

Growing Greens “Green”: A Product Comparison



Organic Compost vs. Synthetic Fertilizer

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The Cradle to Cradle guideline for consumer products proposes that all manufactured goods should be designed with a cyclical, rather than linear, lifetime in mind. This ideal does not come from nowhere, it is meant to mimic cycles in nature, based on the truth that with the exception the input of sunlight, earth is a closed system—there is no “away” in which to throw away our manufactured goods when we are through with them. One such cycle inextricably tied with the survival of the human race is the life cycle of earth’s plantlife; in particular, edible crops in the agriculture industry. Healthy growth of plants is dependent on the input of nutrients, taken up from the soil. One of the most crucial nutrients is nitrogen. While there is abundant nitrogen in our atmosphere, (which is approximately 79% nitrogen), plants are unable to make use of it; it must be “fixed” in the soil, as part of the nitrogen cycle. The cycle continues as follows: let’s assume we start with healthy soil with plenty of nutrients, plenty of nitrogen. The plants take up the nitrogen and grow to ripeness, when they are harvested and presumably eaten, if they are agricultural crops. In an ideal system, the nutrients contained in these plants are not lost to the earth: they are returned as fallen leaves, manure or dead organisms. Because our soil is healthy, there live in it many microbiota, including bacteria, fungi,

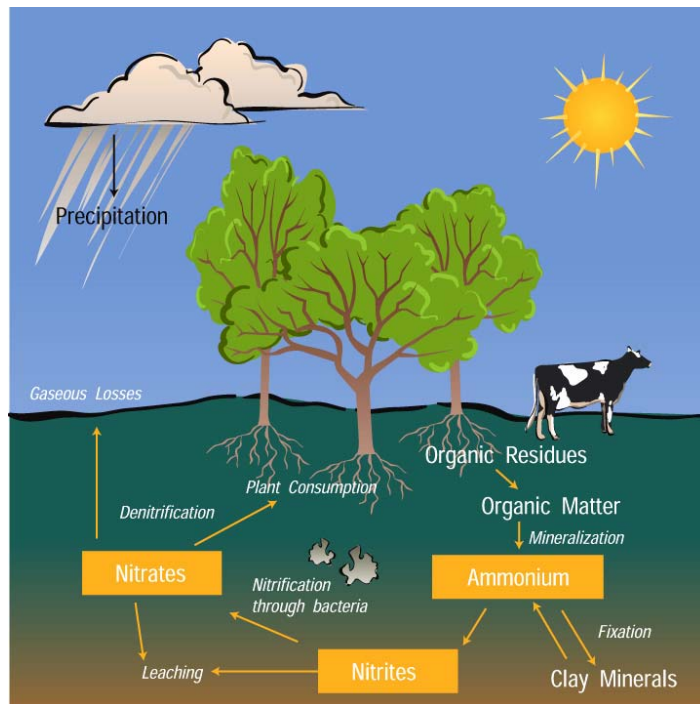


Figure 1: The natural nitrogen cycle⁸

protozoa and earthworms¹. These soil biota feed on the discarded organic residues, and convert them to organic matter called humus, thus fixing the nitrogen back into the soil, so that it can be taken up by the next cycle of crops.

Key to this process is the returning of the nutrients to the soil. If the nitrogen cycle is to be interrupted by the harvesting of crops and incidental removal of the nutrients taken from the soil by these crops, action must also be taken to return these nutrients if the soil is to continue to support life; enter the fertilizer. The aims

of the ideal nitrogen management system are to provide crops with enough inorganic nitrogen at the right time, (here inorganic means compounds without carbon), to avoid resource depletion and nitrogen pollution, and to regulate the mineralization of humus to match, but not exceed, crop needs¹. In other words, to perpetuate the natural nitrogen cycle with no disruptions, in order to maintain the health of the soil and the ecosystem.

Until the industrial age, the only available method for fixing nitrogen to feed plants was by composting: recycling on-farm organic wastes to reuse nitrogen and other nutrients native to the local soil, and in some cases importing off-farm nitrogen in the form of already composted organic materials, if on-farm production did not meet fertilizer needs. Nitrogen fixing by compost is often supplemented by growing ground cover in the form of live vegetation for as much of the year as possible, in the form of legumes to replace nitrogen exported in the harvest, (these crops only take up 1/3 of the soil's nitrogen and fix the rest¹), and various non-legumes to mop up leftover nitrates not taken up by crops to prevent leaching into the ground water¹. (More on causes and effects of leaching later.) Composting and planting varied ground cover approximates the closed nitrogen cycle found in nature, and has been proven sustainable since the beginning of agriculture.

The industrial age gave the production of goods a boost of previously unheard of proportions; the production of fertilizer was no exception. In 1909 Fritz Haber and Carl Bosch developed the Haber-Bosch process for fixing nitrogen on an industrial scale, allowing much higher fertilizer production than ever before². The capability to produce synthetic fertilizer on this scale allowed for new techniques in agriculture: with the use of copious amounts of quick-release synthetic fertilizer, very large scale monoculture farms seemed to offer an imminent end to world hunger, and synthetic fertilizers became the de facto fuel for agriculture—now known as “conventional” agriculture.

With the continued widespread use of synthetic fertilizers, as the 20th century progressed agricultural researchers and farmers began to become more aware of the alarming byproducts of the production, use and after-effects of synthetic fertilizers. Today's environmental movement supports a return to organic agriculture, and the replacement of synthetic fertilizers with good, old fashioned organic compost. Before choosing sides, this paper will compare the production, use and after-effects of organic compost and synthetic fertilizers as used in agriculture.

Production of compost is fairly simple and can be carried out either in your back yard or in large scale production plants. Simply collect organic wastes, (food scraps, yard waste, livestock waste etc.), store somewhere—somewhere warm and dark to expedite the process if you so desire—and leave it to sit for a period of time. Occasional turning with a shovel may be required. While this process is

certainly familiar to most back yard gardeners, it can also be expanded to factory-scale. The only inputs to this process are garbage: this could equally be seen as the beginning of the fertilizer cycle, or the end of the food cycle.

SUSTAINABLE BUSINESS MODEL

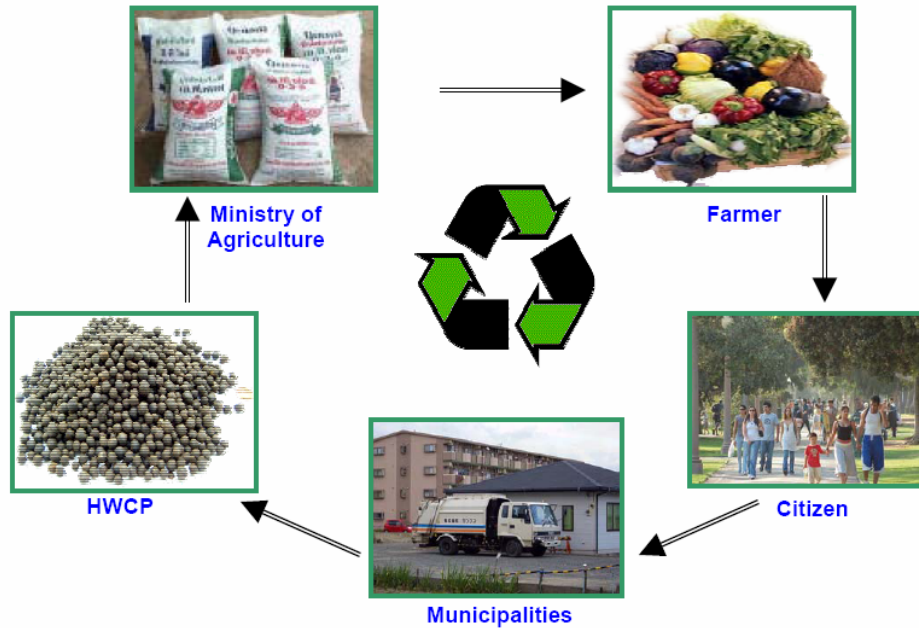


Figure 2: HiWave Compo composting factory model¹¹

Synthetic fertilizer production is not so simple. The Haber-Bosch process uses a high-temperature, high-pressure process to fix atmospheric nitrogen with hydrogen into ammonia²; more than 99% of the world's nitrogen fertilizer is ammonia based. This system requires feedstock, (atmospheric nitrogen, or air, and hydrogen, most often from natural gas⁷), and energy, usually coal⁷. 70-90% of the cost of nitrogen fertilizer production is natural gas². It has been estimated that the manufacturing of synthetic nitrogen accounts for roughly 30% of a conventional farm's energy consumption of fossil fuels¹. University of Kentucky researchers found that 42% of the cost of corn production was fertilizer production¹. Compare this with compost production: no fossil fuels, only cheap garbage...

Most production plants do not use only nitrogen and hydrogen as their inputs. Some production plants input recycled hazardous wastes into their fertilizer production; for example steel industry wastes, for their high zinc content³. These recycled wastes also contain lead, arsenic, cadmium, chromium, nickel and dioxin³. Interestingly, fertilizer producers are only required to list the beneficial nutrients on their labels³, so these additional heavy metals often go unnoted by the consumer.

With any industrial process comes waste. Atmospheric pollutants emitted by the fertilizer industry include gaseous ammonia, ammonium salt aerosols, nitric and nitrous oxides (which contribute to the formation of acid rain), fluorine, oxides of sulfur (more acid rain), fertilizer dust, acid mists, radiation, carbon dioxide and carbon monoxide⁷. Waste waters from industry include compounds of nitrogen, phosphate, potassium, sodium, silica, sulfur, fluorine, sludges and polluted wash water⁷. Solid wastes include phosphogypsum, pyrite ashes, calcium carbonate, soluble salts from potash refining, sand, and plastic bags from transport of the fertilizer⁷.

Once the fertilizer has been produced, it is applied to crops. If this fertilizer is locally produced compost, it fits neatly into the nitrogen cycle: the compost contains nutrients removed from the soil during harvest, which are now reapplied to the soil for uptake by plants. Compost is essentially nutrient-rich dirt, so it is very safe to work with. Organic compost tends to be slow-releasing of its nitrogen. This means that the plants are provided with only as much nitrogen as they can absorb, and the rest is fixed in the soil, (consumed by soil biota), replenishing the soil for the next crop cycle.

Synthetic fertilizers, unlike regular compost, are not as simple to work with, as they usually contain toxic chemicals. (Farmers have died working with anhydrous ammonia, a common ammonia-based synthetic fertilizer¹). Again unlike naturally slow-releasing compost, synthetic fertilizers “mainline” inorganic nitrogen into the soil, bypassing the natural nitrogen cycle, and depriving soil biota of essential nutrients¹. Due to the nutrient stripping properties of large-scale monoculture agriculture, crops growing in depleted soil need this quick fix of nitrogen if they are to sprout at all. (Note how the use of synthetic fertilizers and the desire for increasingly high yields begets greater need for synthetic fertilizer.)



Figure 3: Nitrogen oversaturation of corn roots allows corn rootworm larva to grow⁹

However, by very quickly releasing their entire nitrogen content, synthetic fertilizers flood ecosystems with 100-400 times as much nitrogen as they would normally be exposed to⁶. This saturates the crops, allowing an initial higher yield, but of a lower quality product. Oversaturated crops are more prone to pests, diseases, nutrient imbalances and lodging (falling over)¹. Overfed tomatoes, peppers and squash tend to have lots of foliage but few fruits¹. Overfed leaf and root vegetables tend to have

water produce, poor flavor, short shelf life and unhealthy nitrate concentrations ¹.

Due to the acidifying properties of synthetic fertilizers, (particularly anhydrous ammonia and ammonium salts), excess ammonia after roots are saturated cannot be taken up by the soil ¹. This means that the excess ammonia compounds either leach into the ground water, (taking crucial nutrients such as potassium, calcium and magnesium with them ¹, further depleting the soil while rendering it unable to rebuild nutrients by killing the soil biota), or vaporizes either through the leaves or directly out of the soil ¹.

Remember those heavy metals included, (but not labeled), in the production of the synthetic fertilizers? At this point, those have either been extracted by the crops and have now entered the food chain, or have leached into the ground water—and have now entered the food chain. In an analysis of 29 commonly used synthetic fertilizers, each one contained 22 different heavy metals⁶. 20 of these fertilizers contained levels exceeding limits set on wastes in landfills for arsenic, lead, mercury, cadmium, chromium and dioxin⁶.

But of course, the story doesn't end with the uptake (or non-uptake) of nitrogen by the crops. As mentioned earlier, there are outputs to this cycle other than corn and grain—the ammonium leaching through the soil of course doesn't just leach “away”, never to be seen again. Overuse of nitrogen fertilizers and subsequent leaching of nitrates into the groundwater has been found to be the primary cause of “dead zones” in coastal waters near agricultural land ². The leachates enter bays, estuaries and other bodies of water where they allow large algae blooms. These algae blooms die and decompose, drawing oxygen from the water and suffocating all nearby aquatic life ². Researchers at Oak Ridge National Laboratory's environmental sciences department have found 3,000-8,000 square mile dead zones in the Gulf of Mexico, (caused by Mississippi River basin agriculture runoff), to be the cause of fatal hypoxia in fish, shrimp and shell fish⁶.

Groundwater is also a large source of drinking water. Nitrates in drinking water have been linked to reproductive problems, bladder and ovarian cancer, and blue baby syndrome ², at levels lower than EPA standards of 10ppm⁶.



Figure 4: the result of nitrate leaching into groundwater¹⁰

Volatile nitrate forms, chiefly ammonia, escape into the atmosphere, especially in warm, dry weather¹. Oxidized nitrogen released during fertilizer application contributes to smog at lower atmospheric levels, is a greenhouse gas at middle levels, and destroys ozone at high atmospheric levels². Nitrogen also contributes to acid rain², which kills wildlife and percolates through the soil, further leaching calcium, magnesium and potassium, mobilizing aluminum, and killing yet more soil biota². All of these effects deplete soil nutrient reserves even more, creating greater dependency on quick-fix synthetic fertilizers.

Compare these effects to compost's post-use effects: because compost releases nitrogen slowly throughout the growing season, plants are not oversaturated with nitrogen. Farm comparisons in Europe show that nitrate leaching on organic farms occurs at 40-57% less per hectare than on conventional farms. This gives the soil biota a chance to consume whatever is not taken up by the plants, turning it into humus, and replenishing soil nutrients—another step in the cycle, leaving no toxic byproducts, leaving the soil healthier than when you found it.

With so many benefits to using organic compost, (reusing waste, completing the natural nitrogen cycle, replenishing the soil), and so many drawbacks to synthetic fertilizers, (dependency on fossil fuels, polluting production practices, toxins in the food stream), you may ask why anyone is still using synthetic fertilizers. The answer, as usual, is scale. Many argue that with its lower yields, organic compost simply cannot sustain current-day agricultural needs. However, before even considering fertilizer choice, the numbers don't add up. Grain production in 1999 alone had the capacity to sustain 8 billion people⁵, while population in 1999 was only 6 billion. Total food production is estimated to amount to 3500 calories per person per day⁵—this far exceeds the recommended 2000 calories/day. The solution to world hunger isn't increased agricultural yields, it is a redesign of our entire food infrastructure.

What's more, the majority of grain grown is used as feed for livestock⁵. This is not out of necessity; ruminants, such as cattle and sheep, are naturally 'designed' to thrive on forage, they don't need grain and corn to survive⁵. Once again, increased grain and corn yield is not a realistic, or even wholly relevant, solution to perceived yield problems.

Aside from debates of how much grain the world needs, it must be recognized that no amount of agriculture growth can sustain a growing population if its resource base, (the very soil our food begins in), is depleted or fouled. Conventional agriculture, with its use of synthetic fertilizers, systematically drains nutrients from the soil while polluting the surrounding ecosystem, and then moves on to the next

swathe of land. And we must not forget that the process to produce the very product that is leaching our soil is heavily dependent on fossil fuels—which are about as unsustainable as you can get.

But of course, no solution can be solved by product alone, the product must be applied with good practices, and organic compost is just as susceptible to “green washing” as other “green” products. As more people become aware of the harmful effects of synthetic fertilizers and begin protesting their use, many in the industry simply use “input substitution”: replacing dependency on synthetic fertilizers with “organic” fertilizers, (which technically follow the regulations defining “organic”)⁴, and relying heavily on transport of these products from many miles away. While this is not a long term solution, it should be seen as a step—a very tiny step, but a step—in the right direction, as it indicates a growing awareness of the problem. It is unrealistic to hope for the eyes of the agriculture industry to miraculously be opened to the sustainable benefits of organic compost. If it were to happen, the switch-over would require enormous effort, cost and time. But for now, we can look to the short term, and continue to compost at home and buy from small scale farms who continue to use the age old practice of composting, returning nutrients to the soil, and completing the natural nitrogen cycle.

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