DELTA

THE HEALTH EFFECTS OF

MEDICAL WASTE INCINERATION

A REVIEW OF THE HEALTH EFFECTS OF CHEMICAL, BIOLOGICAL, AND RADIOACTIVE EMISSIONS FROM MEDICAL WASTE INCINERATORS

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ABSTRACT

Incineration has historically been recognized as a preferred method for disposing of medical waste because of its ability to destroy the physical and chemical hazards of the waste, destroy its "recognizability", kill pathogens and reduce the volume of waste by 90 - 95%. Though many hospitals continue to operate on-site incinerators, this waste disposal practice has come under increased public opposition during the past decade due to negative perceptions about the potentially adverse health effects of uncontrolled emissions and a general mistrust of both medical waste incinerator operators and government regulators. In addition, air quality regulations have become dramatically more restrictive The combined effect of public opposition and increased state or local regulatory air emissions restrictions has resulted in many hospitals replacing their historical reliance on in-house incinerators with either off-site regional medical waste incinerators or other non-incineration disposal technology. Both of these may increase the overall risk of medical waste management, due to either increased transportation risks in transporting waste to offsite facilities or due to higher risks of less effective alternate treatment methods.

This paper will review what is known about the risks of medical waste incineration, discuss the current understanding of the emissions of greatest potential health concern, review data gaps in our understanding; and make recommendations for further information needed to comprehensively assess risks of medical waste incineration

FEDERAL REGULATIONS

Clean Air Act The Clean Air Act Amendments of 1990 (CAAA) directed the U S Environmental Protection Agency to develop two programs addressing hazardous air pollutant emissions (HAPs) and new source performance standards (NSPS) for medical waste incinerators. The standards that are now being developed are based on what can be technologically achieved with consideration given to economics. These programs are summarized below.

National Emission Standards for Hazardous Air Pollutants (NESHAP): Title III of the CAAA requires air pollution control for existing, new and modified sources of hazardous air pollutants (HAPs) The amendment specifically defines 189 substances which have been deemed capable of causing adverse human or environmental health effects through inhalation or other exposure routes at high doses Potential health effects cited include carcinogenicity, mutagenicity, teratogenicity, neurotoxicity, reproductive dysfunction or acute or chronic toxicity Of the 189 HAPs identified by the CAAA, 11 are metals and their compounds, which include antimony, arsenic (including arsine), beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel and selenium.

New Source Performance Standards (NSPS)· The Office of Air Quality Planning and Standards of the USEPA is currently developing regulations for air emissions from medical waste incinerators The program includes standards to be developed under Section 129 of the CAAA of 1990, including new source performance standards under Section 111(b) and emission guidelines for existing medical waste incinerators under Section 111(d) of the Clean Air Act. In developing performance standards, the USEPA must develop numerical emission limits for particulate matter, opacity, sulfur dioxide, hydrogen chloride, oxides of nitrogen, carbon monoxide, lead, cadmium, mercury, and dioxins and furans

USEPA's medical waste incinerator regulatory development program comprises three phases· data gathering; data analysis and control alternatives, and proposal and promulgation of standards. Under a recent consent order, EPA must issue a notice of proposed rule making for medical waste incinerators by February 1, 1995 and sign a notice of final rulemaking by April 15, 1996 (1)

CHARACTERISTICS OF MEDICAL WASTE

Because the waste that is burned by a medical facility ultimately determines stack emissions or ash residue contaminants, knowledge of the category, source and volume of waste destined for incineration should be understood. Medical waste encompasses all waste generated by a health care or health-related facility. Depending on the facility, such waste can include a facility's general waste (e.g., office or cafeteria waste), infectious waste, radioactive waste, or chemical waste. In practice, waste streams are often intermixed which complicates the choice of treatment or disposal options

General Waste. General waste consists of those waste materials that are not regulated or handled as hazardous or otherwise potentially dangerous or special waste Examples include paper goods, cardboard, plastics, food scraps, glassware, as well as other miscellaneous general wastes. Such waste originates from any area of a health care facility. U.S hospitals typically generate a median of about 15 pounds of general waste per patient per day (2)

Infectious Waste: Infectious (a.k a biomedical, biohazardous, regulated medical waste, or red-bag waste) consists of those wastes that have been defined in federal, state or local regulation as having a higher likelihood of containing human pathogens and transmitting infectious disease Categories of waste that are typically defined as infectious include microbiological stocks and cultures, blood and blood products, sharps waste (e.g , syringes), human or animal pathological waste, and communicable disease isolation waste Depending on how it is defined, infectious waste typically makes up about 15% of total hospital waste (2)

Chemical Waste Though volumes are small when compared to industrial operations, hospitals routinely use potentially toxic substances for both patient diagnosis and treatment Chemical substances include such materials as antineoplastic drugs (seven of which are listed by the USEPA as hazardous waste), formaldehyde, photographic chemicals, solvents, mercury, waste anesthetic gases as well as other toxic, corrosive, and miscellaneous chemicals (3)

Low-Level Radioactive Waste (LLRW) LLRW is typically generated during the course of patient diagnosis or treatment from nuclear medicine or clinical testing laboratories Typical waste containing radioisotopes often includes anatomical samples from humans and animals, syringes, organic liquids and other aqueous wastes, soiled clothes and paper, material used for clean-up, and scintillation vials.

In one study characterizing LLRW at a 560-bed university hospital connected to the school of medicine, 67% of the LLRW waste generated was characterized as solid, 7% liquid, 8% scintillation vials, and 18% biological for a total LLRW volume of 75.8 cubic meters collected during 1990 (4). Radioisotopes included I^{125} (25.5%), P^{32} (19.1%), H^3 (14 5%), C^{14} (8.7%), S^{35} (6.2%), I^{131} (1 1%), Cr^{51} (0.8%), $C^{45}a$ (0.4%), microspheres (17.6% - isotopes included Gd^{153}, Ce^{141}, Sn^{113}, Ru^{103}, Nb^{95}, and Sc^{46} with each waste package containing five simultaneously), and other isotopes (6.1%)

Plastics and Metals: The plastics content of medical waste has dramatically increased during the past two decades as medical procedures have come to rely on plastic disposable products During the early 1970's plastics accounted for approximately 10% of the overall medical waste stream In the late 1980's, plastics content rose to more than 30% (5), or about 5 times more than municipal solid waste (6) The amount of chlorinated plastics (e g , PVCs) has been found to directly influence the generation of acid gases, and may influence the production of dioxins and furans as well.

Sources of metal in medical waste include needles, surgical blades, and foil wrappers as well as less obvious sources such as fillers, stabilizers, colorants, and inks that are used in the plastics production (5)

Heat Value· Though most medical waste incinerators are rated in pounds/hour, the actual throughput limiting factor is the heat value of the waste. The heat value for medical waste can range from 4,500 Btu/pound to more than 17,000 Btu/pound, with a typical value of about 8,000 - 8,500 Btu/pound, depending on plastic and moisture content (7).

INCINERATION TECHNOLOGIES AND POLLUTION CONTROL

There are several medical waste incineration technologies currently in common use. These include two-stage starved air incineration (which is the most commonly used technology for both on-site and regional facilities), excess air, controlled air and rotary kiln In California, of the 146 operating medical waste incinerators identified, 94% (137 facilities) are smaller on-site incinerators, and 6% (9 facilities) are regional incinerators burning solely medical waste (8).

Brinckman categorized pollutants of combustion into 3 groups: 1) those controlled by the combustion process (e.g , carbon monoxide, hydrocarbons, and organic constituents), 2) particulate matter, which includes metals, possibly dioxins and furans, and entrained ash, and 3) acid gases (e.g., hydrogen chloride, hydrogen fluoride and oxides of sulfur) (9) To limit these, control of pollution from medical waste incinerators requires attention to 3 process periods: pre-combustion (waste stream control); combustion (facility operation and maintenance); and post-combustion (emission control equipment) (10).

Pre-combustion practices to control stack emissions from medical waste incinerators involve identifying the source of substances of concern in the waste stream, and removing these from the waste before incineration. Some types of emissions can be identified by examining the individual components of the waste stream. For example, levels of lead and cadmium in medical waste emissions have been shown to be linked to paper printing inks and plastic stabilizers (11). In addition, medical waste has been found to consist of about 30% plastics, of which approx 15% has been shown to be polyvinyl chlorinated plastic (PVC) PVC, which contains about 45% chlorine, has been identified as the major contributor to hydrochloric acid (HCl) emissions in medical waste incinerators (11). Controlling or excluding substances of concern in the waste stream is the most effective means of reducing pollutant emissions.

Combustion operating practices have a direct effect on pollutant emissions, and incinerator operation and maintenance must be optimized to minimize emissions Combustion efficiency is directly affected by temperature, residence time, and air/fuel mixing. For example, operational parameters were examined as part of the USEPA's regulatory development program for medical waste incinerators (12). The test program collected information from seven incinerators Parameters included combustion temperature, residence time, waste feed rate and excess air levels on carbon monoxide (CO), particulate matter (PM) and chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans (CDD/CDF) emissions (12). Emissions for the seven tested incinerators exhibited greater variability between facilities than within facilities, indicating the effect of combustion controls on emissions. Older facilities were found to be most affected by inadequate secondary chamber temperature. The results indicated that for facilities with adequate residence times and airflow control, secondary chamber temperatures over the 1,600F to 2,000F range had little effect on emissions For newer facilities, the results suggested that control of primary chamber temperature is necessary to minimize CO and CDD/CDF emissions

Post-combustion controls are used to capture pollutants from flue gas to minimize releases to the environment These systems are capable of achieving a substantially high pollutant removal rate Wet scrubbers and fabric filters (baghouses) are two emissions control options to minimize the release of pollutants from medical waste incinerators (13) Three types of wet scrubbers are used. 1) low-energy (spray tower); 2) medium-energy (impingement scrubbers); and 3) high-energy scrubbers (Venturi) Dry scrubber systems mix an alkaline reagent such as sodium bicarbonate or hydrated lime with the flue gas The reagent mixes with the acid gas emissions in the flue gas, producing non-hazardous products such as salts of chlorine which are collected as particulate matter on a fabric filter (baghouse) A secondary acid gas neutralization occurs on the fabric filter as unreacted reagent continues to react with acid gases.

HEALTH EFFECTS

CARCINOGENIC AIR EMISSIONS

California Air Resources Board: In 1990, the California Air Resources Board (CARB) published a report presenting a proposed control measure which was designed to reduce dioxins and other emissions from medical waste incinerators (8) Following the CARB's designation of dioxins as a toxic air contaminant in 1986, the Board evaluated the need and appropriate degree of control for that compound. Medical waste incinerators were given the highest priority by CARB for dioxins control measure development because 1) medical waste incinerators were designated by CARB as having the greatest potential risk of all dioxins sources that it had identified, 2) most of the incinerators identified by CARB were uncontrolled and located in residential areas; and 3) emissions testing conducted by CARB showed that medical waste incinerators are also sources of other pollutants including cadmium, benzene, polycyclic aromatic hydrocarbons, lead, mercury, nitrogen oxides, sulfur dioxide, particulate matter, and hydrochloric acid

A health risk assessment model was used to estimate the potential acute, chronic and cancer health effects from combustion source pollutants The potential cancer risk was determined by taking the lifetime average daily dose of a pollutant and multiplying it by a risk factor which was developed by the California Department of Health Services (DHS) The DHS risk factor for a lifetime of exposure to 1 picogram/cubic meter of dioxins ranged from 24 to 38 chances in a million of contracting cancer Because dioxins emitted to ambient air can accumulate in the environment and create exposures through other routes, a multipathway risk assessment method was developed For the study the estimates of the total potential dioxin risk was based on an average daily dioxins dose exposure from four pathways: 1) inhalation, 2) dermal absorption; 3) soil ingestion, and 4) mother's milk ingestion

Data were derived from emissions tests conducted on eight California medical waste incinerators These incinerators included single chamber units without air emission control systems that processed less than 100 pounds per hour, and multichamber units, most equipped with either a baghouse or wet scrubber, processing from 500 to about 1,000 pounds of waste per hour. Of those units with emissions control equipment, none had been designed for dioxins reductions

Dioxins emissions were expressed in terms of 2,3,7,8-tetrachlorodibenzo-p-dioxins (TCDD) equivalents, based on the relative potency of the fifteen dioxins or furans as compared to 2,3,7,8-TCDD The emissions rates from the eight incinerators ranged from 7 - 216 nanograms of dioxins per kilogram of waste burned (ng/kg) at the controlled facilities, and from 230 - 6,200 ng/kg at the uncontrolled facilities Dioxin emissions, and corresponding risk, were reported to vary widely depending on the waste composition, the incinerator design and operating conditions.

The modeling showed the potential maximum individual risk ranging from 1 to about 250 chances in a million of getting cancer. The three units fitted with wet scrubbers showed a multipathway risk ranging from 1.3 to 15 7 per million cancer risk, and the one unit equipped with a baghouse exhibited a multipathway risk of 180 per million. Extrapolating these figures to all medical waste incinerators statewide, the potential statewide cancer incidence for dioxins emissions ranged from 1 2 to 1.8 cases in populations exposed. One large facility which was described as being equipped with a well-designed incinerator and emission control device, and which met proposed control measures during the test, had risks between 1 and 10 per million

CARB also investigated cadmium emissions rates for the eight incinerators tested, which ranged from 1 2 to 3,183 micrograms of cadmium per kilogram of waste burned at facilities. A risk factor for a lifetime of continuous exposure to 1 nanogram/cubic meter of cadmium was determined to be 2 to 12 chances in a million of contracting cancer by the DHS. The health risk assessment method for cadmium was the same as for dioxin with the exclusion of the mother's milk pathway for cadmium emissions. The maximum individual lifetime risk from cadmium exposure from tested incinerators ranged from less than 1 per million from a controlled facility to 45 per million from an uncontrolled facility Taking only the inhalation exposure into account, the risk ranged from 1 to 15 per million, with seven out of eight incinerators resulting in a risk of less than 10 per million.

Several emission control technologies were evaluated to assess the potential to reduce dioxins The APCDs included wet scrubbers, fabric filters (baghouses), and dry scrubber/fabric filter combinations Source test results reviewed by CARB on medical waste incinerators and on municipal solid waste incinerators conducted by CARB and Environment Canada found that 99% dioxins destruction and removal efficiencies are obtainable for medical waste incinerators operating under normal conditions The dry scrubber/baghouse combination appeared to provide the higher and more consistent reductions in dioxins emissions than wet scrubber systems Based on this, CARB concluded that properly designed dry scrubber/baghouse systems would consistently meet the dioxins emissions requirements of the proposed control measure, though it was also acknowledged that such consistency may very well be achievable using the wet scrubber technology.

A 99% reduction efficiency or an emission rate of 10 nanograms of dioxins per kilogram of waste was identified as best available control technology for dioxins If such controls were applied to the 8 medical waste incinerators and a 99% reduction achieved, the maximum individual dioxins risk per million exposed would range from 1 to 2.5 per million.

New York City Health and Hospitals Corporation The New York City Health and Hospitals Corporation undertook a study of medical waste incinerators that examined short- and long-term health effects based on six future incineration options (7). The study facilities included three regional medical waste incinerators with capacities of 48, 165 and 330 tons per day, one co-incineration facility with a capacity of 2,250 tons per day, and two on-site incinerators with capacities of 4 and 13.6 tons per day. Emission factors were determined based on emissions studies at other facilities, taking into consideration variables such as dispersion factors, facility operation and pollution control equipment.

The long-term effects were judged based on the ability to cause cancer. The cancer risk by inhalation at the point of maximum impact was calculated based on the assumption of a constant inhalation rate equivalent to 20 cubic meters of air per day for a 70-year lifetime, which contains the maximum carcinogen concentrations, and assuming 100% absorption by a 70 kilogram adult The conservative cancer potency factors developed by the USEPA Cancer Assessment Group for dioxins (PCDD/PCDF) and the primary metals of concern (arsenic, chromium VI and cadmium) were included. Other organic carcinogenic emissions were assumed to contribute little to the total risk and therefore were not included in the assessment

The risk of exposure to deposited particles through all related exposure pathways was considered In a separate risk assessment of the Brooklyn Navy Yard resource recovery facility, which was characterized as having been thoroughly scrutinized in legal review, the total inhalation risk for metals and dioxins was observed to be about one third of the total risk Based on this finding, the upper-bound chances of cancer for an individual exposed for a 70-year lifetime at the point of maximum impact was made by applying a multiplier of three times the inhalation risk to account for pathways other than inhalation.

Based on the risk assessment, the chance in 100,000 (10^{-5}) for the most exposed individual to develop cancer due to a lifetime exposure to emissions from each facility was reported as follows

Type of Facility	Tons/Day	Total Risk
Regional	48	0.15
Regional	165	0 014
Regional	330	0.022
Co-Incineration	2250	0.014
On-Site	4	0.48
On-Site	13 6	1.54

The authors noted upper bound risk estimates of less than 10^{-5} as generally acceptable in regulatory reviews, and risks of 1 in a million (10^{-6}) as negligible Based on this assumption, only one on-site hospital incinerator presented a risk that exceeded 1 in 100,000 All other facilities resulted in risk within an acceptable range, and three facilities (two regional and one co-incineration facility) presented a negligible risk. The risk estimates of future incineration options were much lower than those observed by CARB for existing uncontrolled or inadequately controlled medical waste incinerators.

The likelihood of sensitive receptors at the point of maximum ground-level effects was discussed Risk was considered to be insignificantly low for co-incineration facilities and regional facilities due to the large areas affected and the likelihood of such facilities being located in industrial areas. On-site hospital incinerators were noted to have the greatest potential to affect sensitive receptors because many are located in residential areas that may have large numbers of sensitive individuals. The authors stressed the need for site-specific evaluations to make such determinations.

NON-CARCINOGENIC AIR EMISSIONS

As part of the California Air Resources Board's 1990 risk assessment of medical waste incineration, acute and chronic non-cancer health risks from exposure to other emissions from the eight incinerators were examined (8). Results of the dispersion modeling conducted for the cancer risk analysis as described above and the current recommended reference doses (RfDs) from the California Department of Health Services were used to examine potential chronic effects from lifetime average daily doses of cadmium, iron, manganese, nickel, and lead. Ambient background concentrations of these pollutants were not taken into consideration The contribution from the incinerators did not exceed the RfDs for most pollutants, though it was noted that one facility contributed lead emissions amounting to 57% of the lead RfD value.

Potentially acute effects from 24-hour exposures to hydrochloric acid (HCl) and particulate matter were also examined Five of these uncontrolled or inadequately controlled facilities tested were found to be significantly above the RfD for HCl emissions Particulate emissions were not found to contribute to a violation of the ambient particulate standard in California Currently available emission control technologies such as the dry injection/fabric filtration technology have been shown to reduce particulate matter (including heavy metals and dioxins) and HCl emissions to well within regulatory standards (9).

RADIOACTIVE CONTAMINANTS IN AIR AND ASH

The primary regulatory authority for low-level radioactive waste (LLRW) is the U S Nuclear Regulatory Commission (NRC), though state governments have authority to adopt regulations and carry out such programs. Safe levels of isotopes in ambient air and water have been established by the NRC in the form of Maximum Permissible Concentrations (MPC) The MPC levels have been established to protect human health while considering background radiation levels Incineration of LLRW must not be conducted in such a manner that would release radioactive emissions above the NRC's MPC values (14)

A study was conducted on the Mayo Foundation incinerator in Rochester, New York, to identify radioactive releases from stack emissions to ambient air (15) Prior to incinerating LLRW, the Mayo Foundation stores the waste for up to 22 months, depending on the half-life of the specific isotope and the necessary time for the isotope to decay to safe levels Of the 26 isotopes examined, none exceeded the NRC's MPC when measured at the top of the stack. The sum of ratios for all isotopes measured at the top of the stack compared to the NRC's MPC totaled $1\ 5 \times 10^{-4}$. Ratio sums of less than 1 are considered acceptable to the NRC and therefore safe to human health.

In 1992, Brady published a study examining the fate of tritium (H^3), carbon^{14} and iodine^{131} in typical dual-chambered controlled-air medical waste incinerators with wet scrubber emission control systems, with a 99.5-99 9% organic compound destruction and removal efficiency (15) The author reported that when these isotopes are introduced into the incinerator, between 99 9 and 99 95% of C^{14} labeled organic is converted to carbon dioxide and traces of carbonate salts, H^3 burns at similar efficiencies to water vapor, HCl and HI, and that some of the I^{131} labeled sodium iodide converts to hydrogen iodide and elemental iodine, with the remaining sodium iodide generally converting to submicron particulate matter, most of which is vaporized into the gas phase (16).

As reported by the author, because both C^{14} labeled compounds and H^3 burn with greater than 99 95% efficiency, the incinerator ash contains less than 05% of the C^{14} and H^3

introduced into it. If quantities of either C^{14} or H^3 exceed allowable concentrations in the exhaust stack, the only corrective measure is to reduce the volume of these isotopes from entering the incinerator. Between 20 and 30% of the sodium iodide remains as a crystalline ash material which discharges to the incinerator ash, with the remainder of the I^{131} isotopes discharging to the exhaust gas, of which 99% will be removed in the scrubbing system and end up as sodium iodide in the waste liquid from the scrubber

Incinerator ash may contain radioactive levels below the MPCs established by the NRC in 10 CFR 20 In this context, the MPC levels are used by the Mayo Foundation incinerator to calculate the amount of LLRW that can be legally incinerated at the facility during the course of a year (15)

PATHOGENIC AIR EMISSIONS

The release of human pathogenic microorganisms through stack emissions is often stated as a concern by various groups, though the pathogenic hazard to health and the environment is extremely low when recognizing the elements necessary for disease transmission and the principles of microbial destruction.

Infectious disease requires a source of pathogenic microorganisms, a transmission pathway from the source to the host, and inoculation through a portal of entry of enough microbes to cause infection and disease in a susceptible host The pathogens of greatest concern to the public are the human immunodeficiency virus (HIV) and the hepatitis B virus (HBV), neither of which is transmitted via air. Most other pathogens commonly found in both medical waste and municipal waste are opportunistic pathogens, requiring unusual conditions for disease transmission to occur, conditions that would not be favorable to microbial agents that may be emitted through the incinerator stack.

Though stack emission studies are limited, survival and escape of enough human pathogens to the atmosphere capable of causing disease in a susceptible host is unlikely. In 1982, Kelly reported findings from a study examining microbial emission data from a hospital incinerator under actual conditions (17). Temperatures were reported from 1,380° F to 1,900° F in the primary chamber and from 1,200° F to 1,950° F in the secondary chamber. Hospital waste was burned at a rate of 500 - 800 lbs/hr. Retention times were not identified. Bacterial concentrations in the stack gases were observed at concentrations of 231 colonies/m^3 and in ambient air at 148 colonies/m^3. The authors of the study reported that the differences between ambient air (which more than 200% ambient air was added to the primary and secondary chambers) and stack emission bacterial concentrations were not statistically significant ($p>0.05$), but noted that the ambient air did not account for all bacteria recovered from the stack gas Because these bacterial isolates were not identified, it was not determined whether human pathogens were present.

In 1989, Allen *et al.* published findings on the potential for a hospital incinerator to release human pathogenic bacteria to the ambient air through stack emissions (18) The test incinerator, located in a large primary care facility, was described as a manual load, two-chambered unit with a burn capacity of about 100 lbs/hr, designed to maintain a temperature of 1,400° F in both combustion chambers. Bacteria were recovered from stack emissions, though the counts were not significantly different from counts observed in ambient air Bacillus subtilis, the indicator organism used for the study, was not recovered from the stack emissions, suggesting that the source of the recovered bacteria was not from the unburned waste It was concluded that the most likely source of the bacteria in the stack emissions was the incinerator combustion air

Bacterial emissions were examined by Blenkhern and Oakland from a newly constructed conventional oil-fired, two-chamber controlled air clinical waste incinerator, with a primary chamber designed to operate at 1,470° F and the secondary chamber at 1,830° F (19) The system had a minimum design loading rate of 770 lbs/hour. Viable gram positive and gram negative bacteria were recovered from the exhaust flue gases during normal operation in numbers of up to 400 colony forming units/m³ Though reasons for the survival could not be directly explained, the authors postulated that survival may be attributed to rapid transit times of fine particles suspended in air within the incinerator, or to inadequate combustion due to the presence of large volumes of liquids, and that bacterial survival may be a common occurrence in older, inadequately controlled or maintained units The authors did not feel that it was appropriate to attribute any public health hazard to low-level emissions of viable bacteria from clinical incinerator stacks

In a separate study, Segall *et al.* also noted that because microorganisms typically sorb to available particles, most that escape in emissions would be expected to sorb to fly ash particles, further reducing the opportunity for release to the ambient air (20)

PATHOGENIC RELEASES TO ASH

In 1986, the U S EPA concluded that complete and effective combustion of medical waste would have the effect of killing microorganisms in the waste (21). This was also the conclusion of the Mayo Foundation incinerator report, which quoted a declaration by the National Research Council's Committee on Hazardous Biological Agents in the Laboratory as stating " . with primary combustion temperatures of at least 1,600 degrees Fahrenheit, secondary combustion temperatures of 1,800 degrees Fahrenheit with good mixing, and a gaseous retention time of approximately two seconds all pathogens and proteinaceous materials are denatured (14) "

Nevertheless, inadequate combustion practices have been shown to result in viable microorganisms present in incinerator ash. In 1969 Peterson and Stutzenberg examined municipal incinerator residues from four 1960's-era incinerators with operating temperatures ranging from 1,200 - 2,000° F to evaluate the ability of these units to destroy bacteria normally associated with solid waste (22) None of the incinerators were observed to produce a sterile residue The ash from the incinerators was associated with unburned material such as vegetables, animal wastes and newspapers with readable print, which indicated that the waste had not been entirely burned.

A subsequent investigation by Peterson focused on the distribution and survival patterns of pathogenic microorganisms before and after incineration (23). Ash and quench water residues from eight 1960's-era municipal incinerators with recorded operating temperatures of between 1,200 - 2,000° F were examined for total bacteria, total and fecal coliform bacteria, heat-resistant spores and selected enteric pathogenic bacteria Again, none of the incinerators were found to produce a sterile residue The enteric pathogens Salmonella derby and Salmonella st. paul were isolated from quench water of one incinerator Fecal coliform, a bacterial indicator of fecal pollution, was also isolated from seven of the eight incinerators.

Though survival of potentially pathogenic microorganisms would only be expected to occur if a medical waste incinerator was improperly operated, the steps required for disease transmission to occur as identified in the previous section minimize the health risk associated with pathogen survival in ash.

CHEMICAL CONTAMINANTS IN ASH

In 1992, Hasselriis published a report on incinerator ash from medical waste incinerators (24) Based on findings from studies of municipal solid waste incinerator ash studies and limited medical waste ash studies, the author's conclusions included the following points 1) ash residues contain heavy metals that were originally in the waste materials, 2) dry fly ash is a toxic material and should be conditioned with water or moist ash as soon as possible in order to prevent harm to humans and the environment; 3) tests of ash residues and quench water from medical waste incinerators have shown that the leachates from the TCLP test meet the U S EPA limits, on average, although the data may vary widely. The human health significance of these finding was not addressed.

CONCLUDING REMARKS

Though often faced with public opposition, medical waste incineration remains an important option for the treatment, destruction and disposal of medical waste. The incineration industry has changed substantially during the past decade as new regulations are promulgated by state and local authorities, and the need to control pollutant releases to the environment becomes necessary. Current information indicates that medical waste incinerators can operate within acceptable ranges of risk if properly designed, operated and maintained. Pollution prevention practices to remove contaminants from the waste stream before the waste is incinerated is recognized as an important factor in reducing emissions The current state-of-the-art pollution control devices are capable of significantly controlling pollutant releases to the environment, provided these systems are properly designed, operated and maintained

Risk assessments for new facilities have become an important step in understanding the individual pollution control needs for a proposed incinerator Rule-writing initiatives currently underway by the USEPA under authority of the federal Clean Air Act Amendments of 1990 will have the effect of driving inadequately designed facilities out of operation, and will add further assurances to the public that both new medical waste incinerators and existing units are operating in a manner that minimizes impacts to public health and the environment

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