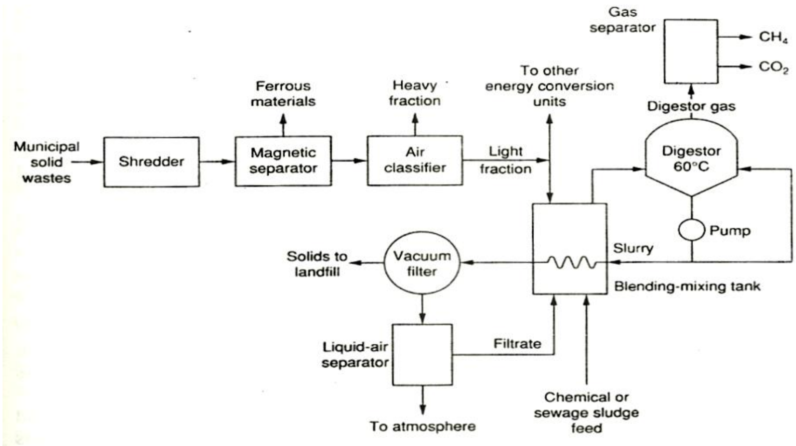
Technology Fact Sheet

Low solid anaerobic digestion[i]

1) Introduction

Low-solid anaerobic digestion is a biological process in which organic wastes are fermented at solid concentration equal to or less than 4-8 percent. The low solid fermentation process is used in many part of the world to generate methane gas from human, animal and agricultural wastes, and from the organic fraction of MSW. One of the disadvantages of LSAD is that considerable water must be added to waste to bring the solid content to the required range of 4 to 8 percent. The addition of water results in a very dilute digested sludge, which must be dewatered prior to disposal. The disposal of the liquid stream resulting from the dewatering step is an important consideration in the selection of the low solids digestion process (Tchobanoglous *et al*, 1993).

Figure 1 Flow diagram for low solid anaerobic digestion process



(Source: Tchobanoglous et al, 1993)

There are three basic steps involved whenever the low-solid anaerobic digestion process is used to produce methane from the organic fraction of MSW. The first step, involves the preparation of the organic wastes such as sorting and separation, and size reduction. The second step involves the addition of moisture and nutrient, blending, pH adjustment to about 6.8, and heating of the slurry to between 55 and 60 ^{o}C, and the anaerobic digestion is carried out in a continuous-flow reactor whose contents are mixed completely. The third step in the process involves the capture, storage, and, if necessary, separation of the gas component. The dewatering of the digested sludge is an additional task that must be accomplished. In general the processing of the digested sludge is so expensive that the process has seldom been used (Tchobanoglous *et al*, 1993).

2) Technical requirements

Carried out in the absence of oxygen, the anaerobic stabilization process or convertion of the organic material in MSW occurs in three step. The first step involves the enzyme-mediated transformation (hydrolysis) of higher molecular mass compounds into compounds suitable for use as of energy and cell tissue. The second step involves the bacterial conversion of the compound s resulting from the first step into identifiable lower-molecular mass intermediate compounds. The third step involves the bacterial convertion of the intermediate compounds into simpler end products, principally methane and carbondioxide.

Table 1 Important technical requirement for low solid anaerobic digestion process

Waste component	Comment
Size of material	Wastes to be digested should be shredded to a size that will not interfere with the efficient functioning of pumping and mixing operations.
Mixing equipment	To achieve optimum results and to avoid scum buildup, mechanical mixing is recommended.
Percentage of solid wastes mixed with sludge	Although amounts of waste varying from 50 to 90+ percent have been used, 60 percent appears to be a reasonable compromise.
Hydraulic and mean cell-residence time	Washout time is in the range of 3 to 4 d. Use 10 to 20 d for design, or base design on results of pilot plant studies.
Loading rate	0.04 to 0.10 $lb/ft^3 \cdot d$ (0.6 to 1.6 $kg/m^3 \cdot d$). Not well defined at present time. Significantly higher rates have been reported.
Solids concentration	Equal to or less than 8 to 10% (4 to 8% typical).
Temperature	Between 85 and 100°F (30 to 38°C) for mesophilic and between 131 and 140°F (55 and 60°C) for thermophilic reactor.
Destruction of volatile solid wastes	Depends on the nature of the waste characteristics. Varies from about 60 to 80 percent; 70 percent can be used for estimating purposes.
Total solids destroyed	Varies from 40 to 60 percent, depending on amount of inert material present originally.
Gas production	8 to 12 ft^3/lb (0.5 to 0.75 m^3/kg) of volatile solids destroyed (CH_4 = 55 percent; CO_2 = 45 percent).

(Source: Tchobanoglous et al, 1993)

3) Status of the technology and its future market potential

Over the past 20 years, LSAD of MSW technology has advanced in Europe because of waste management policies enacted to reduce the long-term health and environmental impacts of landfill disposal. This has led to relatively high landfill tipping fees (compared with the U.S.), which, in combination with generous prices paid for renewable energy, has created an active commercial market for LSAD and other MSW treatment technologies in Europe. Installed AD capacity in Europe is more than 4 million tons per year (Mark, 2008).

In some parts of Europe, source separation of the organic fraction of municipal solid waste is common and even mandatory, which contributes to the growth of biological treatment industries. Regions outside of Europe are also enacting more stringent waste disposal regulations, leading to the development of new LSAD and other MSW conversion plants.

The treatment of solid wastes using LSAD adds several new challenges because of the variety in the feedstock and the space limitations where such facilities would be located. The organic fraction of MSW may contain food, yard waste or paper in varying concentrations, sizes, and composition. Furthermore, MSW is contaminated with non-organics, such as glass and metal, and therefore requires pre-treatment to separate the feedstock. Though the ideal waste stream for an LSAD plant would be source-separated organics, the reality is that there is always a small degree of contamination that must be handled on site.

Despite these challenges, European nations have led the way to expanding LSAD to be a significant part of MSW management. Over 70 plants process MSW either alone or with sewage in Germany, Denmark, France, Spain, Austria, Holland, England, Belgium, and other European nations. Additionally, Israel, Australia and Canada have at least one LSAD plant treating MSW. The typical plant processes between 50,000 and 80,000 tons of organic waste per year, with the largest treating 100,000 tons annually. Some plants accept mixed MSW, for example the Vagron plant that treats 232,000 tons of mixed waste per year, 92,000 tons of which are organics. The expansion to the American market has been stalled by failed attempts, such as that in Los Angeles, as well as by lack of government incentives (Ostrem, 2004).

The future of LSAD as a MSW management strategy depends on several factors ranging from environmental concerns to economic considerations. Some of these include increased process efficiency, reduced construction and operation costs, expanding markets for products and decrease in the availability of landfills. It seems that AD will continue to play a role in MSW, but to what extent is unknown.

4) Contribution of the technology to protection of the environment

LSAD facilities are capable of producing energy and reducing the biodegradable content of the organic waste prior to composting, which reduces emissions of pollutants and greenhouse gases. LSAD has the potential to minimize the environmental impact of waste disposal by reducing the amount of biodegradable materials in landfills.

LSAD of municipal solid waste (MSW) is used in different regions worldwide to:

- Reduce the amount of material being landfilled
- Stabilize organic material before disposal in order to reduce future environmental impacts from air and water emissions
- Recover energy

5) Climate

LSAD has the advantage of generating energy, which reduces emissions of climate hange gases by offsetting emissions from fossil fuelled power stations. It therefore gives higher net carbon savings than composting. If 5.5 million tonnes of waste was treated by LSAD it could generate between 477 and 761 GWh of electricity each year. Compared to composting the same amount of food waste, treating it with LSAD would save between 0.22 and 0.35 million tonnes of CO_2 equivalent, assuming the displaced source is gas-fired electricity generation. Using the soil improver also brings climate benefits through storing up some carbon in the soil and by displacing the use of mineral fertiliser, which requires significant energy input to produce (Friend of the Earth, 2007).

The net greenhouse gas flux from LSAD (Smith *et al*, 2001):

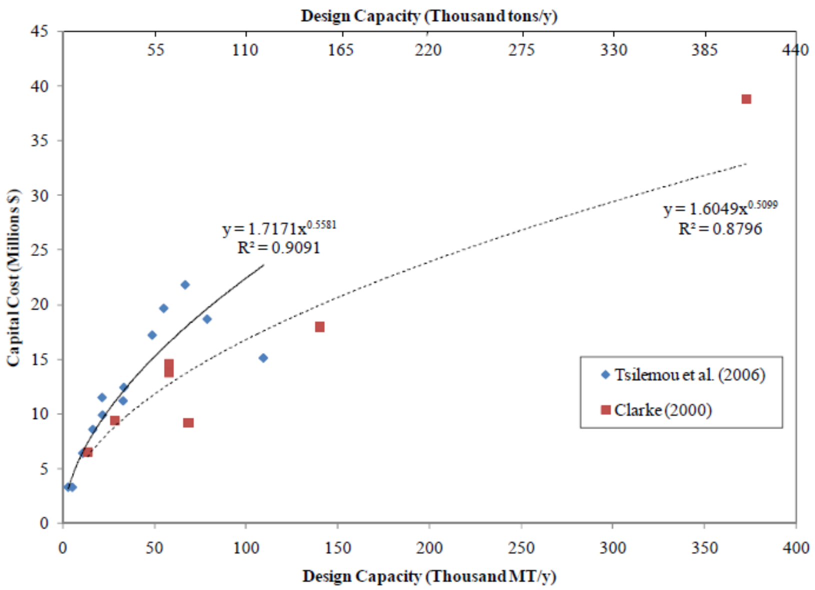
- The net greenhouse gas flux about -33 kg CO2 eq/tonne of MSW
- The net greenhouse gas flux about -461 kg CO2 eq/tonne of MSW (AD, recycling, landfill residue) include sequestration

6) Financial requirements and costs

One comprehensive cost analysis extracted cost data on 16 different MSW AD facilities from the literature and adjusted the data for consistency . The capital costs considered included all predevelopment and construction costs. Operating costs included labor, maintenance, materials, testing, insurance, overheads, and training costs, but not the costs of transporting residuals to disposal sites or any revenues. A second study also published capital and operating costs for a handful of European MSW digesters, but did not adjust the cost data for consistency.The capital and operating costs, originally reported in 2003 euros, were converted to 2007 dollars. Then the data were multiplied by the consumer price index for 2003 to convert to 2007 dollars and the cost curves were plotted (Mark, 2008).

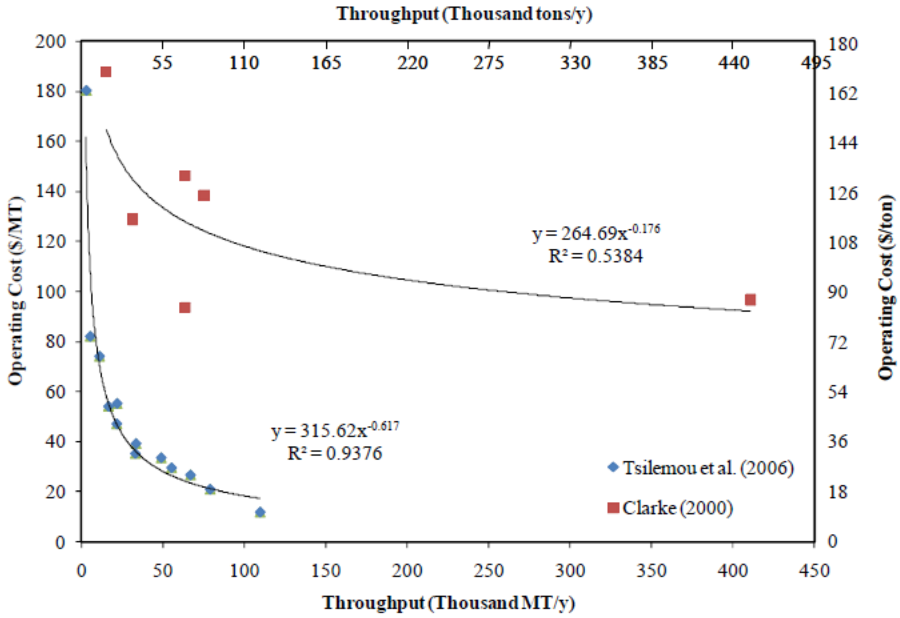
Although separated by 10 years, the capital cost curves from the two studies were very similar. Differences could be due in part to differences in the cost items included in the different studies. There was an economy of scale of about 0.5 for both studies. The operating cost curves were different for the two studies; however, the earlier data did not fit the curve well, indicating that they may not include the same cost items. The data that fit the cost curve had an economy of scale of 0.6. researchers, the estimated capital cost for a 70,000 MT/y (76,000 tons/y) digester proposed for the CSU Channel Islands campus was $17 million. According to the above cost curve, the predicted cost for such a plant is about $19 million. A feasibility study for a similarly sized 63,000 MT/y (69,00 tons/y) digester in Iowa estimated the capital and operating costs to be $14.2 million and $11.14 per MT ($10.11 per ton), respectively. The study found the project to be economically marginal and highly dependent on the amount of heat sold (Mark, 2008).

Figure 2 Capital cost curves for European MSW digesters



(Source: Mark, 2008)

Figure 3 Operating cost curves for European MSW digesters



(Source: Mark, 2008)

7) References

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Smith, A., Brown, K., Ogilvie, S., Rushton, K., and Bates, J. 2001. Waste Management Options and Climate Change, Final report to the European Commission, DG Environment. AEA Technology, Culham.

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[i] **This fact sheet has been extracted from TNA Report - Mitigation for Indonesia. You can access the complete report from the TNA project website http://tech-action.org/**