- IJEP 8 (9) : 676 - 680

Economics of Urban Solid Waste Management

G.K. Roy

Regional Engineering College, Department of Chemical Engineering, Rourkela - 769 008

Social crisis arising out of energy and material shortage and ecological imbalance is going to hit the developed and the developing nations of the world in a big way. Of late, the attention of the city planners and the scientists has rightly been focussed on the huge tonnages of solid waste generated by the urban folk, which otherwise poses a serious threat to the habitat due to its improper and unscientific disposal. On the other hand, hygienic solid waste management techniques are often cost - intensive. Technological innovations with resource or energy winning are economically - balanced propositions for urban solid waste management. In this article, a socio - economic analysis of the traditional and the recent methods of urban solid waste management has been presented. Strategies for economic solid waste management in the Indian context have also been highlighted.

INTRODUCTION

It needs hardly to emphasize that by the turn of the century, most countries of the world, especially the developing ones are likely to face a grim situation arising out of energy and material shortages and environmental pollution. These concerns owe their origin to increasing population, rapid urbanisation, accelerated industrialisation and fast depletion of non - renewable resources. These factors together constitute a potential threat to the quality of life in the years to come, unless remedial measures are taken up. In this changed scenario attention of the scientists, the planners and the public alike has been drawn to the efficient utilization of the solid wastes, which happen to be the by - product of various human activities.

Mass awareness coupled with stringent governmental regulations for the maintenance of a clean habitat are gradually putting an end to the traditional practices of waste disposal, such as dumping on the ground or burning in the open air. In addition, the present situation calls for technological innovations in the field of waste management as there is need to develop new patterns of utilization of renewable resources of the waste stream through efficient recycling.

As per the definition of World Health Organisation solid waste comprises of unwanted and discarded materials from houses, street sweepings, commercial and agricultural operations arising out of mass activities. The urban solid waste (USW) is a mixture of vegetables and non vegetable wastes in cooked and uncooked stages, leftovers, packaging of different kinds, papers, plastics, rags and other fabrics, dust, ash and a variety of combustible and non - combustible matter. The USW excludes the trade and industrial wastes that contain a variety of toxic and hazardons materials.

with rapid migration of rural masses to urban areas, particularly in developing countries, USW is being produced at an ever - increasing rate. The compositions of USW are related primarily to the standard of living and dietary habits of the population. There exists a gulf of difference between the city garbage of a developed country and a developing ones (Table 1). The composition is also time - variant (Table 2). In addition to the qualitative difference, the quantum of generated city garbage shows wide variation too. As for example, a city dweller in the U.S. generates on an average almost six times more USW compared to his Indian counterpart.

Table 1. ***Economic analysis of a modular incinerator of the United States***

Plant capacity	:	20 tonne/day
Work days	:	230/year
Burning capacity	:	90 %
Thermal efficiency	:	50 %
Anticipated life	:	25 year
Initial capital cost, $	:	325000
Annual operating cost, $		

Item	Amount, $	% of total
Materials supplies and ash disposal	13100	8
Labour	113700	65
Utilities (water,		

electricity and fuel oil)	7700	4
Capital charges	39200	23
Total annual cost	173700	
Cost/tonne, $		: 46.2
Gross operating cost per tonne, $		: 46.2
Average revenue per tonne, $		: 10.0
Net disposal cost per tonne, $		: 36.2

Table 2. *Economic and operational data on pilot incinerators of Bombay*

I. Hospital waste incinerator at Group T.B. Hospital : Sewree incinerator cost (1979 - price)	:	Rs. 6.51 lakh
Incinerator capacity, tonne/day	:	1.5
* Cost of incineraton per tonne	:	448
Disposal cost by the conventional method per tonne		220
II. 'RAT' Incinerator at hafkine institute Parel. Incinerator cost (1983—price)	:	Rs. 6.0 lakh
Incinerator capacity, kg/hr	:	100
Incineration cost per hr**	:	Rs. 155
Disposal cost by the conventional method per day	:	Rs. 220

* Includes interest, depreciation, labour and supervision charge, utilities, maintenance)
** Rs. 930/ - day on a 6 - hr working

URBAN SOLID WASTE MANAGEMENT TECHNIQUES

Solid waste management involves interply of six functional elements, namely generation of waste, storage, collection, transfer and transport, processing, and recovery and disposal. It encompasses planning, organization, administration, financial, legal and technological aspects involving interdisciplinary relationships. Inspite of the large expenditure involved, it has received scant attention in developing countries resulting in insanity conditions in most of the towns and cities. The attention provided falls for short of the known and desired practice which could be attributed to public apathy, entrenched habits and traditions and vested interests leading to ineffective management.

There is, however, no single technique which is suitable in all situations. Depending upon the availability of land and its topography, economic .viability,-, available technology and social conditions any one or more of the following techniques could be employed : (i) Open dumping, (ii) Controlled tipping or sanitary landfill, (iii) Composting, (iv) Incineration (with or without power generation), and (v) Pyrolysis.

Open dumping

The cheapest and the oldest method of USW disposal ir 'open dumping' where the refuse is dumped in low - lying areas on the clty out - skirts and levelled by bull - dozers from time to time. In spite of its simplicity in execution, the financial involvement for this traditional method of waste management has been quite high particularly for the big metropolis. As for example, the corporation of greater Bombay spends around 9% of its annual budget which is over 17 crore of rupees per year with an average disposal cost of around Rs. 150 per tonne of USW.

In spite of heavy financial involvement, the drawbacks of open dumping are : (i) exposure to flies and rodents, (ii) a source of nuisance from smell and repulsive appearance, (iii) partial disposition of the loose refuse by the action of wind, and (iv) Serious pollution of surface and ground water. With horizontal growth of cities, particularly metropolis, new housing colonies are coming up close to the former dumping areas and essentially for this reason 'open dumping' should be discontinued in a phased manner.

Sanitary landfill

Sanitary landfill or controlled tipping is the most satisfactory, method of city solid waste disposal where suitable land is available near - by. In this method, the USW is levelled in layers, compacted and covered with earth. The decomposition takes 4 to 6 weeks. Sanitary landfill was tried in England in 1916 and later in 1930 in the United States. Communities in the U.S. have been encouraged to use this technique for USW management for the following reasons : (i) The equipment required to operate is relatively inexpensive and can be used for other municipal operations as well; (ii) Rodent breeding is reduced; (iii) Serious threat to-community health represented by open dumping or burning is avoided; (iv) They can be put to operation quickly; and (v) They can be used to reclaim swamps, marshes, etc. Precisely located and fully operated landfills may even enhance property values,

Composting

Decomposition and stabilization of solid organic waste material has been taking place in nature ever since life appeared on this planet. With the progress of civilization and advancement of scientific knowledge efforts are being directed towards rationalizing and controlling the process in such a way as to make it more effective and efficient. The process that have evolved as a result are referred to as 'composting' and the final product called 'compost'. Application of composting in USW management stems from the following socio - economic objectives : (i) Recycling of organic waste to prepare organic manure, (ii) Hygienic waste dispo sal by the municipalities, and (iii) Supplementing the soil fertilizer in view of short - fall of chemical fertilizer. Normally composting is practised in two different ways, namely window, and mechanical methods.

In the first case, garbage is heaped in rows and mechanically turned over. It takes three weeks for full composting. The Delhi Municipal corporation is operating a window composting plant of 150 tonne/day capacity. In the case of mechanical composting the refuse is shreded and spread over a large area with air blown through the mass. As a result, bio - degradation process is accelerated and completed within a week. For successful operation, the moisture content of USW should be 50 - 55 % because biochemical reaction (that is composting process) slows down when the moisture exceeds 55 % and finally stops at 60 %. Another limiting criterion is carbon : nitrogen ratio which should be less than 35 otherwise the city refuse is to be enriched with respect to its nitrogen content before put to mechanical composting.

Mechanical composting is capital - intensive and maintenance - prone. Production is hampered due to the presence of a large quantity of glass, ceramic and metal pieces. The product is not very attractive to users because of its low nutrient content (N : 0.8 - 1.0 %, P : 0.6 - 0.8 % and K : 0.8 %) and the presence of tiny glass and metal pieces. In Deonar, Bombay a 300 tonne of garbage/day (2 - shift) plant was commissioned in early eighties with an investment of about Rs. 1.5 crore for an annual compost output of 45000 tonne. The product cost of compost is Rs. 60 - 75 / tonne (varies from Rs. 20 - Rs. 80 normally). However, the functioning of the plant has not been very smooth due to high input and operational cost and is on the verge of closing down. The composting plant can become an economically viable proposition when treated as a service rendering unit rather than a remunerative enterprise. Therefore such plants, when under direct ownership and control of municipality, function satisfactorily with the primary objective of garbage disposal, sale of compost being a secondary one. When run privately, cash economy creeps in and the plant is not economically viable. In order to make the composting plant cost - effective, following factors can be looked into while going for new units : (i) Low capital investment, (ii) Low power utilization, (iii) Mobile machinery, (iv) Low transport cost, (v) Selection of garbage, and (vi) Indigenous machinery on the basis of the analysis of garbage.

Incineration

Incineration is a hygienic method of disposal of USW and is in practice since long. Depending on the quantum and characteristics of the refuse, the process can be applied to steam and electricity generation as well. Hamburg has been producing electricity from household refuse since 1896. A few other early refuse - fired energy systems were of Chicago (1877), Paris (1903), New York (1903), Zurich (1904). Japan processes more waste for energy than any other country. While in the United States advanced chemical systems of disposal has been tried, in the rest of the world mass burning energy recovery systems are common. The central European countries have concentrated on high temperature steam systems for electricity generation from USW and used for district heating. In Scadinavian countries generally high pressure hot water is produced for direct heating.

Although around 90 % volume reduction of USW is possible and the process can be coupled with turbo - generator for energy production, incineration process has certain drawbacks, namely : (a) The ash produced from incineration is quite reactive and demands careful disposal; (b) Fines and gaseous effluent produced contribute to air pollution; and (c) Cost of incinerator and additional investment on pollution control devices make the process capital - intensive. The incineration of USW can primarily be conducted in three different modes, that is (i) Direct combustion of unprocessed USW, (ii) Preparation of refuse derived fuel (RDF) and its direct combustion, and (iii) Co - generation.
While in the first method unprocessed USW is incinerated directly, in case of second a few troublesome components are separated in the first step to prepare RDF which burns with a higher thermal efficiency.

Use of USW (as RDF) along with other conventional fuels (for example coal, fuel oil, natural gas) for steam and electricity generation is termed as 'co - generation'. Preparation of RDF induces extra investment and not much break - through has been made in case of 'co - generation'in view of specialized nature of technology involved. Hence direct incineration of unprocessed USW is in wide practice the world over. Incinerators of rotary kiln, multiple health, fluidized bed and other types are available in the capacity range of 50 kg to 20 tonne per hour. In the United States shop fabricated incinerators with single unit capacity of 25 - 30 tonne / day commonly known as 'modular incinerators' are in wide use. Capital cost per daily tonne has increased almost eight - fold during the last twenty five years ($13000-15000 in 1960 to $ 100000 in early eighties) for such units. Calorific value, ash and moisture content in addition to other parameters would indicate whether the waste can sustain combustion of its own without the addition of auxiliary fuels.

Use of auxiliary fuel has adversely effect on the economics of an incineration plant. Relevant economic data for a modular incinerator is presented in table 1. With increase in the incinerator capacity the operating cost is reduced to around $ 30 for a 100 tonne/day unit. Majority of Indian USW is too wet and contains excessive dust. Its calorific value is quite low. The data collected from 33 Indian cities indicate that in most of the cases, the USW requires an auxiliary fuel to sustain combustion. Since the refuse of the developed countries has a much higher calorific value, incinerators function reasonably well and some of these even generate power. In India, small incinerators are used by the Bombay municipal corporation for burning highly contagious pathogenic wastes and dead rats, albeit it is costlier than the conventional method of disposal. (Table 2). Under Indian conditions large scale incineration plants are economically non - viable in view of their capital - intensive character and the low calorific value of city garbage available. Such plants may be attractive to municipal authorities while making marginal contribution to energy supply hut becomes unattractive when it threatens to make a substantial contribution due to non - availability of an economic customer for the vast quantum of power generated.

Pyrolysis

Pyrolysis is an irreversible chemical change brought about by the action of heat in an atmosphere devoid of oxygen. The process is carried out at temperature between 500 - 1000 °C to produce three component streams, namely gas, liquid (tar) and solid (char). Various advantages claimed of the process are ; (i) Substantial volume reduction (50 - 90%), (ii) Production of solid, liquid and gaseous fuels, (iii)Storable / transportable fuel or chrmical feed stock is obtained, (iv) Minimal environmental problem, (v) Less capital investment compared to the incineration process, and (vi) Once started, the process is self - sustaining. The process of pyrolysis, though the most promising method of USW treatment both from the point of view of economic viability and social acceptibility, yet not much headway have been made as regards setting up of full scale commercial plants. A scheme for setting up of a methanol plant based on the pyrolysis of Bombay city garbage is under active consideration. Capital investment for the project when finalised in 1984 was around Rs. 232 crore. Gross profit was estimated to be Rs. 63.5 crore amounting to 27.4% return on capital.

STRATEGIES FOR ECONOMIC SOLID WASTE MANAGEMENT : INDIAN SCENARIO

Improper and unscientific techniques adopted for USW disposal are economically non - viable and socially unacceptable. Recycling of waste for winning energy and resources in an efficient and safe manner is no doubt, an economic proposition particularly for the developing countries, but the recovery is beset with a number of constraints which are to be carefully analysed.

The high cost of mechanical composting plants and the non - utilization of by-products are among the factors which make the process an uneconomic proposition. The most critical link in the process of composting is the segregation operation. Hand sorting of garbage at the compost plant is expensive and insanitary. Better separation methods arc to be evolved. The quality of the final product should be enriched with mineral fertilizers and microbial cultures so as to make the setting up of mechanical composting plant economically viable. Supply of compost at subsidized rates and its free transportation to farms may help *to* popularize this product. The high investment on complete mechanisation of the compost plant coupled with the costs of repair and servicing emphasize the need of setting up of mini - mechanical compost plants which would be more appropriate under the socio - economic conditions prevailing in India.

Process of incineration is not Very much promising in view of its capital - intensive nature and generation of solid and gaseous effluents. It is not relevant in the context of resource recovery also. Winning energy by incineration of USW is not very attractive from economic standpoint particularly for large units as has been discussed earlier.

The residues of pyrolysis, namely combustible gas, tar and charcoal, have economic value, yet these products have not found wide acceptance commercially. The tar is full of water and must be refined. The charcoal contains glass and metal pieces, which have to be separated prior to its use. Further it is necessary to pyrolyze the constituents of USW individually and to determine the overall yield by additive process and to standardize the pyrolysis and gasification steps under Indian conditions.

CONCLUSION

Urban solid waste is a major source of land, water and air pollution when exploited inefficiently, Recycle of these biodegradable materials for the recovery of energy, chemical feed stocks and fertilizer could help to meet the growing needs consistent with the maintenance of a clean habitat.