THE ENVIRONMENTAL AND HEALTH IMPACT OF WASTE COMBUSTION — THE RUSH TO JUDGEMENT VERSUS GETTING THE FACTS FIRST

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ABSTRACT

Research undertaken in response to concerns about the environmental and health impact of combustion of wastes takes time to accumulate. In the meantime public opposition, often based on incomplete and faulty information, may develop, and is often translated into regulations and law. Later, research often reveals faults in the factual basis of public perceptions which led to the law making. This paper illustrates this problem by reviewing the history of concerns about dioxins and ash residues resulting from combustion of municipal solid waste, showing how present knowledge contradicts the assumptions upon which the public perceptions were based. Great reductions in emissions have been achieved, and ground level concentrations are extremely low. Beneficial use of ash residues and compost is inhibited by concern about short and long term leaching potentials, and lack of the data needed to alleviate these concerns. Efforts are continuing to define and apply environmentally sound procedures for beneficial use in order to gain the support of the concerned public.

INTRODUCTION

The public perception of waste combustion technology is largely based on past practices of poor combustion, smoking chimneys, pollution of the environment due to lack of effective emission controls, and leaching of toxics from landfills into the drinking water. This legitimate concern about past practices has often been coupled with "not in my backyard" sentiments in order deliberately to generate opposition to the option of waste processing by combustion. Some of this opposition is motivated by reasonable desires to recycle rather than landfill or incinerate usable materials, to reduce waste quantities, and to minimize the addition of potentially toxic materials to the environment. However, blind, "just say no" opposition interferes with the orderly process of planning the management and disposal of our society's wastes.

The opposition to combustion of wastes has been directed at municipal solid waste (MSW), hazardous wastes (HW) and biomedical wastes (BMW). The technologies used in combustion of these wastes are basically similar, and the regulation of emissions and ash disposal is becoming more and more standardized and applied to all types of solid wastes.

Governmental agencies as well as providers of combustion technology have responded to public concerns by carrying out extensive research and development. As a result, our understanding has increased and technology has been developed and demonstrated which is capable of greatly reducing stack emissions from combustion of MSW and other wastes. In addition, research has been directed at obtaining more and better information on the impacts of combustion technology on environment and health.

In the interim, before these developments have taken place, the orderly process of planning the management of municipal solid waste has often been slowed and in some cases stopped by opposition which has often used faulty arguments based on misinformation or lack of information.

This paper reviews the process of increasing our knowledge regarding reduction of air emissions of criteria pollutants and emissions of toxic metals and trace organics, as well as the leaching characteristics of ash residues from combustion. The chronological course of this research is described, and the magnitudes of present-day emissions are compared with the poor practices of the past. It is evident that the importance of carrying out timely research, hopefully in advance of legislation and regulation, is evident.

The accomplishments of the last decade are remarkable. The next step is to present these accomplishments to the public and the political agencies and institutions which influence public opinion. The process of informing the public should lead to removal of many of the institutional barriers which impede the rational management of our wastes.

The Dioxin Scare

The development of laboratory instrumentation which could detect extremely low concentrations of organic compounds, coupled with the finding that Polychlorinated Dibenzo-*p*-dioxins and Dibenzofurans (PCDD/PCDF or chlorinated dioxins and furans) were extremely toxic to laboratory animals, combined to raise public concern about the potential threat of dioxins to human health and the environment [Suess, 1987] [Rappe, 1987].

Studies and Research

In Sweden, most of the municipal solid waste (MSW) was already being burned in order to recover its thermal energy. When the dioxin issue was raised, desiring to continue this method of disposal, it was decided to impose a 2-year moratorium on the construction of new municipal waste combustors (MWCs), while a comprehensive national program of research was carried out on the alternative methods for municipal waste management. The DRAV project which carried out comprehensive studies of solid waste treatment was started in 1981 and completed in 1985 [Bergvall, 1985]. As a result of this research, it was concluded that with the use of new technology, extremely low emissions of pollutants could be achieved, including those of dioxins and furans. Even though parallel research indicated that higher emission levels could be tolerated without concern for human health, the high levels in the environment, including fish eaten by humans, indicated that all practical measures for reduction of dioxins should be applied. Hence all new plants would have to apply the best available technology, and older plants would have to be retrofitted in time. This approach has been followed in several other European countries.

In Canada, the National Incineration Testing Program (NITEP) was instituted to find out what the emissions from incinerators were, how much they could be reduced by optimizing combustion, and by application of add-on controls [NITEP, 1985]. This program, started in 1984 with a program for optimizing MSW combustion in the basic types of combustion systems, culminated in tests of acid gas and emission control systems. [NITEP, 1986, 1988], and was completed in 1990. The results of this testing program showed that combustion modification could drastically reduce not only dioxin and furan emissions, but also particulate and heavy metals. In addition, the effectiveness of dry-injection and spray-dry scrubbers with fabric filters was demonstrated.

In Europe, the manufacturers of MSW combustion systems carried out extensive research on combustion optimization, using carbon monoxide as the means of measuring the effect of furnace shape and ways of introducing underfire and overfire combustion air [Clarke, 1990].

In the United States, the Ad Hoc Dioxin Committee of the ASME, recognizing the urgent need for fundamental research, initiated the research carried out in 1986 at the Pittsfield MSW combustion facility [Visalli, 1987]. This testing program provided the first and most complete parametric studies of factors influencing combustion ever attempted. A wide range of waste types were burned, and the emissions of carbon monoxide (CO) and trace organics including dioxins and furans were studied under a wide range of temperatures and excess oxygen levels. As a result of these tests, it was confirmed that CO was an excellent surrogate for good combustion as well as for emissions of dioxins and furans, and that there was a clear optimum range of temperature and excess oxygen which would assure optimum destruction of organics [Hasselriis, 1987].

As a result of these research programs, the U.S. EPA established guidelines for good combustion, and standards have been set in industrialized countries requiring the use of available technology. Today, all new municipal incinerators must be provided with good combustion controls, supervised by carbon monoxide measurements, and also with effective add-on emission controls. In Europe, fabric filters and wet scrubbers are recognized as effective emission controls; likewise in the United States, lime scrubbers and fabric filters have been accepted as best available control technology, and wet scrubbers are also being perfected in order to meet current highly stringent emission limits [Clarke, 1987].

During the period of research and development of improved technology, investigations of the health risk of dioxins and furans were also continuing. The Agent Orange lawsuit on behalf of the veterans of Vietnam, the issue of Times Beach, and a lawsuit against the Monsanto Company were developing more data on the effect of dioxins on humans [Beck, 1991]. Previously, only the effect on (sensitive) laboratory animals was available. The irony is that after all the emphasis on control of dioxin and furan emissions, announcements have recently appeared in the press that previous estimates of the toxic effect of dioxins and furans on humans have been grossly exaggerated [*New York Times*, 1991].

The emphasis on reducing dioxins has led to the use of equipment which is also highly effective in removal of heavy metals, including lead, cadmium, chromium and to varying extents, mercury.

The "Incredibly Toxic" Ash Residues

At about the same time that it became evident that dioxin and furan emissions could be controlled to satisfactorily low levels, the basis of opposition to incineration was shifted to the point of discharge of incinerators: the ash residues.

In the rush to find a procedure for determining whether or not waste materials had a potential for being toxic, under the new RCRA law, Oak Ridge National Laboratory was assigned the task of determining the leaching characteristics of MSW, and also of the ash residues from MSW. ORNL placed MSW in leaching tanks filled with water, and produced a leachate which was then used to test the leaching characteristics of ash residues [Francis, 1984, 1987]. This procedure, was developed supposedly to simulate the effect of disposing of ash residues in the same landfill as raw MSW. The synthetic leachate thus produced was found to have a pH ranging from about 5.5 to 7.

To be conservative, it was decided to use a pH of 5, and to use acetic acid to simulate the organic acids which might be produced in the MSW leachate. The Extraction Procedure (EP) leaching procedure thus developed became a U.S. EPA regulation. Ash residues (and other materials) which produced leachates which contained more than 100 times the drinking water standard for the critical toxic metals were to be classified as having a "toxic characteristic" and therefore would have to be disposed in landfills which could safely contain materials which could produce these concentrations if water could leach them.

When the EP leaching procedure was applied to MSW ash residues containing both fly ash and bottom ash, most samples would pass the test. However, fly ash alone would usually fail the test, and samples of mixed fly ash and bottom ash would occasionally fail the test.

Ash residues from waste combustion have been described by activists as "toxic ash" as part of their ammunition in the war against burning. The Environmental Defense Fund collected and published early data to convince the public that since about half of the samples tested in accordance with the EP Toxicity test showed lead and cadmium levels exceeding the EPA standard for characterizing wastes, that ash was toxic and would have to be disposed of in landfills designed for hazardous wastes. Most of the samples had been taken under startup conditions or were grab samples which were not representative of typical ash from the plants, often taken without the knowledge or permission of the operators. This report became the basis for opposition to incineration, and ash residues were given the name "toxic ash." The opposition to waste-to-energy plants used this poor and nonrepresentative information to convince the public that ash was a toxic substance which would inevitably poison the environment.

After acid gas scrubbers were installed, test data began to show that the fly ash containing scrubber product was more highly alkaline, and in laboratory tests tended to fail the EP test. Now the plants with the latest technology were threatened with having to dispose of the ash in hazardous waste landfills, which were expensive and scarce. A plant in Rutland VT was shut down soon after startup and failed economically due to having to dispose of its ash residues in a hazardous waste landfill over 100 miles away.

Serious questions as to the validity of the Extraction Procedure toxicity test were raised after it was applied to MSW combustor ash. Data published in 1982 indicated that ash residues co-disposed with raw MSW did not produce an acid leachate [Rigo, 1982]. Extensive research on the use of ash residues from the MSW combustor in Saugus, Massachusetts, indicated that the leaching of lead and cadmium was sensitive to the pH of the leaching water, and that when the pH ranged from 6 to 10, very little of these metals would be dissolved. Laboratory and ashfill leachate studies done for Westchester County, New York indicated that even over long periods of time metals would not leach out from an ashfill [Cundari, 1986]. The U.S. EPA, responding to criticism of the EP test, developed the TCLP test procedure, but the doubts remained.

Ash and Ash Landfill Leachate Tests

In order to resolve the question as to whether incinerator ash produced leachates containing high levels of the critical metals, the Coalition on Resource Recovery and the Environment (CORRE) co-sponsored with the U.S. EPA comprehensive testing of ash from contemporary facilities employing acid gas scrubbers. Combined bottom and fly ash samples were obtained from five mass-burn MWC state-of-the-art facilities equipped with a variety of pollution control systems. Samples were collected from these facilities employing stringent sample collection procedures to obviate the erroneous effect of taking unsystematic "grab samples" from the sites. Leachate samples were obtained from the companion ash disposal facilities, which were equipped with leachate collection systems or a means of collecting leachate samples [Roffman, 1991].

Six extraction procedures were applied to MWC ashes to determine which provided the best simulation of actual ashfill leachate. The CORRE test program evaluated the Extraction Procedure (EP) test, and the two Toxic Characteristic Leaching Procedure (TCLP) tests, all of which add acetic acid to force the pH to 5.0, and, for comparison, three other leaching procedures which do not force the pH, to ascertain which would be most suitable for simulating what happens in an actual landfill.

The results of this program can be summarized as follows:

(a) The analytical results of the extracts from all six procedures were compared with each other and with leachate collected from the ash disposal facilities. It was found that the EP and TCLP tests (which had been used heretofore and which were prescribed by the U.S. EPA and many states) were poor predictors of actual leaching of metals. On the other hand, the Deionized Water, CO_2 Saturated Deionized Water and Simulated Acid Rain procedures were found to be reasonably good predictors of actual ashfill leachates.

(b) The laboratory extracts of lead and cadmium obtained from the EP, TCLP 1 and TCLP 2 extraction procedures frequently exceeded the EP Maximum Allowable Toxicity Limits. This was not surprising since this had been the basis for the public concerns in the past. On the other hand, none of the extracts from the other three procedures exceeded these limits. Indeed, the majority of these extracts also met the Primary and Secondary Drinking Water standards for metals.

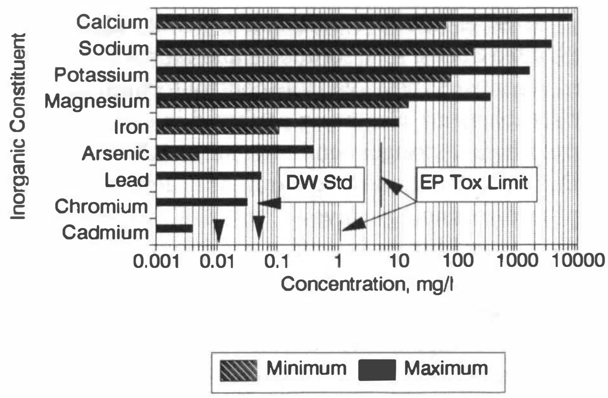

FIG. 1 METALS IN LEACHATE FROM MSW ASH RESIDUE MONOFILLS

(c) None of the field (ashfill) leachate samples exceeded the EP Maximum Allowable Toxicity limits established for the eight critical metals. The leachates were found to be close to the acceptable standards for drinking water, as far as the metals are concerned.

(d) Sulfates found in ashfill leachates ranged widely from 14 to 5080 milligrams per liter (mg/l or parts per million, ppm), and Total Dissolved Solids ranged from 924 to 41,000 mg/l. The concentrations depended on the amount of water which entered the landfill and contributed to leachate.

(e) None of the laboratory extracts contained chlorinated dioxins and furans (PCDDs/PCDFs). This confirmed the findings of the actual field leachate samples that PCDDs/PCDFs were not readily leached from the ash.

The broad conclusion of this study was that: *(a)* the EP and TCLP tests are not good predictors of actual landfill leachates; *(b)* the metals found in leachates from actual ashfills were at levels close to the Primary and Secondary drinking water standards; and *(c)* the main concern about the leachates would be the high levels of total dissolved solids, which were mostly sodium and calcium chloride and sulfate salts.

The minimum and maximum concentrations of the nine metals of major interest, obtained from the CORRE tests of leachates obtained from ashfills, are presented in Fig. 1. The EP toxic maximum limits of 5 mg/l (ppm) for arsenic, lead and chromium, and of 1 mg/l for cadmium was not even closely approached by any of these metals. The drinking water standard (DWS) of 0.05 mg/l was exceeded for some of the arsenic samples, slightly for one lead sample and never for chromium. The concentration for cadmium did not exceed 0.05 mg/l, as compared with the DWS of 0.01 mg/l.

Beneficial Use of Ash Residues

Many tests have shown that the heavy metals in the ash are mainly in chemical or physical forms from which they are not readily leached out under normal conditions, since they would not be subjected to strong acid or alkaline solutions. Many beneficial uses of "incinerator ash" have been applied in the past. In Denmark and Holland, specific rules have been written to encourage the safe use of ash residues for construction. Tests at SUNY, at Stony Brook, Long Island, New York are measuring the leaching characteristics of cement blocks made from MSW ash residues, under normal conditions of above-ground use [*New York Times*, 1990]. In Japan and other countries, portland cement is added to the ash to assure that no leaching will take place. Several facilities in Japan vitrify the ash in order to produce a totally benign material from which the metals do not leach. The ASME Research Committee on Industrial and Municipal Waste, the Department of Energy, New York State Energy Research and Development Authority and other sponsors have developed a major research effort on vitrification of incinerator ash, which will be carried out in 1992. In Europe, procedures for washing of the ash have been used to produce a clean ash which could be readily used; the wash water is processed to remove the salts [Hasselriis, 1991].

The International Working Group on Ash is publishing their review of the state of knowledge on ash residues, which will make a great contribution toward the beneficial use of these residues [Chandler, 1991].

Leaching Characteristics of MSW Ash and Compost

It is a common belief that MSW ash residues readily leach toxic heavy metals, whereas compost made from MSW would not present leaching problems. The Connecticut Department of Agriculture carried out tests to compare the leachates produced by compost made from MSW, and MSW ash residues [Stilwell, 1991]. Figure 2, based on this data, illustrates the similarity of the leachates obtained by leaching these materials in a laboratory lysimeter (leaching column) and from actual compost in the field. In all cases, the ash residues had equal or lower metals contents than the laboratory or field leachates of the compost. The compost leachates obtained from the field were not significantly higher or lower than the laboratory leachate. Only the compost leachate sometimes and somewhat exceeded the public drinking water standards for copper and chromium.

These results should not be surprising since these materials came from essentially the same source. A conclusion that may be drawn is that these materials should all be managed properly. If MSW compost can be applied to the land with proper precautions, so can MSW ash residues.

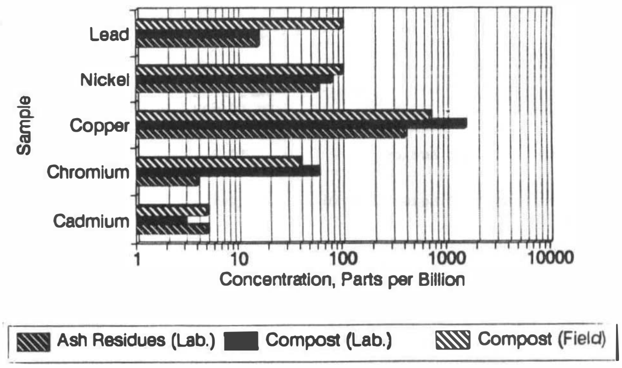

FIG. 2 METALS IN INCINERATOR ASH AND COMPOST LEACHATES

CORRECTING MISCONCEPTIONS

Gradually many of the misconceptions which were used as ammunition by "grassroots" organizations opposing waste-to-energy projects have been corrected as new information has become available.

Environmental dioxins, "the most toxic substances known to man," which have been attributed by activists to the combustion of municipal waste, are now viewed differently.

It has been estimated that combustion of MSW has contributed only a trivial portion of the total dioxins in the environment. Other contributors, such as industrial incinerators, automobiles and paper mills are now identified as significant. The paper mills, having contributed to contamination of fish, are now converting to non-chlorinated methods of bleaching paper [Leary, 1991].

The American Paper Institute, in response to concerns about dioxins in paper and in discharges from paper mills, has said that pulp and paper producers believe current dioxin standards are "too stringent, in light of all the evolving science that has come out" [*New York Times*, 1991].

A recent study provides a new perspective on the quantity of dioxins which has contaminated the Baltic Sea. The entire sea, which is about the size of the State of California, and averages about 60 m in depth, has been estimated to contain about 21 grams of toxic equivalent TCDD [Broman, 1991].

As more data has become available, it is now believed, on the basis of numerous studies, that the affect

TABLE 1 NATIONAL AND INTERNATIONAL HEALTH GUIDELINES FOR DIOXIN

AGENCY	SAFE DOSE* pg/kg/day	SAFETY FACTOR
U.S. Food and Drug Agency Canada	10.0	100
U.S. Centers for Disease Control Netherlands	2.0	500
Germany	1.0	1,000
Promoter Model	0.5	2,000
USEPA (1988)	0.1	10,000
U.S. Centers for Disease Control	0.02	50,000
U.S. EPA (1987) California (1987)	0.006	166,000

* Safe Dose is considered virtually safe, or may pose a theoretical cancer risk of 1 in 1,000,000.

of dioxins on human beings has been exaggerated by about 100 to 1000 times. Risk estimates which arrived at one to ten in a million may therefore be less than one in one billion. In other words, no danger at all.

Table 1 compares the very different views about what constitutes a safe level of human exposure to dioxins. The U.S. EPA guideline of 1987 was revised by a factor of 16 in 1988. However, as compared with the FDA (1985) guideline, even the revised U.S. EPA guideline is more conservative by a factor of 100. The FDA guideline already has a safety factor of 100, so the EPA number is 10,000 times the original risk estimate. The U.S. EPA is reviewing the risk of dioxins again. Imagine engineers using safety factors of these magnitudes!

An official of the Centers for Disease Control told a conference on environmental health that he was wrong 9 years ago to have recommended a buyout of the Missouri town of Times Beach [Houck, 1991].

Toxic effects to humans have recently been evaluated on the basis of large groups of workers who were exposed to dioxin-bearing chemicals for many years. One group of 1520 workers with exposures for up to 20 years, was found to have levels of dioxin in their blood which were as high as 500 times (3600 pg/g) the levels found in the blood of average persons (7 pg/g), and even at these high exposures, only a 50% increase above normal cancer rates was found. Another group, with about 640 pg/g in their blood had cancer rates which were almost identical to that of the general public. These data indicate that the threshold of health effect is somewhere between these exposure levels, that is, between 100 and 500 times the present exposure of the average population [Leary, 1991].

The California Air Resources Board (CARB) estimated that the cancer risks from dioxins from background levels in the Los Angeles Basin ranged as high as several hundred per million exposed persons. The high exposures were evidently related to atmospheric inversions. When estimated exposures from existing medical waste incinerators were compared to these background levels, CARB opined that since the background was so high, "any more is too much," and proposed that emission controls (scrubbers) be required for medical waste incinerators to control dioxins. On the basis of the new findings, dioxins would not be the basis for requiring scrubbers for small incinerators. On the other hand, background levels of cadmium were also estimated to present a cancer risk of several hundred per million exposed persons. CARB recommended that dioxins, not cadmium, should be the basis for requiring emission controls, although the evidence is quite the contrary [CARB, 1990].

Today, researchers are focussing on the recycling of incinerator ash residues, to avoid their useless storage in landfills when they can be used as aggregate in roads, fills, and concrete, as they are in many countries in Europe. Data showing convincingly that these uses can be environmentally sound has been slow in reaching the public. The International Working Group on Ash will soon be publishing the results of several years of work directed to proper disposal, treatment and use of ash residues [Chandler, 1991].

HISTORICAL REDUCTION IN EMISSIONS FROM WASTE-TO-ENERGY FACILITIES

The process of research and development described above has resulted in enormous reductions in emissions from the combustion of solid wastes over the last two decades. This basic fact has not been presented to the public in a clear and convincing way. The following graphical presentations show the scale of these reductions in a form understandable to engineers, scientists and technically-educated persons who may be able to use them to support statements more readily understood by the layman.

Reduction in Dioxin Emissions

Since the "discovery" of the dioxin problem by Olie et al., published in 1977, testing of incinerator stacks for dioxins and furans developed into a new industry. At about the same time that the Pittsfield tests showed that optimizing combustion could minimize the emissions of dioxins [Hasselriis, 1987] Stieglitz, Vogg and Hagenmeier produced convincing evidence that dioxins and furans could and did form in the lower temperature

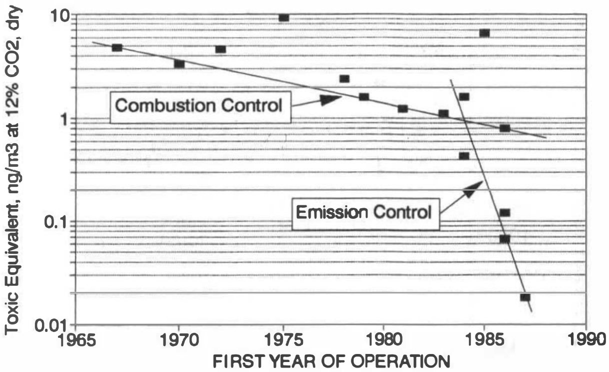

FIG. 3 REDUCTION IN DIOXIN EMISSIONS (U.S. EPA Toxic Equivalents)

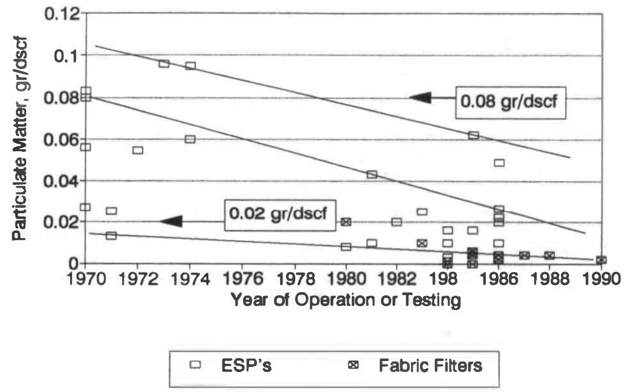

FIG. 4 REDUCTION IN PARTICULATE MATTER (Municipal Waste Combustors)

sections of boilers [Vogg, 1987]. Subsequent tests showed that electrostatic precipitators (ESPs) operating in the 400–500°F range provided ideal locations to form dioxins and furans from precursors, including carbon and chlorine, in the presence of oxygen, moisture and a catalyst such as copper. Recently it has been found that iron was also a good catalyst, and that lime introduced into the furnace has the potential to reduce dioxins by removing the chlorine [Gullett, 1989].

The NITEP tests showed that dioxins and furans, as well as condensible heavy metals could be removed by reducing the temperature of the combustion products below 300°F. The overall result of these developments are shown in Figs. 3–5.

Recently it has been found that mercury can be removed either by the carbon produced by poor combustion, or by carbon injected into the combustion products, prior to collecting the lime, carbon and flyash on a fabric filter [Clarke, 1991].

Total TCDD/DF emissions, reported as high as 5000 ng/m^3 in the 1970's were being reported at levels in the 50–150 ng/m^3 range for facilities without acid gas emission control, a 30–100-time reduction. Figure 3 shows typical Toxic Equivalent emissions reported from 1965 to 1990. Roughly a ten-fold reduction in Toxic Equivalent TCDD emissions took place during the period from 1965 to 1987. The gradual reduction until 1985 is due to improvements in combustion. The drastic reduction after 1985 was the result of employing lime scrubbers and baghouses, operating at temperatures below about 300°F. Overall, a 250-fold reduction exists between the 0.02 and 5 ng/m^3 shown on this graph.

Reductions in Particulate Matter

Particulate matter emissions have been reduced by ESPs from roughly 0.1 grains per dry standard cubic foot (gr/dscf) to 0.010 gr/dscf or less. Fabric filters (baghouses) have demonstrated the ability during testing to reduce particulate emissions to as low as 0.001–0.002 gr/dscf. The range of reduction shown in Fig. 4 is thus 50–100-fold.

Reduction in Metals Emission

The heavy metals of concern, lead and cadmium, have been drastically reduced as the result of reducing particulate matter. The reported emission factors shown in Fig. 5 represent a 4000-fold reduction for lead from 60,000 to 15 lb per million tons. For cadmium they range from 500- to 10,000-fold.

Dispersion of Stack Gases

Up to this point the focus has been on the concentrations of pollutants in the flue gases leaving the stack. Before these gases reach the ground, they will usually be diluted by a factor of 10,000 to several hundred thousand times. The degree of dispersion depends upon specific local conditions, as well as the stack height. The consequence of this dilution is that the concentrations of pollutants at ground level are far below the levels which are acceptable from a health standpoint. Typically, criteria pollutants such as PM, SO_2, and lead and cadmium would be reduced to less than 1% of the Acceptable Air Quality Level (AAQL) even if the dilution were only about 10,000. Dilution factors, mostly based on CARB modeling studies of various types of combustors, are shown in Fig. 6. While each type shows a wide range, all groups have similar magnitudes and ranges. Note that units with higher burning capacities generally have higher stack heights since the buildings are higher [Hasselriis, 1991].

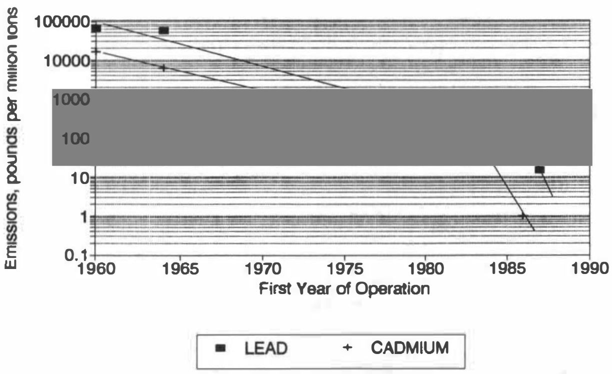

FIG. 5 REDUCTION IN METALS EMISSIONS
(Pounds per million tons)

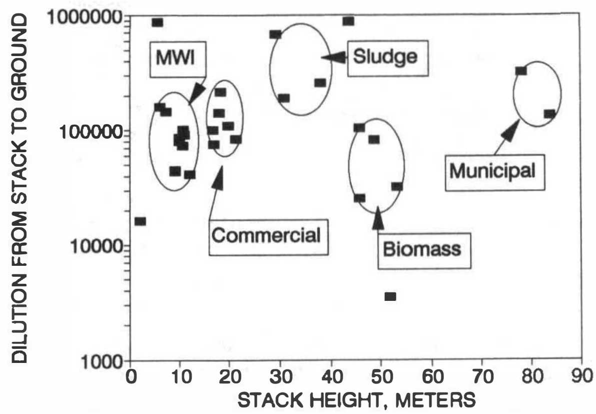

FIG. 6 DILUTION FACTOR VERSUS STACK HEIGHT

CONSENSUS VERSUS CONFRONTATION

A balanced view recognizes that everything in nature, certainly soils, contain trace metals, which are always being leached away by rain. In this context, even though sewage sludge and compost contain heavy metals, the rate of leaching would not be a problem if not too much compost is applied to a given area. If these rules can apply to sludge and compost, they can apply to incinerator ash residues. In Europe and in many localities in the United States rules for application of sludge and compost have been established on the basis of good science. In Europe, similar rules have been in effect for years, encouraging the use of incinerator ash under scientifically-based regulations.

A new national trend is notable: instead of confrontation, we are beginning to see the formation of consensus on environmental issues. Environmentalists who started as "the opposition" are finding that in order to solve problems they must decide to become part of the solution. Engineers, who can also call themselves environmentalists, appreciate opportunities to cooperate and solve problems as a team with the community and government.

Illustrations of this are the following: The recent revisions to the Clean Air Act were developed by consensus meetings. Instead of separate, confrontational meetings with industry and public legislative representatives, the U.S. EPA decided to force the confrontations to take place in the presence of the opposition. An example was the resolution of the concept of earning pollution credits by those utilities able to make major reductions, and selling these credits to those less able. This was proposed by an environmental group, and worked out by consensus. The value of credits are to be developed in a market environment: the commodity market. These developments were described by William G. Rosenberg, Assistant Administrator for Air and Radiation, U.S. EPA, before an AAEE Luncheon in Vancouver, British Columbia.

SUMMARY AND CONCLUSIONS

It is evident, in retrospect, that much money and effort can be wasted when critical factual information is not available at the time when political and regulatory decisions are made.

Currently available data indicates that the health risk to humans which has been attributed to dioxins has been grossly exaggerated, and that heavy metals are the more valid basis for concern.

It appears that leachates from incinerator ash residues, and from composted MSW, contain similar amounts of toxic heavy metals, which are close to or less than the drinking water standard, and that soluble chloride and sulfate salts are the more valid basis for environmental concern. When managed properly, both ash residues and compost can be safely used.

Continuing research is needed in order to develop a balanced view of environmental impact, so that wastes can be managed in an economical and environmentally-protective manner.

The development of consensus approaches to dealing with waste management and its environmental impact should accomplish constructive objectives more efficiently rather than mere confrontation.

Publication of the results of consensus approaches should provide the information upon which sound legislation and regulatory controls should be based.

THE RUSH TO JUDGEMENT

Referring to an article on Alar, the chemical used to improve the quality of apples, J. Craig Potter, former Assistant Administrator of the U.S. EPA, wrote in a letter to the *New York Times:*

> "You clearly show the folly of Government's basing public health policy on weak or incomplete science and media hype. Unfortunately, Alar is not an isolated case.
>
> "I remember very well discussions about the real risks of asbestos that were thrust aside in the rush to judgment largely driven by public perceptions, often based on poor or partial information.
>
> "For once, let's hold off on the hysteria by letting the researchers finish their work. This will let the Government regulators base their decisions on solid science" [Potter, 1991].

This is good advice. Regulations should not run ahead of knowledge. Continued research is needed to provide a sound basis for our activities. The public must be kept informed of current research, to minimize the harmful consequences of perceptions based on the past and outdated information.

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