Compost Emission Factors – Volatile Organic Compounds

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Introduction

Composting, while offering an alternative to landfilling for biodegradable waste, has recently been demonstrated to emit substantial amounts of volatile and semi-volatile compounds to air, in the form of the criteria pollutant VOC, (Volatile Organic Compounds). This has resulted in a realization that composting emissions of VOC may impact our local environment by contributing to the formation of lower atmospheric ozone.

Much of the work in measuring air emissions from composting has come out of California, with its emphasis on VOC, because of its negative effects in the creation of low level ozone. Substantial work on the issue has come out of Europe as well, including work in characterizing Hazardous/Toxic Air Pollutants (HAP/TAPs), greenhouse gas emissions, and odor.

Thus far neither the WA State Department of Ecology, nor the other local air agencies have acted on this new information from outside the state. However, because this Agency's jurisdiction currently holds the greatest number of non-farm composting facilities in the state, the Agency realized the need to produce local emission factors for emission inventories and for determining facility regulatory status. The majority of our composting facilities receive curbside collected green waste mixed with household food waste, while some also receive commercial or institutional food waste. Therefore, the Agency focused first on developing VOC emission factors for these feedstocks (wastes). As other non-farm organics are diverted to composting by our local cities and counties, we may in future projects, develop VOC emission factors for composting those wastes as well.

There are a number of composting related emissions not included in this project. The project did not consider emissions of VOC from farm composting or emissions of VOC from composting solids from municipal wastewater treatment plants. The project did not look at emissions from composting of greenhouse gases, Hazardous Air Pollutants (HAP), Toxic Air Pollutants, or other criteria pollutants, (TAP) as the characterization of these pollutants is still in the early stages world-wide. While some odorous compounds are VOCs, this project did not focus on odors. Separately, the Agency continues to work at understanding and quantifying the sources of odor from green waste and food waste composting.

Technical Approach

An air quality *emission factor* is the relationship between the amount of pollution produced, the amount of raw material processed, and/or the number of product units produced. To develop an emission factor requires evaluation of the variety of factors that contribute to a facility emissions beyond any single emission test report. In developing composting emission factors we used the following process:

1. **Research.** We looked for a variety of composting emission data sets, which came from: test reports; journal papers; government reports; and data from permit applications. The goal: to collect data from as many available sources as possible while recognizing that more information may be identified in the future that may allow further refinement of the developed factors.

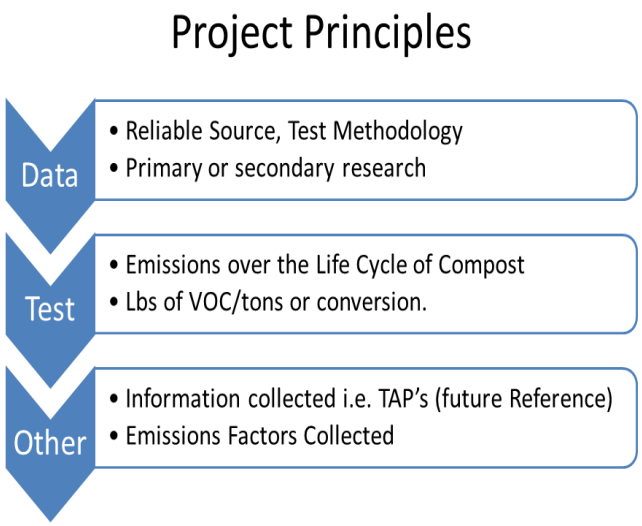
2. **Summarize**. Review each data source and summarize the relevant emission data in a spreadsheet for comparison purposes. Data to include: emission type; test method; whether the data is a composite of multiple tests; and whether the data is spot samples or integrated over the full composting cycle.

3. **Sort**. Sort identified data sources to determine whether to use it for the development of emission factors.

4. **Evaluate**. Evaluate and group emissions data into categories based on what types of operations the data sources represented.

General Description of Data Availability

The methods used for emissions testing of green waste and food waste were first developed in the mid-1990's for projects meant instead to categorize VOC emissions from the composting of bio-solids from municipal waste water treatment plants. During that same period investigations on green waste and food waste were limited to odor emissions. It was not until after 2000 that investigation into compost emissions of VOC from green waste and food waste was moved off of the laboratory bench and onto working compost facilities. The earliest of these took place in 2001 in Colton, CA, by the South Coast AQMD. This study, and more like them in the following years, became the basis of the issuance of new regulations for the South Coast Air Quality Management District and San Joaquin Valley Air Pollution Control District jurisdictions. These regulations called for best management practices to restrict VOC emissions from composting from these California ozone non-attainment areas. These rules came out between 2003 and 2008. Currently, the California Air Resources Board and the local air quality agencies are planning future work addressing the emissions of other criteria pollutants and greenhouse gases from over 400 composting facilities in that state.



While the data from California was from a rich vein, we did not limit ourselves to that state. The project team sifted through many reports, papers, and a few texts that were available in English from both the US and Europe dated from 1994 to 2013.

When the data collection step was completed and the data summarized into spreadsheet tables, it was clear that there were three major grouping of emission types:

- VOC
- HAP/TAP
- Greenhouse Gases

The data summaries identified that VOC data was presented in the reports in a variety of forms and units. These variations were due to the variations in test design and analytical methods. VOC characterization variations included: VOC as carbon; Non-methane Non-ethane Organic Carbon (NMNEOC); and the sum of individual compounds. Varied units included: pounds per ton feedstock; pounds per ton product produced; pounds per hour per square feet surface area; pounds per hour; pounds per hour per 1000 square feet surface area; parts per billion by volume; pounds per cycle; pounds per ton per cycle; pounds per ton per hour; and milligrams per square meter per minute. Additionally, test sampling times varied from spot samples from specified parts of a compost process to integrated sampling over the entire composting cycle.

Other Research Considerations:

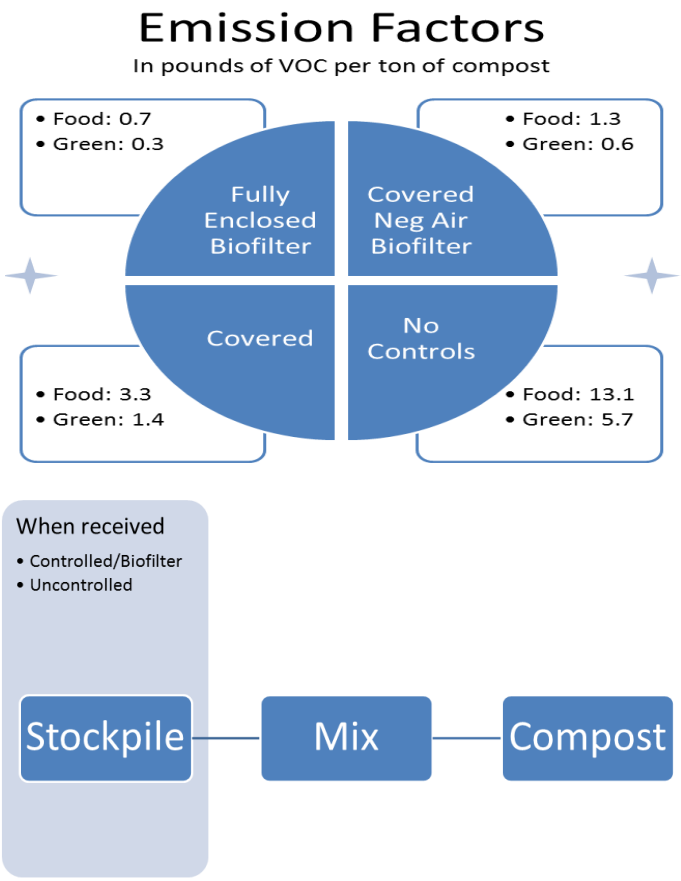
- Criteria for selecting cited sources: Three person project team review and consensus.
- Original works to be reviewed.
- Focus on emission studies that address VOCs. Desirable but not required: TAPs, NH3, NOx, and Methane emissions.
- Odors were outside the scope of this effort.

Emission Factor Summary

Given the wide variations in available data, it was clear that not every test report could be used for the purpose of developing emission factors. The following principles were identified and used for choosing data to be used for emission factors.

- Emission data in lbs- VOC over the course of the composting cycle, per ton of feedstock;
- Emission data in other units that could be converted mathematically into lbs- VOC over the course of the composting cycle, per ton of feedstock; and
- We did not consider papers with emission factors that either did not fit composting as it is done in our jurisdiction, or papers based only on lab bench scale research, not easily translated, into real world composting.

The result of applying these principles to the summarized data was a set of six documents to draw from directly for developing the factors, three more documents which included data which could be converted into the correct units, and 22 documents that were excluded from consideration. After examining these documents further, it was found that the majority of the papers identified by this project were also used as the basis for another agency's development of emission factors, which included factors for stockpiling feed stocks prior to composting, and emission factors for composting in windrows. This was documented in San Joaquin Valley Air Pollution Control District's (SJVAPC) paper, *Compost VOC emission factors.* Because it included the majority of papers identified during this project, it was decided, after reviewing the data for accuracy, to use this single document as the basis for developing emission factors for the project. The approach taken was to extend the simple set of factors in the SJVAPCD document based on our own local set of facilities and types of composting in our area. These included:



- Drafting a set of emission factors based on significant food waste in the compost stream. The data showed that a significant percent of food waste, 15% or greater, increased the emission factor.
- Accounting for the use of tipping buildings and biofilters during stockpiling of incoming wastes. The practice allowed for the evaluation of emissions for feedstock that have emissions prior to being mixed with amendments.
- Accounting for other types of composting other than windrows, as well as their associated control technologies. The practice allowed for the discrete differences in composting methods and credited the facilities with appropriate factors based on the different control technologies.

Accounting for the various types of composting other than windrows and the various control technologies (covers, enclosures, and biofilters) was done by estimating the percent reduction from the base emission factors. The percent reductions were taken from credible sources, and include a reasonable amount of research although the percentages are indirectly connected to specific emission test results.

We chose this approach because in our region, most composting facilities use a variety of emission controls and more efficient composting processes than simple windrows. Similarly, the food waste

emission factor was developed from data in the SJVAPCD document that SJVAPCD explicitly chose not to use due to the limited dataset. For our purposes, we chose to use the food waste data from the SJVAPCD document due to the fact that food waste composting is a substantial part of the composting in our region.

Table 1 below, including the footnotes, summarizes the developed emission factors. This set includes factors for stockpiling and composting for both green waste and food waste:

- Stockpiling of pre-compost material both outdoors and in tipping buildings with biofilters.
- Uncontrolled composting (windrows)
- Covered composting (which includes micro pore covers (gore), aerated static piles, and static piles with biofilter layer)
- Covered piles under negative air exhausted to a biofilter
- Full enclosure exhausted to a biofilter.

This set of factors will account for the majority of current composting and stockpiling activity in our region.

Table 1 – Green and Food Waste Composting Emission Factors

Compost Type[1, 2]	Stockpile (lb.-VOC/wet ton/day)[3]	Enclosed Stockpile (lb.-VOC/wet ton/day)[3,4]	Uncontrolled EF Per Composting Cycle (lb.-VOC/wet ton)[5]	Covered[6]	Covered under negative air to biofilter[7]	Full enclosure with capture to biofilter[8]
Green waste	1.1	0.11	5.7	1.4	0.6	0.3
Food waste[9]			13.1	3.3	1.3	0.7

Notes:

1. These emission factors are not applicable to biosolids, animal manure, or poultry litter.

2. Emission factors are based on input material (as wet tons), not finished material.

3. Stockpile is for emissions from piles of un-composted material prior to beginning composting process.
From *Compost Emission Factors*, San Joaquin Valley Air Pollution Control District, September 15, 2010.

4. Enclosed stockpile is full tipping building under negative air to biofilter.

Presumes a well-designed biofilter with close to 100% control and most emissions being lost from building openings prior to biofilter. See Air Pollution Engineering Manual Second Edition, ed. Wayne T. Davis, 2000, p. 61. Based on 90% emission reduction from, Industrial Composting, Elliot Epstein, p.201, p.202, range given for odor (as surrogate of VOC) 90-100%, low end chosen due to open doors and moving equipment.

5. Emission factors are for uncontrolled emissions from composting (windrows, static piles).

From *Compost Emission Factors*, San Joaquin Valley Air Pollution Control District, September 15, 2010.

Uncontrolled food waste emission factor based on a 2.3 multiplier of greenwaste emissions as discussed in the SJVAPCD report.

6. Includes: micropore covers; aerated static piles/static piles with biofilter layer

75% emission reduction due to an additive or blanket cover over a 14 day period from, *Industrial Composting,* Elliot Epstein, p.187.

75% emission reduction due to micropore covers from, *Industrial Composting,* Elliot Epstein, p. 214.

7. Assumes covered piles under negative air exhausting to a biofilter.

Based on 90% emission reduction from, *Industrial Composting*, Elliot Epstein, p. 202.

8. Full enclosure with capture to biofilter presumed 95 % efficient at reducing VOC emissions.

Based on emission reduction from, Industrial Composting, Elliot Epstein, p.201, p.202, range given for odor (as surrogate of VOC) 90-100%, midrange chosen.

Table 11.3 supports this value as range of VOC removal based on individual compounds is 70-100 percent -- most compounds over 90 %.

9. Food waste emission factor should be used when food waste constitutes 15 percent or greater of the composted material.

Appendix
Composting Emissions Project Bibliography

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