

## Chapter Eight

### Compost

*Please don't let me be misunderstood...*

Compost, like agriculture, is a human creation. You will not find it in nature any more than you will find a corn field, unless humans created it. You will not find an ant-hill in nature, either, unless ants created it. Ants create ant-hills, humans create compost.

Compost is made from organic materials that originated from plants and animals. Humans place the organic material into piles, where natural, ever-present microbes consume them (remember the thermophiles, Mother Nature's housekeepers?). In the process the microbes convert the organic materials into what some people call "humus," others call "earth," and others even call "soil," but it is correctly referred to as "compost." The microbial process that converts the organic material into compost generates internal biological heat, heat generated by the microbes themselves, microbes that live in the presence of oxygen and are therefore termed *aerobic*.

So there you have it: Compost, by definition, has three components: (1) humans make it or *manage* it, (2) the process generates *internal biological* heat, and (3) the organisms that proliferate in the compost do so in the presence of *oxygen*. If these three conditions are not met, then it's not composting, and the end product shouldn't be called compost.

In 2018, the US Composting Council (USCC) defined compost as *the product manufactured through the controlled aerobic, biological decomposition of biodegradable materials. The product has undergone mesophilic and thermophilic temperatures, which significantly reduces the viability of pathogens and weed seeds and stabilizes the carbon such that it is beneficial to plant growth.*

The Association of American Plant Food Control Officials (AAPFCO) approved the new definition for compost because it emphasized the pathogen-removing thermophilic process, differentiating it from many products often confused with compost. *This more completely defines what our products are so that people out there wanting to call their products compost cannot do that without meeting this definition,* said Ron Alexander, the USCC's liaison to AAPFCO, who had labored for years on the updated definition.<sup>1</sup>

A lot of people call a lot of things compost, incorrectly, and it's hurting the composting industry. *We don't want to have the compost industry's product being confused with other products after all the work we've invested in best practices and quality product standards,* said Alexander. The new definition helps the producers of other products, from biochar to mulch to dehydrated food, worm castings, and anaerobic digestate, to more clearly differentiate their products as not being compost. For example, “vermicompost” is a misnomer. The correct term is “vermiculture.” The end product of vermiculture is not compost; it's worm castings. Vermiculture is not dominated by aerobic microorganisms generating biological heat. It's dominated by red worms. Thermophilic microorganisms would kill those worms. The final product is not the same as compost, and it should not be called compost. Nor should a lot of other things that are referred to as compost.

For example, “composting toilets” are not composting toilets. Composting does not take place inside toilets unless internal biological heat is being generated, which is highly unlikely for reasons we will discuss later. What people call “composting toilets” would correctly be referred to as “dry toilets,” or “biological toilets.” But we'll get into this discussion in greater detail in a separate chapter.

The 2018 compost definition is important because the composting industry has worked hard to train and educate people about natural processes that use microbes to reduce or eliminate human pathogens. This is particularly relevant to the recycling of humanure.

We can't blame anyone for incorrectly referring to any rotting vegetation or any brown decayed or dehydrated organic material as "compost." Composting is a young science, and few people in the general public know much about it. With the tidal wave of misinformation that can be found on the internet and everywhere else, it's no wonder there is so much misunderstanding.

The term "compost" is found in literature dating back to at least 1600. Shakespeare no less, is attributed to using the word in Hamlet: Act 3, Scene 4: "*Confess yourself to heaven;/Repent what's past; avoid what is to come;/And do not spread the compost on the weeds;/To make them ranker.*" Back in 1600 Leeuwenhoek hadn't even been born and microorganisms were still a thing of the future. They also didn't have compost thermometers and no way to determine the temperatures of compost piles, if there were any elevated temperatures at all.

Apparently, any pile of rotted organic material was once referred to as "compost." For example, an agricultural guide from 1831 advised, "If you have not had time to root out all the weeds on your premises, you will at least endeavor to prevent their going to seed by cutting off the tops with a scythe or sickle, and it will be good economy to lodge the proceeds of your puttings in your barn, barn yard, or compost bed." They add, "The proper soil for bulbs, in general, is a light rich soil, mixed with a considerable portion of fine sea sand; and the compost generally used, is one third fine sand, one sixth rich loam, one third cow dung and one sixth leaves of trees."<sup>2</sup>

A materia medica published in 1834 recommends using a "*compost of dung, ashes, and nitrous earth*" when growing poppies for opium.<sup>3</sup> Likewise, an 1851 book yielded poetic advice for growing tobacco: *With rich manure first saturate your land, Or better, mix the compost well with sand; Then with this mixture cover o'er your field, And for your care, it bounteous crops will yield.*<sup>4</sup>

Although “compost” was obviously something people used in the nineteenth century for gardening, horticulture, and agriculture to their benefit, it was also something looked down upon in urban areas, as this 1865 report from the Detroit Board of Health reveals: *This committee have learned from the sanitary inspectors of wards, and from their own observations, that there are in many parts of the city alleys filled with decaying compost and human ordure, and alleys and gutters covered with stagnant water...*<sup>5</sup> In 1885 compost heaps were likewise seen as a public health nuisance: *Most important part of the work of defense from disease...all decaying and germinating vegetables should be removed therefrom with all accumulations of rubbish of every kind, and the whole should be destroyed by burning, or removed to the compost heap to be carted away.*

It seems that “compost” had developed a dual personality, a Jekyll and Hyde reputation; sometimes good, sometimes bad, depending on whom you ask. Any pile of garbage, manure, and wood ashes could be considered compost. And it didn’t need to be a pile; it could be a “pit.” In 1911, in his book *Farmers of Forty Centuries*, Professor F. H. King describes “compost pits” in China as being sunken depressions filled with vegetable matter, ashes, and soil, covered with mud or water, *the aim being to have the fiber of all organic material completely broken down, the result being a product of the consistency of mortar.* Wet mortar. This “compost” is then spread on the ground to dry.<sup>6</sup> The word “fermentation,” like “compost,” was used loosely back then, as the contents of a compost pile were considered to be fermenting. Yet fermentation, in biochemistry, is defined as the extraction of energy from carbohydrates in the *absence* of oxygen,<sup>7</sup> whereas composting is an aerobic process in the *presence* of oxygen. Saturated, submerged, anaerobic processes do not produce what we would call compost today.

This distinction is important — the conversion of organic material by microorganisms through the composting process is nothing short of magical. Consider humanure and all those nasty pathogens that may reside in the excretions of infected persons. Composting the humanure will eliminate those disease organisms, or at least reduce them to non-detectable levels. Anaerobic processes can’t make this claim, as pointed

out in the discussion of wastewater treatment systems earlier.

Compost, nevertheless, is getting a bad rap from people calling stuff “compost” when it isn’t. For example, National Geographic published an article in 2016 that stated, *Chinese farmers regularly fertilized their rice paddies with anaerobic (lacking oxygen) composting techniques.*<sup>8</sup> But there aren’t any anaerobic composting techniques. If it’s anaerobic, it’s not composting. A 2011 research study stated, “Compost latrines do not reach temperatures sufficient to destroy all pathogens,” and “Pathogens, mainly helminths, were still present in compost stored for the 6-month contact time.” But these latrines weren’t composting, and they shouldn’t be called compost latrines — they were not producing compost. The same study also concluded, “The majority of composting latrines in developing countries do not reach high enough temperatures for complete pathogen destruction.”<sup>9</sup> That’s because they’re not *composting* latrines, they’re *dry toilets*, a subject that we will revisit later. The words “compost” and “composting” are being used incorrectly.

Having served on the editorial board of the industry journal *Compost Science and Utilization*, and having reviewed research papers related to “composting” and “composting toilets,” I know that there’s a deep misunderstanding about what composting is, not just among the general public, but also among general academia. When PhD candidates or post-doctoral researchers report that their “compost” did not eliminate pathogenic organisms, when in fact they weren’t composting and didn’t have compost at all, then it hurts the composting industry. These are not isolated incidents; this is a widespread problem.

Part of our misunderstanding about compost can be traced back to the roots of compost science. F. H. King’s *Farmers of Forty Centuries* went into detail about Chinese “compost” systems. King shows photos of shallow pools of water, which he refers to as “compost pits.” “*In the preparation of composts, pits are dug, as seen in the illustration, and into them are thrown coarse manure and any roughage in the form of stubble or other refuse which may be available, these materials being saturated with the soft mud dipped from the bottom of the reservoir.*”<sup>10</sup>

King described a Chinese “compost house” constructed for the

purpose of making compost. In preparing the “compost,” *materials are brought daily and spread over one side of the compost floor until the pile has attained a height of five feet. After one foot in depth has been laid and firmed, 1.2 inches of soil or mud is spread over the surface and the process repeated until full height has been attained. Water is added sufficient to keep the whole saturated and to maintain the temperature below that of the body. After a number of weeks, the “compost stacks” are forked over and transferred to the opposite side of the house.*<sup>11</sup>

King further described another “compost” pit: “In it had been placed all the manure and [organic material] of the household and street, all stubble and [organic] roughage from the field, all ashes not to be directly applied” [to the soil], as well as some soil. “Sufficient water was added at intervals to keep the contents completely saturated and nearly submerged. . . .”<sup>12</sup>

Clearly what King was describing was not what we would refer to as *compost* today. Submerging organic material in water or mud creates anaerobic conditions in which temperatures are not likely to rise above the temperature of the human body. Remember that compost bacteria are aerobic and will not multiply in an anaerobic environment. Nevertheless, King’s writing was influential in its day.

Much of compost's current popularity in the West can be attributed to the work of Sir Albert Howard, who wrote *An Agricultural Testament* in 1943 and several other works on aspects of what has now become known as organic agriculture. Howard's discussions of composting techniques focus on the Indore process of composting, a process developed in Indore, India, between the years of 1924 and 1931, just fourteen years after King had published his book. Howard described the Indore process as “a simple development of the Chinese system.”<sup>13</sup>

Howard was impressed with Chinese agriculture. He stated, *The Chinese peasant has hit on a way of supplying his fields with humus by the device of making compost. Compost is the name given to the result of any system of mixing and decaying natural [organic material] in a heap or pit so as to obtain a product resembling what the forest makes on its floor . . .*<sup>14</sup> Any system of decaying organic material produced “compost,” according

to Howard. Today, we differentiate between aerobic systems such as composting, and anaerobic systems since the outputs are entirely different.

The Indore process was first described in detail in Howard's 1931 work, co-authored with Y. D. Wad, *The Waste Products of Agriculture*, in which the authors state, "The Indore process utilizes all the products of agriculture and produces an essential manure." They add that any successful system of manufacturing compost must also fulfill the following conditions: minimal labor, a suitable carbon-nitrogen ratio, an aerobic process with adequate water, no nitrogen loss, a mature end product, microbial stimulation of soil to which the compost is added, and a clean and sanitary process overall.<sup>15</sup> Modern composters would certainly agree with all of this.

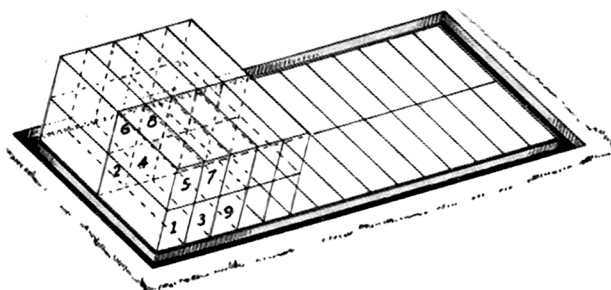
Indore process composting was also done in "pits." According to Howard, "*A convenient size for a compost pit is 30 ft. by 14 ft. and 2 ft. deep with sloping sides. The depth of the pit is most important on account of the aeration factor. It should never exceed 24 inches.*" The pits are filled with a mixture of dung, "urine earth," wood ashes, fungus and bacterial inoculants, vegetable residues, and animal bedding.<sup>16</sup> "*The urine earth and wood ashes are as essential in the manufacture of compost as the plant residues themselves.*"<sup>17</sup> Today we know that neither earth nor wood ashes are required in compost.

According to various accounts of life in the nineteenth century in America, shallow farmyard pits were used as a place for dumping organic garbage, wood ashes, and other household and farmyard residues. Perhaps these provided a place for pigs to wallow and browse, the depression providing a means of containing the material, so it wasn't spread all over the place, as well as a means of collecting water and mud for the pigs to enjoy. Adapting this system to an organics recycling process would make sense, as open piles of garbage would be fly infested and smell badly, at least until the pigs trampled the organic material into the mud where it could anaerobically decay.

Once the materials are deposited in the pit, according to Howard, "*The fermenting mass is now ready for the development of an active fungus*

## HOW TO MAKE "COMPOST" (U.S. Army, 1940)

The army appears to have been influenced by the writings of Sir Albert Howard in the 1930s, judging by the size of the pile and the rectangular, vertical stacks. There is almost nothing in these instructions that is actually relevant to making compost in the 21st century, especially spraying the pile with toxic chemicals.



A compost platform is constructed by leveling off an area of ground, 50 feet long, and 20 feet wide, digging a trench around the area 12 inches wide and 12 inches deep with vertical sides.

Construct a second trench, very shallow, not over 3 inches deep and 4 inches wide, and located just within the edge of the platform.

The manure is placed on the platform as follows: Beginning at one corner, place the manure on an area 3 1/2 ft. long and 10 ft. wide, piling it to a height of 4 to 5 feet, packing it down very tightly and dressing the sides neatly. The sides must at all times be kept vertical.

The second day's supply of manure is placed on the adjacent corner in a similar manner. On the third day, the supply of manure is placed immediately adjacent to the first pile and on the fourth day, adjacent to the second pile, and on the fifth day the supply is piled on top of the first pile.

The manure is thus placed on the platform in the succeeding small sections as shown in the diagram. This is done for the purpose of confining the fly breeding to the smallest possible area. The manure should be kept moist so as to promote decomposition.

**The sides of the pile should be sprayed daily with a mixture of cresol, kerosene and fuel oil.**

Crude oil or a light road oil is used in the trenches, the earth in the trench being kept visibly moist with oil.

**In the preparation of the platform, all vegetation should be removed for a distance of 2 feet from the edges, the earth here tamped down firmly and oiled thoroughly.**

Similarly, the earth beyond the trenches should be freed from vegetation, packed down and oiled. The trenches are to be kept clean at all times. A platform this size should care for the manure of 100 animals for two months.

Source: Essentials of Field Sanitation, Published at the Medical Field Service School Carlisle Barracks, Pennsylvania. Revised Edition 1940.



*growth (the first stage in the manufacture of compost).*”<sup>18</sup> In modern times, composting is done above ground, not in pits; the mass isn’t fermenting (anaerobic), it’s undergoing aerobic degradation; and the first stage of composting is bacterial, typically mesophilic, then thermophilic, not fungal. Making compost is far simpler than what Howard described. I can’t imagine having to dig a pit for housing a compost pile. Go outside and dig a two-foot-deep hole and you’ll soon see what I mean.

Howard admits that the pits will fill with water during heavy rains and recommends building compost “heaps” during the rainy season, *“The dimensions of the heaps should not exceed 7 ft. by 7 ft. at the top, 8 ft. by 8 ft. at the bottom, and 2 ft. in height. The dimensions of these monsoon heaps...must not be exceeded, otherwise aeration difficulties are certain to be encountered.”*<sup>19</sup> Such dimensions today don’t make any sense at all, but we’ll get into compost making in another chapter.

A watering schedule is strictly followed in the Indore process; *otherwise decay will stop*, according to Howard, and turning of the organic mass three times was needed *to ensure uniform mixture and decay, and to provide the necessary amount of water and air as well as a supply of suitable bacteria*. If flies or smells become evident, *the heap should be turned at once with the addition of dung slurry and wood ashes*. The first turn was to take place sixteen days after the pile was built, the second turn one month after the pile was built, and the third turn two months after the building of the pile. It’s no wonder that turning was recommended. Surely the bottom twenty four inches of the pile, being underground, was anaerobic and needed to be brought to the top to drain.

Three months after the pile is built, *the manure is ready, when it should be applied to the land. If kept in heaps longer than three months...nitrogen is certain to be lost.*<sup>20</sup> Again, and with all due respect, immature compost is phytotoxic (kills plants), and I have never made compost that was mature in three months, nor have I witnessed any nitrogen loss due to allowing compost to mature or “cure.” Of course, I have seen others claim their compost is ready in three months, but it probably isn’t, and I’ll explain why in another chapter.

The Indore process subsequently became embraced by agricultur-

ists — a million tons of compost were being made in tea estates in India by 1938. Eight municipal compost pits were in operation in South Africa by 1942. Someone had invented a compost turning machine that was demonstrated in England in 1944, where a hundred machines “sold on the spot.”<sup>21</sup> By the 1940s, the science, and the business, of compost was off and running!

It was once a practice in Asia to apply *raw* applications of human excrement, known as “night soil,” to agricultural fields. Although this kept the soil enriched, it also acted as a vector, or route of transmission, for disease organisms. In the words of Dr. J. W. Scharff, former chief health officer in Singapore (1940), “Though the vegetables thrive, the practice of putting human [manure] directly on the soil is dangerous to health. The heavy toll of sickness and death from various enteric diseases in China is well-known.” It is interesting to note Dr. Scharff’s suggested solution: “We have been inclined to regard the installation of a water-carried system as one of the final aims of civilization.”<sup>22</sup> The World Health Organization also discouraged the use of night soil: “Night soil is sometimes used as a fertilizer, in which case it presents great hazards by promoting the transmission of food-borne enteric [intestinal] disease, and hookworm.”<sup>23</sup>

Composting, on the other hand, creates an environment that destroys disease organisms that can exist in humanure, thereby converting human excrement into a friendly, pleasant-smelling compost safe for food gardens. Composted humanure is entirely different from both night soil and the anaerobic digestate that the Chinese were likely producing in the water-filled “compost pits.”

Perhaps it is better stated by the experts in the field: *From a survey of the literature of night soil treatment, it can be clearly concluded that the only fail-safe night soil method which will assure effective and essentially total pathogen inactivation, including the most resistant helminths [intestinal worms] such as Ascaris [roundworm] eggs and all other bacterial and viral pathogens, is heat treatment to a temperature of 55° to 60°C [131° to 140°F] for several hours.*<sup>24</sup> These experts are specifically referring to the heat of an actual compost pile.