Composting of Municipal Solid Wastes

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ABSTRACT

The generation of municipal solid waste is increasing year by year and there are many options for handling and disposing of these wastes. Currently in United States land disposal is the most common practice to deal with municipal solid wastes. The evolution of waste generation, and increase in population suggest composting as a future alternative. Since municipal solid waste comprises of a high proportion of non-durable goods composting is a suitable technology for reutilizing the organic material.

Composting is a natural biological process in which the degradable part of wastes is transformed to a stable material, with excellent characteristics for application on soils. Thus, it requires a pretreatment such as removal of big fractions and other contaminants that could affect the composting process and final quality of the compost. The decomposition of biodegradable material is carried out by very diverse biota, from bacteria to protozoa and worms. This makes composting a successive stage process, where some organisms play varying roles depending on several factors such as temperature, moisture, and nutrient content among others.

From an industrial point of view, composting must be optimized by controlling several factors. Although this is a natural process, the control of diverse environmental conditions, waste composition, and waste management lead to a faster process, better quality of the final product and few nuisances such as bad odors.

This paper gives an overview of the main aspects of general composting and its application in municipal solid waste treatment.

KEYWORDS

Solid wastes, composting, technologies, C/N, aeration, maturation, curing

INTRODUCTION

Any decomposable material is degraded at normal environmental conditions with more or less time. This is the fundamental basis of composting. Solid urban wastes have a high content of decomposable materials or non durable goods, such as food wastes and paper waste. Although the waste generated has a variable composition, it usually has all the required nutrients for microbial growth. Composting science is focused in controlling all variables that may affect the microbial growth and performance in order to get a stable final product, compost.

Before composting, the non degradable part of waste must be rejected by diverse pre-treatments methods. The degradable part is first processed. Grinding, screening and mixing of materials are some of the treatments prior to the digestion stage where the microorganisms role is fundamental. All the previous treatments are focused on providing the microorganisms a suitable media to act. Optimal structure of waste will allow it to get enough aeration, since composting is mainly aerobic. Furthermore, effects on moisture content and regulation of temperature affect the microbial population and bacteria species during the process. Desirable composting includes mesophilic and thermophilic stages, and allows the performance of a wide range of bacteria and organisms which lead to a product with no more degradable compounds, no odor potential and insects or pathogen source. Mixing materials provides waste with good structure and balanced nutrient and carbon source, avoiding the process being too short – inhibitions – or too long – non economical from the industrial point of view -.

During digestion, the process is monitored with several parameters (temperature, pH, moisture, and C/N ratio the most common). The material is deposed in piles, windrows or other enclosed containers. Different technologies for composting which suitability depends on the kind of waste are available. Different technologies differ in the waste deposition and aeration system basically. Passive methods of aeration result in long composting process, which is suitable for wastes with low fraction of readily degradable compounds.
During the process temperature raises, which kills pathogens and weed seeds, and decreases when no more easily degradable compounds are found and digestion is finishing. If the process is well conducted, digestion stage lasts from 3 weeks to 3 months. The next stage is curing or maturation, where the digested material acquires stability; Compost acquires a conformation similar to the humic acids found in soil, thus can be applied on the soil without risks at the end of the process. Due to its structure and nutrient composition, compost is highly recommended as a fertilizer and improves the structure of soils, increasing infiltration capacity.
At last, composting is an alternative to recycle part of the urban solid wastes and give a useful final product.

CURRENT GENERATION OF MUNICIPAL SOLID URBAN WASTES (MSW)

EPA defines urban wastes as wastes from residential, commercial, institutional, and some industrial sources. MSW are mainly a heterogeneous mixture of paper, plastic, cloth, metal, glass, and organic matter. Figure 1 shows the common composition of MSW. Packaging wastes seems to be the most common waste according to EPA studies (2003). Other products such as municipal sludge, combustion ashes, construction wastes, and non-hazardous industrial process wastes among others are not considered urban wastes by definition.
The solid wastes can also be classified in durable goods such as appliances, non durable goods (paper), packages or containers, food wastes, yard wastes, and other inorganic wastes. Because packaging is important for consumer goods it accounts for more than one-third of the U.S waste stream (Pichtel, 2005). The material that can be degraded usually is named garbage, and the non degradable is called rubbish.

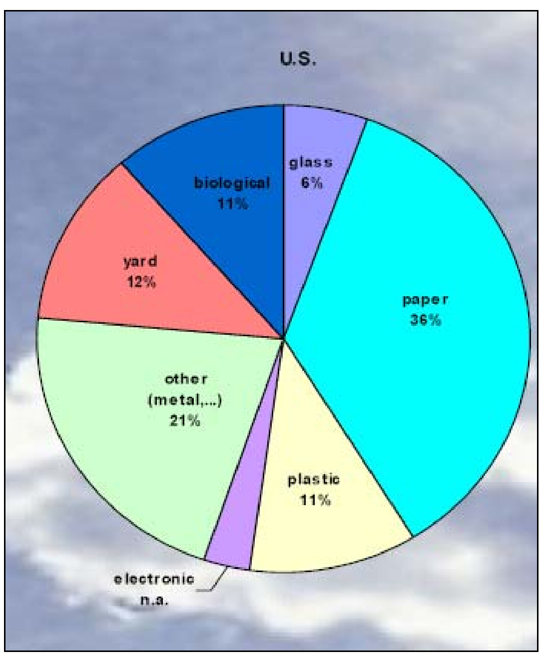

Figure 1: Composition of MSW by weight. Source: IPW, 2005.

The MSW generation, which is proportional with development grade of the country, has been increasing year by year. The estimation of solid urban waste generation for USA was 230 million tones in 2001 (4.4 lb/person/day), and the final projection for 2005 is expected to be 240 millions tones (Tchobanoglous and Kreith, 2002). MSW varies in amount and composition seasonally. During the warm seasons yard wastes increase, and holidays season make the MSW increase in tourist places (Rhyner et al., 1995). Long term changes of composition are due to changes in lifestyle, work patterns, materials substitution, and changes in food processing (Kreith, 1994).
Although there has been a significant public investment in product recycling and biowaste composting, most part of MSW is constantly being buried or burnt. In 2001, 70.3% of U.S. MSW ended in incinerators or in landfills, and four-fifths of that was buried in landfills (Spiegelman and Sheehan, 2005). The reason being that landfill disposal in United States is cheaper since more landfill is available, energy is cheaper and the cost of resources is lower. Another reason is the current American laws. The laws “Resource Conservation and Resource Act (RCRA)” and “Hazardous and solid waste amendments (HSWA)” encourages recycling but does not ban land filling which is banned in other developed countries such as Germany.
Because around 67% of municipal solid wastes generated in US are organic materials (Pichtel, 2005), composting may be an environmental alternative of reutilization of the organic matter, which returns to the natural cycle.

COMPOSTING SCIENCE

Composting is a natural biological process, basically aerobic, carried out by the biota of the wastes. Thus, composting is carried out only on biodegradable wastes. It is a natural process since it happens in nature, but it is usually slower and gives heterogeneous final products if not controlled.
Anaerobic composting releases less energy and methane, carbon dioxide and other products such as low-molecular-weight organic acids are the final products. Because most of the intermediate products have odor potential, and the goal is to get the organic matter partially mineralized and humified, all composting facilities are designed for aerobic composting (Haugh, 1980). Composting time depends on the cycles of the biota as well as other factors discussed in the following sections of the paper, but it takes around one month in optimal conditions (Gasser, 1984). The final product; compost, is stabilized organic matter with similar characteristics as humic substances in the soil. The schematic in figure 2 shows inputs and outputs of the composting process.

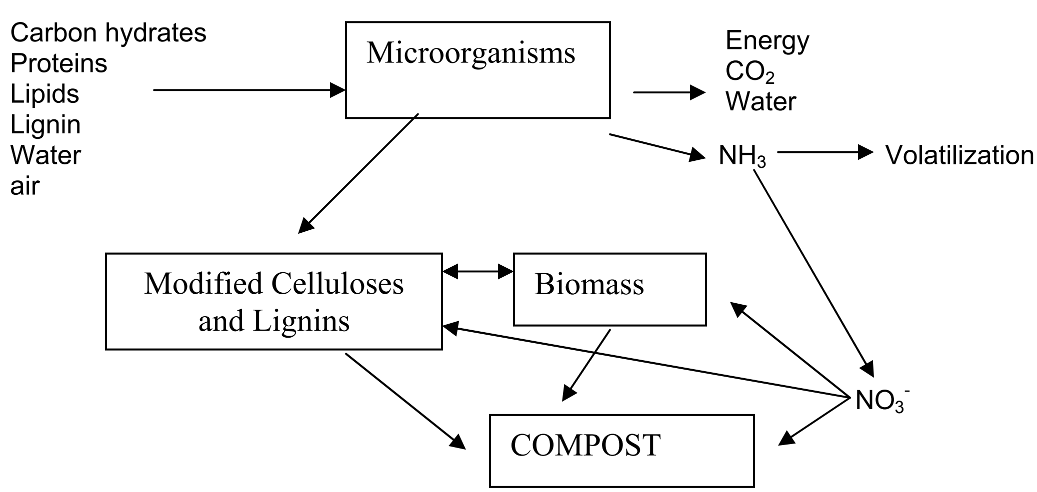

Figure 2: Scheme of the composting process (Source: Teira, 2003)

The compost can be used for diverse purposes. It may be used as a bed in farms of animal production, but the most common use is on land fields. Compost provides soil with extra organic matter, improving its structure and reducing the erosion risk. Furthermore, it is a good fertilizer (it ranges 1-2% Nitrogen, 1-2% Phosphorous, and 2-4% potash according to NRC, 1996) or good supplement for fertilization, and its nitrogen is not immobilized as in the case of fresh manures applied to soils. It also reduces runoff on soils, and is especially important for high erodible soils. Some inconveniences of composting can be time, big spaces needed for the process, possible bad smells during composting, limitation of low temperatures, and the slow availability of its nutrients since they are linked to organic matter (less than 15% of the N is available within the first year of application) although the loss of nutrients by leaching will be lower (Teira, 2003).

BIOTA INVOLVED IN THE COMPOSTING PROCESS

Al the biota needed for the process is already located on the wastes. Some industries have tried to develop strains to make the process faster, but significant results were not found (Pichtel, 2005). The involved microorganisms according its abundance from more to less, are described below (Kreith, 1994):

- Bacteria: Aerobic/facultative anaerobic bacteria. Most of them are rods and endospore formers. Bacteria play an important role since they are the first organisms which start decomposing readily decomposable substrates at the early stages of the process. The biota involved in the process can tolerate a wide range of temperatures. Psychrophilic, mesophilic and thermophilic bacteria are found to be important at different phases of composting Thermophilic bacteria degrade proteins, lipids, hemicelluloses, and carbohydrates. Mesophilic bacteria degrade proteins and carbohydrates easily degradable.
- Actinomycetes: Decompose aromatics, steroids, and phenols amongst others.
- Fungi: Their importance in composting increases when the composting material gets drier, since they are more tolerant to dry environments. They play an important role on lignin and cellulose decomposition.
- Algae
- Protozoa
- Worms
- Larvae

The most important role of the larger organisms is moving, mixing and breaking of materials, so it allows other organisms reaching different sites and helps to get more homogeneity in the process. The most abundant organisms of the different groups can be found in table 1.
From the total available carbon, 80% is used for catabolic reactions while the 20% is for anabolism (Bilietewski et al., 1997). That is the reason why this procedure releases so much energy in the form of heat.

Table 1: Bacteria, actinomycets and Fungi involved in composting (source: Teira, 2003)

Bacteria	**Actinomycets**	**Fungi**
Aerobacter	*Actinobifida chromogena*	Zigomicetos
Aerobacter sp.	Actinoplanes	Absidia
Bacillus	*Actinoplanes sp*	*A. ramosa*
B. brevis	*Microbispora bispora*	*Absidia sp.*
B. cereus	Micromonospora	*Mortierella turficola*
B. circulans complex	*M. parva*	Mucor
B. coagulans tipo A	*M. vulgaris*	*M. miehei*
B. coagulans tipo B	*Micropolyspora faeni*	*M. pusillus*
B. licheniformis	Nocardia	*M. racemosus*
B. megatherium	*N. brasiliensis*	*Rhizomucor sp.*
B. mycoides	*Nocardia sp.*	Ascomicetos
B. spharicus	*Pseudonocardia thermophilia*	*Allescheria terrestris*
B. stearothermophilus	Streptomyces	*Chaetomium thermophilum*
B. subtilis	*S. rectus*	*Dactylomyces crustaceous*
Cellumonas folia	*S. thermofuscus*	*Myriococcum albomyces*
Chondrococcus exiguus	*S. thermovulgaris*	Talaromyces (Penicillium)
Clostridium	*S. violaceus-ruber*	*T. dupontii*
C. thermocellum	*S. thermophilus*	*T. emersonnii*
Clostridium sp.	*S. thermoviolaceus*	*T. thermophilus*
Flavobacterium	*Streptomyces sp.*	*Thermoascus aurantiacus*
Flavobacterium sp.	Thermoactinomyces	Thielavia
Mycrococcus	*T. vulgaris*	*T. thermophila*
Mycrococcus sp.	*T. sacchari*	*T. terrestris*
Myxococcus	Thermomonospora	Basidiomicetos
M. virescens	*T. curvata*	Coprinus
M. fluvus	*T. fusca*	*C. lagopus*
Proteus	*T. glaucus*	*Coprinus sp.*
Proteus sp.	*T. viridis*	*Lenzites sp.*
Pseudomonas	*Thermomonospora sp.*	Deuteromicetos
Pseudomonas sp.	*Thermopilyspora polyspora*	Aspergillus
Sarcina		*A. flavus*
Sarcina sp.		*A. fumigatus*
Thiobacillus		*A. tamarii*
T. tiooxidans		Humicola
T. denitrificans		*H. grisea*
		H. insolens
		H. lanuginosa
		H. stellata
		Sporotrichum thermophile
		Malbranchea pulchella
		Scytalidium thermophilum
		Mycelia sterilia
		Papulaspora thermophila

Table 1 (cont.)

Protozoa	Algae
Chilomonas (paramecium) *Cyathomonas (truncata)* *Lycogala epidendrum* *Cercomonas (crassicanda)*	*Hormidium (nitens)* *Vaucheria (terrestris)* *Euglena mutabilis* *Protococcus vulgaris* *Cactylococcus (bicandatus)* *Clorococcum humicola* *Microcoleus vaginatus* *Porphyridium (cruentum)* *Kentrosphaera sp.*

IMPORTANT FACTORS OF COMPOSTING

Initial compounds and particle size

Composting organisms are heterotrophic, thus they require carbon sources which are present in wastes. Compounds get broken down at different speeds. For instance: carbohydrates>hemicellulose > fats/lipids> cellulose, chitin > lignin (Cooperband, n.d.)

For this reason, fruits and vegetable wastes are easily degraded since they have large amounts of sugars and starches. Leaves and trunks for example have more cellulose and lignin in their composition so they are degraded slowly. Animal wastes and green tissues are sources of amino acids which are required for the growth of composting organisms.

The particle size is heterogeneous, so most of the times waste is shredded. For instance, a good particle size would be 1.25-4 cm (Ratchasima, 2001) although for easily decomposable material larger sizes such as 9.25 cm are also suitable (Kreith, 1994).

Small particle size allows microorganisms to access the substrate easily because they have more surface area. But particles too small can result in small pores that do not allow enough aeration and oxygen access.

Aeration or oxygen concentration

The desired composting is the aerobic, so oxygen concentration in composting material would not go below 5%, 10% being the optimal (Cooperband, n.d.), although it depends on the physical and chemical properties of wastes. During all the process, oxygen located in the center of the material may decrease to low levels; that is the reason why composting requires turning and mixing during the process. It must be considered that at higher temperatures more oxygen is needed.

Temperature

The compositing process is faster up to 170 ºF, but above 170 ºF (around 70-75 ºC) the process stops, since the microbial activity is inhibited. Moisture content of wastes helps to reduce high increase of temperature. The decomposition of cellulose and lignin is enhanced around 45-55 ºC – optimal temperature for Eumycetes and Actinomycetes (Ratchima, 2001).

Also, the respiratory reactions during composting make the temperature rise and it is used as a parameter to control microbial activity. Thermophilic range at the final part of the active stage is desired since high temperatures kill some pathogens and weed seeds, but temperature above 55-60 ºC have to be avoided (Kreith, 1994).

Moisture content
Water is needed by organisms, especially bacteria which is very sensitive to moisture changes. Furthermore, water allows the waste to maintain the temperature and its composting procedure. 40-50% is the ideal range, when it is above 60% means that all pores are filled with water and there will not be enough oxygen. Below 20% no biological process is possible.
Blending or adding water is measures that allow controlling moisture during composting. Moisture is usually tested by hand, taking a sample and pressing it between the fingers.

pH
Optimal pH is around 6-7.5 especially for bacteria although some of the organisms, such as fungi, can grow in a broad range of pH. If pH is less than 4.5 lime is usually added. At initial stages of composting pH decreases by the action of acidogenic bacteria, reaching the neutrality later.

C/N ratio
This ratio is related to the supply of the total carbon relative to total nitrogen. When C is too high (High ratio), composting is slow. When N is too high, most of the ammonia is lost by gas and gives bad odors. Green materials as well as animal wastes have generally low C/N ratios. Some examples of usual C/N ratios are listed in table 2. Desired ratios for composting are around **22-31** (Ratchima, 2001). When the ratio is higher than 30 then C/P must accomplish 120-240 (Teira, 2003). In order to get optimum ratios, materials are often mixed and combined when it is possible. Materials with low C/N ratio and high amounts of available C, small particle size and high moisture content get degraded fast hence consume oxygen faster and may get degraded anaerobically giving bad odors.

Table 2: Some materials and their C/N ratio. (Source: Cooperband, n.d.)

Materials	C:N Ratios
Fall leaves	30-80
Straw	40-100
Wood chips	100-500
Bark	100-130
Mixed paper	150-200
Newspaper, cardboard	560
Vegetable wastes	15-20
Coffee grounds	20
Grass clippings	15-25
Manure	5-25

Pile shape and size
It will affect the temperature and oxygen content. Small piles let oxygen to get diffused but heat is not well retained.

COMPOSTING PHASES

Lag phase: It is the time that biota gets adapted to the media. The easily degradable material starts to being decomposed: sugars, starches, amino acids, simple hemicelluloses… Once this degradation process starts, mesophilic bacteria increase and temperature starts rising. Protozoa and fungi in this phase are not relevant. In this phase, bacteria are the most important organisms. If most of the waste is highly putrescible and yard wastes are involved, lag phase is quite short (Kreith, 1994). The lag phase usually lasts 12 to 24 hours.

Active phase: Bacteria start growing exponentially. Temperature in the waste mass starts increasing at the peak would be 70ºC or even higher until the nutrients start decreasing. The weight and volume of the waste decrease and the material reaches partial stabilization; Due to temperature raise, pathogens and weed seeds are killed. The active phase lasts from 5 days to 5 weeks, depending of the waste composition.

Maturation or curing phase: It starts when the easily decomposable material is over and there is energy generation. Microbial proliferation and temperature decreases until it reaches the ambient temperature. This is the phase of the humification where there is reorganization of organic matter and degradation of the phytotoxic substances. This phase may last from few weeks to a couple of years.

The composting phases can be represented by a temperature curve (figure 3). The type of microorganisms in every phase change according to the temperature reached and the nutrient availability.

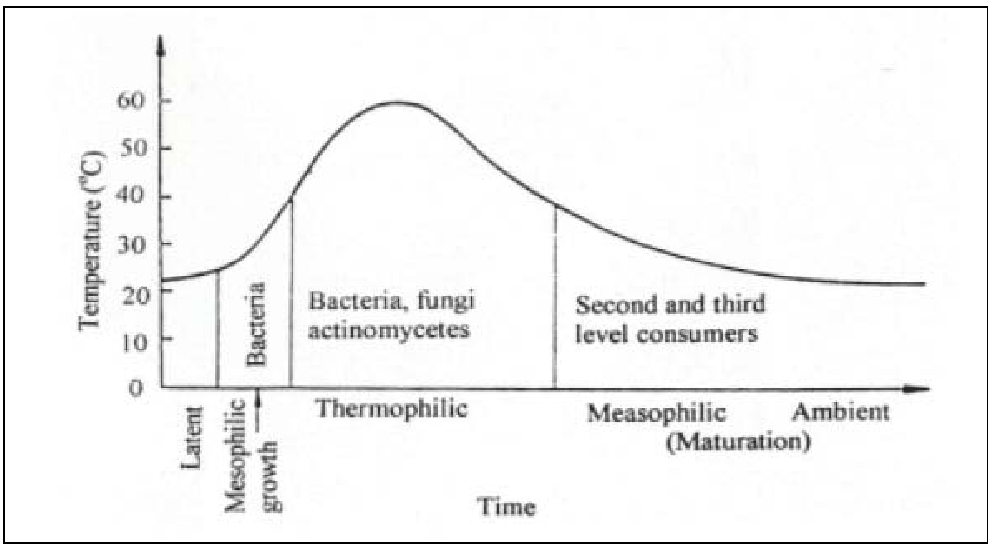

Figure 3: Curve of the temperature followed in a composting pile
(Source: Ratchasima, 2001)

Although composting generally comprises all the phases, material that does not reach the final phase can be also be utilized in certain conditions. For example, the material from the mesophilic and thermophilic phases may be used in extensive crops with nitrogen deficiency. Material from the early maturation can be used extensively in crops before seed (Teira, 2003).
Composting process is considered to be over when the product can be storied indefinitely without the risk of being anaerobic or an appreciable heat generation. The product can be applied on the soil because either its C/N is low or the C content is less available. The final product is stable because of the final state of the organic matter. The final product is mature because it does not have phytotoxic organic acids.

CONTROL PARAMETERS

Composting process although happens naturally must be controlled in order to know if the waste is following an adequate decomposition and thus the final product can be safety applied on the soil and accomplish certain quality factors.

The most common way to monitor the process is by measuring the following parameters:

- Daily temperature
- Daily oxygen content
- Weekly moisture content
- Maturity test: A total of five times, with the Rottergrade test, which is based on the temperature reached by the waste at a kind of lab scale composting process.

Other parameters that may help to know when the process is complete are:

- Odor
- Color (dark brown-black)
- Leachate production
- Porosity
- Flies, fungi and other insects proliferation
- Loss of volatile solids
- Loss of organic matter
- Texture: The final product have a particle fraction around 1-2 mm at this majority, while the initial waste have most of the particles above 12 mm (Teira, 2003)
- Bulk density
- Water retention capacity
- Pathogens and weed seeds
- Soluble salts
- Proteins, fatty acids, N, P, K, NH_4, NO_3, Cellulose, Heavy metals.
- Bacteria precence (*Coliforms* and *Streptococcus faecalis*, *Clostridium perfringens, Salmonella*)
- Germination test:

GENERAL STEPS AND SYSTEMS FOR URBAN WASTES COMPOSTING

The general scheme of composting process is showed in figure 4.

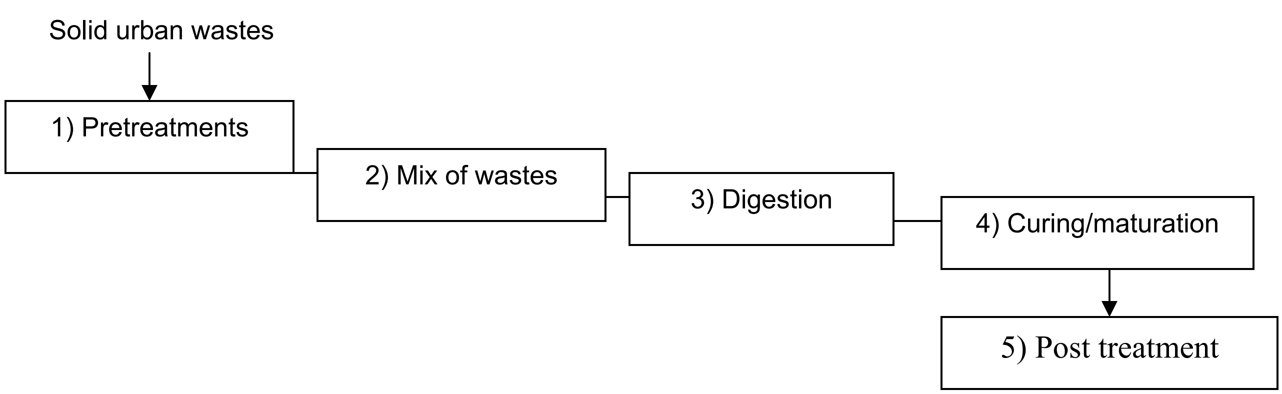

Figure 4: Basic diagram of composting

1) Pretreatments:
Municipal solid wastes have a big heterogeneity and need to achieve the optimal conditions for composting. Some of these operations are the following:

Separation of wastes: Not all the wastes are biodegradable. So the separation of non-biodegradable materials and other contaminants is a requirement before composting this kind of wastes. There are several techniques of separation, depending on the material to separate:
- Sifters: Rotating cylinders or vibrating tables with holes (these last ones are not very efficient for humid residues) (Tabares, 2003). They split the wastes in different sizes. The biggest sizes are plastics, papers, metals, and textile.
- Magnetic separation: The magnets in rotor cylinders remove metals from the wastes. Its efficiency depends on the wastes depth.
- Eddy system: This technology is based on repulsive forces in good conductors, and is useful to separate aluminum and copper for instance.
- Air classifier: A column receives the wastes while air flows against the waste flux, this way there is a separation based on densities
- Ballistic separation: The non organic and denser particles (>2g/cm^3) are separated from the organic and less dense part of waste (<0.5 g/cm^3). A rotor projects the material, which follows different trajectories depending on their density. The denser the particle the closer to the rotor it falls. It is more efficient than the air classifier, and can separate glass pieces, plastics, ceramics, stones and metals from the waste (fig.5).

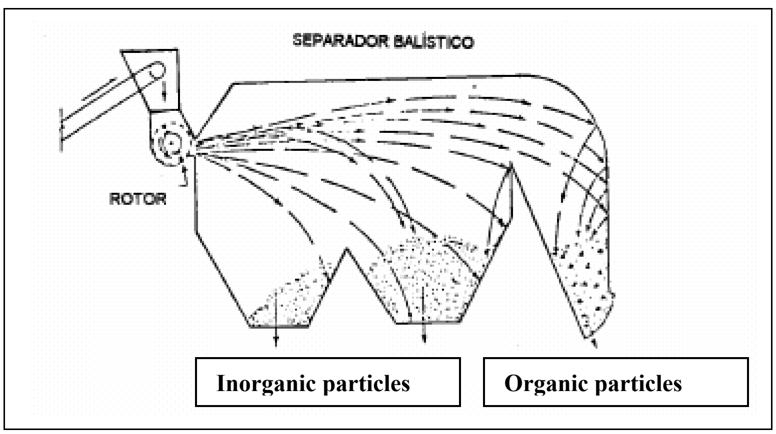

Figure 5: Ballistic classifier (Source: Tabares, 2003)

2) Mix of wastes
The mix of different kind of wastes demands optimizing the compost process just achieving the best microbial activity. This way a right amount of nutrients, oxygen, moisture, pH and temperature levels are ensured (USDA, 2000).
The compost mix may have 3 main components: primary substrate, amendment, and bulking agent. The primary substrate would be the municipal solid waste pretreated. The amended is all material that may be added in order to get a better C:N ratio, pH, improve the stability or optimal moisture. The bulking agent is material with a very low decomposition rate which will provide the waste with a right structure and porosity for the decomposition phase. After maturation, the material may be screened and re-used.

More than one amendment can be added to the waste if is necessary. Some examples of amendments are: Shredded rubber tires, wood chips, crop residue, peanut shells, rice hulls, spoiled hay, silage, leaves, grass clippings, newspapers, and so on. (USDA, 2000)

3) Digestion

The current methods can be classified generally depending on the mechanical operations (static, dynamic), Material deposition (pile, windrows), material isolation (open, enclosed) and process velocity (slow or accelerated) (Teira, 2003). Some of the common methods are following described.

- Passive aerated piles: The material is distributed forming a pile 1.2-1.8 m high and 2.4-3.6 m width. The difference from a windrow is the shape: Piles are elongated and dome shaped. The piles are turned periodically to make temperature go down and keep the porosity that allows the air come through the material. It is called passive because the air comes inside the pile naturally. It does not require much equipment, but since composting is lower there is more risk for anaerobiosi. Piles are disposed on pavements sometimes perforated, so leachate can be released. This method is more often used for leaves composting, where thermophilic conditions are desirable.

-Windrows: Windrows are elongated piles, but the shape depends on the material and climate of the region among other conditions which may include industrial equipment. Typically they are 1.8 m to 3 m high, 4.5 m to 6 m wide, and variable length. The cross section can be rectangular, trapezoidal or triangular. Windrows may be turned about 5-7 turnings during all the decomposition process, which helps when the aeration method is passive. Time of digestion with this method ranges 3-9 weeks. (fig.6)

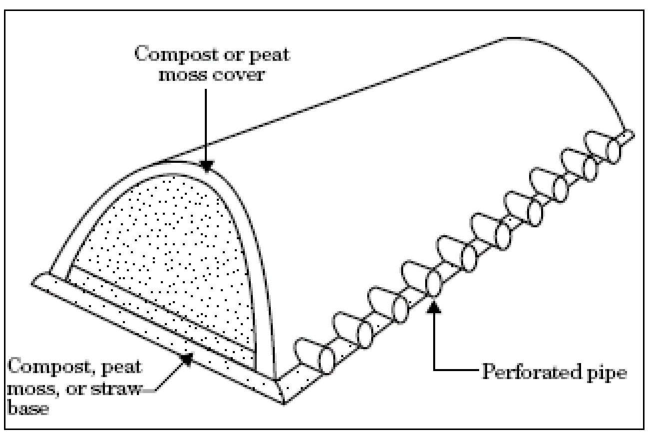

Figure 6: Windrow system of digestion (Source: USDA, 2000)

- Aerated static pile: The difference with aerated windrows is that the pile has some blowers that suction or blow air through the pile continuously or at intervals. It also wallows controlling the temperature during the process, so the pile is usually covered with a layer or already composted material to avoid excessive heat loss (fig.7).

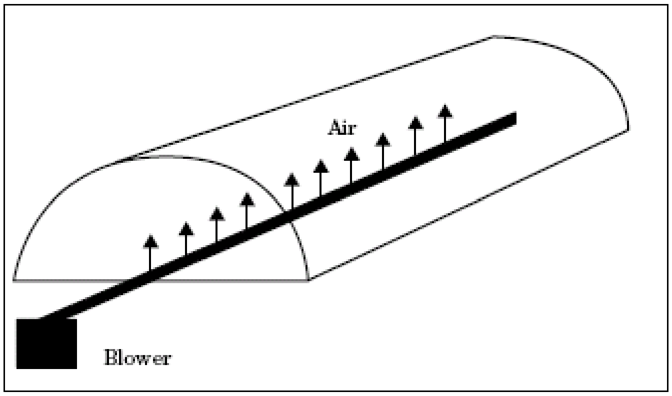

Figure 7: Areated static pile (Source: USDA, 2000)

<u>-In-vessel systems</u>: With this system the composting process is more controlled. It is highly suitable for fast composting processes where the odor can be a concern and there is not enough space.

- Bins: Constructed bins of wood or other material with or without roof. They can be aerated or passive aerated.
- Rectangular agitated bed: They are long beds with an automated turner for periodic turning. The duration of the composting process is determined by the length of the bed and the turning frequency. The retention time of the compost in this system is about 14 days (Rhyner et al., 1995).
- Silos: The decomposition phase is very fast in this system so the maturation will have to be longer. The waste is loaded from the top of the silos, and it's taken from the bottom, where the air is forced through the silo. The collected air on the top can be treated by a biofilter.
- Rotating tube or drum: For small amounts of waste. The tube of 3 meters length has plates and is loaded from the top, and stays in the first baffle plate, and when is filled, the tube is rotated to aerate the compost and empty the first baffle plate.

All the static systems require an adequate porosity to allow air passing through the waste.

4) Maturation/curing
The maturation stage is a prolongation of the decomposition stage. The non mature compost is split in smaller piles (around 2.4 m height and 5-6 m width) is monitored but not as frequently as in the decomposition stage (Teira, 2003).

5) Post-treatments
The final product can be refined, classified and finally packed.

THE COMPOSTING PLANT

The composting plant must be located on a suitable soil and topography. The site has to be graded to avoid standing water, runoff and erosion, with slopes at least 1% to 4% (Pichtel, 2005). Surface area is important since compost facilities require big surfaces, especially if they work with pile or windrows. Some of the common areas and its characteristics are explained, and the figure 8 shows the distribution of a composting plant.

Preprocessing area
Enough space to receive the material and separate it. It will be normally under a roof, so the unloading of the material won't be affected by the climate.

Processing area
It includes all the composting pad and maturation area. The pad surface is usually paved to prevent infiltration of the leachates. An adequate drainage has to be provided for avoiding water pounding, bad odors, or excessive runoff among others. Also good ventilation is required, with air filters with vents over preprocessing equipments.
The curing or mature compost area is just for storing and allow the material to be stabilized, so things such as runoff or infiltration won't be so important in that area. Curing area needs less space, about ¼ of the compost pad (Pichtel, 2005).

Buffer zone
A large buffer zone will make the facility more acceptable for residents and depends on the kind of waste material we are processing, and it is extended on the wind direction. This zone generally is larger than the composting pad, although enclosed facilities can have it smaller since they have more control over the process (Pichtel, 2005).

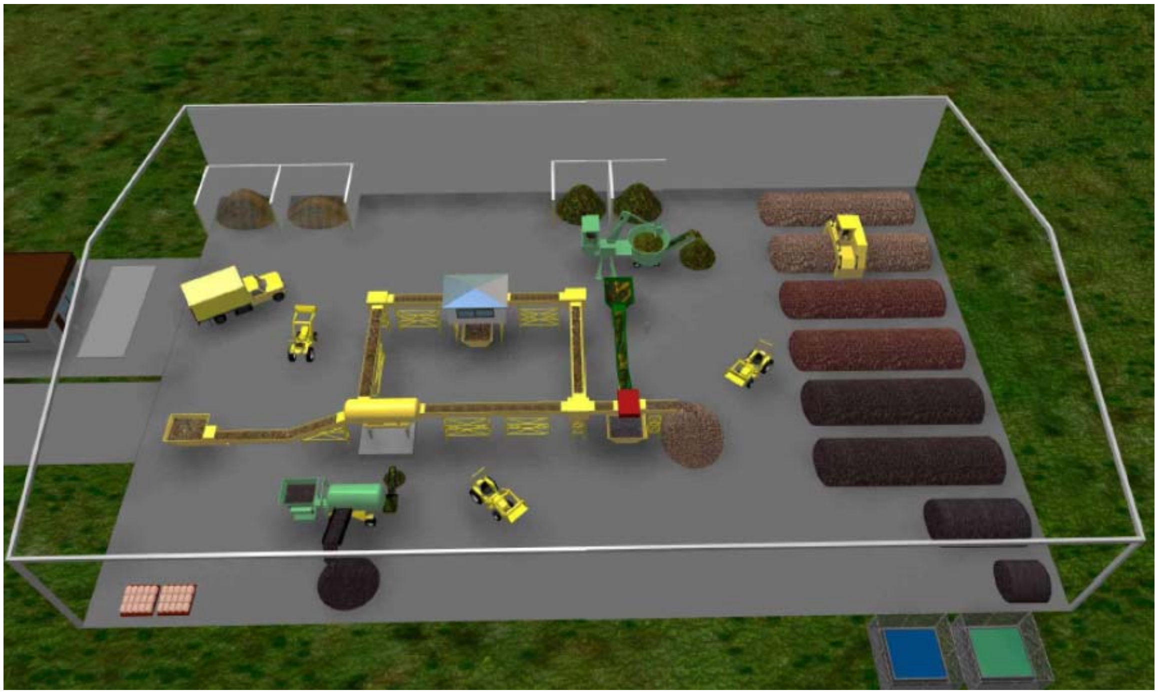

Figure 8: Example of a composting plant (Source: Teira, 2003)

CONCLUSSIONS

The fact that composting is a natural process makes it an ecological technology for treatment of decomposable wastes. But on the other hand, natural processes are more difficult to control, especially because composting includes a large number of microorganisms and their interactions with the waste, environment and themselves. This makes composting difficult to monitor since municipal solid wastes are highly heterogeneous. Furthermore, the seasonal effect on wastes and biota must be considered, and the process may not be suitable in very cold, too dry or too wet regions.

The pre-operations in composting add some expenses to the process, as well as the composting plant, which has to meet some specifications for safety, leachate control, and required area which tends to be a limiting factor.
Also maturity determination of the final product is sometimes complicated although the current standards and the inefficient determination can lead to environmental pollution due to the production of toxic intermediate compounds or compounds with high odor potential (sulfur containing compounds and ammonia-nitrogen containing compounds). Composting time must be adequate not only for acquiring the compost maturity, but also for industry economics: Excessive composting time can lead on higher process expenses and less compost production at the end of the year.
However, current technologies make composting fast and suitable with al kind of degradable wastes. A well monitored process does not give many pollution or hazardous concerns, and allows an effective and complete reutilization of organic matter. Although toxic leachate may be produced during the process, adequate moisture and covering the piles when they are disposed outside and there is precipitation, reduces the amount of leachate. The leachate amount will be always lower than the amount produced by the buried wastes, which release all the water and toxic compounds through the soil and the risk of ground water pollution is extremely high.
Despite of the efforts for splitting durable and non durable goods, the technology leads on the principles of the modern societies where no free spaces for waste disposal are available and the reutilization of wastes is required. So for the same pre-treatment operation, the different fractions from waste may be split and processed for their reutilization.
To summarize, composting may be the future technology for organic wastes treatment. The success of composting and the acceptance of the final product depend on country policies. Informative campaigns and use of incentives may help population to understand the process and farmers to know about compost benefits. The current acceptance of the methodology in certain countries (France, Germany, and Israel) started with a gradual incorporation of the technology in small regions. The technology may be improved then if population is contributing in the waste split from the origin. Waste separation from house holders would decrease energy and costs of waste pre-treatments, and would benefit all the recycle technologies of the following stages.

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