A Manual for Composting in Hotels

A Guide to Composting Yard and Food Wastes for Hotels in Thailand

By Murray Haight and Paul Taylor

Canadian Universities Consortium
Urban Environmental Management Project
Training and Technology Transfer Program

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INTRODUCTION

As part of the Urban Environmental Management Project of the Canadian Universities Consortium, at the Asian Institute of Technology (AIT), the SOLID WASTE MANAGEMENT PROJECT under the supervision of Dr. Murray Haight has been working with a number of tourist resorts and hotels in the Cha Am- Hua Hin communities in Thailand. The project has focused mainly on the development and implementation of environmental monitoring systems with a particular emphasis on waste management. Auditing, training workshops and demonstration projects have been completed. Composting was identified as an option of particular interest to the participants. Compost Management, a Canadian environmental firm, was retained to assist the project director in the provision of on-site composting expertise. Demonstration projects and training sessions together with the production of this guidance document are intended to support the development of on-site composting at resort hotels in Thailand.

This document focuses on the specific needs of grounds maintenance staff and mid-level managers who wish to implement and trouble-shoot their own hotel composting programs, and to use the compost produced. This manual is designed to act as a guide. The following sections of the manual deal with the practical procedures of composting as a means of recycling and reclaiming the organic portions of the wastes arising from maintaining the grounds as well as from the food preparation and dining areas. It describes in sufficient detail the ways and means by which composting can be undertaken. The main objective of composting is to recover and recycle a valuable resource in an economically and environmentally acceptable manner.

The term 'Cleaner Production' (CP) is used periodically in this document. CP refers here to a comprehensive program to improve a hotel's environmental impact through the application of conservation efforts including energy and water use reductions, and promoting the re-use and recycling of wastes such as compostable materials.

WHAT IS COMPOST, AND WHY SHOULD WE MAKE IT ?

Compost is an entirely natural product. It is routinely made without the aid of specialized machinery, patented processes or the addition of any chemicals or special additives. Compost is simply the final result of nature's own recycling system which breaks down organic wastes and returns the nutrients back to the soil.

If left alone compostable wastes such as garden wastes and food scraps break down or 'rot' spontaneously, so long as reasonable conditions are present to support the bacteria and other small creatures that actually do the work. Evidence of the process at work can be found anywhere that organic wastes are allowed to accumulate, including on the forest floor. When left for a period of time, the material will change into organic matter that is often dark brown in colour and is called 'humus'. 'Composting' simply means the management of this natural process in some sort of deliberate and organized way.

Generally, composting is undertaken in a manner that accelerates the natural process, while ensuring that odours do not become a problem. Usually, composting is done simply to produce compost, the final product, which is then used for some type of horticultural application. One example would be to add final compost to potted flowers.

An important component of the fertility of any soil whether it be used for growing food or for ornamental plantings used in hotel landscaping is the percentage of organic matter found in that soil. Natural systems which operate in tropical forests are designed to recycle organic waste in such a way that soil organic matter is always replenished. Man-made harvesting systems and growth practices such as modern agriculture and landscaping tend to consume soil organic matter, and so over time dramatically reduce soil fertility.

Soil organic matter performs a variety of important functions in soil, including:

- Provision of slow-release macronutrients for plants.
- Provision of essential micronutrients needed by plants.
- Provision of water-holding capacity to create drought-resistance.
- Provision of beneficial soil structure; soil organic matter can bind together sandy soils, and help to break up clay soils.
- Provision of a food source and living environment for soil organisms such as earthworms and bacteria that are an essential component of a healthy soil.

A newly constructed compost pile.

Note the size of the pile which is about 1- to 1.5m. in height and about 2 m. across at the base.

This pile consists of mainly yard wastes but also contains within some food preparation area wastes which were placed inside the heap as it was being constructed.

When the percentage of soil organic matter is reduced, it must be replaced if fertility of the soil is to be maintained. Traditionally, replacement has been achieved by the addition of manures and other organic waste materials; but there is rarely enough such material available to replenish and repair the structure of the soil. Since manures are usually not stabilized when applied, care must be taken to limit the amount applied to prevent 'burning' of plants. Depleted soils can often contain as little as 1-3% soil organic matter. Compost typically contains 30-40% organic matter. Even a little compost can go a long way towards rebuilding the fertility of poor soils and bring the organic content up to the 10-15% mark.

Soils that lack sufficient organic matter content require ever-larger applications of chemical fertilizers to maintain crop growth. Soils with sufficient organic matter may continue to need applications of chemical fertilizers but most importantly the amounts required will be reduced which means cost savings and the need to purchase less chemical fertilizers.

At the same time, most hotels in Thailand simply dispose of their garden waste in a landfill, or burn it, or bury it without taking advantage of what the material is capable of doing if it were to be recycled back into the soil through the application of composting.

A composting operation can be successfully done on-site, i.e. somewhere on the property of the hotel, with little effort at many hotels in Thailand. The process can quickly produce significant

quantities of a stable, rich organic material which is ideal for improving soils in any horticultural and landscaping application.

For clarification, it is perhaps important to note that the term *composting* refers to the controlled biological and oxygen requiring process that involves a mixture of organic materials in a solid state passing through a series of stages which are evidenced by an increase in temperature and leading to a product which is a stable, organic matter called *compost*.

WHAT CAN BE COMPOSTED?

While composting can be used to process anything that was ever alive, (i.e. a part of any plant or animal that was alive such as food waste), or to process anything that was made from anything that was ever alive (e.g. paper made from trees), this document will be limited to a consideration of three common hotel waste materials:

Gardening wastes.
Food scraps.
Waste paper.

Anyone who has already successfully undertaken composting using these materials should consider themselves competent to experiment further with any other type of organic waste such as animal manure, by blending in small quantities of the new waste within an established composting pile.

Garden Wastes

Hotels throughout Thailand take good advantage of their climate, and are consequently renowned for their beautiful landscaping. As a result however, significant quantities of garden waste must be collected and disposed of on a year-round basis. Much of this garden waste is commonly discarded of-off site, or is burned on the hotel property if space permits.

Fortunately such mixed garden waste from hotels in tropical climates contains a perfect mix of material which is ideal for composting. For this reason, it is recommended to begin the practice of composting by only using garden wastes. In this manner, basic procedures can be developed and experience gained with a material that is unlikely to create problems for the beginning composter.

There are only a few rules to consider when selecting garden wastes for composting:

- A mix of many different types of plant waste is best,

- If grass clippings make up more than one third of the pile of material, odour problems may be encountered, so an excess of this material should be avoided.
- Woody materials, such as palm fronds or tree branches may be slow to compost. Such materials can be of real benefit to the pile, since they add structure and allow necessary oxygen to penetrate the pile easily, but to be composted they should be chopped up into pieces of about 10-15 cm in length before being added to the compost heap.

Food Wastes

Hotels also produce large quantities of food wastes, both during food preparation and later in the dishwashing areas. Theoretically, all of this material can be composted, though realistically, a given hotel may be limited in how much of this material it can compost for practical reasons, (see the section later in this document on composting of food wastes).

When considering food wastes for composting, wastes arising from food preparation may sometimes be freer of contaminants like plastic and other disposable items than wastes from dish-clearing.

It should be also clearly understood that any kind of food wastes-vegetable, meat and fish-can all be readily composted, and break down equally well. Still, there are two significant cautions to be stressed about the composting of food wastes:

- If significant quantities of meat or fish waste are included, this may lead to problems with animals disturbing the compost piles in some circumstances. Generally, there are simple methods to deal with any such problem however, (again, discussed in the food waste composting section).

- Food wastes are not as ideal a composting feedstock as mixed garden wastes. As a general rule their inclusion in any hotel composting program should be limited to about 25% of the volume of material

composted, unless staff on-site have sufficient experience and confidence to increase this percentage. Normally, higher percentages of food waste in the feedstock can lead to challenges with odour control.

Reasons to include food waste in composting programs include:

- Food wastes are generally higher in nutrients and are a better source of nitrogen than many types of garden wastes- inclusion of food wastes in compost may lead to slightly higher nutrient levels in the finished compost.
- Food wastes, especially those from the dishwashing areas, tend to be very high in water content. This can be an excellent way to add essential water to the compost pile.
- Composting food wastes is one way to contribute to a Cleaner Production program for your hotel.

Paper Wastes

Theoretically, any type of waste paper is compostable, since all paper is produced from something that was once alive-a tree. From a practical perspective however, if paper is to be composted easily, it is best that this waste be in small pieces. For example do not use a corrugated cardboard carton, unless it has been well shredded or torn up into small pieces. Paper wastes should be of a type that readily absorbs water, and for this reason paper hand towels and partially used rolls of toilet paper are good materials for composting.

If large quantities of paper are composted, problems can also arise from the tendency of the material to mat together when moist. This reduces the distribution of oxygen throughout the pile, and does not encourage good composting.

Hotels with an interest in Cleaner Production, however, may wish to manage soiled paper napkins used in food service, or paper hand towels used in kitchen and bathroom areas. If so, this material can be readily composted, though again, should be

limited to no more than approximately 25% of the total compost feedstock by volume.

One additional caution with paper waste pertains to how it is collected. Paper waste tends to attract other types of non-compostable waste, such as plastics and metals. Hotel staff may see paper in a designated container for composting, may think it's a refuse container, and may knowingly or unknowingly contaminate it with non-compostable waste. It may be best to limit the collection of paper to a few carefully designated areas where tight control can be maintained over which types of waste are collected so that contaminants do not enter the process.

In general, any collection program that fails to do a good job of collecting clean, uncontaminated waste as a matter of routine will diminish the success of the entire project. Hotel gardening staff are unlikely to develop enthusiasm for working with contaminated material that they may come to view as one step up from garbage.

Holding a Team Meeting to Plan for a Compost Project

Discussions and decisions about where to conduct the composting operation, how to gather the appropriate waste materials, and deciding who will be responsible are some of the items to be covered. Remember the composting process consists of several phases beginning with a decision to initiate a composting program, involving staff in the collection of materials such as leaves, yard wastes, food preparation and dining area wastes constructing and maintaining the compost pile, preparing the final compost and using it.

HOW TO COMPOST HOTEL GARDEN WASTES

Location of the Composting Project

Perhaps the first question to answer is — where to undertake the composting?

The composting process from start to finish is likely to take something on the order of three to four months. Hotel staff should try to determine approximately how much space up to three months' worth of compostable material is likely to need if the material is placed in piles approximately 1.5 m high.

A hotel composting system ideally should be located some reasonable distance from areas normally frequented by guests. Although a well-managed composting system should not consistently produce offensive odours, there may nonetheless be occasional, mild odours that some hotel guests might not appreciate.

Most compost piles will leak or 'leach' out concentrated, nutrient-rich runoff water from time to time — particularly during the rainy season. It would be undesirable for this runoff to contaminate any source of drinking water or other natural body of water. Thus it is recommended that any composting area be set up with the direction of runoff likely to flow during heavy rains away from any areas that need to be protected, and at least 25 m from any source of drinking water. Likewise, the compost area should be situated in a well-drained area, rather than in an area subject to regular flooding especially during the rainy season. A compost pile that sits for an extended period of time in a pool of water will rapidly become a significant source of odour and will be considerably slowed in the time needed to produce a finished compost.

Some composting operations in tropical climates are built under shelters. Such roof structures may be of some aid in minimizing over-saturation of the compost piles with water during the rainy season, and may also shelter the piles somewhat from the drying effects of the dry season. The effort required to build

any type of shelter may not be justified. Until it is proven necessary, a suggestion at the start is that it may be better to try composting without the expense of constructing a shelter first.

Tools of the Trade

Many composters use a long-handled pitch fork or shovel to easily build piles or windrows and when turning the piles so as to thoroughly mix the materials.

A compost thermometer may be used to check the temperature deep inside the pile. If one is not available inserting your hand into the pile will work.

A screening device such as a drum with the outer walls covered with a wire mesh and a handle for turning may be built. Alternatively, a screen as used for sifting sand will work just as well.

Constructing a Basic Garden Waste Composting Pile

While there are many ways to approach composting, the method recommended here is proven and very reliable, simple, and designed specifically to minimize the amount of labour and time that must be put into maintaining the composting operation.

Begin by constructing a cone of garden waste approximately 1.5 m high. This may take several days or longer depending on the amount of waste being collected from the gardens and food preparation areas. Remember to just keep adding to the existing pile until the size is achieved. In building the pile, try to ensure that the different types of plant material in the waste are reasonably well-mixed throughout the heap. If piled in a cone shape, the pile will naturally form itself with a peaked top and a base approximately 2 m across. This is a good size and shape for handling the material in future for turning and aerating the pile as described later in this document, and for ensuring that oxygen can easily circulate through the pile. Building a pile or heap is a simple method and is ideal for rapid

Deciding on a Good Location and Beginning to Construct the Compost Piles.

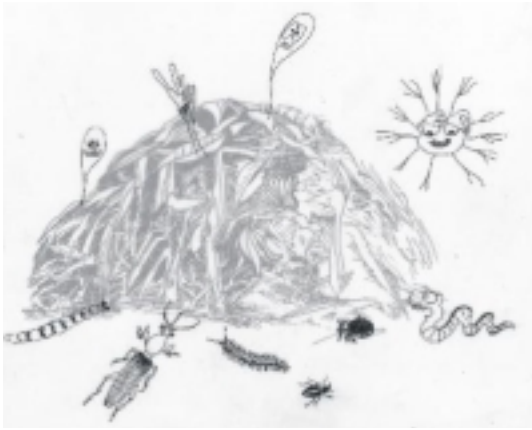
The number of piles to be constructed will depend on the amount of organic wastes available and may vary from season to season. Large leafy material as seen in the hands of the gardener should be shredded or chopped into small pieces to assist with the process.

composting. Once the heap is big enough build another one .

If a lot more waste is available, and as more waste becomes available on subsequent days, extend the cone shape sideways, in one direction, so that over time, a long row of triangular cross-section is produced — always maintain the height of about 1.5 m and the base width of about 2 m. Such a long, triangular pile is called a 'windrow' of compost. There is no limit to how long a windrow can be, except that dictated by the space available. Since the windrow will have to be periodically moved and 'turned' (see discussion later on 'maintaining the compost pile'), it probably doesn't make sense to construct a windrow any longer than would be created from the waste generated in two weeks.

If relatively small amounts of waste are generated at the hotel, it may be that only a cone-shaped pile can be created.

Regardless of the amount of waste produced by a given hotel, after approximately two weeks, start a new pile or windrow so that fresh material doesn't contaminate the older wastes that are already in the process of breaking down.



Composting involves many small organisms that are both visible and invisible. Large organisms including worms and insects chew up the leaves and grass and other organic materials. Bacteria and fungi, which are very tiny, create heat as they digest the organic matter. Nature's helpers mix the organic matter and this eventually results in the release of nutrients which, when applied to potting soil or gardens, can be utilized by the potted or garden plants.

Moisture Content

As soon as the pile is built, it is important to ensure that the pile has the correct moisture content.

Organic waste breaks down into compost largely through the action of bacteria and other microorganisms that digest the waste itself. Most of these creatures actually live in a thin film of water that surrounds individual particles of waste material. If not enough water is present, the composting process will be slowed or even stopped because the bacteria cannot survive. Organic waste left to break down in desert conditions may not visibly change for many years, due largely to a lack of sufficient moisture.

On the other hand, there can be too much water. If a pile of organic waste is completely soaked with moisture, the water

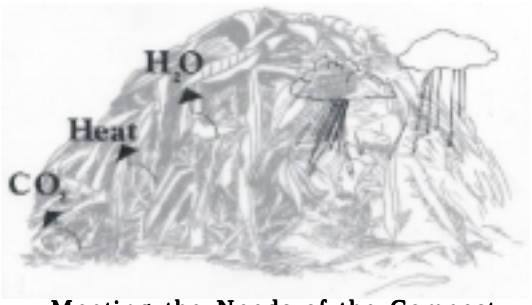
fills in all the pore spaces between the waste particles, and fresh oxygen can no longer reach the bacteria in the pile. While the material will continue to break down using other bacteria that don't need oxygen, the pile will produce bad odours as a result. An example of a process where waste breaks down without access to oxygen can be found in our own digestive system — a process that does produce bad odours.

A balance must be struck between too much water, and not enough. To work well, material that is composting should have between 40 and 60% moisture by weight. It will be rare, however, that hotels are likely to have the ability to measure the moisture content. A good field test is to simply take some material from the centre of the pile into your hands and examine it. If the material is in any way dusty, or small particles of the organic waste can blow away in a breeze, then the moisture content is too low and water should be added. If, on the other hand, you can take some of the material and squeeze it tightly into a ball in your hand, and in doing so squeeze any liquid water at all out of it, then the material is too wet. Ideally, the material should be neither dusty nor noticeably wet, but should leave your hands just very slightly damp.

In building a new pile of garden waste for composting, it is likely that the material will not be moist enough, since much of the material will have been drying in the wind and sun before being collected. In most circumstances, it will be necessary to add water to a new pile, once it is built.

The simplest way to do this is to push a hose, pointing downward, into the top of the pile and let the hose run until water can be seen flowing out of the bottom of the pile. If a windrow has been constructed of fresh material, it will be necessary to repeat this procedure with the hose along the top of the pile every half meter or so until the entire composting row is moistened.

If wet food wastes are eventually incorporated into the composting process, they can provide an important source of substitute moisture for the composting process, and will result in a reduced need for additional water.



Meeting the Needs of the Compost Creatures

All living creatures require air to breathe and decomposers are the same. In addition to fresh air which contains oxygen, they need water, not too much and not too little, and they need organic materials to grow on which must be at the right C:N ratio, and they need time.

Organic matter, oxygen (air) and water are the major inputs required to assist the microorganisms produce compost. As they grow the creatures which assist with the decomposing process produce and release heat. The temperature inside the pile goes up, water is lost, and a colourless gas called carbon dioxide is also released.

Preparing to Turn the Pile

Turning is done to make sure all materials on the outside of the heap end up on the inside of the new pile; all that was inside is moved to the outside.

Turning is important to make sure that large clumps of material are separated.

Turning means tearing down the existing pile and building a new one. Turning can be accomplished manually by using a pitch fork or shovel. The pattern of turning is important to ensure complete mixing and to save on space. The outside layer of the original pile or windrow becomes the interior of the rebuilt pile or windrow.

Maintaining the Composting Process

Once a compost pile is built, and assuming that a good mix of material was used and that the moisture content is appropriate, the pile should begin to heat up after the first day or so. In a pile of the shape and size described in the sections above, temperatures of 50 to 60 degrees C should be readily achieved in the middle core of the pile within a few days. This is normal, and is evidence of good composting activity.

Normally, it is recommended that a compost pile be moved and re-mixed at least a few times during the course of the composting process. This moving and re-mixing is called 'turning the pile' since a common approach is to take down and re-build the pile adjacent to its original position. In doing this, the top of the original pile ends up on the bottom of the new pile, and vice versa.

Turning the pile or windrow achieves several things:

- It re-mixes the material, so that any inconsistencies in distributing different types of waste in the original pile or in properly distributing water in the original pile can be corrected by mixing.
- It breaks up larger pieces of organic waste that are starting to decompose, and thus accelerates the process.
- Importantly, it takes waste on the cool outside of the pile and moves it so that it is now in the warm heart of the pile. If this was never done, waste on the outside would probably not break down for a very long time.
- It allows fresh oxygen to get at material that was in the deepest parts of the pile. When turning, it is good to break up any compacted lumps of waste that may have been formed from settling, to ensure that this material gets lots of access to oxygen.
- It provides the compost manager with a good opportunity to see how well the process is doing, since the entire pile is exposed for inspection. This should include a reassessment of the moisture content. During the dry season, it may well be necessary to add more water at this point, if it can be seen that the moisture content is

again too low. Alternatively, if during the rainy season there is too much moisture it may be wise to cover the pile or windrow with a tarpaulin to reduce the continued uptake of rain water.

If possible, turn the pile about two weeks after it was first constructed, and again about two weeks later. This may be enough. As time goes on, the material will require turning less and less frequently as the waste gradually breaks down into compost. A finished compost resembles soil, and there is no benefit to turning it any further. Turning is most important during the first few weeks of the entire process.

If resources and time permits, more turning through the compost process will generally help to accelerate the process, should this be desirable.

Curing the Compost

As the composting process proceeds, the material will gradually shrink in volume, by 50% to 75% or more. At the same time, the composting process will naturally slow as the waste becomes more and more composted. To facilitate good use of space in the composting area, it may make sense, after perhaps 2-3 months of composting, to combine one or more of the now-reduced piles into one larger pile. If there is no further need for turning this combined pile, it can be simply re-piled in a more compact cone and be left to cure.

'Curing' means allowing the almost-finished compost time to fully mature into a stable product, ready for use on plants. This is described in more detail in the 'Using Compost' section of this document. Remember, the more time you leave the finished pile the better the product will be.

Turning A Composting Windrow

Using a pitch fork or shovel it is necessary to occasionally turn the material. Here we can see the gardener turning the material from the windrow and making a new windrow nearby.

The main reason why it is important to turn the windrow is to aid the microorganisms as they make compost. Turning accomplishes this by managing three factors. 1.) Temperature — turning helps to cool the temperature inside the heap. 2.) Moisture — turning helps to dry the interior if it is too wet or if too dry will indicate that more water should be added. 3.) Oxygen — turning enhances aeration by fluffing the material to make the heap more porous.

How to Add Food Scraps and Other Materials to a Garden Waste Compost Pile

Once hotel staff have mastered the composting of garden wastes, they may want to add other materials for composting — either to achieve Cleaner Production goals or to simply create more compost.

As suggested in the 'What Can be Composted' section of this document, food scraps and certain types of paper waste may be good candidates for adding to the compost pile.

In all cases, it will be important to develop a method of collecting wastes which provides a compost feedstock that is free of contaminants like plastic, metal and glass. None of these materials are compostable, and none are desirable in the finished compost.

Constructing the Pile

If composting food scraps, some changes need to be made to the construction of the original compost pile when compared to simply composting garden wastes.

Food wastes are often wet, very high in nutrients, and tend to have soft tissues. These differences mean that food scraps tend to compost very rapidly, while at the same time making it difficult for oxygen to easily get into the pile—the soft texture and high percentage of moisture offer little structure to keep a compost pile porous and well-ventilated. It is for this reason that a pile made only of food waste would soon become a serious odour problem.

If, however, food scraps are limited to no more than 25% of the total compost pile, and if they are added to the pile in the correct way, little if any odour should be produced.

When building a new compost pile that is to include food wastes, the most practical approach is to build the pile in layers of

alternating garden and food waste. If the food waste is to make up 25% of the volume of the pile, then build each garden waste layer three times thicker than each food waste layer. In building a pile with a total height of 1.5 m for example, it might be advisable to begin starting the pile with a garden waste layer of approximately 20 cm, followed on top by a food waste layer of approximately 5-10 cm, followed by another garden waste layer, and so on until the total height is about 1.5 meters. Remember this may take several days to complete depending on the amount of waste that is available.

The other important consideration is that the food waste layers *not* be built to the edge of the pile, but rather, stop approximately 20 cm from the perimeter of the underlying garden waste layer each time. This is to ensure that *no* food waste is visible on the outside of the finished pile. This is an important procedure to follow and should reduce the chance of animals being attracted to the pile, reduce any potential for odour problems, and ensure that the pile is not unattractive to the guests.

Commonly, food scraps from the hotel kitchen will be relatively high in moisture content, and so may be expected to reduce the need for adding water in the compost pile. Using wet food scraps in this way can be an important way to conserve water that otherwise would be needed for composting. Depending on the time of year expect to still add supplemental water to the pile.

When the compost piles are turned, some effort should be made to ensure that the food scraps are well mixed into the complete mass, to ensure good compost production. As well, after each turning, it is important to make sure that any food scraps that became exposed and are on the outside of the pile get adequately covered with garden waste. Fresh garden waste can be used if necessary. Many of the food materials will break down very rapidly and become unrecognizable long before this happens with garden waste. As a result, concerns about exposed food wastes tend to disappear after the first few weeks of composting.

When using the types of hotel paper waste discussed earlier in this document, the paper can be well mixed with the garden wastes without much further thought. In the first week or two

of composting with added paper material, some care should be exercised to prevent paper debris from being able to blow around. This can be accomplished by ensuring that it is moist and well mixed with all the other materials.

Food waste and paper waste can be good for each other, since the paper needs moisture to compost, and can readily soak up excess moisture that may often be present in the food waste.

How to Work with Materials Other Than Garden

Hotel staff should consider experimenting with any other compostable materials once they have mastered the basics described in this guide. Always ensure that new materials are free from contaminants such as glass, plastic and metal. Always remember that it is best to introduce small quantities of any new waste into the process at first, until experience can be gained.

An important concept to understand when experimenting with other materials is the carbon-to-nitrogen ratio.

The Carbon-to-Nitrogen Ratio

Carbon and nitrogen are two chemical elements found throughout our universe, and in relatively high concentrations in anything that is alive or used to be alive. The ratio between the amount of carbon and the amount of nitrogen in a given waste material is called the carbon-to-nitrogen ratio, or C:N ratio.

All that it is important to understand about the C:N ratio is that composting works best, and smells the least, when the C:N ratio of the mix of waste you are working with is within a certain broad range. If you have too much carbon and too little nitrogen, the compost may break down only very slowly. If you have the reverse — too much nitrogen and too little carbon — the compost will still break down, but odours may be a significant problem.

The mix of garden wastes typically produced by Thai hotels already has an ideal C:N ratio, so this has not been raised as an issue in the earlier parts of this document. But if gardening staff are to avoid problems when experimenting with unusual materials in their compost, a basic understanding of how to work with the C:N ratio will help.

Again, it is important not to have too much waste that is high in carbon, since that will slow the composting process, and it is important not to have too much waste that is high in nitrogen, since odour problems will result.

High-carbon wastes tend to be brown, hard, and are commonly dry. Examples include wood, sawdust, wood shavings, paper, twigs, palm fronds, coconut shells, and the like. It is easy to imagine that a pile of just one of these materials would likely sit for a long time, and not break down easily. Certainly, a pile of just one of these materials would not likely produce a lot of odour. These are signs that the material is high in carbon. Since high-carbon materials tend to be hard and rigid, they also do not do a good job of holding in the heat of composting when placed in a pile. Since these materials do not settle or compact very much, so much air can pass through the pile that proper composting temperatures may never be achieved.

By contrast, materials high in nitrogen tend to have food value, be soft, and commonly are very moist. Examples include food wastes, green plants with no woody stems, sea weed, and manures. It is easy to imagine a pile of any one of these materials beginning to break down and create unpleasant odours in a short time. Since high-nitrogen materials tend to be soft, they tend to settle and compact very quickly. This prevents oxygen from being able to get into and recharge the pile, which again leads to rapid odour problems.

Hotel garden waste usually contains a good mix of both high-carbon materials such as twigs, palm fronds and other woody materials, and somewhat-high nitrogen materials such as soft, leafy green-coloured tissue. In general, when constructing a compost pile from entirely new materials, limit the truly high-nitrogen wastes to about one quarter of the pile, and ensure that the nitrogen wastes are well distributed throughout the pile right from the start.

Checking the Temperature

Materials for composting which have been placed in a windrow should be checked for temperature. Here we see the gardener insert his thermometer into the centre of the compost. If it is too hot, i.e. above 65^0C, it will be necessary to turn the pile; if it is cool just leave the pile as is and repeat checking the temperature in another few days to a week.

Temperature inside the pile or windrow is an ideal indicator of the status of the composting process. The optimal temperature range is between 40 and 60-65^0 C.

At a temperature lower than 40^0 C, the compost process slows down and it may take a long time before the process is completed.

At a temperature higher than 65-70^0C, the temperature becomes too hot and may kill the important microorganisms that complete the process.

Turning the pile or windrow should take place frequently enough to keep the temperature below 70^0C.

UNDERSTANDING COMPOST, WEED SEEDS, AND PLANT DISEASES

Garden waste can be expected to include plant seeds, including weed seeds. Some plant diseases may be found still viable in collected garden waste. Gardening staff may not want to use a compost that contains a lot of weed seeds or potential plant diseases in their gardens, since this might create additional problems and work.

Fortunately, a well-constructed compost pile is the ideal method to solve this problem. Extensive study has proven that weed seeds, plant diseases, and even bacteria that may be found in meat wastes such as *E. coli* are all readily destroyed by the heat of the composting process. Virtually all of these organisms (collectively referred to here as 'pathogens') are susceptible to destruction if sufficiently high temperatures are applied to them for a sufficiently long time.

Research has clearly demonstrated that if a temperature of at least 55^0C can be maintained in a mass of material for at least 15 days, few pathogens (i.e. disease causing pathogens), will survive. The ability of a compost pile to achieve this feat is similar to the pasteurization process used to process foods for safe consumption.

It should be emphasized that pathogenic organisms are not a large issue at the scale of composting discussed in this document, and do not pose any kind of significant threat to the success of such a program. Rather, some understanding and attention paid to this issue will simply result in an even better-quality compost that can consistently be free of weed seeds that might otherwise be a nuisance to gardening staff.

The pathogen issue should have two practical implications for how a hotel compost system is operated. The first is to underline the importance, when turning the pile, of reasonably ensuring that waste from the outside of the pile ends up being in the core of the pile after turning. While hotels will generally lack the equipment to actually verify temperatures in a

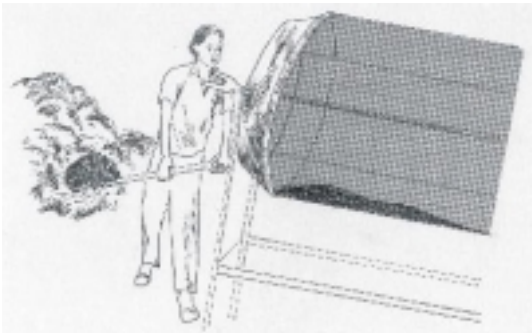
compost pile, one built in the manner described in this document can generally be relied upon to reach the required temperatures for the first month or so of composting. But these temperatures will only be reached in the centre of the pile. The outside of the pile will be the same temperature as the outside air. The pathogens throughout the pile can only be dealt with if all of the material in the pile is exposed to the required high temperatures, normally found only in the core.

The second implication related to pathogen control is that fresh waste should not be added to an existing pile that is more than a few weeks old. It is in the first few weeks that the highest temperatures are produced and the majority of pathogens destroyed. If a given pile of waste has already completed the high-temperature, initial phase of composting and new waste is then added, the new waste may contaminate the already pasteurized waste in the original pile.

USING COMPOST

It is important in beginning a discussion about compost use to first discuss when the compost is ready for use. Composting is a very gradual process that leads from raw waste to pure soil organic matter. At some point along that path, the material can be called compost and is ready for use on plants. But even the international scientific community has been unable to agree on a single definitive test or indicator of when the compost is truly ready for use.

This is an important issue because as compost breaks down, nutrients in the waste are used by the bacteria as a food source to grow. Once compost is mature, nutrients remaining in the compost are in a form readily available to plants. If immature compost is applied to a garden, the bacteria and the plants will be competing for the same nutrients, and plant growth will suffer. Compost should be allowed to fully mature before use, to ensure that this is not a problem.



Screening the Finished Compost

It is often necessary to pass the finished compost through a screen to separate large pieces from the compost. Screening also helps to separate out contaminants such as cans and glass. Here we see the gardener shoveling material from the compost pile into the screening drum. Later he will turn the drum by hand, the compost will pass through the screen and the large material will remain inside.

At least three months should have passed from the beginning of the process until compost is considered ready for use. Remember, more time is always better. The compost will steadily improve with age. Allowing compost to age for six to eight months from the start of the process is a good practice to ensure high quality product.

Finished compost looks much like a rich soil. While it may contain some small leftover pieces of wood and twigs that have yet to break down, there should be no other identifiable pieces of leaves or stems from the original plant material. The heat in the pile will be lost and the aroma or smell should be clean, sweet, and be a pleasant rich earthy smell. The mature product should readily crumble when rolled in the hand.

In many situations, users of compost may not want to use the product if it still contains visible pieces of material that are slow to break down, simply because these remaining pieces may be unattractive. One solution to this is to 'screen' the compost by passing it through a wire or other mesh. If a mesh size of

1-2 cm is used, the fine compost will pass through, and slow-to-compost materials such as the woody parts of palm fronds, coconut husks, branches and the like will remain on the screen. Rather than discarding the larger pieces, they can simply be mixed in with the next compost pile, as they will eventually break down.

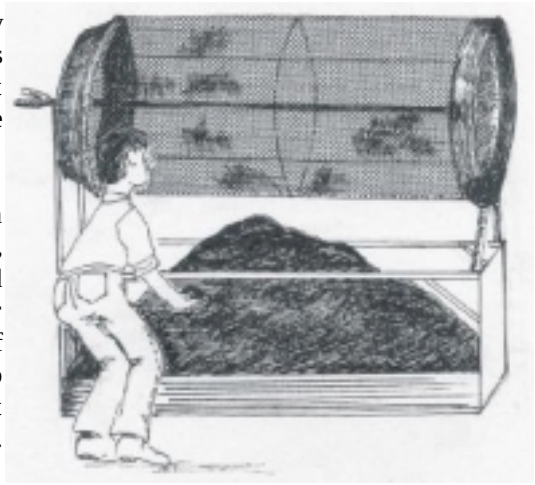
Compost Use in Horticulture

Compost can be of use in improving any soil to be used for any horticultural application. Adding compost to the soil provides additional nutrients that can be used by the plants. Compost also helps to contain moisture (water) and keep the soil loose so that the plant roots can grow better.

It must be understood that pure compost is generally too rich to be used in its pure state. Plants will grow in pure compost, but will rarely grow well. Instead, the finished compost should be diluted with other soils so that the compost makes up 50% or less of the mixture. Much smaller percentages can still be of significant benefit. Gardening staff should be encouraged to try experiments using different ratios of native soil to compost on the same plant species, until an optimal blend can be found. This ratio is likely to be different for different types of plants.

Regular use of compost to improve soils is likely to result in a significantly reduced need to water plants, since the compost can help retain water longer in the soil. Likewise, significantly less commercial fertilizers will likely be needed since compost contains nutrients, but also because use of compost in soil will hold commercial fertilizers longer in the soil, in a form useable by plants, rather than allowing the fertilizers to be leached away.

Generally, compost can be used in two ways. The first is in the creation of potting soils or plant growth media. Compost should be included in any such mix, to a maximum of well less than 50% of the blend, depending on what other ingredients are used. If, for instance, a blend of just compost and sand are used, the



Harvesting and Using Screened Compost

After screening the finished compost can be collected and either stored or used. If stored it will be necessary to shovel the compost into bags until required. Alternatively the compost may placed in a new pile and allowed to cure. Finished, screened compost should be dark brown in colour, have an earthy smell and should feel dry to touch.

compost component could come up to 50%. But if other organic-rich elements are used, such as bark, peat moss, etc., then the compost component should be reduced accordingly. Again, experimentation with different blends will eventually reveal the ideal mix for a given circumstance. In most cases however, inclusion of compost is likely to produce very good results.

The second major way that compost can be used is as a surface application in existing gardens. The material should simply be applied to the surface, and then immediately worked into the underlying soil. Again, it will be important to ensure that the underlying soil dilutes the compost well, so that the compost is ideally less than 50% of resulting soil in the garden. Annual applications of compost in this manner will lead to extremely rich and fertile soils for gardening. Dig it into planting areas to improve the soil, spread it around shrubs, flowers and trees. This helps protect the soil, saves moisture and lowers the temperature.

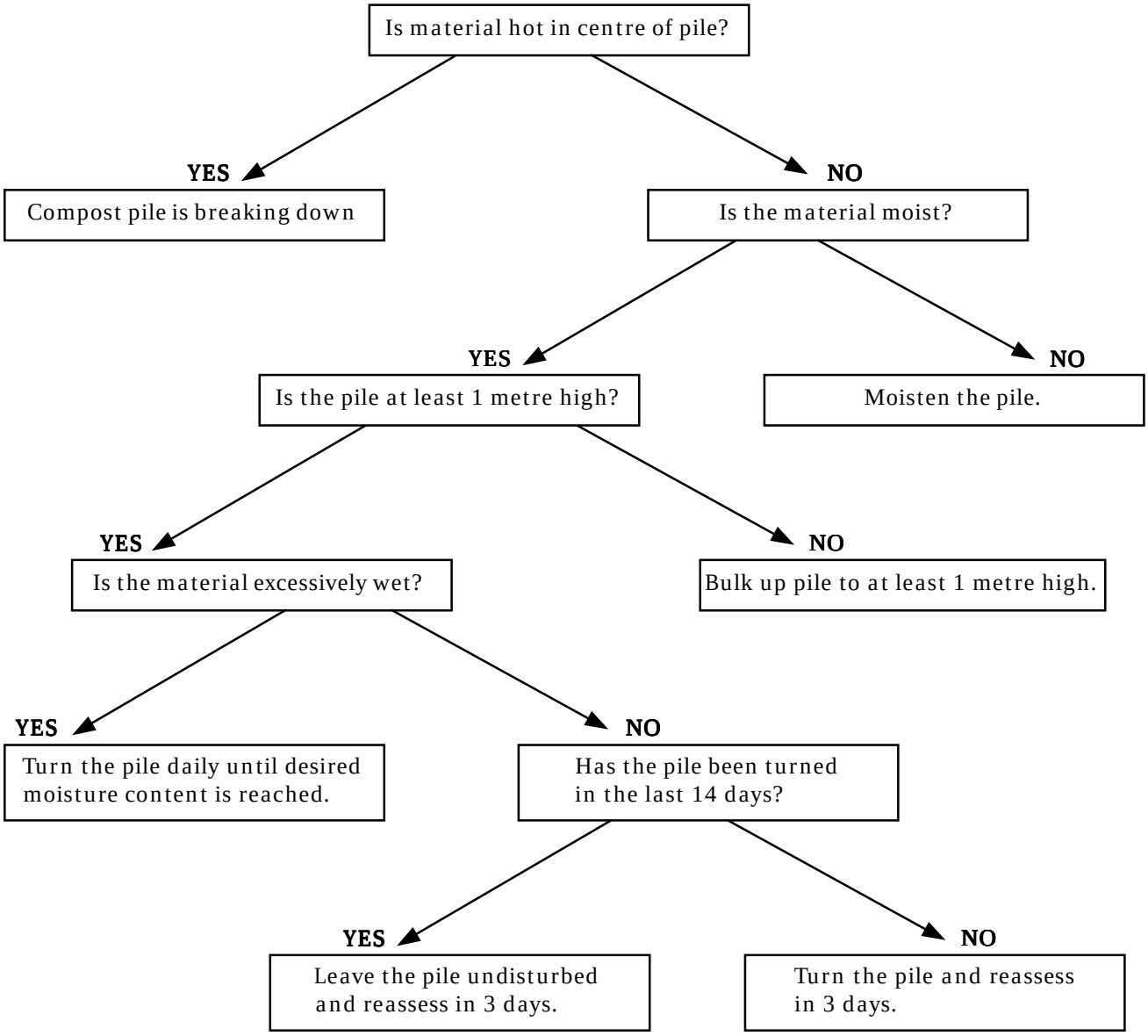
TROUBLE-SHOOTING GUIDE

If problems do arise, the compost manager should review relevant sections of this guide to ensure that key steps have not been missed. This trouble-shooting guide has also been provided to assist in identifying key areas that may need to be amended, in the event that either the compost produces foul odours, or simply does not appear to be breaking down.

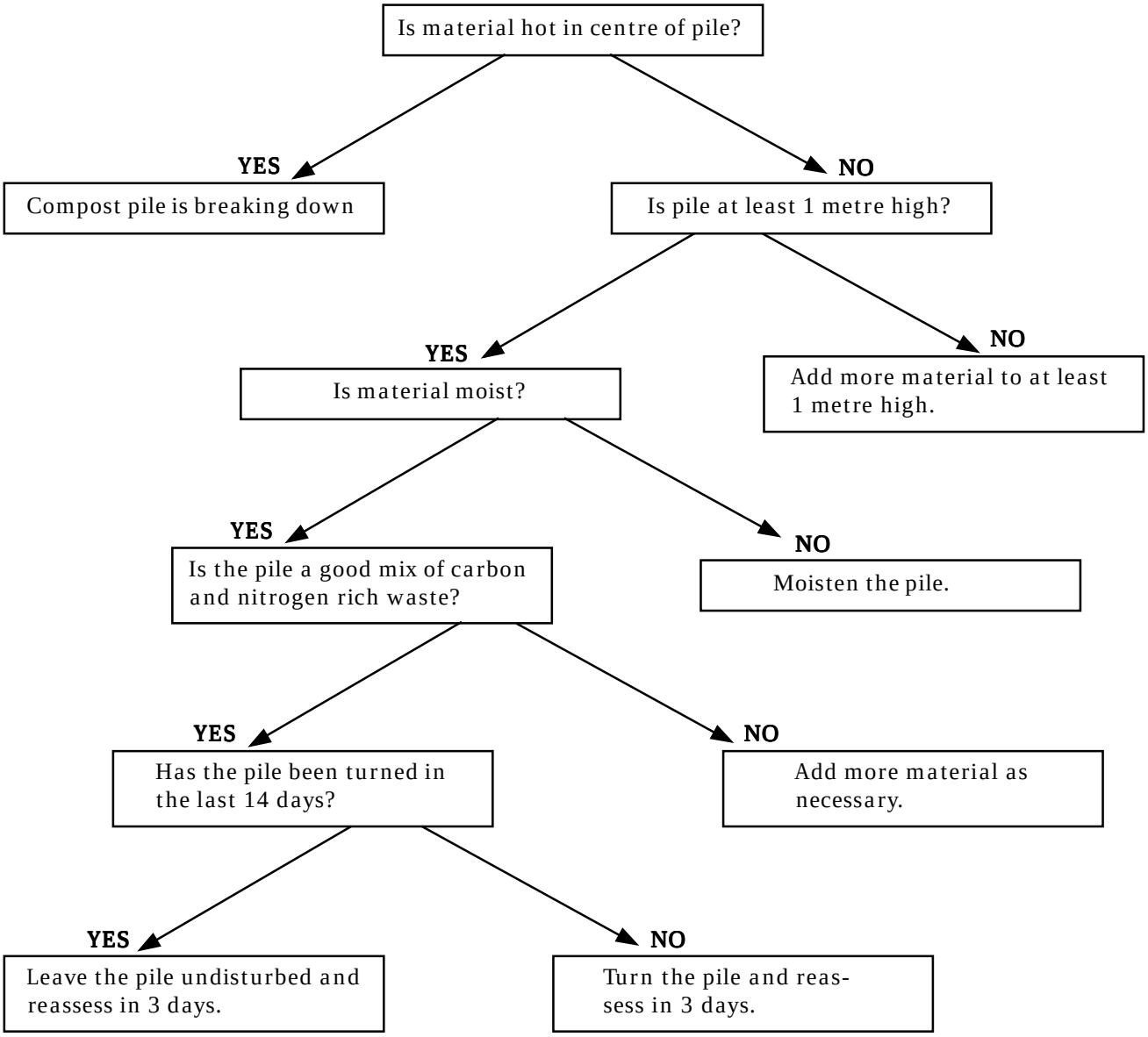
Problem	**Remedy**
Wet, foul-smelling heap	Turn pile and add high-carbon, absorbent materials. Protect pile from rain.
Dry center and little or no decomposition of materials	Turn pile, thoroughly soaking each layer as it is replaced. Cover with plastic to retain moisture.
Dampness and warmth in middle	Increase amount of material in pile only and moisten.
Damp, sweet-smelling heap	Add more nitrogenous materials such as blood meal, fresh manure or urine, and turn or aerate.
Matted, undecomposed layers of leaves or grass clippings	Break up layers with garden fork or shred them, then relayer pile. Avoid adding heavy layers of leaves, grass clippings, hay, or paper unless first shredded.
Large undecomposed items	Screen out undecomposed items and use as starter for next pile.

The following tables have been prepared to serve as a guide to assist in case problems arise.

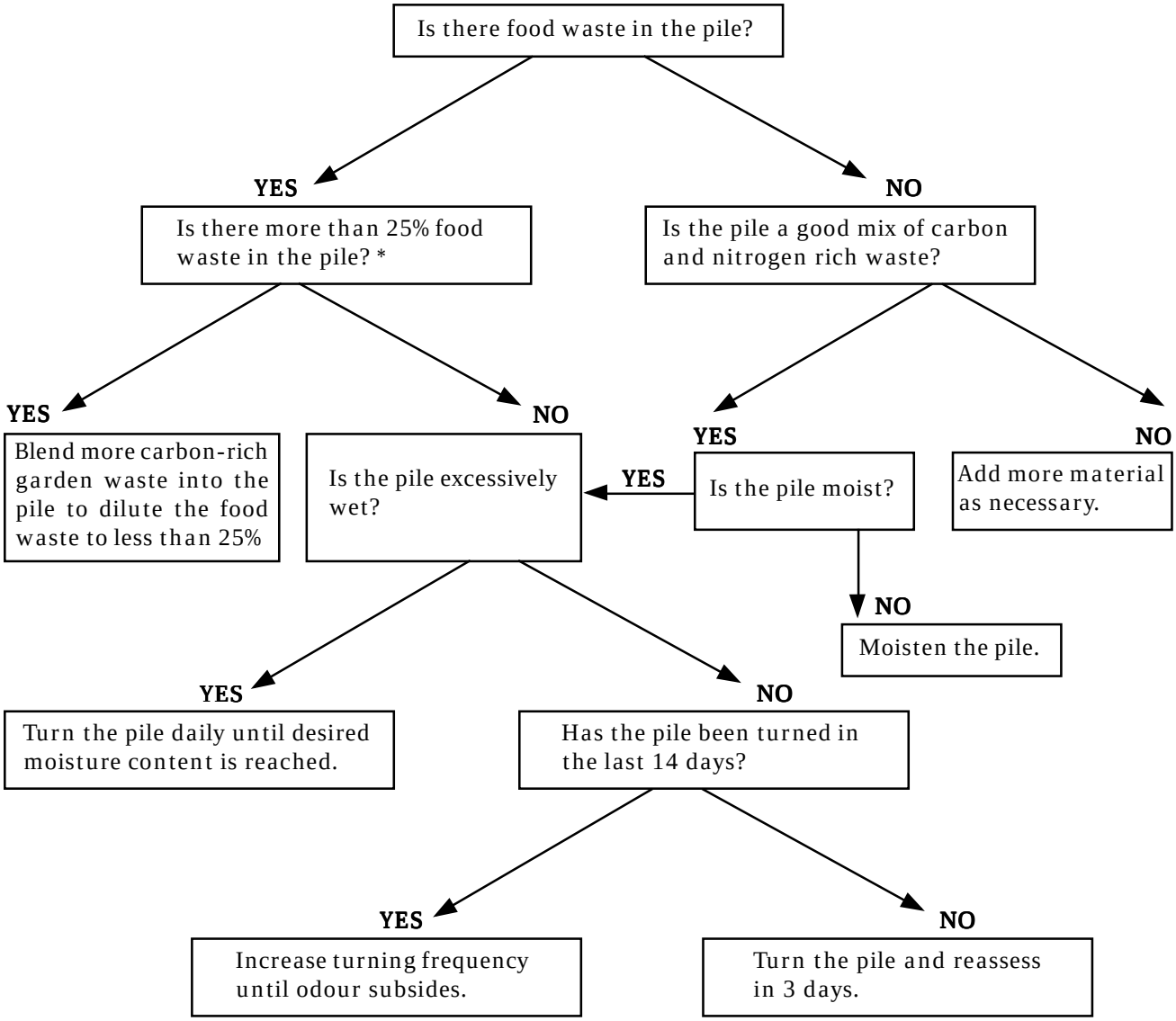
Problem: Compost pile is not breaking down
Troubleshooting Chart for material greater than 4 weeks old



Problem: Compost pile is not breaking down
Troubleshooting Chart for material less than 4 weeks old



Problem: Compost pile is odourous
Troubleshooting Chart for Odourous Compost Pile



* or any other overly nitrogeneous waste such as a chicken dung

Terms and Meanings

Aeration	The process of exposing composting material to oxygen.
Aerobic	A process or condition occurring in the presence of oxygen.
Decomposition	The process of breaking down organic materials through the actions of microorganisms into component parts or basic elements.
Bulking Agent	Material used to add volume to composting feedstocks, aids in aeration. Examples includes pieces of branches or twigs of trees.
C:N	The ratio of carbon to nitrogen.
Compost	Relatively stable humus-like material resulting from the composting process.
Curing	The stage during which materials that are more resistant to breakdown are stabilized; also known as maturation.
Humus	Organic material resulting from decay of plant or animal matter.
Leachate	Liquid formed by water percolating through a mass of solid waste or compost and extracting dissolved or suspended materials from the mass.
Microorganisms	Microscopically small living organisms that metabolize waste materials.
Residuals	Materials removed from the feedstock to the composting process or from the finished compost. Residuals may require landfill disposal and can be removed by screening.
Stability	The state at which the composted material can be stored without causing a nuisance or can be applied to the soil without causing problems.
Static Pile or Heap	A composting method in which the organic materials are piled and periodically turned.
Windrow	An elongated pile of material.
Yard and Garden Debris	Leaves, grass clippings, pruning, etc. discarded from yards and gardens.