Technology Fact Sheet

In vessel composting[i]

1) Introduction

Composting is a biological degradation process in which microorganisms transform organic materials into a soil-like material called compost under controlled conditions. Organic materials that can be used to produce compost include food wastes, leaves, wood, manure, paper and sewage sludge. The decomposition of organic materials is a dynamic, natural process. The difference between natural decay and composting is that during the composting process people control the conditions under which the decomposition takes place (Ripley, S., and Mackenzie, K. 2008).

The primary objectives of composting organic materials are the following:

- Convert biodegradable organic waste into a biologically stable product and reduce the original volume of the waste;
- Retain the nutrient content of the original waste (nitrogen, phosphorus, potassium and micronutrients);
- Produce a product that can support plant growth and improve soil structure;
- and Destroy pathogens or unwanted microorganisms, insect eggs and weed seeds.

All composting systems, regardless of their scale, are designed to provide an environment in which the natural process of aerobic degradation of organic waste is optimized to produce a stable end-product of compost. There are four main types of composting methods:

- Turned windrows
- Aerated static piles
- Enclosed channel system
- In-vessel system

In-vessel composting is accomplished inside an enclosed container or vessel. Type of vessel has been used include vertical tower, horizontal rectangular and circular tanks, and circular rotating tanks. In-vessel composting system can be divided into plug flow and agitated bed. In plug flow system, the relationship between particles in the composting mass stays the same throughout the process and the system operates on the first-in, first-out principle. In an agitated bed system, the composting material is mixed mechanically during the processing. Mechanical systems are designed to minimized odor and process time by controlling environmental conditions such as airflow, temperature, and oxygen concentration. The popularity of in vessel system become increase because of odor control, faster, lower labor cost, and small area requirements. The detention time in vessel varies from 1 to 2 weeks, but virtually system employ a 4- to 12- week curing period after the active composting period (Tchobanoglous *et al*, 1993).

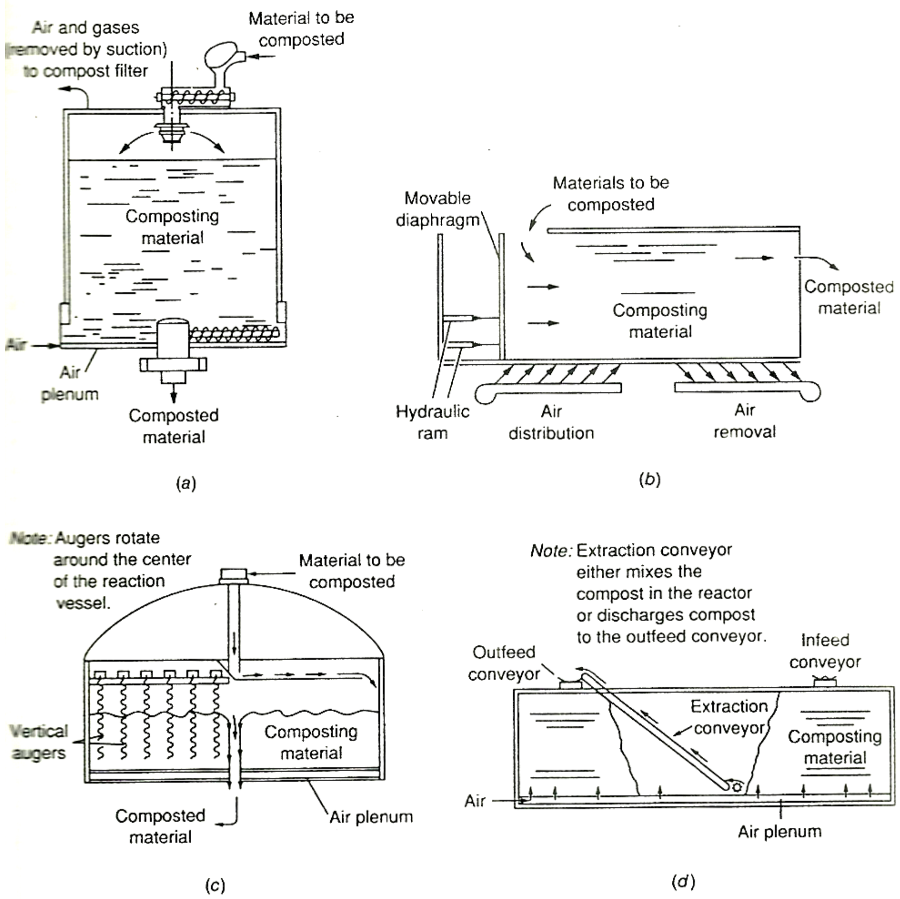
Carried out in the absence of oxygen, the anaerobic stabilization process or convertion of the organic material in MSW occurs in three step. The first step involves the enzyme-mediated transformation (hydrolysis) of higher molecular mass compounds into compounds suitable for use as of energy and cell 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 (Tchobanoglous *et al*, 1993).

2) Technical requirements

With in-vessel systems, the composting process takes place in a confined space, which is usually a highly controlled, sealed chamber. Access is normally restricted; even facility personnel usually do not enter. Composting is an intensive aerobic conversion process in a tunnel with forced air. Organic materials can be processed as a batch, or can be moved progressively through a structure by the pressure of incoming new material. There are many different types of in-vessel systems, including fixed, portable and non-rigid vessels. In-vessel systems can involve channels, tunnels or other types of containers. All invessel systems involve proprietary knowledge or technology and are thus relatively expensive compared with other composting systems. Windrows are needed to cure the compost once it has been processed within the composting vessel.

In-vessel systems require the least amount of space of all composting systems, and most are installed inside a building. However, almost all in-vessel systems require windrows or aerated static piles to finish the composting process after the material has moved through the vessel. In-vessel systems are usually used in locations with relatively high volumes of organic waste generation, and space and/or odour concerns, such as in larger communities. Although in-vessel systems can be designed to process quantities of organic waste as low as 365 tonnes per year, invessel systems are often not economically feasible at such low processing rates. In-vessel composting facilities in Germany and the Netherlands have demonstrated that container in-vessel systems can treat from 3,000 to 20,000 tonnes of vegetable, fruit, and garden waste per year (Ripley, S., and Mackenzie, K. 2008).

Figure 1 In-Vessel Composting units: (a) unmixed verticalplug flow reactor, (b) unmixed horizontal plug flow reactor, (c) mixed (dynamic) vertical reactor, (d) mixed (dynamic) horizontal reactor.



(Source: Tchobanoglous et al, 1993)

In-vessel systems produce compost in the shortest amount of time. For some systems, organic materials remain in the vessel for one to two weeks, and then must be cured for at least a month in optimal conditions.

In-vessel composting systems provide the highest amount of process control and involve the most intensive use of equipment and technology. As a result, these systems also tend to be the most expensive centralized composting method. For example, tunnel systems use compartments made of concrete or another material that can be closed with an insulated door. Each compartment has ventilation equipment, recirculation ducts and a mechanism to heat or cool the recirculated air.

Table 1 Advantages and disadvantages of in-vessel composting

Advantages	Disadvantages
• Require the least amount of land • Most rapid production of compost – highest control of composting parameters. • Odours can be controlled reasonably well inside a building in most cases. • Control release of leachate.	• Most capital intensive. • Requires extensive training of personnel. • Higher maintenance and operational costs.

(Source: Ripley, S., and Mackenzie, K. 2008)

3) Status of the technology and its future market potential

In vessel composting generally widely applied in various states in the USA and Canada. Vessel is used typically shaped tunnel or drum. As has been mentioned in-vessel composting systems reserve the bioreactor for the active stage of the composting process and rely upon windrow systems for the curing and maturation phase of the organic matter. The rationale of these systems is to maintain conditions at optimum levels during the active stage of the process and thus accelerating the microbial activity rate and consequently shortening the active phase.

The economic gain of in-vessel systems in comparison to windrow composting is the reduction of residence time and the increase of its processing capacity as well as the better quality of the end product, since the conditions during the process are usually optimized and controlled at all times. However, the economics of some mechanized systems are more unfavorable than those of windrow systems.

4) Contribution of the technology to protection of the environment

In-vessel composting (IVC) just means that the composting process takes place within an enclosed environment. This allows for the temperature levels to be strictly monitored and controlled. Like any composting process the material relies on natural bacteria to rot the material down. With in-vessel composting the process is much hotter - up to 70 degrees which kills off pathohenic bacteria and weeds.

Environmental Advantages of In-Vessel Composting are;

- Reduces volume of organic waste going to landfills.
- Reduces odor and vermin attraction
- Compost is slow- release and will not leach out.
- Compost conser ves water
- Reduces greenhouse emissions (production of landfill methane also produces $C0_2$ which is more harmful than methane)
- Compost has valuable nutritional value and has a ready market.
- Provides additional recycling credits.

5) Climate

Most of the greenhouse effect attributable to waste management can be ascribed to methane, which is produced by the anaerobic digestion of biodegradable waste in landfills. Approximately one-third of all anthropogenic CH_4 emissions within the EU derive from that source. By contrast, only 1 % of the N_2O emissions and less than 0.5 % of the CO_2 emissions can be traced to landfilled waste. Hence, reducing CH_4 emissions from landfills holds the greatest potential for reducing greenhouse gas emissions in the waste-management context. In-Vessel Composting can reduce the organic waste going to landfill, so that landfill gas production can be reduced.

The net greenhouse gas flux from In-Vessel Composting (Smith *et al*, 2001):

- The net greenhouse gas flux about -10 kg CO2 eq/tonne of MSW
- The net greenhouse gas flux about -461 kg CO2 eq/tonne of MSW (compost, recycling, landfill residue) include sequestration

6) Financial requirements and costs

There are a wide range of costs dependent upon the complexity of the technology and the degree of mechanisation and automation employed. The table below shows indicative capital and O&M for In-Vessel Composting facilities. These costs provided are predominantly based on US examples. Costs in the Indonesia will involve differing site specific issues such as permitting, labour, emission controls and other requirements.

Table 2 Tipical capital, O&M costs for in-vessel composting facilities

Costs	Major System Components	Cost Basis	Cost (US dollars)
Capital Costs	Feedstock derived from processing of commingled waste; enclosed building with concrete floors, MRF processing equipment, and in-vessel composting; enclosed building for curing of compost product	$/ton of capacity per day	25,000 – 50,000
Operation and Maintenance Costs	Feedstock derived from processing of commingled waste; enclosed building with concrete floors, MRF processing equipmmment, and in-vessel composting; enclosed building for curing of compost product	$/ton	30 – 50

(Source: Tchobanoglous, G and Kreith, F (2002))

7) References

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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/**