Waste Incineration:

A Dying Technology

GAIA

Global Anti-Incinerator Alliance
Global Alliance for Incinerator Alternatives

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A Dying Technology

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"In this century of progress, with our knowledge of chemistry, and with the most complete machinery at our disposal, **it seems to me like a lapse into barbarism to destroy this most valuable material simply for the purpose of getting rid of it**, while at the same time we are eager to obtain these very same materials for our fields by purchase from other sources."

Chemist Bruno Terne, 1893

Thanks to the over 375 GAIA members and countless communities around the world fighting to end incineration and wasting, and to make Zero Waste a reality.

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Executive Summary

> Incinerators are an unsustainable and obsolete method for dealing with waste. As global opposition to incineration continues to grow, innovative philosophies and practices for sustainable management of discards are being developed and adopted around the world.

Section 1: The Problems of Incineration

Section 1 deals with the problems of waste incineration: pollutant releases, both to air and other media; economic costs and employment costs; energy loss; unsustainability; and incompatibility with other waste management systems. It also deals with problems specific to Southern countries.

Dioxins are the most notorious pollutant associated with incinerators. They cause a wide range of health problems, including cancer, immune system damage, reproductive and developmental problems. Dioxins biomagnify, meaning that they are passed up the food chain from prey to predator, concentrating in meat and dairy products, and, ultimately, in humans. Dioxins are of particular concern because they are ubiquitous in the environment (and in humans) at levels that have been shown to cause health problems, implying that entire populations are now suffering their ill effects. Worldwide, incinerators are the primary source of dioxins.

Incinerators are also a major source of mercury pollution. Mercury is a powerful neurotoxin, impairing motor, sensory and cognitive functions, and mercury contamination is widespread. Incinerators are also an significant source of other heavy metal pollutants such as lead, cadmium, arsenic, and chromium.

Other pollutants of concern from incinerators include other (non-dioxin) halogenated hydrocarbons; acid gases that are precursors of acid rain; particulates, which impair lung function; and greenhouse gases. However, characterization of incinerator pollutant releases is still incomplete, and many unidentified compounds are present in air emissions and ashes.

Incinerator operators often claim that air emissions are "under control," but evidence indicates that this is not the case. First, for many pollutants, such as dioxins, any additional emissions are unacceptable. Second, emissions monitoring is uneven and deeply flawed, so even current emission levels are not truly known. Third, the data that do exist indicate that incinerators are incapable of meeting even the current regulatory standards.

When air pollution control equipment does function, it removes pollutants from the air and concentrates them in the fly ash, creating a hazardous waste stream that needs further treatment. Thus, the problem of pollutant releases is not solved; the pollutants are simply moved from one medium (air) to another (solids or water). Incinerator ash is highly hazardous but is often poorly regulated. Even landfill disposal is not safe, as landfills leak; but in some places the ash is left exposed to the elements or even spread in residential or food-producing areas.

Incinerators are often deliberately sited in low-income neighborhoods with minority populations, on the theory that politically weak sectors of the population will be less able to resist them. This is a violation of the basic tenets of environmental justice.

Modern incinerators are by far the most expensive approach to waste management; construction costs alone can be hundreds of millions of U.S. dollars. The costs of building and operating an incinerator are inevitably borne by the public. Incinerator companies have devised various complicated financing schemes to lock governments into long-term payments, which have often proved disastrous for local governments. In the United States, many towns have been driven into debt by their incinerators.

Incinerators produce far fewer jobs per ton of waste than alternative technologies and practices, such as recycling. Incinerators also usually displace existing informal recycling networks, causing additional hardship to the poorest of the poor.

Incinerators are often billed as energy producers, since they can generate electricity. However, a detailed life-cycle analysis reveals that incinerators waste more energy than they produce. This is because the products that are incinerated must be replaced with new products. Extracting and processing virgin materials, and making them into new products takes much more energy — and causes more environmental damage — than would reuse, or manufacturing from recycled materials.

Most of the history of waste incineration has been in Northern countries; Southern contexts are likely to be even more problematic for this technology. The lack of monitoring capability means that incinerators are likely to be even more polluting than they are in the North. Administrative problems, such as uncertain budgets and corruption, can interfere with necessary maintenance. Different physical conditions, such as weather and waste characteristics, can render operations difficult or even impossible.

Finally, it must be understood that incinerators are incompatible with other forms of waste management. Incinerators compete for the same budgets and discarded materials with other forms of waste management, and undermine the source separation ethic that drives proper waste handling

Section 2: Alternatives to Incineration

Section 2 deals with the alternatives to incineration. Landfills are not a viable alternative, as they are unsustainable and environmentally problematic. Rather, alternatives must attack the entire notion of waste disposal by recycling all discards back into the human economy or nature itself, thus relieving pressure on natural resources. In order to do so, three assumptions of waste management must be replaced with three new principles. Instead of assuming that society will produce ever-increasing quantities of waste, waste minimization must be given top priority. Discards must be segregated, so that each fraction can be optimally composted or recycled, instead of the current system of mixed-waste disposal. And industries must redesign their products for ease of end-of-life recycling. These principles hold across various waste streams.

The mixed nature of the municipal waste stream destroys much of its value.

Organics contaminate the recyclables and toxics destroy the usefulness of both. Additionally, an increasing portion of the waste stream is made up of synthetics and products which are not designed for easy recycling; these need to be redesigned to be compatible with recycling systems or phased out of use.

Municipal waste programs must conform to local conditions to be successful, and no two will look exactly alike. In particular, programs in the South should not be patterened exactly after programs in the North, as there are different physical, economic, legal and cultural conditions. The informal sector (wastepickers or scavengers) are a significant component of the existing waste system, and the improvement of their employment conditions must be a central component of any municipal waste system in the South. One such successful example is that of the *zabbaleen* of Cairo, who have self-organized a waste collection and recycling system which diverts 85 percent of collected waste and employs 40,000 people.

In general, North or South, systems for handling organic waste are the most important components of a municipal waste system. Organics should be composted, vermicomposted or fed to animals to return their nutrients to the soil. This also ensures an uncontaminated stream of recyclables, which is key to the economics of an alternative waste stream. Recycling creates more jobs per ton of discards than any other activity, and generates a stream of materials that can feed industry.

The greatest barrier to recycling, however, is that most products are not designed to be recycled at the end of their useful lives. This is because manufacturers currently have little economic incentive to do so. Extended Producer Responsibility is a policy approach that requires producers to take back their products and packaging. This gives them the necessary incentive to redesign their products for end-of-life recycling, and without hazardous materials. However, EPR may not always be enforceable or practical, in which case bans of hazardous or problematic materials and products may be appropriate.

Using product bans and EPR to force industrial redesign on the one hand, and waste stream disaggregation, composting and recycling on the other, alternative systems can divert the majority of municipal discards away from landfill or incineration. Many communities have reached 50 percent and higher diversion rates, and several have set their sights on Zero Waste.

Health care is the source of a significant amount of wastes, some of which can be quite expensive to manage. But not all health care waste is potentially infectious or hazardous. The vast majority of the waste produced in health care facilities is identical to municipal waste. A rigorous source separation system is essential to keep the small percentage of waste that is potentially infectious or chemically hazardous segregated from the general waste stream.

Potentially infectious wastes do need treatment and disposal, and several non-incineration technologies are available to disinfect the waste. These technologies are generally cheaper, less technically complicated, and less polluting than incinerators.

A wide range of chemically hazardous wastes, including pharmaceuticals, are produced in small quantities in health care facilities. These are not amenable to incineration. Some, such as mercury, should be eliminated through changes in purchasing; others can be recycled; the rest should be carefully collected and returned to the manufacturer. Case studies show how these principles work in widely varying environments, such as a small maternity clinic in India and a major urban hospital in the United States.

Industrial process wastes tend not to be as mixed as municipal or healthcare wastes, but many of them are chemically hazardous. Clean Production is an approach to industrial redesign that seeks to eliminate hazardous byproducts, reduce overall pollution, and create products and subsequent wastes that are safe within ecological cycles. The principles of Clean Production are:

- the Precautionary Principle, which calls for precaution in the face of scientific uncertainty
- the Preventive Principle, which holds that it is better to prevent harm than remediate it
- the Democratic Principle, under which all those affected by a decision have the right to participate in decision-making
- and the Holistic Principle, which calls for an integrated life-cycle approach to environmental decision-making.

A variety of tools are being employed to implement Clean Production, from policy measures like right-to-know and tax reforms, to UN assistance to firms engaged in Clean Production.

Clean Production cannot answer the problem of existing stockpiles of hazardous wastes, which need some form of treatment besides incineration. A number of programs are developing technologies to address this problem. The standards that have evolved for such technologies are:

- high destruction efficiencies
- containment of all byproducts
- identification of all byproducts
- and no uncontrolled releases.

Several emerging technologies fit these criteria, and have been selected in Japan, Canada and Australia for PCB destruction, and in the United States for chemical weapons destruction. The U.S. chemical weapons program is a success largely because of strong public participation, which pushed an unwilling government to investigate and eventually select safer, non-incineration technologies.

Section 3: Putting Out the Flames

Section 3 discusses the growing rejection of incineration across the globe. Public opposition has killed many proposed and existing incinerators, and is being incorporated into local, national and even international law. Popular resistance to incinerators is global: hundreds of public interest organizations in dozens of countries are engaged in the fight against incineration and in favor of alternatives.

In the United States, business interests and a perceived landfill crisis drove an incinerator building boom in the 1980s. But the boom spawned a massive grassroots movement that defeated more than 300 municipal waste incinerator proposals. The activists fought for higher emission standards and removal of subsidies, which virtually shut down the industry by the end of the 1990’s.

In Japan, the most incinerator-intensive country on Earth, resistance to incineration is nearly universal, with hundreds of anti-dioxin groups operating nationwide. Public pressure has resulted in over 500 incinerators being shut in recent years, but Japanese corporations and government are still heavily invested in the incinerator industry.

In Europe, resistance has taken the form of implementing alternatives. Some areas have cut waste generation dramatically even as populations have climbed. As a result, there is little market for new incinerators in Europe.

In Mozambique, citizens organized across class and color lines to form the country's first indigenous environmental organization. Widely hailed as the return of civil society after the civil war, the organization succeeding in stopping a proposal to incinerate pesticides in a cement kiln in a residential neighborhood.

Elsewhere, activists have had to resort to protests and direct action to stop incineration. Increasingly, however, public opposition is being manifested in the law. Jurisdictions in 15 countries have passed partial bans on incineration, and one country, the Philippines, has banned all incineration.

International law is also starting to bear upon incineration. Three principles of international law – precaution, prevention and limiting transboundary effects – conflict with incineration.

Precaution is cited in the OSPAR, LRTAP, Bamako and Stockholm Conventions and the Rio Declaration, among other documents. Because incineration is effectively an uncontrolled process, with unknown byproducts, and because many of those byproducts are already affecting human health, precaution argues that incineration should be avoided.

Prevention and minimization are widely referenced in international law, most specifically in the Bamako Convention, which explicitly defines incineration as incompatible with prevention and Clean Production practices.

Limiting transboundary effects is a common principle of international law; yet incinerator byproducts, because they transport globally, clearly contradict this principle.

The London, OSPAR and Bamako Conventions also place bans upon incineration at sea and in domestic waters.

The Stockholm Convention, although it does not ban incineration, places severe restrictions on its use. Four of the 12 chemicals subject to the Convention are byproducts of incineration, and the Convention calls for their continuing minimization and elimination. Significantly, the Stockholm Convention talks about total releases, not only air emissions, and clearly calls for countries to prevent the formation – not just release – of these chemicals. Since formation of those four chemicals is virtually inevitable in incineration, this provision sends a clear signal that incineration's end is drawing nigh.

Introduction

Dealing with waste is a challenge common to all human societies. Nature makes no waste: in healthy ecosystems, one species' waste becomes food for the next, in an endless cycle. Modern societies interrupt this cycle in three ways. First, technology has created a wide range of substances that do not exist in nature. Human discards are thus increasingly comprised of plastics, metals, and natural materials laced with hazardous substances (for example, bleached and inked paper), which, in many cases, are difficult or impossible for natural ecosystems to break down. Second, industrial societies use and dispose of much more material per person than their predecessors, and than their counterparts in the less industrialized world. Third, rapid population growth increases the number of people and the total amount of waste generated. As a result, the global ecosystem is overwhelmed, both quantitatively and qualitatively, with what we discard.

Ultimately, human societies rely on the natural environment for all their material needs, including food, clothing, shelter, breathable air, drinkable water, and raw materials for manufacturing and construction. At the same time, all human discards go to the environment. When humans were few and of limited technological capability, we could afford to ignore the relationship between these two processes. Now that we dominate the global ecosystem, that is no longer the case. At the same time that we are confronted with rapid destruction and growing scarcity of natural resources — deforestation, declining fisheries, contaminated groundwater, and so on — we are producing ever-larger quantities of waste that is more hazardous than ever. And our waste disposal practices are increasingly imperiling our resource base.

The conventional wisdom of the waste management industry is that there are only two things to do with waste: burn it or bury it. As the volume, toxicity and persistence of waste have increased, the systems built to deal with it — incinerators and landfills — have become ever more complicated. Modern sanitary landfills may look a little like traditional open dumps, but they are much more complex and expensive, with such features as triple liners, leachate collection systems, multiple, self-contained cells, daily cover, and a permanent cap upon closure. Similarly, modern incinerators are extremely complicated systems, and are among the most expensive of public works. In the end, spending vast sums on landfills and incinerators has created more problems than it has solved.

Luckily, there are better alternatives than landfills and incinerators, even the so-called state of the art burners. As shown by the complementary paradigms of Clean Production and Zero Waste, waste is tangible evidence of economic inefficiency and lost resources. These approaches, at the front and back ends of the materials cycle, work in tandem to replace wasteful, linear systems of production and disposal with cyclical manufacturing processes and product reuse and recycling. Products are redesigned with an eye to elimination of substances that pose disposal hazards or impede recycling. Such an approach reduces the quantity and toxicity of both manufacturing inputs and consumer wastes. By combining a Clean Production approach with Zero Waste systems, communities can eliminate (or "reduce"), re-use, or recycle the vast majority of their municipal waste.[1] These two approaches work in tandem to transform the municipal waste system.

In health care facilities, strict source separation programs can isolate the small portion of medical wastes that requires biological or chemical treatment, for which better and cheaper technologies than incineration are available. This allows the rest of the medical waste stream to be managed along with other, similar household and commercial wastes.

For historical or stockpiled wastes, such as obsolete pesticides, banned products and other existing waste, several non-burn technologies have been pioneered around the world, and more are in the process of development. To close the loop, Extended Producer Responsibility — a policy which forces manufacturers to take responsibility for their products at the end of their useful lives — is an effective means to get manufacturers to redesign their products for easy reuse and recycling.

With the growing prominence of reuse, recycling, and composting, the recognition that many materials traditionally considered waste are in fact raw materials for other processes has brought about a change in terminology. Materials traditionally termed "wastes" — and presumed to be worthless — are now often called "discards," recognizing that, while no longer useful to their original purchasers, they may still be valuable. This shift in terminology and philosophy underpins the move from waste disposal toward materials recovery. To make this shift, however, the emphasis must be on input reduction and product redesign. Simply increasing the recycling of ever burgeoning packaging and badly designed products will not get to the core issue of sustainable materials use and reduced consumption of virgin materials.

This report defines the term "incinerator" broadly. By our definition, an incinerator is any machine or device built or used for the purpose of burning waste. Incinerator proponents often argue that "incineration" is a special form of waste burning, distinguished by high temperature and tight control of combustion conditions. They do so in an attempt to distinguish the current decade's "safe and modern" incinerators from the obviously unsafe ones that were considered modern a decade or two ago. Such claims were common for previous generations of incinerators, but the reality has not changed: high temperatures are not unique to incinerators, and incinerators often operate under much looser control than their builders and operators would like the public to believe. Our discussion of incineration will cover municipal, medical and hazardous waste burners, as well as cement kilns that burn hazardous waste, pyrolysis and gasification devices, and related technologies. Some of the problems to be discussed pertain to open burning of waste.

Section 1:
THE PROBLEMS OF INCINERATION

Plume from UK incinerator causes breathing difficulties and other health problems. © Ralph Ryder/CATs

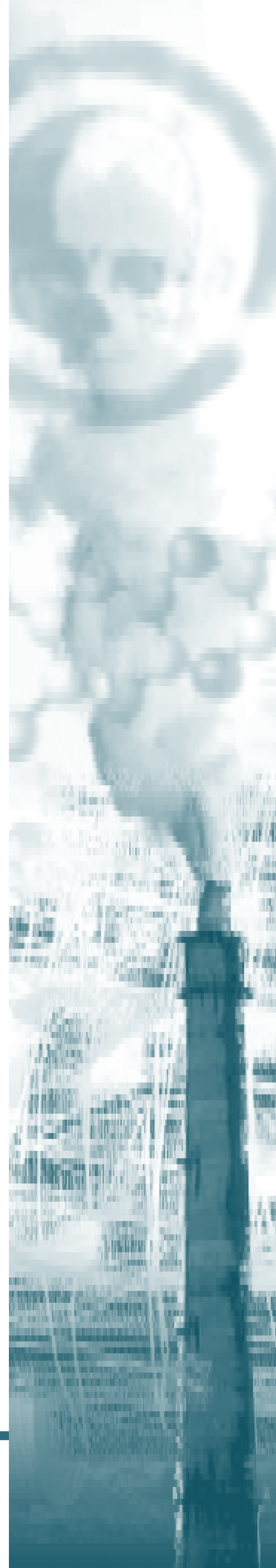
There are many problems with incineration. This section will first address pollution issues, and then discuss questions of economics, sustainability, and the particular difficulties of incineration as a technological import to Southern countries.[2]

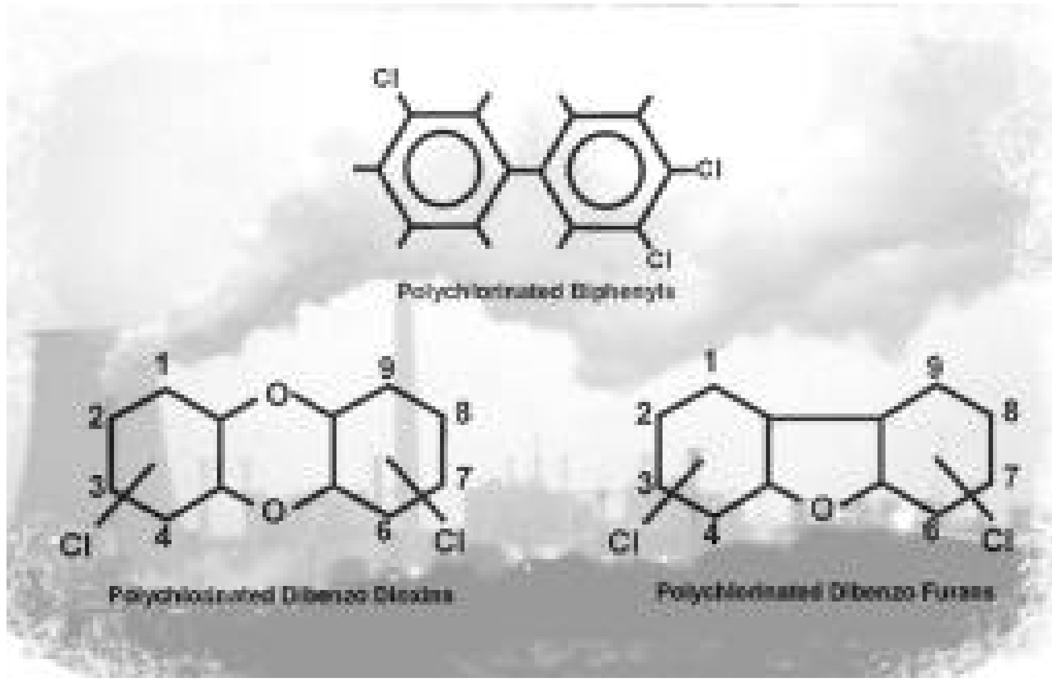
POLLUTANT RELEASES

Pollution is the most recognized and best-studied problem of incineration. Despite intensive scrutiny over many years, however, much remains unknown about releases of pollutants from incinerators. Waste burners produce hundreds of distinct hazardous byproducts, and only a handful of them have been studied thoroughly. Hundreds more may remain unidentified.

Air emissions are most commonly discussed, but incinerators also produce liquid and solid wastes. The bulk of air pollutants come from the smokestack, but "fugitive emissions" also slip out of other parts of the incinerator, and are notoriously difficult to track and eliminate. Liquid releases include scrubber water (from the air pollution control equipment); and releases to land include fly and bottom ash as well as filter cake.

Here we discuss only a few of the most significant pollutants from incinerators. A more complete survey of the scientific literature can be found in the 2001 Greenpeace publication, ***Incineration and Human Health*** *(Please see the Resources section at the end of this report for information on this and other resources).*





Dioxins

"Dioxins" is the common name for a class of pollutants with similar chemical structure and health effects. These include polychlorinated dibenzo dioxins and polychlorinated dibenzo furans. Co-planar polychlorinated biphenyls (PCBs), which have a similar structure and can cause similar toxic effects, are sometimes included in the definition of dioxins. Dioxins are particularly worrisome pollutants because they can cause or aggravate a wide variety of extremely serious health effects, are toxic at very low levels of exposure, and are ubiquitous in the environment.

Dioxins became famous as the culprit in such public health disasters as Love Canal, Seveso, Times Beach, and Agent Orange, in which populations were exposed to large quantities of dioxins. These exposures resulted from improper waste disposal (Love Canal and Times Beach), industrial malfunction (Seveso), and the spraying of a herbicide (Agent Orange) contaminated with dioxins. More recently, in 1999, the introduction of approximately one gram of dioxins and 50 kilograms of PCBs into animal food supplies in Belgium triggered widespread food recalls that caused some US$3 billion in damage to the Belgian economy.[3]

There is an extensive international scientific literature on dioxins' health effects. This research is best summarized in two documents: the U.S. Environmental Protection Agency's (USEPA) "Draft Summary of the Dioxin Reassessment," and "America's Choice: Children's Health or Corporate Profit: The American People's Dioxin Report" by the U.S.-based Center for Health, Environment and Justice. The science summarized in these reports indicates a wide variety of health effects in humans and animals, including cancer, IQ deficits, disrupted sexual development, birth defects, immune system damage, behavioral disorders (such as hyperactivity), diabetes and altered sex ratios. One form of dioxin (2,3,7,8-TCDD) is a known carcinogen and endocrine disruptor, meaning that it interferes with the human body's hormonal system.

Health Effects of Dioxins

© Paul Goettlich/Mindfully.org

The health effects of dioxins have been extensively studied in animals, and to a lesser extent in humans. Binding of a dioxin molecule to a cellular receptor seems to be necessary for expression of biochemical and toxic effects, though some investigators question whether this is how dioxins interfere with the immune system. The dioxin-receptor combination is further processed and transported to the nucleus of a cell where it binds to DNA, interfering with the normal expression of genes. Observed effects include stimulation of enzyme production and alteration of production and metabolism of various hormones, growth factors, and other naturally occurring chemicals.

Of the 75 different congeners (forms) of dioxins and 135 congeners of furans, one — known as 2,3,7,8-TCDD — has received the most scrutiny. However, all congeners are thought to act primarily through the same mechanism: binding to the Ah receptor. Varying degrees of affinity for the Ah receptor thus result in varying degrees of toxicity (reflected in the Toxic Equivalency Factor). As such, it is generally agreed that health effects from the different congeners are similar in nature, varying mostly by degree. The following findings, although derived primarily from studies of 2,3,7,8-TCDD, are generally thought to be valid for all congeners of dioxins and furans.

Dioxin causes cancer in laboratory animals, and several studies of humans show an increased incidence of various forms of cancer. It is also toxic to the immune system, and it interferes with normal reproduction and development. Primate studies show an association between dioxin exposure and endometriosis.[4] Dioxin interferes with thyroid hormone levels in infants.[5] These effects may occur at extremely low exposure levels. Large accidental or occupational exposures cause a skin rash (chloracne), weight loss, fatigue, decreased libido, altered glucose metabolism, and neurological damage.[6] In animal studies, susceptibility to the various forms of toxicity varies considerably among species. Species variability is less marked, however, among fetuses and infants, with some health effects detectable after extremely low exposures even in species whose adults are relatively resistant. There is also evidence of considerable variability of susceptibility among individuals.

Cancer

Dioxin repeatedly causes cancer in virtually all studies in experimental animals at doses well below those which are otherwise toxic.[7] Carcinogenesis is a multi-stage process. Though dioxin does not appear to initiate the events leading to cancer, it behaves as a potent cancer promoter - i.e., once the initial events have occurred, dioxin triggers others necessary for a malignant tumor to appear. It modifies hormones involved in cell growth and differentiation.

This undoubtedly explains how dioxin exposure causes an increased incidence of many different types of tumors. Experimental animals exposed to very low doses of dioxin under varying circumstances may develop cancers of different organs, including the liver, adrenal gland, thyroid, skin, lung, nose, and palate.[8]

Studies of cancer in humans exposed to dioxin have produced mixed results. Some show increased incidence of soft-tissue sarcoma,[9] non-Hodgkin's lymphoma,[10] and nasal cancer.[11] A particularly comprehensive study of workers from 12 different industrial facilities showed increased mortality from soft-tissue sarcomas and all cancers among those exposed to dioxin.[12] Others have not found similar increases.[13] Dioxin is classified as a known human carcinogen by the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA).

Immune system toxicity

Effects on antibody response and other forms of immune-system expression have been extensively studied and documented. Effects on the immune system of the developing organism appear to be among the most sensitive endpoints studied. Extraordinarily low single doses in pregnant animals cause lifelong changes in the immune system of offspring. In experimental animal studies, dioxin exposures of far less than one microgram/kg cause a decreased immune response and increased susceptibility to viral, bacterial, and parasitic infections.[14] Prenatal exposure to dioxin at low levels causes increased growth of transplanted tumor cells in offspring.[15] This may well represent immune-system toxicity since the immune system plays an important role in cancer surveillance and suppression.

A number of studies in humans exposed to dioxin have shown effects on various measurements of the immune system in blood tests. The importance of these changes is not clear. More research is needed to determine if these changes are correlated with increased susceptibility to infection or more severe disease.

Reproductive and developmental toxicity

Animal studies show that dioxin exposure is associated with decreased fertility and litter size and inability to carry pregnancies to term.[16] Offspring have lowered testosterone levels, decreased sperm counts, birth defects, and learning disabilities.[17] Many of these effects are seen at very low exposure levels, demonstrating the exquisite sensitivity of the developing fetus to dioxin. In one rat study, a single low maternal dose of dioxin (0.16 micrograms/kg) on day 15 of pregnancy reduced male testosterone levels, delayed descent of the testicles, made the genital area more female-like, and reduced sperm production and prostate weight in male offspring.[18] It also demasculinized their behavior in months that follow. These results have been replicated in many different laboratories.

Human studies have shown lowered testosterone levels in exposed workers and birth defects in offspring of Vietnam veterans exposed to Agent Orange, an herbicide containing dioxin.[19]

In the U.S., a breast-feeding infant is exposed to approximately 50-60 picograms dioxin (TEQ)/kg/day, a level considerably higher than average adult exposure levels of approximately 3 pg/kg/day. Nursing infant exposures are at levels that cause abnormalities in animal studies. All studies of dioxin toxicity indicate that early development is the stage of life most susceptible to many of its health effects. However, since many of the adverse effects of fetal or infant dioxin exposure may be apparent only much later in life, human epidemiological studies of the results of those exposures have yet to be conducted, since early exposures are impossible to estimate with accuracy.

Most hazardous pollutants are assumed to be of concern only to limited populations exposed to them at high levels. Although there are some populations with high exposure to dioxins, such as Vietnam War veterans or victims of industrial accidents, dioxins have also become a global health threat, because background levels of dioxin exposure in many human populations are high enough to trigger health effects.[20] This means that dioxins have become so widespread that they are now affecting the health of entire populations. For example, by USEPA's most recent estimates, the general population's risks for cancer based on dioxin exposure could be as high as the range of 1 in 100 to 1 in 1,000.[21] In part, this is because dioxins can trigger health effects at extremely low concentrations. Indeed, there is no known level below which dioxins are known to be harmless.[22] Dioxin exposures are typically measured in picograms (one picogram is one trillionth of a gram) per day. At this level of concentration, even detection is difficult.

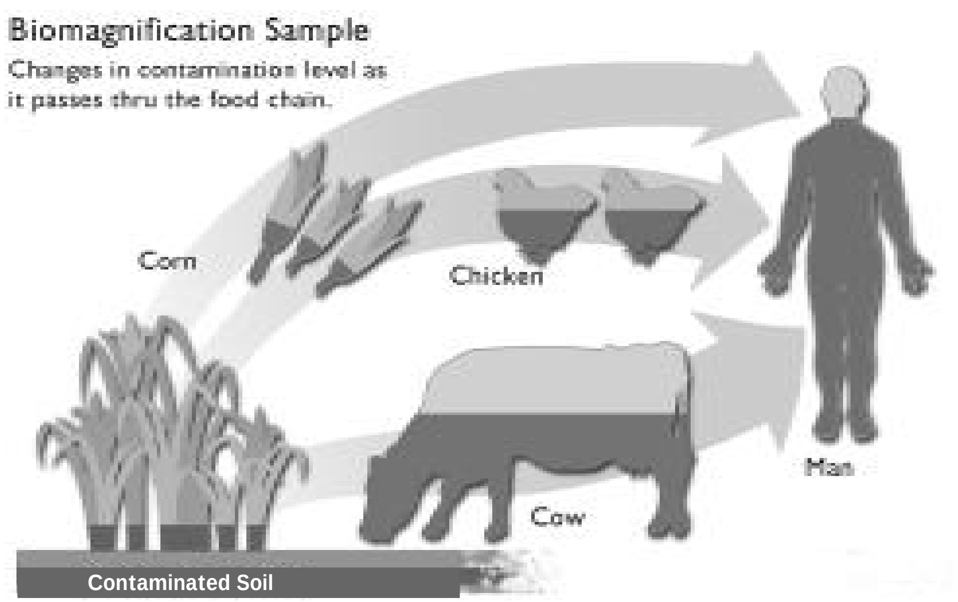
Given the extreme toxicity of low doses of dioxins, concern is mounting about the general population's exposure. In 1998, the World Health Organization (WHO) lowered its recommended Tolerable Daily Intake from 10 picograms TEQ[23] per kilogram bodyweight per day (pg/kg/day) to a "range" of 1 to 4 pg/kg/day.[24] WHO also strongly recommends setting targets in the lower part of the range. This has caused considerable consternation for governments whose populations are already exposed at higher than the recommended levels.

Seeking to reassure the public, the French government's agency for food safety (AFSSA) recently released a study showing that the French population ingested approximately 1.3 pg/kg/day, a level within WHO's "acceptable" range, but exceeding the WHO goal. As this figure is an average, of course, it also indicates that significant sections of the population are likely to be above the 4 pg/kg/day limit. The study also had far more serious problems, as revealed by the French non-governmental organization (NGO), Centre National d'Information Indépendante sur les Déchets (CNIID). It neglected to count dioxin-like PCBs; it ignored all exposure in the first two years of life, when nursing infants are exposed at a higher rate (relative to body weight) than at any other time; it neglected to account for inhalation; and it used outdated norms for calculating dioxin toxicity. Correcting for those errors raised the average French exposure to 4.9 pg/kg/day and the exposure for the 5 percent most exposed (three million people) to 9.45 pg/kg/day — well in excess of any "safe" exposure level.[25] By way of contrast, USEPA's proposed "virtually safe dose" is 0.0064 pg/kg/day.[26]

Dioxins have become virtually impossible to avoid. Everyone on earth is now thought to carry dioxins in his or her body. Long-distance transport of dioxins clearly is possible, since they are found in natural systems virtually everywhere on the globe, including areas far from sources of industrial emissions. Approximately 90 to 95 percent of human exposure to dioxins is from food, particularly meat and dairy products.[28] Dioxins preferentially accumulate in fats and oils, which occur predominantly in living organisms, and are highly persistent because they break down very little in human and animal tissue and in the environment. The half-life of dioxins in the human body is estimated to be 7 years.[29]

Governments have long been aware of the magnitude of dioxin exposure from incineration. As far back as 1985, Olle Aslander, the Dioxin Research Coordinator of the Swedish Environmental Protection Board, said, **"Our [dioxin] analysis of human milk and fish from the Baltic indicated we are in trouble, in very great trouble. In fact...we found babies were consuming [dioxins at] 50-200 times over the daily limit we accept. And in other European countries, we are convinced the levels are higher. Nobody knows how to burn garbage without producing dioxin...the technical development work at incinerator plants has hitherto mostly been of the trial and error type."**

Not much has changed since Mr. Aslander's statement.[27]



Since organisms cannot readily break them down, dioxins move up the food chain, passing from prey to predator. Each level of the food chain thus tends to carry a higher concentration of dioxins in its body, a process known as biomagnification. Humans, at the top of the food chain, receive some of the highest doses of dioxins of any species. As we ingest additional dioxins with every meal but have very little capacity to break them down, the amount present in the body tends to increase over an individual's lifetime. However, infants are most at risk from chronic exposure, both because of their high ratio of food intake to body weight and because much of their diet is mother's milk, which is high in fats and therefore dioxins.

“Dioxins have never killed anyone.”

The nature of environmental pollutants makes it difficult to establish a single pollutant as the cause of death for any given individual. Industry representatives often try to use this fact to obscure the true danger of environmental pollutants and imply that they are harmless. The argument that “dioxins have never killed anyone,” however, is misleading, used only to confuse the public.

There are a number of reasons why it is nearly impossible to tie an individual’s death or disease to exposure to a single chemical. For one thing, humans, unlike laboratory rats, are not exposed to one chemical at a time; at any given time, thousands of synthetic chemicals can be found in any human body. This makes it difficult to establish that any one of those chemicals is the culprit. Second, interactions between the various chemicals are rarely studied; and it is in any case impossible to comprehensively document the interactions between all combinations of the thousands of chemicals to which humans are exposed. Dioxins, like many other synthetic chemicals, are ubiquitous. This means that there is no unexposed human population on earth, which makes it impossible to contrast an exposed population with a “healthy,” unexposed population. Industry will often refer to increased exposure, using “background levels” as a baseline, implying that the average level of exposure is safe. In fact, it is now known that background levels of dioxin exposure are grounds for concern. Environmental exposure also occurs over long periods of time — years, or even decades. This also adds to the difficulty of establishing a direct cause-and-effect relationship in humans.

All of these factors are, of course, cause for ***more*** concern, not less. While it may never be possible to establish dioxins (or any other environmental pollutant) as the sole cause of death, except in a few, rare, acute exposure cases, it is clear that dioxins are causing the premature deaths of thousands of people. Using statistical models, the French environment ministry estimates that dioxins kill between 1800 and 5200 people per year in France alone.[30] This has also been recognized in the courts. For example, in 1991, a St. Louis jury awarded $1.5 million to the family of a truck driver who died in 1984 from cancer allegedly tied to exposure to dioxin-laced waste oil used as a dust-control measure at a truck stop in Missouri.[31]

Although human exposure to dioxins comes largely through food, the original source of virtually all dioxins is industrial processes. In the United States, over 70 percent of all dioxin releases to air come from combustion sources.[32] The share of such releases from incinerators was even higher before the recent sharp decline in medical waste incineration. Approximately 88 percent of U.S. medical waste incinerators have closed since the late 1980s.[33] In USEPA’s first inventory of dioxin air emissions in 1994, medical and municipal waste incinerators were the first and second largest sources respectively, collectively contributing 84 percent to the total. In Japan, incinerators are estimated to cause 93 percent of dioxin air emissions; in Switzerland, 85 percent; in Great Britain, 79 percent; and in Denmark, 70 percent.[34] Authors of the European Dioxin Inventory note, “Despite considerable effort having been spent during the last years to decrease the emissions from municipal waste incinerators, this source type still dominates the input of [dioxins] into the atmosphere.”[35]

However, air emissions of dioxins are not as large as releases to other media, and many governments, by focusing primarily on air emissions, may be missing an even greater potential

“[C]ombustion is the **only** source of sufficient size and ubiquity to account for the PCDD and PCDF in human adipose tissue.”[38]

source of dioxins in the environment. European Union (EU) data indicate that most dioxin from incinerators is released to land, rather than to the air.[36] One study found that only 1.7 percent of an incinerator's dioxin releases went out the stack, with the vast majority released in ash and slag.[37]

Other Halogenated Organic Compounds

In addition to dioxins, incinerators are sources of other halogenated organic compounds.[39] These include polychlorinated biphenyls (PCBs), chlorinated benzenes, polychlorinated naphthalenes (PCN), halogenated phenols, brominated and mixed halogenated dioxins, iodinated dioxins, polychlorinated dibenzothiophenes and many aza-heterocyclic compounds.[40] In general, these substances have been much less studied than dioxins, and less is known about their releases and their health effects. Some of these substances, namely hexachlorobenzene (HCB) and PCBs, are listed as Persistent Organic Pollutants (POPs) under the Stockholm Convention; many are known or suspected carcinogens, and several are thought to have dioxin-like toxicity.

> "POPs have been linked to numerous adverse effects in humans and animals. **Those include cancer, central nervous system damage, reproductive disorders and immune system disruptions.** They are, in fact, lethal."
> — USEPA Administrator Christie Whitman, 2001.[41]

Mercury

Like dioxins, mercury is a persistent, bioaccumulative toxin that can be transported far from where it is emitted into the environment. Since it is an element, mercury cannot be broken down. It is a potent neurotoxin, which means it attacks the body's central nervous system, resulting in disturbances in sensation (tingling and numbness), impaired vision, speech, and motor control, spasms, loss of memory, and even death. Mercury also attacks the heart, kidney and lungs. It is particularly hazardous to developing fetuses, infants and young children, with effects including delayed development of motor functions (walking, talking and speaking), mental retardation, seizure disorders, cerebral palsy, blindness and deafness. Mercury transfers from women to fetuses across the placenta and to infants through breastfeeding, resulting in exposure at critical stages of development.[42]

Incinerators, and medical waste incinerators in particular, are major sources of mercury pollution. In the United States, approximately 39 percent of airborne mercury emissions are from waste incinerators; the global average is approximately 29 percent.[43] Once released into the environment, mercury is readily transformed into methylmercury, which easily enters the food chain and bioaccumulates.

Mercury contamination is widespread. In the United States, the Centers for Disease Control estimate that 375,000 children — about one-tenth of all births — are born each year with an elevated risk of neurological impacts because of low-level mercury exposures during the pregnancy.[44]

> "The emissions from incinerator processes are extremely toxic. Some of the emissions are **carcinogenic**. We know, scientifically, that there is no safe threshold below which we can allow such emissions. We must use every reasonable instrument to eliminate altogether."
> — U.K. Environment Minister Michael Meacher to a House of Lords Inquiry, 1999.[45]

Other Toxic Metals

Incinerators typically release a wide variety of other toxic metals, including lead, cadmium, arsenic, chromium, beryllium, nickel and others.[46] Health effects of these metals include:

- **Lead**: -nervous system disorders, lung and kidney problems, and decreased mental abilities in children exposed in utero and early in life
- **Cadmium**: -kidney disease, lung disorders; high exposures severely damage the lungs and can cause death
- **Arsenic**: -arsenic damages many tissues including nerves, stomach, intestines and skin, causes decreased production of red and white blood cells and abnormal heart rhythm
- **Chromium**: -damages nose, lungs and stomach
- **Beryllium**: -chronic lung problems

Incinerators are significant sources of these forms of air pollutants. Worldwide, incinerators are the source of 21 percent of air emissions of manganese and lead, 19 percent of antimony, 15 percent of tin, and 11 percent of selenium.[47]

Worldwide Atmospheric Emissions of Trace Metals from Waste Incineration[48]

Metal	Atmospheric emissions from waste incineration	
	1000 tons /year	Percent of total emissions
Antimony	0.67	19.0
Arsenic	0.31	3.0
Cadmium	0.75	9.0
Chromium	0.84	2.0
Copper	1.58	4.0
Lead	2.37	20.7
Manganese	8.26	21.0
Mercury	1.16	32.0
Nickel	0.35	0.6
Selenium	0.11	11.0
Tin	0.81	15.0
Vanadium	1.15	1.0
Zinc	5.90	4.0

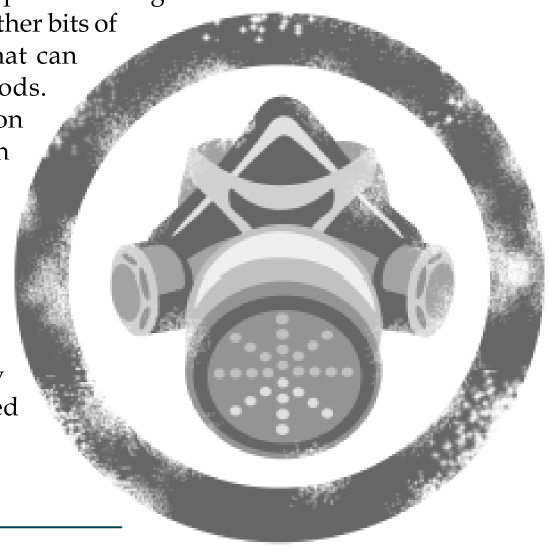
Greenhouse Gases

Incinerator proponents sometimes mistakenly claim that waste burning reduces emissions of greenhouse gases. Their argument is based on the assumption that organic wastes, if not incinerated, will decompose anaerobically in a landfill, producing large quantities of methane (a potent greenhouse gas) that will vent to the atmosphere. However, USEPA concluded in a 1998 study that incineration and landfilling of mixed municipal solid waste yield similar levels of net greenhouse gas emissions.[49]

Furthermore, other approaches to solid waste problems can offer significantly lower greenhouse gas emissions than either incineration or landfilling. Incinerators are a significant source of carbon dioxide (CO_2), producing approximately one ton of CO_2 for each ton of municipal waste incinerated.[50] Through combining waste prevention and reuse of discards with high levels of recycling and composting, communities can substantially reduce waste-management-related emissions of both CO_2 and methane. By eliminating the need to extract more raw materials and manufacture new products to replace those being thrown away, such an approach saves more energy than can be recovered through incineration, reducing net greenhouse gas emissions.[51]

Particulates

Combustion processes such as incineration produce large quantities of ultra-fine particulates — dust, soot and other bits of material less than 2.5 micrometers in diameter— that can remain suspended in the atmosphere for long periods. These particulates can slip through most air pollution control equipment — typical capture rates are between 5 and 30 percent — and are of particular health concern because of their ability to evade the natural filters of the human nasal passages and lodge deep in the lungs. Particulates from incinerators carry heavy metals, dioxins and related compounds on their surfaces.[52] Fine particulates have been linked to asthma, decreased lung function, other respiratory ailments, disruption of heart function, and increased mortality rates.[53]



Other Pollutants

A partial listing of known incinerator releases can be found in appendix A. Many of these pollutants have been associated with significant environmental and human health effects. A few deserve special mention. Acid gases, such as hydrogen chloride (HCl), hydrogen fluoride (HF), hydrogen bromide (HBr), and sulfur oxides (SO_x), can damage incinerators, primarily by corroding air pollution control equipment. They also can cause or exacerbate a wide range of human health problems — especially respiratory disorders — and are acid rain precursors. Nitrogen oxides (NO_x), which are important contributors to photochemical smog as well as acid rain, are difficult to remove from stack gases, as they are chemically neutral. Polycyclic aromatic hydrocarbons (PAH) and volatile organic compounds (VOC) are large classes of chemicals with a wide range of health effects. Incinerator emissions have also been shown to be mutagenic, meaning that they alter human DNA.[54]

Finally, there is the great unknown. Many of the substances released from incinerator stacks or in ash are still unknown, let alone properly studied for human health effects. Even in test burns, when an incinerator is operating under ideal conditions, many unidentified compounds are released.[55] Indeed, one study found that "the amounts of unknown organohalogen compounds formed by waste incineration are higher by orders of magnitude than PCDD/DFs and PCNs."[56] These may help to explain epidemiological studies in France and Britain that have established a strong relationship between various forms of cancer and proximity to an incinerator, but have not yet established mechanisms for these health effects.[57]

PROBLEMS OF CONTROLLING AIR EMISSIONS

Builders and engineers of incinerators often respond to questions about pollution by asserting that "air emissions are under control" in the newest generation of "state of the art" waste burners. Underlying their claims are three unsupportable assumptions. First is the assumption that there are acceptable emissions levels for all the pollutants released by incinerators; second, that incinerator air emissions are now being accurately measured; and third, that emissions, even as currently measured, are within the limits currently defined as "acceptable."

> "It is...generally accepted that emissions standards are based on what can be measured and what is technologically achievable, **rather than what is safe**...This point was accepted by the Environment Agency."
> -U.K. Department of Environment Transport and Regional Affairs Committee, 2001[58]

As discussed above, dioxins are extremely toxic, persistent, ubiquitous pollutants. Current levels of human exposure — and levels measured in human tissue — are at or near those believed to trigger health effects. The general population's exposure to dioxins is already too high. And as the Stockholm Convention's first clause says, dioxins and other POPs "are transported, through air, water and migratory species, across international boundaries and deposited far from their place of release…" making it impossible to situate a point source such as an incinerator to avoid impacts on humans. It is therefore logical that no additional dioxin releases are acceptable. It is certainly true that some nations' current standards are in excess of WHO target levels.

Knowing the true air emissions of an incinerator requires continuous monitoring. However, the most dangerous pollutants are rarely monitored on a continuous basis. The technology for real-time, continuous monitoring of mercury emissions exists but is rarely employed. For dioxins and other halogenated compounds, such technology does not even exist. A quasi-continuous monitoring system (known as AMESA), which does not allow real-time feedback, does exist for dioxin, but is only being used in a few countries.

Instead of continuous monitoring, incinerators are typically subject to one or two dioxin stack tests per year, each test consisting of a single six-hour sample. This sample is then assumed to be representative of year-round emissions. In fact, studies show that such a stack test can drastically underestimate emissions of dioxin, recording as little as 2 percent of the actual total.[59] One reason for this is that dioxin production is not continuous; the majority of dioxins are usually produced in short-term emissions peaks during start-up or shutdown, or under "upset" conditions (conditions in which the incinerator is operating outside specified parameters).[60] Tests are rarely if ever conducted under those circumstances, so testing often misses the majority of dioxins produced.[61]

Tests are often conducted under optimum, or even test burn, conditions because the operating engineers are aware of when tests are to be administered. In these instances, they may take special measures to ensure minimum dioxin production for the duration of the test.[62] Incinerator operators have even been caught reserving "clean" waste that will minimize dioxin production specifically for such tests *(see box)*. Although this may be appropriate for determining the absolute minimum dioxin production under ideal conditions, it is clearly not an indicator of overall performance.[63]

Defeating the Stack Test[64]

© Vasily Mazaev/Foundation for the Realization of Ideas

Incinerator operators often base their claims of safe operation upon stack gas emissions tests that show dioxin emissions below some regulatory level. There are a number of flaws with this argument: to begin with, the assumption that any level of dioxin emissions is safe does not take into account issues of multiple sources, long-distance transport, bioaccumulation, biomagnification and the extremely high background levels of dioxins. But an even more fundamental flaw is in how dioxins are measured. The standard method for measuring dioxins in an incinerator stack is to insert a probe for a period of time from two to six hours. This probe is then removed, the sample is sent to a lab, which analyzes the quantity of dioxins present, calculates the total volume of gases sampled, adjusts for oxygen levels, and returns the result weeks later. The time lag between sampling and test results defeats one of the primary purposes of measuring emissions: to tell the operators when something is awry so that they can take action to identify and fix the problem.

Dioxin emissions are not constant. Most incinerators see "spikes" of dioxin emissions during warm-up, when the furnace is just starting; during shutdowns; and during "upset conditions." An upset condition can be anything from a batch of wet trash that causes furnace temperatures to dip to an out-of-control fire or explosion. Dioxin tests are almost never performed during these circumstances, so periods of high dioxin production are excluded from the test. When the dioxin test does happen to coincide with an upset condition that produces dioxins in excess of the legal norm, some authorities (including the US EPA) have allowed incinerator operators to scratch out that result and try again.

In the U.S., dioxin tests are typically performed once or twice a year, at most, and require substantial advance preparation, because of the physical requirements to place a probe in the stack. Incinerator operators can plan their operations so that the best possible — rather than the typical — emissions levels are recorded. As the Columbus Free Press reported, one such incident occurred in March 1994, in Columbus, Ohio, where the incinerator operator (having exceeded EPA dioxin guidelines by 600 times on a previous test) took special measures to ensure a better result. The operator's logbook recorded deliberate attempts to stockpile special, "clean" trash to ensure a good burn, and to fluff and dry this trash to avoid problems from dampness. The EPA had decided to test only one of the six "lines" (furnaces) of the incinerator, which was then retrofitted with a natural gas burner; and the test was scheduled to avoid peak dioxin production times ("soot blowing"). The Columbus Free Press reported that one EPA official wrote that these actions "might constitute a criminal conspiracy to violate federal environment laws" but the EPA chose to accept the results instead.

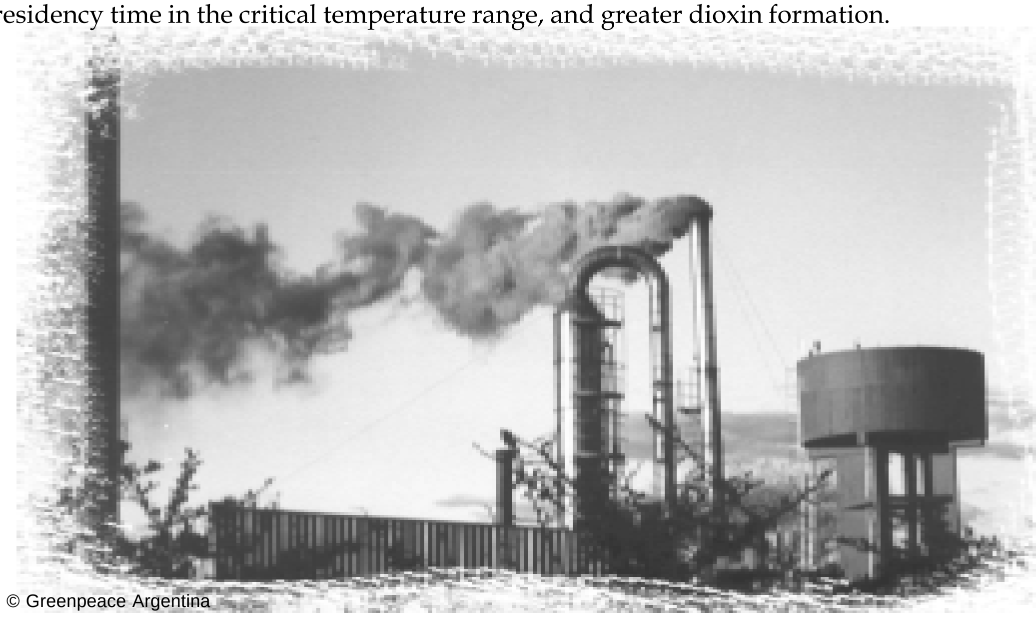
To actually control incinerator emissions requires not just continuous, but real-time monitoring. In other words, the operating engineers must know the emissions levels as they leave the stack, not receive a report two weeks later, if they are to take action to correct any problems. This is not technically possible for dioxins, and is rarely implemented for mercury.

"In monitoring for compliance or other purposes, data generated during the intervals in which a facility is in startup, shutdown, and upset conditions should be included in the hourly emission data recorded and published. **It is during those times that the highest emissions may occur, and omitting them systematically from monitoring data records does not allow for a full characterization of the actual emissions from an incineration facility.**"

— US National Research Council[65]

Even the monitoring systems that are available indicate that incinerator performance in practice is very different from theoretically achievable levels. For example, the Netherlands' most modern municipal waste incinerator reported that its flue gas cleaning system was out of order during 10 percent of its operating time.[66] In the U.K., Greenpeace collected data on the 10 operating municipal waste incinerators that indicated that each one had regularly exceeded its permitted air emissions; one incinerator reported 95 such breaches in a single year. Of the 553 breaches reported among the 10 incinerators, only one resulted in a fine.[67] Given that these are self-reported breaches, and engineers do not have access to continuous monitoring of many pollutants, they probably underestimate the true extent of the problem.

There are also some inherent conflicts in incinerator design that reduce the effectiveness of emissions control technology. It is commonly argued that very high furnace temperatures — above 1000 degrees Celsius — will break down dioxins. This is true, but many studies have established that the majority of dioxins released from incinerators are not formed in the furnace, but rather in exhaust gases, as they cool after leaving the furnace.[68] This makes exhaust gas temperature a key factor in controlling emissions. Maximum dioxin formation occurs between 300 and 600 degrees,[69] although dioxin formation has been observed both above and below this range.[70] To minimize dioxin production, it is necessary to minimize the time exhaust gases stay in that temperature range (the residency time). Some incinerators are fitted with a quench system to rapidly reduce the temperature of exhaust gases as they leave the combustion chamber. In waste-to-energy incinerators, however, the exhaust is run through heat exchangers before quenching. This enables the incinerator to generate electricity, but at the cost of increased residency time in the critical temperature range, and greater dioxin formation.



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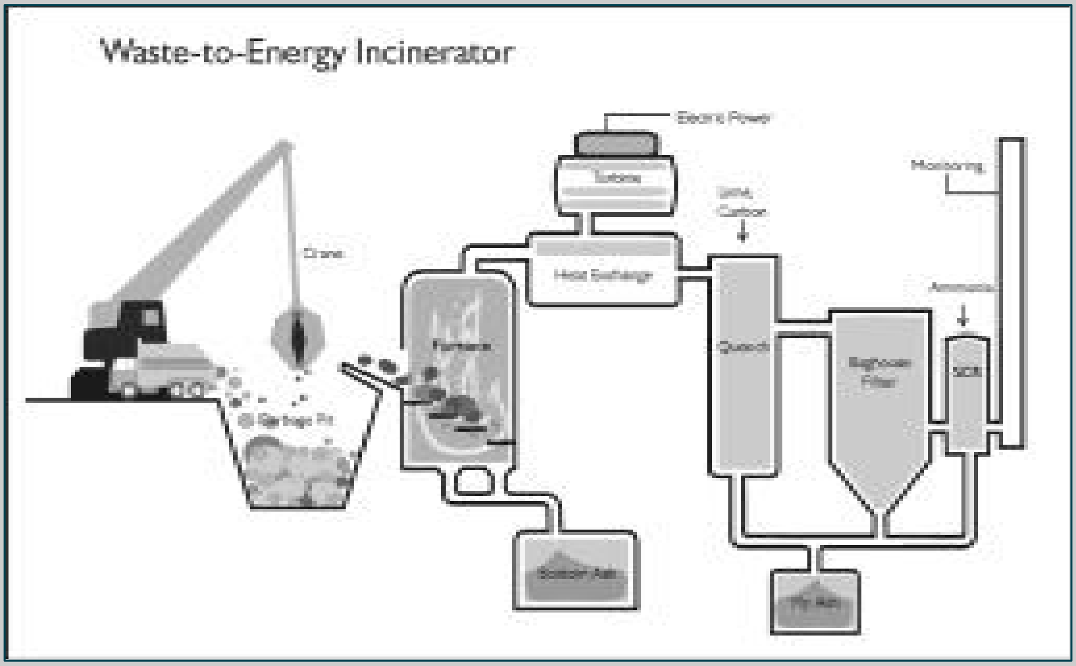

Incinerator Schematic

This schematic indicates the major components of a "modern" waste-to-energy incinerator. Individual facilities vary considerably in their equipment.

- **Garbage Pit**: Trucks dump household wastes into the garbage pit, which is large enough to hold several days' worth of waste. A crane then scoops up the waste and places it in a hopper, which feeds it into the furnace.

- **Furnace**: There are several different grate designs, which are supposed to facilitate oxygenation and complete burnout of the waste. The ash and non-burnable components that fall out of the furnace are called bottom ash.

- **Heat Exchanger**: Hot exhaust gases from the furnace exit through the heat exchanger or boiler, where their heat is drawn off to power a turbine. This is what generates electricity. Unfortunately, this step also tends to run the risk of increased dioxin formation.

- **Quench**: A spray drier, or scrubber, is used to rapidly bring the exhaust gas temperatures below 200°C. Activated carbon and lime are often mixed with the water that is sprayed into the exhaust gases. The carbon adsorbs both dioxins and mercury, which would otherwise pass through the filtration system unchecked. The lime reacts with the acid gases to neutralize them.

- **Baghouse Filter**: This functions like a giant vacuum cleaner, forcing the exhaust gases through fabric filters to trap the particles, including the added carbon and lime.

- **Selective Catalytic Reduction** (SCR): Ammonia or urea is injected to reduce the formation of nitrogen oxides.

- Dust particles and ash that are captured by the pollution control equipment are collected separately and referred to as fly ash.

At the same time, high furnace temperatures required for dioxin destruction increase the volatilization of mercury, and increase the formation of nitric oxide (NO). Nitric oxide, because it is chemically neutral, is quite difficult and expensive to remove from incinerator exhaust. The standard approach is to inject ammonia or urea, but this method is only about 60 percent effective. Ammonia injection, in turn, seems to increase emissions of fine particulates, which are the most dangerous to human health.[71] Once in the environment, NO is converted to nitrogen dioxide (NO_2), a major cause of photochemical smog. Lower furnace temperatures would reduce the amount of NO produced, but increase dioxin formation.

One of the principal means of reducing dioxin and mercury emissions to the air is combining activated carbon injection with fabric filters. Dioxin particles are too small to be stopped by ordinary filters and mercury is generally in gaseous form. So carbon particles are injected into the exhaust gases (often in the quench system); the carbon provides a surface upon which mercury can condense and dioxin particles can form as the exhaust gases cool. The carbon particles themselves are sufficiently large to be trapped by the fabric filters. This is effective in reducing the air emissions; but carbon particles prove to be so effective at inducing dioxin formation that total dioxin formation is increased by up to 30 percent in the presence of carbon injection.[72] Carbon injection decreases air emissions, but cause the fly ash (the trapped carbon particles) to contain much more dioxins than would have otherwise escaped up the stack.

ASH AND OTHER RESIDUES

Incineration is often mistakenly referred to as a waste disposal technology, when in fact it is a waste treatment technology. This is because incineration, like other treatment technologies, produces residues that themselves require treatment and/or disposal, most often in a landfill. Ash — or, in the case of pyrolysis, slag — is the residue from incineration produced in the greatest quantity.[73] Both ash and slag are defined as hazardous wastes under international law.[74] Other significant residues include scrubber water and filter cake (the solids from scrubber water treatment), both of which are usually heavily contaminated with toxics.

Bottom ash from furnaces and fly ash that fell from the electrostatic precipitators at the Harrisburg incinerator in Pennsylvania.

There are two basic types of incinerator ash: bottom ash and fly ash. Bottom ash, also known as clinker, is the residue from the furnace itself, while fly ash is the fine particles trapped by the air pollution control equipment. Bottom ash makes up about 90 percent of the total ash produced and has been shown to contain significant concentrations of heavy metals, organohalogens, and other chemical pollutants.[75] However, the fly ash, although much smaller in volume, is generally far more hazardous. If there is no air pollution control equipment, or it is not functioning, many of the hazardous byproducts will be released into the air instead of being trapped in the fly ash. This reveals a central conundrum of incineration: the cleaner the air emissions, the more hazardous the ash.

One fundamental flaw in many countries' regulatory systems is the failure to consider all the releases from incinerators. Air pollution control is largely a zero-sum game: what is removed from the air emissions must be trapped in the ash. This is particularly clear in the case of heavy metals, which cannot be created or destroyed in an incinerator. The quantity going in must be the same as the quantity going out. Yet heavy metals in particulate form or in fine particles of ash are more dangerous than those same metals in the incoming trash. Freed from the materials in which they were previously bound up, reduced to elemental form or to simpler compounds, they become more mobile and more biologically available. This makes them more likely to enter ground and surface water supplies, to enter the food chain, and to affect humans. Similarly, dioxin releases in ash can be much greater than dioxin releases to air, if the air pollution control equipment is working properly.

In many incinerators, the handling of this ash raises grave concerns. Workers are often exposed to it, sometimes with little or no protective gear. Temporary storage can consist of an open pit, which exposes the particles to the elements, allows dispersal via wind and rain, and defeats the purpose of having collected the ash in the first place. The final disposal site, a landfill, may not be any better. The pollutants of highest concern, such as dioxins and heavy metals, will not break down over time. And, as all landfills eventually leak (according to USEPA),[76] they slowly release the toxins back into the environment. Remarkably, ash or slag is sometimes used as fill for construction or roadbeds. Such practices completely ignore the hazardous nature

Open basin for incinerator ash in Taiwan.
© Taiwan Watch Institute

of the material and its potential for releasing pollutants into the environment during construction, demolition, and ordinary wear and tear. It makes little sense to spend so much money and effort to capture pollutants from incinerator exhaust, only to thoughtlessly release them again into the environment.

One way of reducing ash toxicity is vitrification. The ash is collected within the incinerator in a closed system, to avoid worker exposure, and sent directly to a melting furnace, where the ash is fired into small, glass-like pebbles. By enclosing heavy metals in a hard, physical matrix, vitrification significantly reduces their biological availability and the rate at which they can re-enter the environment. The furnace is hot enough that dioxins should be destroyed, although dioxin formation as exhaust gases cool may still be an issue. The most significant drawback of vitrification is its expense: one study indicates that it increases disposal costs by US$20 to $30 per ton of waste.[77] Another drawback is the large amount of energy required. Vitrification of ash from municipal waste combustion consumes more energy than is generated by burning the trash in the first place.[78] For these reasons, ash vitrification is rarely employed.

Incinerator Ash Re-use: the Example of Byker, Newcastle, UK

Incinerator ash, particularly fly ash, is highly hazardous and must be treated with care, like any other hazardous waste. In an attempt to minimize the dangers of incineration, however, incinerator manufacturers and operators routinely downplay the hazardous nature of the ash. Some even go so far as to bill it as an "inert" material that can be reused for construction or road-building. As a result, incinerator ash is routinely mismanaged, and severe risks to public health often result. Many countries have no proper regulation of incinerator ash at all. Even in Northern countries, regulations often go unenforced, leaving the job of protecting public health to ordinary citizens.

In Newcastle, England, for example, ash from the Byker municipal waste incinerator was regularly spread on pathways, local allotments, parks, and school playing fields. Concerned about the safety of this practice, local resident Val Barton called Communities Against Toxics (CATs), an independent, community based, environmental organization formed in 1990. The information she received led her to arrange for tests to be conducted on some of the ash. For doing so, the Newcastle City Council accusing her of being "alarmist and scaremongering." The test results revealed dangerously high levels of dioxins, arsenic, mercury and lead, and an astonishing level of ignorance within the council, Newcastle Health Authority, the companies operating the incinerator, the UK's Environment Agency, and the British government.

Byker incinerator in Newcastle, UK (above). © Ralph Ryder/CATs

Parents Against Incineration (PAIN) holding their protest in Swansea, UK (below). © Greenpeace

As a consequence of the initial, "resident sponsored" tests, Newcastle University sought the help of German scientists from the Hamburg-based Ergo Laboratories. Their scientists took samples from 23 allotments across Newcastle. As the extent of the contamination became more apparent, key figures from the company, the Area Health Authority, and the Environment Agency began leaving their positions.

These tests revealed dioxin concentrations as high as 9500 nanogram I-TEQ/kg, compared to "target values" of under 5 nanogram I-TEQ/kg. In fact, these dioxin concentrations are some of the highest ever recorded and made public. Heavy metal contamination was similarly stratospheric, including mercury at 2,406 percent, cadmium at 785 percent and lead at 136 percent above background levels.[79]

Eventually, the national Environment Agency was compelled to act, but local citizens consider the government's role tantamount to a coverup. They point out that, although the council maintains that only 2,000 tonnes of ash had been spread over 44 sites during the last six years (between 10 and 150 tons per site), investigations by CATs and local residents have revealed at least 25 other sites that received ash. Recent figures released by the council show much more ash being removed from sites than the council admits was dumped. Consignment notes also show some farms and a riding school as having received ash, which was initially denied by council officials.

Similarly, the recent final report on the contamination excluded all mention of PCBs, claiming that "they would have been destroyed in the incinerator" — despite the fact that PCBs are also produced under incineration. Children under 10 years of age were similarly omitted, and studies by the Environment Agency found levels of 1,100 nanogram/kg at a site where the Ergo lab found 2,200 nanogram/kg.

"The Blucher allotment, which has levels of 9,500 nanogram/kg, has been visited 5 times by EA officials," says Ralph Ryder of CATs. "They claim there are no poultry on the site, but anyone can still see at least 150 chickens running around the place. Residents are still eating the eggs from these birds and I guess killing the odd chicken for Sunday dinner."

EXPENSE

Incinerators tend to come in two varieties: the cheap and the prohibitively expensive. Expensive incinerators are those with the latest air pollution control equipment, regular and frequent emissions monitoring, specialized ash treatment and disposal methods, regular maintenance and a trained operating crew. Even under these conditions, environmental problems are inevitable, as described above. Cheap incinerators are those without some or any of the above-mentioned safeguards. The environmental impact of such devices can only be imagined, as they are in fact not monitored.

© Photo courtesy of Neil Tangri

© Greenpeace

The most technologically advanced incinerators, although still extremely problematic from an environmental standpoint, are astronomically expensive. A recently built 2000-ton-per-day municipal waste incinerator in the Netherlands cost approximately US$500 million.[80] Two recent incinerators in Japan cost US$658 million and US$808 million.[81] Greenpeace Japan recently estimated that Japan spends US$5 to 7 billion per year to build incinerators, with most of the money spent to replace older burners slated for retirement.[82] Since air pollution control equipment makes up a large share of the cost of any incinerator, there are significant economies of scale, and smaller incinerators may not be proportionately cheaper unless sacrifices are made in terms of environmental protection.

Operating expenses for incinerators are also extremely high. To increase efficiency (and limit dioxins emissions), incinerators need to operate 24 hours per day. This requires a crew of trained engineers working around the clock. Equipment costs are also high, and parts must often be purchased from abroad, in hard currency. If ash vitrification is undertaken, it requires an additional fuel source, adding extra operating expenses. Emissions monitoring adds additional costs, with dioxins the most difficult and expensive pollutant to measure. With each standard dioxins emission test costing approximately US$1000, a rigorous testing program — as conducted in Germany and Belgium — will run at least US$26,000 per stack per year.[83] This alone would be a prohibitive cost in most countries; yet without continuous dioxins monitoring, no incinerator can be assured of operating within any limits.

Financing Incinerators

Incineration is by far the most expensive method of waste treatment. The World Bank estimates the cost of incineration to be "an order of magnitude greater than" landfilling.[84] Clearly, financing such an expensive endeavour presents unusual difficulties. Generally, there are three revenue streams for financing incinerators: power sales, tipping fees, and direct government subsidies. Large incinerators (generally for municipal waste) often generate electricity and/or steam power, which can be sold. However, waste is an extremely inefficient fuel, and incinerators cannot compete on the open market with other generators of electricity. For this to be a viable form of financing, incinerator operators require guaranteed prices for electricity well above market rates. The tipping fee is the money paid by a waste generator or waste transporter to the landfill or incinerator. It usually is quoted by the ton of waste delivered. In principle, high tipping fees can be useful incentives to get waste generators to reduce the quantity of waste they produce. But since incinerators are more expensive than landfills, their tipping fees are correspondingly higher (in the U.S., typical incinerator tipping fees are twice what landfills charge).[85] Thus waste generators, given a choice, will simply use available landfills.

Incinerator companies seek to avoid this practice with "put-or-pay" contracts. These are long-term (often 10-30 year) contracts between a waste generator (often a municipality) and the incinerator operator, whereby the generator pledges to deliver a given minimum quantity of waste and pay a given tipping fee for the duration of the contract. Not only do these contracts serve as obstacles to waste minimization or recycling, they have proven devastating to local economies. States and municipal governments sought to meet their obligations under "put-or-pay" contracts by passing laws that required private waste haulers to take their waste to local incinerators. When the U.S. Supreme Court ruled such "flow control" measures unconstitutional in 1994, many municipal governments found themselves responsible for the lost revenue. This is the third form of finance: direct government payment to the companies, either in the form of subsidies or bailouts. No matter which form of financing is employed, the public ends up bearing the cost. Indeed, the World Bank recommends taxing residents of Southern countries 3-4 percent of their household budgets in order to build municipal waste incinerators.[86]

If a municipality, hospital, or enterprise decides to invest in an incinerator, it will be one of the most costly investments that institution undertakes. Many cities have found themselves strapped with substantial long-term debt when revenue from tipping fees fell short of projections (see box). Some jurisdictions, including the country of Sweden, have resorted to importing waste to keep their burners running.[88] Obviously, such expensive projects make even less sense in the context of Southern countries, where public funds are scarcer.

> "We can either send garbage to the incinerator or we can send dollar bills! That's what it amounts to."
>
> — County Commissioner Richard Schwartz,
> Lake County, Florida, USA[87]

Trapped by Debt: Four Examples from the U.S.[89]

New Hampshire:

A dispute between a regional municipal waste incinerator in Claremont, New Hampshire, and the communities it served resulted in 29 nearby towns filing for bankruptcy in September of 1993. At issue was US$1.1 million in back payments owed to the incinerator operators by the towns. The towns were locked into a 20-year "put-or-pay" contract that demanded far higher levels of waste than the towns actually produced. As a result, the local municipalities found themselves paying exorbitant fees to burn waste that they did not produce. Unable to change the contract or switch to other waste management methods, the 29 towns filed for bankruptcy; but the filing was denied by a bankruptcy court, and they eventually had to impose extra taxes on residents in order to pay the incinerator bill.[90]

New Jersey:

In the 1980s, many counties in New Jersey went into debt when they issued bonds to finance modern incinerators and other trash facilities. The counties were assured of a steady stream of garbage, and they thought they would also have guaranteed revenues, thanks to New Jersey's "flow control" law. That law banned garbage haulers from taking their garbage to cheaper out-of- state sites, and required them to deposit their trash at county-designated sites at a fee sufficient to cover debt payments. However, this arrangement collapsed in 1997 when the U.S. Supreme Court let stand a lower court ruling that struck down the state's flow control law.[91] This action allowed New Jersey towns to shop around for cheaper landfill sites in neighboring Pennsylvania. By 2000, 18 New Jersey counties struggled with more than US$1 billion in solid waste debt and no means to generate revenues to repay it. The state has been forced to dip into its general fund to assist some of the counties that have had trouble meeting their debt payments.[92]

Lake County, Florida:

Lake County, Florida is suing to extricate itself from an incinerator contract with incinerator giant Covanta (formerly Ogden-Martin), which critics have panned as a boondoggle. When the county signed the contract in 1988, a landfill shortage was looming, and the county was looking to find a place for local trash. Lake County agreed to issue bonds to finance the incinerator plant, pay for plant upgrades, pay Covanta to operate the plant, and guaranteed to keep it running with a steady stream of garbage every year. The county also agreed to pay Covanta about US$1 million each year, an amount equal to what the company has to pay in property taxes. Since then, the US Supreme Court ruling striking down local laws dictating where haulers can take garbage has worked against the incinerator. Less trash has been delivered to the incinerator than was anticipated. That left Lake County taxpayers grappling to pay for the incinerator. County records reveal that when the incinerator bonds are paid off in 2014, overall costs to local taxpayers for the $70 million incinerator are expected to reach more than $200 million after expenses, loan interest and other costs are factored in. Even then, the county will not own the plant. Ownership will pass to Covanta. Lake County residents now pay a garbage disposal fee of $95 per ton, the highest in the state. The outlook for Lake County and several other municipalities in which Covanta operates incinerator plants is uncertain, as Covanta declared bankruptcy in April 2002.[93]

- **Hudson Falls, New York:**

Residents of Washington and Warren counties in New York State have tried for years to get rid of a taxpayer-subsidized trash incinerator in Hudson Falls that has ignited political scandal and has been a financial disaster for county taxpayers. The contract, signed in the mid-1980s, commits taxpayers to pay the debt service on the US$87 million plant, along with its operating costs, and a management fee to Foster Wheeler, the operator of the plant. Ownership of the plant goes to Foster Wheeler when the debt is paid off. However, promoters overestimated the amount of garbage that the local communities could feed the incinerator. The incinerator's capacity was ten times what the small, mostly rural communities could supply. In order to comply with the "put or pay" clause in the contract with Foster Wheeler, the counties were forced to heavily subsidize bringing waste from outlying areas, while local residents paid the highest fees in the state. When residents filed suit to get out of this bad deal, they were sued by their own government leaders, on the grounds that the residents' suit negatively affected the bond rating for the incinerator. The government officials settled the case and paid US$255,000 to the residents. Attempts to sell the incinerator and renegotiate the debt have been unsuccessful, leaving taxpayers stuck with paying for an incinerator that has lost millions — US$3 million in 1998 alone.[94]

> "In hindsight, **the public sector got most of the risks and the private sector most of the rewards in building waste to energy facilities**."
>
> — Wall Street Journal.[95]

In spite of incineration's problems, some governments and International Finance Institutions promote incineration as development projects, or as part of larger development projects. Incinerators make even less sense as a development scheme than as a waste management technology. An expensive incinerator will require the services of at least one, and more likely several, multinational engineering firms. The funds used, therefore, will not remain in the developing country or generate the ripple effects that are to be expected of any investment in a local economy. Instead, the expenditures will primarily benefit multinational firms based in Europe, the United States, Australia and Japan.

There is some evidence of corruption in incinerator construction and promotion. For example, in Japan, the Fair Trade Commission (FTC) found that five major incinerator companies (Mitsubishi Heavy Industries, NKK, Hitachi Zosen, Takuma and Kawasaki Heavy Industries)

— which between them comprise 70 percent of the large-scale incinerator market — had been colluding, in violation of antitrust laws. The FTC recommended that these companies be excluded from government contracts because of their violations.[96]

In the Philippines, corruption in waste projects is seen as endemic, with officials allegedly receiving up to 40 percent of the value of waste contracts as kickbacks. Since the amount of the contract is basedupon the quantity of waste to be burned, this undermines waste prevention and recycling efforts.[97] And in Germany, corruption involving a single incinerator in Cologne is alleged to have diverted more than US$10 million to individuals and a political party.[98] As with all corruption issues, hard evidence in most cases is difficult to come by, yet the opportunities for collusion between non-transparent governments and firms standing to make a large profit are obvious.

EMPLOYMENT

Incineration, by its nature, is a capital-intensive, rather than labor-intensive, approach to the waste problem. Municipal waste incinerators require an investment of several hundred million dollars (US) and yet generate only a few dozen jobs, primarily for engineers who are in much demand elsewhere. Experience has demonstrated the folly of this approach in Northern countries; in the Southern nations, where capital is harder to come by and labor cheaper, the situation is even more extreme. In contrast, the alternatives, particularly in the case of health care waste and municipal waste, are less capital-intensive and generate more jobs. In the United States, it has been shown that a comprehensive composting, reuse and recycling program generates ten times as many jobs per ton of municipal waste as do incinerators.[99] In countries with cheaper labor, this ratio should be even greater.

Job Creation: Reuse & Recycling Versus Disposal in the United States[100]

Type of Operation	Jobs Per 10,000 Tons per Year
Product Reuse	
Computer Reuse	296
Textile Reclamation	85
Misc. Durables Reuse	62
Wooden Pallet Repair	28
Recycling-Based Manufacturers	25
Paper Mills	18
Glass Product Manufacturers	26
Plastic Product Manufacturers	93
Conventional MRFs[101]	10
Composting	4
Incineration	1
Landfilling	1

Incinerators can also displace people from employment. In many Southern countries, entire populations make a living as resource recoverers,[102] pulling useful and salable items from household and commercial waste. Called scavengers, ragpickers, waste pickers, *catadores* or *pepenadores* in different societies, they are often found sifting through garbage dumps. Others collect discarded items house-to-house. Despite being held in low esteem in most societies, they perform an important service by returning valuable commodities to the economy and reducing the need for landfilling. Although many individuals are driven to such work out of desperation, sometimes it can provide decent employment when occupational health and safety concerns have been addressed (see the box on the *Zabbaleen* of Cairo in section 2).

It is important to note, however, that in developing countries, sending waste to incinerators can deprive some of the most disadvantaged citizens of their livelihood. Indeed, some waste pickers may turn to sorting through ash landfills for salable materials, such as metals, that survive incineration,[103]a task even less lucrative and much more dangerous, because of the high toxicity of the ash. When resource recoverers are displaced, society also loses the benefit of their knowledge and skills. It would be far cheaper — and preserve more jobs — to invest in resource recoverers, helping them improving working conditions and recover a greater proportion of the discards stream.

ENERGY LOSS

Some incinerators, particularly large ones, are married to a boiler and turbine in order to capture a portion of the heat generated as electricity. These are then billed as "waste-to-energy" or "energy recovery" facilities. Proponents argue that these facilities take an unusable waste and convert it to a resource by burning it. However, "waste-to-energy" facilities waste more energy than they capture (see box).[104]

To understand this, it is necessary to recognize that any object that may end up as waste represents more energy than the heat released when it is burned. Any basic life-cycle assessment[105] will show that the calorific value of most items is a small fraction of their "embodied energy," the energy used to extract and process raw materials, turn them into products, and transport those products to market. The embodied energy is all lost when an item is burned in an incinerator.

"Waste-to-energy" incinerators waste more energy than they capture. © Greenpeace

Recycling of the object, on the other hand, avoids the energy costs of additional raw material extraction, as well as some of the transportation and processing energy. Reuse, by eliminating manufacturing, saves the most energy.

Since incinerators have limited thermal efficiency, only a portion of the fuel value of the material burned can be recovered. In a standard waste-to-energy incinerator, at most 35 percent of the calorific value of the waste is recovered as electric power.[106] Where incinerators are linked into a municipal steam distribution system to heat buildings, an additional 40 percent of the calorific value can be recovered. However, such systems require very large capital investments that few countries make, and are, of course, of little use in warm climates.

Recycling Versus Incineration: An Energy Conservation Analysis[107]

Energy Conserved in Recycled Content Manufacturing Compared with Energy from Waste Incineration

Waste Stream Materials	Energy Conserved by Substituting Secondary for Virgin Materials (MJ/Mg)	Energy Generated from MSW Incineration (MJ/Mg)
Paper		
Newspaper	22,398	8,444
Corrugated Cardboard	22,887	7,388
Office (Ledger & Computer Printout)	35,242	8,233
Other Recyclable Paper	21,213	7,600
Plastic		
PET	85,888	210,004
HDPE	74,316	21,004
Other Containers	62,918	16,782
Film/Packaging	75,479	14,566
Other Rigid	68,878	16,782
Glass		
Containers	3,212	106
Other	582	106
Metal		
Aluminum Beverage Containers	256,830	739
Other Aluminum	281,231	317
Other Non-Ferrous	116,288	317
Tin and Bi-Metal Cans	22,097	739
Other Ferrous	17,857	317
Organics		
Food Waste	4,215	2,744
Yard Waste	3,556	3,166
Wood Waste	6,422	7,072
Rubber		
Tires	32,531	14,777
Other Rubber	25,672	11,505
Textile		
Cotton	42,101	7,283
Synthetic	58,292	7,283
Others	10,962	10,713

In many cases, incineration also concentrates ownership and control of energy generation into the hands of a single firm. Whereas waste is owned by the society as a whole, the electricity generated by the incinerator is owned by the operator, and sold back to society. In this manner, the larger society is forced to invest increased energy in production to replace those materials destroyed in the incinerator, *and* pay the incinerator operator for the privilege of getting back a small fraction of the energy in their own waste.

SUSTAINABILITY

From the broader perspective of sustainability, incinerators are a losing proposition. The biosphere is a closed system. As humans increasingly dominate the globe and use most of the earth's resources, we must plan our systems to operate in an environment of material scarcity. Ultimately, this will require a closed-loop economy, in which the output of any industry is either safely assimilated by the environment or becomes the input for another industry. Only this approach will be able to tackle the twin problems of resource scarcity and waste disposal.

"**The latest scheme masquerading as a rational and responsible alternative to landfills is a nationwide — and worldwide — move to drastically increase the use of incineration...**The principal consequence of incineration is thus the transporting of the community's garbage — in gaseous form, through the air — to neighboring communities, across state lines, and indeed, to the atmosphere of the entire globe, where it will linger for many years to come. In effect, we have discovered yet another group of powerless people upon whom we can dump the consequences of our own waste: those who live in the future and cannot hold us accountable. It is still basically a Yard-a-Pult approach. ['The Yard-a-Pult, invented for a "commercial" on the U.S. television comedy show Saturday Night Live, invites disposal of waste by catapulting it over the back fence into the yards of nearby neighbors.']"

— then U.S. Senator Al Gore, 1992.[108]

Incinerators are fundamentally incompatible with a closed-loop economy. They are essentially destroyers of discarded products and materials, and concentrators of toxicity. Incinerators exacerbate waste disposal problems because they do not eliminate waste. Instead, they produce large quantities of hazardous ash, which must then be disposed. By reducing the volume but increasing the toxicity of waste, incineration merely replaces one waste stream with another. Incinerator ash, as mentioned above, has no useful purpose, and is therefore a complete loss to the system.

Equally serious is the resource problem engendered by incineration: when materials are destroyed in an incinerator, rather than being recovered, virgin materials are required for new production. Incinerators thus increase pressure on the natural resource base.

Incineration also removes incentives for waste minimization, and sometimes even creates incentives to generate more waste. Waste minimization is an essential part of any sustainable production process. Easy waste disposal makes it easy to waste resources and create pollution. This is particularly clear in the case of hazardous waste incinerators, which enable firms to haphazardly waste resources and then destroy the evidence. Some of the the most dramatic successes in waste and toxics reduction have been brought about by reducing avenues for easy disposal of hazardous wastes.

> "**Waste is the visible face of inefficiency.** Landfills bury the evidence and incinerators burn it."
> — Dr. Paul Connett

Municipal waste incineration depends on a waste stream with high calorific value; that is, one rich in plastics and wood products (including paper). This sort of waste stream is the hallmark of the unsustainable lifestyle being championed by multinational corporations; and incinerators are being considered for Southern countries in precisely those pockets, such as tourist facilities, where this lifestyle has made significant inroads. The Northern lifestyle and its attendant consumer habits are neither economically achievable nor environmentally sustainable for the majority of the inhabitants of the planet. By facilitating the destruction of plastic and paper waste, incinerators encourage the push to produce disposable luxury goods for a small percentage of the population at the expense of basic necessities for the majority.

> "If everyone lived like the average American, **we would need 5.3 planets to support us**,"
> --Michel Gelobter, Executive Director of Redefining Progress.[109]

Incinerators and Environmental Justice

Incinerators are a problem wherever they may be located, but those who live closest to the burner are usually the ones who suffer the most. They suffer from the air emissions; from "fugitive" ashes and emissions; from the increased truck traffic to and from the incinerator; from decreased property values; and they run the greatest risks in the event of a fire or fly ash spill. Not surprisingly, politically weak communities are the ones who usually pay this price. As with other environmentally noxious facilities, incinerators are disproportionately sited in communities that are poor and belong to racial or ethnic minorities. In 1997, 15 percent of the United States' non-white population lived within 2 miles of a permitted medical waste incinerator, while only 9 percent of the white population did.[110]

It is no mere coincidence, nor the "invisible hand" of the marketplace, that places incinerators in minority and low-income neighborhoods. The pattern of discriminatory facility siting was originally documented in a 1987 report, Toxic Wastes and Race in the United States.[111] In that same year, a consultants' report prepared for the state of California came to public attention. That report (written in 1984), "Political Difficulties Facing Waste-to-Energy Conversion Plant Siting,"[112] was a how-to guide for state officials looking for politically vulnerable communities in which to place incinerators. "All socioeconomic groupings tend to resent the nearby siting of major (waste disposal) facilities, but the middle and upper socioeconomic strata possess better resources to effectuate their opposition," the report says. "Middle and higher socioeconomic strata neighborhoods should not fall at least within (five miles) of the proposed site." The report recommended that incinerators be sited in communities that were rural, conservative, above middle age, Catholic, and poorly educated. The US$183,000 report indicated that such populations would be least likely to effectively resist an incinerator.[113]

The movement that sprang up to combat the practice of deliberately targeting politically weak communities coined the phrase "environmental justice" to describe the convergence of social justice and environmental movements. In 1991, the First National People of Color Environmental Leadership Summit in the United States articulated 17 principles of environmental justice, which call for (among other things) an end to production of toxics; full public participation in decision-making; and the right of individuals to be free of environmental harm.[11]

"**If you were to put an incinerator on Park Avenue, you would drive away the revenue base that supports this city.** The fact of the matter is that where you tend to site things — unfortunately — it tends to be in areas that are also in proximity to people who are just starting their ways up the economic ladder."
— New York City Mayor Michael Bloomberg, 2002.[115]

ADDITIONAL PROBLEMS IN SOUTHERN NATIONS

Most incinerators to date have been built in the global North. Incineration is an extremely expensive technology requiring large capital investments and generating few jobs, so it is reasonable to think of it as a technology more naturally suited for the industrialized North than the South. This history, however, creates an unrealistic track record when evaluating the suitability of incinerators for Southern settings. The critique above has been based upon incineration's performance record in the most technologically advanced countries of our time, as have most other such critiques. It would be difficult, if not impossible, to run an incinerator in a Southern country in the same manner as is typical in, say, Switzerland; and if it were possible, it would be prohibitively expensive.[116] There are many problems particular to transferring icineration technology to Southern countries. Discussed below are a few such known issues; as with all such engineering adventurism, the unanticipated problems are the most forbidding.

- **Lack of monitoring.** Few Southern nations have the ability to regularly monitor stack emissions or incinerator ash toxicity, yet a regular testing regimen is essential to the operation and oversight of any such plant. Indeed, the cuts that have been achieved in air emissions in Northern countries are largely the result of continuous feedback from regular emissions testing. Without that testing, it can only be presumed that Southern incinerators will function at far more polluting levels than their Northern cousins. Even in Northern countries, it is routine for incinerator operators to evade emissions monitoring (see box). The weaker regulatory apparatus of Southern countries would only worsen this situation.

"**Incineration has had very limited use for municipal solid waste and has not had much success in the cities of Asian developing countries** where it has been installed, because most of these cities have encountered many problems with imported incinerators, either due to design problems or high operating and maintenance costs."
— Asian Development Bank

Lack of technical ability to test releases. The lack of monitoring ability is not only due to a lack of legislation, regulations, sufficient government apparatus and the like; also, many countries do not have the technical capacity to conduct tests for dioxins and other important pollutants, and must send such assays abroad for testing. Such testing creates delays in receiving results, and the expense is often prohibitive.

Lack of secure landfills for ash. In most countries, the highly hazardous incinerator ash will be dumped in, at best, an unlined pit, where it runs the risk of contaminating groundwater. It is also usually impossible to control access to the ash landfill, so people and animals may enter it to look for metals or other salable materials in the ash. This of course represents a major danger to human health.

Corruption. Corruption bedevils many major Southern infrastructure projects, but incinerators are particularly troublesome in this regard, as their regular operation depends heavily on capable and independent government monitoring. Corruption is sure to undermine this function.

Shortages of trained personnel. Incinerators in Europe, Japan and North America function with a full complement of highly trained engineers. Few Southern countries are able to muster the necessary numbers of engineers, nor are their skills best utilized in monitoring the burning of trash.

Scavengers sifting through incinerator ash for metals in Phuket, Thailand.
© Greenpeace

Budget uncertainties affect maintenance. One of the keys to a properly run incinerator is regular maintenance and replacement of equipment, which requires significant expenditures. Given the budgetary chaos experienced in many Southern countries, it can be assumed that such maintenance will be less frequent and rigorous than in the North. Other disruptions, such as interruptions in the regular delivery of waste or electricity, are also more frequent, and will have significant impacts on the functioning of an incinerator.

Differing physical conditions. Southern countries can have significantly different physical conditions and waste streams, which can affect incinerator operations. In one case, a Danish incinerator built in New Delhi is completely unable to function because the engineers miscalculated the calorific value (energy content) of the waste.[117] Indian waste contains more inert material (ash, grit) and fewer combustibles (paper, plastic) than European waste. A high calorific value is needed for the waste to sustain combustion; otherwise the flame goes out or merely smolders. Most Southern countries' discards have low calorific value. Other circumstances, including monsoon weather that will moisten garbage, can also be a significant factor.

■ **Lack of robustness of technology.** In general, for a technology to function well in a Southern environment, with an undependable infrastructure and the vagaries of Southern conditions, it must be robust. Incineration, on the other hand, functions well only in extremely limited ranges of several parameters, such as furnace temperature, waste input rate, exhaust gas temperatures, calorific value of waste, and so on.

LACK OF COMPATIBILITY WITH ALTERNATIVES

Finally, it must be noted that incinerators are not compatible with other, more sustainable, forms of discards management. Although it is often claimed that incineration complements recycling programs, experience has shown that this is not the case.[118] Incinerators are so expensive that they often absorb all capital available for waste management. After building an incinerator, governments are often resistant to spend money on recycling and composting programs that can reduce the quantity of material available to be incinerated, thus partially idling the large capital investment in the incinerator.

Many municipalities issue bonds to finance incinerators. In order to meet interest payments on those bonds, an incinerator must generate revenue, which comes from tipping fees, which are directly proportional to the amount of waste burned. This creates a direct incentive for cities to avoid alternative waste management methods that would reduce the quantity of garbage incinerated. In other cases, private companies finance incinerator construction, receiving for doing so "put or pay" contracts with the municipalities whose waste they will burn. Such contracts stipulate that the contractor will receive a minimum monthly payment for burning trash whether or not the city sends sufficient waste to the incinerator. Under such contracts, there is a strong disincentive to reduce waste through recycling, composting or waste prevention.

> **"Once they are built we are talking about creating waste streams for the next 25 years to keep the incinerators going."**
> — Ludwig Kraemer, Head of the European Union Waste Management Directorate, 2000.[119]

Incinerators discourage alternative approaches in subtler ways as well. The mere existence of an incinerator provides an easy and thoughtless disposal mechanism for waste, removing incentives for prevention, re-use and recycling, which are the keys to a sustainable waste management strategy. In medical facilities, the knowledge that all waste is going to be incinerated reduces the perceived need to properly separate waste, even though such waste separation is important for worker safety as well as environmental reasons. Similarly, industries that are offered the "easy" option of incinerating their process wastes have little incentive to minimize its volume or toxicity.

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Section 1 Recommended Readings:

Allsopp, M., Costner, P. and Johnston, P., *Incineration and Human Health: State of Knowledge of the Impacts of Waste Incinerators on Human Health*, Greenpeace Research Laboratories, University of Exeter, U.K., 2001.

Center for Health, Environment and Justice, *America's Choice: Children's Health or Corporate Profit; The American People's Dioxin Report*, Falls Church, Virginia, November 1999.

Connett, P., *Municipal Waste Incineration: a Poor Solution for the Twenty First Century*, a presentation at the 4th Annual International Management Conference on Waste-To-Energy, Nov. 24 & 25, 1998, Amsterdam.

Denison, R., "Environmental Life-cycle Comparisons of Recycling, Landfilling, and Incineration: A Review of Recent Studies," Annual Review of Energy and the Environment, Vol. 21, pp. 191–237, 1996.

ECOTEC Research and Consulting Limited, *Beyond the Bin: the Economics of Waste Management Options: A Final Report to Friends of the Earth, UK Waste and Waste Watch*, 2000.

Gibbs, L. et al., *Dying From Dioxin: A Citizen's Guide to Reclaiming Our Health and Rebuilding Democracy*, South End Press, Boston, Massachusetts, 1995.

Glyszynski, P., and Kruszewska, I., *Western Pyromania Moves East: a Case Study in Hazardous Technology Transfer*, Greenpeace, 1996.

Greenpeace, *Warning: Incineration Can Seriously Damage Your Health; A Report on the Hazardous Waste Incineration Crisis*, 1991

Sound Resource Management, *Competition Between Recycling and Incineration*, Seattle, Washington, 1996.

Section 2:

ALTERNATIVES TO INCINERATION

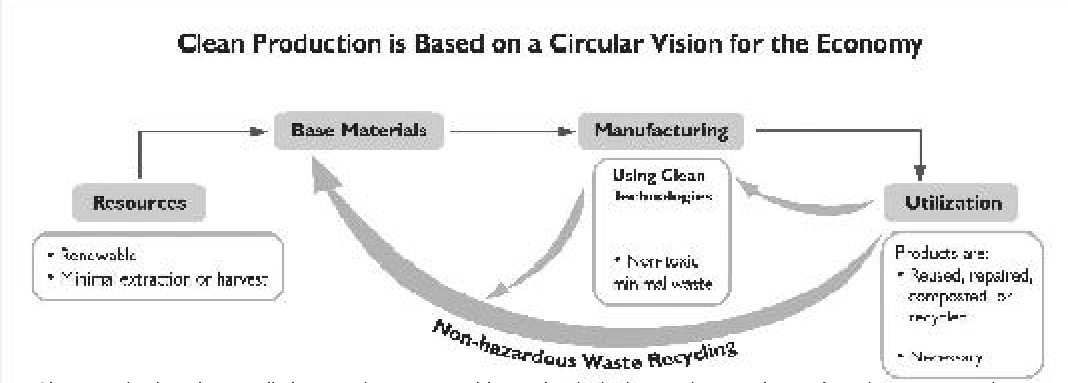
A young waste picker in an incinerator ash landfill in Thailand. © Greenpeace

Incinerators and landfills are both attempts to answer the question, "what do we do with waste?" Over the last century, governments have invested billions of dollars in increasingly sophisticated technologies in the vain hope of making waste disappear. Yet neither incinerators nor landfills truly dispose of waste; each creates significant, hazardous byproducts and generates additional waste streams that require further management. This is because waste, like all matter, can never truly be destroyed. The current paradigm of waste management attempts to impose a linear production model on a cyclical ecosystem. True solutions will be found by challenging this model, and, indeed, by challenging the very notion of waste.

In the linear model of the human economy, materials are first extracted from nature, then processed into goods, then consumed, and finally discarded. When the human economy was small in proportion to the natural world, this model seemed workable. But with human pollution in every corner of the planet,

and a large share of the Earth's resources now going to support human society, we can no longer afford to treat the planet as both granary and cesspit. The challenge, therefore, is not merely to find a new method of dealing with waste, but to completely change the manner in which materials flow through human society. Human discards must not strain the already overtaxed assimilative capacity of the Earth, either because of their quantity or their hazardous, non-biodegradable nature. At the same time, those discards must be fed back into the economy in ways that reduce the pressure on natural resources. At that point, they are no longer wastes, but resources.

Alternative approaches must begin by questioning the fundamental assumptions of traditional waste management. These include the ever increasing quantity of waste generated, the mixing of disparate materials in the waste stream, and failure of much industrial design to take wastes properly into account. Waste generation — particularly municipal waste generation — is often projected to increase without limit for the foreseeable future. This is a convenient assumption for the private sector. Those industries whose lifeblood is managing ever-larger quantities of waste stand to profit by such a trend, as do those industries that have found that they can shift some of the cost of their products onto the public, in the form of waste disposal. But it should be obvious that waste — and therefore resource consumption — cannot grow infinitely on a finite planet.



Clean Production aims to eliminate toxic wastes and inputs by designing products and manufacturing processes in harmony with natural ecological cycles. Clean production is discussed on pages 57-59.

Waste management must therefore be replaced by materials management: creating a closed-loop economy that neither generates significant wastes nor consumes resources beyond their replacement rate. In order to achieve this closed-loop economy, true waste (material that is of no use and must be disposed) must be differentiated from discards: materials that are of no further use to their present owner but are still a resource to be fed back into the economy. This means an end to the mixed waste stream. When discards are mixed, they become useless and appear to require large-scale disposal technologies to manage them. If discards are not commingled, they are amenable to more sensible and effective management strategies such as recycling and composting.

Currently, waste management is treated as wholly unrelated to an economy's production and consumption patterns. Governments collect and manage most waste while private firms and consumers produce it. As a result, private businesses shift a significant portion of their costs onto society as a whole by not taking responsibility for their waste streams and by manufacturing products that cannot readily be recycled. Even when producers do have responsibility for their wastes, such as process wastes from a factory, they rarely pay the full cost of managing them. Incineration and landfilling merely transfer the problem to other populations and future generations. Large-scale industrial redesign is needed to eliminate wastes that result from production and change products so that they are amenable to recycling.

Ultimately, an effective program for dealing with waste is more about materials management than about technology. Although the details vary considerably, three principles are key to solving the waste problem: prevention/minimization, waste stream segregation and industrial redesign.

MUNICIPAL WASTE

Municipal waste, municipal solid waste (MSW), household waste and general waste are all terms used to refer to the mixed waste streams produced by residential and commercial establishments such as houses, apartment blocks, hotels, shops, offices and restaurants. Municipal waste does not usually include residues from industrial manufacturing. Municipal waste is extremely varied in composition and generated in small quantities throughout the city, making it difficult to aggregate into economically viable quantities. That aggregation, however — into distinct classes of material, in quantity — is a key challenge of intelligent materials management.

Trash is created by mixing; a landfill near Minsk, Belarus. © Vasily Mazaev/Foundation for the Realization of Ideas

The fundamental problem of municipal waste is that it is mixed. With the exception of a small share of toxic materials (paints, batteries, vinyl/PVC, etc.), it is generally not hazardous and most of it has some value. Depending on the income level, climate, and culture, municipal waste consists of large portions of food scraps, yard waste such as leaves and grass clippings, paper, glass, cardboard, metals and plastics. All of these materials, save some of the plastics, have value and can be usefully recycled. Mixed together and contaminated with hazardous materials, however, this value is lost.

The second problem of municipal waste is its changing and complex nature. Municipal waste has grown substantially in its complexity and toxicity. When governments first began to consider mass burn and bury technologies a century ago, only 7 percent of municipal discards were products and packaging. In the United States today, products and packaging comprise 75 percent to 87 percent of municipal discards.[120] These products — be they broken office chairs or obsolete computers — are difficult to disassemble and recycle, and many contain hazardous components. Many plastics are hazardous to recycle or cannot be recycled at all. Industries must redesign their products so that they are non-hazardous and can be easily recycled. At the same time, it is important to create reuse and recycling opportunities for discarded materials. These two approaches, at the front and back ends of the materials cycle, work in tandem to transform the municipal waste system.

The Problem with Landfills

This report argues that incineration is an unacceptable form of waste treatment, but it does not endorse raw waste landfilling. Landfilling of raw (unsorted) municipal waste leads to a variety of problems, much of it associated with the organic material.

A child forages a typical dump in the south for recyclables.
© Greenpeace

- **Leachate:** The organic material decomposes, producing acids. These acids mix with rainwater, dissolve heavy metals and other toxics from the waste, and then percolate down through the landfill. If not stopped by a liner, this leachate will eventually contaminate groundwater or surfacewater supplies. If a liner and collection system are in place, leachate treatment becomes an additional problem and expense. However, even with a liner, all landfills eventually leak.

- **Greenhouse gases:** The decomposition of organic material under anaerobic (without oxygen) conditions produces large quantities of methane. Methane is a contributor to the "greenhouse effect," which is driving global climate change.

- **Landfill fires:** Methane is also highly flammable, and landfill fires are common and difficult to put out. The uncontrolled burning of wastes in a landfill is likely to result in air emissions similar to those from incinerators.

- **Vermin:** The organic material can attract rodents and other pests. This is particularly problematic when landfills are located close to areas where people live or work.

- **Odor:** The rotting organics produce a strong, unpleasant odor.

- **Waste of land:** Landfills consume huge areas of land, often near metropolitan areas where available land is scarce.

- **Waste of materials:** Landfills remove resources, both organic and inorganic, from the economy in much the same way as do incinerators.

In Southern countries, landfills are even worse than in the North, as they are often no more than unlined open dumps, scavenged by both people and animals. The precarious living of such resource recoverers has been dramatically demonstrated by the Payatas landfill disaster in the Philippines, where 200 people were killed in a landfill collapse in 2000.[121] As long as people make a living from others' discards, governments must design systems to protect their lives and livelihoods as well as the environment.

MSW in the South

Around the world, communities have adopted a variety of approaches to address both ends of the municipal waste problem. No two of these programs are identical, nor should they be. Successful programs must take into account local cultures, economies, and physical conditions. For example, it is no use designing systems that rely on a 24-hour electricity supply in cities where blackouts are frequent. It is also important to understand traditional systems for handling household waste, and the cultural importance of waste, including who handles it and how. Cow dung, for example, which is viewed only as a contaminant in some countries, is used as a fuel and a construction material in others. To be effective, solutions must be designed locally, by those who will put them into action, rather than imported wholesale.

Several factors make discards management a very different proposition in the South than in the North. Among them:

- The South consumes less. Not only is there less waste per capita, but its composition is very different: more organics, fewer metals, less plastic, and far fewer of the reparable objects (such as furniture and refrigerators) that make up a significant portion of the waste stream in the North.

- Labor is cheap and capital expensive, so capital-intensive solutions such as incinerators make even less sense in the South than they do in the North. Labor-intensive tasks, such as hand sorting of waste, are cheaper and can be more thorough, although attention must be paid to worker safety.

- Cultural norms are different. Solving the municipal waste problem requires extensive public education, changes in individual behavior (practices as simple as putting vegetable peelings in one bucket and paper in another), and new roles for those who have traditionally handled waste.

- Law enforcement is less reliable. Lack of resources, corruption, and lack of transparency in government are facts of life in many Southern countries, and effective programs need to take these factors into account. For example, an outright ban on certain products will be easier to enforce — and therefore more effective — than a graduated tax on content that might be more efficient in an economist's model.

Any solution to municipal waste issues in the South must embrace the informal sector. In most of the world, significant populations make a living by scavenging resalable items from municipal dumps, bundling them into commercially viable quantities, and selling them to a broker or recycler. These activities return valuable materials to the economy, reduce demand for raw materials, and cut the amount of material going to landfill. However, the risks to such individuals are great, and wastepicking is rarely a profitable venture.[122] Too often, policymakers view the informal recycling sector as an obstacle to their plans, rather than as a resource and a constituency. This reduces to their ability to plan and implement changes in the waste management system, because wastepickers are the ones who know the current situation the best and are thus best able to contribute to its redesign. It is also often environmentally unjust: those who bear a disproportionate burden of society's environmental ills should not also be threatened with a loss of livelihood in order to rectify those ills. The challenge of improving discards management in the global South is not only to minimize waste, but also to improve conditions for those who make a living from discards.

The *Zabbaleen* of Cairo[123]

Zero Waste may be a new name, but it is not a new concept. While waste experts in wealthy countries have been coming to the realization that resource flows through a society must be circular rather than linear, the poor of the world have long recognized that any waste is a potentially profitable resource, and have struggled to take advantage of it, for their own sake. In so doing, a few communities have succeeded in creating successful systems of resource management that approach the goal of zero waste and simultaneously employ thousands. One such example is the *zabbaleen* of Cairo.

A Zabbaleen sorting out papers and cardboards for recycling in Cairo, Egypt. © CID

The *zabbaleen* are a community from the south of Egypt who migrated to the city and saw in its trash an economic opportunity. Working with the traditional collectors of paper, they set up door-to-door collection systems, with each family working its own daily route, to collect source-separated household discards. As each collector works the same route, he[124] establishes a working relationship with the families he collects from. These discards are then separated: recyclable materials are resold at market rates; food scraps are fed to pigs; and the rest is trucked to a landfill. Although some families pay the *zabbaleen* for the garbage pickup service, most of their income comes from the sale of recyclable materials.

The success of this system — for the *zabbaleen* and the community as a whole — is evident in the numbers. Approximately 40,000 people are gainfully employed in this system; they collect 3,000 tons of household waste daily; and with their intensive separation scheme, they manage to divert 80-85 percent of household waste away from landfills. All of this occurs with no support from the government or outside agencies. With government permission, the *zabbaleen* could expand their network to cover the two-thirds of Cairo that is currently un- or under-served. Yet instead of looking to these indigenous entrepreneurs, the government has announced that it intends to grant exclusive contracts to foreign multinational waste management companies to collect and landfill all of Cairo's waste. If this plan goes ahead, it will throw the majority of the *zabbaleen* out of work, end their economic independence, and recreate the garbage problem that they have laboriously solved.

A New Direction

Notwithstanding the need for local solutions, there are some broad generalizations that can be made about municipal discards management.

For several reasons, the most important fraction of discards to be dealt with is organic material. First of all, in most countries, it makes up the largest share of waste (see "Waste Composition in Selected Countries" box). Second, it is responsible for most of the problems of landfills and open dumps. Third, mixing organics with paper and cardboard renders the latter unfit for recycling, and increases the difficulty (and unpleasantness) of recovering wood, metals and plastics. Last but not least, the organic fraction of municipal waste is perfectly suited for the cheapest, simplest, and most fundamental recycling method of all: composting. A good composting system will produce a high-quality product that can be used in agriculture — a significant boon in many parts of the world that are suffering from loss of topsoil and soil fertility. As composting can be done with little or no advanced technology, the costs of a separate organics collection and composting program are quite low, and consist of transport, public education, and manual labor. If composting is not viable, for whatever reason, there are alternatives, including feeding the organics to animals or vermicomposting (the use of worms in a contained system to rapidly break down organic waste).

The Citizens' Plan Pays Off

Since the mid-1990s, Nova Scotia, a Canadian province of some 930,000 people on the Atlantic coast, has been the site of some spectacular successes with popular involvement in waste management. An active and engaged citizenry first rejected the expansion of a number of disastrous municipal landfill sites, and then, in a pattern now familiar, rejected the government's proposal for a 500 ton-per-day municipal waste incinerator. At that point, instead of taking the all-too-common approach of ignoring public opinion, the government organized a province-wide consultation process under the auspices of a respected, independent third party. Using data generated by the government's research into waste diversion schemes and pilot projects, a new management plan was prepared by the citizens themselves. The management plan did not even refer to "waste," but rather to "resources." Among other ingredients, the citizens' plan outlawed the disposal of organics or hazardous materials directly into landfills. In Halifax, the capital city, they took it even one step further, requiring that any dirty organics that could not be composted would be screened for hazardous materials, then stabilized before burial.

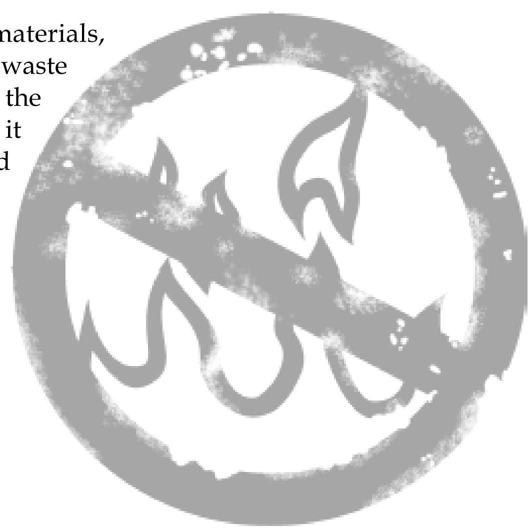
The plan called for a province-wide 50 percent diversion rate within five years. Nova

Scotia passed its self-imposed deadline nine months early, and diversion continues to increase. Halifax,with 40 percent of the province's population, has reached 65 percent diversion. The elements that have made Nova Scotia such a success include:

- Establishing 90 drop-off recycling centers throughout the province which have helped raise return rates for beverage containers to 84 percent.
- Establishing a 10 to 20 cent deposit per beverage container, half of which is returned when returning the container.
- Extending curbside recycling to 100 percent of the population.
- Banning several recyclable materials from the landfill (such as compostable organics, metal and glass containers, HDPE plastics, newsprint and cardboard).
- Offering curbside collection of compostable organics to 75 percent of the population.
- Implementing a province-wide education and awareness campaign.
- Creating a used tire management program, which collects used tires from 900 tire dealers and delivers them to a new recycling facility.
- Establishing stewardship agreements with the newspaper industry, the milk industry, and pharmacies (for used sharps and needles).
- Establishing a province-wide used paint recycling program, funded by industry and beginning June 1, 2002.

As a result of these programs, over 1 billion beverage containers have been recovered in five years; 3.5 million used tires have been recycled since 1997; and 1000 new jobs have been created in the recycling industry. The program is not perfect, but it demonstrates how quickly a non-disposal municipal waste system can be implemented, above all if it has the active involvement of the people. "The success and longevity of our strategy is due mainly to the interaction of the public," says Barry Friesen, the province's Solid Waste-Resource Manager.[125]

A strict segregation scheme for organic materials, preferably at source, can approximately halve the waste problem, with minimal investment. In order for the compost to be usable and marketable, however, it must be free of hazardous material. Extended producer responsibility programs (see below) and separate collection of hazardous wastes are needed to prevent commingling of toxics and organics.



Waste Composition in Selected Countries[126]

(percent by weight)

Location	Organics	Paper and Cardboard	Plastic and Rubber	Glass	Metals
Argentina (Buenos Aires)	38.4	24.1	13.8	5.2	2.5
Brazil	52.5	25.5	2.9	n/a	2.3
Egypt (Cairo)	46	21	4	2	2
Finland	41	37	5	2	3
Hong Kong	37.0	26.6	16.0	3.4	3.1
India (Delhi, low income)	65 - 71	4.8	4.1	2.9	n/a
India (Delhi, high income)	79 - 84	6.3 - 9.0	7.1 - 8.65	0.85 - 2.2	n/a
Ireland	15.1	58.6	10.6	3.4	1.7
Japan (Utsunomiya, rural)	62	17	12	n/a	n/a
Japan (Utsunomiya, urban)	55	22	12	n/a	n/a
Jordan	61	23	4	4	3
Malaysia	32.0	29.5	18.0	4.5	4.3
Nepal (Kathmandu)	67.5	8.8	11.4	1.6	0.9
Philippines (Manila)	42	19	17	3	6
Puerto Rico (San Juan)	30.5	16.0	37.8	4.4	6.5
Russia (Volgograd)	31.7	37	5.2	3.7	3.8
South Africa (Cape Town)	60	15.8	11.4	5.7	3.4
Taiwan	27.76	26.37	23.35	7.31	3.73
Thailand (Bangkok)	29	11	19	10	n/a
United Kingdom (Hampshire)	30.3	32.5	12.8	4.2	5.1
United States	23.0	38.1	10.5	5.5	7.8

Note: This table is provided for illustrative purposes only. Because of significant differences in methodology, definitions and reliability of the data, meaningful comparisons between studies are difficult. Also, not all categories are included here. Significant ones that have been excluded from this table include textiles, inert material (such as ashes from fuel), leather, and "unclassifiable."

Just as organics are recirculated in the economy through composting, the loop can be closed for synthetic materials and products through recycling. Although a smaller component of the waste stream than organics (in most countries), recyclables are the key to the economic success of a sustainable MSW program. Recycling has a number of benefits in addition to reducing waste and reducing the pressure on natural resources by replacing raw materials. It is a significant source of revenue and employment. Most recycling operations in Southern countries lie outside the formal sector, so it is difficult to obtain reliable statistics on employment. In Northern countries, however, the employment benefits of recycling are well documented. In the United States, the sorting of recyclables alone generates ten times as many jobs per kilogram of waste as do landfills and incinerators.[127] Recycling industries in the United States employ approximately 1.1 million people with a combined annual payroll of US$37 billion.[128] This economic stimulus is also reflected in the taxes paid by recycling industries — US$12.9 billion in direct revenues.[129] Job creation figures are likely to be even higher in countries where wages are lower.

An ambitious U.K. study, *Beyond the Bin*, attempted to compare the financial costs and benefits of recycling, incineration and landfill. The variety of different scenarios and the number of externalities[131] that must be included make for a wide range of costs; yet the report concluded that recycling is reliably a less costly option option than landfilling, and far cheaper than incineration.[132] Another recent study compared composting, landfilling and incineration in the European Union and, despite wide variations in costs, found incineration to be the most expensive option.[133]

> Advances in the collection of solid waste and recyclables are only one piece of recycling's economic success. Recycling also has made a vital contribution to job creation and economic development. Recycling creates or expands businesses that collect, process, and broker recovered materials as well as companies that manufacture and distribute products made with recovered materials. **Numerous studies have documented the billions of dollars invested and the thousands of jobs created by recycling.** A 1995 recycling employment study for the state of North Carolina, for instance, documented that recycling activities support more than 8,800 jobs in the state, most of which are in the private sector. The study also found that recycling was a net job creator — for every 100 jobs created by recycling only an estimated 13 were lost in solid waste collection and disposal and virgin material extraction within the state.
>
> — USEPA[130]

Extended Producer Responsibility

The greatest barrier to recycling — perhaps even more formidable than the commingling of discards — is the fact that many products are not designed for easy disassembly and reuse. This problem cannot be addressed at the end of the product life. Extended Producer Responsibility (EPR) is a policy approach that has gained increased popularity in recent years for its use of economic incentives to reduce waste. The basic concept is that firms must take physical or financial responsibility for their products over their entire life cycles; responsibility does not end when the product is sold.

EPR programs are intended to eliminate the opportunity for manufacturers to externalize the costs of eventual disposal of their products onto governments and consumers. If implemented properly, EPR creates a feedback mechanism that drives firms to stop producing non-recyclable and non-reusable products that contain hazardous materials. If producers must re-collect their products and associated packaging at the end of their useful lives, they have a strong incentive to redesign their products to reduce toxicity and be easily recycled. EPR closes the loop, forcing producers to redesign their products to avoid insurmountable disposal problems. EPR has been applied to packaging,[134] durable goods such as cars,[135] tires, electronics and household toxics.[136] Though not flawless, EPR programs have shown considerable potential in forcing cleaner product design and reducing waste of materials.

Product Bans

In some situations, EPR may not be practical, either because products are imported and sold primarily through the informal sector or because government is incapable of enforcing a take-back scheme. Nevertheless, the principle is important: the manufacturers of consumer products must be prohibited from imposing on local communities the responsibility for managing their products at the end of their useful life. In such cases, outright product bans are advisable. Products and packaging that create waste problems (non-recyclable or hazardous waste) for the society, not the producers, should simply not be allowed entry into the economy. Several forms of packaging, such as polyethylene carry bags, which are not practically recyclable, would thus be replaced by reusable or at least recyclable packages. Bans are also appropriate for those materials, such as PVC and heavy metals, that are problematic at every stage of their life cycle.[137]

There are likely to be positive side effects from the elimination of products and materials from the waste stream through EPR programs and bans. One study indicated that banning PVC would result in a dramatic net increase in employment as other industries expanded to replace PVC products.[138]

Diversion Rates and Zero Waste

A conventional measure of the success of municipal waste management programs is the "diversion rate," the share of the waste stream that is eliminated or diverted from landfill or incineration to other, productive uses. It is an imperfect measure, as it is often difficult to quantify waste that is prevented, but still serves as a useful index of the effectiveness of back-end (post-consumer) programs. Using standard methods of segregation, composting, reuse and recycling, it is clear that the majority of waste in most countries can be diverted. Diversion rates of over 50 percent are being achieved in North America; in some places, they reach 70 percent and higher. However, it is not possible to divert 100 percent of municipal waste using conventional end-of-pipe techniques.

As long as waste management companies continue to profit from waste disposal, and other firms can shirk their responsibility for dealing with their wastes and end-of-life products, there will be significant financial incentives to increase the quantity of waste going to landfills and incinerators. These must be tackled with aggressive product bans and EPR policies. Combining these front-end solutions with separated collection systems, intensive recycling and composting has the potential to dramatically change the nature and scale of municipal discards, with diversion rates approaching 100 percent. This fundamentally new vision for society has been termed "Zero Waste" and is rapidly gaining popularity in various parts of the world.[139] Since 1999, 45 percent of New Zealand's Local Authorities have adopted Zero Waste targets. Zero Waste has also been embraced by local governments in Australia, Canada, U.K.

and the United States; by the state governments of Western Australia and California (the latter with a population of 35 million); and at the national level in South Africa.

Examples of Municipal Discards Diversion Rates[140]

Below are listed examples of municipalities, counties and even nations with high rates of municipal waste diversion (re-use, recycling and composting). These examples indicate that municipal discards management systems that achieve high diversion rates are feasible in a number of different countries, with varying economic and physical conditions. Unfortunately, few statistics are available from Southern countries. This does not reflect a lack of recycling in those countries; indeed, successful programs are known to be operating in Brazil, Egypt, Guadeloupe, India and the Philippines, to name a few. Rather, the paucity of data reflects the fact that few attempts have been made to gather comparable data in those places.

Locality	**Diversion Rate** (percent)
Zabbaleen-served areas of Cairo, Egypt	85
Opotiki District, New Zealand	85
Gazzo (Padua), Italy	81
Trenton, Ontario	75
Bellusco (Milan), Italy	73
Netherlands	72
Northumberland County, Ontario, Canada	69
Sidney, Ontario	69
East Prince, Prince Edward Island, Canada	66
Boothbay, Maine, U.S.A.	66
Halifax, Canada	65
Chatham, New Jersey, U.S.A.	65
Falls Church, Virginia, U.S.A.	65
Galway, Ireland	63
Belleville, Ontario	63
Canberra, Australia	61
Bellevue, Washington, U.S.A.	60
Guelph, Ontario, Canada	58
Gisborne District, New Zealand	57
Clifton, New Jersey, U.S.A.	56
Loveland, Colorado, U.S.A.	56
Denmark	54
Bergen County, New Jersey, U.S.A.	54
Worcester, Massachusetts, U.S.A.	54
Leverett, Massachusetts, U.S.A.	53
Ann Arbor, Michigan, U.S.A.	52
Crockett, Texas, U.S.A.	52
Dover, New Hampshire, U.S.A.	52
Kaikoura District, New Zealand	52
Switzerland	50
Nova Scotia, Canada	50
Portland, Oregon, U.S.A.	50
Madison, Wisconsin, U.S.A.	50
Fitchburg, Wisconsin, U.S.A.	50
Visalia, California, U.S.A.	50

Getting to Zero: Steps Towards a Zero Waste Program[141]

Zero Waste is an approach to municipal waste that aims to achieve 100 percent diversion rates through a mixture of waste minimization, industrial redesign, composting, recycling and reuse programs. No two Zero Waste programs are the same, and no one approach will work everywhere; but the ten steps listed below are applicable to most communities pursuing a Zero Waste future.

1. Adopt a goal of Zero Waste: no waste to landfills or incinerators.

2. Seek public input. Citizen involvement, including the informal sector, is crucial.

3. Target a wide range of materials for reuse, recycling and composting (especially several grades of paper and all types of organics) and keep these materials segregated from mixed trash.

4. Compost. Composting is key to achieving 50 percent and higher diversion levels and doing so cost-effectively.

5. Make program participation convenient. The more people participate, the more materials will be diverted from disposal.

6. Institute economic incentives that reward waste reduction and recovery over disposal, such as reduced tipping fees for recyclable and compostable materials and pay-by-volume fees for trash collection.

7. Enact regulations to improve the environment for recycling and recycling-based businesses, such as: banning recyclables from landfills and incinerators; banning products that cannot be reused, repaired, recycled, or composted; and requiring the reuse and recovery of building materials in new construction.

8. Develop markets for recycled materials and products, particularly local manufactures. Government procurement can be a powerful tool to create demand for recycled goods.

9. Require producers to take back their products and packaging at the end of their useful lives (Extended Producer Responsibility programs).

10. Education and outreach are critical for continued participation.

HEALTH CARE WASTE

Health care waste is generally defined as all waste generated by health care facilities, such as hospitals, doctors' offices and clinics, and also often includes waste from veterinary facilities, funeral homes and laboratories that prepare medicines or deal with human tissue. Although health care waste comprises a very small portion of the entire waste stream (less than 2 percent in the United States),[142] it has received considerable attention because of the hazards it poses to human health. It is also an extremely complex problem to tackle, because of the variety of wastes generated by health care facilities. Wastes requiring special attention include those that are potentially infectious (also referred to as biohazardous); sharps (needles, scalpels and other objects capable of breaking the skin); mercury-contaminated wastes; radioactive residues of nuclear medicine; pharmaceuticals; genotoxic and cytotoxic residues of chemotherapy drugs; and a variety of chemically hazardous wastes used in laboratories, x-ray developing, and other medical technologies.

Because of the widespread concern around health care waste — and the recognition that medical waste incinerators are a leading source of dioxins and mercury air emissions — many organizations around the world are addressing this issue. Health care facilities wishing to improve their environmental performance therefore have a vast pool of experience to draw upon. An especially helpful network is Health Care Without Harm (HCWH), an international coalition of over 300 health care providers and non-governmental organizations around the world dedicated to eliminating pollution from the health care sector (for HCWH contact information please see the Resources section). HCWH has member organizations in over 40 industrialized, low-income and middle-income countries, working under the wide variety of conditions found in those nations.

Health care facilities vary widely in their circumstances, including financing, skilled staff, access to infrastructure, treatments offered, etc. Therefore, there is no one approach to health care waste that will fit all facilities. Nevertheless, several principles are common to effective solutions in any context.[143]

In a facility with a well-run system for waste separation at source, those waste streams requiring special handling will account for no more than 15 to 20 percent of the total waste generated. In other words, 80 to 85 percent of all wastes from health care facilities is similar to ordinary municipal waste, and consists of food scraps from the cafeteria, office paper, packaging, and so on. This material can be handled like any other

Top: Incinerators discourage sustainable medical waste management, often becoming a convenient way to mix and burn all waste types(Kerala, India, 2002).

Center: Not only are incinerator releases dangerous for the global environment, they also endanger workers and people nearby, including patients and neighbors. Here, an incinerator operator is wearing a motorcycle helmet instead of respiratory protective gear (Punjab, India, 2002).

Bottom: Broken ash door and clogged air inlets in a year old medical waste incinerator (Kerala, India, 2002) municipal waste, as long as it is kept separate from more hazardous waste streams. Thus a good waste management system for health care facilities must be grounded in a strict and well-maintained source separation program.


A small autoclave in operation.
© Photo courtesy of Neil Tangri

Strict separation at source of the various waste streams requiring special attention is also necessary. Once potentially infectious waste (often known as "red bag" waste) is mixed with non-infectious wastes, all of it must be considered potentially infectious. Similarly, chemical hazards that are easily managed separately may become intractable problems if combined or mixed with other waste streams. As a result, health care institutions must have a multitude of distinct waste streams that are handled and treated separately.

It is often argued that potentially infectious waste requires incineration. In fact, several other disinfection technologies are available and in common use. Using incineration to disinfect waste is overkill, because incineration not only kills the pathogens that are of concern, but destroys the material that they rest upon.[144] Other technologies, such as microwave, or autoclave and its variants, kill the pathogens without chemically altering the waste, thus avoiding the many environmental problems of incineration. These technologies are commercially available, widely used in the health care sector, easier to maintain and properly operate than an incinerator and in many cases cheaper.[145] An assessment of various technologies is to be found in Health Care Without Harm's document "Non-Incineration Medical Waste Treatment Technologies."[146]

After disinfection, it is important that hazardous medical wastes, particularly the sharps, be secured in such a way as to prevent re-use, scavenging, or other forms of human contact. Where secure landfills are not available, WHO recommends encapsulation by filling a sharps container with a cement-like substance to render the sharps immobile and useless.[147] The reuse of hypodermic needles, although it would cut down on waste, has been shown to correlate to a rise in infection rates[148] and thus is one of the few instances where there is good reason to use disposable items, creating a certain amount of unavoidable waste. It should be noted, however, that sharps are typically 1 percent or less of a hospital's waste stream.[149]

> **"Incineration of medical waste converts a potential biological problem into an actual chemical one."**
> — Dr. Paul Connett

In the case of chemical hazards, the old rule of "reduce, reuse, recycle" applies well to the health care sector. Some chemical hazards, such as mercury, can be reduced to the point of elimination.

Mercury is used in a wide range of medical equipment, including thermometers, sphygmomanometers (blood pressure cuffs), and feeding tubes. In normal use, this mercury is completely contained within the equipment. But breakage is a fact of life, and when the mercury is released, it poses an immediate threat to persons in the vicinity, including staff and patients. Mercury that is recovered is often sent either down the sewage drains or with the infectious waste, resulting in discharge to the environment. As mercury is an element, it cannot be broken down by any form of waste treatment. The only way to prevent mercury releases, therefore, is not to use mercury-containing equipment. Fortunately, good substitutes for mercury-containing equipment are now commercially available, and have been shown to be of equal or superior efficacy under field conditions.[150] In fact, many jurisdictions now ban the sale of mercury-based thermometers.

Other chemicals for which no good substitutes exist can be effectively and economically recycled. This is the case for the chemicals used in developing and fixing x-rays, which contain silver and will actually net a profit in recycling. Other laboratory chemicals, such as xylene, can be re-purified and re-used, which avoids both discharges of chemical waste and the need to purchase additional chemicals.

Burning unsorted waste at on-site incinerator in Ngelwezane Hospital, South Africa. © groundWork

Chemotherapy drugs are of particular concern because of their extreme toxic potency and high chemical stability. These drugs exist in small quantities as the unused portion of prescriptions and in larger quantities as expired drugs. Trace quantities of chemotherapy drugs are also found in syringes, bottles, intravenous tubing and other equipment used to store and administer these drugs. In no case should chemotherapy drugs (even in trace quantities) be sent to standard disinfection technologies (such as autoclaves) which will not break them down. Even most incinerators are not capable of reliably breaking down chemotherapy drugs; WHO recommends that, if chemotherapy wastes are to be incinerated, the incinerator must be two-chambered, with the second chamber reaching 1200°C and a residency time of two seconds.[151] Failure to do so will result in the release of these extremely potent toxins directly to the environment. WHO also states that incineration is not the preferred option for chemotherapy drugs.[152] Health care facilities should ideally return unused chemotherapy drugs to the manufacturer where they can either be reformulated or disposed of in a more controlled manner than hospitals can manage. Language mandating such take-backs can be built into contracts with the pharmaceutical companies that supply the drugs.

The importance placed upon waste and toxicity minimization in the health care sector is reflected in a 1997 memorandum of understanding between the American Hospital Association and USEPA. This agreement includes a commitment to reduce total waste by one-third by the year 2005 and by 50 percent by 2010; to virtually eliminate mercury-containing waste by 2005; and to minimize the production of persistent, bioaccumulative, and toxic (PBT) pollutants.[153]

Tackling the Medwaste Monster

Although small in quantity, health care waste can pose major challenges. In areas where it is well-regulated and strictly monitored, the handling, transport, treatment and disposal of health care waste is a costly endeavour. In other settings, where that infrastructure does not exist, there may be no ready infrastructure for the treatment and disposal of health care waste. In either case, a focus on waste minimization and low-technology treatment can greatly reduce the problem.

Beth Israel is a major urban hospital center in New York City with multiple campuses, specialty care units and over 1200 beds. Like many U.S. hospitals in the 1990s, it faced increasing public concern and government regulation about the handling of health care waste. Beth Israel chose to bring on a dedicated health care waste manager, who implemented a comprehensive waste management strategy that includes:

- reducing the tendency of hospital staff to "overclassify," i.e., to treat non-potentially infectious wastes as if they were infectious by placing them in red bags.
- recycling of paper, cardboard, newspapers, magazines and other materials.
- toxicity reduction through in-house recycling of laboratory chemicals, reduced use of PVC, mercury, etc.
- environmentally preferred purchasing.
- on-site waste treatment using non-burn technologies.

At Beth Israel, the proof is in the numbers: "red bag" (potentially infectious waste) was reduced by as much as two-thirds (over 630,000 kg annual reduction from the hospital's largest unit). This was reflected in cost savings of over US$1 million per year — up to 70 percent of the hospital's waste management budget.[154]

At the other end of the spectrum, a small (12 bed) but busy maternity home in Pune, India has discovered that the simple garden technique of composting is enough to answer its needs. The maternity home produces few sharps; placentae and sanitary napkins comprise the majority of its potentially infectious waste. Rather than send these to the city's incinerator, the hospital constructed two small (1 cubic meter) compost bins in the back parking lot. In three years, these two bins have digested 11,500 sanitary napkins, 860 placentae and dressings from 800 surgeries, producing only a dark, thick, mudlike compost. Furthermore, this compost has been tested for pathogens and found to be cleaner than ordinary soil. Hepatitis B, for example, when injected into the compost bins, survived two weeks as opposed to the four weeks that it lasted in ordinary soil. The compost bins are non-odorous and inconspicuous. The one-time capital cost for the bins was roughly equivalent to the annual cost of sending health care waste for incineration.[155]

A focus on waste prevention, good segregation practices, and non-burn treatment technologies can radically reduce both the scope and the hazards of health care waste. These savings are then reflected in lower costs, fewer management headaches, and a cleaner environment.

When dealing with health care waste, the health and safety of workers deserves special attention. Workers in health care institutions, including nurses and cleaning staff, are those most at risk from the poor handling of health care waste. Sharps pose the greatest infection risks at the point of generation and in their movement through the facility. Incineration does nothing to minimize those risks, but it does encourage a lackadaisical approach to segregation. A strict sharps segregation program is crucial for worker safety, but the knowledge that all waste is going to be incinerated undermines such programs.

Health care waste can thus be greatly reduced, both in quantity and toxicity. Certain elements, such as potentially infectious sharps and expired pharmaceuticals, will continue to be a waste stream for the foreseeable future; but these can easily be managed without incineration and without engendering other environmental problems.

HAZARDOUS AND INDUSTRIAL WASTE

Industrial wastes, both hazardous and non-hazardous, are primarily process residues. The natural place to solve this problem, therefore, is in the production processes themselves. At the same time, an entirely new approach to product design is necessary to ensure that discarded products can be easily and safely reclaimed. Clean Production brings these two principles together.

Clean Production is a paradigm shift away from current standards of product and process design. It begins by redesigning the product to avoid hazardous inputs and excess material use. Just as important is redesigning the production process to eliminate hazardous wastes and minimize overall wastes. It attempts to mimic the natural ecological flows of materials by replicating efficient, non-hazardous and useful manufacturing processes and products. Because local material flows can be the most efficient in terms of material, energy, and water use, Clean Production favors the judicious use and consumption of local materials. With the aim of protecting human health, biological integrity and cultural diversity, Clean Production encourages an approach to production and consumption that is precautionary, preventive, and democratic.

Much of the focus of Clean Production is on redesigning industrial processes to eliminate the generation of hazardous wastes. Non-hazardous industrial residues are often easier to reclaim and recycle than household waste because they tend to be less varied in composition, of uniform quality, and generated in significant quantities at specific locations. In other words, they are often effectively “pre-sorted” and thus easier to place with a user, manufacturer or recycler. In fact, materials exchanges in many regions now serve as networking hubs where those wishing to discard manufacturing residues or byproducts are matched with those that can use them.[156]

> **“The significant problems we face cannot be solved at the same level of thinking we were at when we created them.”**
>
> — Albert Einstein

The four principles of Clean Production are:

1) **The Precautionary Principle.** "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically[157]." For more on the Precautionary Principal, please see discussion on International Law in Section Three (Putting Out the Flames).

2) **The Preventive Principle.** It is cheaper and more effective to prevent environmental damage than to attempt to manage or "cure" it. Prevention requires examining the entire product life cycle, from raw-material extraction to ultimate disposal. It encourages the exploration of safer alternatives and the development of cleaner products and technologies. For example, prevention requires changes in processes and products — designing non-hazardous products from materials that can be safely recycled or composted — in order to avoid the generation of waste that is incinerated.

3) **The Democratic Principle.** Clean Production involves all those affected by industrial activities, including workers, consumers, and communities. Access to information and involvement in decision-making, coupled with power and resources, will help to ensure democratic control. Clean Production can only be implemented with the active involvement of workers and consumers within the product chain.

4) **The Holistic Principle.** Society must adopt an integrated approach to resource use and consumption. Effective analysis of environmental issues cannot be piecemeal; instead, analyses must look at entire systems. For each product, consumers need to have access to information about the materials, energy, and people involved in making it. Access to this information helps build alliances for sustainable production and consumption. A holistic approach is also necessary to avoid creating new problems while addressing old ones (e.g. replacing pesticides with genetically engineered plants) or to avoid shifting the risk from one sector to another.

> "Cleaner production is the conceptual and procedural approach to production that demands that all phases of the life-cycle of a product or process should be addressed with the **objective of prevention or minimization of short and long-term risks to humans and the environment.** A total societal commitment is required for effecting this comprehensive approach to achieving the goal of sustainable societies."
>
> —United Nations Environment Program

A number of global initiatives have adopted approaches to material design similar to these four principles. They include the United Nations Environmental Program Cleaner Production Program (UNEP CPP); the Natural Step, an organization based on a set of principles developed by a Swedish cancer physician; and various industrial ecology programs and environmental design programs created by architects, ecological engineers and other business and academic programs. Strategies to promote Clean Production include:

- measuring and reducing resource use and waste
- establishing and strengthening right-to-know laws (e.g. the U.S. Toxics Release Inventory and other Pollutant Release and Transfer Registries)

- conducting product life cycle assessments
- eco-labeling
- strengthening producer responsibility for environmental and health protection (e.g. take-back schemes that require manufacturers to take a product back at the end of its use)
- ecological tax reforms that penalize pollution and create incentives for Clean Production
- redesigning industrial systems to substitute services for products

Clean Production also includes the use of locally available and culturally appropriate materials (promoting self-reliance and reducing dependence on imported materials). Local economic conditions, technical ability to handle synthetic discards, and even climatic conditions will determine the contours of Clean Production in different societies.

Clean Production in Practice

Less Toxic Toys: Moving Toward Cleaner Material Use[158]

Recent concerns about the use of chemical softeners called phthalates in vinyl (PVC) baby toys have stirred an international debate among toy manufacturers, consumers, and governments. Evidence about the safety or danger of phthalates, plastic softening agents which can leach out of toys into babies' mouths when chewed, is still being collected and debated. Meanwhile, some countries, including Denmark, Sweden, the Netherlands, Greece, Austria, France and Germany have taken their own initiatives based on the Precautionary Principle and banned the use of phthalates in soft baby toys.

As the Danish Environment Minister stated in response to legal action by the toy industry: "The scientific proof will unfortunately only be available when the damage is done, and there is real solid basis for concern in this case."[159] Consumer groups note that banning phthalates alone will not address the development of new softeners which might be hazardous or address other dangers from the PVC life cycle (dioxins are created when the feedstocks for PVC are produced, and dioxins are created when PVC is burned). The majority of manufacturers have therefore switched to non-PVC materials to avoid entirely the use of these toxic resins.

Dry Cleaning: Neither Dry Nor Clean[160]

In the United States, the dry cleaning industry is traditionally viewed as a small, neighborhood-based industry. But the nation's almost 40,000 dry cleaners constitute one of the largest users of chlorinated solvents, a class of chemicals associated with a variety of environmental and human health impacts. The dry cleaning industry uses perchloroethylene (PERC), a toxic and environmentally dangerous solvent linked to several forms of cancer in dry cleaning workers. Revelations about groundwater contamination and fugitive emissions in residential buildings have led to additional liabilities and restrictions for the industry.

Hundreds of cleaners are PERC-free in the United States today and as many as 3,000 offer safer, water-based "wet cleaning" in their shops. Wet cleaning and liquid carbon dioxide offer the most promising and non-toxic alternatives. Both remove stains well, although wet cleaning is based primarily on the skill of the workers while carbon dioxide uses new, sometimes expensive machinery.

Waste Not a Drop

When Namibian Breweries decided to open a new sorghum beer facility in the inland desert of Namibia in 1997, it also adopted a new principle: "good beer, no chemicals, no pollution, more sales and more jobs." Working with an array of specialists, the brewery embedded itself in a complex of projects that were designed to feed off of each other's waste products, imitating natural materials cycles. Spent grain from the brewing process is used to raise mushrooms (400 kg per week) and pigs (120 per year) for food. The pig manure is then sent to a digester to produce methane, which substitutes for firewood. The investment of US$400,000 in these additional systems paid itself back in just four years.[161]

Alternative Technologies for Hazardous Waste Stockpiles

Clean Production offers a methodology for eliminating hazardous industrial process wastes, as well as eliminating the hazardous components of products which will eventually become waste. However, Clean Production is unable to address the problem of stockpiles that already exist.

Stockpiles of hazardous wastes (also referred to as historic wastes) such as pesticides, PCBs, chemical warfare materials and other military wastes, are found around the globe. The mere existence of these toxic stockpiles poses a threat to nearby communities. In the case of POPs, the threat is also global in nature. Treatment of such wastes is therefore a matter of urgency, and recycling is inappropriate. Using incineration would result in the problems described in the preceding section, plus additional issues unique to the dangerous nature of the substances — for example, the release of chemical warfare agents out of the stack, which has been documented in several cases.[162] The only interim solution for treatment of these wastes is through technologies that can prevent, to the greatest extent possible, additional hazardous releases into the environment.

Citizen Participation in Weapons Destruction[163]

The U.S. Army is poised to spend over $20 billion to burn its stockpile of 30,000 tons of chemical weapons. To do so, the Army plans to use four-furnace incinerators located in communities where the weapons are stored. Citizens living near these stockpile sites want nothing more than to have the deadly weapons destroyed immediately. However, the issue of how to dispose of them remains a complex debate between government officials (both military and civilian) and citizens concerned with the health impacts of incinerator emissions. The Army's first weapons incinerator, on Kalama Island in the Pacific, and its currently operating incinerator in Tooele, Utah have been plagued with fires, shutdowns and leaks of chemical agent within the facility and out of the smokestack.

The decision to burn the most lethal chemicals on the planet was made in the mid-1980s without citizen input. In addition to the problems common to all incinerators, chemical weapons incinerators offer the added threat of chemical agent releases out of the smokestack. In 1991, the **Chemical Weapons Working Group** (CWWG) formed as a citizens grassroots coalition advocating the safe, non-incineration disposal of chemical weapons and citizen involvement in the decision-making process.

Although the Army itself had destroyed lethal chemical agents with a neutralization process back in the 1970s, and despite significant advances made in the efficiency of neutralization and other non-incineration processes, the Army refused to consider these safer methods. Its attitudes about hazardous waste disposal remained stuck in the 1970s and 80s, despite the advent of safer, more efficient technologies.

The CWWG's advocacy for safer, cleaner chemical weapons disposal began to pay off in 1996 when the U.S. Congress passed legislation mandating that the Department of Defense identify, demonstrate and implement at least two non-incineration chemical weapons disposal technologies. As a result, the Assembled Chemical Weapons Assessment (ACWA) program was born.

The ACWA program was an entirely new "level of thinking" for the military. The program includes a Dialogue, consisting of military decision-makers, state and federal environmental regulators, citizen representatives and grassroots environmental activists. The Dialogue, operating by consensus, was empowered to: 1) create technology demonstration criteria; 2) ensure clear communication and flow of information; 3) share oversight of technology demonstrations; and 4) report findings and recommendations back to the U.S. Congress.

Four of the six technologies demonstrated through ACWA passed testing, and were recommended by the Dialogue for implementation. These technologies are: neutralization and a biological treatment; neutralization and supercritical water oxidation; neutralization, supercritical water oxidation and gas phase chemical reduction; and electrochemical oxidation. Two technologies that did not pass demonstrations are Startech's plasma arc and Teledyne Commodore's Solvated Electron Technology.

In Spring 2002 the Department of Defense chose a neutralization and biological treatment method for disposal of mustard agent-filled weapons stored in Pueblo, Colorado. In January 2003 the Department of Defense chose neutralization followed by supercritical water oxidation for disposal of nerve and mustard agent-filled weapons stored in Richmond, Kentucky. In addition, existing chemical weapons incinerators could be retrofitted with an ACWA technology.

Meanwhile, the U.S. Army continues to plod along with its incineration program. As it has, scheduled deadlines have slipped, costs have skyrocketed, lawsuits have proliferated, and the Army's credibility has reached an all-time low. Technical failures continue to plague the incinerator facilities.

The Department of Defense may never have looked seriously at non-incineration technologies without pressure from the CWWG, and if the U.S. Congress had not forced them. But as a result of the ACWA technology search and demonstrations, several communities may soon have safer, cleaner, faster, cheaper technologies available for chemical weapons disposal. The U.S. Environmental Protection Agency has found that the same technologies can be used for safer treatment of a wide range of hazardous wastes, such as PCBs, pesticides and other contaminated materials.[164]

That is where citizen involvement can lead.

Effective hazardous waste treatment technologies should meet the following criteria:

- Achievement of the highest possible destruction efficiency, using the most sensitive analytical techniques. Note that the term "**destruction efficiency**" takes into account all waste outputs (effluents to air, land and water) while "destruction removal efficiency," or DRE, only applies to air emissions. An incinerator achieving a high DRE may still show poor performance on overall destruction efficiency.[165]

- Containment of all byproducts. Given that any technology may produce hazardous byproducts, it is important that those byproducts not be released to the environment. Some refer to containment capability as "hold-test-release." The ideal technology can control the waste and byproducts in a contained environment. The option to re-process wastes within the contained system is also ideal, in order to achieve a higher destruction efficiency.

- Identification of all byproducts. It is impossible to assess the efficiency of a technology that cannot even identify the quantity and toxicity of its byproducts.

- No uncontrolled releases. Regulatory agencies give facilities permits under the assumption that they will perform perfectly. This logic defies the nature and experience of incinerator operations. A precautionary approach to hazardous waste destruction means seeking to prevent, rather than manage, hazardous waste releases.

Other important attributes of effective systems are operation at low temperatures and low pressures; minimal input of caustic solutions; and advanced monitoring systems, to provide a safer, more accountable work environment. Incineration does not meet any of these criteria.

No technology is perfect, and no installation will operate perfectly all the time. That is why end-of-pipe technologies, good as they may prove to be, are not adequate substitutes for the primary practices of waste prevention and toxics minimization. However, the technologies listed below have shown the capability to treat historical hazardous wastes in a contained, controlled system, without combustion. Other technologies now in development at laboratory and pilot scale may prove successful for hazardous waste destruction in the near future.

Some Non-Incineration Technologies for Hazardous Waste Treatment[166]

Technology	Process Description	Potential Advantages	Current Uses
Base Catalyzed Dechlorination	Wastes reacted with alkali metal hydroxide, hydrogen and catalyst material. Results in salts, water and carbon.	Reportedly high destruction efficiencies. No dioxin formation.	Licensed in the United States, Australia, Mexico, Japan, Spain. Potential demonstration for PCBs through United Nations project.
Biodegradation (in enclosed vessel)	Microorganisms destroy organic compounds in liquid solutions. Requires high oxygen/nitrogen input.	Low temperature, low pressure. No dioxin formation. Contained process.	Chosen for destruction of chemical weapons neutralent in the United States. Potential use on other military explosive wastes. Typically used for commercial wastewater treatment.
Chemical Neutralization	Waste is mixed with water and caustic solution. Typically requires secondary treatment.	Low temperature, low pressure. Contained and controlled process. No dioxin formation.	Chosen for treatment of chemical agents in the United States.
Electrochemical Oxidation (Silver II)	Wastes are exposed to nitric acid and silver nitrate treated in an electrochemical cell.	Low temperature, low pressure. High destruction efficiency. Ability to reuse/recycle process input materials. Contained process. No dioxin formation.	Under consideration for chemical weapons disposal in the United States. Assessed for treatment of radioactive wastes.
Electrochemical Oxidation (CerOx)	Similar to above, but using cerium rather than silver nitrate.	Same as above; cerium is less hazardous than silver nitrate.	Demonstration unit at the University of Nevada, United States. Under consideration for destruction of chemical agent neutralent waste.
Gas Phase Chemical Reduction	Waste is exposed to hydrogen and high heat, resulting in methane and hydrogen chloride.	Contained, controlled system. Potential for reprocessing byproducts. High destruction efficiency.	Used commercially in Australia and Japan for PCBs and other hazardous waste contaminated materials. Currently under consideration for chemical weapons destruction in the United States. Potential demonstration for PCB destruction through United Nations project.
Solvated Electron Technology	Sodium metal and ammonia used to reduce hazardous wastes to salts and hydrocarbon compounds.	Reported high destruction efficiencies.	Commercially available in the United States for treatment of PCBs.
Supercritical Water Oxidation	Waste is dissolved at high temperature and pressure and treated with oxygen or hydrogen peroxide.	Contained, controlled system. Potential for reprocessing byproducts. High destruction efficiencies.	Under consideration for chemical weapons destruction in the United States. Assessed for use on radioactive wastes in the United States.
Wet Air Oxidation	Liquid waste is oxidized and hydrolyzed in water at moderate temperature and	Contained, controlled system. No dioxin formation.	Vendor claims 300 systems worldwide, for treatment of hazardous sludges and wastewater.

Non-combustion technologies are starting to make inroads into the treatment of wastes that have traditionally been incinerated. Gas phase chemical reduction has been used in Canada, Australia and Japan to treat PCB stockpiles. The U.S. Government has adopted biological treatment methods for one of its chemical weapons stockpiles. Two agencies of the United Nations — UNDP and UNIDO — have launched an important project whose explicit aim is to eliminate the barriers that deter the use of non-combustion technologies for POPs treatment. The existence of this project shows that there is support within the UN system and within some governments for the view that incineration is an inappropriate form of POPs treatment. However, there still exist regulatory, technical, and economic barriers to the easy implementation of alternative technologies. In order to provide countries with POPs stockpiles a viable option to incineration, the UN agencies are planning full-scale demonstration projects of PCB treatment in Slovakia and the Philippines. The technologies currently under consideration for this project are gas phase chemical reduction, base catalyzed dechlorination and sodium reduction, although more technologies may be added as information becomes available.

Non-incineration technologies do not guarantee trouble-free destruction of hazardous wastes. Some do, however, offer a reasonable alternative for a wide range of commercial and military wastes that would otherwise be destined for an incinerator.

Section 2 Recommended Readings:

ANPED Clean Production Resource List, http://www.anped.org/PDF/11spaccleanprsclist.pdf

Connett, P., "Medical Waste Incineration: A Mismatch Between Problem and Solution," The Ecologist Asia, Vol. 5, No. 2, March/April 1997.

Costner, P. et al, *Technical Criteria for the Destruction of Stockpiled Persistent Organic Pollutants*, Greenpeace International Science Unit, October 1998.

Crowe, E., and Schade, M., *Learning Not to Burn: A Primer for Citizens on Alternatives to Burning Hazardous Waste*, 2002.

Geiser, K., *Materials Matter*. Boston: MIT Press, 2001.

Health Care Without Harm, *Going Green: A Resource Kit for Pollution Prevention in Health Care*, 2001.

Health Care Without Harm, *Medical Waste Treatment Technologies: Evaluating Non-Incineration Alternatives: A Tool for Health Care Staff and Concerned Community Members*, 2000.

Health Care Without Harm, *Non-Incineration Medical Waste Treatment Technologies: A Resource for Hospital Administrators, Facility Managers, Health Care Professionals, Environmental Advocates, and Community Members*, August 2001.

Health Care Without Harm, *Update on Pyrolysis: a Non-traditional Thermal Treatment Technology*, 2002.

Kela, M. et al., *Managing Hospital Waste: A Guide for Health Care Facilities* (Revised Edition), Srishti, New Delhi, 2000.

McRae, G., *Eleven Recommendations for Improving Health Care Waste Management*, CGH Environmental Strategies, December 1997 (revised May 2000).

Murray, R., *Creating Wealth from Waste*, Demos, London, 1999.

Platt, B., *Resources up in Flames: The Economic Pitfalls of Incineration versus a Zero Waste Approach in the Global South*, Global Alliance for Incinerator Alternatives, 2003.

Srishti, *Hospital Waste: Time to Act; Srishti's Factsheets on 8 Priority Areas*, New Delhi, 2000.

Thorpe, B., *Citizen's Guide to Clean Production*, Clean Production Network, August 1999.

Wingspread Statement on the Precautionary Principle, published in *Rachel's Environment & Health News*, #586, February 19, 1998, www.rachel.org

Section III:

PUTTING OUT THE FLAMES

Citizens protest against wasting and burning in the first Global Day of Action on waste incineration on 17 June 2002 © FoE Derby

In city after city, country after country, the incineration industry has proven itself to be phenomenally unpopular. Existing and proposed incinerators are regularly met with vocal opposition from local residents and public interest organizations. In hundreds of cases, the public has succeeded in shutting down operating plants or preventing the construction of new ones. The widespread resistance to incineration is a testament to the popular rejection of this technology. In the short term, popular rejection does not always translate into government rejection, because of industry influence in governments, among other factors. But in the long term, as national bans and international treaties take effect, citizen opposition to incinerators is slowly being translated into law.

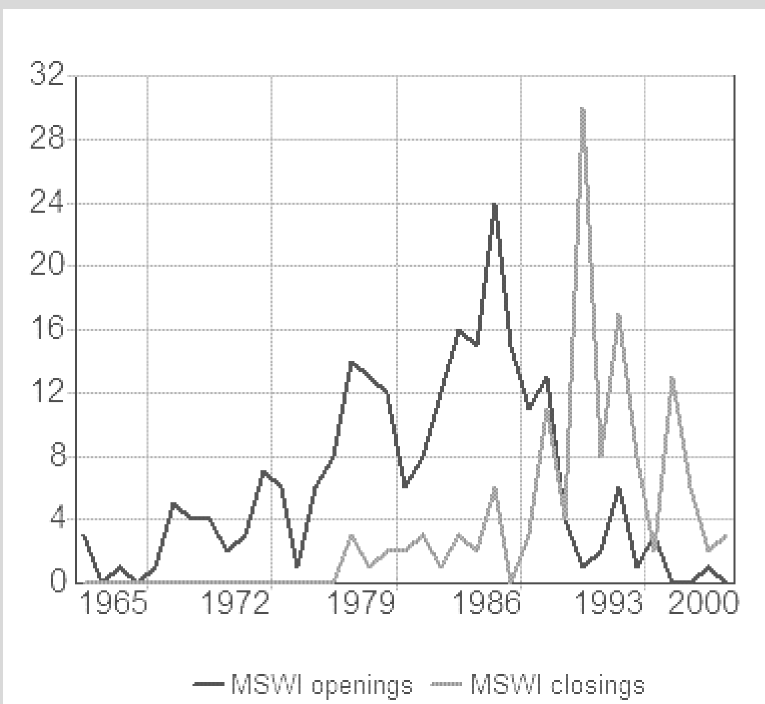
THE RISE AND FALL OF THE AMERICAN BURNER

The rapid rise and fall of the incinerator industry was most dramatic in the United States. Although the country built its first municipal waste burner in 1885, incineration was a minor industry until the 1970s, when a confluence of factors spurred hundreds of proposals for municipal and medical waste incinerators. These factors included tax breaks, guaranteed electricity sales, a perceived landfill crisis, and the collapse of the nuclear power industry in the face of public opposition and spiraling costs.[167] When orders for new nuclear plants dried up, large engineering firms went looking for similarly grandiose public works projects to enable them to continue benefiting from government subsidies. For companies such as Westinghouse, General Electric, Babcock & Wilcox, and Combustion Engineering, municipal waste incineration was the answer.[168]

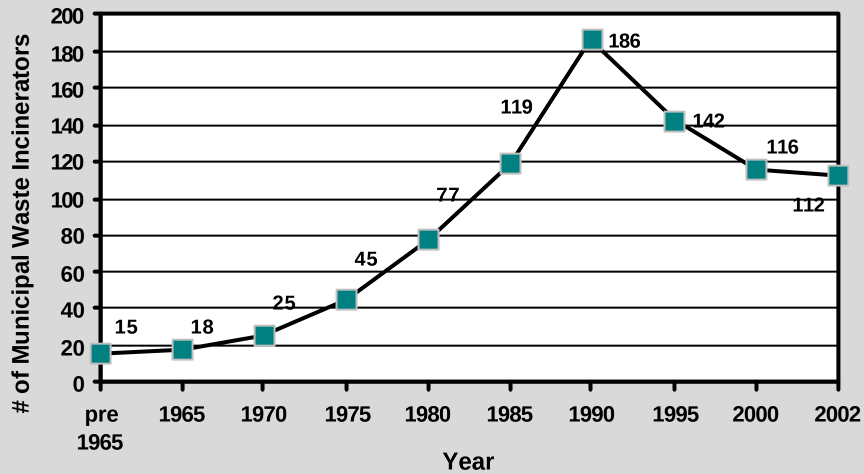
At the same time, ocean dumping of waste produced widely reported incidents of medical waste washing up on beaches, resulting in the closure of popular swimming areas. Combined with the new awareness of HIV/AIDS, this led to greater public concern over health care waste and a call for stepped-up treatment. Many hospitals, fearful of spreading infection, lawsuits or just bad publicity, adopted on-site medical waste incinerators not only to treat their health care waste, but also to remove the hospital's fingerprints on the waste. A syringe or bandage could conceivably be traced to the hospital of origin, but incinerator ash could not.

As a result, incinerator construction increased dramatically in the United States in the 1980's. Yet the trend lasted little more than a decade. By 1990 incineration had clearly crested, and the industry has suffered extreme contraction since then. The number of operating municipal waste incinerators, for example, peaked in 1991 at 171, and has fallen steadily in the decade since.[169] The rapid expansion of incineration sparked one of the largest and most effective grassroots environmental movements in American history.[170] In approximately 15 years, this loosely-linked network of mostly volunteer activists succeeded in stopping over 300 proposed municipal waste incinerators across the country, and in imposing increasingly strict air emissions standards, effectively killing off the American municipal waste incinerator industry.[171]

Openings and Closings of Municipal Solid Waste Incinerators in the United States[172]



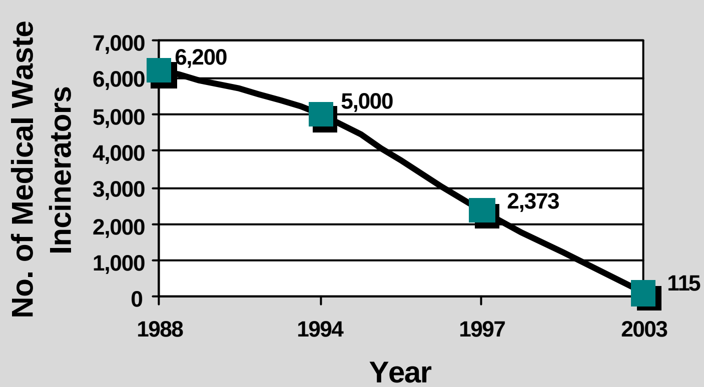
Municipal Solid Waste Incinerators in Operation in the United States[173]



These activists were often derided as NIMBYs (Not In My Back Yard) — people who were selfishly unwilling to share the burdens of modern technology. Although many were drawn to the issue when they felt their own health and wellbeing were directly threatened, they quickly realized the global dimensions of the problems, and became engaged at the policy level as well. As a result of this public pressure, many states and localities in the United States passed bans or restrictions on incinerators (See Appendix B), and the Federal government began to regulate incinerator air emissions, beginning in 1987. This forced the closure of most of the smaller incinerators. The case of medical waste incinerators is particularly dramatic. No one knows exactly how many medical waste incinerators operated in the US in the 1980's, but USEPA estimated 6,200 in 1988.[174] By 2002, that number was down to 767, and falling; of those, only three were built since 1996.[175] In Michigan, for example, all but one of the 290 medical waste incinerators in the state closed down rather than attempt to meet Federal emissions limits imposed in 1997.[176] In 1999, three states certified that they had no operating medical waste incinerators at all.[177]

> NIMBY is industry's name for **democracy in action**.
> — Dr. Paul Connett

Medical Waste Incinerators in the United States[178]



It is significant to note that since June 1996, only seven new medical waste incinerators have been constructed in the United States. The seven new incinerators are very much lower than the original EPA projection of 700 new incinerators that were expected to have been built between 1995 to 2000 based on past trends.

References:

December 1988: "Hospital Waste Combustion Study-Data Gathering Phase," US EPA.

July 1994: "Medical Waste Incinerators-Background Information for Proposed Standards and Guidelines: Industry Profile Report for New and Existing Facilities," US EPA.

January 1996: "Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Medical Waste Incinerators," US EPA.

June 2003: "Status of Current HMIWI Efforts," presentation by Fred L. Porter, US EPA, at the Medical Waste Institute.

Davidson County, North Carolina is listed in the Guinness Book of World Records for having **15,000** people show up for a public hearing on a waste incinerator in 1987 — the most public participation at a public hearing in the history of the United States. This hearing never took place because of the record turnout of residents. The state's Hazardous Waste Treatment Commission had to be escorted out of the county by the Highway Patrol for their own safety. The Commission never came back.[179]

End of the Incinerator Era

According to the U.S. Department of Energy in 1997, "The WTE [incinerator] market has been steadily shrinking in the USA, (and in Europe and Japan) due to the following reasons:

"1. The Federal Tax Policy no longer favors investment in the capital-intensive (because of expensive pollution control and monitoring equipment) WTE technologies. (WTE companies previously had tax-credit benefits.)
"2. Energy regulations, which once required utilities to buy WTE energy at favourable rates, have been revamped.
"3. There have been increasing challenges to interstate waste movement.
"4. With increasing awareness and protest by communities, the governments have been forced to involve them in the decision-making process. This sometimes means having to leave the waste management option to the communities themselves. People are increasingly opting for recycling and composting of waste, and out of WTE."[180]

At the same time as emissions standards were becoming more stringent, some of the subsidies to incinerators were rolled back. In particular, the U.S. Supreme Court ruled that put-or-pay contracts — under which a community was required to deliver its garbage to an incinerator and could not look for cheaper options — were illegal. Caught between public opposition, increasing environmental standards and loss of subsidies, the incinerator industry simply packed up. Indeed, its demise in the United States was so dramatic that it garnered a front-page story in the premier business newspaper, the *Wall Street Journal*.[181] It is now virtually impossible to build a new incinerator in the United States. As a result, the U.S. incinerator manufacturers have either left the industry or shifted to exporting incinerators.

The Demise of the Incinerator Industry, in Their Own Words

"...there is substantial doubt about the Company's ability to continue as a going concern....Because of the downturn in Pacific Rim markets and new USEPA regulations, the Company has concentrated its current marketing efforts on other areas of Asia and selected domestic markets."

— **Consumat Environmental Systems**, an incinerator builder, in a U.S. securities filing.[182]

"Unless there are many changes in the solid waste industry, the waste-to-energy industry will continue in an asset management mode....In other words, there´s no new business on the horizon....Everybody else that was ever in the waste-to-energy business, starting with companies like Monsanto and Occidental Petroleum, General Electric and Boeing and on and on — of the probably 100 companies that were once in waste-to-energy, there are three left."

— **David Sussman**, senior vice president of environmental affairs of Ogden Corporation (now Covanta).[183]

Incineration is a " ***dead technology***," an official of Security Environmental Systems announced when SES dropped its plans to build California's first hazardous waste incinerator when it was required to prepare an environmental impact report and a health risk assessment.[184]

"The only economic thing for Foster Wheeler to do is to just blow the [incinerator] up."
— **John McGinty**, industry analyst on the Robbins incinerator in suburban Chicago, one of many financially unviable incinerators.[185]

Having defeated the incinerators, American activists were not content to send their waste to landfills. Instead, they poured their energies into recycling and composting programs, which took off with equal speed — doubling in number between 1985 and 1991.[186] California was the first state to embrace a goal of diverting 50 percent of waste by 2000, and is now officially committed to a goal of Zero Waste. By 1999, more than 135 million Americans (half the country's population) were served by curbside recycling programs — more than the number that vote in presidential elections![187]

GLOBAL RESISTANCE

Across the globe, public interest organizations and popular efforts have stopped incinerator proposals, shut down existing incinerators and fought for legislation to ban or restrict waste incineration. Organized resistance to incineration is active in hundreds of communities and on every continent (see map). In 2001 alone, for example, major incinerator proposals were defeated by public opposition in France, Haiti, Ireland, Poland, South Africa, Thailand, the United Kingdom, and Venezuela. And in June 2002, 126 groups in 54 countries participated in the first global day of action against incineration. In December 2000, more than 75 individuals representing public interest organizations in 23 countries met near Johannesburg, South Africa, to launch GAIA. The acronym stands for two names: the Global Anti-Incinerator Alliance and the Global Alliance for Incinerator Alternatives, indicating that GAIA members work both against incineration and to implement alternatives. As of May 2003, GAIA had 378 member organizations in 68 countries, and it continues to expand rapidly.

In every country, opposition to incineration takes a unique form; and it is shaped by the political, physical, and cultural characteristics of that nation. In Japan, for example, resistance is "everywhere," in the words of an incinerator industry representative,[188] primarily in the form of hundreds of local anti-dioxin groups throughout the country, representing tens of thousands of ordinary Japanese citizens. These organizations have succeeded in making dioxin a household word throughout the country and imposing increasingly stringent regulations on the industry.

According to the Japan International Cooperation Agency, which promotes the construction of incinerators abroad, "Incineration [facilities]...are generally considered to be a nuisance. Organized movements against them frequently surface, thus making construction difficult. The basic complaint centers around negative [environmental] impacts caused when technical defects occur."[189] However, Japan is a densely populated country with little available land, so it has not had the luxury of landfilling its waste while developing a recycling system, as the United States has done. Also, an unusually tight nexus between industry and government has kept the incinerator industry alive. With approximately 1800 municipal waste incinerators and thousands of medical and industrial waste burners, Japan is the most incinerator-intensive country on Earth. It also burns the largest percentage of its municipal waste — 75 percent[190] — and the UNEP estimates that in 1995 Japanese waste incinerators alone were the source of 35% of global dioxin emissions.[191]

Global Movement Against Waste Incineration

Nevertheless, citizen efforts in Japan have slowed down many incinerator proposals, and forced those that are constructed to face stiffer environmental controls than the national norm. "If municipalities do not accept the citizens' requests for standards lower than the national level, in fact, it will be impossible to site a plant. Municipalities are forced to accept the demands," said one government official. "The most important reason we monitor and keep plants clean is because of the opposition, regardless of the costs. Otherwise, we cannot build incinerators at all."[192] Public demands for stricter emissions standards have forced the closure of over 500 incinerators since 1998.[193] But with Japanese industry making fortunes in the construction of incinerators both at home and abroad, Japanese activists face an uphill battle, despite their numbers and expertise.

> "We believe that incineration will **never** play a major role in truly sustainable waste management."
>
> — U.K. House of Commons select committee, 2001.[194]

In Europe, home to the largest incinerator construction firms, resistance has also been widespread, although governments were able to commit to more extensive incineration before being checked by popular dissent. Active opposition to incinerator siting exists in virtually every European country, and has succeeded in blocking the majority of the incinerators proposed since the early 1980's.[195] INFORM, a U.S. environmental policy research organization investigating European incineration practices, found as early as 1986 that, "despite the view held by some in the United States that European plants are sited 'without incident,' all the facilities visited by INFORM confronted opposition."[196]

Indeed, industry watchers now consider the European incinerator market "mature," meaning that there is no scope to build new incinerators; at most, old ones that are retired may be replaced. But even this looks unlikely, since Europeans have dramatically stepped up their composting and recycling rates, reducing the flow of trash to incinerators.[197] This has resulted

Protest against environmental injustice at the 2002 Earth Summit in South Africa © Manny Calonzo/GAIA

> **"Citizens from across the globe speak out against the use of incinerators to deal with the excesses of our throw-away society."**
>
> — Signed by over one hundred fifty NGO delegates from 38 countries during the Johannesburg Summit

in the closure of some existing plants that can no longer obtain sufficient waste to function; others must import waste across national borders in order to have sufficient trash to burn.[198] The European Union has also developed the concept of the "waste hierarchy" — a prioritization of strategies that should be used to address waste. Waste prevention is at the top of the hierarchy, indicating that it is the most favored activity; recycling and composting in the middle; and incineration and landfilling at the bottom.

Some parts of Europe have gone farther. In Bavaria, Germany, home to one of the world's leading incinerator manufacturers,[200] public opposition took the form of a public referendum on incineration. Das Bessere Müllkonzept (The Better Garbage Concept) was a legislative program put forward by a coalition of citizens' organizations in 1989 that proposed a ban on incineration, source separation of household waste, local responsibility for waste management, and the development of intensive recycling and composting operations. In order to even qualify for the ballot, ten percent of the voting population (in this case, 850,000 people) had to go to a polling place and sign a petition in favor of the referendum over the course of just two weeks. The coalition collected over 1 million signatures but then narrowly lost the vote itself, in a campaign marred by approximately 700 alleged breaches of the election law.[201] The strength of the campaign did induce the government to adopt some waste reduction measures, however, which have resulted in an overall decrease in the total waste produced in Bavaria since 1991, in spite of population increases.[202]

The Medical Community Speaks Out Against Incineration

Citizen efforts have been bolstered by the support of various civil society groups, particularly professional associations, which have lent increased legitimacy to the public's concerns about human health and the environment. This has become particularly important around issues of dioxins and other toxics, where the science is intricate, evolving, and highly politicized. Incinerator proponents routinely distort the scientific evidence, using tools such as risk assessment to deceive the public about health risks. For example, one consultant indicates that the risk of contracting cancer from an incinerator is less than from eating peanut butter sandwiches.[203]

In this atmosphere of disinformation, ordinary people find it difficult to distinguish fact from fiction, and the imprimatur of respected organizations is important to legitimize the scientific or factual arguments that public interest groups make. Organizations that have taken a stand against incineration include the World Federation of Public Health Associations, the International Council of Nurses, the American Public Health Association, the American Nurses Association, the Bavarian Medical Association, the German Medical Association of the Munich Region, the California Medical Association, the Massachusetts Medical Society, and Physicians for Social Responsibility.

In the global South as well, citizens have been active in opposing incineration. Mozambique's first environmental organization to emerge after the civil war formed specifically to head off a proposal to incinerate obsolete pesticides in a cement kiln in a residential neighborhood. Livaningo's formation is significant not only for its struggle, but because it reaches across class and color lines in a fractured society. It was widely heralded as the re-establishment of a new, postwar civil society in Mozambique. Nevertheless, the struggle to prevent pesticide incineration became a long battle, with local residents traveling as far as Denmark to persuade the Danish government (the project funder) that the pesticides should be returned to their country of origin instead. Eventually, under pressure from Livaningo and

European groups, the Danish government not only abandoned the incineration of pesticides in Mozambique, it announced that it would no longer promote the use of cement kilns for pesticide destruction anywhere. That battle won, Livaningo is now tackling issues of medical and municipal waste incineration.

Struggles against incineration often pit resource-poor community activists against an alliance of industry and government officials. As such, citizens must often resort to direct action of various kinds, from marches and demonstrations to sit-ins and hunger strikes, in order to bend the government to the public will. In the U.K., Greenpeace activists physically occupied an incinerator, blocking the loading cranes and smokestacks, in order to shut it down. They were ultimately removed by the police, arrested, and charged with trespass. However, the jury refused to convict them, finding instead that they acted in the public interest.[204] In Kwangju, South Korea, launching pad for that country's successful democracy struggle in the 1980s, veteran activists are now engaged in fighting the incinerator industry. They see the government's

Koreans oppose the planned incinerator facility in Masan.© KFEM/KWMN

attempts to impose incineration on communities as a direct affront to the democracy for which they fought. "If we can beat a military dictatorship backed by the full strength of the U.S. military," says one, "we can certainly defeat an incinerator!"[205] In Lebanon, a sit-in in front of a municipal waste incinerator prevented the delivery of waste for two weeks. The Minister for the Environment declared that as long as the public continued to blockade the incinerator, the government would stop collecting waste. This sparked a large-scale community protest. When the police cracked down, the protestors became unruly, and in the ensuing confusion, the incinerator was destroyed — literally torched. The government did not repair the incinerator, but instead built a nearby separation facility for recycling.[206]

At the policy level, citizen efforts to legally restrict incineration have been successful in many jurisdictions in at least 15 countries (see Appendix B). Although some of these moratoria have expired, and one ban was overturned after heavy industry lobbying, they have largely been effective in preventing the construction of new incinerators. In 1999, the Philippines made history as the first nation to ban all forms of incineration. This was entirely the result of the efforts of public interest groups, and has been continuously under attack by both industry and international agencies such as the Asian Development Bank, which see it as an affront to their commercial interests. Other nations, reluctant to legally commit themselves to a ban on incineration, have nevertheless stated that they will avoid incineration as a matter of policy. For example, the Greek Ministry of the Environment has prohibited the use of incineration for municipal wastes.[207] The Turkish Minister for the Environment issued a circular stating that incineration should be phased out and replaced with clean technologies such as recycling, sterilization of clinical waste and "proper" landfilling. He cited high investment and operating costs, dioxin and furan emissions, and high monitoring costs as reasons why incineration was being phased out worldwide.[208]

The Philippine Incinerator Ban[209]

In 1999, the Philippines became the first country in the world to prohibit all forms of waste incineration, including open burning. This environmental milestone was achieved after years of campaigning by environmental and community groups opposing proposals for incinerators, landfills and dumpsites in various parts of the country.

Prior to the passage of the incineration ban, a key feature of the Clean Air Act, multinational waste management companies targeted the Philippines because they saw enormous business opportunities in the worsening garbage problems of Metro Manila and the country's other major urban centers. Representatives from such firms—which included Ogden (now Covanta), Vivendi (formerly Générale des Eaux), Steinmuller, Asea Brown Boveri, Olivine and some Japanese companies—fanned out across the country, presenting flashy incinerator proposals to unsuspecting national and local government officials.

In some instances, such initiatives had the backing of foreign diplomats, including the Swedish and Danish embassies, economic groupings, such as the American and European Chambers of Commerce, and development banks and multilateral aid agencies like the Asian Development Bank and the Japan International Cooperation Agency (JICA). These powerful foreign business and government institutions worked with incinerator promoters in the Philippine government to prevent the ban from being legislated. They sent letters to the Philippine Congress warning of World Trade Organization sanctions, arranged special lobby missions, and organized foreign junkets for Philippine officials to witness firsthand the operation of modern, "clean" incinerators in industrialized countries.

The anti-incinerator activists, however, were not to be intimidated. The environmental groups banded together with various sectoral and community groups to form the Clean Air Coalition. The coalition later presented to Congress more than two million signatures in support of the incineration ban and the removal of lead from fuels in the Philippine Clean Air Act of 1999. Linking with anti-landfill groups and communities, the Clean Air Coalition eventually expanded to become the Eco-Waste coalition, with more than a hundred members nationwide. The broadened coalition successfully campaigned for the approval of an Ecological Waste Management Act, which mandated the source segregation and recycling of municipal waste. The same law also reaffirmed the ban on incineration. The mix of policy advocacy, public campaigning, coalition work and citizen's resistance at the grassroots level is steering the Philippines in the right direction, forcing the adoption of real solutions to the country's waste problems.

INTERNATIONAL LAW

The growing consensus against incineration has also been reflected in the body of international environmental law, which has increasingly restricted its use and acceptability. In a few cases, conventions have addressed the question of incineration head-on. More often, however, international lawmakers have preferred to articulate a number of general principles that mitigate against the use of incineration and its variants (such as pyrolysis). When incorporated into national law and policy-making, these principles clearly push nations away from the use of incineration, although they still fall short of outright bans. Communities and advocates for sustainable discards systems can use the following language from treaties and conventions as leverage, especially those treaties and conventions that a country has signed or ratified. The International POPs Elimination Network and Basel Action Network can provide information on status of countries with respect to the Stockholm Convention and Basel Convention (see Resources section for contact information).

The Precautionary Principle was devised to solve the problem that scientific uncertainty poses for policy-making. Many countries will not restrict an activity or substance until it has been proven harmful to human health or the environment. On its face, this seems a reasonable approach. However, given the thousands of synthetic chemicals to which humans are exposed, the complexities (largely unexplored) of interactions between these chemicals, and the limited research budgets of most countries, it is simply not feasible to test every conceivable combination of chemicals for their effects on humans. Even if that were feasible, it would still be impossible to conclusively establish causal links between a particular facility's releases and the illness or death of any individual or group of individuals. In any case, by the time such a causal link is established, it is too late: the population has already been exposed and suffered the consequences. This has sarcastically been referred to as the "count the dead bodies technique" of chemicals testing.

At any given time, therefore, many substances are in the "gray area" of scientific uncertainty: their harmful effects are not conclusively proven, but sufficient evidence of harm exists to suspect that they are not safe. The Precautionary Principle, as stated in the 1998 Wingspread Statement, is: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context, the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action."[210]

> **"Lack of evidence of harm is not evidence of lack of harm."** – Anonymous

Several important documents in international law reference the Precautionary Principle, although each uses a somewhat different formulation, and some refer to it without any definition. It is clearly spelled out as principle 15 of the Rio Declaration on Environment and Development, adopted at the Earth Summit in Rio de Janeiro, Brazil, in 1992: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The 1996 Protocol to the London Convention states as its first general obligation that: "...Parties shall apply a precautionary approach...whereby appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects." Precaution is also referenced in the Preamble to the Protocol to the Convention on Long-Range Transboundary Air Pollution (LRTAP) on Persistent Organic Pollutants, a European regional treaty concerned with cross-border air pollution effects. Under the OSPAR Convention for the protection of the North Atlantic Ocean, implementing the Precautionary Principle with respect to the marine environment is an obligation of the signatory nations.[211] The Bamako Convention[212] similarly obligates its members to implement the precautionary approach "without waiting for scientific proof" of the harms in question.

Most recently, the Precautionary Principle is "embedded" in the Stockholm Convention on Persistent Organic Pollutants. It is referenced in the Preamble; in the Objective; and it is operationalized in at least two significant ways. The Stockholm Convention begins by listing 12 chemical substances that are subject to restriction, but it is envisioned to add new substances, in accordance with the Precautionary Principle. In other words, under the existing treaty framework, "lack of full scientific certainty shall not prevent" a chemical from being listed if the signatory nations have sufficient evidence to indicate that the chemical meets the POPs criteria and is of concern. Secondly, the treaty enjoins parties to use Best Available Techniques in order to minimize the production and release of POPs from new and existing sources, and the definition of Best Available Techniques includes precaution.

The Precautionary Principle bears on incineration in two different ways. First, combustion is an extremely complex process, and it is still not known precisely what substances are produced and released through the incineration of wastes. This is particularly true when the waste in question is highly variegated, as in the case of municipal or health care waste. Without knowing the pollutants produced, their quantities, environmental fate, or health effects, it is impossible to assure the safety of such a process (even if the known dangers could somehow be eliminated). Thus, precaution argues for avoiding the activity, i.e., incineration. Second, many of the substances which have been identified in air emissions and incinerator ash have varied and subtle effects on the human body, which are still being investigated. Some, such as lead and PCBs, may also interact with each other or other pollutants present in the environment to create synergistic effects. Given the uncertainty surrounding these health effects, precaution again argues for avoiding their production and release.

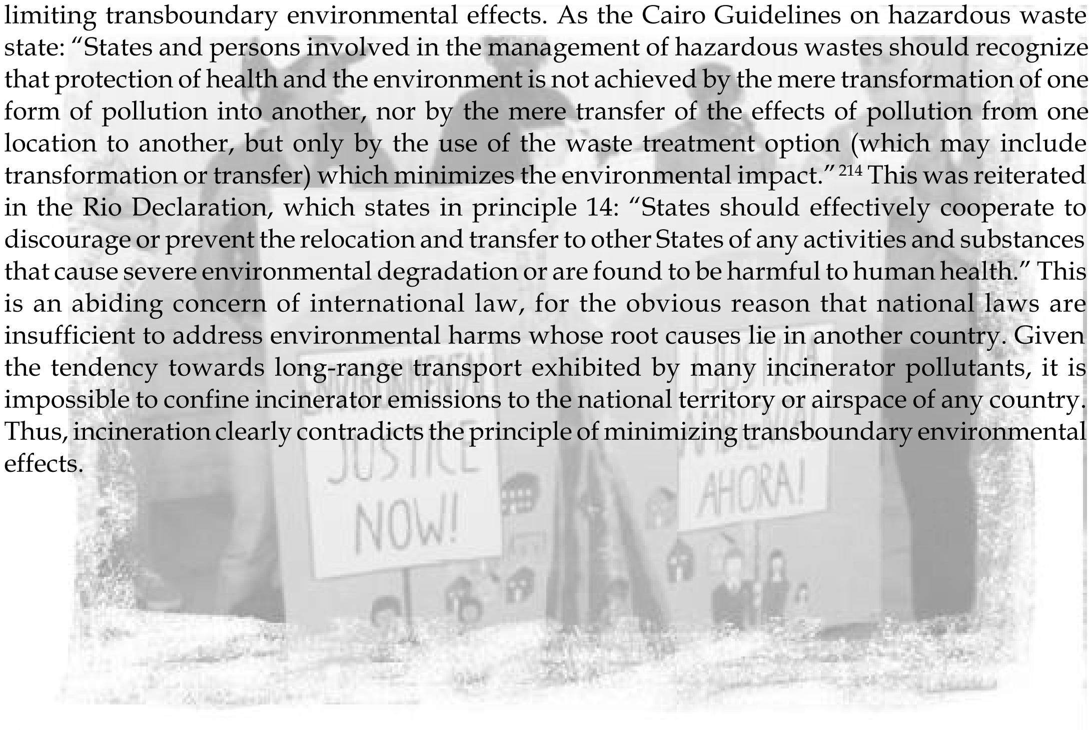
A second principle found in international law, although more rarely mentioned by name, is prevention. This is simply the common-sense notion that it is better to prevent harm than to allow damage to occur and then attempt to mitigate it or clean it up. International law clearly indicates that the minimization of environmental damage is to be prioritized over end-of-pipe techniques. Thus, Agenda 21, the framework document adopted at the Earth Summit in 1992, states that a target of hazardous waste policy must be "preventing or minimizing the generation of hazardous wastes as part of an overall integrated cleaner production approach."

Minimization is also specifically required in the LRTAP Convention of 1979;[213] the World Charter for Nature, adopted by the UN General Assembly in 1982; the UNEP Governing Council Decision on Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes of 1987; the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal of 1989; the Convention on the Transboundary Effects of Industrial Accidents of 1992; and the Washington Declaration on Protection of the Marine Environment from Land-Based Activities of 1995. Prevention is explicitly brought to the fore in the European Union's waste hierarchy, which prioritizes waste avoidance and waste minimization, and places incineration and landfilling in the least-preferred categories. As with the Precautionary Principle, prevention is woven throughout the Stockholm Convention. It is referenced in the Preamble and is present in the specific obligations. Most significantly, the Convention speaks of preventing the formation and release of POPs — indicating that end-of-pipe technologies which seek to destroy or trap the pollutants are not sufficient: their very formation should be prevented. This is the true application of the prevention principle.

It is the Bamako Convention, however, which most clearly lays out the prevention principle and its implications for industry, saying: "Each party shall...ensure that the generation of hazardous wastes within the area under its jurisdiction is reduced to a minimum taking into account social, technological and economic aspects." It then goes on to specifically require the implementation of clean production: "Each Party shall strive to adopt and implement the preventive, precautionary approach to pollution problems...through the application of clean production methods, rather than the pursuit of a permissible emissions approach based on assimilative capacity assumptions." It then goes on to define clean production methods as applicable to the entire life cycle of the product, including: "raw material selection, extraction and processing; product conceptualisation, design, manufacture and assemblage; materials transport during all phases; industrial and household usage; reintroduction of the product into industrial systems or nature when it no longer serves a useful function. Clean production shall not include 'end-of-pipe' pollution controls such as filters and scrubbers, or chemical, physical or biological treatment. Measures which reduce the volume of waste by incineration or concentration, mask the hazard by dilution, or transfer pollutants from one environmental medium to another, are also excluded."

The Bamako Convention's detailed wording clearly indicates the contradiction between prevention and incineration. On the one hand, incineration, as a waste treatment technology, is an indication of a failure to implement clean production and waste minimization. On the other hand, as a technology that produces hazardous byproducts, incineration itself runs counter to the prevention principle.

The third principle, cited in documents too numerous to mention, is the importance of limiting transboundary environmental effects. As the Cairo Guidelines on hazardous waste state: "States and persons involved in the management of hazardous wastes should recognize that protection of health and the environment is not achieved by the mere transformation of one form of pollution into another, nor by the mere transfer of the effects of pollution from one location to another, but only by the use of the waste treatment option (which may include transformation or transfer) which minimizes the environmental impact."[214] This was reiterated in the Rio Declaration, which states in principle 14: "States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health." This is an abiding concern of international law, for the obvious reason that national laws are insufficient to address environmental harms whose root causes lie in another country. Given the tendency towards long-range transport exhibited by many incinerator pollutants, it is impossible to confine incinerator emissions to the national territory or airspace of any country. Thus, incineration clearly contradicts the principle of minimizing transboundary environmental effects.



The International Joint Commission's Statement on Incineration

A Policy Statement On Incineration of Municipal Waste by the International Joint Commission (excerpt):

iii) Any further deployment of this technology [incineration] by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities.

iv) The total amount of persistent toxic substances released by incineration facilities in a jurisdiction, defined as the sum of those to the atmosphere and in the residuals, must also be decreased whenever a new incineration facility is permitted.

The International Joint Commission is an independent, bilateral body set up by the United States of America and Canada to prevent and resolve disputes under the 1909 Boundary Waters Treaty.[215]

In addition to these general principles, several treaties single out incineration for partial bans. In 1996, the Protocol to the London Convention outlawed incineration at sea. The Protocol replaced the 1972 London Convention,[216] which banned ocean waste dumping, but not hazardous waste incineration at sea. Ocean incineration had been practiced by a few countries since 1969, in an effort to avoid national air emissions norms. Thirty-seven of the countries party to the London Convention agreed to a phase-out by 1993, but, in fact, the last incinerator ship had ceased operation in 1989.[217] In 1998, the OSPAR Convention re-affirmed this ban on at-sea incineration, although its applicability is limited to the North Atlantic. The Bamako Convention, as has already been mentioned, clearly defines incineration as an end-of-pipe technology not compatible with clean production; it also outlaws incineration at sea but includes territorial and internal waters as well as the high seas in its ban. The Bamako and Basel Conventions also define the wastes resulting from incineration and pyrolysis as hazardous wastes subject to the respective treaties. And the Stockholm Convention, although stopping short of a global ban on incineration, throws up several formidable barriers to its use.

THE STOCKHOLM CONVENTION AND INCINERATION[218]

The Stockholm Convention on Persistent Organic Pollutants (POPs)[219] is an international treaty, concluded in 2001, that seeks to protect human health and the environment from a particular class of synthetic chemicals, namely POPs. Initially, the treaty applies to 12 pollutants, of which eight are pesticides,[220] two are industrial chemicals (hexachlorobenzene and PCBs);and two are produced only as unintentional byproducts (dioxins and furans). In fact, the latter three are themselves classes of chemicals. The treaty includes provisions to expand this list to include other chemicals, using the Precautionary Principle to judge their fitness for inclusion in the list.

Although the Stockholm Convention does not ban incineration or even the construction of new incinerators, it does place serious obstacles in the path of any incineration project. The Convention specifically states in Annex C that "waste incinerators, including co-incinerators of municipal, hazardous or medical waste or of sewage sludge; cement kilns firing hazardous waste" are among the technologies that have the "potential for comparatively high formation and release of such unintentional POPs." In fact, incinerators are significant sources of four of the 12 listed pollutants: dioxins, furans, PCBs, and hexachlorobenzene. As such, incinerators as a class are clearly subject to the restrictions of the Stockholm Convention.

The Convention requires parties to take "measures to reduce the total releases derived from anthropogenic sources" of the unintentional POPs. Within this context, it becomes very difficult to justify any new or additional sources of POPs, such as a new incinerator or increased quantities of waste sent to an existing incinerator. This could be interpreted to allow new sources of POPs if they were counterbalanced by much deeper cuts in POPs production or releases from other sources; but that is not made explicit in the treaty. As it stands, the treaty clearly requires parties to take action to reduce overall releases.

In fact, the Convention goes further; it is the strongest legal expression to date of the preference for source prevention over mere control of environmental hazards. For most of the intentionally produced POPs, the Convention requires elimination. For the unintentionally produced, or byproduct, pollutants, the treaty's Article 5 establishes a goal of their "continuing minimization and, where feasible, ultimate elimination."

The Stockholm Convention makes a significant departure from past policy regarding incineration's environmental impacts because it does not apply to air emissions alone for determining dioxins minimization rates. Rather, the Stockholm Convention looks at *total releases*, which include solid and liquid residues, including residues from air pollution control devices (fly ashes). Most past justification of incinerators was based on the argument that dioxin emissions to the atmosphere could be captured and therefore controlled. However, the Stockholm Convention considers such solid and liquid releases to be part of what must be continually minimized and, where feasible, eliminated.

Indeed, Article 5 also contains a particularly relevant substitution principle, which states that Parties to the treaty shall "Promote the development and, where it deems appropriate, require the use of substitute or modified materials, products and processes to prevent the formation and release of [unintentional POPs]." It is important to note the use of the term "formation" and to realize that this obligation makes it apparent that where there are alternative methods of waste management, any process that produces dioxins should be avoided. Again, with such clear signals provided for in this new body of international law, it is especially difficult to justify creating a new source of unintentional POPs, no matter how many end-of-pipe control measures are envisaged. The Convention recognizes that such technologies are not equivalent to preventing the formation of POPs, and therefore specifically calls for the use of substitute processes.

The Stockholm Convention also contains strong direction on the management and treatment of existing stockpiles of POPs wastes (which are often treated in hazardous waste incinerators). Article 6 calls for Parties to take measures so that POPs wastes are "disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of persistent organic pollutants." Although this text is followed with some caveats, such as excepting low levels of POPs content, which must await further interpretation, the use of the words "destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs," is meant again to be inclusive of all formation and outputs (not just air emissions). This goes far beyond what has previously been envisaged for any chemical waste in international law.

While it is true that many countries currently continue to operate various types of incinerators, the Stockholm Convention has placed the future of incineration and all waste combustion in great doubt. Existing incinerators will no doubt continue to operate for some years to come, but it will now become increasingly difficult to justify the construction of new incinerators. As feasible alternatives exist to all types of incineration, the treaty's requirement to "eliminate and substitute" processes for new sources will be the operating principle. Indeed it will take a fundamental bending of the intent of the Stockholm Convention to promote any new source of POPs while alternatives exist.

One hundred twenty-seven nations signed the treaty in May 2001 in Stockholm. Although the Convention will not come into force until 50 nations have ratified it, and then only in the ratifying countries, it is not toothless in the interim. Under international law, signing a treaty is a statement of commitment to comply with the treaty; and governments that do sign are enjoined from taking actions that are clearly prejudicial to the goals of the treaty, even though they may not yet have ratified it. As such, the Stockholm Convention is already a barrier against the construction of any new incinerator in signatory nations.

Section 3 Recommended Readings:

Luscombe, D., and Costner, P., *Zero Toxics: Sources of By-product POPs and Their Elimination*, Greenpeace International, May 2001.

Rachel's Environment and Health News, Environmental Research Foundation, www.rachel.org

Walsh, E., Warland, R. and Smith, D., *Don't Burn it Here: Grassroots Challenges to Trash Incinerators*, University Park, PA: Pennsylvania State University Press, 1997.

CONCLUSIONS

Incineration is a dying technology. It has failed to deliver on virtually every count imaginable,

- As a waste treatment technology, it is unreliable and produces a secondary waste stream more dangerous than the original
- As an energy production method, it is inefficient and wasteful of resources
- As an economic development tool, it is a catastrophe
- Its environmental problems are still being tallied
- It is profoundly unpopular and undemocratic

In spite of all of the above, incineration's promoters are still active, arguing perennially that the new generation of devices has solved all of last year's problems. For many, of course, there is a direct financial incentive for supporting incineration, and so the scientific debate becomes clouded by private interests. Each decade brings a new set of technologies for air emissions control, ash treatment, furnace design, etc., all desperately tinkering with a technology that is fundamentally misguided. For the problem of incineration is not just the technology: it is the purpose of the technology and its ascribed goals.

As long as waste is considered an inevitable consequence of human activity, we will contend with the problem of waste disposal: getting rid of it. Waste disposal is never going to be a sustainable exercise. On a planet stressed beyond capacity by toxics and desperately short of resources for the majority of its people, a fundamental re-evaluation of waste generation and materials use is needed. Humans are continuously extracting resources from the environment, and returning only waste. Much of that waste cannot be usefully absorbed or refashioned, because of its volume or synthetic or hazardous nature. On a finite planet, this kind of activity clearly can continue for only a limited amount of time before we literally choke on our own waste. No new furnace design or filtration system is going to alter this fundamental issue: waste generation and disposal removes materials from useful circulation, which further impoverishes the planet.

Only by altering the systems of production, transportation and consumption can society change this dynamic. The solutions indicated in the second section of this report all attempt to address this issue. Through waste minimization, toxics reduction, re-use, recycling, composting, and a host of other strategies, we can sharply cut the leakage of materials out of the economy. These strategies simultaneously reduce our demands on the earth's resources and our discharges of waste. They ultimately may bring us to a stable, sustainable economy.

In terms of policy, the way forward for governments is clear. They need to put a stop to existing and proposed incinerators, and implement alternatives. Although incineration's problems are universal, there are no universal solutions. Each country, each city, each industry and each institution will have to develop its own systems for sustainable materials management. In many cases, these will be local, even extremely local: backyard composting at the household level, for example. In other cases — the application of Extended Producer Responsibility to items in international trade — changes may need to reach across the globe. There will be no "one size fits all" model; however, we have laid out some general principles that successful systems are likely to follow and a few examples that may indicate model programs.

For individuals and activists, there are at least two clearly demarcated fronts on which to engage the issue. Continuing to close incinerators, landfills, and other end-of-pipe technologies puts increasing pressure on the entire economy to produce less-hazardous waste, and less of it. At the same time, viable alternatives are needed. Although these are usually the domain of government, few governments or industries have shown the creativity and commitment necessary to actively engage the public and create appropriate, home-grown materials management systems. As such, it will be important for some time into the future for individuals and public-interest organizations to describe and realize practical alternative solutions. Ultimately, of course, governments must become more responsive to the people they serve, but in the meantime, ordinary citizens will continue to lead the way.

GLOSSARY

ACWA (Assembled Chemical Weapons Assessment): a program of the U.S. government to demonstrate the viability of non-incineration methods for treatment of chemical weapons stockpiles.

AFSSA (Agence Française de Sécurité Sanitaire des Aliments): the agency for food safety in the French Ministry of Health.

Basel Convention: an international treaty which, as amended (with the Basel Ban) prohibits the export of hazardous waste from OECD (wealthy) countries to non-OECD countries.

Bamako Convention: an international treaty which regulates hazardous waste within Africa, including a ban on importing hazardous waste from outside the continent and provisions for minimization of hazardous waste generation.

bioaccumulation: the process in which a pollutant builds up in the body over an individual's lifetime.

biomagnification: the process by which a pollutant becomes increasingly concentrated as it moves up the food chain.

body burden: the load of a given pollutant that an individual carries in his/her body.

bottom ash (also, clinker): the residue from an incinerator that falls through the grate mechanism at the bottom of the furnace.

Clean Production: an approach to designing products and manufacturing processes that takes a life cycle view of all material flows, from extraction of the raw material to product manufacture and the ultimate fate of the product at the end of its life. It aims to eliminate toxic wastes and inputs and promote the judicious use of renewable energy and materials.

clinker: see bottom ash.

destruction and removal efficiency (DRE): a measure of the efficacy of a treatment technology for preventing the release to air of a given pollutant. DRE is the percentage of the pollutant in the waste stream that is not released to the air through the stack. Releases to other media are considered "removal." Cf. destruction efficiency.

destruction efficiency (DE): Another measure of the efficacy of treatment technologies. DE is the percentage of pollutant that is destroyed by treatment, i.e., not released in gaseous, liquid or solid form. Cf. destruction and removal efficiency.

dioxins: as used in this report, polychlorinated dibenzo dioxins (PCDD), polychlorinated dibenzo furans (PCDF) and coplanar polychlorinated biphenyls (PCBs). These are all aromatic chemical compounds formed during the incineration process. Dioxins belong to the class of chemicals known as persistent organic pollutants (POPs).

discards: materials of no immediate use to their present owner, to be differentiated from waste, which are materials of no possible use to anyone.

diversion rate: the percentage of discards that are re-used, recycled, composted or otherwise prevented from being wasted.

emissions: releases of byproducts from a process (e.g. incineration) to the air. Cf. releases.

end-of-pipe: interventions to reduce the environmental impact of an activity that are not integrated into the design but added at the end of the process, often as an afterthought.

energy recovery: a euphemism usually used for waste-to-energy or energy-from-waste incineration.

energy-from-waste (EFW): incineration with an attached steam turbine to generate electricity. This term occasionally refers to non-incineration technologies.

extended producer responsibility (EPR): a policy approach that makes firms responsible for their products and packaging in the post-consumer phase, providing an incentive to design products for end-of-life recycling.

flow control: legal measures adopted by certain jurisdictions to ensure that all municipal discards from that jurisdiction go to a particular waste treatment facility rather than finding the cheapest option available on the market.

fly ash: the ash recovered from an incinerator's air pollution control equipment. Cf. bottom ash.

hazardous waste: wastes which are corrosive, ignitable, reactive or toxic.

health care waste: all waste generated by health care facilities, such as hospitals, doctors' offices and clinics; also includes veterinary facilities, funeral homes and laboratories that prepare medicines or deal with human tissue.

life cycle assessment: a process to evaluate the environmental burdens associated with a product, process, or activity by identifying energy and materials used and wastes released to the environment, and to evaluate and implement opportunities to affect environmental improvements.

lipophilic: (chemicals which) have an affinity for and tend to combine with lipids (fatty substances).

medical waste: an ambiguous term, sometimes used to refer to all health care waste and sometimes only to that portion which is potentially infectious.

microgram: 1 x 10-6 gram, or one one-millionth of a gram.

MNCs (multinational corporations): see TNCs.

municipal discards: as MSW, below, but disaggregated so that each fraction can be dealt with appropriately (recycling, composting, etc.).

municipal solid waste (MSW): the mixed waste stream produced by residential and commercial establishments (but generally not industry).

nanogram: 1 x 10-9 gram, or one one-billionth of a gram.

neutralent: the liquid waste stream resulting from neutralization of chemicals weapons agent.

NGO (non-governmental organization): usually refers to non-profit organizations working for the public interest.

Northern: as used in this report, Northern refers to those countries with relatively high per capita (average) incomes and large industrial bases, roughly corresponding to the 30 member countries of the Organization for Economic Cooperation and Development. It is not a strictly geographic term. Cf. Southern.

PBTs (persistent, bioaccumulative toxics): a class of chemicals whose members are persistent in the environment; bioaccumulate in living creatures; and are toxic to life.

PCBs (polychlorinated biphenyls): a class of chemicals composed of two benzene rings linked by a single carbon-carbon bond, with one or more chlorine atoms in place of hydrogen. Often, coplanar PCBs (those with the two benzene rings in the same plane) are included in the set of dioxin-like compounds for their similar structure, origin, and effects.

PCDD (polychlorinated dibenzo dioxin): a class of chemicals, referred to as dioxins, composed of two benzene rings linked by two oxygen molecules, with one or more chlorine atoms in place of hydrogen.

PCDF (polychlorinated dibenzo furan): a class of chemicals, referred to as furans, composed of two benzene rings, linked with a carbon-carbon bond and through a single oxygen molecule, with one or more chlorine atoms in place of hydrogen. Furans are considered dioxin-like compounds for their similar structure, origin, and effects.

picogram: 1 x 10-12 gram, or one one-trillionth of a gram.

pg/kg/day: picograms per kilogram of body weight per day. A measurement of the rate of intake of a pollutant (usually dioxins) relative to a person's body weight.

POPs (Persistent Organic Pollutants): synthetic chemicals which display the following properties: they are organic (composed of hydrocarbons); persist long times in the environment; are capable of long-distance transport; and are toxic to humans. Subject to regulation under the Stockholm Convention.

Precautionary Principle: the principle that, in cases of scientific uncertainty regarding the safety of an activity, the burden of proof should rest with the proponent of the activity rather than with the persons to be affected; and that action should be taken to prevent harm whenever there is credible evidence that harm is occurring or is likely to occur, even when the exact nature and magnitude of the harm is not proven.

Preventive Principle: the principle that prevention of harm is always preferable to amelioration or compensation after the fact.

process wastes: byproducts of production processes such as manufacturing.

PVC (polyvinyl chloride): a common form of plastic, often referred to as vinyl, with chlorine as a major component.

pyrolysis: a form of incineration in which waste is treated in a depleted-oxygen environment, producing a gas, which is burned, and other byproducts, including slag. Legally classified as a form of incineration in the European Union and United States.

quench: a pollution control device in an incinerator which sprays water into the exhaust gases shortly after they leave the furnace chamber. The object is to quickly reduce the gases' temperature to less than 200°C, the minimum temperature for dioxin formation.

releases: all byproducts from a process (e.g. incineration) including emissions (to air), effluent (to water bodies) and solids (to land).

slag: a fused, solid byproduct of pyrolysis or incineration.

Southern: as used in this report, Southern refers to most of the countries of Africa, Asia, Latin America and island nations; also referred to as Third World, developing, or less-industrialized countries. It is not a strictly geographic term. Cf. Northern.

Stockholm Convention: The Stockholm Convention on Persistent Organic Pollutants. An international treaty which bans or regulates production and emissions of a class of synthetic chemicals.

TDI (tolerable daily intake): the maximum amount of a chemical which can theoretically be safely ingested. WHO and various governments set TDIs for some chemicals of concern.

TEF (toxic equivalency factor): a value that is empirically assigned to each congener (type) of dioxins and furans to represent their toxic potency relative to 2,3,7,8-TCDD (which has a TEF of 1).

TEQ (toxic equivalency): a calculated figure used to estimate the overall toxicity of multiple congeners (types) of dioxin-like chemicals at once. There are two primary TEQ systems, I-TEQ (International) and WHO, which yield slightly different results. The TEQ for a given sample is calculated by multiplying the quantity (mass) of each congener in the sample by that congener's TEF, then adding the results together.

t**ipping fee:** the fee charged, usually by weight, for the privilege of depositing waste in a landfill or at an incinerator.

TNCs (transnational corporations): companies with operations in multiple countries. Also MNCs.

UN: the United Nations.

UNDP (United Nations Development Program): an agency of the United Nations whose primary mission is to reduce poverty worldwide.

UNEP (United Nations Environment Programme): an agency of the United Nations whose mission is to encourage sustainable development through sound environmental practices everywhere.

UNIDO (United Nations Industrial Development Organization): an agency of the United Nations dedicated to helping Southern countries' industrial bases develop.

USEPA (United States Environmental Protection Agency): an agency of the United States government.

vitrification: a rarely-used process of melting ash and allowing it to cool into glass-like balls. The intention is to destroy some organic compounds and make pollutants in the ash less available to the environment.

waste-to-energy (WTE): see energy-from-waste.

WHO (World Health Organization): an agency of the United Nations working to improve human health.

Zero Waste: a philosophy and a design principle that includes recycling but goes further by taking a "whole system" approach to the entire flow of resources and waste through human society. Zero Waste maximizes recycling, minimizes waste and ensures that products are made to be reused, repaired or recycled back into nature or the marketplace.

APPENDIX A: Air Emissions from Incineration

From Municipal Waste Incinerators[221]

pentane
trichlorofluoromethane
acetonitrile
acetone
iodomethane
dichloromethane
2-methyl-2-propanol
2-methylpentane
chloroform
ethyl acetate
2,2-dimethyl-3-pentanol
cyclohexane
benzene
2-methylhexane
3-methylhexane
1,3-dimethylcyclopentane
1,2-dimethylcyclopentane
trichloroethene
heptane
methylcyclohexane
ethylcyclopentane
2-hexanone
toluene
1,2-dimethylcyclohexane
2-methylpropyl acetate
3-methyleneheptane
paraldehyde
octane
tetrachloroethylene
butanoic acid ethyl ester
butyl acetate
ethylcyclohexane
2-methyloctane
dimethyldioxane
2-furanecarboxaldehyde
chlorobenzene
methyl hexanol
trimethylcyclohexane
ethyl
benzene
formic acid
xylene
acetic acid
aliphatic carbonyl
ethylmethylcyclohexane
2-heptanone
2-butoxyethanol
nonane
isopropyl benzene
propylcyclohexane
dimethyloctane
pentanecarboxylic acid
propyl benzene
benzaldehyde
5-methyl-2-furane carboxaldehyde
1-ethyl-2-methylbenzene
1,3,5-trimethylbenzene
trimethylbenzene
benzonitrile
methylpropylcyclohexane
2-chlorophenol
1,2,4-trimethylbenzene
phenol
1,3-dichlorobenzene
1,4-dichlorobenzene
decane
hexanecarboxylic acid
1-ethyl-4-methylbenzene
2-methylisopropylbenzene
benzyl alcohol
trimethylbenzene
1-methyl-3-propylbenzene
2-ethyl-1,4-dimethylbenzene
2-methylbenzaldehyde
1-methyl-2-propylbenzene
methyl decane
4-methylbenzaldehyde
1-ethyl-3,5-dimethylbenzene
1-methyl-(1-pro-penyl)benzene
bromochlorobenzene
4-methylphenol
benzoic acid methyl ester
2-chloro-6-methylphenol
ethyldimethylbenzene
undecane
heptanecarboxylic acid
1-(chloromethyl)-4-methylbenzene
1,3-diethylbenzene
1,2,3-trichlorobenzene
4-methylbenzyl
alcohol
ethylhex anoic acid
ethyl benzaldehyde
2,4-dichlorophenol
1,2,4-trichlorobenzene
naphthalene
cyclopentasiloxanedecamethyl
methyl acetophenone
ethanol-1-(2-butoxyethoxy)
4-chlorophenol
benzothiazole
benzoic acid
octanoic acid
2-bromo-4-chlorophenol
1,2,5-trichlorobenzene
dodecane
bromochlorophenol
2,4-dichloro-6-methylphenol
dichloromethylphenol
hydroxybenzonitrile
tetrachlorobenzene
methylbenzoic acid
trichlorophenol
2-(hydroxymethyl) benzoic acid
2-ethylnaphthalene-1,2,3,4-tetrahydro
2,4,6-trichlorophenol
4-ethylacetophenone
2,3,5-trichlorophenol
4-chlorobenzoic acid
2,3,4-trichlorophenol
1,2,3,5-tetrachlorobenzene
1,1'biphenyl (2-ethenyl-naphthalene)
3,4,5-trichlorophenol
chlorobenzoic acid
2-hydroxy-3,5-dichlorobenzaldehyde
2-methylbiphenyl
2-nitrostyrene(2-nitroethenylbenzene)
decanecarboxylic acid
hydroxymethoxybenzaldehyde
hydroxychloroacetophenone
ethylbenzoic acid
2,6-dichloro-4-nitrophenol
sulphonic acid
m.w. 192
4-bromo-2,5-dichlorophenol
2-ethylbiphenyl
bromodichlorophenol
1(3H)-isobenzofuranone-5-methyl
dimethylphthalate
2,6-di-tertiary-butyl-p-benzoquinone
3,4,6-trichloro-1-methyl-phenol
2-tertiary-butyl-4-methoxyphenol
2,2'-dimethylbiphenyl
2,3'-dimethylbiphenyl
pentachlorobenzene
bibenzyl
2,4'-dimethylbiphenyl
1-methyl-2-phenylmethylbenzene
benzoic acid phenyl ester
2,3,4,6-tetrachlorophenol
tetrachlorobenzofurane
fluorene
phthalic ester
dodecanecarboxylic acid
3,3'-dimethylbiphenyl
3,4'-dimethylbiphenyl
hexadecane
benzophenone
tridecanoic acid
hexachlorobenzene
heptadecane

fluorenone
dibenzothiophene
pentachlorophenol
sulphonic acid m.w. 224
phenanthrene
tetradecanecarboxylic acid
octadecane
phthelic ester
tetradecanoic acid isopropyl ester
caffeine
12-methyltetradecacarboxylic acid
pentadecacarboxylic acid
methylphenanthrene
nonedecane
9-hexadecene carboxylic acid
anthraquinone
dibutylphthalate
hexadecanoic acid
eicosane
methylhexadecanoic acid
fluoroanthene
pentachlorobiphenyl
heptadecanecarboxylic acid
octadecadienal
pentachlorobiphenyl
aliphatic amide
octadecanecarboxylic acid
hexadecane amide
docosane
hexachlorobiphenyl
benzylbutylphthalate
aliphatic amide
diisooctylphthalate
hexadecanoic acid hexadecyl ester
cholesterol

From Hazardous Waste Incinerators[222]

acetone
acetonitrile
acetophenone
benzaldehyde
benzene
benzenedicarboxaldehyde
benzofuran
benzoic acid
bis(2-ethylhexyl)phthalate
1-bromodecane
bromofluorobenzene
bromoform
bromomethane
butylbenzylphthalate
C8H18
carbon tetrachloride
chlorobenzene
1-chlorobutane
chlorocyclohexanol
1-chlorodecane
chlorodibromomethane
2-chloroethyl vinyl ether
chloroform
1-chlorohexane
chloromethane
1-chlorononane
1-chloropentane
cyclohexane
cyclohexanol
cyclohexene
1-decene
dibutylphthalate
dichloroacetylene
dichlorobromomethane
1,2-dichlorobenzene
1,4-dichlorobenzene
1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethylene
dichlorodifluoromethane
dichloromethane
2,4-dichlorophenol
diethylphthalate
dimethyl ether
3,7-dimethyloctanol
dioctyl adipate
ethenylethylbenzene
ethylbenzaldehyde
ethylbenzene
ethylbenzoic acid
ethylphenol
(ethylphenyl) ethanone
ethynylbenzene
formaldehyde
heptane
hexachlorobenzene
hexachlorobutadiene
hexanal
1-hexene
methane
methylcyclohexane
methyl ethyl ketone
2-methyl hexane
3-methyleneheptane
3-methylhexane
5,7-methylundecane
naphthalene
nonane
nonanol
4-octene
pentachlorophenol
phenol
polychlorinated biphenyls (PCBs)
polychlorinated dibenzo-p-dioxins (dioxins)
polychlorinated dibenzofurans (furans)
pentanal
phenol
phenylacetylene
phenylbutenone
1,1'-(1,4-phenylene)bisethanone
bisethanone
phenylpropenol
propenylmethylbenzene
1,1,2,2-tetrachloroethane
tetrachloroethylene
tetradecane
tetramethyloxirane
toluene
1,2,4-trichlorobenzene
1,1,1-trichloroethane
1,1,2-trichloroethane
trichloroethylene
trichlorofluoromethane
trichlorotrifluoroethane
2,3,6-trimethyldecane
trimethylhexane
2,3,5-trichlorophenol
vinyl chloride

APPENDIX B:
Incinerator Bans and Moratoria

INTERNATIONAL:
1996: the Protocol to the London Convention banned incineration at sea globally.
1996: the Bamako Convention banned incineration at sea, on territorial or internal waters in Africa.
1992: the OSPAR Convention banned incineration at sea in the north-east Atlantic.

ARGENTINA:
2003: the city Council of Granadero Baigorria, Santa Fe province, outlawed medical waste incineration.
2002: the Buenos Aires City Council passed a law that bans incineration of medical waste. This includes medical waste generated in the city and sent outside for treatment.
2002: the City Council of Villa Constitución, Santa Fé province, banned the construction of incinerators.
2002: the City Council of Coronel Bogado, Santa Fé province, banned the construction of incinerators.
2002: the City Council of Marcos Juarez, Córdoba province, outlawed the construction of incinerators.
2002: the Municipal Council of Casilda, Santa Fe province, banned hazardous waste incineration for 180 days. The resolution was extended for another 180 days in November 2002.
2002: the City Council of Capitán Bermúdez outlawed all type of waste incineration.
2001: the province of San Juan banned crematoria in urban and semi-urban areas.

BRAZIL:
1995: the Municipality of Diadema, State of Sao Paulo, approved a law banning incinerators for municipal waste. The city council states that the waste problem should be tackled using reduce, reuse, and recycling policies.

CANADA:
2001: the Province of Ontario enacted a hazardous waste plan that includes the phaseout of all hospital medical waste incinerators.

CHILE:
1976: Resolución 07077 banned incineration in several metropolitan areas of the country.

CZECH REPUBLIC:
1997: Cepi, district Pardubice banned construction of new waste incinerators.

GERMANY:
1995: the largest, most populated and most industrialized state in Germany — North Rhine/Westfalia — bans municipal solid waste incinerators.

GREECE:
1994: the national government approved legislation declaring it illegal to burn hazardous waste in waste-to-energy plants. In 2001, the Minister for the Environment formally declared a policy of prohibiting municipal waste incineration.

INDIA:
1998: the central government banned incineration of chlorinated plastics nationally. The city of Hyderabad in the state of Andhra Pradesh banned on-site hospital waste incineration.

IRELAND:
1999: although no formal ban is in place, Ireland closed all of its medical waste incinerators.

JAPAN:
1998: the Ministry of Health and Welfare revised the laws to allow disposal of PCBs using chemical methods. Although there is no formal ban on incineration of PCBs, there is an informal proscription on PCB incineration.

MALTA:
2001: all public and private hospitals were to eliminate clinical waste incineration by 2001.

PHILIPPINES:
1999: the Clean Air Act was passed which bans all types of waste incineration. The law extends to municipal, medical and hazardous industrial wastes.

SLOVAKIA:
2001: banned waste importation for incineration.

SPAIN:
1995: the regional government of Aragón established autoclaving as the required form of treatment for medical waste, effectively eliminating medical waste incineration.

UNITED STATES:
STATES
Delaware, 2000: state prohibited new solid waste incinerators within three miles of a residential property, church, school, park, or hospital.

Iowa, 1993: state enacted a moratorium on commercial medical waste incinerators. Moratorium still in place. Moratorium does not extend to incinerators operated by a hospital or consortium of hospitals.

Louisiana, 2000: state revised its statute Title 33, which prohibits municipalities of more than 500,000 from owning, operating or contracting garbage incinerators in areas zoned for residential or commercial use.

Maryland, 1997: state prohibited construction of municipal waste incinerators within one mile of an elementary or secondary school.

Massachusetts, 1991: state enacted a moratorium on new construction or expansion of solid waste incinerators. Moratorium still in place.

Rhode Island, 1992: state banned the construction of new municipal solid waste incinerators. First U.S. state to enact such a ban.

West Virginia, 1994: state banned the construction of new municipal and commercial waste incinerators. Permits pilot tire incineration projects.

COUNTIES

Alameda County, California, 1990: voter initiative "Waste Reduction and Recycling Act" passed, banning waste incinerators in the county. A later court ruling limits the ban to the unincorporated areas of the county, however, there are no operating municipal waste incinerators in Alameda county.

Anne Arundel County, Maryland, 2001: county banned solid waste and medical waste incinerators.

CITIES

Brisbane, California, 1988: city banned new construction of waste incinerators.

Chicago, Illinois, 2000: city banned municipal waste incineration. The ban extends to burning waste in schools and apartment buildings.

San Diego, California, 1987: ordinance stipulates that waste incinerators cannot be sited within a certain radius of schools and daycare centers, which results in no eligible land being available for incinerators.

Ellenburg, New York, 1990: town banned waste incinerators.

New York City, 1989: Banned all apartment house incinerators by 1993. By 1993, all 2,200 apartment house incinerators that were in operation in 1989 were shut down.

MORATORIA:

Several states in the United States, including Arkansas, Wisconsin and Mississippi, have enacted moratoria on medical or municipal waste incinerators that have since expired or been lifted. The US EPA enacted a nationwide, 18-month freeze on new construction of hazardous waste incinerators in 1993. Two unsuccessful bills were introduced in the US Congress during the 1990s to enact a moratorium on new waste incinerators.

Other examples of incinerator moratoria worldwide include:

1982: Berkeley, California passes a ballot initiative banning garbage burning plants for five years. The moratorium allowed the city to develop recycling programs which became national models.

1985: Sweden implemented a 2-year moratorium on new incinerators.

1990: In the Flemish-speaking part of Belgium, public pressure resulted in a 5-year moratorium on new municipal waste incinerators.

1992: Ontario, Canada banned new municipal incinerators. In 1996 a new conservative government overturned the ban.

1992: Baltimore, Maryland passed 5-year moratorium on new municipal incinerators.

REFERENCES

Alcock et al., "An Updated PCDD/F Atmospheric Emission Inventory Based on Recent Emissions Measurement Programme," Organohalogen Compounds, vol. 36, pp.105-108, 1998.

Allen, J.R., Barsotti, D.A., Lambrecht, L.K., et al., "Reproductive Effects of Halogenated Aromatic Hydrocarbons on Non-Human Primates," Annals of the New York Academy of Sciences, vol. 320, pp. 419-425, 1979.

Altwicker, E.R., Konduri, R.K.N.V., Lin, C., and Milligan, M.S., "Rapid Formation of Polychlorinated Dioxins/Furans in the Post Combustion Region During Heterogeneous Combustion," Chemosphere, vol. 25, no. 12, pp. 1935-1944, 1992.

Asahi Shimbun, "Hundreds of Dirty Incinerators at End of Road," May 29, 2002.

Associated Press (AP), "Japan Is the Land of Rising Garbage Heaps," December 9, 2000b.

AP, "Philippines Residents at Collapsed Garbage Dump File Class-Action Suit," August 2, 2000a.

Aytekin, Favzi, Circular issued by the Turkish Minister for the Environment, translated by Banu Dokmecibasi, 22 September 1999.

Babone, F., Bovenzi, M., Cavallieri, F., and Stanta, G., "Air Pollution and Lung Cancer in Trieste, Italy," American Journal of Epidemiology, 141: 1161-1169, 1994.

Bailey, Jeff, "Up in Smoke: Fading Garbage Crisis Leaves Incinerators Competing for Trash," Wall Street Journal, Page A1, August 11, 1993.

Biggeri. A., Barbone, F., Lagazio, C., Bovenzi, M., and Stanta, G., "Air Pollution and Lung Cancer in Trieste, Italy: Spatial Analysis of Risk as a Function of Distance from Sources," Environmental Health Perspectives, vol. 104, no. 7, pp. 750-754, 1996.

Biocycle magazine, "The State of Garbage" annual survey, 1996.

Biocycle magazine, "The State of Garbage" annual survey, 1997.

Biocycle magazine, "The State of Garbage" annual survey, 2000.

Birnbaum, Linda, "Re-evaluation of Dioxin," Presentation to the 102nd Meeting of the Great Lakes Water Quality Board, Chicago, Illinois, July 15, 1993, cited in ToxCat vol. 2 no. 8.

Blumenstock, M., Zimmermann, R., Schramm, K.-W., Kettrup, A., "Influence of Combustion Conditions on the PCDD/F-, PCB-, PCBz- and PAH- Concentrations in the Post-Combustion Chamber of a Waste Incineration Pilot Plant," Chemosphere, vol. 40, pp. 987-993, 2000.

Bond Buyer, "NJ Bill Approval May Mean $1.1B Transportation Refunding," p. 43, November 28, 2001.

Center for Voting and Democracy, "Voting Turnout," see www.fairvote.org/turnout.

Centers for Disease Control and Prevention, "Blood and Hair Mercury Levels in Young Children and Women of Childbearing Age — United States, 1999," Morbidity and Mortality Weekly Report, vol. 50, no. 8, pp. 140-3, March 2, 2001.

Centre National d'Information Indépendante sur les Déchets (CNIID), "Le Ministère de la Santé A Manipulé les Chiffres de Contamination des Français par les Dioxines," press release, October 24, 2000. Available at www.cniid.org.

Chang, D., Richards, M., and Huffman, G., "Studies of POHC DE During Simulated Atomization Failure in a Turbulent Flame Reactor," in Land Disposal, Remedial Action, Incineration and Treatment of Hazardous Waste, Proceedings of the Fourteenth Annual Research Symposium, U.S. EPA Hazardous Waste Engineering Laboratory, Cincinnati, EPA 600/9-88/021, p. 302, July 1988.

Chang, M., and Lin, J., "Memory Effect on the Dioxin Emissions from Municipal Waste Incinerator in Taiwan," Chemosphere, vol. 45, pp. 1151-1157, 2001.

Chicago Tribune, "Foster Wheeler Woes July 30, 1998.

Cointreau-Levine, Sandra, "Sanitary Landfill Design and Siting Criteria," Infrastructure Notes, Urban No. UE-12, World Bank, March 1996.

Commission for Racial Justice, Toxic Wastes and Race in the United States, New York: United Church of Christ, 1987.

Connett, Paul, and Sheehan, Bill, A Citizen's Agenda for Zero Waste, G&G Video and Grassroots Recycling Network, October 2001.

Connett, Paul, "Medical Waste Incineration: A Mismatch Between Problem and Solution The Ecologist Asia, vol. 5, no. 2, March/April 1997.

Consumat Environmental Systems, 1998 10-K report filed with the U.S. Securities and Exchange Commission, 1998.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972.

Cook, R., "Incineration: Technology Versus Science?" Proceedings of the Third Annual National Symposium on the Incineration of Industrial Wastes, San Diego, CA, March 1989.

Costner, Pat, et al., Technical Criteria for the Destruction of Stockpiled Persistent Organic Pollutants, Greenpeace International Science Unit, October 1998.

Crowe, Elizabeth, and Schade, Mike, Learning Not to Burn: a Primer for Citizens on Alternatives to Burning Hazardous Waste, June 2002.

Davies, Terry, and Lowe, Adam, Environmental Implications of the Health Care Service Sector," Resources for the Future, 1999.

De Fre, R. and Wevers, M., "Underestimation of Dioxin Inventories," Organohalogen Compounds, vol. 36, pp. 17-20, 1998.

Dellinger, B., Taylor, P., Tiery, D., Pan J., and Lee, C.C., "Pathways of PIC Formation in Hazardous Waste Incinerators," in Land Disposal, Remedial Action, Incineration and Treatment of Hazardous Waste, Proceedings of the Fourteenth Annual Research Symposium, U.S. EPA Hazardous Waste Engineering Laboratory, Cincinnati, EPA 600/9-88/021, July 1988.

Denison, Richard, and Ruston, John, eds., "Recycling and Incineration: Evaluating the Choices," Environmental Defense Fund, Washington, D.C.: Island Press, 1990.

Denison, Richard, "Environmental Life-Cycle Comparisons of Recycling, Landfilling, and Incineration: A Review of Recent Studies Annual Review of Energy and the Environment, vol. 21, pp. 191–237, 1996.

Dente, B., Fareri, P., and Ligteringen, J., eds., The Waste and the Backyard: The Creation of Waste Facilities: Success Stories in Six European Countries, Boston: Kluwer Academic Publishers, 1998.

DeRosa, David, Out of Fashion: Moving Beyond Toxic Cleaners for the Fabric Care Industry, Greenpeace USA, 2001. Available at: http://www.greenpeaceusa.org/toxics.

Deutsche Presse-Agentur, "Schroeder Hit by Arrest of Top Ex-SPD Officials in Scandal," June 13, 2002.

DeVito, M.J., Birnbaum, L.S. et al., "Comparisons of Estimated Human Body Burdens of Dioxinlike Chemical and TCDD Body Burdens in Experimentally Exposed Animals Environmental Health Perspectives, vol. 103, no. 9, pp. 820-831, Sept. 1995.

Diggle, P.J., "A Point Process Modelling Approach to Raised Incidence of a Rare Phenomenon in the Vicinity of a Prespecified Point," Journal of the Royal Statistical Society, Series A, vol. 153, pp. 349-362, 1990.

Doucet, Lawrence, "EPA's Final Hospital/Medical/Infectious Waste Incinerator Regulations: Requirements, Compliance Decisions, and Related Environmental Issues," Doucet & Mainka, P.C., undated.

Dutta, Manoj, ed., Delhi: Waste Disposal in Engineered Landfills, Solid Waste Disposal and Recycling in Delhi, a Case Study, New Delhi: Narosa Publishing House, 1997.

Eberg, Jan, Waste Policy and Learning: Policy Dynamics of Waste Management and Waste Incineration in the Netherlands and Bavaria, Delft, The Netherlands: Uitgeverij Eburon, 1997.

ECOTEC Research and Consulting Limited, Beyond the Bin: The Economics of Waste Management Options, Friends of the Earth and UK Waste and Waste Watch, 2000.

Egeland, G.M., Sweney, M.H., Fingerhut, M.A., et al., "Total Serum Testosterone and Gonadotropins in Workers Exposed to Dioxin," American Journal of Epidemiology, vol. 139, no. 3, pp. 272-281, 1994.

Eitzer, B., and Hites, R., "Airborne Dioxins and Furans: Sources and Fates," Environmental Science and Technology, vol. 20, p. 1185, 1986.

Elliot, P., Eaton, N., Shaddick, G., and Carter, R., "Cancer Incidence Near Municipal Solid Waste Incinerators In Great Britain. Part 2: Histopathological and Case-Note Review of Primary Liver Cancer Cases," British Journal of Cancer, vol. 82, no. 5, pp. 1103-1106, 2000.

Elliot, P., Hills, M., Beresford, J., Kleinschmidt, I., Jolley, D., Pattenden, S., Rodrigues, L., Westlake, A., and Rose, G., "Incidence of Cancers of the Larynx and Lung Near Incinerators of Waste Solvents and Oils in Great Britain," The Lancet, vol. 339, pp. 854-858, April 4, 1992.

Elliot, P., Shaddick, G., Kleinschmidt, I., Jolley, D., Walls, P., Beresford, J., and Grundy, C., "Cancer Incidence Near Municipal Solid Waste Incinerators in Great Britain," British Journal of Cancer, vol. 73, pp. 702-710, 1996.

Elston, Suzanne, "Zero Waste Turns Garbage Into Savings," Environmental News Network, January 2, 2000.

Endo, Kazunobu, informative web page on the waste situation of Utsunomiya, Japan, http://plaza22.mbn.or.jp/~gomigenryo/report/rp000530-1.html, accessed May 2002.

Environment and Development, edition 7, vol. 2, July/August 1997.

Environment Support Group, Towards Evolving a Sustainable Community Level Solid Waste Management Strategy by Way of Building the Capacities of Solid Waste Workers (Pourakarmikas) of the Bangalore Municipal Corporation, 1999.

Environmental Protection Agency of Ireland, Ireland: National Waste Database, Report 1998, March 2000.

Environmental Working Group and Health Care Without Harm, First, Do No Harm, March 1997.

Erickson, J.D., Mulinare, J., McClain, P.W., et al., "Vietnam Veterans' Risks For Fathering Babies With Birth Defects," JAMA, vol. 252, pp. 903-912, 1984.

Erikkson, M., Hardell, L., Berg, N.O., et al., "Soft-Tissue Sarcomas and Exposure to Chemical Substances: A Case-Referent Study," British Journal of Industrial Medicine, vol. 38, pp. 27-33, 1981.

European Commission, European Dioxin Inventory, vol. 1, p. 32, October 1999. Available at: http://europa.eu.int/comm/environment/dioxin.

Falandysz, J., and Rappe, C., "Specific Pattern of Tetrachloronapthalenes in Black Cormorant," Chemosphere, vol. 35, pp. 1737-1746, 1997.

Fangmark, I., Stromberg, B., Berge, N., and Rappe, C., "Influence of Small Fly Ash Particles on the Post-Combustion Formation of PCDDs, PCDFs, PCBzs, and CPs in a Pilot Incinerator," Chemosphere, vol. 29, pp. 1903-1909, 1994.

Fingerhut, M.A., Halperin, W.E., Marlow, D.A., et al., "Cancer Mortality In Workers Exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin," New England Journal of Medicine, vol. 324, pp. 212-218, 1991.

Fishbein, Bette K, "EPR: What Does It Mean? Where Is It Headed?" Pollution Prevention Review, vol. 8, pp. 43-55, 1998.

French Ministry of the Environment, Comite de Prevention et de Precaution, Recommandation Dioxines, April 3, 1998.

Friend, Gil, “Industrial Ecology in Motion,” New Bottom Line, vol. 4.21, October 24, 1995.
Ganla, Nirmala, et al., “Sujala Biosanitizer — an Effective Alternative Medical Waste Disposal Technique,” presented at AMOGS conference, Pune, India, February 2001.
Geiselman, Bruce, “Special Reports: Waste-to-Energy’s Future Dims,” Waste News, May 3, 1999.
Georgieva, Kristalina, and Varma, Keshav, “Foreword,” in Rand, T., Haukohl, J., and Marxen, U., Municipal Solid Waste Incineration: Requirements for a Successful Project, World Bank Technical Paper No. 462, 2000.
Ghosh, A.K., “Comparative Statement of Technological Evaluation of Waste Autoclave and Waste Microwave,” West Bengal Health Systems Development Project, Department of Health & Family Welfare, Government of West Bengal, India, 2002.
Giugliano, M., Cernuschi, S., Grosso, M., Miglio, R., Aloigi, E., “PCDD/F Mass Balance in the Flue Gas Cleaning Units of a MSW Incineration Plant,” Chemosphere, vol. 46, pp. 1321-1328, 2002.
Glenn, Jim, “The State of Garbage in America,” BioCycle, April 1999.
Gobierno de la Ciudad de Buenos Aires (Dirección General de Higiene Urbana),”Estudio de Calidad de los Residuos Sólidos Urbanos de la Ciudad de Buenos Aires,” 2001.
Gore, Al, Earth in the Balance, New York: Houghton Mifflin, pp. 156-7, 1992.
Greenpeace Japan, The Construction Cost of Municipal Waste Incinerators and Counter Measures Against Dioxin: The Entire Picture of Domestic Expenditure and Its Trend, May 2001.
Greenpeace U.K., “Greenpeace Volunteers Acquitted Over Shutting Britain’s Biggest Waste Incinerator,” press release, 13 October 2001b, available at: http://www.greenpeace.org.uk/ntentlookup.cfm?ucidparam=20010613145457&CFID=104791&CFTOKEN=23681125&MenuPoint=D-D.
Greenpeace U.K., Criminal Damage: A Review of the Performance of Municipal Waste Incinerators in the UK, 2001a.
Greenpeace, “Greenpeace Blocks Import of Waste for Incineration,” press release, November 28, 2000.
Greenpeace, Warning: Incineration Can Seriously Damage Your Health; A Report on the Hazardous Waste Incineration Crisis, 1991.
Guardian, “Children at Risk From Poisoned Ash on Paths,” May 8, 2000.
Hardell, L., and Sandstrom, A., “Case-Control Study: Soft-Tissue Sarcomas and Exposure to Phenoxyacetic Acids or Chlorophenols,” British Journal of Cancer, vol. 39, pp. 711-717, 1979.
Hardell, L., Erikkson, M., Lenner, P., et al., “Malignant Lymphoma and Exposure to Chemicals, Especially Organic Solvents, Chlorophenols, and Phenoxy Acids: A Case-Control Study,” British Journal of Cancer, vol. 43, pp. 169-176, 1981.
Hardell, L., Johansson, B., Axelson, O., “Epidemiological Study of Nasal and Nasopharyngeal Cancer and Their Relation to Phenoxy Acid or Chlorophenol Exposure,” American Journal of Industrial Medicine, vol. 3, pp. 247-257, 1982.
Harris, Jeff, and Muir, Tom, “A Technical and Socio-Economic Comparison of Options to Products Dervied from the Chlor-Alkali Industry,” Organohalogen Compounds, vol. 38, pp.331-336, 1998.
Hazardous Waste News, “Company Says It Is Out of Incinerator Business,” June 17, 1991.
Health Care Without Harm, Non-Incineration Medical Waste Treatment Technologies: A Resource for Hospital Administrators, Facility Managers, Health Care Professionals, Environmental Advocates, and Community Members, 2001.
Heeb et al., “Distribution of Halogenated Phenols Including Mixed Brominated and Chlorinated Phenols in Municipal Waste Incineration Flue Gas,” Chemosphere, vol. 31, no. 4, pp. 3033-3041, 1995.
Hegberg, Bruce A., Hallenbeck, William H., Brenniman, Gary R., “Municipal Solid Waste Incineration With Energy Recovery: Technologies, Facilities, and Vendors for Less Than 550 Tons Per Day,” University of Illinois Center for Solid Waste Management and Research, Office of Technology Transfer, School of Public Health, 1990.
Hencke, David, “Britain Steps Out of Line on Incinerators,” Guardian, Friday, May 19, 2000. Available at: http://www.guardian.co.uk/Archive/Article/0,4273,4019735,00.html.
Hering and Greeley, Collection and Disposal of Municipal Refuse, New York: McGraw-Hill, 1931.
Hershkowitz, Allen, and Salerni, Eugene, Garbage Management in Japan: Leading the Way, New York, New York: INFORM, 1987.
Hershkowitz, Allen, Garbage Burning: Lessons from Europe: Consensus and Controversy in Four European States, New York, N.Y.: INFORM, 1986.
Hirschorn, J., and Oldenburg, K., Prosperity Without Pollution: The Prevention Strategy for Industry and Consumers, New York: J. Wiley & Sons, 1990.
Hogg, Dominic, “Costs for Municipal Waste Management in the EU: Final Report to Directorate General Environment, European Commission,” Eunomia Research & Consulting, April 2002.
Hong Kong Environmental Protection Department, “Estimated Composition of Municipal Solid Waste Disposed of at Waste Facilities,” (available at www.info.gov.hk/epd/english/environmentinhk/waste/data/monit_sw2000_ch2_t5.html), 2000.
House, R.V., Lauer, R.D., Murray, M.J., et.al., “Examination of Immune Parameters and Host Resistance Mechanisms in B6C3F1 Mice Following Adult Exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin,” Journal of Toxicology and Environmental Health, vol. 31, pp. 203-215, 1990.
Howard, C.V., “Particulate Aerosols, Incinerators and Health,” in P. Nicolopoulou-Stamini, ed., Health Impacts of Waste Management Policies, Proceedings of the Seminar “Health Impacts of Waste Management Policies,” (Hippocrates Foundation, Kos, Greece, 12-14 Nov 1998), Kluwer Academic Publishers, 2000.

Huang, H., and Beukens, A., “On the Mechanisms of Dioxin Formation in Combustion Processes,” Chemosphere, vol. 31, pp. 4099-4117, 1995.
Huff, J., “Dioxins and Mammalian Carcinogenesis, “ in Schecter, A., ed., Dioxins and Health, New York: Plenum Press, 1994.
Hunsinger, H., Kreisz, S., Seifert, H., “Behavior of Chlorinated Aromatic Compounds in the High-Temperature Range of Waste Incineration Plants,” Organohalogen Compounds, vol. 31, pp. 382-387, 1997.
Independent, “County Recycling Rate Is Best in Nation: Report,” March 7, 2001.
Institute for Local Self-Reliance (ILSR), “Product Stewardship in British Columbia,” Facts to Act On Series, no. 39, October 2000a.
ILSR, “The Five Most Dangerous Myths About Recycling,” September 1996.
ILSR, Incineration Critique and Scenario for Recycling and Economic Development in Bangkok, Thailand, for Greenpeace Southeast Asia, February 2001.
ILSR, “Job Creation: Reuse and Recycling versus Disposal” (Chart), Washington, DC, 1997. www.ilsr.org/recycling
ILSR, Manila: Wasting and Recycling in Metropolitan Manila, Philippines, October 2000b.
International Centre for Integrated Mountain Development, et al., Nepal: State of the Environment, 2001, 2001.
International Joint Commission, “A Policy Statement on Incineration of Municipal Waste,” Ontario, Canada, 1996.
International Maritime Organization, A Brief Description of the London Convention 1972 and the 1996 Protocol, 2001.
Iskandar Kamel, Laila, Cairo: A City That Learns from the Mokattam Recyclers, Community and Institutional Development (C.I.D.), The Social Research Center, The American University in Cairo, Egypt, March 1999.
Jackson, Herb, “Trash-Facility Aid Bill Likely to Die in Assembly,” The Record, p. A3, Nov. 27, 2001.
Jay, K., and Stieglitz, L., “Identification and Quantification of Volatile Organic Components in Emissions of Waste Incineration Plants,” Chemosphere, vol. 30, no. 7, pp. 1249-1260, 1995.
Jochnowitz, Jay, “Bordewich Blasts Sweeney for Inaction on Burn Plant,” The Times Union, p.B7, Oct. 2, 1998.
Kang, H.K., Weatherbee, L., Breslin, P.P., et.al., “Soft Tissue Sarcomas and Military Service in Vietnam: A Case Comparison Group Analysis of Hospital Patients,” Journal of Occupational Medicine, vol. 28, pp. 1215-1218, 1986.
Kashima et al., “Characteristics of Extractable Organic Halogens in Ash Samples from Medical Solid Waste Incinerator,” Organohalogen Compounds, vol. 41, pp. 191-194, 1999.
Kawano, M., Ueda, M., Matsui, M., Kashima, Y., Matsuda, M., and Wakimoto, T., “Extractable Organic Halogens (EOX: Cl, Br and I), Polychlorinated Naphthalenes and Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ashes from Incinerators Located in Japan,” Organohalogen Compounds, vol. 36, pp. 221-224, 1998.
Kiser, John, and Zannes, Maria, IWSA Directory of Waste-To-Energy Plants, Year 2000, Washington, DC: Integrated Waste Services Association, 2000.
Knox, E.G., and Gilman, E.A., “Migration Patterns of Children With Cancer in Britain,” Journal of Epidemiological Community Health, vol. 52, pp. 716-726, 1998.
Knox, E.G., “Childhood Cancers, Birthplaces, Incinerators and Landfill Sites,” International Journal of Epidemiology, vol. 29, pp. 391-397, 2000.
Kociba, R.J., Keeler, A., Park, G.N., et al., “2,3,7,8-tetrachlorodibenzo-p-dioxin: Results of a 13-Week Oral Toxicity Study in Rats,” Toxicology and Applied Pharmacology, vol. 35, pp. 553-574, 1976.
Laliotis, Kostas (Greek Minister of the Environment), statement to Parliament, parliamentary registry no. 10457B, March 5, 2001.
Ledgerwood, Sean, “Hitting 65 percent Diversion With Recycling, Composting,” Biocycle, vol. 40, no. 3, March 1999.
Lee, G. F., and Jones-Lee, A., “Dry Tomb Landfills,” MSW Management, vol. 6, pp. 82-89, 1996.
Lemieux, P., Lee, C., Ryan, J., Lutes, C., “Bench-scale Studies on the Simultaneous Formation of Pcbs and PCDD/Fs From Combustion Systems,” Waste Management, vol. 21, pp. 419-425, 2001.
Luster, M.I., Boorman, G.A., Dean, J.H., “Examination of Bone Marrow, Immunologic Parameters, and Host Susceptibility Following Pre- and Post-Natal Exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), International Journal of Immunopharmacology, vol. 2, pp.301-310, 1980.
Ma, et al., “Mutagens in Urine Sampled Repetitively from Municipal Waste Incinerator Works and Water Treatment Workers,” Journal of Toxicology and Environmental Health, vol. 37, pp. 483-494, 1992.
Mably, T.A., Moore, R.W., Peterson, R.E., “In Utero and Lactational Exposure of Male Rats to 2,3,7,8-tetrachlorodibenzo-p-dioxin: 1. Effects on Androgenic Status,” Toxicology and Applied Pharmacology, vol. 114, pp. 97-107, 1992.
Maine State Planning Office, “Boothbay Region Refuse Disposal District,” January 2002.
Markandu, ND et al., “The Mercury Sphygmomanometer Should Be Abandoned Before It Is Proscribed,” Journal of Human Hypertension, vol. 14, pp. 31-36, 2000.
McLachlan, M.S., “Digestive Tract Absorption of Polychlorinated Dibenzo-p-dioxins, Dibenzofurans, and Biphenyls in a Nursing Infant,” Toxicology and Applied Pharmacology, vol.123, p. 68, 1993.
McMullen, Cheryl A., “Many States Have Yet to File Emission Plans,” Waste News, February 7, 2000.
McRae, Glenn, “Eleven Recommendations for Improving Health Care Waste Management,” CGH Environmental Strategies, December 1997 (revised May 2000).
Meacher, Michael (U.K. Minister for the Environment), “Waste Incineration,” evidence to the House of Lords Select Committee

on the European Communities, 11th report, HL Paper 71, 15 June 1999.
Menon, Meena, “Scrap Pickers Demand Coverage by Labor Laws,” Inter Press Service, May 18, 2000.
Montague, Peter, “New Evidence That All Landfills Leak,” Rachel’s Environmental and Health News, no. 316, Environmental Research Foundation, Dec. 16, 1992.
Montague, Peter, “The Precautionary Principle,” Rachel’s Environment & Health Weekly, no. 586, Environmental Research Foundation, February 19, 1998.
Morris, Jeffrey, and Canzoneri, Diana, Recycling Versus Incineration: An Energy Conservation Analysis, Sound Resource Management Group (SRMG) Seattle, Washington, September, 1992. (This report has been summarized in the Sound Resource Management’s publication, The Monthly UnEconomist, vol. 2, no. 2-4, February, March and April 2000.)
Motavelli, Jim, “Zero Waste,” E Magazine, March-April 2001.
Mschigeni, Keto, and Pauli, Gunter, “Brewing a Future,” Yes! Magazine, Issue 2, Spring 1997.
Multinational Monitor, “Smoke and Mirrors,” November 1993.
Murray, F.J., Smith, F.A., Nitschke, G.G., et.al., “Three-Generation Reproduction Study of Rats Given 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the Diet,” Toxicology and Applied Pharmacology, vol. 50, pp. 241-252, 1979.
Murray, Robin, Creating Wealth from Waste, London: Demos, pp. 33-34, 1999.
National Academy of Sciences, Toxicological Effects of Methylmercury, 2000.
National Research Council, Waste Incineration and Public Health, Washington D.C.: National Academy Press, 2000.
Nessel, C.S., and Gallo, M.A., “Dioxins and Related Compounds,” in Lippmann, M., ed., Environmental Toxicants, Van Nostrand Reinhold, New York, 1992.
Nito S., and Ishizaki S., “Identification of Azaarenes and Other Basic Compounds in Fly Ash From Municipal Waste Incinerator by Gas Chromatography and Mass Spectrometry,” Chemosphere, vol. 25, no. 8, pp. 1755-1772, 1997.
Nova Scotia Department of the Environment, Nova Scotia: Too Good to Waste: Status Report 2001 of Solid Waste-Resource Management in Nova Scotia, March 2001.
Orlando Sentinel, “Lake Must Dump Incinerator Deal,” March 20, 2002b.
Orlando Sentinel, “Troubles Take Toll on Covanta,” March 15, 2002a.
Patandin, S., Dagnelie, P.C., Mulder, P.G.H., de Coul, E.O., van der Veen, J.E., Weisglas-Kuperus, N., Sauer, P.J.J., “Dietary Exposure to Polychlorinated Biphenyls and Dioxins From Infancy Until Adulthood: A Comparison Between Breast-Feeding, Toddler, and Long-Term Exposure,” Environmental Health Perspectives, vol. 107, p. 45, 1999.
Pereira Neto, J.T., Manual de Compostagem, 1992.
Pirrone, Nicola et al., “Regional Differences in Worldwide Emissions of Mercury to the Atmosphere,” Atmospheric Environment, vol. 30, no. 17, pp. 2981-1987, 1996.
Platt, Brenda, and Seldman, Neil, Wasting and Recycling in the United States 2000, Athens, Georgia: GrassRoots Recycling Network, 2000.
Platt, Brenda, “Aiming for Zero Waste: Ten Steps to Get Started,” ILSR, Washington, DC, 2002.
Pluim, J.J., deVilder, J., Olie, K., et al., “Effects of Pre- and Postnatal Exposure to Chlorinated Dioxins and Furans on Human Neonatal Thyroid Concentrations,” Environmental Health Perspectives, vol. 101, pp. 504-508, 1993.
Pollack, Andrew, “In Japan’s Burnt Trash, Dioxin Threat,” The New York Times, Section 1, p. 10, April 27, 1997.
Pope, C. Arden, et al., “Health Effects of Particulate Air Pollution: Time for Reassessment?” Environmental Health Perspectives, vol. 103, no. 5, pp. 472-480, May 1995.
Powell, J. Stephen, Political Difficulties Facing Waste-to-Energy Conversion Plant Siting, Cerrell Associates for California Waste Management Board, 1984.
Project in Development and the Environment, Comparing Environmental Health Risks in Cairo, vol. 2, 1994.
Puckett, Jim, Basel Action Network, “The Stockholm Convention: Marking the Beginning of an End to Waste Incineration,” GAIA Campaigner, vol. 1, Issue 1, July-September 2001.
Puerto Rico Administration of Environmental Affairs, “Eco Futures Report,” 1994.
Quass, U., and Fermann, M., “Identification of Relevant Industrial Sources of Dioxins and Furans in Europe (The European Dioxin Inventory),” Final Report No. 43, Essen, Germany: Landesumweltamt Nordrhein-Westfalen, 1997.
R. W. Beck Inc., “U.S. Recycling Economic Information Study,” National Recycling Coalition, July 2001.
Rand, T., Haukohl, J., Marxen, U., “Municipal Solid Waste Incineration: Requirements for a Successful Project,” World Bank Technical Paper No. 462, 2000.
Redefining Progress, “Online Quiz Measures Human ‘Footprint’ on Earth’s Resources,” media release, April 10, 2002. Available at: http://www.rprogress.org/media/releases/020410_ef.html.
Rier, S.E., Martin, D.C., Bowman, R.E., et al., “Endometriosis in Rhesus Monkeys (Macaca Mulatta) Following Chronic Exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin,” Fundamental and Applied Toxicology, vol. 21, pp. 433-441, 1993.
Ryder, Ralph, “The Environmental Issues of PVC,” Communities Against Toxics Research Unit, 2000.
Sakai et al., “World Trends in Municipal Solid Waste Management,” Waste Management, vol. 16, Nos. 5/6, pp. 341-350, 1996.
Schantz, S.L., and Bowman, R.E., “Learning in Monkeys Exposed Perinatally to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD),” Neurotoxicology and Teratology, vol. 11, pp.13-19, 1989.
Schmid, J., Elser, A., Strobel, R., Crowe, M., Dangerous Substances in Waste, Copenhagen: European Environment

Agency, 2000.
Seifman, David, “Mike Pushes Incinerators - but Not in His Back Yard,” New York Post, p. 2, March 26, 2002.
Sinkkonen et al., “Tetra- and Pentachlorodibenzothiophenes Are Formed in Waste Combustion,” Chemosphere, vol. 23, no. 5, pp. 583-387, 1991.
Sison, Marites, “Metro Garbage Problem Rooted in Money, Politics,” Philippine Star, February 18, 2002.
Smith, A.H., Fisher, D.O., Giles, H.J., et al., “The New Zealand Soft Tissue Sarcoma Case-Control Study: Interview Findings Concerning Phenoxyacetic Acid Exposure,” Chemosphere, vol. 12, pp. 565-571, 1983.
Sound Resource Management, Competition Between Recycling and Incineration, Seattle, Washington, 1996.
St. Louis City Circuit Court, Overmann v. Syntex, July 12, 1991.
Stanners, D., and Bourdeau P., eds., Europe’s Environment, The Dobris Assessment, Copenhagen: European Environment Agency, 1995.
Sweeney, M.H., Hornung, R.W., Wall, D.K., et.al., “Prevalence of Diabetes and Elevated Serum Glucose Levels in Workers Exposed to 2,3,7,8-tetrachloro-p-dioxin,” Organohalogens, vol.11, pp. 225-226, 1992.
Taiwan Environmental Protection Agency, Yearbook of Environmental Protection Statistics, 2001.
Taylor, P., and Lenoir, D., ”Chloroaromatic Formation in Incineration Processes,” The Science of the Total Environment, vol. 269, pp.1-24, 2001.
Thigpen, J.E., Faith, R.E., McConnell, E.E., and Moore, J.A., ”Increased Susceptibility to Bacterial Infection as a Sequela of Exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin,” Infectious Immunology, vol.12, pp.1319-1324, 1975.
Thorpe, Beverley, Citizen’s Guide to Clean Production, Clean Production Network, August 1999.
Times of India, “Govt Told to Fix Blame for Failure of Garbage Plant,” April 11, 2001.
Trautman, Jerry, Michigan Department of Environmental Quality, Air Quality Division, statement at a public hearing on the Hamtramck medical waste incinerator, October 30, 2001.
Trenholm, A., and Lee, C.C., “Analysis of PIC and Total Mass Emissions from an Incinerator,” in Land Disposal, Remedial Action, Incineration and Treatment of Hazardous Waste, Proceedings of the Twelfth Annual Research Symposium, U.S. Environmental Protection Agency (USEPA), Hazardous Waste Engineering Research Laboratory, Cincinnati OH, EPA 600/ 9-86/022, August 1986.
Trenholm, A., and Thurnau, R., “Total Mass Emissions from a Hazardous Waste Incinerator,” in Land Disposal, Remedial Action, Incineration, and Treatment of Hazardous Waste, Proceedings of the Thirteenth Annual Research Symposium, U.S.EPA Hazardous Waste Engineering Laboratory, Cincinnati, EPA/600/9- 87/015, July 1987.
Tucker, A.N., Vore, S.J., and Luster, M.I., “Suppression of B Cell Differentiation by 2,3,7,8-tetrachlorodibenzo-p-dioxin,” Molecular Pharmacology, vol. 29, pp. 372-377, 1986.
Union Leader, “NH-Vt. Solid Waste District Votes to Pay Wheelabrator $ 1 Million,” p. 5, March 19, 1994b.
Union Leader, “Waste Project Appeals Ruling,” p. 5, February 26, 1994a.
United Kingdom Department of Environment Transport and Regional Affairs Committee, Report HC 39-I, Delivering Sustainable Waste Management, vol. 1, paragraph 93, March 2001.
United Kingdom Parliamentary Select Committee on Environment, Transport and Regional Affairs, “Delivering Sustainable Waste Management, Fifth Report,” 2001. HC 36.1, March 14, 2001. http://www.parliament.the-stationery-office.co.uk/pa/cm200001/cmselect/cmenvtra/36/3602.htm.
United Nations Environment Programme (UNEP), UNEP Governing Council Decision on Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes, adopted by the UNEP Governing Council at Cairo, 17 June 1987.
UNEP Chemicals, Dioxin and Furan Inventories: National and Regional Emissions of PCDD/PCDF, Geneva, Switzerland, May 1999.
United States Agency for Toxic Substances and Disease Registry, Toxic FAQs: Mercury, April 1999.
United States Department of Energy (DOE), “Chapter 8: Public Policy Affecting the Waste-to-Energy Industry,” Renewable Energy Annual 1996, April 1997.
United States DOE, National Energy Technology Laboratory (NETL), A Comparison of Gasification and Incineration of Hazardous Wastes, DCN 99.803931.02, by Radian International LLC, March 30, 2000.
United States DOE, Renewable Energy Annual 2000 (With Data for 1999), March 2001. Available at: http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea_sum.html.
United States Environmental Protection Agency (USEPA) and American Hospital Association, Memorandum of Understanding, July 30, 1998b.
USEPA, “40 CFR Part 60 Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Medical Waste Incinerators; Proposed Rule,” Federal Register, vol. 61, no. 120, pp. 31735 - 31779. June 20, 1996. Available at: http://www.epa.gov/ttn/atw/129/hmiwi/fr62096.pdf.
USEPA, Background Document for the Development of PIC Regulations from Hazardous Waste Incinerators, Draft Final Report, Office of Solid Waste, Washington D.C., October 1989.
USEPA, Characterization of Municipal Solid Waste in the United States, Update, 1997.
USEPA, “Cutting the Waste Stream in Half: Community Record-Setters Show How,” EPA-530-F-99-017, October 1999b.
USEPA, Dioxin: Summary of the Dioxin Reassessment Science, 2000a.

USEPA, Draft dioxin reassessment, EPA/600/AP-92/001f, 1992.
USEPA, Exposure and Human Health Reassessment of 2,3,7,8- Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds, Part I: Estimating Exposure to Dioxin Like Compounds, Volume 2: Sources of Dioxin Like Compounds in the United States, Draft Final Report EPA/600/P-00/001Bb, (http://www.epa.gov/ncea) September 2000c.
USEPA, Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste, EPA530-R-98-013, September 1998a.
USEPA, "Hospital Waste Combustion Study: Data Gathering Phase," EPA-450/3-88-017, Springfield, VA: National Technical Information Service, December 1988.
USEPA, "Medical Waste Incinerators-Background Information for Proposed Standards and Guidelines: Industry Profile Report for New and Existing Facilities," EPA-453/R-94-042a, July 1994. Available at: http://www.epa.gov/ttn/atw/129/hmiwi/indprof.zip.
USEPA, Memo to Commission for Environmental Cooperation: "Final Response to the Commission for Environmental Cooperation Relating to the Compliance Status of Existing Hospital/Medical/Infectious Waste Incinerators and Municipal Waste Combustors With Respect to Dioxin/Furan and Mercury Emissions," November 6, 2000b.
USEPA, "Municipal Solid Waste Basic Facts," June 20, 2001. Available at: http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm, accessed May 2002.
USEPA, National Dioxin Study Tier 4 — Combustion Sources: Engineering Analysis Report, U.S. EPA Office of Air Quality Planning and Standards, Washington D.C., 450-84-014h, 1987.
USEPA, Office of Solid Waste and Emergency Response, Final Technical Support Document for HWC MACT Standards Volume III: Selection of MACT Standards and Technologies, 1999a.
USEPA, Potential Applicability of Assembled Chemical Weapons Assessment Technologies to RCRA Waste Streams and Contaminated Media, August 2000d.
USEPA, "Puzzled About Recycling's Value? Look Beyond the Bin," EPA530-K-98-008, January 1998c.
U.S. Supreme Court, Denial of Certiorari, Atlantic Coast Demolition & Recycling Inc. v. Board of Chosen Freeholders of Atlantic County et al., 112 F.3d 652, 3d Cir., 1997.
Van Larebeke, Nik, et al., "The Belgian PCB and Dioxin Incident of January-June 1999: Exposure Data and Potential Impact on Health," Environmental Health Perspectives vol. 109, no.3, March 2001.
Van Leeuwen F., and Younes, M., "WHO Revises the Tolerable Daily Intake (TDI) for Dioxins," Organohalogen Compounds, vol. 38, pp. 295-298, 1998.
Viel, J.F., Arveux, P., Baverel, J., and Cahn J.Y., "Soft-Tissue sarcoma and Non-Hodgkin's Lymphoma Clusters Around a Municipal Solid Waste Incinerator With High Dioxin Emission Levels," American Journal of Epidemiology, vol.152, pp. 13-19, 2000.
Wall Street Journal, "Burning Issue: Energy from Garbage Loses Some of Promise as Wave of the Future," p. 1, June 16, 1988.
Walsh, Edward J., Warland, Rex, and Smith, D. Clayton, Don't Burn It Here: Grassroots Challenges to Trash Incinerators, University Park, Pa.: Pennsylvania State University Press, 1997.
Ward, Mike, "State Board Denies Using Siting Report; Study Identifies Least Likely Incinerator Foes Los Angeles Times, July 16, 1987.
Wenborn, M., King, K., Buckley-Golder, D., Gascon, J., "Releases of Dioxins and Furans to Land and Water in Europe, Final Report," Report produced for Landesumwaltamt Nordrhein-Westfalen, Germany on behalf of European Commission DG Environment, September 1999.
Whitman, Christie (USEPA Administrator), in transcript of press conference, "President George W. Bush Delivers Remarks Regarding POPs Treaty," April 19, 2001.
Wolfe, W.H., Michalek, J.E., Miner, J.C., et al., "Paternal Serum Dioxin and Reproductive Outcomes Among Veterans of Operation Ranch Hand," Epidemiology, vol. 6, no. 1, pp. 17-22, 1995.
Work On Waste, "North Carolina: Part 2," Waste Not, issue 164, September 12, 1991.
Work On Waste, Waste Not, issue 244, Sept. 1993.
Work On Waste, Waste Not, issue 302, September 1994.
World Health Organization, "Factsheet 253: Wastes from Healthcare Activities," 2000.
World Health Organization, "Fact Sheet 225: Dioxins and Their Effects On Human Health," June 1999b.
World Health Organization, Safe Management of Wastes from Health Care Activities, pg. 113, 1999a.
Yasuhara, A., and Morita, M., "Formation of Chlorinated Aromatic Hydrocarbons by Thermal Decomposition of Vinylidene Chloride Polymer." Environmental Science and Technology vol. 22, no. 6, pp. 646-650, 1988.
Zero Emissions Research Initiative, Press release: "First Non-Waste Beer Brewery," Mon, 27 Jan 1997.
Zero Waste New Zealand Trust, "Zero Waste Communities: Progress to Date," May 2002.

ENDNOTES

1. Composting, which recycles organic materials and nutrients, is generally considered a form of recycling; municipal waste is also commonly called "household" or "general" waste.
2. See the glossary for the use of the terms "Southern" and "Northern" in this report.
3. Van Larebeke, 2001.
4. Rier et al., 1993.
5. Pluim et al., 1993.
6. Nessel and Gallo, 1992; and Sweeney et al., 1992.
7. USEPA, 1992.
8. Huff, 1994.
9. Hardell and Sandstrom, 1979; and Erikkson et al., 1981.
10. Hardell et al., 1981.
11. Hardell et al., 1982.
12. Fingerhut et al., 1991.
13. Smith et al., 1983; and Kang et al., 1986.
14. Thigpen et al., 1975; House et al., 1990; Tucker et al., 1986.
15. Luster et al., 1980.
16. Murray et al., 1979; Allen, 1979.
17. Kociba et al., 1976; and Schantz and Bowman, 1989.
18. Mably et al., 1992.
19. Egeland et al., 1994; Erickson et al., 1984; Wolfe et al., 1995.
20. DeVito and Birnbaum, 1995.
21. USEPA, 2000a.
22. Birnbaum, 1993.
23. Because there are so many different chemicals that fall into the class of dioxins, furans, and PCBs, scientists have devised a metric to indicate the overall dioxin-like toxicity of all these chemicals combined. This is known as the toxic equivalency, or TEQ. It is calculated as follows: each congener (variant) of dioxin is assigned a toxic equivalency factor (TEF) depending on its potency, as established by research. The most powerful of the dioxin congeners, 2,3,7,8-TCDD, is assigned the TEF 1; the other congeners all have lesser values. For any given sample, the quantity of each congener is multiplied by that congener's TEF; these figures are then added to determine the overall TEQ for the sample. All references to dioxin quantities in this report are in terms of TEQ.
24. Van Leeuwen and Younes, 1998.
25. CNIID, 2000.
26. McLachlan, 1993; and Patandin, et al., 1999.
27. Hershkowitz, 1986.
28. USEPA, 2000c.
29. WHO, 1999b; "half-life" is the time it takes for the amount of a substance present to be reduced by half.
30. French Ministry of the Environment, 1998.
31. Overmann v. Syntex, 1991.
32. USEPA, 2000c, p. 18.
33. Available data on numbers of medical waste incinerators in the United States have not been very precise until quite recently. In December 1988, EPA's "Hospital Waste Combustion Study - Data Gathering Phase" estimated, based on discussions with manufacturers approximately 6,200 existing incinerators. On November 6, 2000, EPA reported to the Commission for Environmental Cooperation (CEC) that at most 767 medical waste incinerators would be operating as of September 15, 2002. This represents a closure of 88 percent of the 6,200 incinerators operating in 1988.
34. UNEP Chemicals, 1999.
35. European Commission, 1999.
36. Quass and Fermann, 1997; and Wenborn, et al., 1999.
37. Giugliano, et al., 2002.
38. Eitzer and Hites, 1986.
39. Halogenated organics are those containing the elements fluorine, chlorine, bromine, or iodine, which share important chemical properties and tend to form similar compounds.
40. Blumenstock, et al, 2000; Falandysz and Rappe, 1997; Heeb et al, 1995; Kashima et al, 1999; Sinkkonen et al, 1991; and Nito and Ishizaki, 1997.
41. Whitman, 2001.
42. National Academy Of Sciences, 2000 and Agency For Toxic Substances And Disease Registry, 1999.
43. Pirrone et al., 1996.
44. Centers for Disease Control and Prevention, 2001.
45. Meacher, 1999.
46. Schmid, et al., 2000.
47. Ibid.
48. Table from Stanners and Bourdeau, 1995.
49. USEPA, 1998a. p. ES-15.
50. Ibid.
51. Morris and Canzoneri, 1992.
52. Howard, 2000.
53. Pope et al., 1995.
54. Ma, et al, 1992.
55. USEPA, 1989.
56. Kawano et al., 1998.
57. Viel et al., 2000; Biggeri et al., 1996; Babone et al., 1994; Diggle, 1990; Elliot et al., 1992; Elliot et al., 1996; Elliot et al., 2000; Knox, 2000; and Knox and Gilman, 1998
58. U.K. Department of Environment Transport and Regional Affairs Committee, 2001.
59. De Fre and Wevers, 1998.
60. Alcock et al., 1998.
61. "Generally, data are not collected during startup, shutdowns, and upset conditions — when the greatest emissions are expected to occur. Furthermore, such data are typically based on a few stack samples for each pollutant. Thus, the adequacy of such emissions data to characterize fully the contribution of incineration to ambient pollutant concentrations for health-effects assessments is uncertain." National Research Council 2000. pp. 57-58.
62. Cook, 1989.
63. For more information on errors in measuring incinerator emissions and performance, see "Warning: Incineration Can Seriously Damage Your Health; A Report on the Hazardous Waste Incineration Crisis," Greenpeace, 1991.
64. Adapted from Waste Not 302, 1994.
65. National Research Council, 2000, p. 9.
66. Eberg, 1997, p. 112.
67. Greenpeace UK, 2001a.
68. Taylor and Lenoir, 2001; Lemieux, et al., 2001; Blumenstock, et al., 2000; USEPA, 2000c; U.S. Department of Energy 2000; USEPA, 1999a; Fangmark, et al., 1994; and Altwicker, et al., 1992.
69. Yasuhara, 1988; Huang, 1995.
70. Hunsinger, 1997.
71. Howard, 2000.
72. Chang and Lin, 2001.
73. Incinerators can also be run so as to produce a slag, rather than ash, residue.

74. The Bamako Convention specifically defines incinerator residues and pyrolysis wastes as hazardous wastes. The Basel Convention defines pyrolysis wastes as hazardous and incinerator residues as "Wastes Requiring Special Consideration," but also gives a long list of constituents, most of which are typically found in incinerator residues, and defines any waste containing one or more of those constituents to be hazardous waste.
75. Greenpeace, 1991.
76. Environmental Research Foundation, 1992.
77. Hershkowitz and Salerni, 1987, p. 77.
78. Personal communication of the author with operating engineers at a municipal waste incinerator in Ryugasaki, Japan.
79. Guardian, 2000.
80. Gemeentelijke Dienst Afvalverwerking, personal communication with Dr. Kees Olie, 1995, as reported by Dr. Paul Connett.
81. The 200 ton per day Shibuya incinerator in Tokyo cost 70 billion yen (approximately US$658 million at 1999 exchange rates); the 400 ton per day Ikebukuro incinerator in Toshima ward, also in Tokyo cost 86 billion yen (approximately US$808 million); personal communication, Dr. Harumi Ishizawa, July 1999.
82. Greenpeace Japan, 2001, p.1.
83. Germany and Belgium have adopted a quasi-continuous monitoring of dioxins using the AMESA method. Instead of the standard methodology of conducting one six-hour test per year (at most), quasi-continuous monitoring employs a single probe for two weeks, then replaces it with another for two weeks; etc. Thus, at all times the stack is being monitored for dioxin emissions. A year-long monitoring program would therefore result in 26 samples, each one reflecting two weeks' worth of dioxins emissions.
84. Georgieva, 2000; and Cointreau-Levine, 1996.
85. Bailey, 1993.
86. Rand, 2000.
87. Work On Waste, 1994.
88. Greenpeace, 2000, and personal communication, Emma Öberg.
89. By Marcia Carroll, Research Director, Multinationals Resource Center.
90. The Union Leader, 1994a; The Union Leader, 1994b; Work on Waste, 1993.
91. U.S. Supreme Court, 1997.
92. Jackson, 2001; and Bond Buyer, 2001.
93. Orlando Sentinel, 2002a; and Orlando Sentinel, 2002b.
94. Jochnowitz, 1998; and Multinational Monitor, 1993.
95. Bailey, 1993.
96. Greenpeace Japan, 2001, p. 6.
97. Sison, 2002.
98. Deutsche Presse-Agentur, 2002.
99. Platt and Seldman, 2000.
100. Institute for Local Self-Reliance, 1997.
101. Materials Recovery Facilities: sorting centers where recyclables and reusables are separated from waste.
102. "Resource recoverer" is used to refer to those who actually recover materials from the discards stream and return them to the economy; they are distinct from recyclers, who reprocess that material into new products.
103. Observed by the author in Phuket, Thailand.
104. Denison, 1996; for a more recent economic comparison of incineration and recycling on sustainability grounds, see ECOTEC, 2000.
105. For a comparison of various life-cycle assessments contrasting municipal waste incineration with landfilling and recycling, see Denison, 1996.
106. Rand, 2000.
107. Morris and Canzoneri, 1992.
108.Gore, 1992.
109. Redefining Progress, 2002.
110. Environmental Working Group and Health Care Without Harm, 1997. pp.30-31.
111. Commission for Racial Justice, 1987.
112. Powell, 1984.
113. Ward, 1987.
114. The complete list of Principles of Environmental Justice is available at: www.ejrc.cau.edu/princej.html
115. Seifman, 2002.
116. See, for example, figures on non-functioning or poorly-functioning incinerators in "Managing Clinical Waste in Developing Countries," WHO, 1994.
117. The Times of India, 2001; personal communication with Ravi Agarwal, Srishti, India.
118. Sound Resource Management, 1996.
119. Hencke, 2000.
120. Hering and Greeley, 1931, p. 13; USEPA, 1997.
121. Associated Press, 2000a.
122. Menon, 2000; Environment Support Group, 1999.
123. Adapted from Iskandar Kamel, 1999.
124. For cultural reasons, the work is sex-segregated. Men do the door-to-door collection and women the sorting.
125. Nova Scotia Department of the Environment, 2001; private communication, Dr. Paul Connett, August 2001; and private communication, Barry Friesen, April 2002.
126. Sources:
Argentina: Gobierno de la Ciudad e Buenos Aires, 2001.
Brazil: Pereira Neto, 1992.
Egypt: Project in Development and the Environment, 1994.Finland: Stanners and Bourdeau, 1995.
Hong Kong: Hong Kong Environmental Protection Department, 2000.
India: Dutta, 1997.
Ireland: Environmental Protection Agency of Ireland, 2000.
Japan: Endo, 2002.
Jordan: Environment and Development, 1997.
Malaysia: Mohd Riduan Ismail, 1995.
Nepal: International Centre for Integrated Mountain Development, 2001, p. 104.
Philippines: Institute for Local Self-Reliance, 2000b.
Puerto Rico: Puerto Rico Administration of Environmental Affairs, 1994.
Russia: Environment Department, Russia, 1998.
Taiwan: Taiwan Environmental Protection Agency, 2001.
Thailand: Institute for Local Self-Reliance, 2001.
U.K.: Parliamentary Select Committee on Environment, Transport and Regional Affairs, 2001.
U.S.: USEPA, 2001.
127. Institute for Local Self-Reliance, 1996.
128. Beck, 2001.
129. Ibid.
130. USEPA, 1998c.
131. In economics, externalities are those costs imposed upon a third party, in other words, costs not accounted for in the transaction. Pollution is the classic example.

132. ECOTEC, 2000.
133. Hogg, 2002.
134. For example, so-called "bottle bills" which require a small deposit on beverage bottles; the deposit is returned when the bottle is returned. A more comprehensive system is Germany's "Grüne Punkt" (green dot) system.
135. Fishbein, 1998.
136. Fishbein, 1998; Institute for Local Self-Reliance, 2000a.
137. Ryder, 2000.
138. Harris and Muir, 1998; the study indicated that the PVC industry employs 6,908 people in Canada, but if it were phased out, the resulting increase in manufacture of other products would generate 173,931 jobs, for a net increase of 167,023 jobs.
139. Elston, 2000; and Motavelli, 2001.
140. In some cases, these figures reflect residential municipal waste diversion rates, rather than overall municipal waste diversion rates. Residential rates exclude discards from offices and commercial establishments, which tend to be somewhat more uniform.
Sources:
Denmark, Netherlands and Switzerland: Murray, 1999, pp. 33-34.
Galway: personal communication, Aine Suttle, Galway for a Safe Environment; April 2002.
Italy: Connett and Sheehan, 2001, p.19.
Canberra: personal communication, Sarah Hurren, Planning Project Officer, ACT NOWaste, April 2002.
New Zealand: Zero Waste New Zealand Trust, 2002.
Prince Edward Island: Ledgerwood, 1999.
Nova Scotia: Connett and Sheehan, 2001, p.18.
Northumberland County, Ontario, Canada: Independent, 2001.
Other Ontario Cities: Connett and Sheehan, 2001, p.18.
Boothbay: Maine State Planning Office, 2002.
Other United States Locales: USEPA, 1999b.
141. Adapted from "Aiming for Zero Waste: Ten Steps to Get Started," Brenda Platt, Institute for Local Self-Reliance, Washington, DC, 2002.
142. Davies and Lowe, 1999, p. v.
143. For a generalized step-by-step approach that hospitals in Southern countries can take to improve their medical waste management, see McRae, 2000.
144. Connett, 1997.
145. Ghosh, 2002.
146. Health Care Without Harm, 2001.
147. World Health Organization, 1999, pg. 113.
148. World Health Organization, 2000.
149. Ibid.
150. Markandu, et al, 2000. For alternatives to mercury-bearing equipment, see The Sustainable Hospitals website at the University of Massachusetts Lowell: http://www.sustainablehospitals.org or the National Institutes of Health: http://www.nih.gov/od/ors/ds/nomercury/alternatives.htm.
151. World Health Organization, 1999a, pg. 113.
152. Ibid.
153. USEPA, 1998b.
154. Personal communication, Janet Brown, Medical Waste Manager, Beth Israel Medical Center.
155. Ganla et al., 2001.
156. For more information on materials exchanges, see:
http://www.ciwmb.ca.gov/CalMAX
For lists of materials exchanges, see:
http://www.metrokc.gov/hazwaste/imex/exchanges.html
http://www.ciwmb.ca.gov/Reuse/Links/Exchange.htm
http://www.wastexchange.org/exchanges/top_list.cfm
and http://www.recycle.net/recycle/exch/index.html.
157 Montague, 1998.
158. By Charlie Cray.
159. Thorpe, 1999, p.5.
160. By Charlie Cray.
161. Personal communication, Gunter Pauli, Director of Zero Emissions Research and Initiatives Foundation, May 2002.
162. At least 14 such releases so far from the U.S. Army's chemical weapons incinerators, according to Mr. Kevin Gildner and Mr. Conrad Whyne, Program Manager for Chemical Demilitarization at the Kentucky Citizens Advisory Commission meeting, January 2002.
163. By Elizabeth Crowe, Chemical Weapons Working Group.
164. USEPA, 2000d.
165. Costner, et al, 1998.
166. Crowe and Schade, 2002.
167. U.S. Department of Energy, 1997.
168. Walsh, et al., 1997.
169. "The State of Garbage" annual surveys published in Biocycle magazine.
170. Walsh et al., 1997.
171. Personal communication, Paul and Ellen Connett at Work on Waste, editors of Waste Not. April 2002.
172. Data from: U.S. Department of Energy, 2001; John van der Harst, Recycling Advocates of Middle Tennessee; Kiser and Zannes 2000; Denison and Ruston, 1990; Hegberg et al., 1990; and interviews with local authorities.
173 Data from: U.S. Department of Energy, 2001; John van der Harst, Recycling Advocates of Middle Tennessee; Kiser and Zannes 2000; Denison and Ruston, 1990; Hegberg et al., 1990; and interviews with local authorities.
174. USEPA, 1988.
175. USEPA, 2000b.
176. Statement by Jerry Trautman, Michigan Department of Environmental Quality, Air Quality Division, at a public hearing October 30, 2001 on the Hamtramck medical waste incinerator.
177. McMullen, 2000.
178. Compiled by Jorge Emmanuel, PhD., from: USEPA 2000b; USEPA 1988; USEPA 1996; and USEPA 1994.
179. Work on Waste, 1991.
180. U.S. Department of Energy, 1997.
181. Wall Street Journal, 1988.
182. Consumat Environmental Systems, 1998.
183. Geiselman, 1999.
184. Hazardous Waste News, 1991.
185. Chicago Tribune, 1998.
186. USEPA figures as cited in Walsh, et al., 1997.
187. Glenn, 1999; and the Center for Voting and Democracy <www.fairvote.org>.
188. Hershkowitz and Salerni, 1987. p. 72. The official cited is Mr. K. Nakazato, the head of overseas market development at Takuma Industries.
189. Ibid., p.75.
190. Pollack, 1997; Associated Press, 2000b.
191. UNEP Chemicals, 1999.
192. Hershkowitz, 1987, p.76.

193. Asahi Shimbun, 2002.
194. U.K. Parliamentary Select Committee on Environment, Transport and Regional Affairs, 2001.
195. Dente et al., 1998, p.3.
196. Hershkowitz, 1986, p. 42.
197. Eberg, 1997, p. 98 and 134.
198. Greenpeace, 2000; personal communication, Emma Öberg.
199. Hencke, 2000.
200. Martin GmbH fur Umwelt und Eneregietechnik, headquartered in Munich.
201. Eberg, 1997, pp. 137-8.
202. Eberg, 1997, p. 125.
203. Doucet, undated.
204. Greenpeace U.K., 2001b.
205. Interviews by the author in Kwangju, South Korea, 1999.
206. Personal communication, Zeina al-Hajj, April 2002.
207. Laliotis, 2001.
208. Aytekin, 1999.
209. by Von Hernandez, Toxics Campaigner, Greenpeace International and Co-coordinator, GAIA.
210. The Wingspread statement has become the definitive version of the Precautionary Principle; see Montague, 1998 at <www.rachel.org>.
211. The OSPAR Convention is formally known as the Convention for the Protection of the Marine Environment of the North-East Atlantic.
212. The Bamako Convention on the Ban of Import Into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes Within Africa, concluded 29 January 1991.
213.Convention on Long-Range Transboundary Air Pollution (LRTAP).
214. UNEP,1987.
215. International Joint Commission, 1996.
216. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972.
217. Eberg, 1997, p. 70.
218. Adapted from "The Stockholm Convention: Marking the Beginning of an End to Waste Incineration," GAIA Campaigner, Vol. 1 Issue 2, by Jim Puckett, Coordinator, Basel Action Network.
219. The treaty is available online at http://www.pops.int.
220.The pesticides are: Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Mirex, Toxaphene, and DDT.
221. Jay and Stieglitz, 1995.
222. Trenholm and Lee, 1986; Dellinger, et al., 1988; Trenholm and Thurnau, 1987; Chang, et al. 1988; USEPA 1989; USEPA 1987.

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Institute for Local Self-Reliance
2425 18th Street, NW
Washington, DC 20009-2096
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Telephone: +1 202 232 4108
Fax: +1 202 332 0463
ilsr@ilsr.org
http://www.ilsr.org

International POPs Elimination Network
c/o Center for International Environmental Law
1367 Connecticut Ave., NW, Suite 300
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Telephone: +1 202 785 8700
Fax: +1 202 785 8701
http://www.ipen.org

Lowell Center for Sustainable Production
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Lowell, MA 01854
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Telephone: +1 978 934 2980
Fax: +1 978 452 5711
LCSP@uml.edu
http://www.uml.edu/centers/LCSP

National Cleaner Production Centers Programme
United Nations Industrial Development Organization
PO Box 300, A 1400 Vienna
Austria
Telephone: +43 1 26026 5079
Fax: +43 1 21346 6819
ncpc@unido.org
http://www.unido.org/doc/331390.htmls

National Institutes of Health
Information on alternatives to mercury-bearing medical products
http://www.nih.gov/od/ors/ds/nomercury/alternatives.htm

Pesticide Action Network Latin America
Alianza por una Mejor Calidad de Vida/Red de Acción en Plaguicidas
Avenida Providencia N° 365, Dpto. N° 41
Providencia, Santiago de Chile.
Telephone: +562 3416742
Fax: +562 3416742
rapal@rapal.cl
http://www.rap-al.org

Pesticide Action Network Africa
BP: 15938 Dakar-Fann
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Phone +221 825 49 14
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panafrica@pan-africa.sn
http://www.pan-africa.sn

Pesticide Action Network Asia and the Pacific
P.O. Box 1170
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panap@panap.net
http://www.panap.net

Pesticide Action Network Europe
Eurolink Centre
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Fax: +44 207 274 9084
coordinator@pan-europe.net
http://www.pan-europe.net

Pesticide Action Network North America
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panna@panna.org
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Silicon Valley Toxics Coalition
760 N. First Street San Jose, CA 95112
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Telephone: +1 408 287 6707
Fax: +1 408 287 6771
svtc@svtc.org
http://www.svtc.org

Srishti / Toxics Link
H-2 Jungpura Extension
New Delhi-14, India
Telephone: +91 11 432 1747, 8006, 0711
srishtidel@vsnl.net
http://www.toxicslink.org/medical

Sustainable Hospitals Project
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Lowell, MA 01854, USA
Telephone: +1 978 934 3386
shp@uml.edu
http://www.sustainablehospitals.org

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Fax: +31 182 550313
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http://www.waste.nl

Waste Prevention Association "3R"
P.O.Box 54
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http://www.otzo.most.org.pl

Zero Waste New Zealand Trust
PO Box 33 1695
Takapuna , Auckland
New Zealand
Telephone: +64 9 486 0734
Fax: +64 9 489 3232
mailbox@zerowaste.co.nz
http://www.zerowaste.co.nz

United Nations Environment Programme
Interim Secretariat for the Stockholm Convention on Persistent Organic Pollutants
11 13 Chemin des Anémones
1219 Châtelaine, Geneva
Switzerland
Tel.: +41 22 917 8191
Fax: +41 22 797 3460
ssc@chemicals.unep.ch
http://www.pops.int

World Alliance for Breastfeeding Action
PO Box 1200, 10850 Penang,
Malaysia
Telephone: + 604 658 4816
Fax: +604 657 2655
secr@waba.po.my
http://waba.org.my or http://waba.org.br

World Wildlife Fund International
Avenue du Mont-Blanc
1196 Gland, Switzerland
Phone: +41 22 364 91 11
Fax: +41 22 364 53 58
http://www.wwf.org

Zero Waste Alliance International
PO Box 33239
Takapuna, Auckland
New Zealand
Telephone: + 649 9178340
jdickinson@zwia.org

Materials Exchanges:

Associação de Combate aos POPs
Associação de Consciência à Prevenção Ocupacional
http://acpo94.sites.uol.com.br (Portugese)

California Integrated Waste Management Board
http://www.ciwmb.ca.gov/Reuse/Links/Exchange.htm

Center for Health Environment and Justice
http://www.chej.org

Environmental Research Foundation
http://www.rachel.org

Essential Information
http://www.essential.org

Internet Resources on Waste and Chemicals
http://www.most.org.pl/otzo/en/web-p2w.htm

The Community Recycling Network
http://www.crn.org.uk

US EPA National Center for Environmental Assessment
http://cfpub.epa.gov/ncea/cfm/dioxin.cfm

Waste Age
http://www.wasteage.com

Waste News
http://www.wastenews.com

Work on Waste
http://www.workonwaste.org

Zero Emissions Research Initiatives
http://www.zeri.org