Waste Management and Global Climate

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Elected officials, regulators, scientists, and consumers seldom think about the environment in holistic, integrated terms—a shortcoming that is evident in the lack of discussions of the connections between waste management and global climate change.

Twenty years ago, a popular air quality control strategy was to shut down municipal incinerators and bury solid waste. During the 1980s, we came full circle when many proponents viewed modern incineration technology as the solution to landfill problems. One astute observer remarked that the law of conservation of mass was replaced with the law of conservation of mess.

To be sure, important evolutionary thinking has begun. The concept of "integrated waste management"—with the four R's of reduction, reuse, recycling, and resource recovery (incineration)—has taken hold. Manufacturers increasingly have instituted "waste minimization" or "pollution prevention" programs, including the use of recycled materials and changes in product formulations, to reduce plant emissions and improve the "green marketing" image of their products.

On the other hand, as a nation of specialists, we still do not deal effectively with interrelated environmental issues. When I have suggested to colleagues that recycling and energy conservation are important air pollution control strategies, I have mostly encountered blank stares.

With few exceptions, we have much farther to go in considering comprehensive environmental relationships and developing policies for global climate change. To the best of my knowledge, no one has asked the question of how waste management practices affect global climate change. Instead, a few specific waste practices have been identified as major causal factors related to certain global climate issues (for example, the effect of refrigerant disposal upon the ozone layer or the production of methane from landfills as a contributor to global warming). Let us at least begin by asking in a comprehensive and conceptual way how waste management practices relate to climate change.

Global Climate Issues

The two primary global climate change issues are stratospheric ozone depletion and global warming.[1] Among the family of halocarbon compounds, chlorofluorocarbons (CFCs)—CFC11 and CFC12 in particular—are the most important agents in depleting the upper atmospheric ozone layer. With respect to global warming, carbon dioxide is the most abundant and significant greenhouse gas. Atmospheric concentrations of carbon dioxide are increasing at about 0.4 percent per year and are believed responsible for about 50 percent of the commitment to global warming.

Methane, about 20 times more potent in global warming per molecule than carbon dioxide, is increasing at a rate of about 1 percent per year; it is responsible for about 20 percent of the commitment to global warming. Nitrous oxide, currently increasing at a rate of about 0.25 percent per year, is responsible for about 6 percent of global warming commitment. CFCs account for about 15 percent of the commitment to global warming.[2] Other halogens, methyl chloroform, and other nitrogen oxides play a lesser role in global warming.

Strategies

Waste management often means many different things to different people. As conventionally defined, solid-waste management strategies for garbage and refuse include waste reduction, reuse and recycling, composting, landfill disposal, and incineration.

Other solid wastes besides garbage and refuse include sewage sludge, which can be incinerated, spread over land, or converted to byproducts (such as fertilizer or fill materials); animal manures, with similar treatment options; and agricultural wastes, which are normally left to decompose, removed through "open burning," or converted to biomass fuels. In the context of greenhouse gases, the latter two wastes are important on a global scale.[3]

Similar waste management strategies have been adopted for hazardous wastes. Strategies for waste minimization and recycling have been launched to stabilize the deterioration of the ozone layer. In accordance with the Montreal Protocol, substitutions for the most harmful CFCs are being developed, and the recycling of existing refrigerants is being required.

Waste management strategies can be evaluated by how they affect the emission of the greenhouse gases—primarily methane, carbon dioxide, and cholorofluorocarbons. With respect to solid wastes, conventional landfill methods produce significant quantities of methane gas as a decomposition product. Because scientists are uncertain about the amount of methane produced by widespread global activities such as rice cultivation, biomass burning (related to land use and agriculture), and even cattle digestive processes, a rough estimate is that about 10 percent of total methane emissions are from landfill sources.

Nonetheless, landfill management practices are important for two reasons. Most experts agree that landfill operations are likely to increase rapidly in developing countries. Second, with good practice, studies indicate that it may be possible to reduce methane emissions from landfills in the United States and stabilize methane emissions globally.

Methane emissions ultimately have to be removed or vented from landfills for safety reasons. Landfill methane generally is not suitable for pipeline natural gas; however, methane gas is being used increasingly for small-scale electrical generation as an alternate source of energy. As a greenhouse gas, carbon dioxide gases given off as a combustion product are much more benign than the original methane emitted from the landfill.

Solid-waste incineration also produces carbon dioxide and nitrogen oxides; the latter gases depend in part on the amount of biomass materials in the waste stream. Although these greenhouse gases are also an improvement over uncontrolled methane that could result if solid wastes were buried in landfills, various management practices can further "offset" the carbon dioxide emissions from waste incineration.

For example, waste-to-energy facilities, if properly sized to generate electricity, can partially reduce the need for conventional electrical power generation. However, optimal environmental benefits depend on two practices frequently neglected by waste-to-energy proponents whose primary goal is to maximize revenues.

First, energy efficiency, and therefore the carbon dioxide emissions offset, is enhanced if the waste-to-energy facility can use the waste heat for industrial, commercial, or residential use (that is, if the facility is designed for cogeneration). This is frequently the case in nations such as Sweden where high fossil fuel energy prices have resulted in better planning.

Second, an important practice that can increase the carbon dioxide offset is careful integration and sizing of the waste-to-energy facility so that it matches the available waste stream that remains after the waste reduction, recycling, and composting components of an overall solid-waste management program are in place. By removing noncombustible and high-moisture-content materials, the energy Btu content of the waste stream is improved and energy conservation benefits from recycling materials can be realized.

Incineration is also an important means of disposal of sewage sludge, accounting for about 25 percent of that waste. A similar portion is sent to landfills where, if buried, it contributes to the production of methane gases.

Waste heat recovery from incineration of sewage sludge is impractical because of the high water content of the sludge. Presently, the best alternatives for sludge disposal, such as land applications and fertilizer production, are also often impractical due to the high content of toxic metals. This situation underscores the importance of waste reduction and waste minimization as primary waste management strategies.

Waste reduction strategies also help reduce greenhouse gases by reducing the amount of materials that must be landfilled or incinerated. Waste reduction can take place by eliminating unnecessary packaging, lengthening the product life, or using recycled materials in manufacturing a product. Reusing and recycling materials, such as metals, newsprint, boxes and containers, and plastics, has the same effect. In addition, recycled materials are an important way to conserve energy used in primary manufacturing processes, which provides the added benefit of reducing carbon dioxide emission.[4]

Some of these strategies have been applied to hazardous waste as well. For industries that produce hazardous waste, waste minimization is becoming the preferred strategy, followed by incineration. Although there are no data on carbon dioxide emissions from hazardous-waste incineration, it is likely a tiny portion of the total emissions. Nevertheless, there is symbolic importance in these efforts because of the need to gain global cooperation in reducing carbon dioxide emissions.

It may be possible to develop emission offsets, such as revegetation, for carbon dioxide emitted from hazardous waste incineration. Such a procedure could help internalize the environmental cost and further stimulate waste minimization practices. Some organic liquids and solids have a moderate Btu content and waste-heat recovery may be possible to partially offset carbon dioxide emissions. In certain cement kilns and large incinerators that burn hazardous wastes, the design has included waste heat recovery.

Conclusion

The two primary global climate-change issues at present are the ozone layer depletion and global warming. It is, therefore, desirable to promote waste management practices that reduce the presence of chlorofluorocarbons and other primary greenhouse gases such as methane and carbon dioxide. Waste-management practices, such as recycling chlorofluorocarbons and substituting other materials for chlorofluorocarbons, represent key ways to protect the ozone layer and reduce greenhouse gas concentrations.

Waste reduction practices and the recycling of materials also can reduce the amount of material going to landfills and thus the amount of the methane emitted into the atmosphere. Other waste-management practices, such as composting and incineration, also can reduce methane production. Finally, the use of landfill methane to generate electricity can curb its atmospheric impacts.

Although the generation of carbon dioxide from the incineration of solid and hazardous wastes is a small percentage of total carbon dioxide emissions, the recovery of waste-heat energy and the generation of electricity can help offset these emissions. Recycling metals, plastics, and papers can significantly reduce primary energy consumption and carbon dioxide emissions.

Most important of all, however, is the need to carefully consider the intricate links among environmental issues and components of the environmental system. Only then can we devise strategies that address the problems directly and comprehensively, rather than simply taking small steps that move the problem from one medium to another.

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NOTES

1. I do not wish to imply that there are not other possible global climate changes that could occur and that may ultimately be deemed important: changes in atmospheric trace gas composition, incoming solar radiation, cloudiness, precipitation, and winds all may be possible and may all affect global warming.
2. Data compiled from the Environmental Protection Agency (EPA) report, "Policy Options for Stabilizing Global Climate," (Washington, DC: EPA, Office of Policy and Planning, February 1989).
3. Wood, agricultural wastes, and manure are the primary sources of fuel energy in the Third World. Agricultural burning is also used to clear land for both settlement and planting. Collectively, these activities account for most carbon dioxide emissions in the Third World. In the United States, animal manures are important, not as sources of greenhouse gases, but as sources of non-point water pollution.
4. In some instances, energy savings are dramatic. For example, recycled steel saves 75 percent of the energy required in production from virgin materials; recycled aluminum saves about 90 percent. Actual energy savings from recycled materials depend on the amount of processing and transporting.