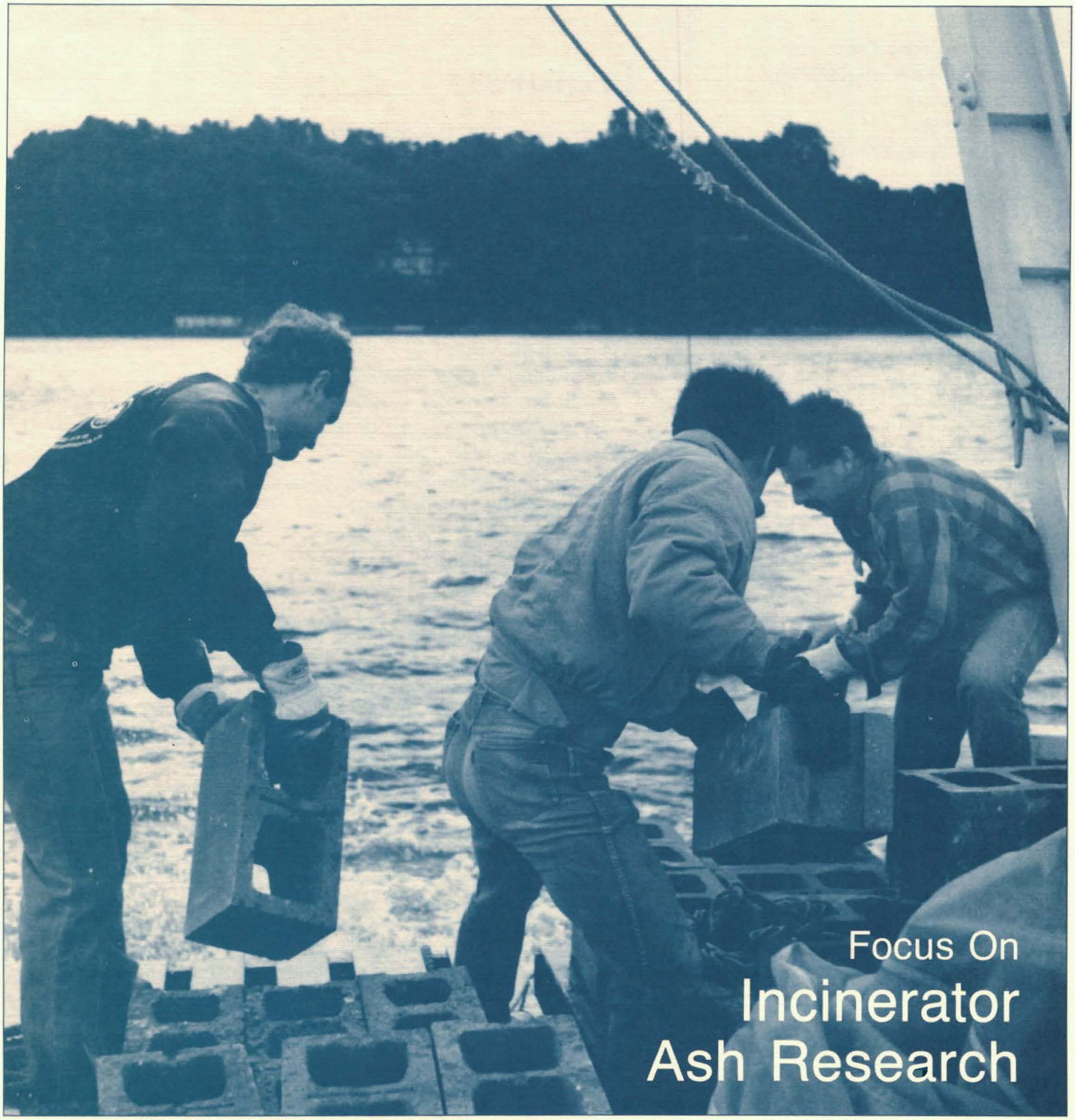
waste management research Report

News from State University of New York at Buffalo and Stony Brook, and Cornell University

Vol. 1, No. 2 Spring 1989



Waste Management Research Report

Vol. 1, No. 2 Spring 1989

Research news coordinated through:

The New York State Center for Hazardous Waste Management

Executive Director
Dr. Ralph Rumer
State University of New York at Buffalo
207 Jarvis Hall
Buffalo, New York 14260
(716) 636-3446

ESF Coordinator
Dr. Helmuth Resch
State University of New York
College of Environmental Science and Forestry
Syracuse, New York 13210
(315) 470-6606

Waste Management Institute

Director
Dr. R. Lawrence Swanson
Marine Sciences Research Center
State University of New York at Stony Brook
Stony Brook, New York 11794
(516) 632-8704

Cornell Waste Management Institute and the New York State Solid Waste Combustion Institute

Director
Dr. Richard Schuler
Center for Environmental Research
Cornell University
468 Hollister Hall
Ithaca, New York 14853
(607) 255-7535

Editorial Offices:

123 Bray Hall
SUNY College of Environmental Science and Forestry
Syracuse, New York 13210
(315) 470-6644

Editor
Louise W. Laughton

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About This Newsletter

Waste Management Research Report appears three times per year in order to share research results from the publication's contributing institutions. Each issue will focus on one major area of concern in the field of waste management and will highlight the contributing institution where researchers devote their efforts to the featured topic.

The Waste Management Institute, Marine Sciences Research Center, State University of New York at Stony Brook, is responsible for this *Report*, which focuses on incinerator ash. The New York State Center for Hazardous Waste Management, State University of New York at Buffalo, will be responsible for the fall, 1989, issue, which will focus on bio-degradation.

August 3 is the deadline for submitting articles for the fall issue. Please include black-and-white glossy photographs with article submissions, as well as a head-and-shoulders photograph of each author, also black-and-white glossy. August 10 is the deadline for submitting fall news briefs and announcements. Mail all material to Louise W. Laughton at the editorial office address.

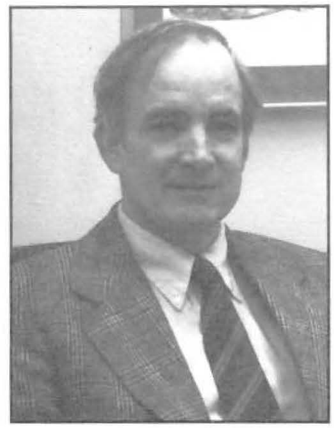
On the Cover

Blocks containing stabilized incinerator ash are placed in Long Island Sound during construction of an artificial reef.

Director's Comment

Residuals Management Needs "Holistic" Decision Process

By R. Lawrence Swanson



R. Lawrence Swanson

Effective residuals management remains an elusive goal. Those of us who live in the New York—New Jersey metropolitan area are constantly reminded that we have degraded our environment to unacceptable levels. Air quality standards are exceeded, ground water is polluted on Long Island, significant portions of the Hudson River are polluted as we face a pending drought, and our estuarine and coastal waters are some of the most degraded in the United States.

These conditions are a consequence of unthoughtful development practices and our inattention and inability to deal with wastes. Where is the most appropriate place to put residual wastes? Ultimately, we can put these materials in three media—the air, the land, the water. How do we make these decisions?

The National Advisory Committee on Oceans and Atmosphere (NACOA) in 1981, in a report entitled, "The Role of the Ocean in a Waste Management Strategy," emphasized that the medium selected to receive waste is generally the one least regulated—not the one that would result in the least environmental harm. The ultimate consequence of this process is that decisions about residuals management are biased by "the regulation."

Recent actions that ruled out specific media for receiving wastes include the closures of most landfills on Long Island by December, 1990, passage of the Ocean Dumping Ban Act, and the decision by the U.S. Environmental Protection Agency (EPA) to forego ocean incineration.

In the case of the Ocean Dumping Ban Act, Congress legislatively requires an end to dumping of sewage sludge in the ocean by 1991. Municipalities in the New York City area are exploring alternatives that include landfilling and incineration. This is despite the fact that our air quality is poor and our drinking water is deteriorating in quality and quantity. Perhaps to some, there is the solace that some sludge may be shipped to neighboring states. It is appropriate to ask, "Have we made a wise decision? Are we deriving the greatest environmental benefit for an affordable price?"

There are several important marine environmental investigations being undertaken under the leadership of EPA and in cooperation with other federal agencies and the states. These include the Long Island Sound Study, the New York—New Jersey Harbor Estuary Program, and the New York Bight Restoration Plan. Each have admirable goals of preserving and restoring particular marine systems. However, how will the mechanisms for improving each of the marine systems impact the others? Also, what are the implications of proposed restoration measures to the air we breathe and the land we inhabit?

Holistic or multimedia residuals management makes sense to nearly everyone. But our common failures to do it result from how we have traditionally approached these management questions. Academic programs provide training

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R. Lawrence Swanson is director of the Waste Management Institute of the Marine Sciences Research Center, State University of New York at Stony Brook.

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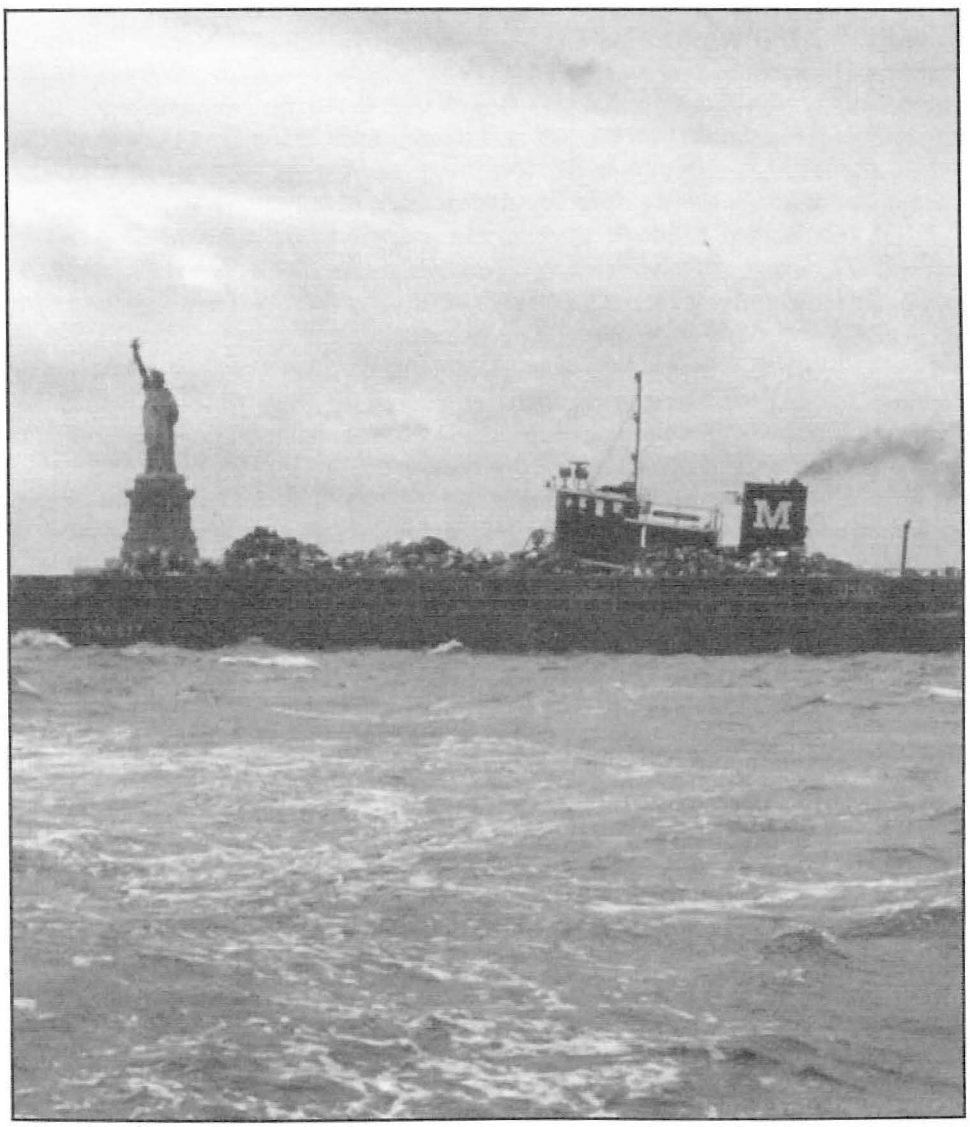
in terrestrial ecology, marine sciences, and atmospheric sciences. Agencies responsible for management of environmental resources and for developing and implementing waste regulations dealing with wastes are generally organized along similar lines. The Congress, which writes our environmental laws, is perhaps even more segmented. Committees and subcommittees often deal with specific media and with specific agencies. Environmental groups are often concerned only with air, water, land, or specific regions.

The notion of multimedia assessment is not new; however, it is not clear that much is being done to embrace it. Perhaps less is being done to establish mechanisms for implementing results of these multimedia assessments.

The academic community is in a good position to help assure that the multimedia approach to residuals management is undertaken. Of course, much must be done through research. However, it is equally important that the need for such assessments is emphasized through the various educational and outreach components of the university as well. In particular, even though the three institutes dealing with waste management in New York State were created and funded to undertake specific missions, there is an opportunity to pool our resources and expertise to address the broader issue of holistic multimedia assessment.



Correction:

The picture at right ran in the Winter, 1989, issue of this publication with the implication that municipal solid waste is dumped at sea. The practice, in fact, ended in 1934. The laden barge in the photograph is transporting municipal solid waste from New York City to the Fresh Kills landfill on Staten Island.

Stabilized Incinerator Ash Tested in Construction of Artificial Reef

By F. J. Roethel and V. T. Breslin

The subject of ash disposal from waste-to-energy plants is vitally important to the industry. The Marine Sciences Research Center has found that blocks made from incinerator ash and cement may be safely used to construct reefs which attract marine life.

As more communities turn to waste-to-energy facilities to help solve their solid waste disposal problems, the amount of ash created by these facilities increases. Incineration of solid waste produces particulate residues which are often rich in lead, cadmium, copper, and zinc because of the concentration which occurs as a result of reduction. It has been shown that such metals can sometimes be leached from ash residues, giving rise to special concerns that incineration ash be disposed of in an environmentally acceptable manner.

In urban coastal areas where landfills are few and increasingly distant, ocean disposal of stabilized incineration residues (SIR) may provide an acceptable alternative to current landfill practices. Previous studies have demonstrated that the stabilization of combustion residues (coal fly ash, oil ash) using additives (lime, sodium carbonate, Portland cement) can be used to produce solid blocks that are environmentally acceptable in the sea.

In May, 1985, a research program was initiated at the Marine Sciences Research Center to examine the feasibility of utilizing SIR for artificial-reef construction in the ocean. Results of these studies showed that particulate incineration residues could be combined with cement to form a solid block possessing physical properties necessary for ocean disposal.

The stabilized residues were subjected to regulatory extraction protocols (E.P. Toxicity and TCLP), and in no instance did the metal concentrations in the leachates exceed the regulatory limits for toxicity. Bioassays revealed no adverse effects on the phytoplankton communities exposed to elutriate concentrations higher than could be encountered under normal disposal conditions. The success of the laboratory studies resulted in securing the necessary permits for placing an artificial habitat, constructed using SIR, in coastal waters.

Dr. Frank J. Roethel is an Assistant Research Professor and Dr. Vincent Breslin a Senior Research Scientist at the Waste Management Institute, Marine Sciences Research Center, State University of New York at Stony Brook.

Frank J. Roethel

Vincent Breslin

Ash Samples

Incineration residues for block making were collected from the Westchester Resource Recovery Facility, Westchester County, NY, in November, 1986. Combined ash, a mixture of bottom ash and fly ash, was collected. Prior to making the blocks, the combined ash was sieved to particle sizes less than three-eighths of an inch. The larger particles were crushed with a jaw-crusher and resieved. Screening was necessary to prevent large particles from damaging the block-making equipment.

Block Production

Block manufacturing was conducted in December, 1986, at the research facilities of the Besser Company at the Alpena Community College, Alpena, Michigan. Block fabrication employed conventional block-making machines currently used by the industry.

The block mix components (combined ash, crushed ash, and Portland Type II cement) were fed in weighed amounts from hoppers into a mixer. Water was then added to adjust the moisture content of the mix. The mix formulation consisted of 63.8 percent combined ash, 21.2 percent crushed ash, and 15 percent Portland Type II cement, with a total mix moisture content of 10.2 percent. The well-mixed materials were then fed into the loader of the block-making machine.

A block-making machine uses vibration and pressure to mold the mixture into blocks. The block mold (8-by-8-by-16 inches, hollow core), rests on a steel pallet during the molding process, and the material is fed into the mold box by vibration. Shoes then descend on top of the mold to exert pressure, and a second cycle of vibration

Continued on page 4

Reef Construction

Continued from page 3

begins as the mold consolidates the material into blocks. After compaction, the mold lifts, and the pallet holding the block emerges from the machine while a new pallet is pushed under the mold box for the next molding cycle. The pallets of blocks are loaded on racks and cured in steam kilns. Blockmaking is fast: a block machine can process 30 tons of material per hour.

Reef Placement

The "Narrows" region of Conscience Bay, Long Island Sound, NY, was selected as the site for the in situ investigations of the interactions of SIR with the marine environment. Conscience Bay is a small embayment immediately west of the Port Jefferson Harbor channel on the northern shore of Long Island (Figure 1). Tidal currents within the "Narrows" can exceed 6 mph. As a result, the sediments of Conscience Bay at the reef site are predominantly composed of poorly-sorted gravel and coarse sand. The water temperature within Conscience Bay varies from 32 to 76° F.

On April 27-28, 1987, stabilized incineration residue blocks (SIRBs) and standard cement blocks were submerged in about 26 feet depth (mean high tide) in Conscience Bay. They were arranged underwater to produce two separate structures, one from SIRBs and the other from cement blocks, approximately 5 feet apart (Figure 1). Each reef was designed to maximize the surface area exposed to seawater and to provide numerous crevices to facilitate biological colonization.

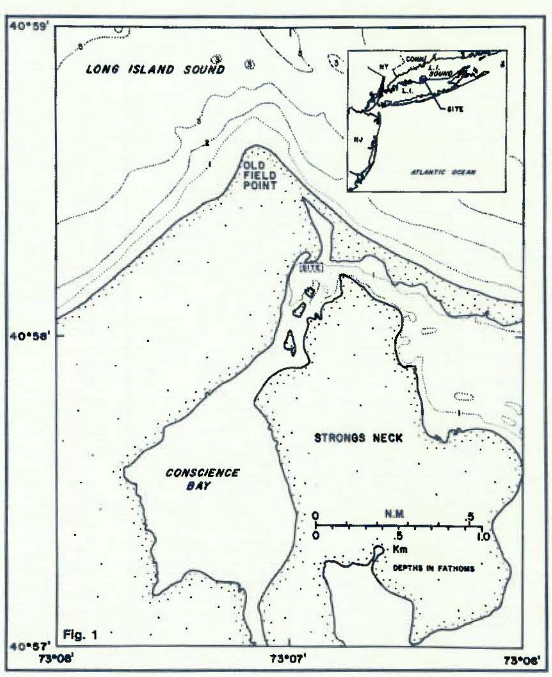
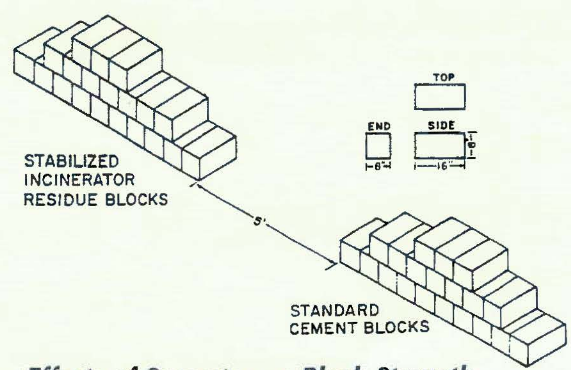


Fig. 1



Effects of Seawater on Block Strength

One day, net unconfined compressive strengths of the blocks fabricated in Alpena, MI, averaged 697 psi which after 28 days of air curing increased to 1118 psi. Details of the physical properties of the blocks are given in another paper (Roethel et al., 1987). These values far exceed the minimum unconfined compressive strength criteria of 300 psi necessary for marine disposal of stabilized products.

SIRBs destined for reef construction were placed in flow-through sea tables at the Flax Pond Laboratory during January, 1987, to determine the change in unconfined compressive strengths of the blocks due to prolonged seawater exposure. Results of these tests show that the strengths of the SIRBs increased with increasing seawater exposure. As of January, 1988, after 358 days of seawater exposure, the strengths had increased from 985 psi to 1372 psi.

After placement in Conscience Bay in April, 1987, both SIRBs and cement blocks were periodically retrieved from the reef site for unconfined compressive strength testing. Blocks were last retrieved during May, 1988, and results show that after 380 days of seawater exposure, the strengths of SIRBs remained constant at 1103 psi. The strength of the cement blocks, by comparison, decreased from 1087 psi to 779 psi after 380 days of seawater exposure.

Elemental Composition of SIR

For the purpose of classification, major elements are defined as those elements present in concentrations greater than 1 milligram; minor elements are those in the range 1 milligram to 100 micrograms; and trace elements are those present in concentrations less than 100 micrograms.

Major elements found in both combined residues and crushed residues include silicon, aluminum, iron, zinc, lead, and copper (Table 1). Chromium was present in the residues in minor amounts and cadmium was present in trace amounts.

The elemental composition of stabilized residue blocks generally reflect the composition of the 3:1 mix ratio of the combined and crushed particulate residues (Table 1). However, due to the presence of Portland Type II cement, the metal content of the stabilized blocks is slightly less than the metal content of the particulate residues.

Major elements in the stabilized residues include calcium, magnesium, sodium, potassium, aluminum, silicon, iron, lead, zinc, and copper (Table 2). Manganese and chromium were present in minor amounts, and cadmium was present as a trace component.

Effects of Seawater Exposure

Analyses of the elemental composition of blocks submerged in Conscience Bay were performed to detect any release of block components to the surrounding seawater and to identify chemical reactions that take place within the blocks that could effect their success in the marine environment.

Of the 13 metals analyzed, only an enrichment of magnesium and a depletion of potassium in the submerged SIRBs was observed when compared to the corresponding metal content of the unsubmerged SIRBs (Table 2).

Magnesium enrichment in stabilized waste products exposed to seawater has been observed in both laboratory and field studies. Brucite formation and ion exchange processes may account for the observed magnesium enrichment in SIRBs.

Precipitation of brucite [$Mg(OH_2)$] has been observed in the pore spaces of both SIRBs and coal waste blocks after prolonged seawater exposure. The equilibrium pH of brucite in seawater is 9:55. The estimated pore water pH of the residue blocks was shown to exceed pH 11.0,

Table 1 Elemental Composition of Particulate Incineration Residues

Element	Combined Ash[1]	Crushed Ash[2]
Silicon (%)	18.90	19.80
Aluminum (%)	5.53	4.11
Iron (%)	8.00	19.50
Copper*	2,240	1,710
Manganese*	1,330	1,420
Zinc*	5,520	2,030
Lead*	3,960	4,450
Chromium*	207	400
Cadmium*	37.50	10.00

[1] Initially passed through 3/8" sieve
[2] After crushing passed through 3/8" sieve
* Micrograms per gram

which may result in the removal of magnesium from seawater via the precipitation of the magnesium hydroxide (brucite).

Another mechanism which may contribute to the enrichment of magnesium in the SIRBs is the exchange of magnesium for calcium in calcite resulting in high magnesium calcite on the surfaces of the blocks. X-ray diffractograms of coal waste material exposed to seawater consistently showed a shift in the main calcite (211) peak, which indicates some substitution of magnesium for calcium in the calcite.

Potassium is a major element in the SIRBs, and a decrease in the potassium concentration was observed in the submerged blocks (Table 2). Potassium loss was also observed in stabilized

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Table 2 Elemental Composition of SIRBs Submerged in Seawater

Metal	Unsubmerged Block (0 Days)	Submerged Block (165 days)	Submerged Block (380 days)
Calcium (%)	15.70	15.93	14.27
Magnesium (%)	1.13	1.41	1.44
Sodium (%)	2.39	2.34	2.37
Potassium (%)	0.82	0.69	0.63
Aluminum (%)	4.17	4.15	4.44
Silicon (%)	16.76	16.73	16.95
Iron (%)	7.25	6.60	7.03
*Lead	3,580	3,520	3,550
*Zinc	3,760	3,838	4,090
*Chromium	178	200	193
*Copper	1,260	1,560	1,400
*Manganese	1,020	969	1,100
*Cadmium	23.60	24.50	26.20

* Micrograms per gram

Table 3 Elemental Composition of Attached Reef Biomass

Element	Collection Date	Concrete Block[a] (X_c)	Reef Block[a] (X_r)	ANOVA[b] Result
Al (%)	8/25	0.82 (0.09)	0.76 (0.08)	ns
	9/11	0.83 (0.01)	0.80 (0.08)	ns
Fe (%)	8/25	1.52 (0.09)	1.45 (0.05)	ns
	9/11	1.54 (0.09)	1.51 (0.03)	ns
Pb (ug/g)	8/25	35.3 (2.6)	34.4 (0.8)	ns
	9/11	36.8 (1.1)	36.1 (2.0)	ns
Zn (ug/g)	8/25	174 (7.8)	173 (9.2)	ns
	9/11	184 (15)	187 (6)	ns
Cr (ug/g)	8/25	31.2 (1.7)	30.4 (1.0)	ns
	9/11	34.6 (2.1)	35.1 (1.6)	ns
Cu (ug/g)	8/25	57.2 (4.0)	60.8 (1.5)	ns
	9/11	65.3 (4.7)	67.0 (4.8)	ns
Mn (ug/g)	8/25	4970 (300)	4610 (400)	ns
	9/11	7040 (450)	6790 (200)	ns
Cd (ug/g)	8/25	0.44 (0.04)	0.41 (0.04)	ns
	9/11	0.51 (0.04)	0.53 (0.04)	ns

a Data shown are the means and standard deviations of replicate analysis of samples collected on 25 August and 11 September, 1987. For 8/25 concrete block n=7; 8/25 reef block n=8; 9/11 concrete block n=4; 9/11 reef block n=7.

b The hypothesis H_O:$X_c = X_r$ was tested for each metal on each date using a single classification analysis of variance (Sokal & Rohlf, 1969), where X_c and X_r are the mean metal concentrations measured on replicate analyses of samples obtained from concrete and incineration residue block surfaces, respectively.

ns indicates no significant difference observed.

Reef Construction

Continued from page 5

coal waste blocks with prolonged seawater exposure. The loss of potassium may be due to soluble potassium compounds in the SIRBs.

The metals of environmental concern, lead, chromium, copper, zinc, and cadmium, were effectively retained within the SIRBs (Table 2). The high alkalinity of the particulate residues, the Portland Type II cement additive, and the alkalinity of the seawater combined to create a favorable environment within the blocks for the retention of metals.

The estimated pore water pH of the SIRBs in seawater exceeds pH 11.0. The high alkalinity within the SIRBs favors the formation of metal precipitates such as lead hydroxides and copper carbonates. Incineration residues are also rich in iron and manganese which form hydrous oxide phases at high pH, resulting in the adsorption or coprecipitation of other metal ions in solution.

Cement is not only an important additive for block strength development, it may also act to reduce metal leaching. Portland cement has been demonstrated to contribute to the effective retention of metals within stabilized waste blocks.

Biological Colonization

Diver and photographic surveys were conducted to document the organisms colonizing the two reef structures. Both reef structures were colonized rapidly, with hydroids attached to all sides of the reef structures within six weeks of placement. As the summer progressed, bryozoan colonies replaced the hydroids as the dominant species growing on the surfaces of the reef structures. In addition, the reef structures attracted several fish species. Blackfish, cunner, and winter flounder were commonly observed in and around the reef sites, and silversides, toadfish, and killifish were also seen.

Attached Reef Biomass

To determine if the attached biomass was accumulating metals as a result of association with the SIRBs, samples of the hydroids Tubularia sp. and Sertularia sp. were removed from both the SIRBs and the cement blocks on August 25 and September 11, 1987. The digested tissue was analyzed for aluminum, iron, lead, zinc, chromium, copper, manganese, and cadmium (Table 3). Hydroids were chosen for these studies since these organisms attach themselves to the surfaces of the blocks and are the dominant

Methods of Analysis

Acid Digestion of Incineration Residues

Samples of the combined and crushed residues were oven dried at 230° F, ground using a mortar and pestle, and sieved to obtain a powder of less than 425 microns.

Samples of the SIRBs, both retrieved from Conscience Bay and those not exposed to seawater, were analyzed for metals. Side sections (over 800 grams) of the blocks were broken with a hammer and chisel. The exposed surfaces of the submerged blocks were carefully scraped to remove the attached biomass while minimizing the removal of any of the block surface. The block sections were then ground with a mortar and pestle, oven dried at 230° F for 24 hours, and sieved to a particle size of less than 425 microns.

Samples (0.500 gram plus or minus 0.001 gram) were placed into a 125 milliliter HDPE bottle, followed by the addition of 10 milliliters of distilled-deionized (DID) water. After the addition of 10 milliliters of concentrated Ultrex HF, the mixture was mechanically shaken for 24 hours. Then 70 milliliters of saturated (120° F) H_3BO_3 solution were added. The mixture was shaken for an additional 24 hours. The digests were then filtered through a 0.40 micron Nuclepore membrane filter and transferred into 100 milliliter volumetric flasks. The volume was adjusted to 100 milliliters with DID water.

The digests were then analyzed by flame atomic absorption spectrophotometry (AAS) for calcium, sodium, potassium, magnesium, iron, zinc, copper, manganese, lead, cadmium (air- acetylene), and aluminum, silicon, chromium (nitrous oxide-acetylene).

Acid Digestion of Biomass Materials

Divers periodically removed the biomass material from both the concrete and the incineration residue blocks. The samples were primarily composed of hydroids, Tubularia sp., and Sertularia sp. and were carefully removed in situ with plastic scissors to avoid removing any block material along with the biomass. Biomass samples were then placed into acid-washed plastic bottles and returned to the laboratory. Once in the laboratory, the samples were rinsed with DID to remove salts and particles adhering to the organisms and freeze-dried for 24 hours.

Freeze-dried biomass samples were ground to a fine powder using a mortar and pestle. Samples (0.500 gram plus or minus 0.001 gram) of the powdered tissue were transferred into 125 milliliter Erlenmeyer flasks and covered with a watch glass. To these samples, 10 milliliters of Ultrex HNO_3 were added and the samples were allowed to digest at room temperature for two hours, followed by digestion at 140° F on a hot plate for four hours. The samples were removed from the heat and allowed to stand overnight. The samples were again heated to 140° F on the hot plate, then filtered hot through Whatman No. 42 ashless filter paper into 100 milliliter volumetric flasks. The samples were brought to volume with DID water.

The digests were analyzed by flame AAS for aluminum (nitrous oxide-acetylene), iron, manganese, zinc, and copper (air-acetylene). Graphite furnace AAS was used for the analysis of chromium, lead, and cadmium.

organisms present during these sampling periods. The hydroids also serve as a food source for other members of the reef community.

A one-way analysis of variance was used to determine if the metal contents of the hydroids growing on the SIRBs were significantly different from the metal contents of the hydroids growing on the cement blocks. The two groups were found not to be significantly different on each of the two sampling dates.

Metal contents of the hydroids were significantly different in the hydroid biomass collected on September 11 as compared to hydroids collected on August 25 for each respective reef structure. A similar pattern was observed in earlier studies for hydroids growing on coal waste and cement blocks in Conscience Bay, suggesting changes in the water quality surrounding the reef site, maturity of the hydroids at the time of collection, and sample inhomogeneity may account for the observed differences in the metal contents of the hydroids on the different sampling dates.

Conclusions

Particulate incineration residues, when combined with Portland cement, can be successfully stabilized into solid blocks using conventional block-making technology. The establishment of the Conscience Bay reef site constructed using SIR has provided a unique opportunity to study

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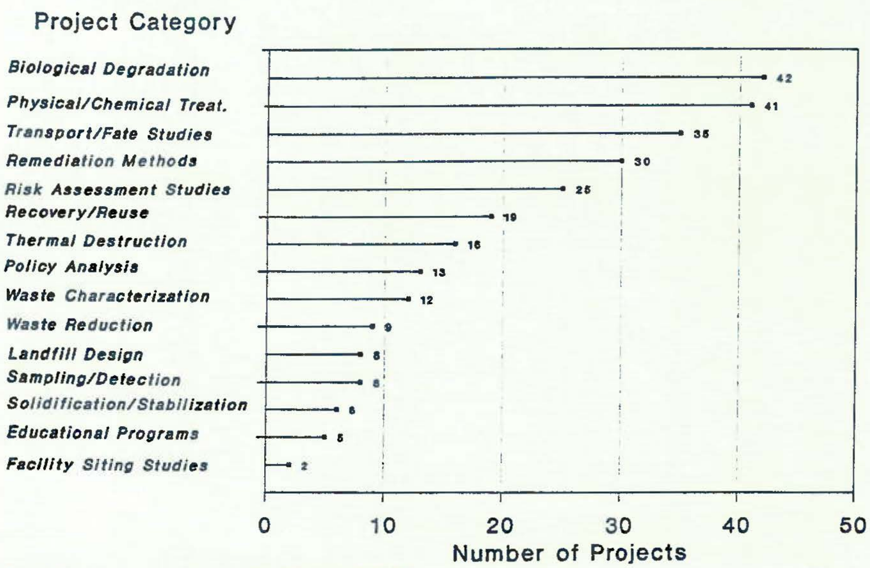
(Hazardous Waste Management)
CURRENT R & D PROJECTS (1989)



Inventory from selected centers in U.S.

Buffalo Center To Publish Research Survey

The Center for Hazardous Waste Management, State University of New York at Buffalo, has compiled information on current research at various centers across the nation. The Center for Hazardous Waste Management will publish the information in the near future in order to facilitate dialogue among the various centers and to assist in the development of collaborative efforts in dealing with the nation's pressing hazardous waste problems.

The following centers have provided information on their respective research programs:

Center for Environmental Management (Tufts University)

Center for Hazardous & Toxic Substance Management (New Jersey Institute of Technology)

Engineering Research Center for Hazardous Substances Control (University of California at Los Angeles)

EPA Hazardous Substance Research Centers:

- Regions 1 & 2 (New Jersey Institute of Technology)
- Regions 3 & 5 (University of Michigan)
- Regions 4 & 6 (North Carolina State University)
- Regions 7 & 8 (Kansas State University)
- Regions 9 & 10 (Stanford University)

Gulf Coast Hazardous Substances Research Center (Lamar University)

Hazardous Waste Research Center (Louisiana State University)

Hazardous Waste Research and Information Center (Illinois Department of Energy and Natural Resources)

Industrial Waste Elimination Research Center (Illinois Institute of Technology)

New York State Center for Hazardous Waste Management (State University at Buffalo)

New York State Energy Research and Development Authority

The report contains a brief description of each center and a list of current research and development projects, including the names of the investigators, their affiliation, and a contact telephone number.

The projects have been classified according to specific research categories. The figure at left above provides a summary of the 271 projects inventoried according to research category.

Reef Constructed In L.I. Sound

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the in situ interactions of SIRBs with the marine environment. Results of this study have shown that the SIRBs have retained their strengths even after prolonged seawater exposure. Metals of environmental concern, including lead and cadmium, are retained within the cementitious matrix of the SIRBs after 12 months of submersion at the reef site.

To date, no adverse environmental impacts have been observed at the Conscience Bay reef site due to the presence of the SIRBs. Continued monitoring of the reef site is planned and will provide data to more clearly define the long-term effects of SIR in the marine environment.

References

Roethel, F. J., V. T. Breslin, V. Schaeperkoetter, K. Park and R. Gregg. 1987. "The fixation of incinerator residues; Phase II," Marine Sciences Research Center 87-3, State University of New York at Stony Brook, New York, 221 pp.

Acknowledgements

This work was supported by funding obtained from the New York State Legislature through the efforts of Senator Caesar Trunzo. We are also indebted to Mr. George Proios, Executive Director of the New York State Legislative Commission on Water Resource Needs of Long Island, for his valuable assistance.

Buffalo Center Approves Funding For New Projects

The Executive Board of the New York State Center for Hazardous Waste Management, State University of New York at Buffalo, February 24, 1989, approved funding for the following new projects:

Clarkson University, "Utilizing a Rule-Based Expert System for Minimizing Industrial Hazardous Waste: A Demonstration Project"; A. Collins and J. DePinto, investigators; industrial partner, ALCOA.

New York University Medical Center, "Bioremediation Strategies for Benzenes and Naphthalenes under Anaerobic Conditions"; L. Young, investigator.

Rensselaer Polytechnic Institute, "Evaluation of Productive Uses of Hazardous Solid Waste Generated by the General Electric Silicone Products Division, at Waterford, NY"; S. Wiberley, investigator; industrial partner, General Electric Co.

Syracuse University, "Nonaqueous Enzymatic Conversion of Recalcitrant Polyaromatic Hydrocarbons to Readily Biodegradable Substrates"; A. Friedman, investigator.

State University of New York at Buffalo, "Electrocoagulation for Hazardous Waste Management: Fundamental Aspects, Applications, and Economic Feasibility"; J. Jensen and J. Van Benschoten, investigators; industrial partner, Electro-Pure Systems, Inc.

In addition, the following projects were approved for continuation funding:

Manhattan College, "Air-Stripper Off-gas Adsorption for Hazardous Waste Sites and Contaminated Groundwater"; J. Mueller, investigator.

State University of New York at Buffalo, "Combustion Characteristics of Hazardous Liquid Wastes"; N. Ashgriz and J. Felske, investigators; industrial partner, Occidental Chemical Corp.

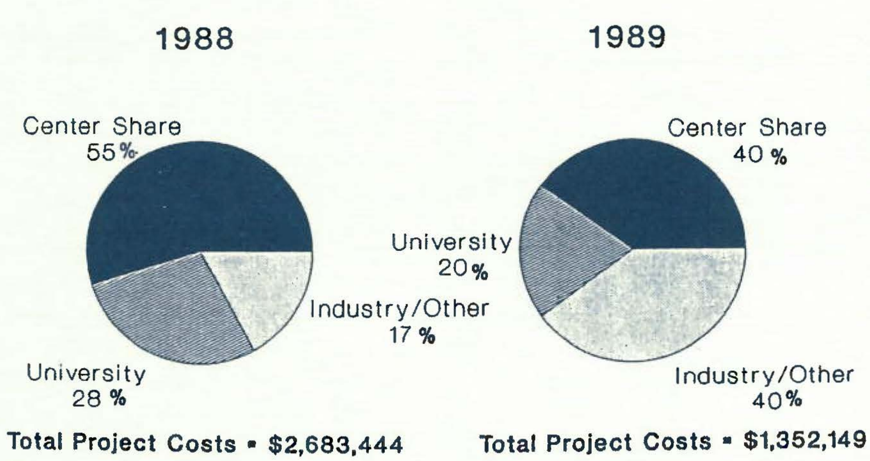
State University of New York at Buffalo, "Extraction of Organic Pollutants Using Enhanced Surfactant Flushing: Phase II-Initial Field Tests"; J. Fountain and D. Hodge, investigators; industrial partner, Bell Aerospace Textron.

The funding distributions for the 15 projects selected in 1988 and the eight projects selected thus far in 1989 are displayed in the accompanying pie chart.

Readers desiring more information should contact the New York State Center for Hazardous Waste Management, State University of New York at Buffalo, 207 Jarvis Hall, Buffalo, NY, 14260.

COST SHARING OF SELECTED PROJECTS

NY Center for Hazardous Waste Mgmt



Charter Members Complete Terms On Buffalo Board

Dr. Roland W. Schmitt, president of Rensselaer Polytechnic Institute, Troy, NY, and Milton L. Norsworthy, plant manager, Olin Corporation, Niagara Falls, NY, recently completed one year of service on the Executive Board of the New York State Center for Hazardous Waste Management, State University of New York at Buffalo. The Center thanks them for their service as charter members of the Board and appreciates their valuable counsel.

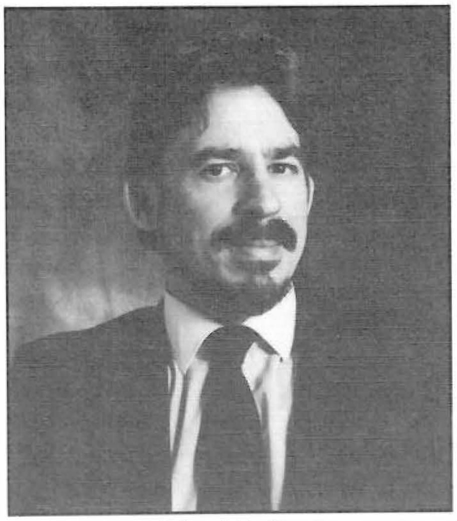
Governor Mario Cuomo appointed Dr. Schmitt to his one-year term on the Board and will name his replacement. The New York State Senate appointed Norsworthy and will name his replacement.

Hazardous Waste Conference Set

The Second Annual New York State Hazardous Waste Reduction Conference will be June 13 and 14, 1989, at the Desmond Americana in Albany, NY. The New York State Department of Environmental Conservation and the Business Council of New York State, and New York Chemical Alliance, Inc. are sponsors of the meeting.

For more information, call (518) 485-8400.

Ryan Named Director: Buffalo Affiliates Program



Michael E. Ryan

Dr. Michael E. Ryan, associate professor of chemical engineering at State University of New York at Buffalo, has been named director of the Business-Industry Affiliates Program of the New York State Center for Hazardous Waste Management.

Ryan's background in both academia and industry will be an asset in developing the program and consulting on technical issues. In addition to teaching at SUNY-Buffalo, Ryan was a visiting professor at McGill University, Montreal, PQ, Canada, and the University of California at Davis. He worked as a quality control engineer for Imperial Oil in Canada and has done consulting work for Buffalo-based companies, including Allied Chemical Corp., Carborundum, and GENCOR.

Ryan earned undergraduate, graduate, and Ph.D. degrees in chemical engineering at McGill University. His major research interests include polymer processing, rheology, non-Newtonian fluid mechanics, and the processing and characterization of ceramic systems.

The new director is author of more than 120 papers and technical presentations. His current research project, "Integrated Software Package for the Extrusion Blow Molding and Injection Blow Molding Processes," is funded by the National Research Council of Canada.

Conference Scheduled

The Fourth Annual Conference on Hazardous Wastes—Science and Management will be October 10 - 12, 1989, at Canoe Island Lodge, Diamond Point, NY, on Lake George. The conference is jointly sponsored by the Environmental Scientists Committee, Capital District Chapter of the New York Water Pollution Control Association, and the Environmental Engineering and Environmental Sciences Program of Rensselaer Polytechnic Institute.

The conference begins with dinner and a speaker on Tuesday evening and ends on Thursday afternoon. Invited speakers will discuss topics such as educational needs, progress in analytical and modeling methods, environmental concerns, experiences in cleanup of contaminated sites, risk assessment, and progress in ongoing programs in hazardous waste management. The dinner speaker on Wednesday night will present a non-technical subject. Besides the beautiful location on the shore of Lake George at the height of the fall foliage color, a boat ride on Lake George is scheduled as part of the program. For further information and registration forms, contact Bev Ryan, Environmental Engineering and Environmental Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180-3590 or telephone (518) 276-6381.

SWCI At Cornell Awards Grants

The New York State Solid Waste Combustion Institute announces the following research awards. The projects funded address major research questions in combustion technologies, air emissions, and residuals management. They cover a broad range of approaches from basic and applied research to instrumentation and measurement.

Two projects focus on the development of on-line incineration monitoring capability, one on basic combustion research using radioactive tracing of particles, one on development of a new laboratory surrogate technique for analysis of ash leaching in landfills, and one on improving mechanical dewatering of sewage sludge in preparation for its incineration.

Principal investigators' abstracts follow.

"Mechanism of PCDD/PCDF-Formation in Incinerators: A U.S./Sweden Collaborative Study." Dr. Elmar R. Altwicker, *Rensselaer Polytechnic Institute* and Dr. Christopher Rappe, *Institute of Environmental Chemistry, University of Umea, Sweden*. (3 year project)

This collaborative study is a mechanistic one with the objectives of identifying thermal conditions that favor formation and destruction of polychlorodibenzo-p-dioxins and polychlorodibenzofurans (PCDD/PCDFs). Emphasis will be placed on the use of 13C-labelled precursors and their disappearance rate, as well as product formation rate and distribution. A plug flow micro reactor has been used by the Swedish group for the study of PCDD-destruction, and a spouted bed reactor (heterogeneous phase) has been used at Rensselaer Polytechnic Institute to investigate flame combustion of chlorobenzenes and pentachlorophenol. These reactors enable the determination of a number of combustion variables over residence time distributions that are important in incinerators.

The results will lead to global kinetic rate parameters which can be evaluated against relevant thermodynamic and kinetic models. The study will provide an improved understanding and quantification of parameters that influence PCDD/PCDF formation and destruction in incinerators.

"Solid Waste Combustion Diagnostics." Dr. Terrill A. Cool, *Cornell University*. (3 year project)

Methods for efficient, controlled combustion, without contamination of the environment from harmful byproducts, are urgently needed. Adequate diagnostic techniques are presently unavailable for direct continuous monitoring of hazardous contaminants in the flue gases of incinerators. This study uses resonance-enhanced multiphoton ionization (REMPI), a new laser-based diagnostic method, for the ultrasensitive, in situ detection of chlorinated aromatic hydrocarbons and their surrogates in flue gases. A major goal is the use of REMPI spectroscopy for real-time continuous monitoring of selected principal hazardous contaminants in flue gases of municipal and hazardous waste incinerators. The laser-based diagnostic methods would enable pollutant formation to be correlated with combustor operating conditions and the chemical composition of the waste stream.

"Improvement of Sludge Combustion Properties." Dr. Richard I. Dick, *Cornell University*. (3 year project)

Combustion of wastewater treatment sludge could offer significant advantages. Sludge combustion is rare because it is the most expensive of all sludge management options. It is costly because dewatering is expensive and inefficient. The objective of this research is to develop fundamental understanding of the dewatering behavior of compressible sludges in the complex mechanical dewatering devices that have evolved empirically. This will be fulfilled by developing filtration dewatering cells that permit exploration of the mechanisms operating in complex, full-scale dewatering systems.

Temporal and spatial distributions of suspended solids concentrations and solid phase stresses in dewatering cakes are needed to analyze rigorously the mechanisms controlling compressible cake filtration. These data will be calculated from observations of X-ray attenuation and porewater pressure in sludge cakes during dewatering. Such data already have been gathered from simple filtration cells; in this research, they will be obtained using complex apparatus, duplicating conditions in actual dewatering equipment. Sludges conditioned in a wide variety of ways will be examined in dynamic dewatering experiments. Results will permit identification of conditions required for effective sludge dewatering so as to achieve economically competitive sludge combustion.

"Characterization of Leachates from Municipal Incinerator Ash Materials." Dr. Thomas Theis, *Clarkson University*. (2 year project)

The land disposal of ash materials produced from solid waste incineration may represent a source of toxic elements to the subsurface environment. This research will investigate the leachate composition of flux of potentially toxic inorganic species through the application of small mini dynamic columns. These reactors preserve the major features of the disposal environment while permitting the rapid output of leachate data. Samples of ash will be obtained from an operating municipal solid waste combustion facility. Batch extractions will be performed in order to obtain qualitative information, targeting those trace species of concern, providing preliminary release rate data, and defining the major ion chemical composition. Other measurements to be made on the ashes will include specific surface area, pore and particle size distributions, and surface titratable site densities. The end result of this research will consist of an experimental technique and data analysis software capable of defining elemental fluxes from solid waste combustion ashes relatively rapidly and under conditions representative of the disposal environment.

"Detection and Analysis of Waste Combustion Products by Analytical Spectroscopy Spectral Signature in the Presence of Overlapping Spectra." Dr. G.J. Wolga and Dr. F.C. Gouldin, *Cornell University*. (3 year project)

There is need for combustion gas monitoring systems which can be used to monitor combustion processes as part of a combustion feedback control system and to monitor air pollutant emission levels to help insure emission standards are satisfied. Sensors employing infrared absorption spectroscopy have the potential for meeting both of these needs. The objective of this research is threefold: to study at high spectral resolution the absorption spectra of waste combustion gases and identify different spectral regions where the spectral signatures of the chemical species of interest are most distinct; to develop data analysis algorithms to help in the retrieval of temperature and composition data from the raw absorption data; and to assess the accuracy of absorption measurements made using the recommended spectral signatures and data analysis algorithms. The results will be of interest to instrument manufacturers, to combustor designers who are considering feedback control of combustion, and to regulators who wish a more accurate evaluation of absorption spectroscopy as an approach to the problem of continuous monitoring.

Announcements

Stony Brook Publications

A conference on "Floatable Wastes in the Ocean," held at State University of New York at Stony Brook in March, attracted more than 100 participants. They represented various federal, state, and local agencies; the medical profession, environmental organizations, and concerned private citizens.

The meeting was organized by the Waste Management Institute of the SUNY Stony Brook Marine Sciences Research Center. The conference summarized what is currently known about floatable and medical wastes—what they are, where they come from, and how they get to area beaches. Social, economic, and health impacts on the local region were discussed, as well as management strategies for dealing with floatables.

The Waste Management Institute is preparing an Executive Summary of the conference, and all papers presented at the conference will be published in a Proceedings volume. For more information, call the Institute at (516) 632-8704.

50-State Guide

The *Resource Guide to State Environmental Management* is available from:

The Council of State Governments
Iron Works Pike, P.O. Box 11910
Lexington, KY 40578-9989

or by calling (606) 231-1939. The price is $40. The material also is available on 5 1/4-inch floppy disks for use on IBM-driven Lotus 1-2-3 and dBase+ programs. The electronic format, which includes the book, costs $240.

Biodegradable Plastics Could Create New Problems and Fail to Solve Old Ones

By Ellen Z. Harrison

Ellen Z. Harrison

Everyone is talking about biodegradable plastics these days. Environmentally conscious consumers wonder whether to buy degradable trash bags and diapers or whether to choose plastic or paper bags at the grocery store. Government officials at local, state, and federal levels are considering laws that would require plastics to be degradable. Before we rush to change our buying habits or to adopt such laws, let's ask what problems degradable plastics really solve—and what problems they cause.

Degradable sounds good, but is it?

Plastics are composed of carbon and hydrogen atoms bound together in long chains called polymers. Under normal atmospheric reactions, plastics break down very slowly or not at all. Recently researchers have found that adding small amounts of additives (like five percent cornstarch) can make a plastic biodegradable (subject to breakdown by microbes) or photodegradable (subject to breakdown by light). But just how fast and under what conditions the plastic products break down to earn the name "degradable" is an issue on which neither scientists nor the public has come to agreement.

Currently, about 65 percent of our solid waste is biodegradable. Most of that is in the form of paper (30 percent by weight) plus food (17 percent) and yard wastes (17 percent). The fact that such a large portion of our current waste stream is biodegradable certainly has not meant that these wastes cause no problems when we dispose of them.

Even though so much of our waste is presently biodegradable, we are rapidly running out of space in our existing landfills, and groundwater pollution from landfills remains a serious problem. Moreover, biodegradable wastes can persist unchanged for decades, taking up valuable space. "Garbologist" William Rathje, the professor at the University of Arizona who made news when he dug into landfills around the U.S., unearthed 30-year-old newspapers that were readable and carrots that looked almost good enough to eat despite long-term burial in landfills.

Landfills often are kept dry in order to minimize groundwater pollution. However, the dry conditions that are maintained to avert water pollution render the landfill environment too dry for the organic action that degrades the wastes. The result often is a very slow rate of decomposition in today's landfills. Plastics, whether bio- or photodegradable, would decompose no more rapidly in landfills than do the biodegradable wastes just discussed.

In the long run, decomposition of wastes in landfills will eventually reduce the size of the mound. A volume reduction of about 30 percent occurs when methane, carbon dioxide, and water escape as products of the decomposition process. This landfill "space" may not be a significant advantage when weighed against the disadvantages of degradable plastics.

Where wastes are burned, degradability is irrelevant. The behavior of degradable plastics is not likely to be different from that of permanent plastics in an incinerator.

Are degradable plastics safe?

The goal of degradation is to break down the plastic into carbon dioxide and water. Some of the so-called degradable plastics, however, may simply break down into very tiny pieces without changing the chemical nature of the plastic at all. In the breakdown of those plastics that do degrade, products are released into the environment. In the case of plastics, we know little about these products. It is possible that toxic chemicals are released into the air and water as degradable plastics decompose. Research into the question of degradation processes and products is just beginning. Before jumping onto the biodegradable bandwagon, we need to know what is really taking place in degradation and whether there may be harmful consequences.

Reduce, reuse, and recycle are primary goals in waste management. Degradable plastics don't accomplish any of them. It would be far more

Ellen Z. Harrison is Senior Extension Associate and Outreach Coordinator, Cornell Waste Management Institute, Cornell Center for Environmental Research, Ithaca, NY.

useful to develop practical methods for recycling plastics of all kinds than to make them degradable. In fact, degradable plastics are a real threat to the rapidly emerging field of plastics recycling. Manufacturers have begun to use recycled plastics in products such as carpeting and plastic lumber. For uses such as these, durability of the plastic, not degradability, is desirable. As we contaminate the waste stream with degradable plastics, we threaten our prospects for recycling plastic.

Another concern is whether degradable plastic can be used as safe substitutes for plastic products now on the market. For example, there is concern that food packaged in biodegradable plastics might become contaminated with bacteria. No food-contact applications for degradable plastics have been allowed by the Food and Drug Administration. Making a plastic degradable may reduce its strength so that a thicker plastic may be needed to do the job. Thicker plastics, in turn, slow the rate of degradation—and increase costs.

Some of the motivation behind legislation requiring products to be degradable is really directed at solving litter problems or halting the depletion of the ozone layer caused by the use chlorofluorocarbons (CFCs) in the manufacture of some foamed polystyrene. If these issues are the major concern, there may be more appropriate ways to reduce litter and protect the ozone layer than to mandate degradable plastics.

Six-ring connectors for soft drinks and beer, for example, are frequent targets of legislation requiring degradable plastics. Six-rings are a menace to wildlife that becomes tangled up in them. Making the connectors degradable might help—if nothing gets caught in them in the months or years before the plastic degrades. However, simply outlawing six-rings or changing their design might be far more effective in accomplishing the goal. Surely there are other ways to keep a six-pack together.

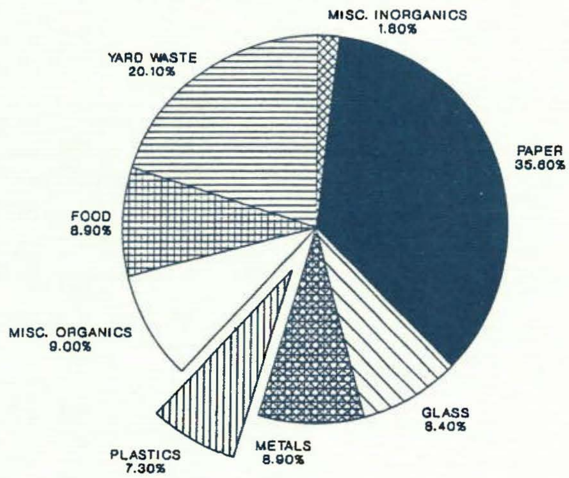
Disposable diapers are another significant concern. They make up an astonishingly high one-to-three percent of our solid waste stream. Degradation of the plastic liners doesn't address the more serious problem of diapers in the waste stream. In addition to representing a large fraction of our trash, our landfills and garbage collection systems aren't designed to handle human bodily wastes. Whether degradable or not, disposable diapers from both infants and incontinent adults pose potential health problems.

Beneficial uses for degradable plastics?

There are some applications in which degradable plastics, if we can ensure that the breakdown products are safe, are appropriate. Such uses include degradable films used for agricultural mulch and bags (plastic or paper) used for collection of leaves and yard wastes which are then composted. Rapid degradation would eliminate the need to pick up and dispose of plastic mulch and would prevent contamination of the compost by the plastic. In these cases degradation really would be an asset.

What should the environmentally conscious consumer do? Go back to the principal goals. Reduce. Don't buy disposable. Don't use more

1986 U.S. DISCARDS



where less—or none—will do. Say "no thanks" to extra packaging. Reuse. A lot of what we throw away could be used again or given to others to use. Recycle. Recycling programs are springing up all over, and paper and glass are often the first materials targeted by a program. Until plastic recycling catches up, choose paper grocery bags and glass containers on the basis of recyclability, and see that they get recycled.

The use of plastics is increasing rapidly, and with their extremely long life this is a significant concern. Degradable plastics may have a place, once we are convinced that they are safe and effective. But they will not solve our waste problems, and they are no substitute for waste reduction and recycling.

On the following pages, Ellen Harrison puts the biodegradable plastics issue into the overall picture of plastics in the waste stream of the United States. The percentage of plastic waste is increasing, and legislators across the country are considering laws aimed at reducing it. .

Percentage of Plastic Increases Every Year

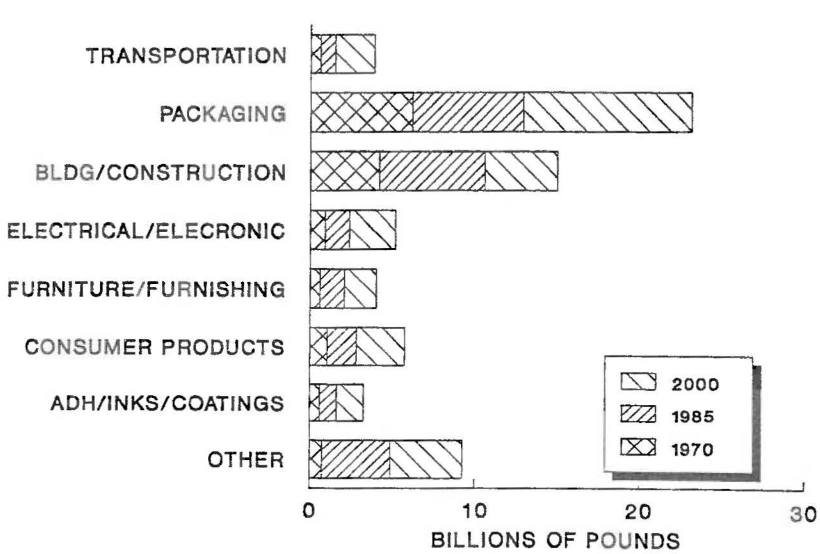
By Ellen Z. Harrison

Plastics make up seven-to-eight percent of the weight of municipal solid waste in the United States, and the proportion of plastics in our refuse is growing rapidly. By the year 2000, it is estimated that as much as 14 percent of our solid waste will contain discarded plastics. As consumers, we witness this rapid growth in the use of plastics in our daily lives. For example, products once available in glass bottles now can be purchased only in plastic containers.

While plastics are used in making many products, packaging accounts for 50-to-80 percent of the plastic discards in the U.S. About one-fourth of the 45 billion pounds of plastics sold in the U.S. is used in short-life applications like packaging. Packaging accounts for about one-third of the weight of our waste stream. Of that, paper makes up about half, while about one-sixth of packaging is composed of plastics.

Waste quantity figures typically are given in weight, but volume is also an important consideration with plastics. Ninety percent of our wastes in the U.S. are landfilled, and we are running out of space. Definitive data are not available, but, if looked at by volume, the proportion of plastics in our trash is approximately three times greater than its share by weight. Major advantages of plastics are the facts that they are light and tend to retain their shape. They are not easily crushed. This latter property, however, presents a challenge to plastics recycling programs because of large space requirements for storage, collection, and transport equipment.

PLASTICS GROWTH BY MARKET, 1970-2000



INDUSTRIAL NOT SHOWN DUE TO LOW VOLUME

What are plastics?

Plastics are an array of chemicals made up of polymers which are long chains of hydrocarbons (carbon atoms linked together in chains with hydrogen atoms attached to them). Differences in the way these carbon and hydrogen atoms are bound together and the substances which are added to them produce the variety of plastics on the market today.

Some commonly used plastics include:

PO (polyoleofins):

- LPDE (low density polyethylene)—27 percent of 1988 domestic plastic resin demand. Familiar as plastic film items like grocery bags.
- PET (polyethylene terepthalate) familiar as soft drink bottles HDPE (high density polyethylene)—21 percent of 1988 domestic plastic resin demand. Familiar as milk and water jugs, detergent bottles, and the base cups of soft drink containers.
- PP (polypropylene)—17 percent of 1988 domestic plastic resin demand. Familiar as durable items, fibers and diaper liners.

PVC (polyvinyl chloride)—22 percent of 1988 domestic demand. Commonly used in durable construction products such as pipes and siding.

PS (polystyrene)—14 percent of 1988 domestic plastic resin demand. Familiar in foamed form ("styrofoam" is a particular brand name) as fast-food packaging, hot cups, and meat trays; also used in rigid and semi-rigid containers.

Multi-layer or barrier plastics combine various plastics in layers with different properties. Common in squeezable bottles.

Credits: "1986 U.S. Discards," page 13, Franklin Associates. "Plastics Growth by Market, 1970-2000," left, adapted from Mass. DEQE, 1988, Plastics Recycling Plan and Chem. Systems, Inc. 1987.

The release of chlorofluorocarbons (CFCs) into the atmosphere has been linked to the destruction of the layer of ozone in our atmosphere which is critical in protecting us from harmful radiation. Coolants in refrigerators and air conditioners are the primary contributors. CFCs are still used as blowing agents in the manufacture of some foamed polystyrene, although this is a relatively small part of total CFC usage. According to the Society for the Plastics Industry, CFCs are not used in making any of the hotcups and food containers used by consumers.

Can plastic be recycled?

Less than one percent of plastic is being recycled today, but the ability to recycle plastics is growing rapidly. Products which are, or can be, made from recycled plastics include non-food containers, trash cans, fiber-fill for vests and jackets, traffic cones, carpet backing, insulation, plastic lumber, and drainpipe.

Because the waste stream contains a mix of plastics with different properties, separating the various types before recycling them into new products and finding uses for mixed plastics are major challenges in plastics recycling. This is complicated further by the growth of multi-layer packaging in which layers of different plastics are fused into one container (such as some catsup bottles, for example).

Many plastic manufacturers are adopting an identification system under which containers are stamped with a code indicating the type of plastic from which they are made. Coding may make it possible to sort—in the recycling process—all containers that are made of a single type of plastic. However, the codes must be read by eye, an impractical feature where rapid sorting is desirable in recycling facilities that pass wastes along on conveyor belts.

Technology is being developed to use mechanical and chemical processes to separate different types of plastics, such as PET and HDPE. Similarly, technologies to remove the labels, caps, and rings from plastic soda bottles are being developed.

As we look to recycling as a solution to the problems of waste disposal and depletion of natural resources, we need to consider the number of times the product made from recycled plastics can, itself, be recycled. Glass containers, for example, can be recycled indefinitely. In contrast, many of the products made from recycled plastics must be discarded after a single use. We need to keep the goal of continued recycling and reuse in mind.

Concerns over possible contamination prohibit the use of recycled or degradable plastics in food contact applications. Beverage containers, for example, cannot be recycled back into beverage containers because of concerns over bacterial or toxic contamination. There is concern that containers used by householders to store toxics such as pesticides may find their way into recycled materials. Since plastics may adsorb these pesticides, any containers subsequently made from these recycled plastics may be contaminated and, therefore, unsuitable for food storage. Progress in the development of new recycling technologies and materials development may eventually allow plastics to be recycled into food-contact applications.

Legislation at the federal, state, and local level has sought to address some of the concerns over plastics in the waste stream. In 1988, the federal Environmental Protection Agency (EPA) was directed to write regulations requiring all plastic rings used to hold together six-packs to be made of degradable materials. Another federal law prohibits the disposal of plastics by U.S. ships within 25 miles of any coast.

At the state level, 16 states, including New York, have passed laws requiring six-pack plastic rings to be made of degradable plastics. Some local laws, such as one passed by Suffolk County, NY, ban non-degradable, retailer-added packaging such as plastic fast food packaging and grocery bags. This law is being challenged by a number of organizations. Another local law, in effect in Newark, NJ, bans the use of plastic food packaging for which CFCs was used as a blowing agent.

Laws designed to promote recyclable packaging and the use of recycled materials in packaging are being considered by a number of states, including New York.

Standards and Definitions

Current definitions and standards for terms like "degradable" or "recycled" are not straightforward. Degradation rates depend on conditions of light, moisture, and oxygen. Products that may degrade rapidly in one set of conditions may last for many years in less favorable conditions. Products defined as made of recycled materials may contain anywhere from one-to-100 percent secondary materials. These secondary materials may be industrial scrap or "post-consumer" materials. As legislation is considered and manufacturers make product claims, these complexities should be kept in mind.

For additional information about plastics recycling and a bibliography of sources, call or write the Cornell Waste Management Institute, 468 Hollister Hall, Ithaca, NY 14853.

Incineration Attracts Attention By Donald Lisk

Donald J. Lisk

Incineration of municipal solid waste (MSW) is receiving renewed attention owing to the threat of groundwater pollution from landfill leachates and the general unsightliness of dump sites. When MSW incinerators are properly managed, the sale of generated steam and electricity serves to reduce their cost of operation. The greatest public concerns about incineration are potential exposure to emitted gases and particulates as well as safe disposal of the resultant ash. The possible health effects of these have been under study by researchers at Cornell University.

Studies began with securing fly ash or bottom ash from one-fourth of all the operating MSW incinerators in the United States. These were analyzed for 36 elements, pH, radioactivity, soluble salts, organic matter, and asbestos. Surprisingly, over half of the ashes contained high concentrations of organic matter ranging from 10 to 75 percent dry weight. In some, newsprint could still be read on the paper remaining in the ash. Radioactivity was very low. Salt content, pH and heavy metal concentrations varied widely. Asbestos was usually absent. Among organics analyzed, PCDDs, PAHs, phthalates, PCBs, chlorinated benzenes, benzothiophenes and mutagens were found. PAH concentration varied directly with that of organic matter. Nitrosomorphiline was found in one ash that utilized morpholine as a steam descalant.

Possible contamination of water sources by incinerator ash landfill leachates is of concern. It was found that aqueous leachates of the ashes contained appreciable concentrations of a number of heavy metals as well as nitrate. Goldfish exposed to such leachates accumulated cadmium but showed no internal tissue lesions when examined histologically.

Uptake of elements by deep-rooted plants growing over soil-capped ash landfills can occur with potential element deposition in foraging wildlife or farm animals. Earthworms can also move such ash upward into the root zone of shallow-rooted grasses. Perennial ryegrass and Swiss chard, when grown on soils containing each of the ashes, concentrated cadmium, lead and zinc, the concentrations of which showed a high degree of correlation with those in the respective ashes. The Swiss chard was fed to mice and their tissues showed concentrations of cadmium markedly higher than those of control mice fed soil-grown chard. Inhalation exposure to gases and particulate emissions from refuse incinerators has been little studied. Guinea pigs were therefore exposed to MSW fly ashes in inhalation chambers. Lung tissue exhibited a number of histologic lesions and showed increased concentrations of cadmium, lead, zinc and mercury compared to control animals.

As mentioned above, incinerator ashes were found to be mutagenic. Incinerator workers inhaling ash particulates or leaking combustion gases would expectedly exhibit urinary mutagens. The urine of over 100 workers in seven incinerator plants was therefore analyzed for mutagens using the urine of water treatment plant workers as the controls. Twenty-one percent of the incinerator workers showed the presence of mutagens while only one percent of the water workers' urine samples were positive.

The possible efficacy of ash as an additive to cement for building materials and to immobilize toxic elements in it has been studied. Refuse incinerator fly ashes and bottom ashes have been incorporated at increasing percentages into cement. Compressive strength measurements have shown that cement containing up to 30 weight percent of such ashes exceeds ASTM minimum standards for construction of interior or exterior load-bearing walls or sidewalks. The ashes have also been incorporated into ceramics or melted into soft glass. The cement, ceramic and glass materials easily passed the EP Tox Test showing the new composites to be highly effective in preventing leaching losses of toxic elements if such materials are disposed in landfills.

It is obvious that the completeness of combustion of refuse in MSW incinerators has several advantages:

(1) It reduces emissions of toxic organics such as PCDDs and PAHs.

(2) It reduces the tendency of ashes disposed in landfills to lower the pH of aqueous leachates resulting in greater loss of toxic metals.

(3) It enables the ash to be solidified in cement, ceramics or glass without having to first destroy remaining organic matter.

(4) It assures more efficient production of steam and electricity.

Co-investigators in these studies included, in addition to the author: Ralph O. Mumma and Dale C. Raupach, Pennsylvania State University; Barbara S. Shane and Charles Henry, Louisiana State University; Charles G. Manos, and Kusum Patel-Mandlik, Environmental Science and Engineering, Inc., Gainesville, Florida; Gilbert S. Stoewsand, Joseph H. Hotchkiss, John G. Babish, Janet Scarlett, Larry Carbone, Jan Spitsberger, and Renee C. Pearson, Cornell University.

Dr. Donald J. Lisk is Professor of Toxicology and Director of the Toxic Chemicals Laboratory at the New York State College of Agriculture and Life Sciences at Cornell University, Ithaca, NY.

Guest Comment

Incinerator-Ash Research Funded

By Owen H. Johnson and Caesar Trunzo

Problems surrounding disposal of ash from resource recovery plants are due not only to a lack of landfill sites but also to lack of imagination. Our throw-away society is conditioned to think that once a product is used we can discard it, usually by burying it above our precious water supply. If, instead, we look for multiple uses of products, and keep in mind that resources are increasingly scarce, we remove the need to discard everything.

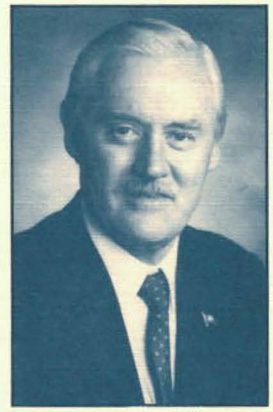
We are proud to have been involved at the beginning of the "ash" project at the Waste Management Institute (WMI) of the Marine Sciences Research Center at State University of New York at Stony Brook by securing necessary funds in the State Budget. The project focuses on developing innovative and productive uses for ash generated by municipal solid waste incinerators.

Current research shows that both fly and bottom ash from refuse-to-energy facilities can be stabilized and used in solid, cinder block-like forms that may pose no environmental threat to marine and terrestrial systems. WMI scientists are monitoring an artificial reef made of ash blocks, and results are very promising. Over the next years, WMI research will provide a strong scientific base for developing public policy to deal with Long Island's solid waste crisis.

There are many potential uses for incinerator ash. This is important when you consider that if all Long Island's 13 townships build resource recovery plants, they could produce over two million tons of ash annually. Another part of the Stony Brook "ash" project involves building a boathouse of stabilized incinerator-ash blocks. Researchers will study its structural integrity over time and test for any potential leaching into the underlying soil. And, a project at Stony Brook, funded by the New York State Center for Hazardous Waste Management at SUNY Buffalo, uses ash in the construction of shore protection devices. The project demonstrates the cooperative spirit of the state's waste management institutes.

In other parts of the country and Europe, ash has proved successful as road bedding material. Other potential uses include consumer products such as ready-mix cements. Cements require tons of aggregate each day which now come from sand and gravel pits in the New York metropolitan area. As those mines disappear, ash could become valuable as an aggregate substitute.

In our roles as Chairman of the Senate Environmental Conservation Committee and Senate Chairman of the Legislative Commission on Water Resource Needs of Long Island, we look for solutions to the seemingly overwhelming waste problem. We look forward to working with Stony Brook's WMI, as well as Cornell's WMI and SUNY Buffalo's Center for Hazardous Waste Management. The entire nation will look to these fine institutions as research progresses and new technologies for dealing with solid waste develop. We are confident that innovative research and technology development in our state's universities and cooperative effort with neighboring states will achieve solutions to solid waste problems. To implement those solutions into public policy, we need the support of everyone—state, county, and local officials, as well as the local citizenry.



Owen Johnson

Caesar Trunzo

"Guest Comment" provides a forum for debate of complex waste management issues. The opinions expressed are those of the authors. The editors reserve the right to edit for length.

New York State Senator Owen H. Johnson (R-Babylon) represents the 4th District in the New York State Senate. He is chairman of the Senate Committee on Environmental Conservation and chairman of the Senate Subcommittee on the Long Island Marine District. Senator Caesar Trunzo (R-Brentwood) represents the 3rd District and is co-chairman of the New York State Legislative Commission on Water Resources Needs of Long Island.

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123 Bray Hall
SUNY College of Environmental Science
and Forestry
Syracuse, New York 13210
(315) 470-6644

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