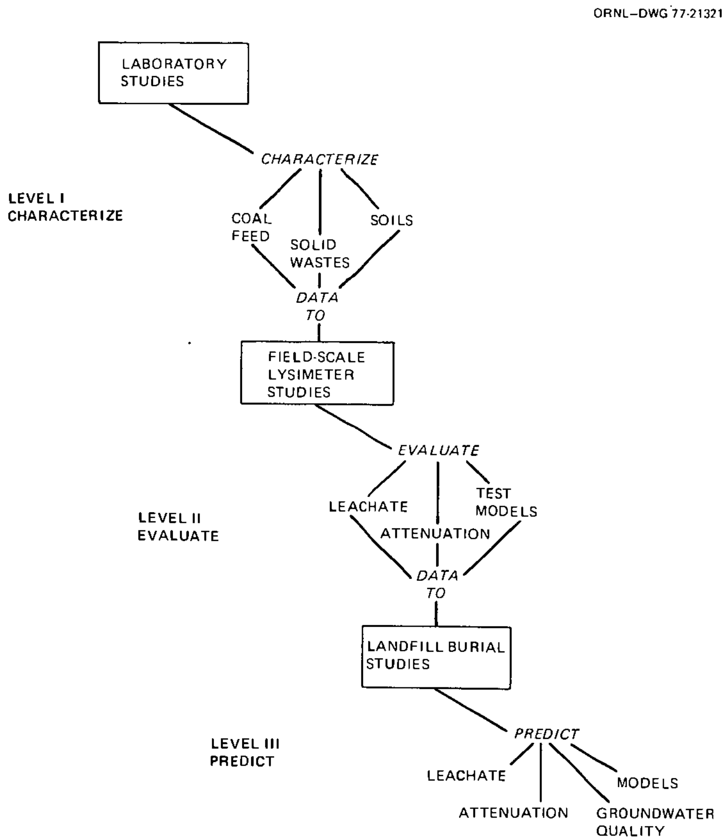


Fig. 6. Tiered approach of the ORNL Experimental Landfill Program.

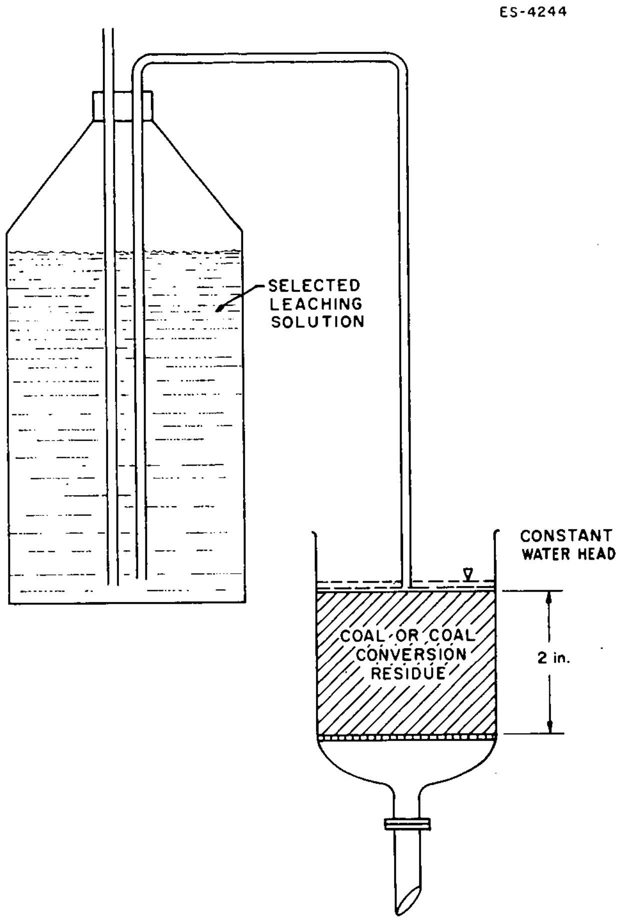
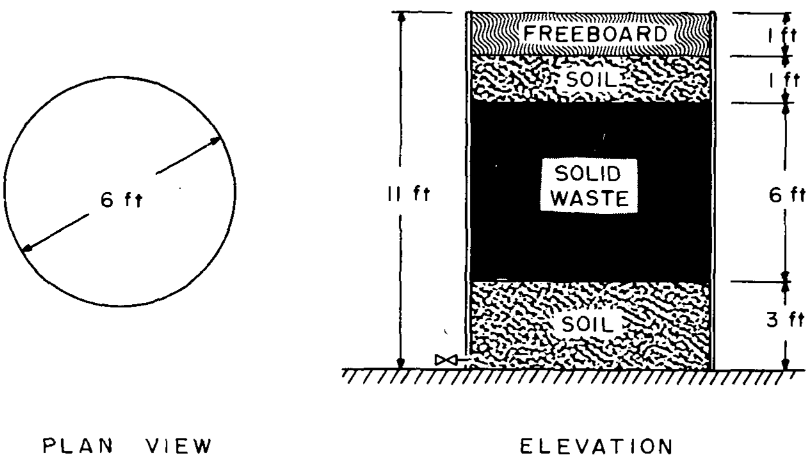


Fig. 7. Typical constant-water-head leaching column.

ES-4245



NOTES:
1. MATERIALS OF CONSTRUCTION – FIBERGLASS, PVC, OR ALUMINUM
2. SAMPLING MAINLY AT BOTTOM; SOME LYSIMETERS WITH SAMPLING POINTS AT VARIOUS DEPTHS
3. RELYING ON NATURAL RAINFALL WHEN POSSIBLE
4. PLACED ABOVEGROUND INSTEAD OF UNDERGROUND TO SIMPLIFY SAMPLING AND TO REDUCE COSTS

Fig. 8. Typical lysimeter.