The Science of Composting

While our ancestors realized that compost was helpful for growing plants and food resources and also for improving soil health, they did not know how or why it worked. Our knowledge about the science of composting comes from research conducted over the past 50 years as compared to the 2,000 plus years that we humans have been composting.

In the natural process of aerobic decomposition, the work is performed by numerous healthy decomposer organisms.

So where do these decomposer organisms come from?

A **microorganism** or **microbe** is a microscopic organism, which may be single-celled or multicellular. Microorganisms are very diverse and include all bacteria, archaea and most protozoa. This group also contains some fungi, algae, and some micro-animals such as rotifers. Microorganisms live in every part of the biosphere, including soil, hot springs, the deepest parts of the ocean, high in the atmosphere, and inside rocks. Microorganisms, under certain test conditions, have been observed to thrive in the vacuum of outer space. Microorganisms likely far outweigh all other living things combined. In 2014, scientists confirmed the existence of microorganisms living 800 m below the ice of Antarctica. According to one researcher, "You can find microbes everywhere — they're extremely adaptable to conditions, and survive wherever they are."

Microorganisms are crucial to nutrient recycling in ecosystems as they act as decomposers. As some microorganisms can fix nitrogen, they are a vital part of the nitrogen cycle, and recent studies indicate that airborne microorganisms may play a role in precipitation and weather. Microorganisms are also exploited in biotechnology, both in traditional food and beverage preparation, and in modern technologies based on genetic engineering. A small proportion of microorganisms are pathogenic, causing disease and even death in plants and animals.

Microorganisms in Composting

Microorganisms such as bacteria, fungi and Actinomycetes account for most of the decomposition that takes place in a healthy aerobic composting effort. They are considered as being chemical decomposers because they change the chemistry of organic materials. The larger decomposers or macroorganisms, include mites, centipedes, sow bugs, snails, millipedes, springtails, spiders, slugs, beetles, ants, flies, nematodes, flatworms, rotifers and worms. They are considered physical decomposers because they grind, bite, suck, tear and chew materials into smaller pieces.

Of all of these organisms, aerobic bacteria are the most important decomposers. They are very abundant; there may be millions in a gram of soil or decaying organic matter. You would need 25,000 of them laid end to end to make an inch (24.5mm). They are most nutritionally diverse of all organisms and can eat nearly anything. They are also the preferred organisms, because they provide the most rapid and effective composting. Bacteria utilize carbon as a source of energy (to keep on eating) and nitrogen to build protein in their bodies (so that they can grow and reproduce). They obtain energy by oxidizing organic materials, especially the carbon fraction. This oxidation process heats up the biomass (the composting materials) from ambient air temperatures. If proper conditions are present, the biomass will heat up rapidly due to the bacteria that are present consuming and decomposing readily decomposable materials.

While bacteria can eat a wide variety of organic materials, they have difficulty escaping unfavourable environments due to their size and lack of complexity. Changes in oxygen, moisture, temperature and acidity can be lethal to the bacteria or they become inactive. Aerobic bacteria need oxygen levels greater than 5% (we humans require +19%). They also excrete plant nutrients such as nitrogen, phosphorous and magnesium. When oxygen levels fall below 5%, the healthy bacteria die and decomposition slows by as much as 90% and anaerobic microorganisms take over and in the on-going process, produce a lot of useless organic acids and amines (ammonia-like substances) which are unpleasantly smelly and in some cases are toxic to plants. Methane is a sinister bi-product of an anaerobic breakdown and is 30 times more harmful to the atmosphere, as a heat trapping gas, than is $C0_2$.

There are different types of aerobic bacteria – and their populations will vary according to the biomass temperature. **Psychrophillic** bacteria work in the lowest temperature range. They are most active at 13C and upto 21C. They give off a small amount heat in comparison to other types of bacteria, yet the heat they produce is sufficient to activate another set of bacteria, **Mesophillic** bacteria who will take over. Their working temperature range is generally between 21-38C. When the temperature rises to above 38C the Mesophillic bacteria begin to die off or move to cooler regions within the biomass. They are then replaced by heat-loving **Thermophilic** bacteria. Thermophilic bacteria thrive at temperatures ranging from 45-71C and this bacteria continues the decomposition process, raising the temperature range to 54-71C, where it generally stabilizes. These high temperatures normally only last for 3 to 5 days. As the temperature then cools the Mesophillic bacteria again become more dominant. The Mesophillic bacteria then consume any remaining organic materials with the help of other organisms. The drop in temperature is not a sign that composting is complete, but rather an indication that the process is entering another phase. While high temperatures have the advantage of killing pathogenic organisms and weed seeds, they are not essential to a healthy aerobic decomposition. (Note – operating temperatures of the Aerobin Home Composter have been recorded up to 75C).

While the various types of bacteria are at work, other microorganisms are also contributing to the degradation process. **Actinomycetes**, a higher-form bacteria similar to fungi and molds, are responsible for the pleasant sweet earthy smell of aerobic compost.

Key factors affecting the Composting Process

There are certain key environmental factors which affect the speed of composting. The organisms are a living thing (not unlike we humans) – so they require food (carbon & nitrogen), air and water. When provided with the correct balance, they will produce compost quickly. Other factors also influence the speed of composting – surface area or particle size (big = slow & small = faster) and temperature retention within the biomass.

Food Factor

Organic materials provide food for organisms in the form of carbon & nitrogen. Bacteria use carbon for energy and protein to grow and reproduce. Carbon & nitrogen levels vary with each organic material. Carbon-rich materials tend to be dry & brown such as dried leaves, straw and wood chips. Nitrogen materials tend to be wet & green, such as fresh grass and food scraps (fruit & vegetables). (Note - the carbon/nitrogen content of various materials is provided in the Aerobin Compost Simulator on the Aerobin website.) A C:N ratio ranging between 25:1 and 40:1 is the optimum combination for rapid decomposition.

Air Factor

Proper aeration is a key environmental factor in the composting process. Most microorganisms need oxygen to produce energy, grow quickly and consume more materials – in effect to survive and thrive. Aeration involves the replacement of oxygen deficient air within the biomass with fresh air containing oxygen. Natural aeration occurs when warm or hot air rises thru the biomass and draws fresh air into the biomass (a chimney effect). As the composting process progresses the porosity of the biomass reduces and so the air passage thru the biomass closes up. In addition air circulation can be impeded if the biomass materials become water saturated. Normally the aerating of the biomass is only possible with manual intervention – turning the biomass over. (Note – in the case of the Aerobin this is avoided with the patented aeration lung).

Moisture Factor

Decomposing organisms need water to live. Microbial activity occurs most rapidly in thin water films on the surface of organic materials. Microorganisms can only utilize organic molecules that are dissolved in water. The optimum moisture content should range from 45 to 65%. If there is less than 45% moisture, the bacteria can slow down and may become dormant. If there is more than 65%, water will either force air out of the biomass or restrict the flow of air through the biomass, both potentially suffocating the aerobic bacteria. Anaerobic bacteria will then take over. Since its difficult to measure moisture, as a rule of thumb, the biomass should be about as moist as a wrung-out kitchen sponge. Water can always be added if the biomass is too dry.

Temperature Factor

In most Home Composting devices the outside air temperature can impact the decomposition process. Warmer outside (ambient) temperatures in late Spring, Summer and early Autumn (Fall) stimulate the bacteria and speed of decomposition. Low Winter temperatures will slow or stop the composting process – which will resume as temperatures again seasonally rise. (Refer Aerobin Refrigerated Shipping Container trial).

Particle Size Factor

Particle size of the Carbon/Nitrogen materials affects the rate of organic material breakdown. Microorganisms are able to digest more, generate more heat and multiple faster with smaller pieces of material. So the smaller the particle size then the greater the surface area that is exposed to the microorganisms which also then provides for more organisms. That's why a whole Pumpkin chopped into small particles will decompose quicker than the same Pumpkin being composted 'whole'. Never 'powder' materials – this will only compact and impede air circulation – chop, shred, split, bruise or puncture to increase surface area by reducing the particle size. An easy way to shed leaves (either 'Green' or 'Brown') is to mow them along with the lawn and they are collected at the same time in the Lawn Movers Catcher.

Volume Factor

Volume is key to retaining heat within the biomass and decomposing material. So if the biomass is reducing by volume quickly (suggesting that a healthy aerobic decomposition is at work) then keep adding fresh new materials. The rule of thumb is more is better!

So what should you retain from all of the 'The Science of Composting'?

- ❖ Healthy aerobic composting isn't an accident of nature – there are specific parameters that must exist to support the process
- ❖ Healthy aerobic composting is good for the environment
- ❖ The engine room of a healthy aerobic composting process is the healthy microbes
- ❖ These microbes require food, air & water (moisture) – deprive them of any one of these and they will perish and the process will change from a healthy aerobic decomposition to a unhealthy anaerobic decomposition
- ❖ The hotter the biomass, the quicker the decomposition and other benefits are obtained – pathogens are neutralized and weed seeds destroyed
- ❖ And perhaps the most important message that we draw from this is – Aerobin simply provides an environment where by healthy aerobic composting can flourish and in many climates year round.

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