Compost

Compost - soil bank for the future

The word 'compost' conjures up images of an untidy heap of assorted kitchen and vegetable remains at the far end of the garden. A more scientific definition of compost would be *the product of natural degradation of botanical and putrescible waste by the action of bacteria, fungi and other organisms in the presence of an adequate air supply*. The biological decomposition processes break down complex organic substances into carbon dioxide, water and a residue: compost. The final product is relatively stable and can be used as a soil improver, a mulch or as a component in a growing medium. Further biological processes in the soil turn compost into humus.

Composting. This occurs when there is a plentiful supply of oxygen, moisture and warmth. Compost must be regularly aerated, by turning the heap or by injecting air into the composting material, for the process to be successful. Under properly controlled conditions the temperature of composting refuse will rise to levels which are sufficient to kill pests, weed seeds and pathogenic bacteria.

Anaerobic fermentation. This occurs when the oxygen supply is restricted. Complex hydrocarbons are broken down into reduced intermediate by-products; methane - which has a potential value as a fuel - and carbon dioxide are released. Anaerobic decomposition - called fermentation or digestion - occurs all the time in landfill sites containing household refuse.

Decomposition. Three main classes of micro-organisms are involved in the decomposition of refuse: bacteria, fungi and actinomycetes. Bacteria and fungi predominate as the organic material begins to decompose. If sufficient air is available, the metabolic activity of these micro-organisms is so great that temperatures can rise to 70^{o}C or more. At this stage, only heat-tolerant (thermophilic) bacteria and actinomycetes can continue to decompose the waste. Gradually, as the substrate is consumed, the rate of decomposition slows, the compost cools, and the fungi and non-thermophilic bacteria become active again. All micro-organisms need water to function; if the moisture content of composting waste falls below 40 per cent, microbial activity slows. If the moisture content is too high, however, air spaces within the composting material fill with water, creating anaerobic conditions which can cause unpleasant odours. As the waste decomposes, its composition changes. This is reflected in the ratio of its carbon to nitrogen content (referred to as the C:N ratio) The C:N ratio of the 'fresh' organic fraction of domestic refuse is around 20:1 - this gradually decreases as composting proceeds. In mature composts the C:N ratio is around 12:1. If immature compost with a high C:N is applied to the soil, the continuing decomposition of the carbonaceous substrate can 'lock up' nitrogen from the soil.

The end point of composting, mature compost, is hard to define but C:N ratios are useful indicators. Immature compost may be prone to self-heating as decomposition continues, may be odorous, and may contain substances which are harmful to plants.

Mature compost is a valuable substance. It can act as:

- ***A soil conditioner*** *- improving soil structure, especially for heavy clay soils. Compost also retains moisture and so helps to improve light sandy soils. It reduces soil erosion or desertification, and helps to bind nutrients, preventing them from being washed out of the soil.*
- ***A soil fertiliser*** *- encouraging a vigorous root system.*
- ***A mulch*** *- if applied around plants it will smother small weeds and prevent the surface soil from drying out.*
- ***A peat substitute*** *- for use in potting mixtures.*

Household refuse contains a high proportion of organic materials which are suitable for composting. The compostable fraction of domestic waste includes food scraps, animal wastes, soft plant materials, paper and card. However, not all materials of biological origin decompose fully during composting. Less readily decomposed materials include wood, bone and industrially 'altered' organic materials such as leather. Data on refuse composition is notoriously unreliable, but surveys show that municipal solid waste often contains as much as 50 per cent organic material. In countries where less processed food is consumed, waste with a far higher concentration of compostable materials is produced.

A typical aerobic composting system has several stages:

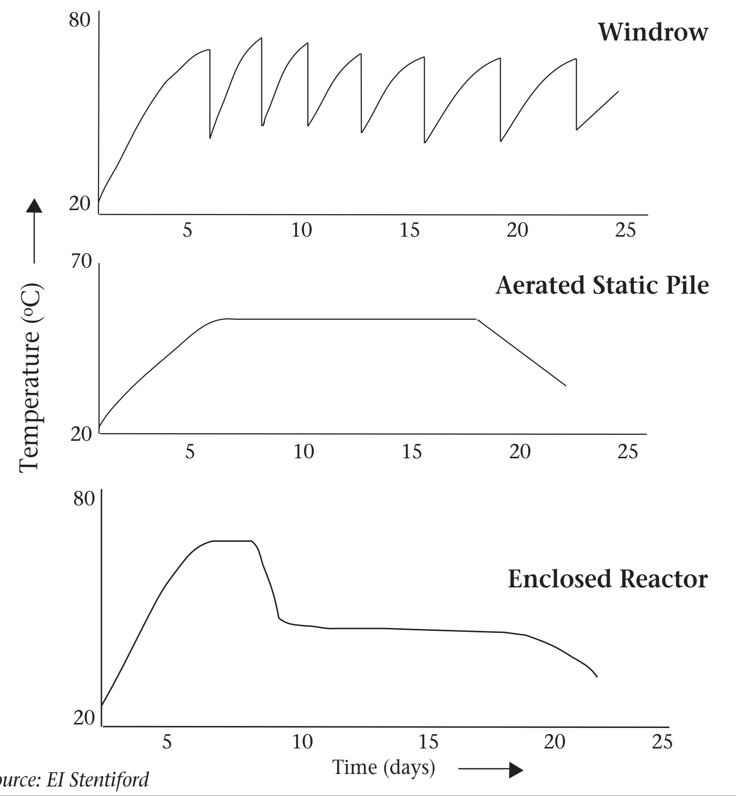
Pre-processing
High quality compost needs a pre-sorting stage, ideally by source separation at the household. Mixed waste plants usually need to modify the incoming refuse, making it more suitable for composting. With unsorted waste, materials recovery takes place at this stage, and the waste can be shredded and/or screened to homogenise the organic fraction.

Decomposition
Methods used for the large-scale production of compost fall into three main categories. **Windrow composting** uses mechanical turning to aerate periodically the composting waste, which is placed in elongated heaps up to two metres high.

In **aerated static pile systems**, the waste is carefully piled over a ventilated floor area or a perforated pipe, through which air can be passed. The ventilation may be vacuum-induced, with air drawn inwards through the waste. This allows any odours produced to be contained and, if necessary, treated. Alternatively, air may be blown outwards through the composting waste; this method is often preferred as it allows the heat from the most rapidly decomposing waste at the centre or base of the pile to be transmitted to the outer, cooler regions. Forced aeration systems generally have higher capital costs, and lower operating costs, than windrow systems.

A variety of **enclosed reactor systems** may be used, which are designed to allow close control over temperature, *(see charts above)* moisture and aeration

Temperature Profiles for Alternative Compost Systems



Source: EI Stentiford

and mixing rates, but which also require a high investment of capital. These technologically more advanced systems are typically applied to more complex mixtures of wastes, or where land availability is a problem.

Maturation
Even when the compost has been stabilised using one of the above methods, it may not be ready for use. During decomposition, complex organic molecules are converted by stages into simpler compounds. Some of the intermediate breakdown products in this process can be toxic to crops. The compost may need to pass through a final maturation or curing stage while these plant toxins are further decomposed before it can be used. This may take weeks or months.

The amount of compost which a mixed municipal waste composting plant can produce will, of course, vary according to the quantities of waste received, but will also depend on the composition of the waste and the quality required of the final product. Most organic waste has a high moisture content, and there is a substantial drying effect during composting; there is also a considerable loss in dry weight, due to the transformation of organic carbon to gaseous carbon dioxide. The final stages of processing the composted material also have an effect on the yield of a composting plant. For high quality compost, it is usually necessary to incorporate a final sorting stage to remove uncomposted particles and inert contaminants such as glass or plastic.

Compost from mixed domestic wastes is not easily marketed. Cases of failure to find markets have been well documented in Germany and other European countries. However, compost produced by plants in the Middle East has been in such demand that in some cases would-be customers have had to join a two year waiting list. Composts produced in Japan (from sewage sludge, agricultural and municipal wastes) and the former USSR are used almost exclusively by farmers. Increasingly, countries are favouring the separate collection of putrescible household wastes. In the Netherlands, separate collection systems have been mandatory since 1994. Austria, Germany and Switzerland all have similar requirements now in place.

Calculations indicate all the waste that could be produced in Europe would only be sufficient to cover ten per cent of agricultural land.

Compost must compete with other soil conditioners, and municipal authorities have been reluctant to invest in plants without an assured market for the product. Markets have been hampered by poor quality, badly stabilised compost, with visible contaminants such as pieces of glass and plastic. However, even when no ready market is available, composting can provide an effective means of reducing the polluting potential of household refuse. Composting stabilises degradable materials and reduces their volume, conserving landfill space and decreasing the risk of pollution from landfill gas and leachate. Another objection to municipal compost is that it may contain heavy metals (and other toxic substances) because of its origin as mixed refuse. It is difficult to separate out the main sources of heavy metals before composting, and research is currently under way to improve the process. Most of the heavy metals present are found in the smallest particles of the household waste, so effective screening can remove a high proportion. However, complete removal of these contaminants is rarely possible. Some of the most difficult metal-rich contaminants to remove are household dust (which can have a high lead content), staples, wine bottle caps and batteries. To produce high quality composts, it is far better to ensure that contaminants do not mix with the compostable waste, by source separation for central composting, or by composting at home.

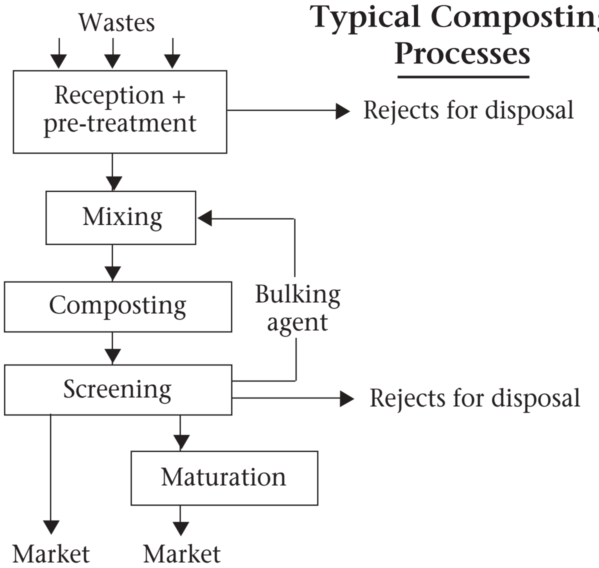
If the individual householder composts the organic refuse his household produces, not only is it removed from the waste stream at source, but the householder has complete control over the type of refuse he puts on the compost heap, and can therefore include only biodegradable material. Since conditions inside a garden compost heap cannot be controlled as closely as in a large-scale composting plant, animal wastes etc should not be included. Where it is not possible for householders to compost their own refuse, the local authority can operate a service in which the organic fraction is collected separately from other rubbish. In this case, the resulting compost will be of a much more consistent quality, and many of the problems (such as contamination with heavy metals) are minimised.

In Britain, the number of central composting schemes have increased significantly in recent years. Often the feedstock is green waste collected at municipal civic amenity sites, sometimes co-composted with sewage sludge, although several selective collection schemes are now in operation. In these, householders separate kitchen and garden waste from the rest of the waste stream.

In Germany, composting activity has increased considerably in recent years. In 1985, 12 facilities produced around 0.25 million tonnes pa. By 1993, there were around 100 plants in operation, yielding 1.1 million tonnes pa. By the end of 1996 there were more than 380 plants operating, 244 of which produced a high quality certified compost.

In the 1980s, French composting facilities would traditionally process mixed household solid waste. As a result, the product was of low quality, tainted by heavy metals and containing sharp glass and plastic film. As farmers demanded higher quality material for land application, so end-markets for mixed waste compost declined. Early in the 1990s a few municipalities (Bapaume, Niort, Lille and Le Creusot) introduced selective kerbside collection for compostable waste. Of these, Bapaume has now developed a

Typical Composting Processes



Information Sheet

cost-effective system that works well in a rural or semi-urban setting. The Bapaume experiment, which collected green wastes, kitchen wastes, disposable nappies and cartons) demonstrated a range of benefits:

- *bio-bins collected 40 per cent of the waste stream*
- *more than 95 per cent of the bio-bin contents were compostable*
- *less than one per cent of bio-bins were refused by collectors*

Trials were scaled up into a commercial composting plant using the OTVD-SILODA process. The unit, operational in 1997, processes up to 14,000 tonnes pa as more municipalities join the scheme. A survey in France in 1993 suggested that there were 73 MSW composting units (no source separation), 30 green waste composting plants, 16 farmyard manure composting facilities, ten mixed organics composting plants and five experimental source-separated plants.

In America, the total number of garden waste composting facilities reached more than 3,300 in 1995. Some two-thirds of these involve the composting of leaves collected in the autumn. Around half of USA states have programmes to support home composting. More than 20 states have banned garden wastes from direct landfill disposal. In 1993, 18 pilot programmes were underway to evaluate composting of compostable (non-garden) wastes. These were mainly windrow systems with capacities up to around 100 tonnes per day. Most took source-separated material from residential, commercial or industrial sectors.

In Japan, composting plants have been built in many cities, to reduce the waste load to incineration facilities. By the mid-1990s some 29 composting units were operating in Japan.

In less prosperous nations, there is often a higher level of organic material in the waste stream. Brazil, which produces some 90,000 tonnes MSW each day with an organic content of up to 60 per cent, now has 74 composting plants, 19 per cent of which are fully mechanised. Around 30 municipalities in Brazil employ some form of source-separation for organic waste, further improving the quality of the final product. The demand for compost made from source-separated MSW should increase as experience in its manufacture and use grows. This trend is supported by the continuing development of schemes to standardise and certify quality composts. It is already used for spreading on areas of salty land to restore fertility, and as the world's topsoil is already being lost at the rate of three tonnes per acre every year, it seems likely that compost will eventually be in demand for restoring the structure of farm soils everywhere. Moreover, current research into the co-composting of organic MSW with sewage sludge suggests that the resulting product might prove an acceptable general purpose fertiliser. Since landfill space is at a premium throughout the Western world, reducing the volumes going to landfill by removing the organic fraction in this way makes obvious sense - in both economic and environmental terms.

The production of compost from source-separated MSW will increase with the introduction of legislation to prevent landfilling waste with, for example, a total organic content above ten per cent. With the growing preference for recovery targets, composting is set to become an increasingly popular waste management tool.

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