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Composting As Wise Waste Diversion Technique

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COMPOSTING AS WISE WASTE DIVERSION TECHNIQUE

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COMPOSTING AS WISE WASTE DIVERSION TECHNIQUE

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Abstract

There are several MSW management approaches, but the most effective are source reduction, recycling, and reuse called (3R), which can prevent or divert materials from the waste stream. Source reduction involves altering the design, manufacture, or use of products and materials to reduce the amount and toxicity of what gets thrown away. The other approaches are recycling and reuse processes, in which inorganic part can be separated to achieve recycled products while, organic waste or green waste can be decompose to produce usable substance called **compost**. This alternative approach for handling organic waste turned as wise waste alternative for achieving environmental friendly end product which would reduces waste burden from landfills and creates sustainable environment.

Generally, the paper discusses process and importance of organic composting as an alternative approach in reducing and diverting the organic waste burden from the traditional waste disposal methods like, landfilling or incineration and analyses its advantages towards the municipalities and local communities in adopting organic waste diversion approach to achieve natural soil conditioner called **Compost**.

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Naeem Memon

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1. Introduction

1.1 Background

The waste management system is designed to assist municipalities to develop a comprehensive, long term system for the management of municipal wastes, including industrial, commercial and institutional wastes, within a specified planning area. There are several MSW management practices, but the most effective are source reduction, recycling and reuse called **(3R),** which can prevent or divert materials from the waste stream. Source reduction involves altering the design, manufacture, or use of products and materials to reduce the amount and toxicity of what gets thrown away. The other approaches are recycle and reuse processes, in which **inorganic** part can be separated to achieve recycled products while, **organic waste** or green waste like food waste and yard trimmings can be decomposes, mainly with the help of naturally occurred microorganisms (mainly bacteria and fungi) or some times engineered ones under controlled conditions, and producing a reusable humus-like substance called **compost**. This alternative approach for handling organic waste turned as a **wise waste diversion** for achieving environmental friendly useable end product (compost) which is not only reduces the waste burden from landfills but also generates valuable resources to combat the future energy needs.

The most significant portion of municipal solid waste (MSW) stream is organic which is a compostable in nature and therefore the technique involves in decomposing the waste called composting. It has the potential to divert a large proportion of material from traditional disposal methods like, landfill and combustion/incineration. It is also important that, the end product (compost) produced be of highest quality so that, if that could be used in agriculture, would not adversely affect human and animal health, food production and the natural environment.

1.1.1 Solid waste management system and its principles

Solid waste management is defined as the systematic organization and administration of activities which provide for the planning, financing, and operational processes for managing solid waste. Operational processes include storage, separation, collection, transport, treatment, diversion for other management purposes like, recycling, **composting**, combustion/incerination, and land filling of solid waste (Tchobanoglous et al. 1993).

Integrated solid waste management system is the whole process of managing the waste from planning to final disposal stage, according to U.S Environmental Protection Agency (USEPA),

"A process for managing solid wastes and materials diverted from solid waste through a combination of source reduction, recycling, combustion and land filling". (USEPA 1998)

The professional approach to handle waste management is based on these three principles are:

1. **Waste prevention/reduction**: This is a key factor in any waste management strategy and if we can reduce the amount of waste generated in the first place and reduce its hazardousness by reducing the presence of dangerous substances in products, then disposing of it will automatically become simpler.
2. **Recycling and reuse**: If waste cannot be prevented, as many of the materials as possible should be recovered, preferably by recycling. It is also described as diversion of specific materials from solid waste stream and processing of those materials for the use as new products and/or other productive uses including **composting** could reduce the overall environmental impact.
3. **Improving final disposal and monitoring**: Where possible, waste that cannot be recycled or reused should be safely incinerated, and with the landfill, only used as a last resort. Both these methods need close monitoring because of their potential for causing severe environmental damage.

THE PROCESS OF SOLID WASTE MANAGEMENT

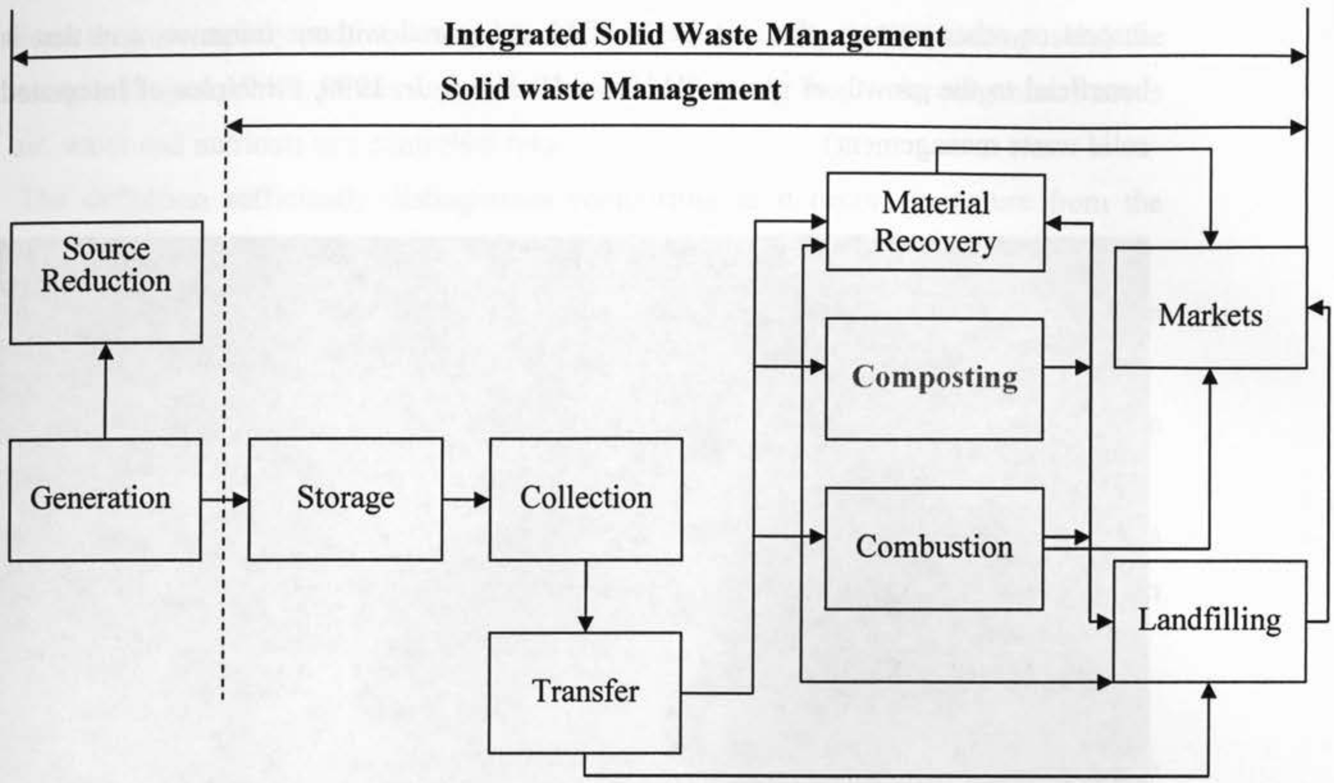


Fig: 1 (Flow diagram of integrated solid waste management)

1.1.2 Defining Composting technology and types

Composting Definitions:

"It's the biological decomposition and stabilization of organic substrates, under conditions that allow development of **thermophilic** temperatures as a result of biologically produced heat, to produce a final product **(compost)** that is stable, free of pathogens and plants seeds, and can be beneficially applied to land." **(Robert T.Haug)**

"**Composting** is the <u>biological decomposition</u> of wastes of plants or animal origin under <u>controlled circumstances</u> to a condition <u>sufficiently stable</u> for nuisance free storage and for use in land application." (MOE, Ontario)

"**Compost** an organic soil conditioner that has been stabilized to a humas like product that is free of viable human and plant pathogens and plant seeds, that does not attract insects or other vectors, that can be handled and stored without nuisance, and that is beneficial to the growth of plants. (H.Lanier Hickman, Jr. 1999, Principles of Integrated solid waste management)

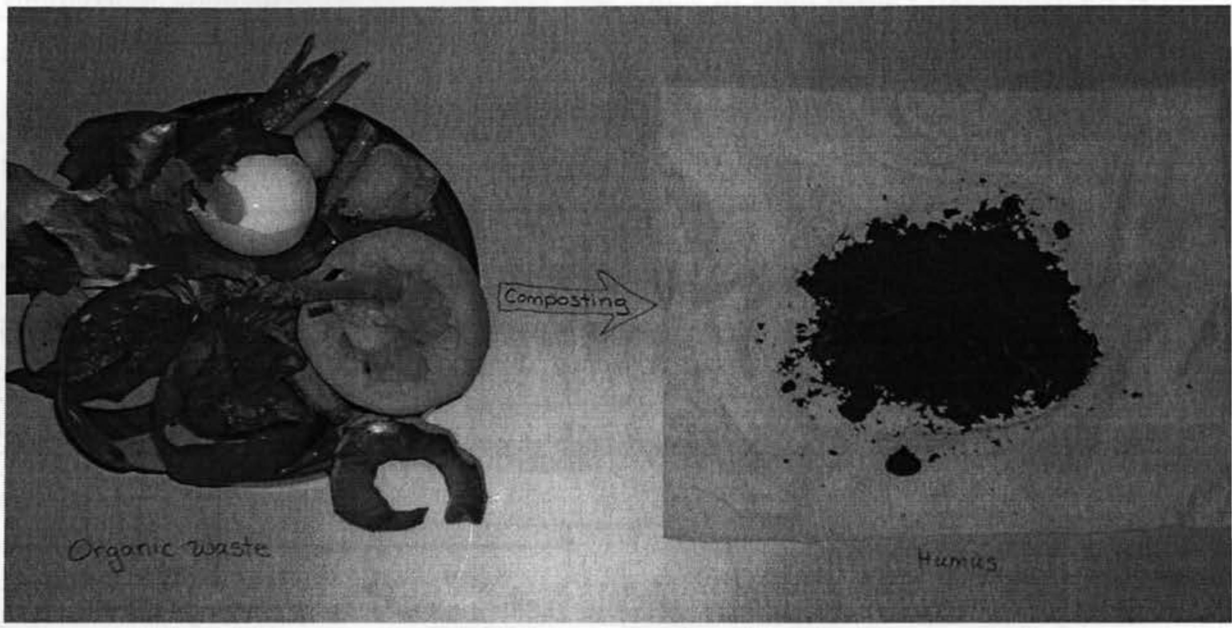


Fig: 2 (Transformation of compost)

Composting background

Composting has increased dramatically in recent years and has been recognized as a means of Solid Waste Management. Now a day's landfill approach has been seemed inappropriate method and expensive way for disposal of solid waste generated in modern communities. The most significant portion of municipal solid waste (MSW) stream is compostable and therefore composting has gained the potential to divert a large proportion of material from traditional disposal methods like, landfill and incineration. It is also important that, the end product **(compost)** produced be of highest quality so that, if that could be used in agriculture, would not adversely affect human and animal health, food production and the natural environment.

Composting is not only a source of food for the things we plant but also it is a part of the solution to the problem of burying our waste in landfill sites. In this technique, large volumes of municipal solid waste can be handled by the natural process of decomposition. The microorganism in the waste are given an environment which allows them to grow rapidly and work at peak efficiency in breaking down (decomposing) the waste and upon all the process to run at its peak efficiency they (microorganism) needs air, water and nutrients at a controlled rate.

The definition sufficiently distinguishes composting as it occurs in nature from the restrictive sense of a waste treatment option. Key terms in the definition are:

1. Biological decomposition, this term implies that composting as waste treatment option is for the most part restricted to organic wastes.

2. Controlled condition, this term distinguishes engineered composting from the simple decomposition that takes place in an open dump or in a feedlot.

3. Sufficiently stable, this term is an important requirement to any compost operation, as the compost product to be innocuous with respect to environmental impact and effect on plant growth, it must be sufficiently stable.

Most biological **stabilization** and conversion processes deal with dilute aqueous solution, and only limited temperature elevations are possible. **Thermophilic** temperatures in aqueous solutions can be achieved if substrates concentrations are high and special provisions **aeration (air)** are employed.

Types of composting

1. **Aerobic** composting is the decomposition of organic substrates in the presence of **oxygen** (air) and the main products of biological metabolism are carbon dioxide, water, and heat.
2. **Anaerobic** composting is the biological decomposition of organic substrates in the **absence of oxygen**. Metabolic end products of anaerobic decomposition are methane, carbon dioxide, and numerous low molecular weight intermediates such as organic acids and alcohols. Anaerobic composting releases significantly less energy per weight of organic decomposed compared to aerobic composting. And, also anaerobic composting has a higher odor potential because of the nature of

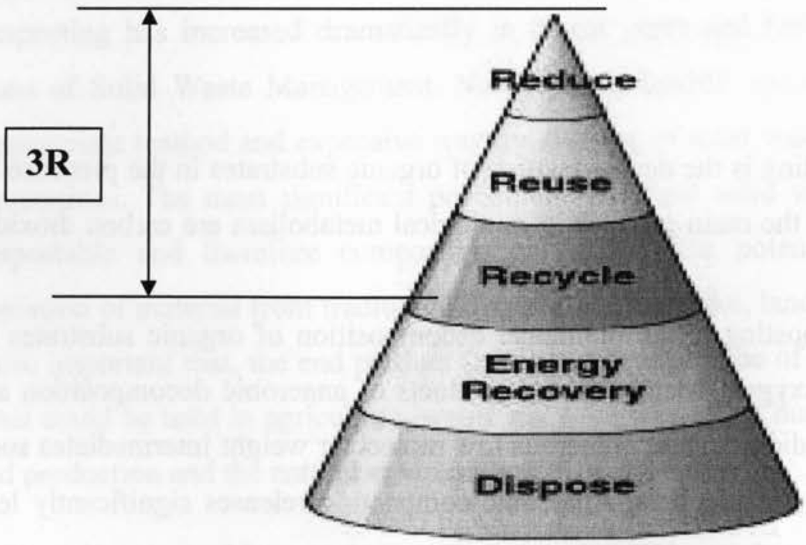
many intermediate metabolites. For these reasons almost all **engineered compost systems** are aerobic.

1.2 Objectives of waste management system

The objectives of waste management system follows the international environmental policies, generally accepted guiding principle of sustainable development that combines with the aspects of ecology, economy and social security.

The objectives and targets of the Waste Management Strategy can be represented in the Waste Management Hierarchy, as illustrated below. The hierarchy highlights the need to move practices away from landfill disposal and to promote reduction, reuse, recycling and recovery.

Fundamentals to achieving these policy objectives are recognition and acceptance by all sections of society, as producers of waste, of their responsibility to support and adopt more sustainable waste management practices, both at home and at work. It is implicit therefore that the perception of waste as an unwanted, but in fact a necessary by-product would need to be change, with recognition of its potential as a renewable resource.



(Waste Management Hierarchy)

Fig: 3

1.2.1 Composting objectives and its benefits

The objectives of composting have traditionally been to convert biologically putrescible organics into a stabilized form and to destroy the organisms pathogenic to humans. Composting is a form of recycling, like the other recycling methods, of yard trimmings and municipal solid waste can help decreases the amount of solid waste that must be sent to a landfill or combustor, thereby reducing disposal costs. At the same time, composting also yields valuable products that can be used by farmers, landscapers, horticulturists, government agencies, and property owners as a soil amendment or mulch. The compost product improves the condition of soil, reduces erosion, and helps suppress plant diseases. It is also capable of destroying plant diseases, weed seeds, insects, and insect eggs. Composting can also effect considerable drying, which has particular value with wet substrates such as municipal and industrial sludge's. Decomposition of substrate organics together with drying during composting can reduce the cost of subsequent handling and increase the attractiveness of compost for reuse or disposal.

Organic composts can accomplish a number of beneficial purposes, when applied to the land;

- Compost can serve as a source of organic matter for maintaining or building supplies of soil humus, necessary for proper soil structure and moisture holding capacity.
- Compost can improve the growth and vigor of crops in commercial agriculture and home related uses. Colonization by beneficial microorganisms during the latter stages of composting appears to be responsible for inducing disease suppression.

2. Classification of composting system

A number of approaches have been used to categorize composting systems. The most basic distinction is between systems, in which the composting material is contained in a reactor and those in which it is not called non-reactor. (Haug 1993)

Systems that uses reactors are popularly termed "mechanical","enclosed",or "in-vessel", whereas, those that **do not** are often termed "open" systems or "non-reactor."

U.S. practice has adopted the term "in-vessel" for reactor type systems but in chemical engineering practice for the design of processing plants can be classified are;

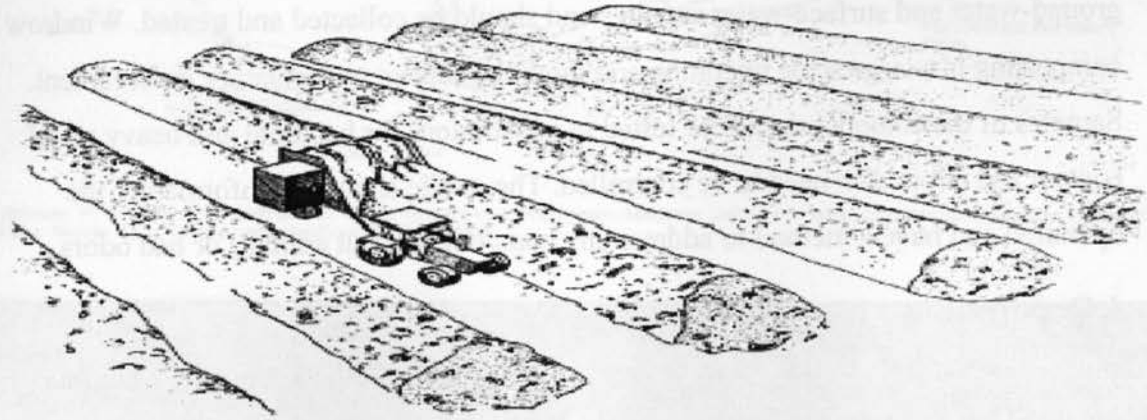
1. **Non-Reactor Processes**
2. **Reactor Processes**

2.1 <u>Non-reactor systems ("open")</u> are divided between those that maintain an agitated solids bed and those that employ a static bed. An agitated solids bed means that the composting mixture is disturbed or broken up in some manner during the compost cycle. This may be by periodic turning, tumbling, or other methods of agitation. The most common composting methods are listed below under the sub-categories of non-reactor process,

<u>a) Aerated (turned) windrows composting</u>

Composting takes on main organic waste and is formed into rows of long piles called "windrows" and aerated by turning the pile periodically by either manual or mechanical means. The ideal pile height, which is between 4 and 8 feet, allows for a pile large enough to generate sufficient heat and maintain temperatures, yet small enough to allow oxygen to flow to the windrow's core. The ideal pile width is between 14 and 16 feet. (Shown on fig. 4)

Windrow Composting with an Elevating Face Windrow Turner



Source: Reprinted with permission from Rynk, et al., *On Farm Composting Handbook, 1992* (NRAES-54)

<u>Fig: 4</u> **Aerated (turned) windrows composting**

Factors to be concern:

1. Types of Waste and Waste Generators

Identify large volumes of diverse wastes, including yard trimmings, food wastes and animal byproducts (such as fish and poultry wastes). Quantify large volume generators, such as by entire communities and high volume food-processing businesses (e.g., restaurants, grocery stores, cafeterias, packing plants).

2. Climate or Seasonal Considerations

In a warm, arid climate, windrows are sometimes covered or placed under a shelter to prevent water from evaporating. In rainy seasons, the shapes of the pile can be adjusted so that water runs off the top of the pile rather than being absorbed into the pile. Also, windrow composting can work in cold climates. Often the outside of the pile might freeze, but in its core, a windrow can reach 140 °F.

3. Environmental Concerns

Leach ate is liquid released during the composting process and can contaminate local ground-water and surface-water supplies and should be collected and treated. Windrow composting is a large scale operation and might be subject to regulatory enforcement. Samples of the compost should be tested in a laboratory for bacterial and heavy metal content and odors also need to be controlled. The public should be informed of the operation and have a method to address any complaints about animals or bad odors.

4. Requirements

Windrow composting often requires large tracts of land, sturdy equipment, a continual supply of labor to maintain and operate the facility, and patience to experiment with various materials mixtures and turning frequencies.

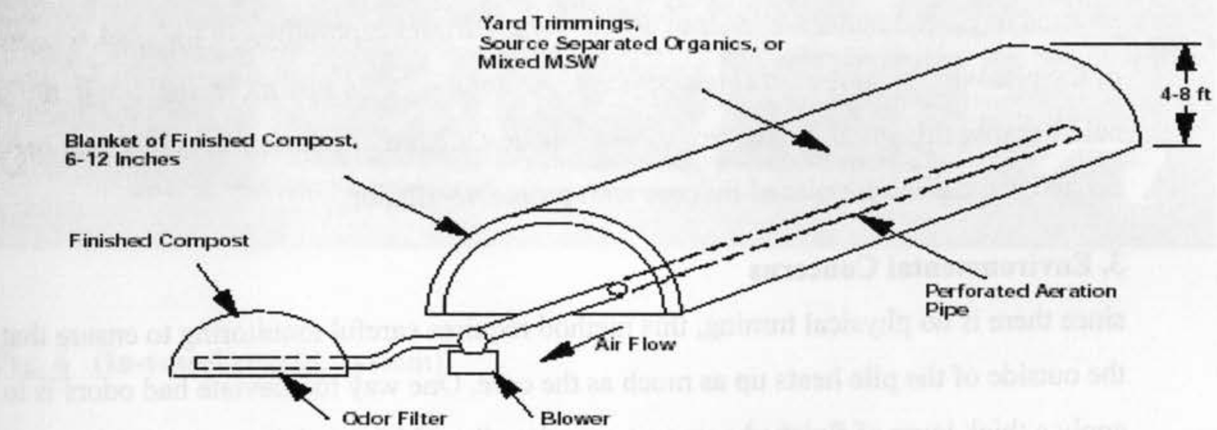
Method potential

This method will yield significant amounts of compost, which might require assistance to market the end-product. Alternatively, local governments can make the compost to feed their needs for public parks and recreations centers and available to residents for a low or no cost.

b) Aerated static pile composting

In aerated static pile composting, organic waste is mixed together in one large pile instead of rows (Fig. 5). To aerate the pile, layers of loosely piled bulking agents (e.g., wood chips, shredded newspaper) are added so that air can pass from the bottom to the top of the pile. The piles also can be placed over a network of pipes that deliver air into or draw air out of the pile. Air blowers might be activated by a timer or a temperature sensor.

Aerated Static Pile for Composting MSW



Source: P. O'Leary, P. Walsh and A. Razvi, University of Wisconsin-Madison Solid and Hazardous Waste Education Center, reprinted from *Waste Age* Correspondence Course 1989-1990

Fig: 5 **Aerated static pile composting**

Factors to be concern:

1. Types of Waste and Waste Generators

Aerated static piles are suitable for a relatively homogenous mix of organic waste and work well for larger quantity generators of yard trimmings and compostable municipal solid waste (e.g., food scraps, paper products), which might include local governments, landscapers, or farms. This method, however, does not work well for composting animal byproducts or grease from food processing industries.

2. Climate or Seasonal Considerations

Like windrow composting, in a warm, arid climate, aerated static piles are sometimes covered or placed under a shelter to prevent water from evaporating. In the cold, the core of the pile will retain its warm temperature, but aeration might be more difficult in the cold because this method involves passive air flowing rather than active turning. Some aerated static piles are placed indoors with proper ventilation.

3. Environmental Concerns

since there is no physical turning, this method requires careful monitoring to ensure that the outside of the pile heats up as much as the core. One way to alleviate bad odors is to apply a thick layer of finished compost over the pile, which can help maintain high temperatures throughout the pile.

4. Requirements

This method typically requires equipment such as blowers, pipes, sensors, and for which might involve significant costs and technical assistance. Having a controlled supply of air enables construction of large piles, which require less land than the windrow method.

Method potential

This method produces compost relatively quickly—within 3 to 6 months.

2.2 Reactor systems ("in-vessel") Reactor processes are first classified according to the manner of solids flow as either vertical flow reactors or horizontal flow reactors. Horizontal flow includes a number of reactor types in which the reactor is inclined slightly from the horizontal to promote solids flow.

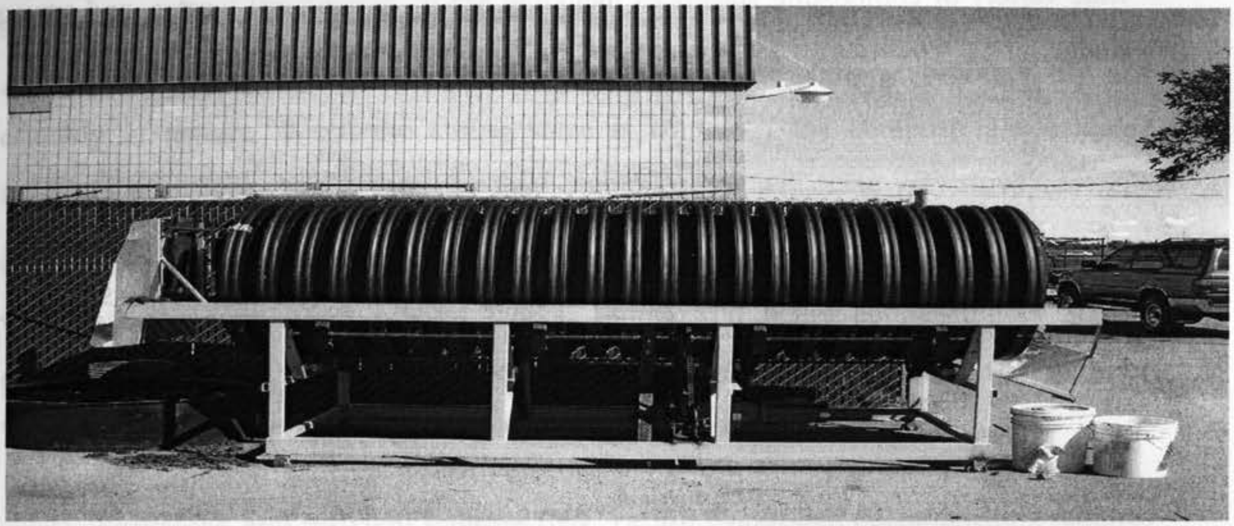


Fig: 6 (In-vessel reactor system)

a) Vertical Flow composting process

The vertical moving packed bed reactor has been widely applied to composting of sludge cake amended with sawdust and other material. Several version of this reactor are available and included circular and rectangular reactor geometries with counter-current and co-current aeration patterns. Material depth inside the reactor is typically about 6 to 9m. One reason for the popularity of this reactor style is the relatively low cost per unit of working volume.

b) Horizontal and Inclined Flow Composting process

Horizontal flow reactors are divided into those that employ a rotating or rotary drum (tumbling solids bed reactor), those that use a bin structure if varying geometry and method of agitation (agitated solids bed reactors), and those that use bin type structure but with a static solids bed (static solids bed reactor).such systems have been applied to a wide variety of composting substrates including MSW, agricultural wastes, and sewage sludge.

3. Understanding the Composting Process

The composting process occurs in two major phases. In the first stage, microorganisms decompose the composting feedstock into simpler compounds, producing heat as a result of their metabolic activities. The size of the composting pile is reduced during this stage. In the second stage, the compost product is cured or finished. Microorganisms deplete the supply of of readily available nutrients in the compost, which, in turn, slow their activity. As a result, heat generation gradually diminishes and the compost becomes dry and crumbly in texture. When the curing stage is complete, the compost is considered stabilized or mature. Any further microbial decomposition will occur very slowly.

One of the most important steps for evaluating composting options is to become familiar with how the composting process works. Before you begin composting or start a composting program, you should understand the seven primary variables that must be "controlled" during composting process are:

1) **Feedstock and nutrient balance (N/C ratio):** Controlled decomposition requires a proper balance of "green" organic materials (e.g., grass clippings, food scraps, manure), which contain large amounts of nitrogen, and "brown" organic materials (e.g., dry leaves, wood chips, branches), which contain large amounts of carbon but little nitrogen. Obtaining the right nutrient mix requires experimentation and patience and is part of the art and science of composting.

2) **Particle size:** Grinding, chipping, and shredding materials increases the surface area on which the microorganism can feed. Smaller particles also produce a more homogeneous compost mixture and improve pile insulation to help maintain optimum temperatures (see below). If the particles are too small, however, they might prevent air from flowing freely through the pile.

3) **Moisture content:** Microorganisms living in a compost pile need an adequate amount of moisture to survive. Water is the key element that helps transports. Substances within the compost pile and make the nutrients in organic material accessible to the microbes. Organic material contains some moisture in varying

amounts, but moisture also might come in the form of rainfall or intentional watering.

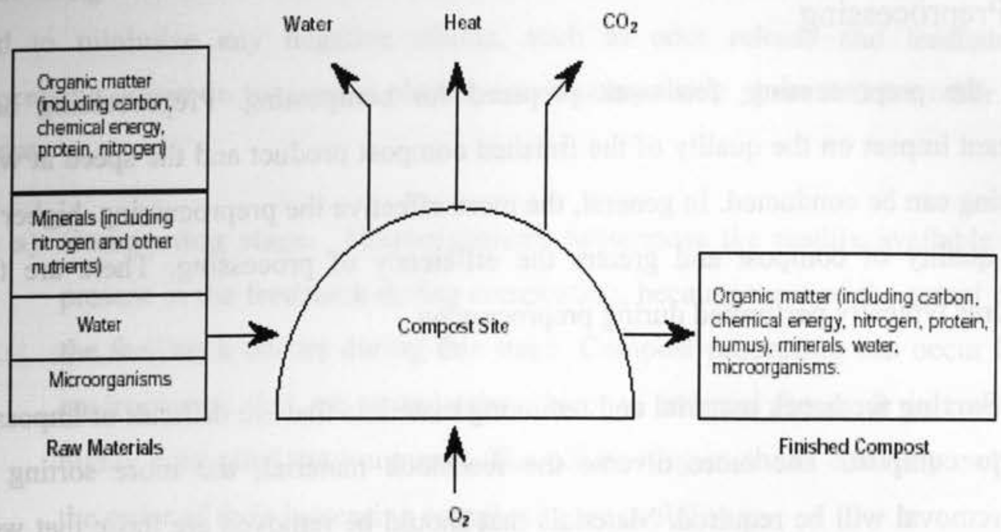
4) **Oxygen flow:** Turning the pile, placing the pile on a series of pipes, or including bulking agents such as wood chips and shredded newspaper all help aerate the pile. Aerating the pile allows decomposition to occur at a faster rate than anaerobic conditions. Care must be taken, however, not to provide too much oxygen, which can dry out the pile and impede the composting process.

5) **Temperature:** Microorganisms require a certain temperature range for optimal activity. Certain temperatures promote rapid composting and destroy pathogens and weed seeds. Microbial activity can raise the temperature of the pile's core to at least 140 °F. If the temperature does not increase, anaerobic conditions (i.e., rotting) occur. Controlling the previous four factors can bring about the proper temperature.

6) **Time:** With respect to overall compost process, the parameter of time should be an interval sufficiently long to permit the process to reach its desired goal. Therefore, the compost process is sufficiently complete as soon as the composting mass has been stabilized such that: 1)it can be stored without causing nuisances; and 2)it has reached a stage of maturity at which it is not inhibitory to plant growth.

7) **pH balance:** For most applications, compost should not be too acidic or too alkaline. A pH range between 7 and 8 is optimum. A low pH generally indicates lack of oxygen.

The Composting Process



The carbon, chemical energy, protein, and water in the finished compost is less than that in the raw materials. The finished compost has more humus. The volume of the finished compost is 50% or less of the volume of raw material.

Source: Reprinted with permission from Rynk, et al., *On Farm Composting Handbook*, 1992 (NRAES-54)

Source: U.S. EPA, 1986.

<u>Fig: 7</u> **(Composting process diagram)**

3.1 Processing methods

3.1.1 Preprocessing

During the preprocessing, feedstock prepared for composting. Preprocessing has a significant impact on the quality of the finished compost product and the speed at which processing can be conducted. In general, the more effective the preprocessing, higher will be the quality of compost and greater the efficiency of processing. There are three procedures typically performed during preprocessing.

a) **Sorting** feedstock material and removing materials that are difficult or impossible to compost. The more diverse the feedstock material, the more sorting and removal will be required. Materials that should be removed are those that would interfere with mechanical composting operations, inhibits the decomposition process, cause safety problems for those working with or using compost, or detract from the overall aesthetic value of the finished compost product.
b) **Reducing the particle size** of the feedstock. Size reduction usually is performed after non-compostable have been separated from the compostable feedstock. The primary reason for performing size reduction is to increase the surface area to volume ratio of feedstock material. Maximizing composting efficiency requires establishing a balance between reducing particle size and maintaining aerobic conditions. Size reduction can also homogenize MSW feedstock materials, achieving greater uniformity of moisture and nutrients to encourage even decomposition.
c) **Treating feedstock materials** to optimize composting conditions. To enhance composting feedstock can be treated before processing. Such treatment can optimize moisture content, carbon-to-nitrogen (C: N) ratio, and acidity/alkalinity (pH).

3.1.2 Processing

After feedstock materials are preprocessed, they can be introduced into compost processing operations. During processing, various methods can be employed to decompose the feedstock materials and transform them into a finished compost product. Processing methods should be chosen to maximize the speed of the composting process and to minimize any negative effects, such as odor release and leachate runoff. Processing occurs in two major phases, one is composting phase and the other is curing phase.

a) Composting stage. Microorganisms decompose the readily available nutrients present in the feedstock during composting, because most of the actual change in the feedstock occurs during this stage. Compost processing can occur in simple environments that are completely subject to external forces or in complex and highly controlled environments. The composting methods currently employed in the order of their increasing complexity are as follows:

- **Passive piles**
- **Turned windrows**
- **Aerated static piles**
- **In-vessel systems**

b) Curing stage. Once the materials have been composted, they should be cured. Curing should take place once the materials are adequately stable. During the curing stage, compost is stabilized as the remaining available nutrients are metabolized by microorganisms that are still present and therefore microbial activity diminishes as the available nutrients are depleted. Curing operation can be conducted on available sections of compost storage or processing area. In general, the area needed for curing purposes is one quarter of the size needed during the composting process. The curing process should continue for a minimum of one month (Rynk et al., 1992). It is also important to note, that curing is not just a matter of time but also depends on the favorability of conditions for the process to be completed. Once the curing process is completed, the finished compost should not have an unpleasant odor.

3.1.3 Odor control

While odor might seem to be a superficial measure of a composting facility's success, odor is potentially a serious problem at all types of composting facilities. In planning stage of a facility, decision makers should examine composting conditions and odor prevention and control approaches at existing facilities to develop a control strategy for their operations. The types of odor controls chosen depend on the odor sources, the degree of odor reduction required, and the characteristics of compounds causing the odor.

In addition to the **process and engineering control**, there should be careful monitoring and control of the composting process will help to avoid anaerobic conditions and keep odors to a minimum.

a) **Process control.** At facilities that compost yard trimmings and /or MSW, procedures that can help prevent or minimize odors include.

- Forming incoming materials into windrows promptly.
- Making sure windrows are small enough to ensure that oxygen can penetrate from the outside and guard against the formation of foul smelling anaerobic core but large enough for the interior reach optimal temperature.
- Providing aeration by completely mixing the feedstock and regularly turning the piles.
- Breaking down piles that are wet and odorous and spreading them for drying.
- Avoid standing pools of water or ponding through proper grading and use of equipment.

b) **Engineering controls.** Many municipal composting facilities uses sophisticated odor control technologies to treat exhaust gases from decomposing feedstock. Some facilities collect and treat odorous gases from tipping and composting areas. There are several odor control methods like, odor piles, biofilters, wet scrubbers, adsorption, dispersion enhancement, and combustion. Combustion is effective but can be expensive (Ellis, 1991). **Biofilters and air scrubbers** are gaining acceptance as effective means for odor control.

3.1.4 Post processing

Post processing is optional but normally is performed to refine the compost product to meet end use specification and market requirements. During post processing, compost can be analyzed to ensure that stabilization is complete. Compost can also be tested for chemical or pathogenic contamination and tested to determine nutrient levels, size reduced, blended with other materials, stored, and or bagged.

4. State legislation and initiations in Canada

BUREAU DE NORMALISATION DU QUÉBEC (BNQ)

The **BNQ** deals mainly with environmental, health, safety, construction and public works issues. Moreover, as an organization drafting standards (ODS) accredited by the standards council of Canada (SCC), the **BNQ** has been given primary responsibility over the following areas:

- Soil amendments.
- Organic fertilizers (with the exception of chemical fertilizers).
- Arboriculture.
- Fertilization.
- Greenhouse products.
- Treatment of municipal sewage.
- Treatment and quality of municipal drinking water.

In November 1992, following a request from representatives of the **composting** industry, the BNQ informed the SCC that it would develop a national standard for **compost** within the scope of its responsibilities regarding **soil amendments** and **fertilization.**

CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME)

During the past few years, interest in composting as an alternative for the management of the organic portion of waste has increased significantly in Canada. As a result, through a national committee, the **CCME** has begun developing national guidelines for the production and utilization of **compost** for all provinces and territories. The specific objectives of these guidelines are:

- To protect the environment and public health throughout the country.
- To encourage source separation of municipal solid waste in order to produce high quality compost.
- To develop harmonized, nation-wide compost standards that will accommodate various groups and diverse interests.

- To ensure consumer confidence by establishing national quality criteria for compost.
- To ensure that composting is allowed to develop as a waste/resource management solution and as an environmentally conscious industry that diverts organic waste from landfills and incinerators.

The **CCME** guidelines have four criteria for compost quality and safety i.e., **maturity, foreign matter, trace elements** and **pathogenic organisms.**

AGRICULTURE AND AGRI-FOOD CANADA (AAFC)

AAFC is currently working at adopting safety criteria from the BNQ standard in the *Fertilizers Act and Regulations.* AAFC anticipates including criteria for trace elements, pathogenic organisms and sharp objects.

The following three distinct outcomes will result from these three organizations are:

- A national Canadian standard for the composting industry (**BNQ**);
- Guidelines for compost (**CCME**); and
- The adoption of new mandatory criteria for compost (**AAFC**).

The five categories of quality criteria for compost considered by these three organizations are:

1. **Maturity.**
2. **Foreign matter.**
3. **Trace elements.**
4. **Pathogenic organisms.**
5. **Organic contaminants.**

Note: Standardized testing methods are needed that would certify the maturity and stability of different compost batches. The quality of compost is largely defined by its intended use. High quality compost is used in agriculture, horticulture, landscaping, and home gardening. Medium and low quality compost is used in erosion control, roadside landscaping, as a landfill cover, and in land reclamation projects.

CITY OF TORONTO GREEN BIN PROGRAM

City of Toronto, Solid Waste Management Services has initiated variety of **3Rs** programs (Reduce, Reuse, Recycle) to help residents and businesses to reduce their production of waste.The Green Bin Program for diversion of organics waste was started in 2002 and approximately 510,000 single-family households' can put their organics (fruit and vegetables scraps, paper towels, coffee grinds, etc.) out for separate collection along with garbage and recycling.

This Green Bin Program was initiated from Etobicoke district in September 2002, Scarborough in June 2003 and then Toronto, East York and York joined in September 2004. On October 25, 2005, approximately 124,000 single family homes in the North York community contributed, that brings the total to 510,000 single family households. (Source*: City of Toronto)*

Table: 1

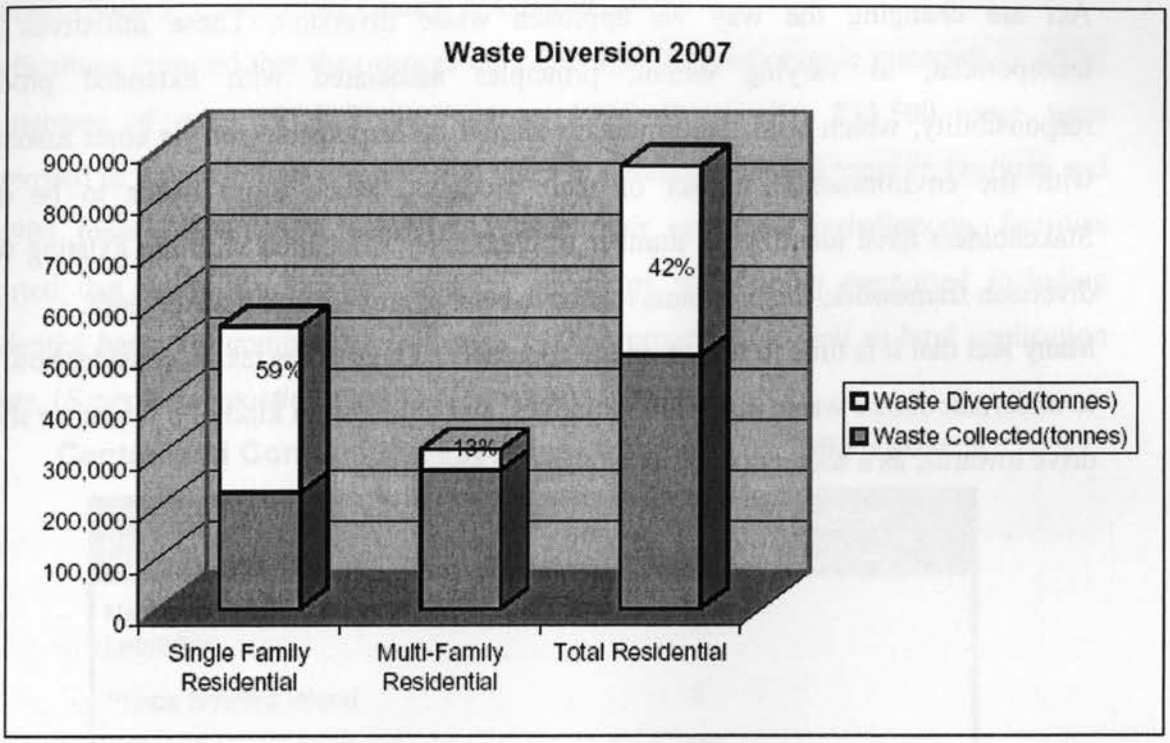
Overall residential waste diversion in 2007

Blue/grey box program	154,799 Tonnes
Leaf/yard/xmas trees	**77,509 Tonnes**
Backyard composting	**18,652 Tonnes**
Green bin SSO	**85,552 Tonnes**
Environment days/depots	860 Tonnes
Large appliances/scrap metal	4,422 Tonnes
Grass cycling	**11,296 Tonnes**
Household Hazardous waste	1,086 Tonnes
Beer store deposit returns	6,545 Tonnes
LCBO deposits return	6,570 Tonnes
Diversion in Tonnes	**367,291 Tonnes**
Waste	**497,809 Tonnes**
Total (diversion and waste)	**865,100 Tonnes**
Diversion in %	**42%**

Contd. Table: 1

2007 Residential Waste Diversion

	Waste Collected(tonnes)	Waste Diverted(tonnes)	Diversion Rate
Single Family Residential	226,787	326,313	59%
Multi-Family Residential	271,022	40,978	13%
Total Residential	497,809	367,291	42%



Graph: 1 (Residential waste analysis in 2007) **Source: City of Toronto**

THE WASTE DIVERSION ACT, 2002

The *Waste Diversion Act, 2002* is Ontario's main legislation to promote the reduction, reuse and recycling of waste through the development, implementation and operation of waste diversion programs. Over the past few years much progress has been made on waste diversion in Ontario. Programs initiated and developed under the Waste Diversion Act are changing the way we approach waste diversion. These initiatives have incorporated, to varying extent, principles associated with extended producer responsibility, which hold that producers should be responsible for the costs associated with the environmental impact of their products. Much more needs to be done. Stakeholders have identified a number of challenges associated with the existing waste diversion framework, the programs that have been approved, and the Act itself.

Many feel that it is time to reflect on the approaches Ontario has taken, consider how best to undertake future waste diversion initiatives, and define what kind of a future we should drive towards, as a society.(*source: Ministry of Environment*)

5. Compost Facilities & Design Criteria

Composting facilities in Canada

The ***Composting Council of Canada*** received input from **244** of the **344** facilities identified, a response rate of **71%.** Of the 244 facilities surveyed, **42** surveys were conducted with facilities in Atlantic Canada (**17 per cent of total**), **94** surveys in Québec/Ontario (**39 per cent of total**) and **108** surveys in Western Canada (**44 per cent of total**). (*Source: Composting council of Canada, 2005*)

The facilities reported that they processed **1,650,000** tones of organic materials in 1998, an increase of over **197,000** tones versus 1996. Regionally, **235,500** tones were composted in **Atlantic Canada, 565,000** tones in **Quebec, 519,300** tones in **Ontario** and **328,900** tones in **Western Canada.** Within their operating jurisdictions, facilities reported that additional organic recovery programs were being supported including residential backyard composting and grass cycling programs as well as land application efforts. (*Source: composting council of Canada*)

Centralized Composting Facilities in Canada in 1998*Table: 2

Province/Territory	Number of Centralized Composting Facilities
Newfoundland & Labrador	**3**
Prince Edward Island	**1**
Nova Scotia	**15**
New Brunswick	**33**
Quebec	**49**
Ontario	**71**
Manitoba	**22**
Saskatchewan	**19**
Alberta	**84**
British Columbia	**46**
Yukon	**1**
TOTAL	**344**

(* by provincial/territorial ministries of environment*)

5.1 Sitting a New Facility

Site selection is an extremely important decision that should be made only after careful consideration, as each situation is unique. The deliberation over site selection should take into account proximity to residences and streams, prevailing winds, traffic patterns, travel distance and its effect on equipment and labor costs, and other factors, such as local zoning requirements. Composting facilities, including all buildings, processing and storage areas and access roads, should provide a minimum separation distance of **100 meters** from the property line of the nearest residence, school, place of worship, hospital, or other public institution. The following are the factors considering prior to execution of project:

1. Public Participation	2. Buffer Zone
3. County/Municipal Permits	4. Location
5. Water Table	6. Percolation
7. Water Supply	8. Stream Encroachment and Water Pollution
9. Electrical supply	10. Security

These above rules may be promulgated by the state environmental agency, the state agriculture department or possibly by a local agency. Even if there are no pertinent regulations, if a site causes pollution or generates significant neighbor concerns, it may be shut down or the operator may be liable for damages.

A number of technical, social, economic, and political factors will shape decisions on locating a facility. Some of the major factors in facility sitting include:

- Convenient location to minimize hauling distances.
- Assurance of an adequate buffer between the facility and nearby residents.
- Suitable site topography and soil characteristics.
- Sufficient land area for the volume and type of material to be processed.

5.1.1 Location

Potentially suitable locations for composting facilities include areas adjacent to recycling drop-off centers and in the buffer areas of existing or closed landfills, transfer stations, and wastewater treatment plants. A centrally located facility close to the source of compost feedstock will maximize efficiency and convenience while reducing expenses associated with hauling these materials and distributing the finished compost product.

Locating a site with an extensive natural buffer zone, planted with trees and shrubs, is an effective way to reduce the potential impacts that a new composting facility might have on the surrounding neighborhoods.

5.1.2 Topography

Potential sites should be evaluated in regard to the amount of alteration that the topography requires. Some clearing and grading will be necessary for proper composting, but minimizing this work is desirable in order to reduce expenses and maintain trees on the perimeter of the site, which act as a buffer. A composting site should be appropriately graded to avoid standing pools of water and runoff. To avoid ponding and erosion, the land slope at a composting site should be at least 1 percent and ideally 2-4 percent. (Rynk et al., 1992)

5.1.3 Area Requirements & Sizing a Composting Pad

An outdoor compost facility can be engineered so that it can be located on a wide variety of soils and sites. It is best to choose a site **high on the landscape** and well away from surface water bodies to reduce the chance that runoff from the site will enter surface water and reduce the chance that surface water will flow onto the pad.

A slope of about 2% is desirable to prevent ponding of water. Steep slopes are not satisfactory because of potential problems with erosion, vehicular access, and equipment operation. Compost windrows should run up and down the slope, rather than across, to allow runoff water to move between the piles rather than through them.

5.1.3.1 Compost pads

Determining the size of a pad is dependent on different factors. Planning space for active windrows and for curing piles, storage of bulking materials, and a possible sales area (for screening and bagging) and space to store the equipments. The area required for composting depends on the volume and types of material processed, the size and shape of piles, windrow or in-vessel technology used, and the time required to complete the process. Static piles and turned windrow methods require more land than the more intensive forced aeration and in-vessel system methods.

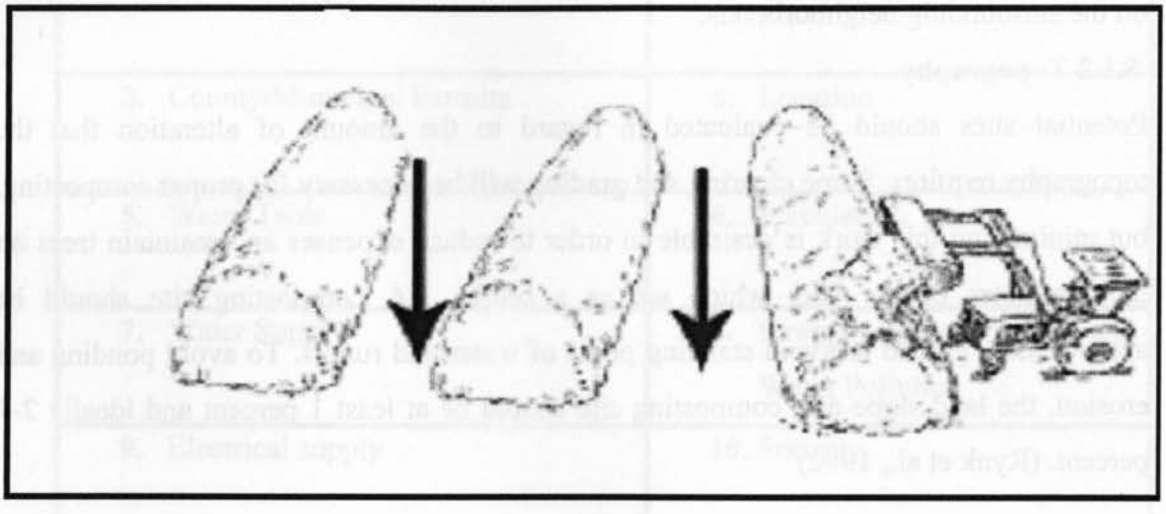


Fig: 8 (Pads are graded to 2-4%)

Pad Types

One consideration in selecting the type of pad to construct is longevity. Some materials like **concrete** or **asphalt** are long lasting, but may require demolition if no longer desired. Other considerations are cost and availability of materials. Cost will vary depending on what is available in different areas.

Recycled asphalt is often available for trucking cost, and concrete millings generally cost less than gravel. New asphalt and concrete bear the highest costs. Local construction projects often need to dump excess asphalt and concrete at the end of a project. If your site is close enough, you may be able to take advantage. Some of the more common pad types include:

i) Filter Fabric and Gravel

The combination of fabric and gravel makes a good working surface. A combination of sand and gravel can also make a good surface. Fabric is available at farm implement and construction supply dealers. First the topsoil is removed from the surface. Then filter fabric is rolled out to cover the surface and 12"-18" of gravel are put on top of the cloth. The layers are then compacted and ready for use.

ii) Fabric and Sand

These can work well especially on pads that need to avoid gravel in the completed compost but do not mind having sand in the completed compost. Of course, the sand will not be as durable as the gravel pad.

iii) Lime Stabilized Earth

Modification and stabilization of highway and airport pavement subgrades using lime is a well-established, time tested practice in the United States. This technology may have applications in pad construction but has been tested very little.

iv) Compacted Soil

Some soils are well enough drained that they can be compacted and used as a pad without adding gravel or other materials to make it more stable. This type of pad can be hard to work if precipitation rates are high, but can easily be eliminated if the pad is no longer needed.

5.1.3.2 <u>Leachate consideration</u>

An important part of choosing a pad surface is deciding how to manage water. Leachate, formed when water percolates through the organic material, can be harmful to ground and surface water, because it can deplete oxygen and may contain unacceptably high levels of nitrogen phosphorus or pollutants. An initial bed of carbonaceous, bulking materials underneath the compost pile can help absorb excess moisture and keep it in the windrow.

If the compost site is at the bottom of a slope, **berms** can be built to divert runoff water around the pad.

When leachate is generated then some measures that can help prevent water pollution includes:

i) Collection Lagoons

Retention ponds can be constructed to hold runoff from normal operations as well as excessive runoff resulting from storms. Sand filtration of lagoon outlet waters can help to reduce pollutant loads. Discharge from a lagoon may require a permit even if passed through a sand filter. Lagoons need to be emptied before going into a wet season unless evaporation rate exceeds precipitation and runoff into the lagoon. Solids need to be removed periodically and can be put back into windrows for composting. The liquids can be used to irrigate appropriate field crops, to hydrate dry compost piles, or in some locations must be transported to a sewage treatment facility. Recovered solids often contain high moisture, so they may need to be dried out with carbonaceous material so they can efficiently compost.

ii) Berm Compost Socks

A berm of compost can be used to slow and/or control excess water from piles or storm events. A berm of finished compost 24" tall x 24" wide, triangular in cross section and as long as needed downslope of the pile and perpendicular to the slope will absorb moisture and help control leachate.

iii) Tanks

Leachate collection tanks can be buried below the pad surface. Grading of the pad can direct the leachate into the tank. When emptied, the liquid can be used to add moisture to the piles, irrigated on appropriate crops or disposed of at a sewage treatment plant. If possible, solids can be mixed into suspension so that much of the solid material can be removed with the liquids.

iv) Filter Strips

A vegetated section of soil downslope of the compost pad can help absorb nutrients and particulates that run off the pad surface. When possible, on unimproved surfaces, keep vegetation between the windrows as well to absorb additional leachate.

5.2 Design consideration

Once a site has been identified, a facility must be designed to meet the community's composting needs. The good idea is to visit other composting facilities to view different designs and operation first hand. When developing the initial facility design, future expansion possibilities should be considered in the configuration. The following are critical to the deign of a facility.

5.2.1 Pre-processing area

A preprocessing or staging area offers room to receive collected feedstock and sort or separate materials as needed. Receiving materials in a preprocessing area will eliminate the need for delivery trucks to unload directly into windrows in poor weather condition. The size and design of the preprocessing area depends on the amount of incoming materials and way the materials are collected and sorted. The tipping area is often roofed in areas subject to severe weather conditions. The floor should be strong enough to support collection vehicles and hardened to withstand the scraping of equipment such as front-end loaders.

The minimum ceiling height of an enclosed tipping area depends on the clearances that the various types of hauling vehicles require to discharge their MSW. The tipping floor area should allow a minimum maneuvering distance of no less than one-and-a-half (1 1/2) times the length of the delivery vehicle.

5.2.2 Processing area

The processing area, composed of the composting pad and the curing area must be carefully designed for efficient composting. Design specifications for this area will differ considerably depending on whether the composting facility processes yard trimmings or MSW feedstock.

Grading the surface of the pad to meet the optimal slope also will help prevent erosion by allowing for gentle drainage. For further protection of windrows against erosion, windrows should be arranged parallel to the grade to allow runoff to flow between piles instead of through them. (Richard et al., 1990; Mielke et al., 1989)

The size of the composting pad depends primarily on the amount of material that the facility receives for composting and the level of technology that will be used. The windrow turning equipment influences aisle width, which in turn influences the size of the composting pad.

The common design is to line the windrows in pairs 5 feet apart with 15 foot aisles between each pair. Proper ventilation is required in enclosed preprocessing and processing areas because the air within the structure can be a source of bioaerosols, odors, dust, and excess moisture.

A curing area also should be part of the design of the processing site. This area is used to hold the compost for the last phase of the composting process, to allow the material to stabilize and cool. The space requirement for curing is based upon the amount of organic material composted, the pile height and spacing, and the length of the time that the compost is cured (Rynk et al., 1992). In general, the curing area needs less space, requiring only about one-quarter of the area of the compost pad (Richard et al., 1990; Uconn CES, 1989)

5.2.3 Post processing area

A post processing area at composting facilities can be used to conduct quality control testing of compost; to perform screening, size reduction, and blending operations; to compost in preparation for market; and to store the compost. Almost one-fifth of the area of the composting pad is sufficient (Richard et al., 1990).

Cured compost should be stored away from surface water and drainage paths. A stored capacity of at least 3 months should be incorporated into site designs for composting facilities.

5.2.4 Buffer Zone

The buffer zone frequently needs to be several times the size of the composting pad, particularly when the composting operation is adjacent to residential areas or businesses. During site design, the direction of prevailing wind should be noted and the buffer zone extended in this direction. This will help minimize the transport of odor and bioaerosols downwind of the facility.

In general, larger the buffer zone, the greater the acceptance of facility among residents. The buffer zone required by a composting facility depends largely on the type of feedstock being composted and the level of technology employed at the facility. State and local regulations frequently require minimal buffer zone sizes or specify the distances that composting operations must be from property lines, residences, or adjacent businesses and from surface water or sub-surface water supplies.

5.2.5 Access and Onsite Roads

The type and amount of traffic into and out of facility should be considered in the design process. Traffic at a site is largely dependent on the volume of materials that flows through the facility and the type of collection system in place. There should be permanent roads leading to tipping and storage areas, where as access to roads should be graveled or paved to handle large vehicles during adverse weather conditions.

5.2.6 Site Facilities and Security

Composting operation might require one or more building to house various site functions, from maintenance and administrative work to personnel facilities. Site buildings should have, at a minimum, electricity, heat, air conditioning, a toilet, and drinking water. All facilities should have a telephone or radio in case of emergencies. \

5.2.7 Site Maintenance

Good housekeeping at the site is important. There should be no ruts, standing water or garbage on the site. Site perimeters should be mowed to avoid contaminating piles with weed seed that will blow in. Good maintenance keeps the operation running smoothly.

6. Composting Process Design & Control

(A comparative study on waste decomposition, USEPA)

The main determinant of composting process performance is decomposition rate. This rate is negatively affected by temperatures exceeding 6O°C owing to the inactivation of the responsible microbial community. Nonetheless, composting masses typically self-heat to 8O°C, at which point the rate of decomposition is low. A method known as the **Rutgers strategy** has been developed to counter this tendency by removing heat through on-demand ventilation (thermostatic control of a blower). Compared with the **Beltsville method** (the approach that is in current widespread use), the Rutgers strategy yields high-rate composting that decomposes approximately four times the waste in half the time. Though the method can be used in enclosed (in-vessel) configurations, the unenclosed static pile is very suitable for its implementation. The static pile has the advantage of being structurally and operationally simple and capital non intensive.

Significance of the Rutgers-Beltsville Comparison

The **Beltsville** static pile composting process, which was developed specifically for sewage sludge treatment and is widely used, has the advantage of structural and operational simplicity. However, this process (like others) tends to produce high temperatures that inhibit and slow decomposition. A means of countering this tendency is known as the **Rutgers** composting process control strategy. The Rutgers strategy can be implemented in static pile configuration, thereby retaining structural and operational simplicity while benefiting from rapid decomposition. The Rutgers and the Beltsville Processes are compared in Table.3

The different results produced by the two strategies originate in the management of ventilation. The Rutgers strategy focuses on heat removal for temperature control, whereas the Beltsville Process maintains an oxygenated condition.

Fundamental differences in the Rutgers and Beltsville composting Strategies

Table: 3

Item	Process Control Strategy Rutgers	Beltsville
Process control operational objective	Maintain 60°C temperature ceiling	Maintain O_2 at 5% to 15%
Blower control	Fixed schedule initially, followed by temperature feedback	Fixed schedule throughout
Blower sizing	Must meet peak demand for heat removal	Prescribed as 1/3 hp per 50-ton pile
Blower operation mode	Forced-pressure	Vacuum-induced
Consequences of strategy	System oxygenated; a high rate of heat generation† and vaporization; dryness may come to inhibit activity unless prevented; good pathogen kill.	System oxygenated; temperature peaks by default at an inhibitively high level (~80°C); a low rate of heat generation † and vaporization; good pathogen kill.

*Both strategies were implemented in an unenclosed static pile configuration.
†Heat generation is equivalent to decomposition.

6.1 Mathematical Expression of Composting Process Control Dynamics

The control dynamics of the composting system can be expressed in mathematical form based on the behavior induced by the two strategies:

$$Q_v = 0.9\ m\ (h_{out} - h_{in})$$

Where, Q_v = heat removed through vaporization (energy/time)
0.9 = approximate proportion of the total heat removed through vaporization

m = dry air mass flow (mass dry air/time)

h_{out} = enthalpy of the outlet air (energy/mass dry air)

h_{in} = enthalpy of the inlet air (energy/mass dry air)

The numerical constant (**0.9**) is based on the estimate that **90%** of the ventilative heat removal is
through vaporization (the remainder is through sensible heating).

The goal in waste treatment is to maximize Q_v, because it represents the rate of decomposition. Mathematically, a large Q_v, is obtainable by making **m** and/or h_{out} large (some conditions apply).

The heat generation temperature interaction dictates that a high value of Q_v, is sustainable by

manipulating **m** so that h_{out} corresponds to =<6O °C. Since the rate of heat generation is time-variable, no specific value of **m** (specific ventilation rate) can be prescribed. Rather, ventilation must be constantly adjusted to match the instantaneous rate of heat generation. This formalizes the rationale for on-demand ventilative heat removal by means of temperature feedback control of a blower (i.e., the **Rutgers strategy**).

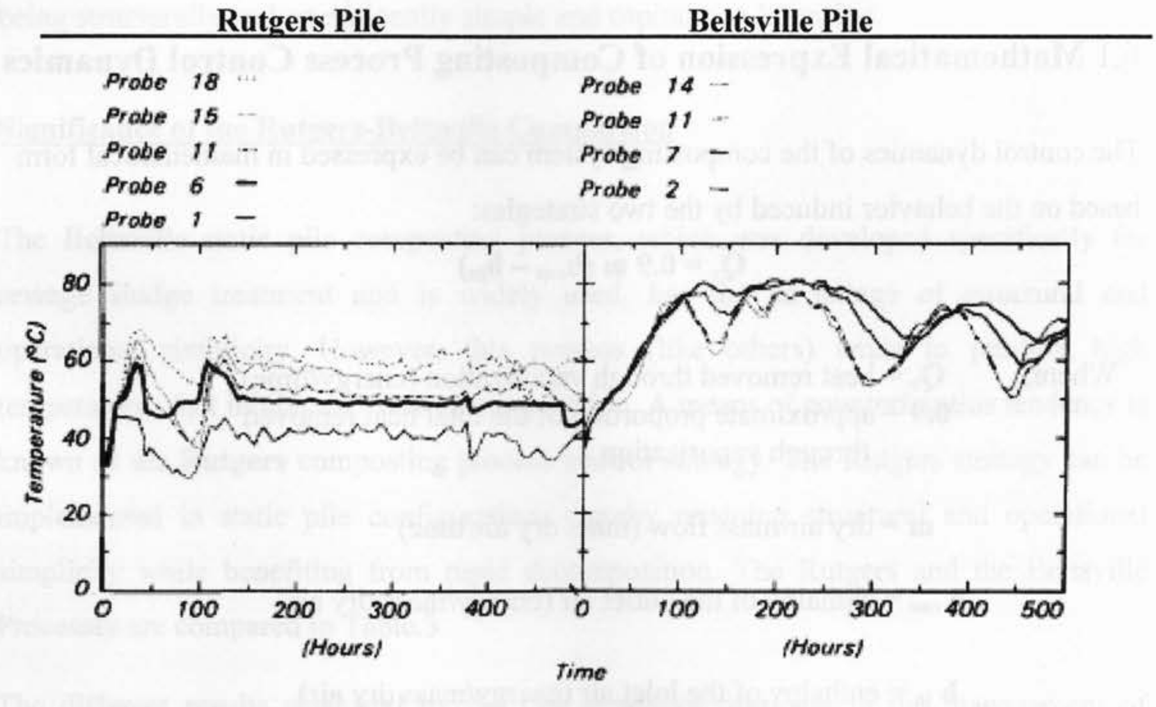


Fig:9

(Temperatures of selected vertical series of probes, left, Rutgers pile, Right Beltsville pile)

7. <u>**Conclusion:**</u>

In general, with the recognition and understanding that we have evolved as a wasteful and disposable society, the need and desire to change our habits has become an economic and environmental necessity. The environment has become a major issue as we stand witness to the pollution and degradation assaults our actions have on this planet. The adage that we must "think globally and act locally" is the most beneficial action we could follow in becoming responsible stewards of our planet and its resources.

One of the largest environmental concerns receiving public attention today is solid waste management. This widespread interest has resulted in setting a national goal of more than 50% reduction in solid waste by the year 2010. In order to achieve this goal, the material components and life cycles of the materials in the solid waste stream need to be understood.

Organic materials, such as news print, paper, cardboard, leaves, yard wastes, kitchen wastes, trees, and shrubs comprise an estimated 60-75% (by weight) of the solid waste disposed. An opportunity for achieving a significant portion of our waste reduction goal exists in the 35-45% of organic wastes which can be achievable with the implementation of a composting system. A diversion of 100% of the aforementioned organic materials will almost equal all other forms of recycling. Without implementation of composting system, it will be extremely difficult to achieve the goal of more than 50% of waste reduction by the year 2010.

Many Municipalities faced with the reality of rapidly filling landfills and public pressures are considering the benefits and economics of implementing a composting system as a significant part of their waste management plan.

Between the decision to implement a composting system and the success of organic waste diversion, lies the complexity of balancing the equation of economics and practicality. Issues influencing this equation, comprise collection, processing, marketing, environmental impacts, financial commitments, legislative and regulatory controls, operational and end-product standards, and the overall sustainability of the project.

Technically...........

- No single technology has an outright advantage over another but system must be carefully developed and operated to achieve success.
- Selecting a mixed MSW composting system facilities have closed as result of operational problems, principally odors.
- Achieving a maximum decomposition rate should be the explicit goal of composting process design and control.
- Achieving a maximum decomposition rate should be approached through temperature feedback control of one or more blowers.
- Rutgers strategy (which employs on-demand ventilation through temperature feedback control) should be implemented at the lowest possible capital costs consistent with operational considerations.

"Aerated static piles are best suited to sites which have suitable land available for the piles and a buffer area."

- This paper has demonstrated that composting is being recognized as viable waste management alternative.

- It is difficult to make an economic comparison in Canada of operating facilities and composting technologies used in other countries due to climate differences, variable wages, equipment availability and land cost etc.

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