UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

EPA-SAB-EEC-90-010

OFFICE OF
THE ADMINISTRATOR

March 27, 1990

Honorable William K. Reilly
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Reilly:

The Science Advisory Board has completed its review of the Office of Research and Development's (ORD) Municipal Waste Combustion Ash Solidification/Stabilization (S/S) research program. It was based on briefing materials and discussions with staff in a review meeting conducted on September 18-19, 1989 by the Municipal Waste Combustion Ash Subcommittee (MWCAS) of the Environmental Engineering Committee (EEC), and on selected materials provided to the MWCAS in May and June, 1989.

The issues reviewed by the Subcommittee were (1) appropriate testing procedures to be applied to S/S ash products and reuse products made from S/S ash to determine long-term environmental effects, and (2) methods of testing to determine the bioavailability and toxicity of S/S ash products.

The ORD staff are to be complimented on their formation and effective use of a Technical Advisory Panel (TAP). The TAP provided focused technical input on the best applications of ORD's limited funding.

Highlights of our findings and recommendations for long-term effects research are as follows. The highly variable array of ashes from many combustion facilities dictates that test routines developed must apply to the behavior of various products of different ashes. The research should address both the properties of the leachate and the physical and chemical characteristics of the solid matrix in order to define the breakdown and exposure of surfaces of stabilized products. There is a need to continually evaluate the effect of weathering, possible dynamic abrasion and erosion, the effects of salts, microbial activity and swelling of ash. Deterministic models of transport mechanisms may be useful to assess relative effectiveness of the various S/S treatment processes.

Bioavailability and toxicity should be examined as two distinct and separate phenomena. While limited in scope, bioassays can be used effectively for making relative comparisons of the toxicities of leachates derived from various ashes and products. Extensive bioassay testing will be required, and no single bioassay procedure can adequately assess biological effects of residue reuse or disposal alternatives.

The Municipal Waste Combustion Ash research program should be reviewed for adequacy of funding. This program should emphasize front-end prevention at least as much as back-end treatment. Additionally, the potential risks associated with ash disposal should be compared with long-term risks associated with alternative municipal solid waste disposal options.

We appreciate the opportunity to provide advice to the Office of Research and Development's municipal waste combustion ash research program on this important topic, and look forward to your response.

Sincerely,

Raymond C. Loehr, Chairman
Executive Committee
Science Advisory Board

Richard A. Conway, Chairman
Environmental Engineering Committee
Science Advisory Board

Ben B. Ewing, Chairman
Municipal Waste Combustion Ash
Subcommittee
Science Advisory Board

EPA U.S. Environmental Protection Agency Washington, DC
EPA-SAB-EEC-90-010

Report of the Municipal Waste Combustion Ash Subcommittee

Review of the ORD Municipal Waste Combustion Ash Solidification/ Stabilization Research Program

A SCIENCE ADVISORY BOARD REPORT

March 1990

EPA-SAB-EEC-90-010

REPORT OF THE MUNICIPAL WASTE COMBUSTION ASH SUBCOMMITTEE OF THE ENVIRONMENTAL ENGINEERING COMMITTEE

REVIEW OF THE OFFICE OF RESEARCH AND DEVELOPMENT'S MUNICIPAL WASTE COMBUSTION ASH SOLIDIFICATION/STABILIZATION RESEARCH PROGRAM

MARCH, 1990

NOTICE

This report has been written as a part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide a balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency; hence, the comments of this report do not necessarily represent the views and policies of the Environmental Protection Agency or of other Federal agencies. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

The Municipal Waste Combustion Ash Subcommittee (MWCAS) reviewed the Agency's municipal waste combustion ash solidification/stabilization (S/S) research program. The issues reviewed were (1) appropriate testing procedures to be applied to S/S ash products and reuse products made from S/S ash to determine long-term environmental effects, and (2) methods of testing to determine the bioavailability and toxicity of S/S ash products.

The Subcommittee's findings and recommendations for long-term effects research dealt with test routines and leach testing research, focusing upon the properties of the leachate and the physical and chemical characteristics of the solid matrix in order to define the breakdown and exposure of surfaces of stabilized products, the need to evaluate weathering, and for some reuse alternatives, of dynamic abrasion and erosion. Other findings and recommendations dealt with the effect of salts, microbial activity and swelling of ash upon the long-term usefulness of concrete products, and the usefulness of deterministic models of transport mechanisms to assess relative effectiveness of the various S/S treatment processes.

Highlights of the findings and recommendations for bioavailability and toxicity dealt with examining bioavailability and biotoxicity as two distinct and separate phenomena, the effectiveness of bioassays for making relative comparisons of the toxicities of leachates derived from various ashes and products, the need for extensive bioassay testing, and the finding that no single bioassay procedure can adequately assess biological effects of residue reuse or disposal alternatives.

Key Words: Ash, Ash Research, Municipal Waste Combustion Ash, Ash Solidification/Stabilization

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1.0 EXECUTIVE SUMMARY

The Municipal Waste Combustion Ash Subcommittee (MWCAS) of the Science Advisory Board's (SAB) Environmental Engineering Committee (EEC) reviewed the Agency's municipal waste combustion ash solidification/stabilization (S/S) research program. The issues reviewed were (1) appropriate testing procedures to be applied to S/S ash products and reuse products made from S/S ash to determine long-term environmental effects, and (2) methods of testing to determine the bioavailability and biotoxicity of S/S ash products.

Highlights of the findings and recommendations for long-term effects research are as follows:

a. The highly variable array of ashes from many combustion facilities dictates that test routines developed must apply to the behavior of various products of different ashes.

b. The research program should address both the properties of the leachate and the physical and chemical characteristics of the solid matrix in order to define the breakdown and exposure of surfaces of stabilized products.

c. There is a need to continually evaluate the effect of weathering, and possible dynamic abrasion and erosion, the effect of salts, microbial activity and swelling of ash, for evaluation of the long-term effect of use of S/S products for some purposes such as road base or building materials.

d. Deterministic models of transport mechanisms may be useful to assess relative effectiveness of the various S/S treatment processes.

In discussing bioavailability and toxicity, the Subcommittee recommendations the following:

e. Bioavailability and toxicity should be examined as two distinct and separate phenomena.

f. While limited in scope, bioassays can be used effectively for making relative comparisons of the toxicities of leachates derived from various ashes and products.

g. Extensive bioassay testing will be required, and no single bioassay procedure can adequately assess biological effects of residue reuse or disposal alternatives.

The Subcommittee is concerned that the Municipal Waste Combustion Ash research program is inadequately funded. The Municipal Waste Combustion Ash program should emphasize front-end prevention at least as much as back-end treatment. Additionally,

the potential risks associated with ash disposal should be compared with long-term risks associated with alternative municipal solid waste disposal options.

The Office of Research and Development (ORD) has established and used a Technical Advisory Panel (TAP) to guide its management of the S/S program to effectively use the very limited resources of money and manpower.

2.0 INTRODUCTION

At the request of the Office of Solid Waste (OSW), the Office of Research and Development (ORD) has instituted a research program on municipal solid waste (MSW) disposal and particularly on the handling, disposal and possible reuse of ash produced by the incineration of MSW. While this is a continuing program, the current research is focused on the solidification and stabilization of municipal waste combustion ash (S/S). Phase I of the program, which is already in progress, is a demonstration of the technical feasibility of various methods of S/S and characterization of the short-term environmental behavior of the products of S/S.

The Science Advisory Board was asked to review the Municipal Waste Combustion Ash (MWCA) research program and assigned the review to the Environmental Engineering Committee (EEC). The EEC has established a MWCA Subcommittee, members of which are listed in this report.

The Subcommittee (MWCAS) has been charged with (a) a continuing review of the ORD MWCA research program, and (b) more immediately, consideration of two issues related to the current S/S demonstration. These two issues, considered at the initial meeting of the Subcommittee, were (1) the appropriate testing procedures to be applied to the S/S ash products and reuse products made from the S/S ash to determine the long-term environmental effects, and (2) appropriate methods of testing to determine the bioavailability and "biotoxicity" of S/S ash products.

The issues to be considered at the initial meeting were worked out during an August 17, 1989 teleconference between EPA personnel of the ORD and the Risk Reduction Engineering Laboratory (RREL) together with members and staff of the EEC. On September 18 & 19, 1989, the MWCA Subcommittee held its initial meeting in Washington, DC to review the current MWCA research program and consider the two issues of long-term effects and bioavailability/toxicity. The documents which had been made available to the Subcommittee and were reviewed by its members prior to that initial meeting are listed in Appendix C. During the meeting, the MWCAS was provided copies of the briefing materials used by Mr. Carlton C. Wiles of the RREL.

The ORD staff has organized a Technical Advisory Panel (TAP) consisting of approximately 26 experts from various agency and interested organizations and has used the group effectively in guiding the management decisions for the program. The Agency staff is to be complimented for their use of peer review for its research program.

3.0 LONG-TERM EFFECTS

The first issue the MWCAS considered had to do with the testing required to enable the prediction of long-term environmental effects of products made from MWC ash residue. The MWCAS made the following observations:

a. Any test routine used to predict long-term effects must apply to the behavior of various products of different ashes from different incinerators, produced by different S/S processes under both disposal conditions and for different reuses. A single-site assessment is not expected to be adequate to provide data which are applicable to the highly variable array of ashes from the many municipal combustion facilities.

The selection of an ash management practice, a S/S process, or use of ash products depends largely on ash characteristics. Ash (fly ash, bottom ash or combined ash) should be tested for quality and variability of the ash at several sites. The phase I program is limited to ash from a single site. Therefore, the results may not be broad enough to be applicable to the highly variable array of ashes from the many municipal combustion facilities.

The criteria for site selection should include data availability, such as the approximate waste input composition, the incineration system design and operating conditions, and the performance of the air pollution control device(s) used with the municipal waste combustor. Such data are valuable for understanding and managing the overall solid waste and incineration ash programs.

Tests to be used will depend on what products are being tested, what process was used to produce them, and what scenario is to be mirrored. The facility used to produce the ash, the air pollution control devices installed and the performance of the devices and the process by which the ash is treated for S/S should be identified and described. Fly ash will be the most difficult residue for which to predict long-term behavior, because that behavior will depend significantly on ash characteristics determined primarily by the combustion conditions and secondarily by the air pollution control devices which captured the ash.

Although present practice generally provides for combined ash disposal, the research should be directed toward evaluating S/S processes separately on fly ash and bottom ash, as well as combined ash. Certain S/S processes might very well be more applicable to either the fly ash or bottom ash long-term disposal problem.

b. Addressing long-term (and short-term) environmental behavior requires a fundamental understanding of geochemical reactions expected to cause the leaching and mobilization of chemicals contained in the residues. It is therefore recommended that the research plan focus on the solid phase, including identifying the original quantities, chemical species and physical forms of inorganic chemicals of interest. Furthermore, laboratory tests should be conducted to develop data for specifying the mechanistic basis that would quantitatively define the breakdown, the exposure of surfaces and resulting releases of the chemicals from the stabilized products.

To address long-term environmental behavior of products prepared by S/S of MWCA, the EPA ORD plans to carry out several laboratory tests and measure concentrations of chemicals in the aqueous extracts. These tests span from regulatory extraction tests (i.e., TCLP) to monolith leach tests for estimating diffusion-dominated transfer of chemicals into the aqueous phase. In addition to the leaching tests for untreated and treated MWCA, several physical tests will also be carried out. The scientific principles underlying the long-term behavior of chemicals in waste are intimately connected to dissolution reactions between solids and liquids. Therefore tests on the solid phases are needed in addition to leachate solution tests. An accurate understanding of these reactions and quantification based on data from laboratory experiments can provide a capability to predict release of chemicals from MWCA products.

Two options are available to address the science and the data needs for long-term predictions. The first approach is fundamental and provides a mechanistic understanding of applicable equilibrium and kinetic reactions; but it uses relatively short-term input data. The second approach is empirical and uses statistical correlations of short-term nature. However, the only realistic option to predict long-term behavior is the fundamental approach using models with good empirical and necessarily short-term input data. The EPA's current research plan appears to utilize the second approach. However, analysis of the data to be gathered through equilibrium speciation models ,such as MINTEQ and ECHEM (Appendix D, references 4 and 14) can offer insights into the applicability of the mechanistic approach to predicting leaching from the products of MWCA. The aqueous concentration measurements alone will not yield the understanding necessary for predicting long-term environmental behavior.

It is recommended that the research include an analysis of the solids for the explicit purpose of identifying quantities and types of solid phases of the inorganic chemicals of interest to the Agency. For a long-term behavior prediction, not only does one need to have a specific identity of solubility/dissolution reactions, but also one needs to know how much of the total amount of the chemicals would actually be available for leaching and how this relates to the receptor environment. One additional challenge in this research program is the ability to develop testing procedures and data for the mechanistic basis that would quantitatively define the breakdown and exposure of surfaces of the stabilized products.

c. There is a need to continually evaluate the effect of weathering and, for some reuse alternatives, the dynamic effect of abrasion and erosion, because the physical changes of the matrix may alter the rate of leaching of the resultant constituents from the matrix and also the mechanical integrity of the material.

The stability or mobility of the reuse products (such as for roads, construction and various beneficial uses in the energy industry) should continue to be evaluated both with and without weathering, abrasion, and erosion. The effect these processes have on the surface area, and the surface properties of the solid matrix must be considered. This reinforces the need for understanding both the chemistry of the aqueous phase and the physical and chemical nature of the solid matrix.

d. While mathematical transport and fate models may not be quantitatively predictive, they may still be useful for determining which contaminants warrant further study of their potential environmental impact, as well as for determining relative effectiveness of the various S/S treatment processes.

The Subcommittee questions whether existing models for transport and fate of contaminants in environmental media can be used to quantitatively predict the migration of chemical constituents from stabilized ash. Also, difficulty in estimating the rate of release of contaminants from the solid phase makes the input data for these models uncertain. Therefore, it is very doubtful that the prediction will provide the basis for reliable estimates of the exposure and health risk to target populations. Still, it is believed by the Subcommittee that some of the better transport models could be very useful in determining which contaminants are sufficiently mobile to warrant further study. These models might be used to analyze the data to indicate the relative effectiveness of the S/S treatment processes. If one cannot quantitatively estimate the mobility of chemicals leaching from the ash product, one might, at the very least, determine the relative mobility of

the constituents.

e. Better predictions of long-term behavior can be made for certain chemicals than for others. Chemicals should be identified and focused upon to fill data gaps.

The scientific basis for predicting the leaching of inorganic chemicals is incomplete for most trace elements. Although some of the major constituents (e.g., calcium and silicon) have well defined dissolution/precipitation chemistry, similar reliable foundation needs to be developed for a target set of trace elements. It is recommended that selected elements be chosen and research focused on the development of the data to fill the key data gaps hindering capability to accurately predict release of chemicals from residues or stabilized products.

Since this research is to fill data gaps on MWCA S/S products, there are many constituents which are being analyzed even though they may not be present in appreciable, or significant, quantities. Therefore, it is very important that appropriate data analyses be carried out on a real-time basis to identify as early as possible those chemical constituents that need to be focused upon.

f. The high salt content of MWCA could limit the long-term usefulness of concrete for reuse. Further examination of acceptable standards for allowable salt content of aggregate used for reinforced concrete is recommended.

There is need to evaluate impacts of various chemical species (e.g., sodium, potassium, calcium, zinc and chloride) on the integrity of portland-cement concrete in those cases where the proposed reuse of the stabilized ash is by incorporation into concrete. Especially in the case of reinforced concrete products, where the reinforcing steel is susceptible to electrolytic corrosion in the presence of these ions, there is a serious need to avoid leachable salts. These species may also affect properties related to mechanical fracture and embrittlement.

Standards have been established for allowable chloride content of aggregate used for reinforced concrete. The Agency should consult with the various sources of potentially useful information. For instance, the Highway Research Board, concrete manufacturers, trade association standards (such as ASTM Designation: C618-89 or ASTM Designation: C311-88) and agencies such as the Bureau of Reclamation or the U.S. Army Corps of Engineers should be consulted concerning allowable salt content, as well as other specifications that may be of concern when ash is incorporated in concrete.

g. If microbial activity shifts the pH or the oxidation-reduction potential (Eh), the solubility of toxic metals can change. The effects of microbial activity should be included in the assessment of long-term performance.

Microbial activity may be supported by organic matter in the ash products, or, more likely, in the milieu surrounding the ash product in its place of use or in a monofill. If the stabilized ash is used for highway base and is in contact with organics-rich soil, microbial activity may change the pH or Eh. If MWC ash is disposed in a monofill, the organic matter in the ash may support some microbial activity, but it is more likely to be an inorganic interaction phenomenon. Long-term environmental performance assessment should take these possible changes into consideration when studying the solubility of metals.

h. The tendency of the ash matrix to swell upon adsorption of moisture may have long-term adverse effects on some uses of the stabilized product. Tests should incorporate this phenomenon in the evaluation procedure.

There is a need for incorporating some test in the evaluation procedure to obtain an indication of expected swelling due to the hygroscopic nature and surface features of the ash mixture. Many road base and sub-base construction requirements cannot tolerate large amounts of ash or S/S ash products because of this hygroscopic property and the numerous freeze-thaw cycles.

4.0 BIOAVAILABILITY/TOXICITY

The Subcommittee was also asked to comment on possible tests to evaluate the toxicity and bioavailability of MWCA S/S products.

a. The committee recommends that the potential for toxicity and bioavailability of MWCA S/S be examined as separate phenomena.

Bioavailability can be demonstrated by measuring the uptake of the chemicals of interest into organisms. Alternatively, when exposed organisms respond with physiological or pathological changes, then by implication the compounds or some ingredients of the mixture have been demonstrated to be toxic.

Existing laboratory methods are adequate to examine many aspects of bioavailability in animals and plants under standardized conditions (Appendix D, reference 26). However, the applicability of these methods to complex situations, such as the bioavailability of substances in amended soils to plants and animals, will require validation of existing tests or the development of new

methodologies.

b. Bioassays, like chemical analyses, are only tools in the assessment of the potential environmental impact of disposal and reuse alternatives.

From the information received by the MWCAS, it is clear that at present the potential roles of various forms of biological testing for the assessment of ashes and ash products are still poorly defined. The Agency appears to champion the position that bioassay results can be used directly to assure the public that appropriate policy decisions are being made. However, bioassays are no more than tools in such assessments. The most important aspects in the use of these tools are the specific applications and the proper interpretation of the results.

Sometimes the most difficult decisions relate to when bioassays are the most appropriate tools to use, given the expense and difficulties in interpretation of many bioassay results. Thus, to date it has not been found to be necessary to conduct bioassays or risk assessments on other recycled resources, such as glass, paper, and aluminum cans.

From a technical point of view alone, a number of issues need to be considered to evaluate the desirability of biological testing. In toxicity studies the responses of organisms, specific organs, or cellular components are measured in relation to exposures to specified concentrations of compounds or mixtures of compounds, preferably at a graded series of concentrations. Each biological test has specific strengths and specific limitations, because such tests are in fact model systems where each test examines only a specific aspect of the "real world" conditions. Biological systems incorporate a complex system of chemical and physical phenomena, and therefore the interpretation of tests done on biological model systems is exceedingly complex. In any event, bioassays need to be supplemented by leaching tests and models to predict exposure conditions likely to be encountered in the real-world environment.

c. No single bioassay procedure can adequately assess the biological effects of residue reuse and/or disposal alternatives.

Should it be found to be necessary to conduct bioassays because potential exposures derived from MWCA S/S materials are deemed to be high, then no single bioassay procedure exists that will adequately demonstrate the multiple toxicological end-points that could potentially occur. This will require a battery of bioassays using a range of test species. Ancillary problems include the great variability of components in the ash, and differences in the physical characteristics of the ash that will

ultimately affect the biological availability of such components.

d. While limited in scope, bioassays can be used effectively for making relative comparisons of the toxicities of leachates derived from various ashes and products derived from MWCA.

Bioassays in their broadest sense are tools that can be used for many purposes. Among these are evaluations of comparative toxicities of leachates derived from various ashes and various products of ashes. Such evaluations are much more limited in scope, but can assess the interacting effects of components in mixtures within the limitations of the specific bioassay procedures utilized. Such studies can be relatively inexpensive and can be used as an adjunct to chemical analyses.

e. It is important to establish (as a baseline) the background bioavailability of the constituents of interest for the environment into which the S/S MWCA products are to be utilized.

Absent any credible baseline information, expected perturbations to the ambient environment due to S/S MWCA constituents cannot be established. The assessment of potential risks associated with ash and products derived from ash needs to be compared with an assessment of the background concentrations of the same compounds that may already be present due to natural sources or due to normal human activities. This approach is encouraged as an adjunct activity, because comparative risk assessments have a much firmer scientific basis than absolute risk assessments.

f. Another approach is to base the approval of reuse and disposal alternatives on confirmation that the leachate from S/S products meet some multiple of drinking water standards or water quality criteria.

If realistic methods could be developed which produce conditions similar to those produced under "real world" conditions, then a comparison of the contaminant concentrations found in the leachates with published water quality criteria and drinking water standards would allow an initial evaluation of the relative toxicity for the protection of aquatic life and human health. The Agency does have considerable information on bioconcentration, and this phenomenon has been made an integral part of the present water quality criteria. It should be noted that the bioconcentration issue has been found to be important for highly hydrophobic organic chemicals, but is generally not important for inorganic chemicals, with a few notable exceptions (e.g., mercury).

5.0 OTHER RELATED ISSUES

a. The Subcommittee is concerned that the level of funding for the municipal waste combustion ash research program may be inadequate.

It is estimated that at present there are approximately 200 municipal waste incinerators in operation or under construction and that over 100 municipal waste incinerators are under procurement or in the planning stages. The construction cost of each is in the range of tens of millions to several hundreds of millions of dollars. This represents a national investment of perhaps $17 billion (See Appendix D, references 29 and 30 and note below). Each of these 200 municipal waste incinerators is facing the problem of what to do about its ash residues. The over 100 municipal waste incinerators yet to be built will also face these same problems with the ash residues. The estimated ORD budget for the Phase I S/S research program is less than $1 million. It seems inadequate that only 0.006 percent of the Federal component of the public investment is being devoted to solution of the ash disposal problem within the ORD budget.

At its initial meeting, MWCAS heard presentations from persons associated with state agencies and academic institutions in New York and in Florida. It was learned that these states are each devoting more financial resources to MWCA research than is EPA. The Agency should continue to leverage funding its research programs with state and private entities.

We recommend that funding for MWCA research be reviewed for adequacy in light of the above. We also recommend that the Agency track significant federal, state, municipal, and private sector activities in municipal waste combustion.

NOTE: Personal communication of March 20, 1990 Between Mr. Steven Levy of the USEPA Office of Solid Waste with Dr. K. Jack Kooyoomjian of the Science Advisory Board staff.

Facilities	Number	Combined Total Capacity (Tons/Day)	Approx. Cost To Construct Per Ton Capacity	Approx. Total Construction Cost(Billions)
In Operation	167	91,705	$75,000	$6.9
Under Construction	39	40,586	$100,000	$4.06
Under Procurement	63	56,086	$125,000	$6.26
In Planning Stages	51	---	---	---
				Total = $17.22

b. The municipal waste combustion ash research should emphasize front-end prevention instead of back-end treatment.

MWC ash quality is the key to proper ash disposal or reuse that affords adequate protection to the environment. Ash quality differs among fly ash, bottom ash, and combined ash. It varies with input waste characteristics, design and operating conditions of an incinerator, and to some extent to the air pollution control device used. Obtaining a good knowledge of highly varying ash quality could be difficult and costly. However, if undesirable chemical or consumer products in the waste can be prevented by front-end removal activities, then the quality of ash could be improved for either disposal or reuse without exceeding environmentally acceptable levels or performance specifications for ultimate use end-products.

c. Potential risks associated with ash disposal should be compared with risks associated with alternative municipal solid waste disposal options.

The risks inherent in municipal waste incineration, including the ancillary risks due to disposal of residuals from incineration, are receiving a great deal of attention by the public and the Agency. In many ways the concerns seem to be on a mutually reinforcing spiral. The anticipation appears to be that all aspects associated with the incineration process would be free of health risks. At the same time it is clear that other legitimate solid waste disposal management options for the handling of municipal waste, such as recycling and landfilling, have not received the same level of scrutiny as ash disposal options. This appears to be due to a lack of data and due to preconceived notions that these processes are relatively free of risks so that they do not merit investigation. This sentiment may be misplaced and may lead to inappropriate actions relating to the minimization of risks associated with waste disposal options.

APPENDIX A - THE CHARGE TO THE SUBCOMMITTEE

Based on materials submitted to MWCAS and conference with Agency personnel, the following charge for the Subcommittee evolved:

a) continuing review of the ORD MWCA research program, and

b) consideration of two issues related to the current S/S demonstration. These two issues, considered at the initial meeting of the Subcommittee, were (1) the appropriate testing procedures to be applied to the S/S ash products and reuse products made from the S/S to determine the long-term environmental effects, and (2) appropriate methods of testing to determine the bioavailability and "biotoxicity" of S/S products.

APPENDIX B - GLOSSARY OF TERMS AND ACRONYMS

ASME-	AMERICAN SOCIETY OF MECHANICAL ENGINEERS
EEC-	ENVIRONMENTAL ENGINEERING COMMITTEE OF THE SCIENCE ADVISORY BOARD
ECHEM-	EQUILIBRIUM CHEMISTRY (GEOCHEMICAL COMPUTER CODE FOR SPECIATION OF INORGANIC CHEMICALS)
Eh-	OXYGEN-REDUCTION POTENTIAL
EPRI-	ELECTRIC POWER RESEARCH INSTITUTE
EPA-	U.S. ENVIRONMENTAL PROTECTION AGENCY
MINTEQ-	A COMBINATION OF TWO EQUILIBRIUM GEOCHEMICAL COMPUTER CODES (MINERAL EQUILIBRIUM CODE (MINTEQ) AND SPECIATION CODE (WATEQ3) FOR SPECIATION OF INORGANIC CHEMICALS)
MITE-	MUNICIPAL INNOVATIVE TECHNOLOGY EVALUATION
MSW-	MUNICIPAL SOLID WASTE
MWCA-	MUNICIPAL WASTE COMBUSTION ASH
MWCAS-	MUNICIPAL WASTE COMBUSTION ASH SUBCOMMITTEE
NTIS-	NATIONAL TECHNICAL INFORMATION SERVICE
ORD-	OFFICE OF RESEARCH AND DEVELOPMENT OF THE U.S. EPA
OSW-	OFFICE OF SOLID WASTE OF THE U.S. EPA
pH-	THE NEGATIVE LOG OF THE HYDROGEN ION CONCENTRATION
RREL-	RISK REDUCTION ENGINEERING LABORATORY OF THE U.S. EPA
SAB-	SCIENCE ADVISORY BOARD OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY
S/S-	SOLIDIFICATION/STABILIZATION
TAP-	TECHNICAL ADVISORY PANEL
TCLP-	TOXICITY CHARACTERISTIC LEACHING PROCEDURE

APPENDIX C - INITIAL REVIEW DOCUMENTS

Item 1: A copy of the Request for Participation that has been sent to potential participants. This document describes the S/S program, but concentrates on Phase I. This document also includes tables of tests and analyses proposed for characterizing and evaluating the untreated and treated residues.

Item 2: A list of members of the Technical Advisory Panel (TAP) which was established to assist in the selection of tests and analyses to be used, evaluation of potential processes for including in the program, evaluation of data and similar aspects of the program. This panel was considered necessary to have a program that is credible to state and local authorities likely to implement potential processes, as well as the public.

Item 3: A copy of cost estimates prepared for conducting Phase I. This estimate was prepared by a small sub-group of the TAP.

Item 4: Several items of information which provide background on the generation of the program and previous activities. These include a letter from Carlton C. Wiles to the TAP,a letter from Carlton C. Wiles to John H. Skinner dated Oct. 27, 1988 describing the S/S program, and a letter from Wiles to Skinner dated March 4, 1988 submitting a proposed plan for the S/S program.

Item 5: A description of the Municipal Innovative Technology Evaluation (MITE) program. The MWC Ash S/S program is now being considered a MITE prototype.

Item 6: Some issues which will or may affect the conduct and outcome of the program.

Item 7: A letter from Wiles to Kooyoomjian dated June 5, 1989 identifying other questions/issues on which MWCAS could focus.

APPENDIX D - RESOURCE MATERIAL

1) ASME White Paper on Research Needs for Municipal Waste Combustor Residue Management, 1988, 10 pages

2) ASTM, Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete, Astm Designation c618-89, pages 296-298

3) ASTM, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete, Astm Designation C311-88, pp. 185-189

4) Battelle Pacific Northwest Laboratory, FASTCHEM™, Package, Volume 4, User's Guide to the ECHEM Equilibrium Geochemistry Code, EPRI Report Number EA 5870-ccm, September 1988

5) Baumeister, T. ed., Standard Handbook for Mechanical Engineers, McGraw-Hill Book Company, New York, 1978

6) Briefing by EPA's ORD Staff entitled "Municipal Waste Combustion Ash Solidification/Stabilization Program'" dated Sept. 18-19, 1989, 22 pages

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