Measuring Emissions of Organic Waste

Calculating carbon emissions from decomposed organic waste

While it isn't on purpose: humans create huge amounts of waste that ultimately ends up inside a landfill. And estimates from 2018 show that the United States alone was responsible for processing 292 million tons of municipal solid waste (MSW) — 2.8% of which came from Colorado. (EPA 2018, CDPHE 2018)

This is problematic because harmful carbon emissions are emitted into the atmosphere as this material decomposes over time. (IPCC 2019) But it is possible to reduce the global warming potential for some of these emissions by diverting organic material from an anoxic landfill to an aerobic waste management facility.

The IPCC recommends reducing all carbon emissions

What variables are needed to calculate carbon emissions of organic waste?

This report attempts to quantify the carbon emissions generated from 1 ton of organic waste when it is sent to an **aerobic composting facility** and an **anoxic landfill**. To do so, the following processes were considered: 1) emissions during decomposition, 2) carbon captured via gas collection wells, and 3) additional emissions generated via gas-to-energy production. Further research would need to be completed to include emissions from the transportation & heavy machinery involved at both locations.

Symbol	Description	Assumed values	
[DOC]	Degradable Organic Carbon (Dry weight)	38%	
[DOC_F]	Degradable Organic Carbon Fraction	55%	
[K_C]	Assumed flux time for compost facility	100%	
[K_L]	Assumed flux time for landfill	100%	
[F_C]	Fraction of gas by volume at compost facility CO_2 | CH_4	100%	0%
[F_L]	Fraction of gas by volume at landfill [1] CO_2 | CH_4	40%	60%
[R_C]	Gas capture recovery rate via vertical wells at compost facility	0%	
[R_L]	Gas capture recovery rate via vertical wells at landfill	35%	
[C]	Assumed emissions differences between methane gas and coal	50%	

Table 1. Assumed values used to calculate carbon emissions as organic waste decomposes at an aerobic compost facility and an anoxic landfill (Appendix A-F)

What are the key differences between landfills and composting facilities?

Landfills and composting facilities are two common ways in which organic waste can be processed by a municipality. Inside a landfill, the organic waste is mixed together with other non-organic material under anoxic conditions where decomposition is slow and methane production is high. At a composting facility, it is processed independently under conditions that speed up decomposition rates. Minimal methane is produced inside composting facilities.

Carbon dioxide and methane are both considered to be harmful greenhouse gases — but methane has a global warming potential 36X worse. (EPA 2021)

The measurements of carbon for this project include:
- Emissions during the decomposition of organic waste
- Emissions collected via vertical gas wells
- Emissions during the gas-to-energy process

Compost facility

While these facilities can drastically reduce methane production, they do produce carbon dioxide. This is a greenhouse gas; and it should be reduced.
Aerobic

Defining characteristics

Creates methane	No
Average decomposition time	90 days
Facilities in Colorado	32
Composition: organic waste	>99%
Composition: other	<1%

(CDPHE 2018)

Landfill

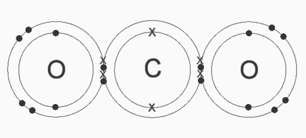
17% of all human-caused methane comes from decomposition occurring within landfills. (APPENDIX E) This is a greenhouse gas; and it should be reduced.
Anoxic

Defining characteristics

Creates methane	Yes
Average decomposition time	50+ years
Facilities in Colorado	81
Composition: organic waste	37%
Composition: other	63%

(CDPHE 2018)

What are the most common greenhouse gases emitted from decomposing organic waste?

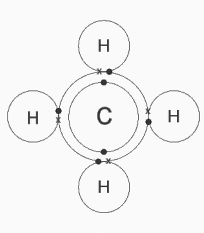


Carbon dioxide

CO_2 has a GWP of 1 regardless of the time period used. This is because it is the gas being used as the reference. These emissions do cause an increase to atmospheric carbon concentrations that will last for thousands of years. (EPA 2021, EPA 1995)

With oxygen · Aerobic · Compost

1X GWP



Methane

CH_4 is estimated to have a GWP between 28–36 over 100 years. It lasts about a decade on average, and absorbs more energy than CO_2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. (EPA 2021)

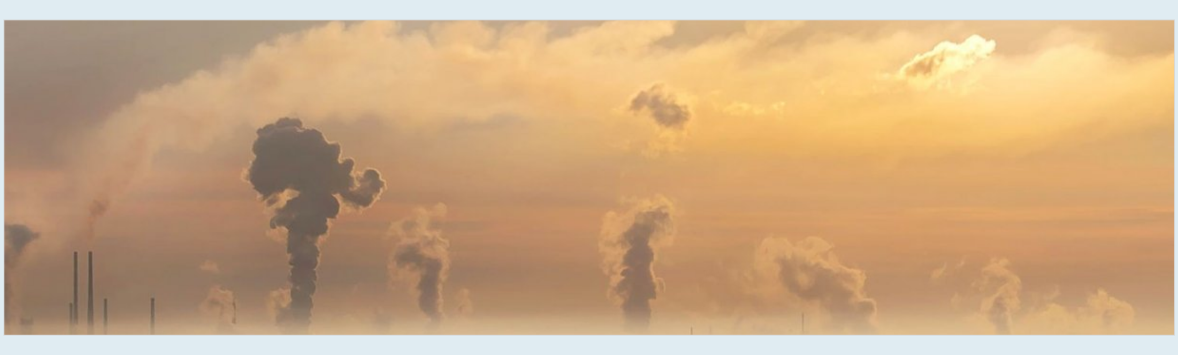
Without oxygen · Anoxic · Landfill

36X GWP

Why is the global warming potential important to consider with emissions?

The global warming potential (**GWP**) was initially created to allow comparisons of the global warming impacts of different gases. Specifically: it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of CO_2. The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWP is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases, and allows policymakers to compare emissions reduction opportunities across sectors and gases. **Methane's GWP is 36X.**
(EPA 2021)

Measuring emissions of organic waste



PROCESSES CONSIDERED	WEIGHT (TONS)	CARBON (TONS)		GLOBAL WARMING POTENTIAL	
		COMPOST	LANDFILL	COMPOST	LANDFILL
Decomposition	1	0.209	0.209	0.209	4.598
Vertical well CH_4 capture	1	0.000	-0.073	0.000	-1.609
CH_4 instead of coal	1	0.000	-0.037	0.000	-0.805
Total	**1**	**0.209**	**0.099**	**0.209**	**2.184**

Table 2. Carbon emissions for organic waste w/ global warming potential
Carbon emissions from organic waste during three phases: [1] decomposition, [2] vertical well gas collection at landfills, and [3] energy re-emissions during the gas-to-energy process. Additional research would need to be completed to understand more emission sources.

Appendix G

Sources

CDC — Landfill Gas Basics — 2001
CDPHE — Status of the Solid Waste Program Colorado — 2018
EPA — Advancing Sustainable Materials Management — 2018
EPA — Landfill Gas Energy Basics — 2021
EPA — Understanding Global Warming Potentials — 2021
EPA — GHG Emissions Methodologies for Biogenic Emissions — 2010
Heede — Emissions of CO_2 and CH_4 from fossil fuels — 2016
IPCC — Waste Generation + Composition + Management Data — 2019
Schlesinger — The Global Carbon and Oxygen Cycles — 2020
Spokas — Methane Gas Collection Efficiency — 2006

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