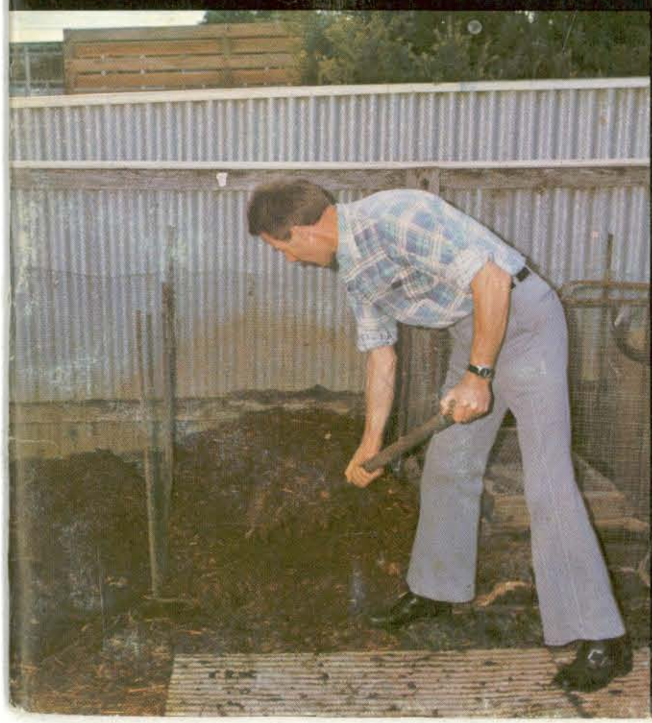
COMPOSTING



COMPOSTING

MAKING SOIL IMPROVER FROM RUBBISH

Discovering Soils No. 3

CSIRO DIVISION OF SOILS

Contents

CONVERSION TABLE

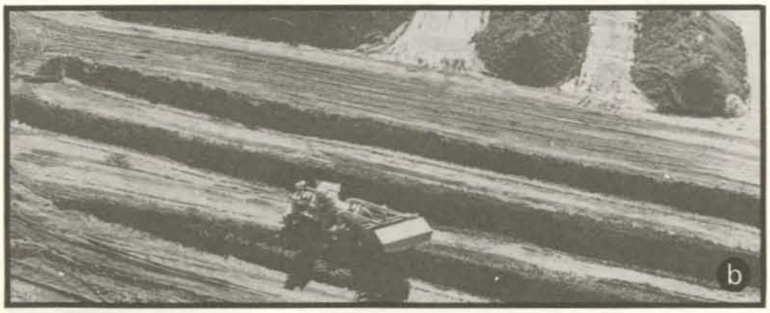
1 g = 1 gram = 0.035 ounces (1 ounce = 28.35 g)
1 ml = 1 millilitre = 0.0018 pints (1 pint = 568 ml)
1 cm = 1 centimetre = 0.4 inches (1 inch = 2.54 cm)
1 m = 1 metre = 100 cm = 3.28 feet = 39.37 inches

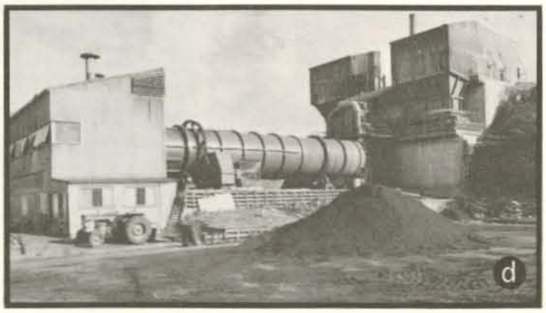
Composting–
Making soil improver from rubbish

Rubbish is one product our society makes very well. We make mountains and oceans of it. We dump it in holes and in the sea, bury it and burn it. But when we run out of holes, when the sea cannot take any more, and when we get sick of smoke in our eyes, what do we do then?

One answer given by those who are concerned about our soils and food production system is: "Compost it and return it to the soil". They are, of course, referring to the many organic materials that we throw away or burn – lawn clippings, leaves, weeds, sawdust, paper, kitchen scraps, seaweed, etc. The compost heap can convert this bulky "rubbish" into a soil improver and fertilizer.

This booklet is about the science and art of making compost, and has a bit of philosphy too.





Options for organic wastes
(a) Typical Australian land-fill rubbish tip – dirty, smoky, smelly.
(b) American community composting facility.
(c) Turning and mixing a heap.
(d) Auckland (N.Z.) Municipal Compost Plant.

Composting – What is it?

Any organic materials thrown into a heap will eventually be reduced in size by small animals and rotted down by microorganisms already present on them or that come from the underlying soil. This sort of thing has been happening for millions of years in litters on forest floors and other places where organic materials accumulate.

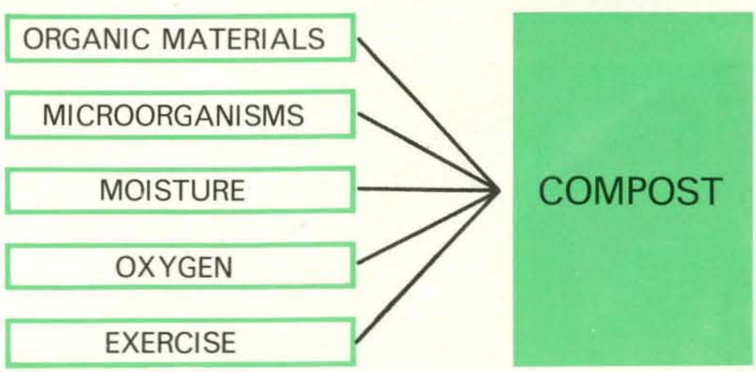
Composting is really just a method of speeding up the natural processes of rotting, but in the compost heap we can control the process to suit ourselves. Good technique ensures minimal losses of nutrients and hence their maximum return to the soil.

The Chinese, Japanese and other Asian peoples have been making compost for at least 4000 years, returning to their soils via compost heaps, sheds or pits every scrap of animal and vegetable "rubbish" and much mineral matter from canal bottoms. Their methods were made known to the rest of the world through a book called "Farmers of Forty Centuries", written in 1911 by Dr F. H. King, an American soil scientist. Sir Albert Howard, a British agronomist who worked in India during the first 40 years of this century, distilled the best from these composting methods. After many years of patiently studying the various possible techniques he devised the Indore composting process. Since 1931 it has been the basis of most home garden compost heaps.

Many later studies have added to our information about the composting process so that in home gardens and on an industrial scale composting has had much of the guess-work taken out of it. We know how to make a good product.

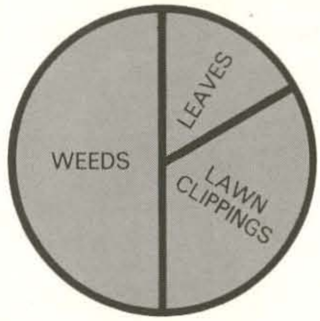
Ingredients

The essential ingredients of a compost heap are organic materials, microorganisms, moisture and oxygen (and a little soil, gypsum, dolomite or lime).



Organic materials

Compost of high fertilizer value can only come from "high quality" rubbish. The most important aspect of quality is the carbon: nitrogen (C/N) ratio of the organic materials used. Microorganisms need both carbon and nitrogen to make protein. As they use about 30 parts by weight of carbon for each part of nitrogen used, we need to supply them with materials having a C/N ratio of about 30. Microbial activity is reduced at higher C/N ratios (low nitrogen supply) and valuable nitrogen may be lost as ammonia gas if the C/N ratio is lower than about 30. In practice, it has been found that the average C/N ratio of the materials in a garden compost heap should be slightly less than this – in the range 25 to 30 – for the heap to work well. The table will help you achieve somewhere near the optimum C/N ratio.



Approximate composition of some organic materials

Material	C/N Ratio (Weight/ Weight)	% Moisture in material	gC/100g moist material	gN/100g moist material
Lawn clippings	20	85	6	0.3
Weeds	19	85	6	0.3
Leaves	60	40	24	0.4
Paper	170	10	36	0.2
Fruit wastes	35	80	8	0.2
Food wastes	15	80	8	0.5
Sawdust	450	15	34	0.08
Chicken droppings (no sawdust)	7	20	30	4.3
Chicken litter (typical)	10	30	25	2.5
Straw	100	10	36	0.4
Cattle droppings	12	50	20	1.7
Human urine	–	–	–	0.9
Seaweed	25	80	8	0.3
Pine needles	70	25	35	0.5

This commercial shredder does an excellent job of reducing the size of woody garden wastes such as prunings.

Examples of mixtures with C/N ratios between 25 and 30

Lawn clippings : sawdust, 12:1

$$\frac{C}{N} = \frac{(12 \times 6) + (1 \times 34)}{(12 \times 0.3) + (1 \times 0.08)} = 29$$

Lawn clippings : weeds : leaves, 2:3:1

$$\frac{C}{N} = \frac{(2 \times 6) + (3 \times 6) + (1 \times 24)}{(2 \times 0.3) + (3 \times 0.3) + (1 \times 0.4)} = 28$$

Leaves : sawdust : cattle droppings, 2:1:2.5

$$\frac{C}{N} = \frac{(2 \times 24) + (1 \times 34) + (2.5 \times 20)}{(2 \times 0.4) + (1 \times 0.08) + (2.5 \times 1.7)} = 26$$

Fruit wastes : lawn clippings, 2:1.5

$$\frac{C}{N} = \frac{(2 \times 8) + (1.5 \times 6)}{(2 \times 0.2) \times (1.5 \times 0.3)} = 29$$

Weeds : paper : chicken litter, 4:3:1

$$\frac{C}{N} = \frac{(4 \times 6) + (3 \times 36) + (1 \times 30)}{(4 \times 0.3) + (3 \times 0.2) + (1 \times 4.3)} = 27$$

Leaves : weeds : paper : chicken droppings : urine, 3:3:1:0.5:1
(e.g. 300g + 300g + 100g + 50g + 100 ml)

$$\frac{C}{N} = \frac{(3 \times 24) + (3 \times 6) + (1 \times 36) + (0.5 \times 30)}{(3 \times 0.4) + (3 \times 0.2) + (1 \times 0.2) + (0.5 \times 4.3) + (1 \times 0.9)} = 28$$

Note: The table gives average figures. It should be realized that a given type of organic material can vary considerably according to source. The above mixtures may need to be varied to suit local sources and conditions.

Further mixtures may be formulated according to the materials available. Provided the C/N ratio is right, it is not essential that animal manures are included. Urea is the best source of extra nitrogen if high-nitrogen organics are not available in sufficient quantities to compost large quantities of leaves or other low-nitrogen materials. Two grams of urea contain 0.9 g N (equivalent to 100 ml urine).

Microorganisms also need abundant supplies of the other nutrient elements, with phosphorus being particularly important. A carbon/phosphorus (C/P) ratio in the range 75 to 150 is needed. As leaves (especially gum leaves), woody plant residues and sometimes even lawn clippings have C/P ratios above 150, it is desirable to add extra phosphorus to most compost heaps so as to ensure rapid decomposition. Superphosphate can be used, but if you prefer a more natural source of phosphorus, use rock phosphate or poultry manure, at about 500 g or 7 kg per cubic metre of materials, respectively. The availability to plants of much of the phosphorus of rock phosphate and some of the trace element content of rock dusts is greatly increased by passage through a compost heap.

The other nutrients needed by microorganisms are usually present in sufficient amounts if a wide range of organic materials is used.

Grinding or chopping up the organic materials speeds decomposition by increasing the surface area available to microorganisms. In practice, fine grinding is unnecessary; chopping to pieces 5-10 cm long gives satisfactory results, unless you want fine compost quickly.

Materials such as gum leaves and pine needles can be used in compost heaps, but they must be given a little more time than more succulent materials or less woody leaves.

The salt content of seaweed which has recently been thrown up onto the beach or which has recently been washed in the rain will not cause any problems. But wash encrusted salt from seaweed which has been collected from high up the beach in dry weather.

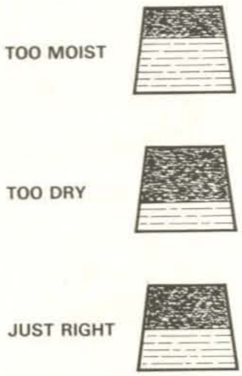
When composting sawdust and/or shavings for use in potting mixes, aim for a C/N ratio of about 80. These materials are resistant to decomposition. Much of any N added to give a C/N ratio of 25-30 is lost from the heap before it can be used by microorganisms. Use 1-2 kg urea per cubic metre of wood wastes or, better, about 5% by volume of poultry manure. Add 3-5 kg of a 1:1 limestone/dolomite mixture to each cubic metre of wood wastes, as they are very acid.

Two Australian-made shredders for converting garden 'wastes' into material for mulching or composting.

Microorganisms

Some hundreds of species of microorganisms, mostly bacteria, fungi and actinomycetes (branching bacteria), are involved in decomposing organic materials. Most organic materials have a native population of microorganisms and others are added to a compost heap in the garden soil often mixed into or layered amongst the organic materials. These microorganisms start their work of decomposition as soon as moisture and oxygen concentrations are favourable. Many research studies have shown that special preparations of fungi, bacteria or "enzymes" are not needed for rapid decomposition; there are plenty of organisms in the materials commonly used to make compost. Adding more is like adding a pebble to a rockslide. The end results are the same with or without the pebble. Only when materials such as

sawdust and seaweed, which are only lightly endowed with microorganisms, are to form a high proportion of the heap is decomposition rate increased by inoculation. The best inoculants are compost from a previous batch, well decomposed leaf litter and poultry manure. Use about 5 percent by volume. The only 'activator' needed is a source of nitrogen. Urea is the cheapest 'packet' source.



Moisture

The moisture content of a compost heap is very important. Below about 40% moisture (40 g water in 100 g moist materials; i.e. 40 g water + 60 g dry matter), organic matter will not decompose rapidly. Over about 60% moisture not enough air can get into the heap and it tends to become anaerobic (no oxygen). It is best therefore to aim at 50 to 55% moisture. This is about the moisture content of a lightly squeezed sponge. It feels damp, but not soggy. Keeping a compost heap moist enough is one of the main problems facing composters in Australia. Repeatedly moisten the heap in hot, dry weather. Composting in a pit will conserve moisture. Dry materials should be thoroughly moistened before incorporation into the heap. Protect the heap if rain is likely to make it too wet.

Oxygen

Those microorganisms that need oxygen are called aerobes and those that do not are called anaerobes. Organic materials in heaps are decomposed most rapidly by aerobes. They need plenty of air, many cubic metres a day for a garden compost heap of reasonable size. Inadequate aeration allows anaerobes to take over from aerobes inside the heap, leading to the production of foul odours at best and to a 'compost' which has a low pH and is toxic to plants at worst. Good aeration is very important if you are in a hurry to get useable compost.

Changes inside the heap

Temperature

Heaps of moist organic materials heat up because the heat given off by microorganisms as they feed and multiply is kept in the heap by the insulating properties of the organic materials. Figure 1 shows how the temperature changes in a typical heap. In large heaps the top temperature may exceed 60°C, in small heaps perhaps no more than 55°C. This is because large heaps have a smaller surface area to volume ratio than small heaps, and so lose relatively less heat. Large heaps are therefore more efficient than small heaps in winter.

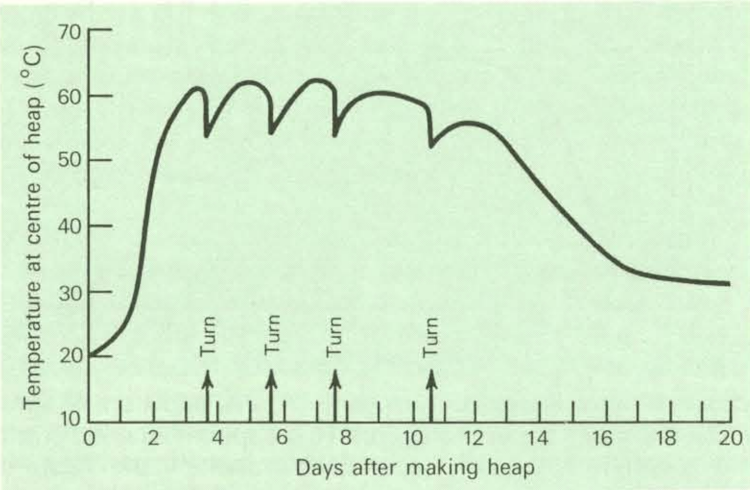


Figure 1. Changes in the temperature of a typical turned compost heap of the Berkeley type.

You can use the heat produced by a compost heap to heat a greenhouse. A bonus is that the carbon dioxide given off boosts plant growth. Keep the nitrogen content of the heap on the low side in order to avoid excessive production of ammonia gas, which could injure plants.

Scientists refer to the stages of the temperature cycle below 40°C as the mesophilic stage and the stage above 40°C as the thermophilic. Marked changes occur in the microbial population as the temperature moves past 40°C. The mesophilic organisms (those that like a middle temperature range as we human beings do) die out and are replaced by an upsurge in the population of thermophilic organisms (those that like high temperatures). Later, as the temperature drops, mesophilic organisms re-invade the centre of the heap from the cooler outer layers. Decomposition of organic materials is fastest in the thermophilic stage.

During turning for aeration, the interior temperature may drop 5 or 10°C, but it returns to the initial temperature in a few hours.

Heaps should be no larger than 2.5 metres wide and 1.5 metres high, but of course they can be of any length. Higher or wider heaps must be provided with some means of getting air into the centre of the heap.

Composting is most rapid in the temperature range 45-55°C. Some form of insulation may be necessary in winter in very cold areas if the temperature is to reach this range.

pH

Initially, the pH of a compost heap is slightly acidic (Figure 2) because the cell sap of plants is acidic. Then the heap becomes even more acidic (lower pH) due to acids such as acetic, citric, tartaric, lactic, 2-ketogluconic, sulphuric, nitric, etc., produced by bacteria. During the thermophilic stage the heap becomes alkaline through ammonia formation and, finally, near neutral or slightly alkaline as the ammonia is converted to protein and the natural buffering capacity of humus dominates the scene.

Tests at the University of California, Berkeley way back in 1953 showed that adding lime to a compost heap can

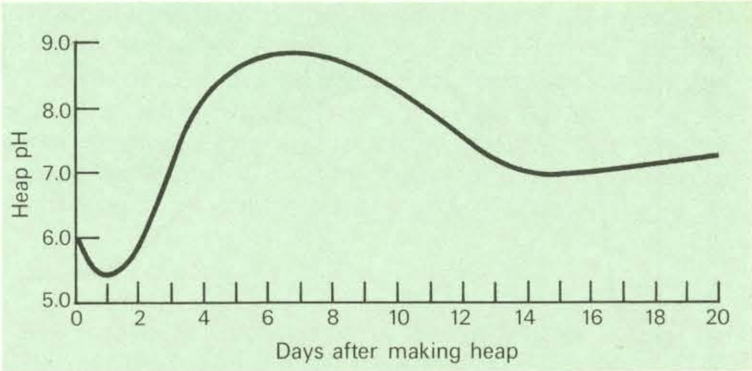


Figure 2. Changes in the pH of a typical compost heap of the Berkeley type. Minor changes during turning are not shown. Similar changes would occur in unturned heaps, but the time scale would be extended.

cause serious losses of nitrogen. (A 2% addition of lime caused a 40% loss of nitrogen.) This happens mainly in the thermophilic stage of decomposition when the heap is alkaline anyway. Lime increases the alkalinity of the heap; this reduces the solubility of ammonia in the water of the heap, and so increases the proportion of ammonia in gaseous form. A greater proportion of the ammonia can then escape into the atmosphere.

To lime or not to lime that is the question

Generally, therefore, it is best not to add lime, dolomite, ashes or other liming materials to compost heaps. If our soil is acid it is better to add a liming material direct to it rather than via a compost heap. Liming materials do improve the physical appearance and ease of handling of composting material, but gypsum, phosphatic fertilizers, and soil added with weeds, have the same effect. The best compromise is to copy the practice of mushroom growers. They add gypsum to the materials they use to make the compost on which they will grow their mushrooms. Use 4-6 kg gypsum per cubic metre of materials.

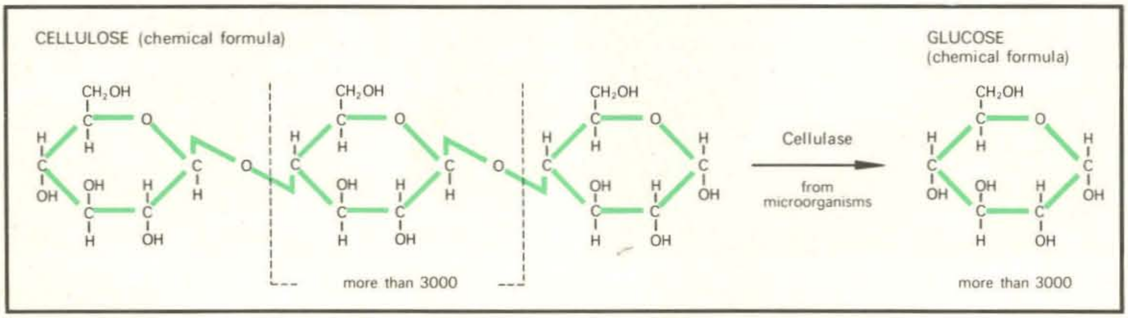
So far this discussion has been about liming or not liming largish compost heaps that are well-aerated through frequent turning. The contents of compost bins may need to be treated differently. Because of limited air movement into bins, their contents are probably more often than not partially anaerobic. Compost produced in a partially anaerobic environment is generally more acid than that produced in a well-aerated heap. What happens is that parts of the heap don't get past the early stages of decomposition shown in Figure 2, so acids produced by bacteria accumulate. (This happens in extreme form during the production of silage by farmers. Green grass is piled into a pit and air is sealed out with a layer of plastic sheeting or soil. The grass is preserved, or pickled, through the production of acids, mainly lactic and acetic. The pH of silage is around 4.0 to 5.0. Peat and peat moss are also formed under anaerobic conditions and are acidic.)

Lime added to a partially anaerobic compost bin would modify the composting process and would give a less acidic compost. If our soil is alkaline we may prefer to have an acidic compost, but if our soil is acid the addition of a small amount of lime to a compost bin could be worthwhile.

Dolomite can be substituted for lime if there is a need for extra magnesium, as when large amounts of poultry manure are being applied to a relatively sandy soil.

Chemical

Compost heaps are akin to complex chemical factories. Many changes take place in the course of decomposition. Even before the microbes start their work, enzymes in plant cells have started to break up proteins into amino acids. Then the microorganisms grab all the soluble compounds — the sugars, amino acids, inorganic nitrogen (mainly ammonium nitrogen) and start breaking up the starches (into sugar), fats (into glycerol and organic acids), proteins (into amino acids) and cellulose (into sugars) and incorporating the bits into their own structures. At times more ammonia is produced from proteins than the microbes can handle and some may escape, but eventually they catch up. Plant nitrogen is converted to the protein of microorganisms and eventually some is converted into nitrate, a ready source of nitrogen for plants.

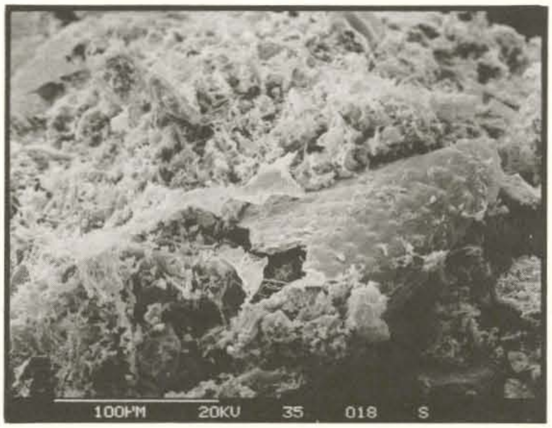


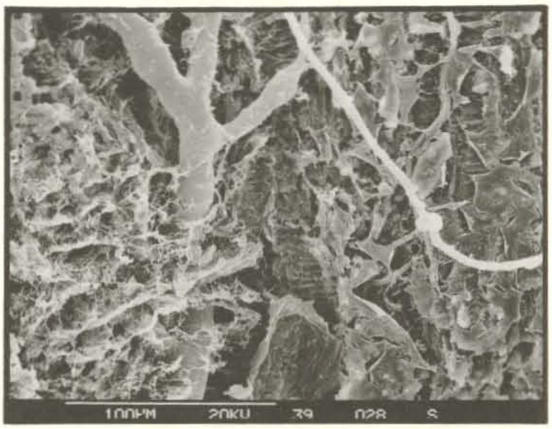
Lignin, a compound of the cell walls of plants, is somewhat resistant to microbial decomposition, but even it is eventually broken down. Microorganisms in the compost heap and later in the soil convert lignin and other plant components into the very large stable molecules that make up the black humus of soils. It is thought that these molecules are able to join soil particles together into aggregates and so improve soil structure, although other, less resistant parts of soil organic matter, roots and bacterial gums for example, also contribute. As these humus components are slowly broken down by other soil organisms, the various nutrient elements they contain are released to plant roots.

Much of the carbon of the original organic materials is "burnt" by microorganisms in their life processes and ends up as carbon dioxide gas. This loss causes a 30 to 60 percent decrease in dry weight of the heap and a volume reduction of around two-thirds.

Microbiological

During aerobic composting the microbial population is continually changing. In the first mesophilic stage, fungi and acid-producing bacteria multiply on readily available foodstuffs such as amino acids, sugars and starches. Their activity produces heat and eventually the thermophiles take over in the interior of the heap. The thermophilic bacteria decompose protein and non-cellulose carbohydrate components such as fats and the hemi-celluloses (similar to cellulose, but composed of mannose and galactose as well as glucose). Thermophilic actinomycetes appear to be more heat tolerant than many other bacteria and their numbers increase greatly during the thermophilic stage. Some are able to decompose cellulose.





Two mite's-eye views of a tiny particle of compost. Left: Remains of part of an insect wing surrounded by plant cells in an advanced stage of decomposition. Much of the fine material is humus. Right: Strands of fungal hyphae amongst plant cell debris.

Thermophilic fungi proliferate in the 40 to 60°C range but die above 60°. They decompose hemi-cellulose and cellulose and so are particularly important in the formation of compost.

As the availability of food decreases, the thermophilic organisms decrease their activity, heap temperature falls, and mesophilic organisms invade the interior from the outer layers that remained relatively cool during the thermophilic stage. It appears that at least some of these invaders can use cellulose and hemicellulose, but not as well as the thermophiles. They continue the decomposition process and no doubt also decompose the remains of many thermophilic microorganisms.

Microorganisms decompose plant materials mainly by means of enzymes they excrete. Enzymes are large, complex protein molecules that enable chemical reactions to take place without actually being used up themselves: they are catalysts. An example of an enzyme production system close to home is that of the saliva glands in our mouths. Saliva contains an enzyme called amylase that is able to break up starch into sugars.

In compost heaps, microorganisms probably excrete many hundreds of enzymes that enable them to break organic materials, including each other, into smaller bits that they can use as food. For example, many organisms excrete an enzyme called cellulase that can break up cellulose (a major component of cell walls, and of the paper of this page) into glucose. This can then be absorbed by the organism and "burnt" to provide energy for its life processes.

Pathogens

An important function of the compost heap is the destruction of pathogens and parasites of both plants and animals, and weed seeds. Most are killed at temperatures of 55 to 60° C and so do not survive the thermophilic stage.
Composting at temperatures above 55° C for about 3 weeks gets rid of most pathogens. If some are known to be present initially, it is important to make sure that all materials spend some time in the hottest part of the heap. Thus the bacteria that produce wilts in tomatoes, the bacteria that blight beans, the fungi that cause rusts and eelworms that attack roots can all be killed in a hot compost heap. Burning need not be resorted to for diseased plants *provided they get hot enough inside the heap.* Some weed seeds, notably those with hard coats, survive even the hottest of compost heaps.

Methods of making compost

The method you choose depends on how quickly you need the compost, how much exercise you want, and the amounts of materials and space available. The range of options is from a much-exercise, rapid method — here called the Berkeley method — to heaps and bins that give a product in about a year, but with no effort after setting up.

Berkeley method

This method arose out of research conducted at the University of California, Berkeley, in the 1950's.

Materials with an average C/N ratio of 25 to 30 are gathered together in sufficient amounts to make a heap of at least one cubic metre. The different materials can either be added in layers or they can be mixed together before they are made into a heap. If layering, alternate materials of high and low nitrogen content. Do not make any one layer deeper than about 15 cm, otherwise some layers may form into mats which are difficult to break up. The minimum size can be a bit less than one cubic metre in summer but as much as two cubic metres in winter if a high enough temperature is to be reached. Wet dry materials before adding to the heap and add more water as needed during making.

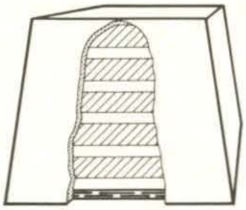
Steam rising during turning of a free-standing compost heap in the author's garden. It was made from autumn leaves, lawn clippings, weeds and shredded corn stalks. Air is sucked in through the sides of a heap such as this by hot air rising through the apex. Leaves stockpiled in the background were to be composted with nitrogenous materials as these became available.

The heap is turned, mixed and aerated after three or four days and thereafter every two or three days until the fourteenth, when the compost should be ready for use, although perhaps a little coarse. Another week of composting will give a finer product. Care should be taken to ensure that all materials spend some time in the hottest part of the heap, so that weed seeds and pathogens are destroyed. Frequent turning for adequate aeration is the secret of success for rapid composting. The materials should be 'fluffed-up' with a fork during each turning to maximize aeration. Improved aeration is also achieved by building the heap on a platform made from loosely fitting wooden planks. Another method is to build the heap around posts which are pulled out after the heap has been completed, or over a length of drainage pipe stretching the full length of the heap.

Indore method

This is essentially the method devised by Sir Albert Howard. The name is that of the Indian state where he worked.

The Indore method involves minimum effort, but it takes a long time to produce a usable product. Alternate



layers of low nitrogen and high nitrogen materials are heaped on top of one another to a height of about 1.5 m. The heap should be about 2 m square at the bottom, tapering to about 1.2 m if it is free-standing. Of course if it is contained by boards, bricks or wire mesh it would have vertical sides. A foundation layer of brush, prunings or tree branches helps aeration. The heap is covered with a 5 cm layer of compacted soil to deter flies and to prevent the escape of foul odours. If, through lack of sufficient materials at the one time, the heap has to be built over several weeks, each top-layer should be covered with soil.

If the heap is turned, the first turning should be eight to ten days after making, and then again after a further thirty or forty days. The compost should be ready for use about a month later. The process takes a year if the heap is not turned at all.

The Indore compost heap can very rapidly become anaerobic and therefore does not usually generate sufficient heat to kill undesirable organisms and seeds. Its anaerobic nature can also generate foul odours, hence the need to encase the heap with soil, or to aerate it through turning.

Often, through lack of time and energy, home garden compost heaps tend to be more like the Indore heap than the Berkeley, but the more we tend towards the Berkeley type heap through frequent mixing, the more rapidly will finished compost, and weed and disease-free compost at that, be produced. Accumulating organic materials in a reasonably dry state should make it possible for a Berkeley type heap of adequate size to be made every month or so in the average home garden.

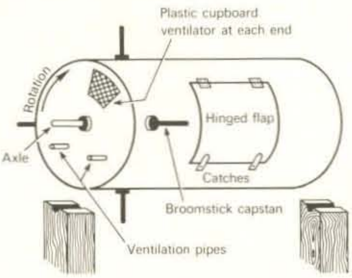
Two variants of the methods described here are sheet composting and organic paths. In these the materials are spread in a relatively thin (up to 25 cm) layer on a garden bed or pathway between beds. The materials slowly decompose over some months. They can then be either dug into the underlying soil or used elsewhere.

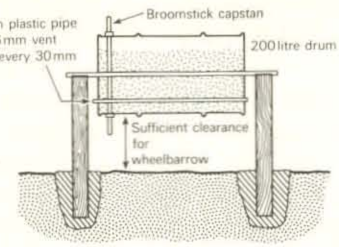
Compost bins

Bins are useful for people with small gardens and little space. They do an excellent job of composting kitchen scraps and moderate amounts of garden materials. Add soil or finished compost in small amounts from time to time to prevent "pugging" in sloppy kitchen wastes and to provide a full range of microbes. Either buy bins already provided with aeration holes near the top or cut some holes yourself. Fix some fly screen across the holes. Leave some air space between the lower edge of the bin and the ground. This gap may also have to be screened if rats, dogs or birds repeatedly scratch compost from the bin.

Gardeners with larger requirements can purchase several bins but it is cheaper to make rough bins from railway sleepers, scrap timber, bricks (leave air spaces), wire netting or old galvanised iron, or to simply make heaps. Some gardeners find that both a bin and a larger scale heap are needed — one for kitchen scraps and the other for garden refuse.

This bin copes with all the household scraps of an average family. Plastic rubbish bins do not make good compost bins as they rapidly disintegrate in sunlight.





A 200 litre steel drum can make an inexpensive compost bin.

Operate rotary bins on a batch system. Fully charge and take through to completed compost without adding extra materials. Loss of heat through bin walls means that the compost may not get hot enough to give a good kill of weed seeds.

An alternative for those with enough space is to allow hens to do most of the hard work of composting. All kitchen scraps and garden wastes are thrown into the hen-run. The hens eat what they can and mix the rest up with their excreta. After some months you can start to remove some of the deep litter as needed. This way you get both eggs and recycled nutrients.

Earthworms

Earthworms can be employed to do part or all of the work of composting organic materials. The earthworms themselves reduce the size of the organic materials as they eat it; bacteria in their gut and castings continue the decomposition. Special worm cultures can be set up to convert all kitchen scraps into vermicompost, as described in the companion booklet "Earthworms for Gardeners and Fishermen". Earthworms often invade heaps of the Indore type and contribute to the composting. They must not be introduced into Berkeley-type heaps until the heap has cooled down.

Trouble shooting

There are four main reasons why compost heaps fail.

(a) They are too wet. The tell-tale sign of this is the production of foul odours. The problem may be overcome by adding dry materials (with due regard to C/N ratios) and/or by more frequent turning.

(b) They are too dry. The cause here will be obvious if the heap is dug into. Sprinkling with water during remaking is the cure.

(c) Carbon/nitrogen ratio too high. This problem is indicated if the heap "works" for a while and then slows down, even though the moisture content is satisfactory. There are no foul odours produced. The cure is to add high-nitrogen materials such as lawn clippings, animal manure (including dog faeces and human urine) or a nitrogenous fertilizer.

(d) Lack of other nutrients. Mixtures of organic materials as listed in this booklet should usually contain adequate levels of the nutrients needed by microorganisms. Probably the only one likely to be limiting is phosphorus.

A caution

If you look inside a partly finished compost heap you will often notice that the organic materials have turned white or grey-white. This is because they are covered with thermophilic actinomycetes doing a good job of breaking them down. That's as it should be. But these microorganisms produce very large numbers of spores. If the compost heap dries out and is disturbed, clouds of these spores go into the air. The compost maker will find them rather irritating to breath.

The compost maker's best protection is to make sure that materials being composted, and finished compost, are kept moist at all times so that spores do not fly into the air unnecessarily. This simple precaution ensures that composting is a very safe process, probably a lot safer than burning, with the breathing of smoke involved, and certainly safer than the smelly business of saving food scraps for weekly collection for dumping in large open dumps.

Leaf mould is a specialized form of compost made from leaves (including pine needles). It is very useful as a base for potting mixes. To the moistened leaves add a source of nitrogen (blood-and-bone, urea, poultry manure) and some lime/dolomite/wood ash. Make into a heap 30-40 cm deep and inoculate with earthworms (preferably *Lumbricus rubellus*) if there are none in the soil beneath the heap. You can start using the leaf mould in 6-12 months.

Using the product

We supply the right conditons; microorganisms do the rest for us. In the end they give us a pleasant smelling, dark, crumbly material that is at once soil conditioner, fertilizer and suppressor of soil-borne diseases of plants.

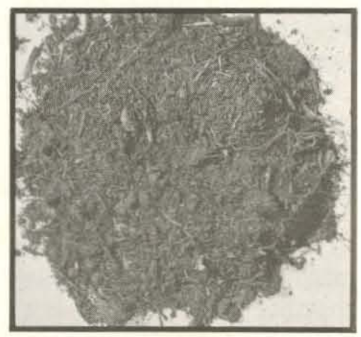
Compost may be used around mature plants as soon as the temperature of the heap has come down below 40° C – say three weeks after building the heap. Leaving it cure for a few more weeks will improve it by increasing its fineness and reducing the need of microorganisms in it for the nitrogen that we want our plants to have. Finished compost has a pleasant earthy smell, has few recognizable pieces of the original organic materials and is a fairly uniform dark brown or black colour. Rain can leach nutrients from finished compost, so cover finished heaps until they are used.

Sieved compost may be used as a top dressing for lawns, but you will spread weeds if all seeds have not been killed. Otherwise it may be either dug into garden beds for vegetables or flowers, spread as a mulch around shrubs and trees (keeping 40 to 50 cm away from the trunks of fruit trees) or spread between rows of growing plants. Rain or sprinkler water will wash nutrients from compost mulches into the soil and plant roots will grow up into the lower layer.

It is sometimes stated that it is best not to dig compost into soils as this does not happen in natural situations such as forest floors. Digging it in amongst established plants is certainly undesirable as the digging might damage roots. But in vegetable beds, which are unnatural anyway, distributing the compost down through the soil will give plant roots quicker and more intimate contact with it than if it were just spread on the surface. Australian research has shown that considerable amounts of nitrogen can be lost from organic residues such as grass tops and animal dung lying on the surface of the soil; burying has been shown to reduce this loss and to boost plant growth. Also, by digging it in we partly copy the natural activity of earthworms, only we speed the process up to suit our crops. Few of the earthworm species present in southern Australian gardens are surface feeders, so it seems likely that buried compost will increase earthworm activity to a greater extent than unburied compost.

Shredded corn stalks

A mixture of corn stalks, lawn clippings and straw after six days in a Berkeley type compost heap.



Mature compost three weeks later.

Perhaps a useful compromise is to dig our compost into beds for annual crops so that the roots of these crops get maximum amounts of nutrients early in their growing period, but to add a further layer to the soil surface during the growing season as a mulch and extra supply of nutrients. For perennials, surface application is really the only option available.

The physical or soil conditioner effects of compost are perhaps more important than the fertilizer effects. Poor soil structure inhibits root growth and so reduces the ability of a plant to reach needed nutrients. Compost promotes the aggregation of soil particles so that structure

is improved. Roots, air and water can move through the soil more easily. In addition, the water-holding capacity of the soil is increased, so plants are less prone to drought. Digging is easier. Other soil conditioner effects include an increased ability of the soil to absorb rapid changes in acidity and alkalinity and the neutralization of toxic substances such as organic toxins produced by some plants, and toxic metals.

Rates of application needed to improve the physical properties of soils vary from soil to soil. Sandy soils and very difficult-to-manage clay soils benefit from rates as high as 10 kg per square metre (16.7 lb per square yard) for the first few years of an improvement program. Later maintenance applications could be around 3 kg per square metre (5.5 lb per square yard). This latter rate would also supply a fair proportion of the nutrient elements needed by many plants once severe deficiencies have been corrected.

The fertilizer value of a compost is directly related to the quality of the organic materials used. Materials of low nutrient content give compost of low fertilizer value. Typical contents are 1.4 to 3.5% nitrogen, 0.3 to 1.0% phosphorus and 0.4 to 2.0% potassium with smaller amounts of other nutrients. Some composts are therefore relatively low in plant nutrients and good growth can only be achieved by supplementing them with manufactured fertilizers or animal manure. One advantage of compost is that the nutrients in it become slowly available throughout the growing season and so are less easily lost by leaching than are nutrients in soluble fertilizers. The effect is particularly beneficial for nitrogen, which can be readily lost as nitrate from applications of soluble fertilizers. Another specific effect of compost is that organic acids released during microbial activity increase the availability of phosphorus to plants.

Well matured fine compost can be used as a major component of seed-raising mixes.

Composts contain small concentrations of various plant growth hormones and vitamins. Concentrations decrease with increasing time of composting. There is no evidence that plants benefit from the minute amounts added in normal applications of compost.

Further information about the fertilizer value of composts may be found in the companion booklet "Food for Plants."

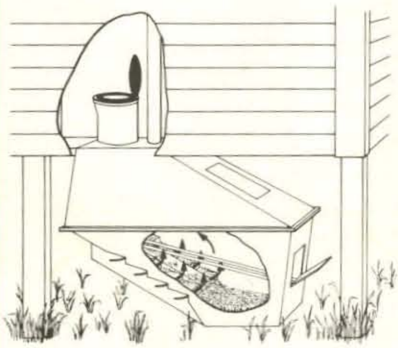
For an organic seedling starter solution, steep 1 part of matured compost in 3 parts water for 2 days. Dilute the liquid until it is a light amber colour and water over the seedlings.

Along with other organic amendments such as green manures, compost reduces the levels of plant pathogens (bacteria and fungi) and parasitic nematodes in soils. It does this mainly by increasing the general level of biological activity in the soil, so that more fungal spores and other "resting" stages of these pathogens and parasites are destroyed than would otherwise have been the case.

Conclusion

Once upon a time most organic "wastes", including human excreta, were returned to farmland. In fact, until little more than a century ago, not much else was available, except for bones, and bird droppings (e.g. guano used by the Incas). For a while the pendulum swung very hard in the direction of near total reliance on manufactured fertilizers in many countries. More recently the pendulum has swung back a little towards greater appreciation of the advantages of returning organic materials to soils. Market gardeners use large quantities of manures from stables, piggeries and chicken houses, sewage sludges are dried and incorporated into fertilizer mixtures, effluents from sewage treatment works irrigate forests and farmlands, solid municipal wastes are composted and sold as soil conditioners, integrated methane and fertilizer producing units are available for villages and farms, simple twin-toilet systems (one is used while the contents of the other is fermenting to compost) and composting toilets are used increasingly. Millions have learnt to conserve their "wastes".

The BIO-LOO HUMUS TOILET is smaller than the Tao-Throne, so it will often be a more practical alternative. Suppliers of both: Environment Equipment (A'Asia) Pty. Ltd., East Melbourne, VIC.



One method of installing the Tao-Throne — a composting toilet approved by health authorities in Sweden and many U.S. States. Wastes are converted by aerobic decomposition to a rich compost free from harmful organisms that can be removed as needed through a small trap-door. The Tao-Throne and other composting toilets provide an ecologically sane alternative to water-based sewers.

Small beginnings perhaps, but at least a start towards a less wasteful use of the finite resources of our planet. The Chinese, it seems, return at least 90 percent of their organic wastes to their soils. It is not beyond our capabilities to devise systems for doing the same in other political and cultural environments. The simple compost heap multiplied by millions is one step in that direction, a step that we can all take without waiting for "them" to do something about it.

Further reading

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