DISPOSAL OF SOLID WASTES

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Summary

Disposal is the "no alternative" option because it is the last functional element in the solid waste management system and the ultimate fate of all wastes that are of no further value. As the terminal action for pollution control of solid waste, the final target of disposal is to isolate solid waste and its environmental impact from biosphere, to limit the infection of hazardous components in wastes to be lower than acceptable levels, and to guarantee the safety of human's health and environment.

The highest rank in the hierarchy of integrated solid waste management is source reduction. From the perspective of the community, source reduction is the most desired activity, because the community does not incur costs for waste handling, transporting, and disposal for waste that is never created and delivered to the waste management system.

As the patterns of waste generation become more diffuse and the total quantity of waste increases, the logistics of collection becomes more complex. At the same time, transfer operations become a necessity when haul distance to processing centers or disposal sites increases so that direct hauling is no longer economically feasible. Of the total amount of expenses for solid waste management system, approximately 60 to 90 percent is spent on the collection and transfer phase. This fact is important because a small percentage improvement in the collection and transfer operations can result in a significant savings in the overall cost.

The safe and reliable long-term disposal of solid waste residues is an important component of integrated solid waste management. Historically, landfills have been the most economical and environmentally acceptable method for the disposal of solid wastes in most of the countries. Even with implementation of waste reduction, recycling, transformation and energy recovery technologies, disposal of residual solid waste in landfill still remains a necessary component of waste management system.

The most commonly used thermal conversion process is incineration, which can be used to reduce the original volume of the combustible fraction of MSW by approximately 80 to 90 percent. In addition, the recovery of energy in the form of heat is another attractive feature of the incineration system.

If the biodegradable organic materials in the MSW are subjected to aerobic or anaerobic microbacterial decomposition, the end product remaining after microbiological activity has essentially ceased, is a humus material commonly known as *compost*. This biological and chemical conversion technology of solid waste is called composting.

1. Conception of Waste Disposal

On the general concept, "disposal" means to put waste into a landfill for the purpose of final burial, destruction or placement for future recovery. As the terminal action for pollution control of solid waste, the final target of disposal is isolating solid waste and its environmental impact from biosphere and to keep humankind and environment from any unacceptable hazard from the infection of hazardous components in wastes. The object of final disposal is that the wastes can not be processed and used further.

In addition, recovery is also included in the final disposal. For example, the waste produced from certain industrial process could become a useful raw material to another industrial process. The improvement of industrial technologies would facilitate reuse of historical wastes. But in fact, permanent isolation**,** by means of multiform natural and /or artificial barriers to isolate hazardous wastes from the biosphere, is the most paramount technology of final disposal, including landfill, land treatment and ocean treatment.

With a rigorous definition, "disposal" means the activities to minimize the quantity of produced solid wastes, to decrease and even eliminate hazardous components in solid wastes, the activities to contain solid wastes in a location or facilities which meet environmental protecting standard without the need to isolate from the biological environment. For meeting the specifications of disposal, some treatment process modifying the physical, chemical or biological characteristic of solid wastes would be introduced like compost, incineration and/or others.

Public intervention is very important when dealing with urban MSWM. There are sometimes situations in which the difficulty experienced by environmental officers in planning and directing a project in a social way may overshadow the need for technical solutions to MSWM problems especially to wastes disposal that involves environmental quality mightily. In other cases, there is a tendency for MSWM decisions to be made without sufficient planning, to take into account only some aspects of a situation, to be based on a short-term view of the situation, or to be influenced by the interests of policy makers. Overcoming these tendencies will greatly facilitate the identification of the best solution in the given circumstances.

In the whole process from waste minimization to final disposal, how to decide a technical strategy is connected in numerous ways to many decision-makers in environmental, economic, and social issues. Most of the answers in waste management have broader implications. It means, a technology or policy has to embody a reasonable balance of feasible, sustainable, environmentally beneficial, and socially sensitive points to MSWM problems. To make a best choice, not only arrives a single or simple goal in MSWM, it is very important to take into account the concrete demands of the region where a proposed solution is to be implemented. The variety of factors that help determine what is appropriate in a situation is sufficiently large that any recommended scheme must be tested against the reality of a particular circumstance.

Beyond specific condition, additional investments in environmental improvement are often led to confine people's action. It is even more evident in developing countries. In these countries, policy makers should not only be concerned with absolute avoidance of environmental pollution and/or risk to human beings, but they should also make

investment yield the greatest return to society. We have to get the point, where a balance among environmental benefits, social benefits and economic benefits is achieved. In any country, the expenses for wastes disposal must constitute a principal part in integrated environmental improvement. Socialization of wastes disposal activity would be inevitable gradually.

The basic concepts of different disposal technologies of municipal wastes and brief review are described in this chapter. This arrangement is intended to facilitate the transfer of information and ideas among regions and to present a unified discussion of some issues that are similar in different areas of the world. Because there are myriad differences, in the conditions for making decisions, from one place to another, we could not ignore these differences, but try to draw some general conclusions that may nevertheless have wide applicability.

2. Criteria for Evaluating of Wastes Disposal Orientation

For getting a best choice from different technology and/or policy, decision-makers should consider a series of factors designed to facilitate comparison of the available alternatives. Before a well-informed decision can be made, to make these factors clear will shed light on particular key points that need to be resolved in advance.

2.1 Technical and Social Feasibility

First of all, that if the technology is a competent to accomplish the basic scheduled goal in the circumstances where it would be used has to be verified. The decision maker must be sure that the basic characteristic of a certain technology is compatible with the target before any decision has been made. In addition, cost often restricted by actual financial condition and public opinion, which mightily influence the feasibility depends what are the environmental and social benefits of project.

2.2 Balance among Cost and Perfectibility of Disposal Activity

The cost of wastes disposal is always fluctuating sharply about environmental soundness and environmental benefits of the proposed technology. A good decision-maker needs to find appropriate balance between the cost and environmental benefit to make the project most cost-effective. It means, an over-exacting disposal standard would only get a little environmental benefit with a huge extra cost.

2.3 Consistency with Macroscopically Municipal Plan

Do these effects promote or conflict with overall social goals of the society? The eventual antinomy between the macroscopic municipal plan and project has to be prevented. What would be affected by the adoption of this technology or policy in administration and society is another criterion.

3. Background Conditions that Affect Disposal Orientation

Compared with water treatment, selection of disposal system of solid wastes is more

sensible to society and nature. For example, incineration would degrade air quality by dust and chemicals primarily while landfilling and composting contaminate groundwater with organic matters, heavy metals and air with stench, infection and gas. Decision-makers need to assess how the specific, prevailing background conditions constrain the choices available. The list of conditions that help determine sound practice includes:

3.1 Level of Economic Development and Technological Development

This depends on the kind of disposal technology selected, and a comparison of the nonrecurring expense for facilities construction, on the operational cost and on the technical requirement would be identified in general. For example, the cost of incineration treatment on both facilities construction and operation is much higher than landfill. The most important element for simply equipped composting is marketing demand for composting products. In developing countries, to run a synthetic municipal waste incineration or modern composting system under limited financial support and crude technical conditions would be very difficult.

3.2 Natural Conditions

Most of natural conditions, such as topography, soil characteristics, and type and proximity of bodies of water; climate temperature, rainfall, propensity for thermal inversions, and winds, are important considerations in the process of decision making for the location of waste disposal to a great extent.

3.3 Characteristic of Wastes

These conditions are primarily affected by human activities. Waste characteristics including density, moisture content, combustibility, ability of recycle, and inclusion of hazardous waste in MSW; the characteristics of municipal wastes are closely related to city characteristics such as size, population density, and infrastructure development.

3.4 Political Considerations

Environmental policies, land policies and public environmental regulations frequently interfere with the normal technical scheme. The degree to which decisions are constrained by political considerations, and the nature of those constraints, degree of importance assigned to the various temporary elements.

These background conditions can occur in a huge number of combinations and even with contradictions. This means, that decision-making has to be coordinated to a particular situation referring to these conditions where they affect what should be considered optimum orientation, but it cannot substitute for on-site analysis of the interplay of these factors.

It is apparent that making accurate decisions about MSWM issues can be a complex task. Both long-term and short-term plan is needed to get a balance of cost-effectiveness and

environmental benefit. In a developing country where there is often paucity of funds and serious pollution, the disposal process of municipal waste could be separated into two steps, for example. The target of first step should be to accomplish preliminary harmlessness of waste, pollution control and people's health. The project for the first step should be a system with low investment, getting results fast and short construction period. It could be landfill or simply equipped composting plant for example. Both highly effective modernized facilities (such as large-scale incineration system) and clear environmental benefit would need to be achieved in the latter step.

Decisions regarding waste disposal have large effects on the present and future welfare of people in an area. To practice an ineffective technology will shift the burden of cleanup efforts to future generations. On the other hand, a wise choice of a logical technology or practice can sometimes resolve present problems adequately, while preserving funds for expeditiously resolving other environmental, social, or economic problems.

4. Judgment for Maneuverability of Project

To choose a proper waste treatment system, decision maker has to consider direct positive environmental effects and possible negative effects at the same time. Both short-term and long-term plans should be oriented toward compatible results that can be achieved within the given constraints. In order to establish an exercisable and cost-effective MSWM system, an engineer must evaluate how well the disposal system matches with the other existing or proposed environmental systems. The following aspects could be selected to check the maneuverability of recommended system.

- Choosing a proper system that improves and does not deteriorate the environment and/or aggravate exist critical resources burden. For instance, it is inadequate to build a large-scale landfill without waste compacting in a crowded city or an area in which groundwater has been seriously polluted;
- Sized facilities so they can handle the portion of the waste stream they were designed for, without overlap or competing with other components;
- The facilities should be located such that transportation costs are minimized and appropriate transportation networks are used;
- The system could be operated under concerted financial condition persistently and all discharged pollutants of the system meet relevant environment standards.

5. Waste Reduction

Increasing amounts of municipal wastes is among the topics of major concern today in most cities. On the basis of "from cradle to grave" management principle (also known as Life Cycle Analysis), the logical starting point for solid waste management is to reduce the amounts of waste that must be managed. Agenda 21, the agreement reached among participating nations at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, emphasized, in Chapter 21, that reducing wastes and maximizing environmentally sound waste reuse and recycling should be the first steps in waste management. The environmental, social, and economic benefits of integrating practices of waste reduction into MSWM are the bases for an emerging worldwide agenda for solid waste management.

5.1 Main Consideration for Municipal Waste Reduction

Waste reduction, in all its meaning, is to reduce wastes that have to be collected and disposed of by solid waste authorities to prevent recyclable and compostable organic matters from appending to final waste streams. It is necessary to clarify some important concepts in this field:

- **Source reduction:** To reduce solid wastes at the point of generation. It is the most active and economic way to decrease municipal waste stream. Source Reduction could be accomplished in deferent ways. **Source separation** is the main process which means keeping different categories of recyclable matter and organic matter separate at source, i.e., at the point of generation, to facilitate reuse, recycling, and composting.
- **Waste recovery, materials recovery, or waste diversion**: To obtain useful materials from municipal waste both by source separation or sorting out from mixed wastes that can be reused or recycled. The premise of it is waste classification**,** which means to sort out recyclable components before or after they have been mixed together for collection.
- **Reuse and recycling**: using an unbroken "waste" product for the same or a different purpose is called as "reuse". If the original product has been transformed into secondary resources for manufacturing new products, the material recovery process is called as "recycling".

Action for waste reduction can take place in many routes for achieving waste reduction in different stages in a waste stream. It is as follows:

Source Reduction:

- to enhance consumer's consciousness about environmental protection by public education;
- to reduce the quantity of materials used in products or packaging;
- to urge producers of products to accept a degree of responsibility on treatment or recovery of the wastes produced from the products they manage;
- to reduce production and application of perishable consumer goods.

Classification and Recovery

- diversion of materials from the waste stream through waste exchange.

5.2. Systems of Waste Reduction and Materials Recover

In the affluent countries, the main motivations for waste reduction are related to the high cost and scarcity of sites for landfills, and the menace caused by toxic materials in the wastes. In some developing countries that even do not have significant disposal pressures, because they cannot afford to spend more money and effort on the increased quantities of wastes that will inevitably be produced as consumption levels rise.

The differences of MSWM between the industrialized and the developing countries are clearly apparent in waste reduction and materials recovery. Rising living standards and the richness of mass production have reduced markets for used materials in the affluent countries.

There is a great potential for waste reduction in developed countries, and recycling has endured and the recovery of synthetic or processed materials is now being emphasized. Whereas, in most of the developing world, traditional labor-intensive practices of repair, reuse, and waste trading persist.

In the developing countries, the greatest potential for waste reduction currently rests with diverting organic and construction wastes. The reason is that organic matters are the largest category of MSW and the greatest reduction in wastes for disposal can be achieved by diverting organic matters.

Typical Systems for Source Separation and Materials Recovery

Industrial countries

- Source separation of different categories of waste by the government or private industries;
- Collection of organics for large-scale composting;
- Promotion of backyard composting;
- Public educational campaigns to sustain participation in all aspects of waste reduction.

In many industrialized countries, municipal governments, private industries or foundations heavily subsidize source separation and curbside collection programs. When municipal funding is withdrawn, the scope of materials recovery may be greatly reduced. These countries usually have the institutional competence and capacity in urban government to integrate local and regional waste management plans.

Citizens tend to be highly aware of the problems and to cooperate in separation programs. Undeveloped or fluctuating markets for recyclable materials, however, continue to limit cost recovery and the diversion of materials from landfills.

Developing countries

The engines of waste recovery and recycling in the poorer countries include: scarcity or expense of raw materials, the existence of poverty, the low wages of workers, and the large markets for used goods and products. Wastes have a value. For compost, the majority of municipal wastes in dump sites as well as materials recovery could be utilized in developing countries.

Because so many people are engaged in the activities of materials recovery, processing, and recycling, it is still hard to be organized by governments and social organizations.

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Biographical Sketch

Yuan Guangyu is Professor of Dept. of Environmental Science & Engineering, Tsinghua University, Beijing, China; Committee member of Chinese Environmental Radiochemistry Professional Commission. During 1963-1970 he was National Defense Scientific and Technological Commission, Beijing, and since 1970 he is with the Dept. of Environ. Eng. Tsinghua Univ. His Background is Radioactive Chemistry and Nuclear Fuel Technology and his current activity and interest are in Environmental Engineering.

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