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Organiser:

School of Life Sciences
The Chinese University of Hong Kong
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The Jockey Club "Field So Good" Community Composting Programme
- Educational Booklet -

# KNOWING THE FACTS AND SCIENCE OF COMPOSTING

Understand the importance of composting,
and rethink the way to sustainable development

Author: Ng Wai Shing@Homeland Green

# Content



**Knowing the Facts and Science of Composting**

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# 賽馬會 Jockey Club "Field So Good"

# 好壞

## 城市有機堆肥計劃

## — Community Composting Programme —

Recycling of organic resources can **reduce carbon emission**. Encouraging local farming can increase landscape greening and reduce carbon footprint, mitigating **the global problem of climate change**!

The industrial and commercial businesses in Hong Kong generate a great deal of organic refuse every day. However, because of the low recycling rate, incompatible producing technologies and lack of promotion, the demands of compost from local agriculture and horticulture can only be met by imports rather than local supply.

The objective of the Jockey Club "Field So Good" Community Composting Programme is to create a platform for recycling organic resources, to establish standardised mode of production, and to produce high quality organic compost. In the process, youth participation will be engaged. The compost, thus produced, will benefit the farming industry, improving the quality of crops and soil of local farms.

# The Jockey Club "Field So Good" Community Composting Programme

## 1. RECYCLING

organic refuse of local food factories through the new composting facility

## 2. RESEARCHING INTO & PRODUCING

high quality organic compost products; establishing standardised mode of production


## 3. ENGAGING

young people committed to environmental protection in farming and composting activities

## 4. TRAINING

"Field So Good" youth ambassadors for composting promotion activities

## 5. PROMOTING

organic composting to the farming industry; publicising the importance of land rehabilitation

## 6. SHARING

the outcomes of the programme; distributing the organic compost produced from the recycled organic resources

## Sponsor

Working with Government, non-governmental organisations and community partners, **The Hong Kong Jockey Club Charities Trust** is committed to improving the quality of life of the people of Hong Kong, as well as building a sustainable future for Hong Kong. Over the years, the Trust has sponsored many large-scale environmental projects, and this Programme is one of the fully funded projects.

## Organiser

The School of Life Sciences of **The Chinese University of Hong Kong** is the organiser of the Programme and responsible for the research. Led by Prof Chu Lee-man, the Programme has investigated the efficient production of high quality compost using organic refuse created by the local food factories, and assessed the benefits of organic composting to local agriculture and horticulture.

## Co-organisers

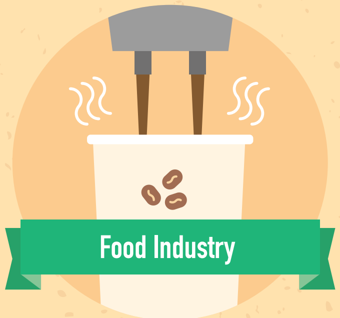
**FoodCycle+** is a local registered social enterprise, working on upcycling and reuse of local organic resources in local agriculture through its innovative upcycled green products. It is responsible for the operation of compost production and community promotion for the Programme.

**Hong Kong Children & Youth Services** endeavours to create a favourable environment where children, youths and their family members can develop their potential and realise their goals. It is responsible for recruiting and providing training to the young people interested in promoting environmental protection, for assisting various community promotion events.

## Stakeholders Participating in the Programme


We are liaising with farms, gardens and gardening shops to encourage them to try out the quality organic compost developed and produced through this Programme, with a view to promoting widespread use by the industries.


The Programme serves as an example of recycling and converting organic refuse into organic compose with commercial value. Through sharing the underlying technologies, it will help drive further diversification of the recycling industry.

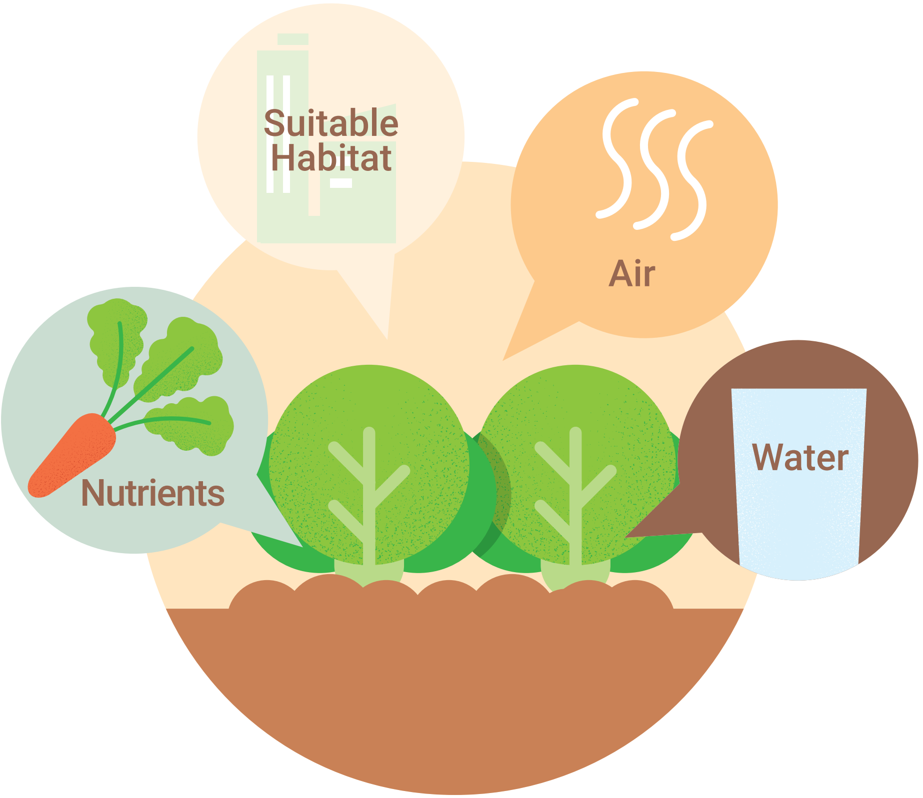



Our current targets mainly include soya meal from soya product factories, lees from beer brewery, tea and coffee dregs from tea shops and cafes, and we are also exploring other potential organic resources for recycling.

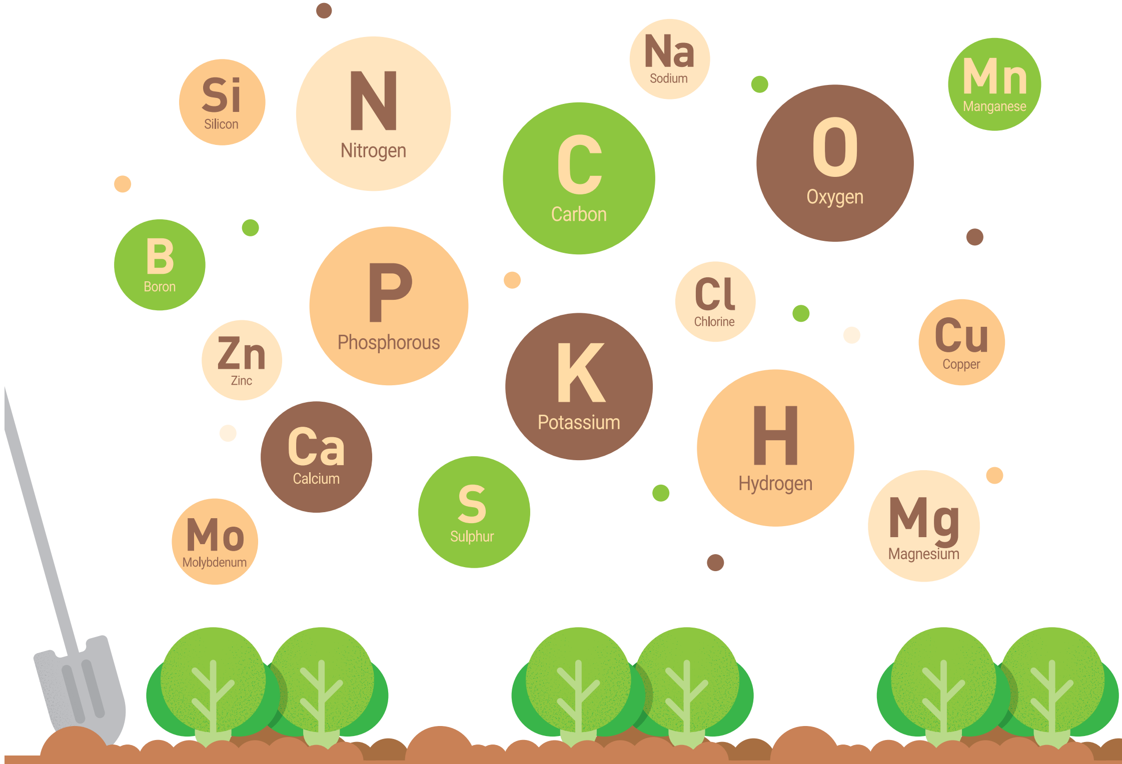

Land conservation is a cross-generation task. We will seek in the community environmental protection leaders for tomorrow, and nurture them through immersion in the promotion events.

# What are required for plant growth?

Being organism, plants require air, water, nutrients and a suitable habitat, just like us.





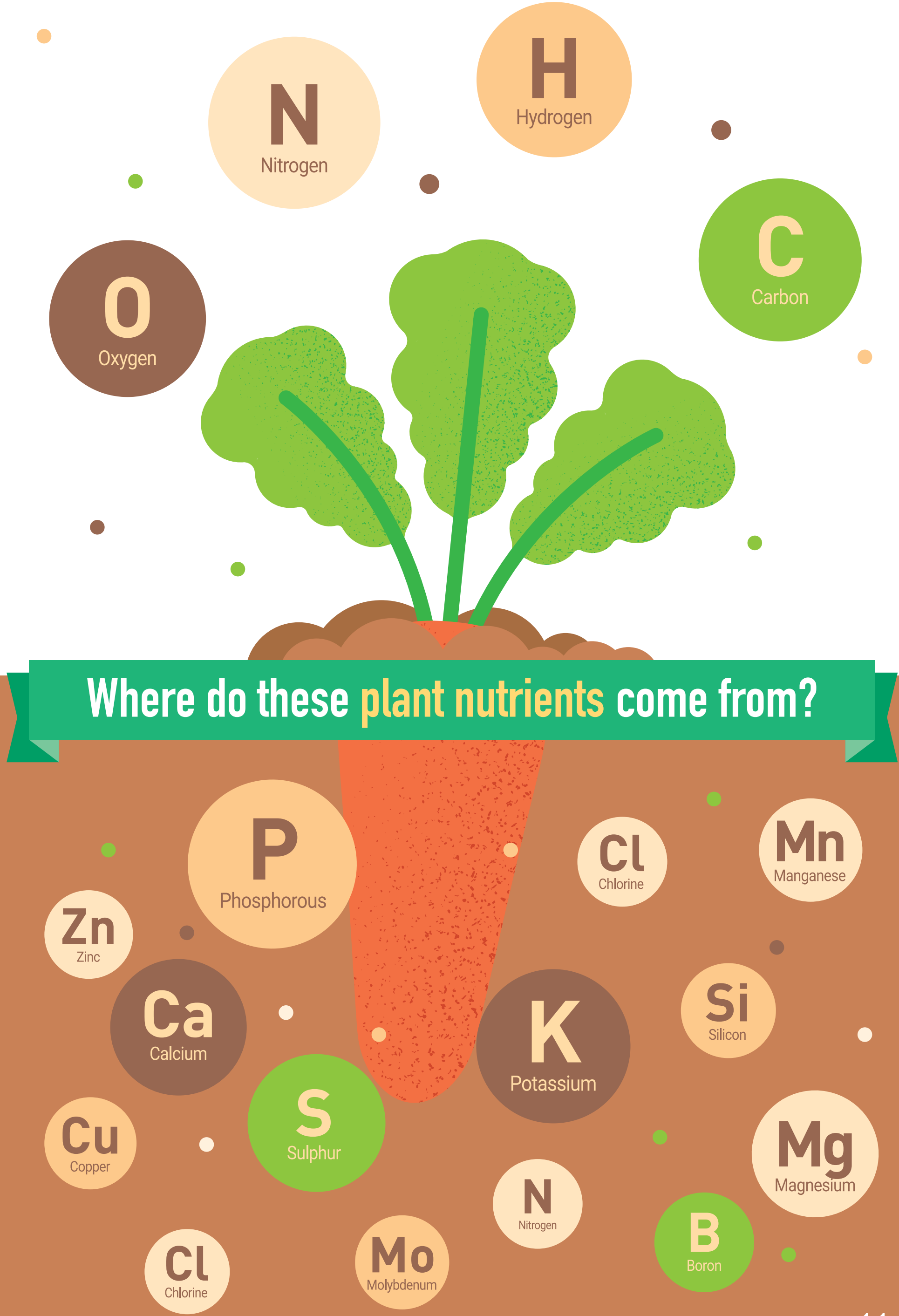

## Nutrients required for plant growth

We should be familiar with air and water. Let's look at the nutrients required for plant growth. Plants require at least 18 chemical elements, or plant nutrients, to grow healthily:

- Some in larger amount: carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium
- Some in lesser amount: calcium, magnesium, sulphur
- Some in minute amount yet essential: iron, zinc, copper, manganese, molybdenum, sodium, boron, silicon, chlorine

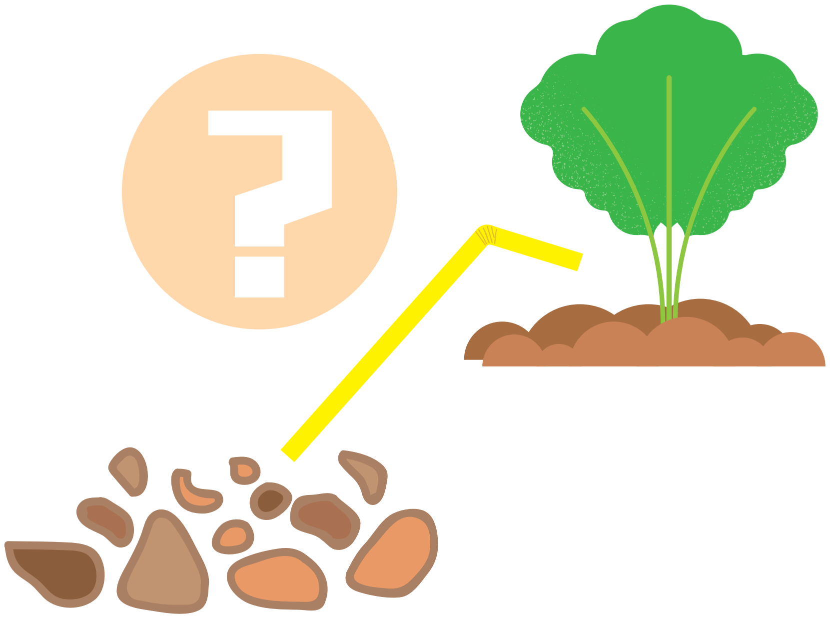
# Where do these plant nutrients come from?

The elements of carbon, hydrogen, oxygen and nitrogen that the plants need in abundance come from the air, but the rest largely come from mineral sands, the main component of soil.  In the other words, many plant nutrients come from the mineral sands in soil, which we call mineral nutrients.



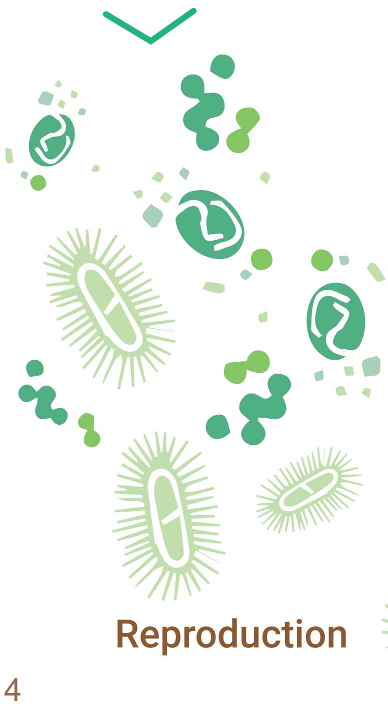
## So, Where do these mineral sands come from?

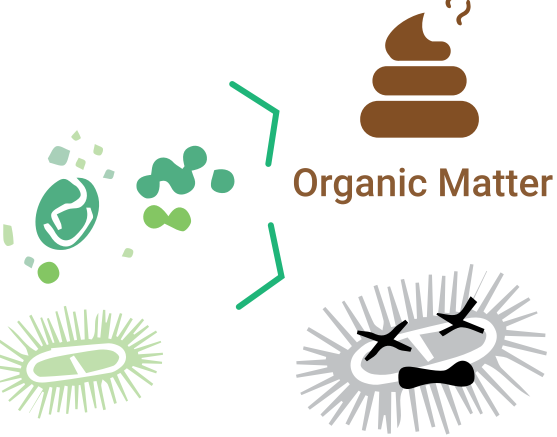
When the lithosphere of the Earth formed, it contained various chemical elements but not any live forms. After ages of weathering and erosion, the bedrock gradually breaks up from its surface into smaller fragments. As time goes by, these fragments break down even further into smaller stones and gravels, and finally into small particles of minerals, which are the main source of mineral nutrients for plants.



However, nothing can grow with just mineral sands. Although there are nutrients in the mineral sands, they are not readily available to plants. So, what enables the extraction of these nutrients from the mineral sands for use by the plants?

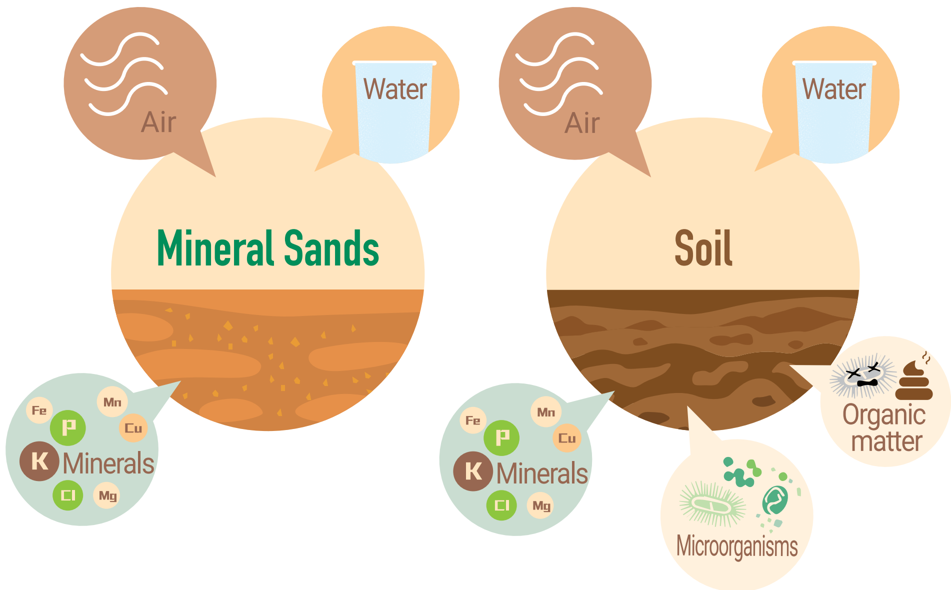

According to modern science, some organisms so tiny that cannot be seen with our naked eyes, which we call microorganisms, miraculously came into being on Earth a few billion years ago. Some of them could make use of the nutrients in the mineral sands and live in small spaces between particles. Even more amazing, some were capable of photosynthesis, capturing the carbon dioxide in the atmosphere to produce food for their own growth and reproduction. This has led to the gradual cumulation of organic matter (i.e. complex carbon-containing compounds) from their metabolic wastes and remains. The organic matter in turn provided nutrients and habitats for the subsequent organisms. In other words, organisms capable of photosynthesis have established a symbiotic relationship with microorganisms since the early days.






When many more such organisms have lived and died, a layer of organic matter rich in mineral nutrients and carbon compounds accumulates between the mineral sands, forming the soil under our feet today. Hence, mineral sands alone are not soil, as soil must contain microorganisms and organic matter.



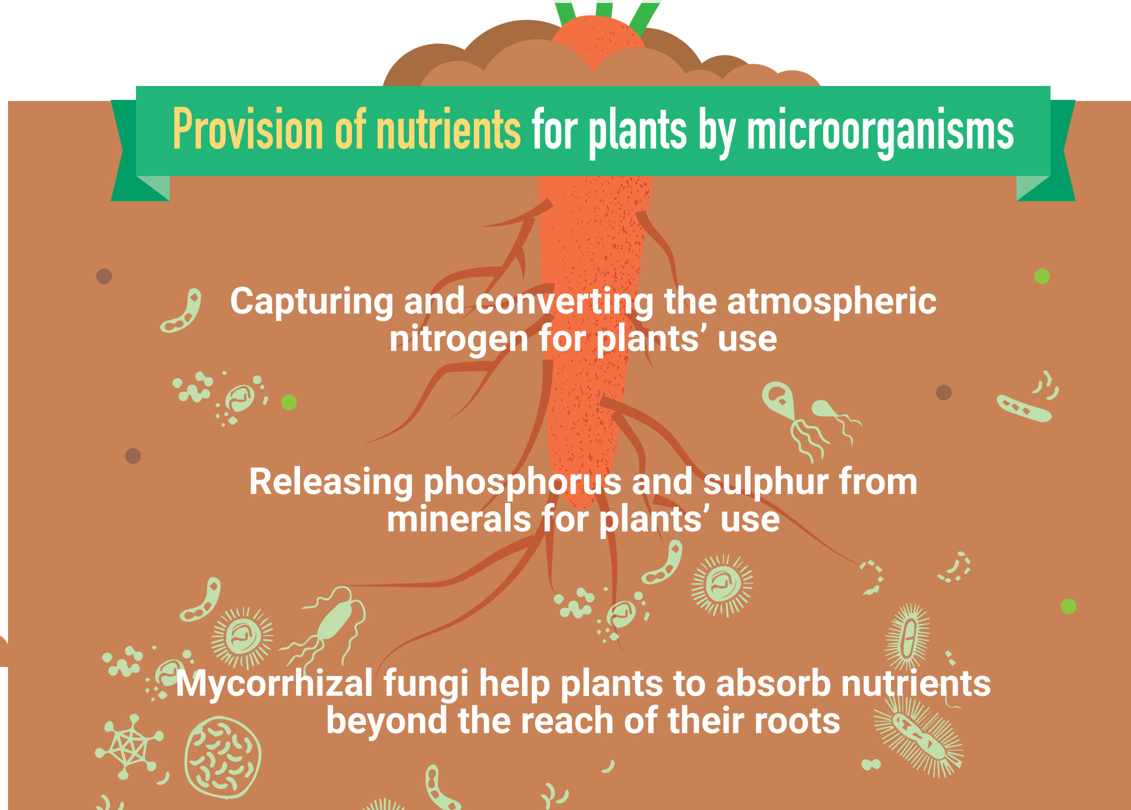

## There is a world of difference between mineral sands & soil

# Evolution of plants

Through the long history of evolution, plants capable of producing food through photosynthesis have increased in size, functional and structural complexity, as well as species diversity. The organic matter added to the mineral sands after the death of these plants formed more soil continuously, thus enabling the appearance of more diverse plant species.


Despite evolution, the nutrients required by the plants for photosynthesis are still extracted from the mineral sands by the microorganisms in the air and the soil, enabling the plants to produce food for themselves, grow and reproduce.

As various terrestrial plants emerged through continuous evolution, the microorganisms below the land surface also became more diverse.  To name a few, some microorganisms can capture and convert the atmospheric nitrogen into nitrogen-containing compounds that plants need, while some others secrete acids and enzymes that could unlock the phosphorus and sulphur in minerals and make them available to plants.  Some fungi called mycorrhizal fungi can form symbiotic association with plant roots, enabling the plants to access nutrients beyond their root systems.

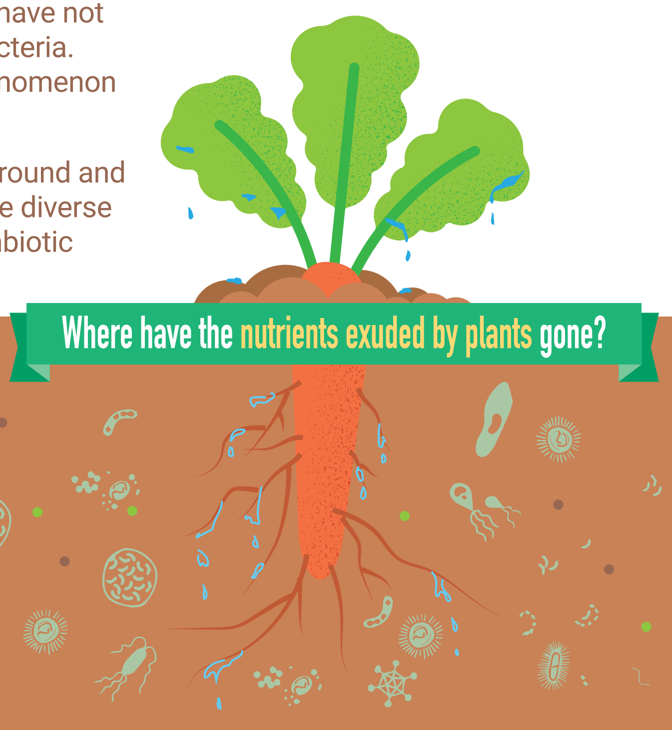


# Why would microorganisms keep providing nutrients to plants?

We had no idea that the sugars, proteins and lipids produced by plants are not all for the use of their own growth and reproduction. Above ground, various parts of the plants would secret nutrients to nourish those microorganisms providing protection to them; underground, the plants exude nutrients from their roots to feed those soil microorganisms providing services to them.

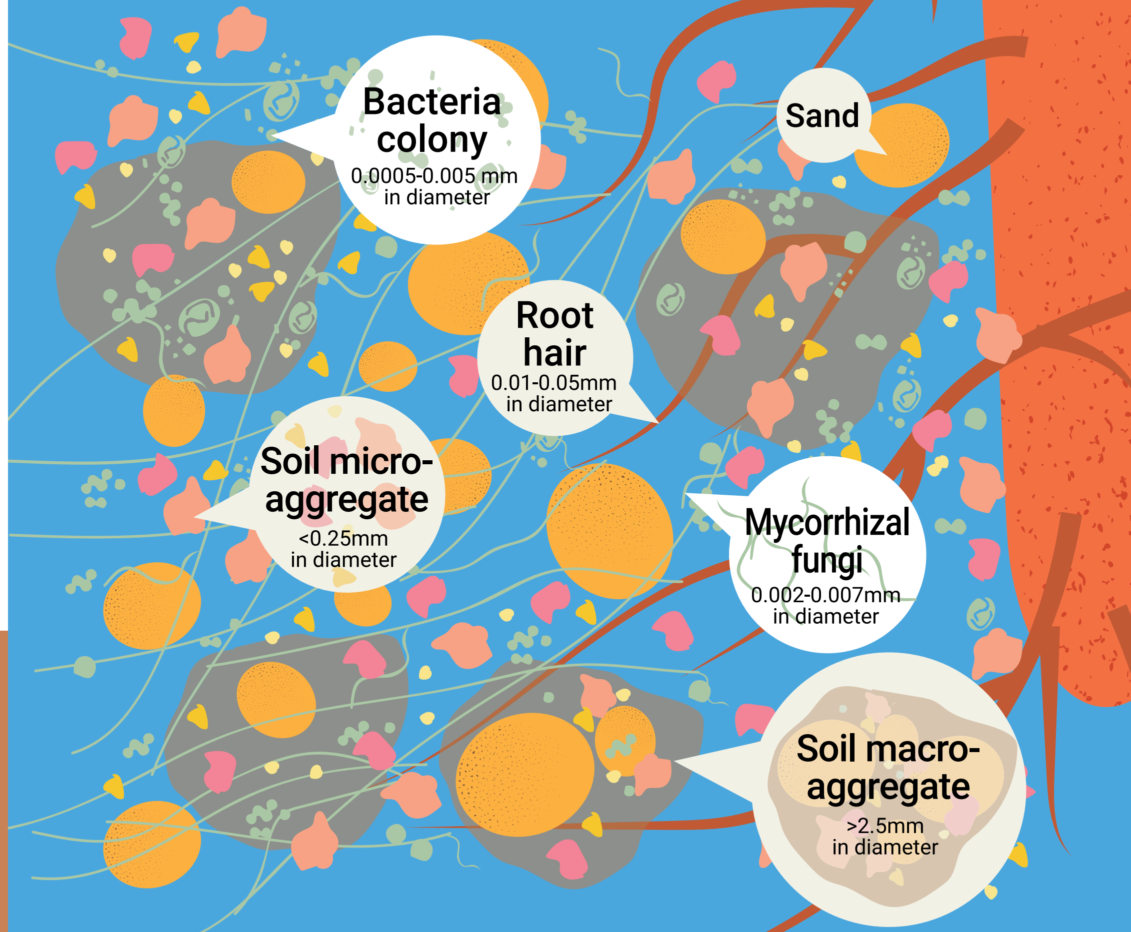
Recent scientific studies have discovered that, plant roots exude nutrients as bait to attract specific bacteria in the soil. The root tips will then engulf the bacteria into the intracellular space between cell wall and cell membrane, dissolving the cell wall of the bacteria to obtain the nutrients inside. These wall-less bacteria can still survive and multiply in the plant roots, and will be transferred to the tips of root hairs where they exit. These bacteria, being nurtured by the nutrients exuded from the plant, will grow back the cell wall. They continue to extract the nutrients from the mineral sands and multiply themselves, and be ready for the next round of servicing the plants. Furthermore, the plants will not have root hairs if they have not engulfed the symbiotic bacteria. Scientists named this phenomenon as "rhizophagy cycle".

As the organisms above ground and underground become more diverse through evolution, the symbiotic relationship established



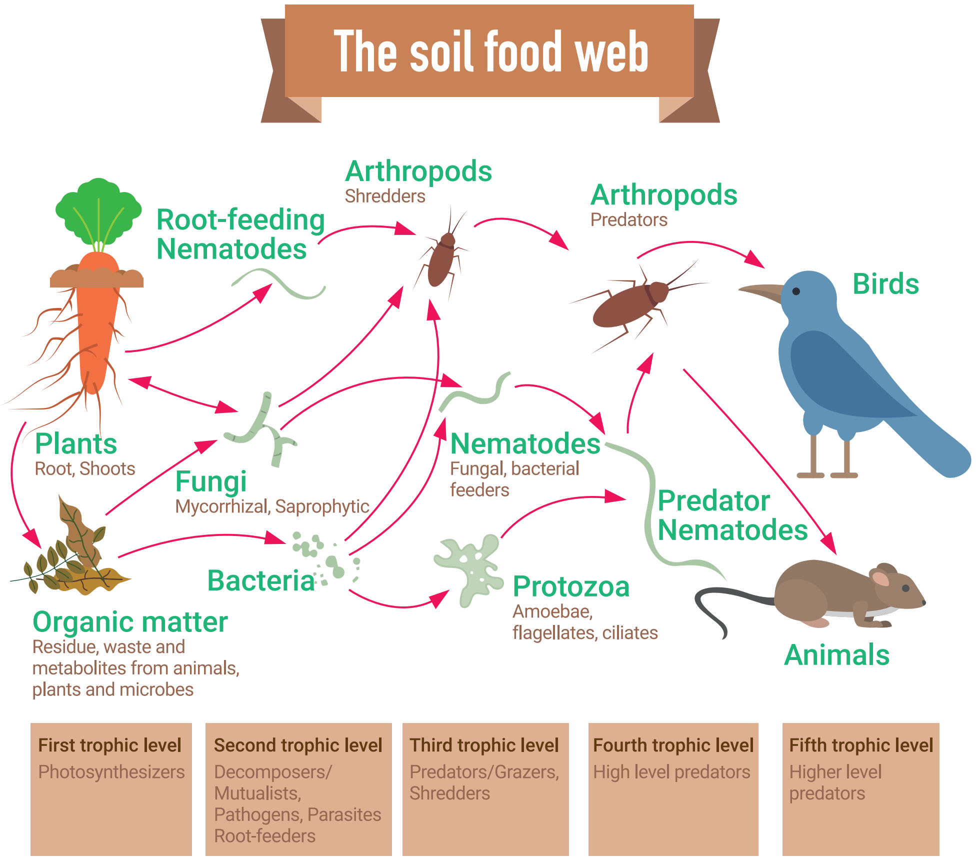



Besides, soil microorganisms have other beneficial functions to plants. For example, some microorganisms can form a protective layer around plant roots against pathogens and pests; some others would secrete sticky substance that binds clays into microaggregates; the long hyphae of mycorrhizal fungi would further bind these microaggregates together forming macroaggregates visible to our naked eyes. Such soil structure enhanced by the microorganisms has better porosity and aeration, making the soil a better habitat for the growth of microorganisms and plants.



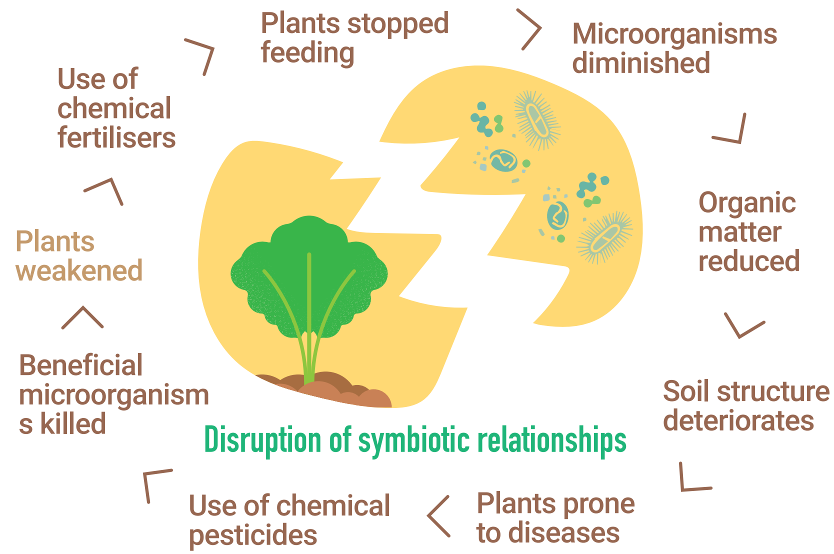

▲ The blue background is the water held by the soil aggregates.

After billions years of evolution for lives on Earth, every gram of healthy soil today may have up to 25,000 species of bacteria. It is estimated that one tablespoon of healthy, mature soil can have some 50 billion microorganisms. Besides bacteria and fungi, there are also various organismal communities at different trophic levels, which are interdependent. Scientists call this “soil food web”, where the organisms in each trophic level can be food for predators in the next level. At each higher trophic level, the organisms are larger in size and fewer in population. Some of them are visible to us like the well-known earthworms. Since the organisms in each of the trophic levels have different nutrient elements requirements, the predatory relationships allow various mineral nutrients to be recycled in the soil and be available for the use by plants.



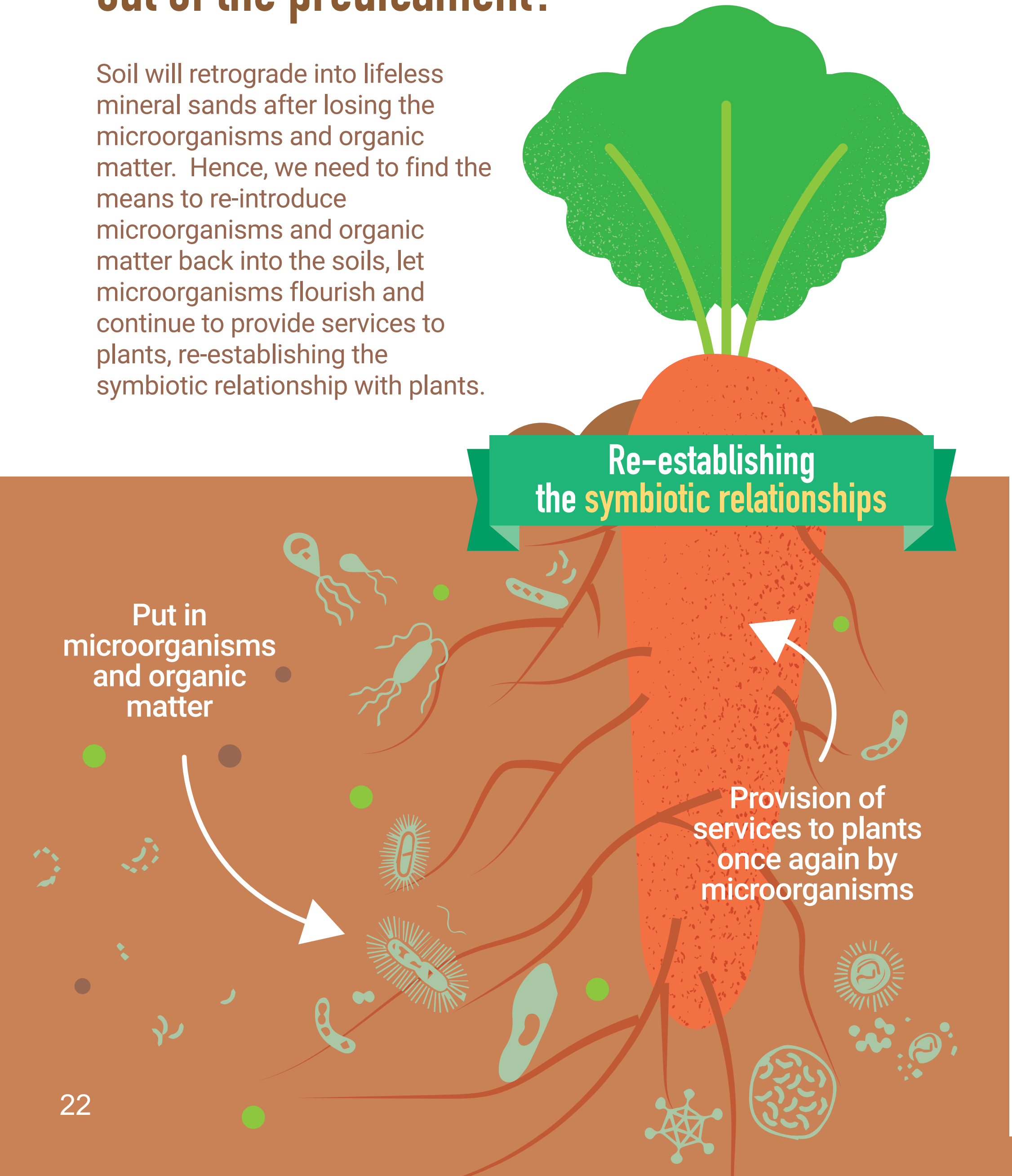



Before human history, the symbiotic relationships established in nature worked well on Earth. The relationships were disrupted when man began to cultivate the land for food. As human population expands through time, the demand for food keeps increasing. At the dawn of the 20th century, people erroneously believed that plant growth and yield could be increased through applying nutrients manually. Then starting from some seven decades ago, the few nutrients thought to be most essential to plants were produced by chemical processes and applied to farmlands extensively in the form of chemical fertilisers, with the real need of plants for balanced nutrients completely neglected. In the initial two to three decades, the use of chemical fertilisers seemed to have increased the yield. However, the manual application of chemical fertilisers has bit by bit replaced the work of soil microorganisms, and the plants have also gradually stopped feeding them in return. Microorganisms in soil diminish, thus producing less organic matter and the soil structure deteriorates. Having nutrition out-of-balance and losing the protection of soil microorganisms, plants are more prone to diseases. The agribusiness then turns to massive use of pesticides. While suppressing the pests above ground, the pesticides also destroy the microorganisms underground that have established symbiotic relationships with the plants, resulting in a vicious cycle. Even worse, a substantial portion of the water-soluble fertilisers applied on the farmlands are not used by the plants and becomes fertiliser run-off underground or in nearby drainage, causing various chemical contaminations of water sources. This is a global predicament as a consequence of the extensive use of agrochemicals for decades.



# Are we capable of getting out of the predicament?

Soil will retrograde into lifeless mineral sands after losing the microorganisms and organic matter. Hence, we need to find the means to re-introduce microorganisms and organic matter back into the soils, let microorganisms flourish and continue to provide services to plants, re-establishing the symbiotic relationship with plants.





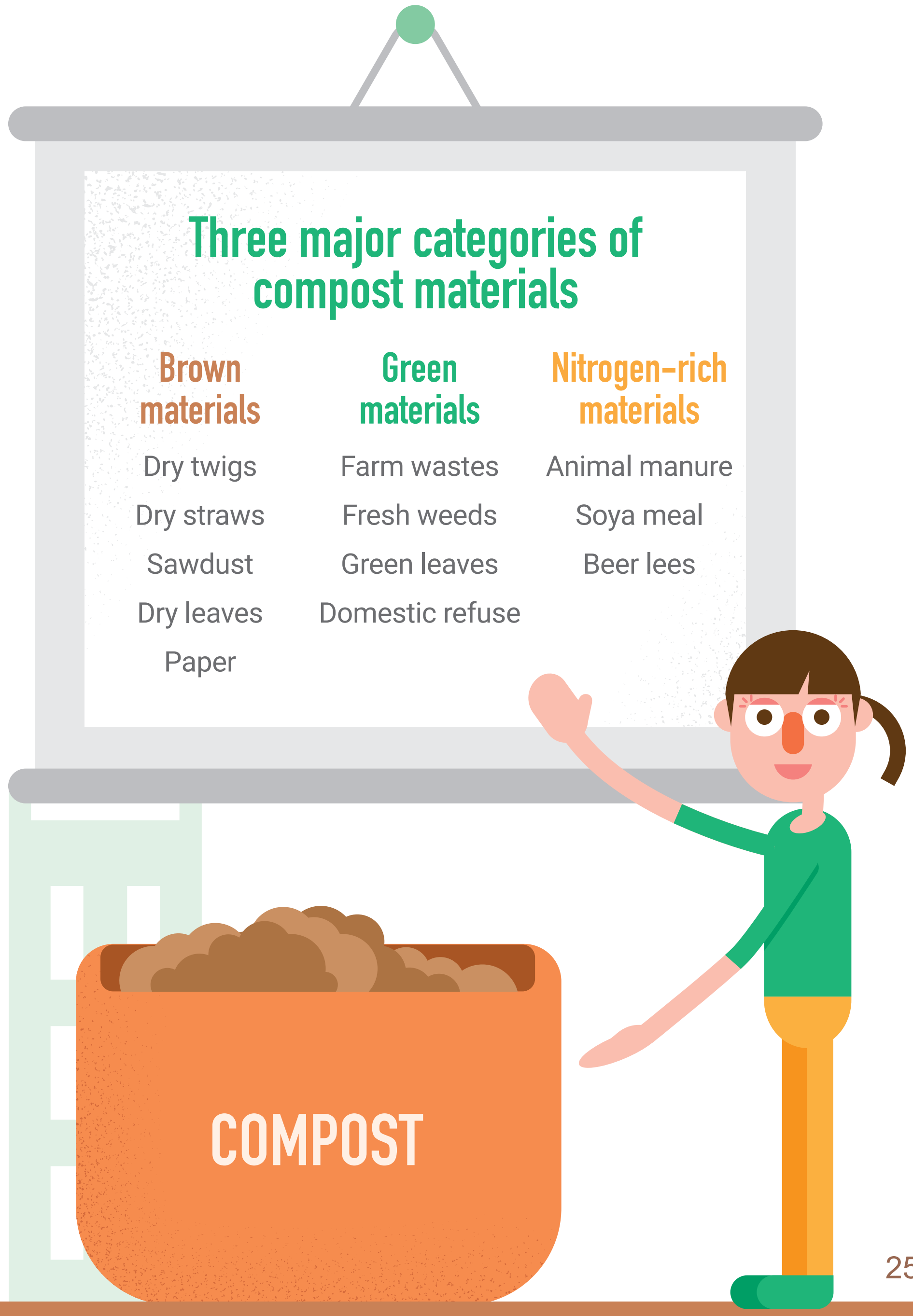

# What is composting?

In Nature, all live forms will be decomposed by microorganisms after death and eventually be returned to the soil as organic matter. This used to be the natural cycle before human removing natural forests and habitats of plants and animals extensively for building cities. In modern cities, the food chains are so much extended that the organic matter fails to be returned to the land. Composting is modelling on the natural process, by providing organic refuse as food to let beneficial microorganisms to multiply rapidly in a controlled environment, producing large quantity of organic matter at the same time.

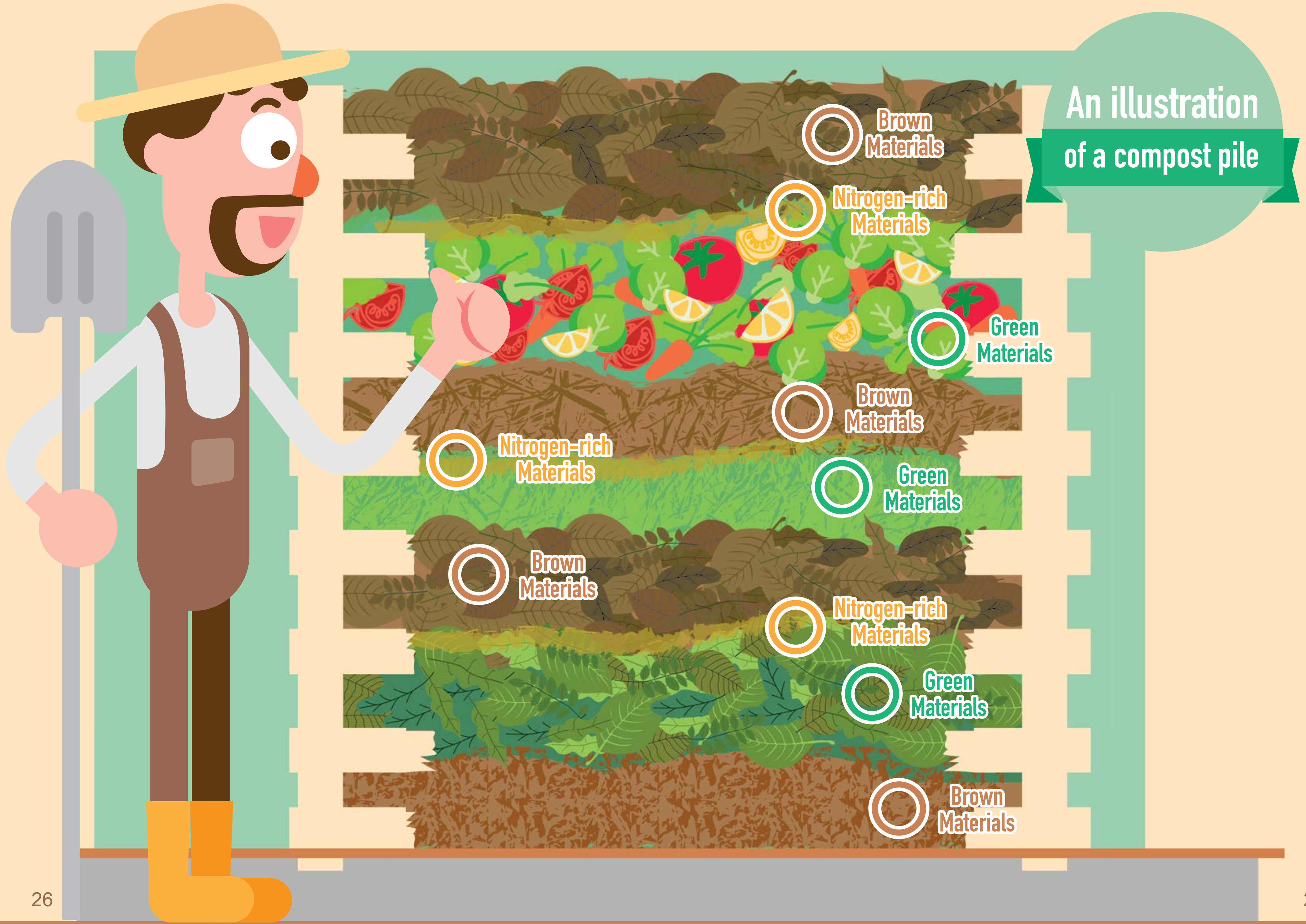
# Where do the ingredients (organic refuse) for composting come from?

In principle, any substances that were once living thing can be used for composting, as they all contain carbohydrates, proteins, lipids and many other minerals, i.e. containing plenty of carbon and nitrogen. They can be classified into three major categories based on their carbon and nitrogen contents:

- "Brown materials" contain more complex carbohydrates such as lignocellulose, with very little nitrogen. They usually have a brownish colour as the bulk is withered plants, e.g. dry twigs, dry straws, sawdust, dry leaves, paper, etc.
- "Green materials" contain simple carbohydrates such as sugars and thin cellulose, and a bit of protein. They usually have a green colour as the bulk is fresh plant wastes, e.g. non-woody farm wastes, fresh weeds, green leaves, domestic refuse, etc.
- "Nitrogen-rich materials" contain mainly proteins and some lipids, with relatively low carbohydrates content, e.g. animal manure, soya meal, beer lees, etc.



## An illustration of a compost pile



In the natural world, bacteria and fungi are the primary decomposers of organic matter. They have different feeding habits. Bacteria are only capable of digesting simple proteins, sugars, simple cellulose, etc., but not complex lignocellulose and lipids, which fungi can digest.

Hence in a compost pile, materials containing nitrogen and sugars will be digested by bacteria first, while it will take longer for fungi to digest lipids and lignocellulose.

According to the test results, some of the compost materials used in this Programme can be categorised by their carbon-to-nitrogen (C/N) ratio as follows:

### Brown materials

C/N ratio > 30 : 1

Orange and pineapple peel from catering business;

Potato peel from chips producers;

dregs from herbal tea factories

### Green materials

C/N ratio > 15-30 : 1

Coffee dregs from cafes;

Spent mushroom substrate from mushroom growers

### Nitrogen-rich materials

C/N ratio < 15 : 1

Soya meal from bean product factories;

Beer lees from breweries;

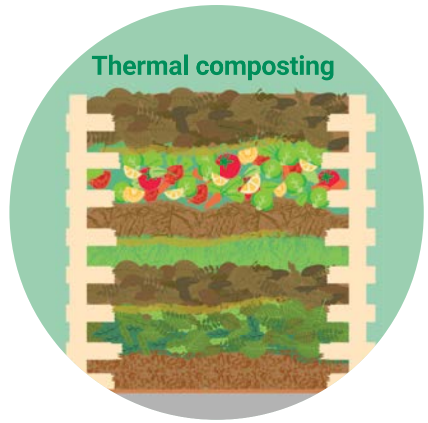
Scraps and dregs from catering business;

Soup dregs from producers

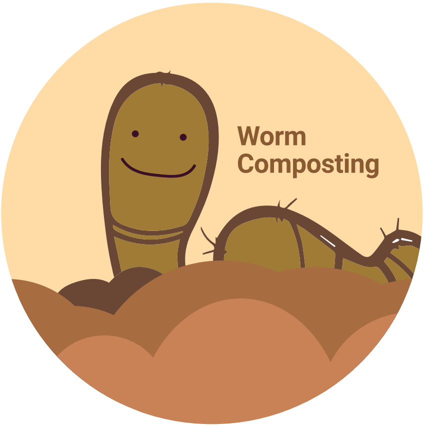


# A reference on composting methods


Microorganisms can be found everywhere. Basically, all organic refuse carries bacteria and fungi. Being put in a pile, the abundance food will naturally let the bacteria and fungi multiply until all digestible food is exhausted. This process is called decomposition, where the wastes is turned into compost rich in microorganisms and organic matter. This is known as natural composting.



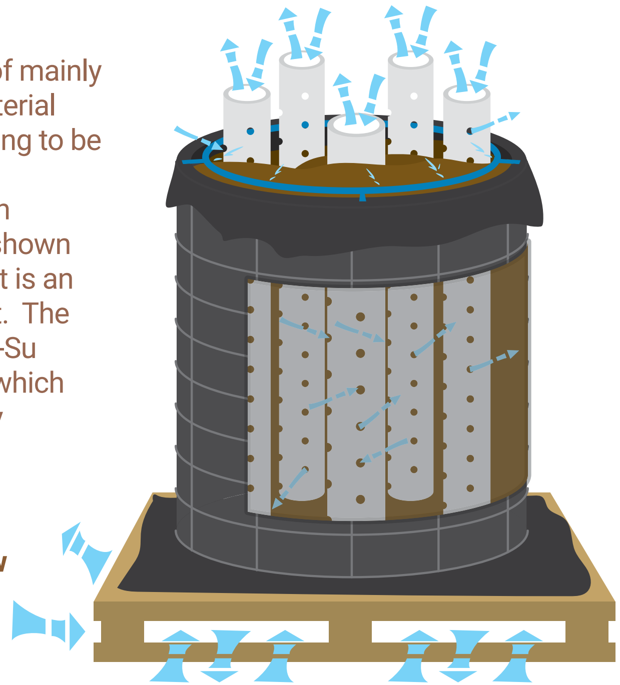

Alternatively, we can select compost materials based on their C/N ratios on purpose to produce compost with higher bacteria or fungi content according to our need. The method allows the beneficial aerobic microorganisms to multiply rapidly in a manageable environment and generate a lot of heat, thus raising the pile temperature. When the temperature reaches 57°C or above, the weed seeds and the mostly anaerobic pathogenic microorganisms in the compost materials cannot survive. At the same time, the pile temperature should be kept under 70°C, to avoid carbonisation of the compost materials under high temperature, affecting the compost quality. After all the compost materials have been digested, there is no more food to let the microorganisms multiply. Pile temperature stops rising and returns to the ambient level. The mature compost contains no weed seeds and pathogenic microorganisms. This is known as thermal composting, which will also be the method adopted in this Programme. The size of a thermal compost pile should be at least one cubic meter, as the core of a smaller pile will lose heat too fast, thus forbidding the temperature from reaching a threshold of killing weed seeds and pathogens.




Furthermore, some people use specific species of earthworms to compost organic refuse, which is called worm composting. The preferred worms feed on domestic refuse, coffee dregs, dry leaves, paper, etc. As earthworms cannot stand high temperature, avoid adding too much green materials or nitrogen-rich materials, otherwise the microorganisms may multiply too rapidly thus generating too much heat. Because of the body structure and biochemical functions of the earthworms, worm castings excreted are microorganism and organic matter enriched. Hence, vermicompost is an excellent soil conditioner.

Dr David Johnson, an American molecular biologist and research scientist, has designed a bioreactor capable of composting substrates of mainly carbon-rich dry plant material aerobically without needing to be turned, producing fungal dominate compost rich in humus. Practices have shown that the compost product is an efficient soil amendment. The device is called Johnson-Su Composting Bioreactor, which has become more widely adopted in recent years.

**Johnson-Su Composting Bioreactor**





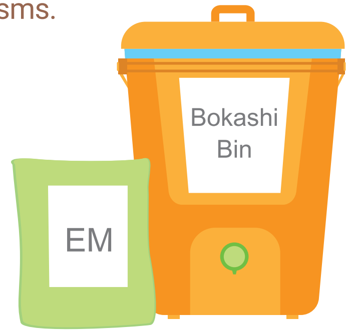

# Fermenting domestic refuse into Bokashi

For all organisms, certain gases are vital for maintaining their living state. The gas required by most terrestrial animals, e.g. human and animals in general, is oxygen. But the concentration of oxygen that different organisms require or can tolerate is different. Too little or too much can both threaten their lives.

Different species of microorganisms have different requirements for oxygen concentration. For the ease of discussions in agriculture, soil microorganisms can be grouped into four categories:

1. **Obligate Aerobes** 〉 can only grow in abundant supply of oxygen
2. **Facultative Anaerobes** 〉 can grow in both aerobic and anaerobic conditions, but thrive in the presence of oxygen
3. **Aerotolerant Anaerobes** 〉 can grow in both aerobic and anaerobic conditions, but do not use oxygen
4. **Obligate Anaerobes** 〉 can only grow without oxygen

Recent studies show that the soil microorganisms beneficial to healthy plant growth are mainly facultative or aerotolerant. Some decades ago, Prof Teruo Higa, a Japanese scientist, successfully developed a compound microbial fertiliser called Effective Microorganisms (EM), comprising mainly Bacillus, photosynthetic bacteria, lactic acid bacteria, yeast, Actinobacteria, etc., where Bacillus, lactic acid bacteria and yeast are all facultative organisms. This development has promoted the use of microorganisms in agriculture. Bokashi, produced by anaerobic fermentation using EM and shredded dry plant materials, are well received by organic farming communities. Besides applying directly to the soil, Bokashi can also be used as a substrate of thermal composting.



# How to tell if a compost is good or not?

Good mature compost contains plenty of microorganisms, as well as organic matter including fulvic acid and humic acid, and will provide a suitable habitat for microorganisms once applied to soil.  Therefore, the quality of compost is determined by the diversity and population of its microorganisms, and its organic matter content.

Generally speaking, we can look out for the following properties of compost:

**Colour** — dark brown, like the colour of 70% dark chocolate, indicating that it is rich in organic matter and has not been carbonised.

**Appearance** — the raw materials for composting are beyond recognition, indicating that the compost is mature.

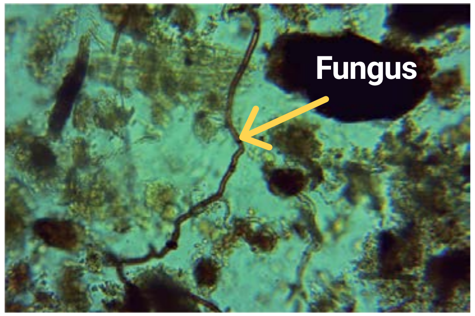
**Temperature** — has risen to >55ºC for several days before returning to ambient temperature, indicating that the compost is mature.

**Moisture** — take a handful of compost and squeeze.  It should react like a wet sponge staying compressed where a film of water can be felt between the fingers but releases no water droplets, indicating the moisture content is about 50-60%.  Water is essential for the survival of microorganisms.  If the compost is too dry, the microorganisms will become dormant or die.

**Smell** — a pleasant earthy smell like the forest floor; stinky smell indicates that the compost has not been properly managed.

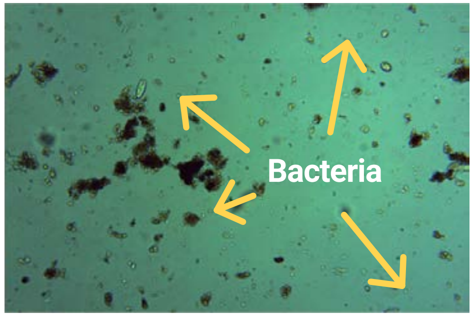


However, whether the microorganisms in the compost are good or bad, plentiful or scanty, is hard to be determined simply by senses.  Examination and observation using microscope or using meters that can measure the amount of compost microorganisms directly are necessary.



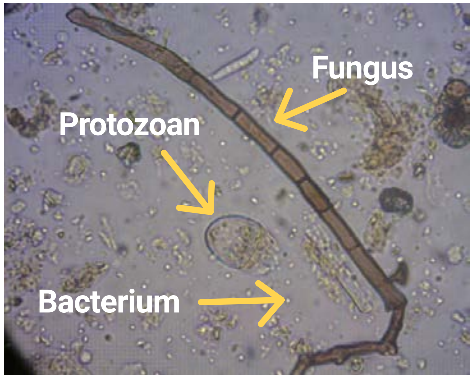

The brownish thread at the centre of this microscopic image of a compost sample is a fungal hypha.

(Photo source: https://www.wiggleroom.org/microscopy.html)




Large numbers of bacteria are seen in this microscopic image of a compost sample.

(Photo source: https://wiggleroom.org/microscopy.html)




A variety of microorganisms as well as plenty of bacteria are seen in this microscopic image of a compost sample.

(Photo source: https://thermalcomposting.wordpress.com/workshops/)

# How to apply mature compost?

Substrate amendment | Brewing compost tea | Seedling cultivation

## 1. Substrate amendment

Farmland soil – Soil fertility comes from the beneficial microorganisms and the organic matter, which will be returned back to the soil through applying compost. Since all plants will establish symbiotic relationships with microorganisms, returning microorganisms to the soil through applying compost will facilitate re-establishing the symbiotic relationships, allowing plants to exude nutrients to feed the microorganisms, which in return make nutrients available to the plants. Organic matter provides nutrients and improve the soil structure.

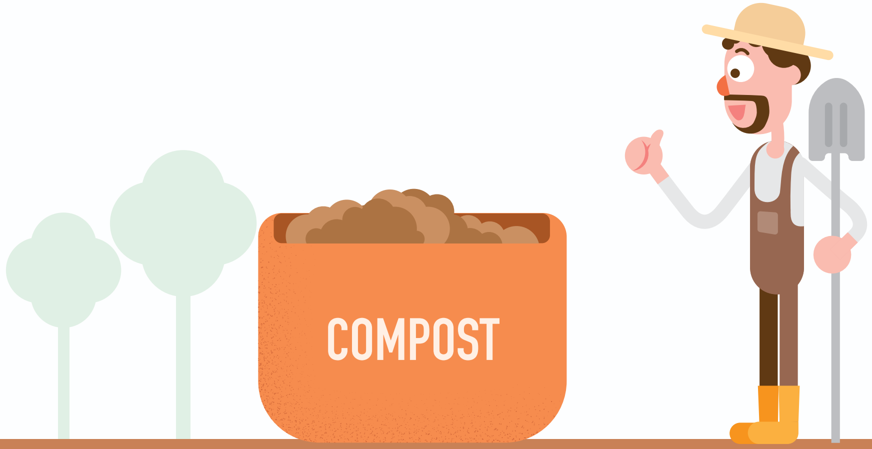
**Method for reference:**

Before transplanting, spread 2-8 cm of compost over the soil and mix it slightly with the topsoil. Start transplanting right afterwards so that the plants can feed the microorganisms in the compost promptly with food produced through photosynthesis and exuded from the roots. The soil surface should always be covered with green plants or mulch, providing an optimal habitat for the soil microorganisms.

Non-farmland substrates – non-farmland substrates are usually a mixture of peat, perlite, vermiculite, etc., containing no microorganisms. Adding composts to the substrates can increase the organic matter and introduce microorganisms into the substrates for establishing symbiotic relationship and providing service to the plants.

**Method for reference:**

Mix 1 part of compost and 2-5 parts of substrates.



## 2. Brewing compost tea

Consider brewing compost extract or compost tea if the supply of compost is limited.

**Method for reference:**

**Brewing compost extract:**

Place compost in a fine mesh bag and then have it suspended inside a custom-made vessel filled with water. Flush the bag with a powerful air pump to bring out the microorganisms. The liquid rich in microorganisms can be sprayed on the surface of soil and leaves. As no food is added, the compost extract so brewed does not have a high density of microorganisms and is available to be used for a few days.

**Brewing compost tea:**

Place compost in a fine mesh bag and then have it suspended inside a custom-made vessel filled with water. Add in food suitable for the microorganisms and aerate the vessel with a powerful air pump to provide suitable conditions, allowing the microorganisms to multiply rapidly with adequate supply of water, oxygen and food for about 24-26 hours. The resulting liquid can be sprayed on the surface of soil and leaves. As food is added, the compost tea so brewed has a very high density of microorganisms and should be used within 2 hours. Otherwise, the microorganisms in the compost tea will have not enough oxygen supply and die, or anaerobic pathogens will develop.



## 3. Seedling cultivation

The purpose of using composts in seedling cultivation is to let the seeds or seedlings establish symbiotic relationship with the microorganisms from an early stage, laying a solid foundation for the healthy growth of the plants.

**Method for reference:**

Mix 1 part of compost and 2-5 parts of seeding soil for use as substrates.

Alternatively, soak the seeds or roots of the seedlings briefly in the compost extract or compost tea before sowing or transplanting.

# What are the other benefits of turning organic refuse into compost?

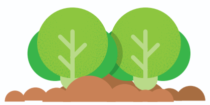
Besides for applying to farmlands to make the soil and plants healthier, turning organic refuse into compost has the following benefits as well:

**Benefits to the environment:**
All cities in the world are facing waste management problems. According to the statistics of the Environmental Protection Department, among the 11,428 tonnes of average daily municipal solid wastes disposed at Hong Kong's landfills in 2018, about 3,600 tonnes (31%) were domestic refuse, 2,700 tonnes (24%) waste paper, and 340 tonnes (3%) yard wastes, accounting for over half (58%) of all the municipal solid wastes dumped. If treated by composting, organic refuse will not be disposed at landfills, reducing the land required for waste treatment and the greenhouse gas emission, as methane will be emitted by the rotting of organic refuse in the landfills.

**Benefits to the farmers:**
Increase in soil fertility and yield, while decrease in pests, thus reducing the use of fertilisers and pesticides. In the long run, increase in income, and decrease in material input and production costs.

**Benefits to human health:**
Human health will be promoted if farmers can produce more nutritious crops and reduce greenhouse gas emission to the atmosphere through applying compost.


Promote human health


Healthy soil and plants


Increase in farmers' income


Reduce land required for waste treatment


Reduce greenhouse gas emission



# Experience sharing on composting by local farmers

# Mr Chan & Mrs Eva Chan

Mr Chan and his wife Eva have been farming in Kai Leng, Sheung Shui for about five years, producing organic vegetables and fruits for local sale. They used to practice natural composting by simply piling the farm wastes and weeds collected in an unused corner of the farm. The compost materials were rather homogeneous and the temperature and humidity of the pile were neither measured nor monitored. They found that the efficacy of the compost produced was just average. Then they learnt about thermal composting under a controlled environment in a composting seminar a year ago. They put it into practice right afterwards, using more diverse compost materials besides farm wastes and weeds, such as dry twigs and leaves, domestic refuse, spent mushroom substrates, etc. They have constructed several composting piles of about 1 cubic meter each with discarded wooden pallets. Compost thermometer is used to take the pile temperature daily, to ensure that the pile temperature has reached 57°C, killing the pathogenic microorganisms and weed seeds. The piles are turned before the temperature reaching 70°C to avoid carbonisation of the compost materials under high temperature.

One of the thermal compost piles prepared by Mr Chan and Mrs Eva Chan

They maintain about 7-8 piles in their farm. Mature compost is applied to surface of the soil with crops, and then covered with dry leave mulch. Since individual piles are prepared on different dates, there is a constant supply of mature compost.



Having accumulated one year of experience, they are very satisfied with the benefits of thermal composting, including:

String beans harvested at the same time.


Leaves of asparagus lettuce harvested at the same time


"The crops are growing more healthily than before, and more resistant to pests and diseases! The colour, fragrance and taste of the crops have all improved. Only compost is used as soil amendment and no need to apply fertilisers anymore."

Compost is applied to surface of the soil and then covered with dry leave mulch in Eva's cucumber field.

Mr Chan is intrigued by the impressive results brought about by composting. Taking charge of composting of the farm, he is planning to expand the scale gradually. His wife Eva will continue focusing on the planting and sales of crops.

# Q & A for composting

## 1 Is compost a fertiliser?

Compost contains the nutrients that plants need. The higher diversity the compost materials used, the more nutritious the compost is. Besides providing fertilisers to the plants, the compost returns the rich microorganisms and organic matter inside back into the soil, enabling the microorganisms to multiply and grow healthily, and continue providing services to the plants. When the symbiotic relationship between microorganisms and plants are re-established, the microorganisms will naturally provide diverse and balanced nutrients to plants.

## 2 What to do if the temperature of the compost pile does not rise or the compost materials do not decompose after a long time?

Check the following if the temperature of the compost pile does not rise or the compost materials do not decompose after a long time:

- Whether the size of the pile is at least 1 cubic meter. If the compost pile is too small, the heat generated by the microorganisms inside during the pile decomposition will be lost quickly, resulting in no or little rise in temperature.
- The rise in pile temperature is mainly due to the decomposition of green materials and nitrogen-rich materials by bacteria. If the pile has too much brown materials but inadequate green materials and nitrogen-rich materials, the bacteria will not have sufficient food to sustain their multiplying, resulting in no or little rise in temperature.
- Microorganisms need water to survive. If the moisture content is too low, the microorganisms will become dormant or die, instead of multiplying. Check whether the compost materials are too dry. The optimal moisture content is about 50-60% (take a handful of the compost materials and squeeze, a film of water can be felt between the fingers but release no water droplets.)



## 3 What if the compost pile stinks?

Properly managed composting should not stink, but have a pleasant earthy smell. Stinky smell in general indicates that the pile is too wet. Alternatively, the compost materials may have so much green or nitrogen-rich materials that the bacteria decomposing these materials multiply too rapidly, thus depleting the oxygen and creating an anaerobic environment inside the pile. Most anaerobes generate stinky smell when decompose the compost materials. To rectify the situation, reduce the water content and increase the C/N ratio of the stinky pile by blending in an appropriate amount of brown materials like dry leaves.

## 4 What if the compost pile attracts flies?

If the pile has decaying food exposed, flies will be easily attracted. Domestic refuse and food containing sugars should be placed deep inside the pile and separated. Cover the top of the pile with a layer of brown materials to avoid exposure.

## 5 What if the compost pile attracts rats?

Rats may feed and nest in the pile. Placing domestic refuse deep inside the pile should mitigate this problem.

## 6 What if the compost has insects?

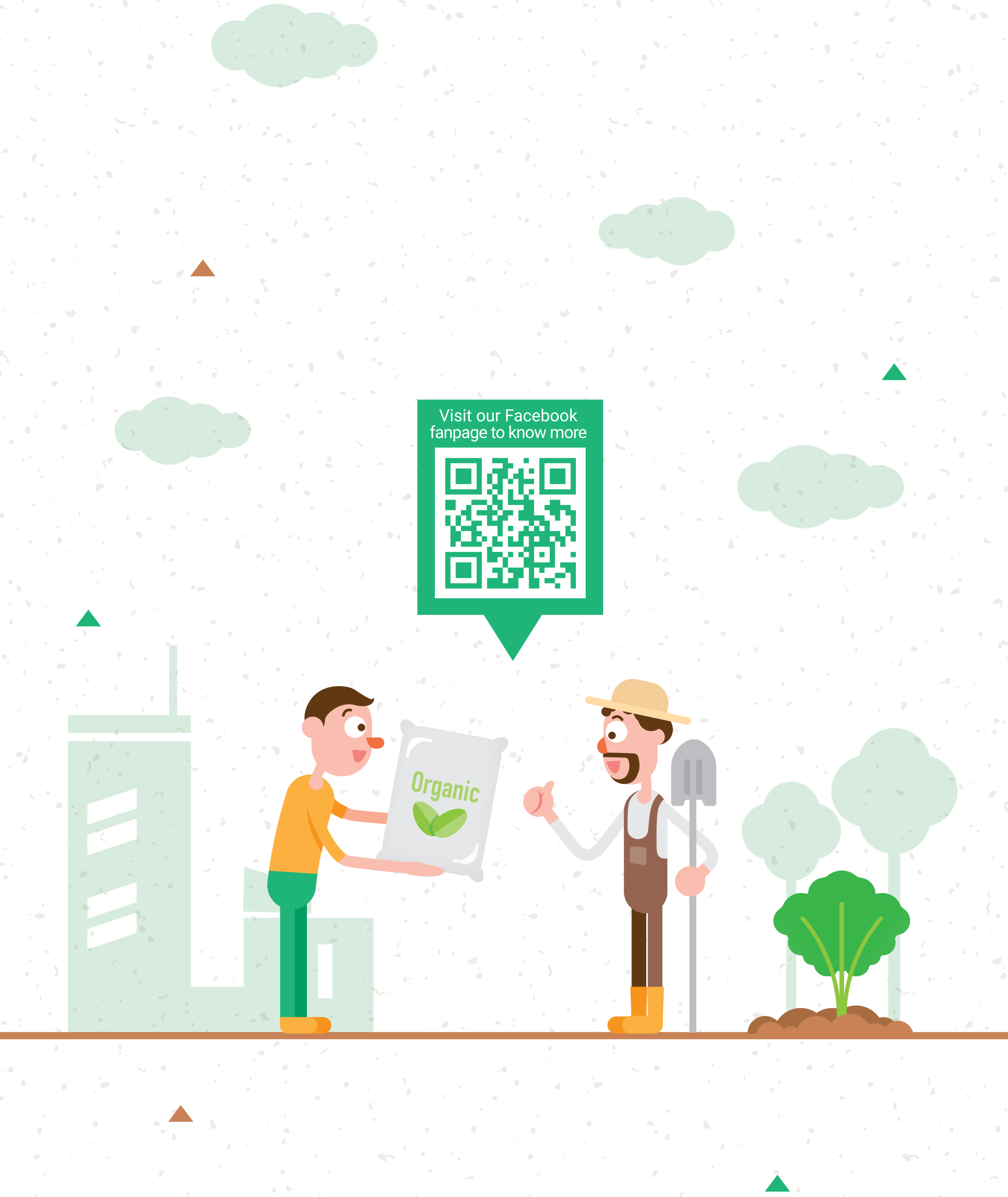
Good compost has various organismal communities at different trophic levels. Besides those invisible microorganisms such as bacteria, fungi, protozoa, nematodes, etc., there are also visible organisms like worms. Some of them can facilitate the decomposition of compost materials. Since the organisms in each of the trophic levels have different nutrient requirements, their predatory relationships allow various nutrients in the compost materials to be recycled. Hence, it is normal to find insects in compost .

## 7 What if the compost has some white threads?

The white threads in the compost are actinobacteria or hyphae of fungi. Both are microorganisms commonly found in compost. They secrete enzymes to digest the complex organic matters such as cellulose and lignin, thus facilitating decomposition of the compost materials. It is normal to find them in compost. 。

## 8 Is compost still good after a long period of storage?

Well prepared mature compost is rich in active beneficial microorganisms, which need air, water, nutrients and suitable habitats. When compost is stored for too long, the water inside will gradually evaporate and the food for the microorganisms will be slowly consumed. Hence, the microorganisms will become dormant or even die. The quality of the compose will deteriorate as the vitality and quantity of the microorganisms inside decrease. Therefore, the compost should best be used within 6 months after composting completes.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