

USCC Factsheet

Greenhouse Gases and the Role of Composting: A Primer for Compost Producers¹

The biggest benefit of composting with respect to Global Climate Change comes from avoiding the production of methane.

Good composting practices minimize greenhouse gas emissions.

The use of compost provides numerous greenhouse gas benefits, both directly through carbon sequestration and indirectly through improved soil health, reduced soil loss, increased water infiltration and storage, and reduction in other inputs.

Anyone who as ever tended a compost pile, from a balcony worm bin to 1000 ton per day facility, is sure that what they are doing is GOOD FOR THE ENVIRONMENT. However, the increased focus on Global Warming and Climate Change is challenging this assumption and forcing composters to look to new answers to new questions. The goal of this factsheet is to provide composters with some basic definitions relating to Global Climate Change, help them understand composting's role, and offer some direction for additional resources.

What is Global Climate Change ?

Global Climate Change is the result of increased average temperature of the Earth's oceans and atmosphere, with profound consequences for humanity and the world as a whole. Some of these consequences include rising sea level endangering coastal populations, more extreme weather, and

¹ Based on the article "Composting and Greenhouse Gas Emissions" by Sally Brown and Scott Subler, BioCycle, March, 2007, Vol. 48, No. 3, page 37-8.

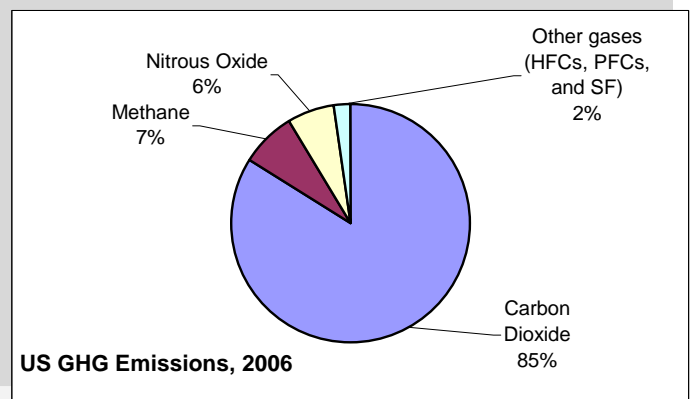
threats to agricultural production. Human health will be jeopardized by all of these changes."²

What is causing Global Climate Change?

The primary engine that drives the Earth's climate is the sun. A certain percentage of the solar energy that reaches our planet is trapped in the atmosphere by a process known as the "greenhouse effect," first described by Joseph Fourier back in 1829³. The primary gas responsible for this effect is carbon dioxide, CO₂⁴. While CO₂ levels in the atmosphere have changed over the course of Earth's history, it has become clear that human activities since the industrial revolution has caused a dramatic jump in the CO₂ levels, as we have developed a fossil-fuel based economy. That increase in CO₂ means that a greater fraction of the sun's energy is trapped rather than escaping each day, driving overall temperatures up.

What are greenhouse gases?

Greenhouse gases (GHG) are gases in the atmosphere that act to trap heat near the Earth's surface. While these gases and this effect are naturally occurring, human activities have caused an increase in the levels of these gases and thus an increase in their effect. Because of the lag time between emission and effect (up to 100 years) it is too late to completely prevent some climate change, but there is much that can be done to reduce emissions and thus reduce the rate and extent of the change, giving us more time to prepare and adapt to those changes.



Carbon dioxide (CO₂) is the main GHG. In 2005, the US released 6,090 Tg (Teragrams, or trillions of grams) of CO₂, which accounted for 85% of all US GHG emissions.⁵ The burning of fossils fuels for energy and transportation was responsible for 95% of the CO₂ emitted. Since other gases, such as methane (CH₄) and nitrous oxide (N₂O), are more effective at trapping heat than CO₂, the amounts and effects of

² From "Climate Change 101: Understanding and Responding to Global Climate Change", published by the Pew Center on Global Climate Change, www.pewclimate.org.

³ Greenhouse effect. (2008, October 22). *New World Encyclopedia*.

⁴ Technically, water vapor has a bigger impact than CO₂, but since it is not anthropogenic (of human origin) it is not regulated or considered a GHG by the International Panel on Climate Change

⁵ Statistics on GHG emissions for the US are drawn from the USEPA website on climate change, <http://epa.gov/climatechange/index.html>

other gases are computed in terms of CO₂ equivalents (Table 1). In 2005, 539 Tg of CO₂ equivalents were released as CH₄, and 469 as N₂O.

Table 1. Global warming equivalencies of primary GHGs

Gas	Global Warming Potential (GWP) ^a	Atmospheric Lifetime
Carbon Dioxide	1	50-200
Methane	21	12±3
Nitrous Oxide	310	120

^aGWP of CH₄ and N₂O were changed to 23 and 296 respectively in the Third Assessment done by the IPCC. The equivalencies from the second assessment, shown above, are still used by the EPA so that updated inventories can be compared with former inventories and trends can be tracked.

How are greenhouse gases changing?

In order to tell if policies aimed at curbing Global Climate Change are having an effect, we need to have an inventory of GHGs. An inventory attempts to total and track the amount of GHGs that are released into the atmosphere each year and how much carbon is removed. Inventories can be done by countries, states, industries and even individuals. The United Nations Framework Convention on Climate Change (UNFCCC), of which the United States is a member, commits the country to performing an annual inventory of GHG sources and sinks. The Intergovernmental Panel on Climate Change (IPCC) provides the protocols by which the inventory is done. In doing the inventory, only anthropogenic (manmade) emissions are counted as “sources”. Likewise, since carbon is naturally constantly being taken out of the atmosphere through photosynthesis, that does not count as removal. Only processes that store carbon for longer periods of time, called sequestration, are counted as “sinks”. The US has provided GHG inventories for the years 1990 through 2007, reporting sources and sinks by gas, by industry and by sector.

How do organic discards contribute to greenhouse gases?

By definition, all organic discards contain carbon. When they decompose naturally under aerobic conditions the CO₂ they give off is part of the natural short-term carbon cycle⁶. Since this is part of the natural flux of CO₂ it is not considered in GHG computations. However, when those organic discards are placed in an anaerobic environment the decomposers will convert and release the carbon as methane and other volatile organic compounds which can contribute to global climate change. Organic discards that are high in nitrogen, such as food scraps, manures and grass clippings, under wet and oxygen-limited conditions, can also produce N₂O during decomposition, roughly 300 times worse than carbon dioxide.

⁶ Carbon is constantly removed from the atmosphere by plant photosynthesis, moved among organisms through the foodweb and released by via decomposition.

How does composting effect Global Climate Change?

To understand what effect composting has, we have to break the composting system into three components: the feedstocks, the composting process, and how the use compost product is used. Composting will have an impact based on what might have happened to the feedstocks if they were not composted, how the composting operation is run, and what happens to the compost. Positive impacts include emissions avoidance and carbon sequestration. Negative impacts result from emissions from the diesel powered processing equipment used to process feedstocks. The net effect is determined by adding up the benefits and detriments of each component.

Part 1: Feedstocks

If material that would otherwise end up producing methane or nitrous oxide is composted instead, this results in *avoided emissions*. Some common situations where this might apply include food wastes that are going to landfills and manures that get stored in uncovered lagoons. For example, every metric dry ton of food that goes to a landfill may generate .25 metric tons of methane in the first 120 days. Thus composting this food waste reduces emissions by the equivalent of up to 6 metric tons of CO₂. By the same token, if grass clippings that were going to a landfill were redirected to a composter, that would result in increased methane emissions at the landfill (up to about 2 tons of CO₂ equivalents for every ton of grass, depending on how the landfill is managed).

Transportation costs also have to be taken into account. If the composting facility is closer than the landfill (as is often the case, as landfills become more regional and take trash from further afield), then less energy will be used in transporting the waste, another benefit. On the other hand, if the food collection required more vehicle trips (or vehicle miles or use of less efficient vehicles) than would have been otherwise, then that would result in increased emissions, reducing the total avoidance. However, since methane is so much more damaging than CO₂, the vehicle “costs” are usually far outweighed by the benefits of methane reduction. For example, a long haul truck can carry about 30 wet tons of material. At 20% solids, that is 6 dry tons of food waste. For a 200 mile round trip the truck will emit 327 kg of CO₂. The total CO₂ equivalent of methane avoided by composting is 36 MG or 36,000 kg. That truck would have to drive back and forth from LA to New York City seven times to before the emissions outweighed the avoidance!

The US sent 25 million tons of food waste to landfills in 2005. The GHG impact of composting this mass would be the equivalent of removing 7.8 million passenger cars from the road.

Part 2: Composting Process

The EPA recognizes that well-run composters emit little methane and N₂O from the biological process of composting, so have little impact in GHG. Of course, the compost process uses diesel fuel to run grinders, turners, front-end loaders and the like. The burning of this fuel creates GHG emissions, as does electricity used to operate blowers, pumps, etc. If the

energy comes from bio-based fuels, like biodiesel or methane-fired generators, or other renewable energy sources, those emissions would be reduced from a GHG accounting perspective (because the carbon emitted is coming from the short term carbon cycle and replacing the carbon from fossil fuels, which is coming out of long term storage).

This is not to say the composting itself can't have GHG emissions. Both methane and nitrous oxide have been observed coming from compost piles (Hao, 2001, Sommer and Moller, 2000, Lopez-Real and Baptista, 1996). Methane forms under anaerobic conditions, often found at the bottom of piles. In the real world this probably happens frequently, but the methane is then oxidized as it reaches more aerobic portions of the pile and before leaving the pile. N₂O formation is less well understood, occurring closer to the surface where oxygen is limited but not absent and where nitrogen is in excess. The CO₂ released during composting is considered biogenic, not anthropogenic, so is not considered in greenhouse gas calculations. **Good composting practices that balance the carbon:nitrogen ratio and provide adequate aeration and moisture will minimize GHG emissions.**

Part 3: Compost Use

Compost that is incorporated into the soil will continue to breakdown. Depending on the soil management practices, temperature, rainfall and feedstocks; a portion of that composted organic matter may become part of the soil's long term carbon pool (sequestration).

In addition, there are a number of indirect effects, such as, increased soil moisture holding capacity and a reduction in the need for fertilizers, herbicide or fungicide. This could result in less irrigation, which would mean less energy used and avoidance of associated GHGs. The same is true when compost use results in reduced fertilizer, herbicide or fungicide use.

In a detailed life cycle analysis of windrow composting in Australia, the emissions from the production of compost and composted mulch were more than outweighed by the benefits of the use of composted products. The emissions came from the use of fuel, water and electricity in compost production, transport and application. The benefits came from carbon sequestration and the reduction in fertilizers, electricity, water and herbicides (and thereby reducing the emissions associated with the production and use of these items). The net benefit persisted even if the composted products were transported over 400 miles to the application site and the trucks returned empty (Sharma and Campbell, 2003).⁷

Conclusion

The impact of composting on climate change is the sum of the three components of the compost system: the feedstocks, the process, and the end use.

- ④ The biggest benefit for most composting projects comes from emission avoidance; primarily from keeping methane-generating organics out of landfills or lagoons. Landfills with methane capture systems result in less GHG benefits.

(see USCC factsheet *Keep Organics Out of Landfills* for more details).

- ④ The composting process has the potential to produce some GHG, though those can be minimized. Good composting practices that balance the carbon:nitrogen ratio and provide adequate aeration and moisture will minimize GHG emissions.
- ④ The end use of the compost provides some GHG benefits, both directly through sequestration and indirectly through improved soil health, reduced soil loss, increased water infiltration and storage, and reduction of other inputs.

The actual benefits of a specific facility or system will have to be determined on a case-by-case basis. For more info on carbon credits for composters, see USCC factsheet *Composting and Carbon Credits*.

References:

- Brown, S and Subler, S, 2007, *Composting and Greenhouse Gas Emissions*, BioCycle, Vol. 48, No. 3, page 37-8.
- Compost Science & Utilization. Vol. 4, no. 3, pp. 71-82.
- Hao X, Chang C, Larney FJ and Travis GR. 2001. Greenhouse gas emissions during cattle feedlot manure composting. *Journal of Environmental Quality* 30: 376-386
- Lopez-Real, J; Baptista, M 1996 Preliminary comparative study of three manure composting systems and their influence on process parameters and methane emissions
- New World Encyclopedia contributors, "Greenhouse effect," *New World Encyclopedia*, http://www.newworldencyclopedia.org/entry/Greenhouse_effect?oldid=836468 (accessed December 3, 2008).
- Pew Center on Global Climate Change, 2006, *Climate Change 101: Understanding and Responding to Global Climate Change*, Arlington, VA
- Sharma, G and Campbell, A., 2003, *Life Cycle Inventory and Life Cycle Assessment for Windrow Composting Systems*, Recycled Organics Unit, University of New South Wales, Sydney, Australia
- Sommer, S.G. and Moller, H.B. (2000) Emission of greenhouse gases during composting of deep litter from pig production - effect of straw content. *J. Agric. Sci., Camb.*, 134: 327-335

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⁷ The full report is available from the Recycled Organics Unit website, www.recycledorganics.com