THE ENVIRONMENTAL COSTS OF LANDFILLS AND INCINERATORS

ENVIRONMENTAL POLLUTANTS and the URBAN ECONOMY

Argonne National Laboratory
Energy and Environmental Systems Division

The University of Chicago
Center for Urban Studies

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The Solid Waste Disposal Problem

Solid wastes are producing increasingly significant cost problems, political controversy, and environmental degradation, particularly in larger metropolitan areas where intensive urbanization increases the amount of such waste while simultaneously decreasing the availability of suitable disposal areas.

"Solid waste" generally refers to garbage and other forms of solid residuals generated by residential, commercial, and industrial sources. In this document solid waste will only refer to non-hazardous municipal wastes. Given that quantities of solid waste will continue to increase, the preferred method of disposal must be ascertained. Presently, the major means of disposal is by sanitary landfills. However, in metropolitan areas such as Chicago, there has been a tendency to use incinerators. This document summarizes a comparative analysis of the total social costs of landfills and incinerators. The analysis was based on data from the Chicago metropolitan area.

The costs usually used to compare sanitary landfills and incinerators are those of investment, operation, and transportation. However, in order to determine the total costs, this analysis also estimated the *environmental* costs. The result is a more balanced and comprehensive comparison than usual of solid waste disposal alternatives.

Characteristics of Landfills and Incinerators

At a properly operated sanitary landfill, solid waste is compacted and covered with six or more inches of earth. Refuse is not burned at a sanitary landfill and neither ground nor surface water pollution should occur.

The capital costs of a landfill are low compared to those of other disposal methods. Once operating, a landfill can receive all types of solid waste (except toxic or radioactive materials) and does not require separate collections or sorting prior to disposal. A landfill also can handle sudden increased loads with little additional personnel or equipment. Upon completion of a landfill, the land can normally be reclaimed for such uses as golf courses, playgrounds, or parking lots.

However, a landfill does require relatively large tracts of land and potential sites are often under another governmental jurisdiction, which can create political difficulties. The cost of transporting waste also rises as the distance of a landfill from collection points increases.

The alternative of using incinerators also has certain advantages and disadvantages. An incinerator operation including the disposal of the waste residue requires much less land than a landfill and can be located closer to the area it serves. The capital and operating costs of incinerators are, however, considerably higher than those of landfills. Skilled personnel to operate and maintain an incinerator also are needed because of the complexity of the furnace equipment. Control devices are required to reduce the amount of dust and fly ash discharged from an incinerator's stack, but even a properly designed incinerator will give off smoke and odors if it is improperly operated.

Methods Used to Calculate Environmental Costs

Environmental costs are not borne directly by those disposing of wastes; they are borne by persons living in areas where, for example, the air has been polluted by emissions from a solid waste incinerator or the value of property surrounding a landfill has dropped. Generally, no provision is made to compensate persons who may suffer or risk loss because of the environmental costs of solid waste disposal.

The environmental costs associated with a sanitary landfill are estimated via changes in property values adjacent to a landfill site, which were obtained from the 1970 Census of Housing. Changes in property values around a landfill are attributed to the presence of the landfill site. The changes in property value serve as a single measure in which environmental costs produced by a landfill are captured. The calculations were done for 55 landfill sites in the Chicago Standard Metropolitan Statistical Area (SMSA). Figure 1 shows the location of these landfills and of the eight incinerators in the area in 1973.

The environmental costs of incinerators were calculated using air dispersion and damage models. A computerized air dispersion model was employed to estimate the geographic area affected by the dispersion of dust and fly ash from an incinerator stack. The extent of damage, which varies according to the residential density of the affected area, was quantified by a damage model. The damage model generates estimates of the change in air quality at predetermined receptor points due to incinerator emissions and applies damage coefficients from statistical studies of effects of air quality changes.

Comparison of Total Social Costs

The results of the analysis indicate that the total social costs in the Chicago area including environmental costs of incinerators are almost four times those of landfills. This is shown in Table 1. collection costs other than transport to the disposal site do not appear in this comparison because they are the same regardless of whether the solid wastes are taken to a landfill or incinerator. They were estimated to be \$22 per ton in 1970 dollars.

TABLE 1. Costs of Landfills and Incinerators in the Chicago SMSA
(per ton, 1970 \$)

	Landfill	Incinerator
Investment Cost	\$0.25	\$ 1.85
Operating Cost	1.00	5.00
Transportation Cost	3.00	1.50
Environmental Cost	0.07	8.00
Total Social Cost*	\$4.32	\$16.35

*Not including collection costs, estimated to be \$22/ton for both methods

In calculating the environmental costs of landfills, it was found that property values varied with (1) the number of degrees a house is from the prevailing

Fig. 1. Landfill and Incinerator Locations in the Chicago Metropolitan Area.

downwind direction from the landfill site and (2) distance from the site. The downwind direction is significant because the concentration of odor and dust from a landfill site would most likely be greater in the downwind direction. Housing values were found to increase with distance from a landfill site, for a distance equivalent to three city blocks.

Environmental costs were estimated to average \$60,500 per landfill site. Since the other costs (investments, operating, transportation) are on a per-ton-of-solid-waste basis, the environmental costs were converted to an annual per-ton basis, resulting in an annual environmental cost of five to seven cents per ton depending on the daily volume that a landfill handles. The higher figure is shown in Table 1.

In contrast to landfills, whose environmental influence was found to have a three-block range in a sparsely populated area, incinerators' air pollutant emissions can affect an area extending 20 miles from the incinerator sites, which in Chicago are located near the Central Business District (CBD) area. The environmental damage is greater in a 20-mile densely populated area than in a three-block sparsely populated one. These costs were found to be \$8 per ton, substantially higher than those of landfills.

In the other three categories shown in Table 1, incinerator costs are higher for investment and operating but lower for transportation.

While landfills do require a greater land area, the initial capital costs of incinerators are significantly higher. Land costs of landfills were estimated using a price of \$2,000 per acre, while the incinerator capital investment cost was estimated using an average capital cost of \$6,150 per ton design capacity per day. Translating these figures to a per-ton basis, the incinerator costs of \$1.85 per ton are significantly higher than the landfill costs of 25 cents per ton, even though the incinerator capital cost figure used is a conservative estimate.

Incinerators are, however, generally located closer to the areas they serve than are landfills; incinerator transportation costs are estimated to be, on the average, one-half of those for landfills.

The significance of these results becomes more apparent when it is recognized that they are, to some extent, biased against landfills since no allowance is made for the value of the uses to which the land can be put after the landfill is filled and reclaimed. Reclaimed sanitary landfills can, for example, be used for parks, recreational areas, or parking lots. Generally, landfills are ready for use two years after they are completely filled. If benefit estimates for such uses were made, the total social cost for landfills would be lower than shown in Table 1; however, the order of magnitude of the total cost difference is such that this additional refinement need not be explicitly considered.

Cost Effects of Landfill Location

Given the cost figures in Table 1, it is possible to estimate the waste-source-to-disposal site distance at which total landfill costs equal total incineration costs. This is of interest because in urban areas, the only vacant land suitable for landfills may be on a city's outskirts. Presented here are the results of a sample calculation of the break-even distance for City of Chicago landfills.

In making this estimate, it is assumed that incinerators remain in their present location, and only the location of landfills, and hence the transportation costs for landfills, change. Essentially, we are estimating the distance from the center of Chicago at which transportation costs are high enough to offset a landfill's lower investment, operating, and environmental costs.

At any distance less than the break-even distance, landfills are cheaper because the share of the other cost components in the total cost, relative to that of transportation, is very low. (For example, the total cost is relatively insensitive to changes in land prices.) At any distance beyond the break-even point, landfill total costs are higher than those of incinerators.

Landfill transportation costs are estimated at 25 cents per ton per mile. If environmental costs are not considered, the break-even distance is 23-26 miles. The range reflects consideration of possible differences in land values. When environmental costs are considered, the break-even distance increases to 45-50 miles. These estimates are based on the use of conventional truck hauling methods; if the solid waste was hauled by rail, then economies of scale would be present and the break-even distance would extend farther into the agricultural area surrounding Chicago.

The 23-26 mile break-even radius (based on exclusion of environmental costs) includes vacant areas, some of which are near industrial areas. But at this distance, political jurisdictional problems may prevent the City of Chicago from using available land for solid waste disposal. From a purely economic viewpoint, however, there does not seem to be any reason for restricting landfilling of Chicago's solid waste outside of Chicago.

However, since decisions regarding incinerators and landfills in the past had to be made without consideration of environmental costs, and given the political difficulties within the 23-26 mile range, the choice of incineration may be understandable. But in view of the high environmental costs of incineration, and the availability of vacant land in the Chicago area within the 45-50 mile break-even distance, the construction of new incinerators appears to be economically unjustifiable, and indeed no such construction is presently being planned.

Furthermore, if we consider the transportation and environmental components alone, we find that even operating the existing incinerators may not be economically sound, and the use of landfills should be considered instead.

Operating incinerators may not be economically sound; landfills should be considered instead.

Policy Implications

The following conclusions are derived for the Chicago example. However, Chicago may be a typical case and the conclusions below may carry over to other major cities.

The total costs of using landfills for solid waste disposal in the Chicago area are significantly less than those of using incinerators. The costs of landfills are lower both on the basis of (1) investment and operating costs alone, which is the usual method of comparison, and (2) total social costs including environmental costs. The inclusion of environmental costs makes the landfill alternative even more favorable economically.

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