San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

# Compost Emission Factor Report

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## I. Introduction

This report provides the basis for the San Joaquin Valley Air Pollution Control District (District) composting emission factors (EFs) for volatile organic compounds (VOC) and ammonia ($NH_3$). The District originally issued this report in September 15, 2010; however, it was revised on November 12, 2021 to adopt the subsequent 2015 California Air Resource Board (CARB) EFs for organic material (waste) composting, to revise the organic material stockpile EF for VOC, and to add ammonia emission factors. The organic material EFs contain the following categories: green waste, up to 15% food waste, and grape pomace.

Accurate emission factors are required for the proper implementation of applicable air quality regulations and also for the evaluation of appropriate technologies and practices to reduce emissions. The EFs in this report are based on a detailed review of the available science. As would be the case with EFs for other sources, the District's EF should reflect the best scientific information that is currently available. The District's composting-related EFs are summarized in the table below.

Table 1: Summary of District Composting EFs.

| **Operation Type** | **Emission Factors** | |
|---|---|---|
| | **VOC** | **$NH_3$** |
| Organic Material Stockpile* | 0.2 lb/wet ton/day | 0.02 lb/wet ton/day |
| Biosolids, Manure, Poultry Litter, and Co-Compost Stockpile | 0.02 lb/wet ton/day | 0.001 lb/wet ton/day |
| Organic Material Composting** | 3.58 lb/wet ton | 0.78 lb/wet ton |
| Biosolids, Manure, and Poultry Litter, and Co-Composting** | 1.78 lb/wet ton | 2.93 lb/wet ton |

* The organic material stockpile EF shall be used for the following types of organic material stockpiles: green waste, 15% food waste, and grape pomace.
**Emission Factors represent the entirety of the composting cycle, i.e. start of the active phase through completion of the curing phase.

Pursuant to District Rule 4565, "co-composting" is defined as a composting process where biosolids and/or animal manure and/or poultry litter are mixed with other materials, including amendments, to produce compost.

## II. Background

### *A. Air Quality*

The San Joaquin Valley Air Basin has an inland Mediterranean climate characterized by hot, dry summers and cool, foggy winters. The San Joaquin Valley is surrounded by mountains on the east, west, and south sides. This creates stagnant air patterns that trap pollution, particularly in the south of the San Joaquin Valley. Additionally, the sunshine and hot weather, which are prevalent in the summer, lead to the formation of ozone (photochemical smog). Because of the San Joaquin Valley's geographic and meteorological conditions, it is extremely sensitive to increases in emissions and experiences some of the worst air quality in the nation.

The San Joaquin Valley Air Basin is classified as an extreme non-attainment area for the health-based, federal eight-hour ozone standard, and is also classified as a nonattainment area for the federal PM-2.5 (fine particulate matter) standard.

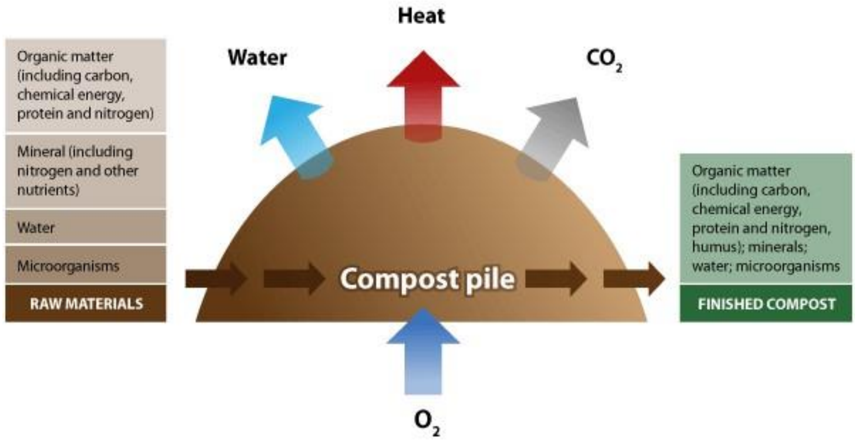
### *B. Composting*

Compost operations can be sources of smog-forming VOCs, fine particulate matter, ammonia ($NH_3$), and greenhouse gases such as carbon dioxide ($CO_2$) and methane ($CH_4$). The emissions are directly emitted from the decomposition of organic material. Composting is a process that involves the biological break down of organic matter, typically into marketable products (soil amendments, animal bedding, and alternative daily cover at landfills). Composting uses wastes from a wide-variety of sources, such as curbside green waste, landscaping, agricultural processing, crop harvesting, food consumption, and forest management.

There are two general categories of composting, aerobic and anaerobic:

Aerobic composting is the decomposition of organic material by microbiological organisms (microbes) in the presence of oxygen ($O_2$). This oxidation process theoretically results in $CO_2$, water ($H_2O$), and organic matter, including nitrates, sulphates, and other minerals. Figure 1 below is a visual presentation of theoretic aerobic composting:

Figure 1: Aerobic Compost. [1]




Anaerobic composting is the decomposition of organic matter by microbes in the absence of $O_2$. During this digestion process, a gas primarily composed of $CH_4$ and $CO_2$, known as biogas, waste gas or digester gas is produced. Biogas also consists of nitrogen ($N_2$), $O_2$, $NH_3$, hydrogen sulfide ($H_2S$), and various VOCs. However, these additional products are generated in relatively small amounts when compared to the amount of $CH_4$ and $CO_2$ produced.

*C. Purpose of the District*

The District is a public health agency whose mission is to improve the health and quality of life for all Valley residents through efficient, effective and entrepreneurial air quality management strategies. To protect the health of Valley residents, the District works toward achieving attainment with health-based ambient air quality standards as required under state and federal law. To achieve this goal, the District develops and adopts air quality attainment plans that include control measures aimed at further reducing emissions from a broad range of sources of air pollution.

As mandated by the federal Clean Air Act, the District adopted its 8-hr ozone attainment plan to demonstrate how the Valley would reach attainment with the federal eight-hour ozone standard. In developing the ozone attainment plan every feasible measure to reduce emissions of ozone precursors (VOC and NOx) was explored. Green waste composting was a control measure identified in a previous ozone plan, and as such, Rule 4566 (*Organic Material Composting Operations*) was adopted. However, even with the development of Rule 4566, the District will be relying heavily on state and federal governments to significantly reduce emissions from mobile sources of pollution.

1 http://www.londonfoodrecycling.co.uk

The San Joaquin Valley will need the development and adoption of future, not-yet-developed, clean air technologies to reach attainment by the 2023 deadline. Achieving the goal of attainment with air quality standards will require continued contributions from all industries, businesses, and individuals in the San Joaquin Valley.

*District Permit Applicability*

A critical tool that the air districts use to limit increases in emissions of air pollutants and to assure compliance with air quality regulations is the issuance of conditional construction and operating permits to commercial, industrial, and agricultural sources of air pollution. Since the 1970s, the District and its predecessors have issued tens of thousands of conditional permits that are being used to assure compliance with air pollution control requirements throughout the Valley. District permits address the requirements of federal standards, state regulations, and District rules that specifically apply to a source of air pollution. New and modified sources of air pollution are also subject to the more protective requirements of "New Source Review", which are determined on a case-by-case basis and are also included in the permit.

For composting operations, District permitting is required if the emissions of any pollutant exceeds 2.0 pounds per day. As mentioned above, the primary pollutants of concern for composting operations are VOC and $NH_3$. There may also be some emissions of fine particulate matter from material handling/transfer processes; however, these emissions tend to be small due to the typically high moisture content of compost materials.

## III. EF Determination Analysis

Many factors, which are related, affect the composting process that makes it difficult to scientifically analyze composting from an air emissions standpoint. The major factors affecting compost are oxygen, moisture, seasonal temperature fluctuation, temperature increases resulting from microbial respiration, nutrients (especially carbon and nitrogen), feedstock variability and pH. As such, the District will rely heavily on actual test data for this emission factor determination.

### *A. Green Waste Composting EFs*

The EFs are based on the available source test data for organic material composting sites. The District contracted a review of this data to Charles E. Schmidt with the goal of establishing green waste EFs for rule making purposes. The report was intended to identify the tests that utilized appropriate sampling and analytical methods and that were statistically relevant. As a result, the following report was prepared: "Organic Material Composting and Drying focusing on

Greenwaste Compost Air Emissions Data Review", by Thomas R. Card and Charles E. Schmidt, June 2008. This report will be referred to as the "green waste report" hereafter within this document.

The tests were based on the concept of flux emissions escaping the green waste piles. In this context, flux means the rate of mass flow of fluid gases through a given surface area. For example, the flux emissions may be measured in units of mg-VOC/min-$m^2$. Knowing the total composting period of time, surface pile area, and pile mass, the flux emission factors may be converted to typical EFs used for permitting and rule making, such as in units of lb-VOC/ton. The flux emissions were primarily sampled using the SCAQMD Modified USEPA surface emission isolation flux chamber method, and analyzed using SCAQMD Method 25.3 for total VOCs.

Table 5.1 of the green waste report summarizes the most relevant green waste composting data. The relevant test locations identified in Table 5.1 are Site X, CIWMB Modesto, NorCal, CIWMB Tierra Verde, and two at SCAQMD Inland. Since the compilation of the green waste report, another relevant test was performed at the Northern Recycling Zamora Compost Facility. This test was also conducted by Card and Schmidt. The summary is contained in Tables 2 and 3 below.

1.) Green Waste Stockpile EF

The green waste EFs shown in the Table 2 below are based on a one day stockpile period. While a one day stockpiling period may not be how every facility in the SJV operates, the EF can be applied on a case-by-case basis when stockpiling time periods are known. Also of note, the source test reports do not show the Table 2 numbers directly. The source tests each reported the stockpile EF based on their own site-specific stockpile period. For example, the Northern Recycling Zamora stockpile test assumed the EF for a 90-day stockpile time. The Northern Recycling Zamora stockpile sampling was performed on days 1 and 7, which is representative of normal SJV stockpiling. To arrive at the 90-day stockpile EF, it was assumed the average rates measured on days 1 and 7 were emitted for 90 days. The District reduced the EF to a one-day basis for this EF report. Each of the other stockpile EFs were normalized to a one day basis as well.

Table 2: Green Waste Stockpile VOC EF

| Site | Sampling Age of Material | Season Samples Taken | EF (lb-VOC/wet ton/day) |
|---|---|---|---|
| Northern Recycling Zamora | Day 1 & Day 7 | Spring | 0.126 |
| NorCal Jepson Prairie (Vacaville) | Day 1 | Summer | 0.422 |
| SCAQMD Inland #1 ("Summer") | Day 2 | Fall | 0.135* |
| SCAQMD Inland #2 ("Winter") | Day 2 | Fall | 0.101* |
| **Average** | | | **0.2** |

*2.798 and 0.907 were identified in the South Coast AQMD reports for Inland #1 and Inland #2, respectively; however, after a review of the data, South Coast AQMD corrected the values to 0.135 for Inland #1 and 0.101 for Inland #2.

The District surveyed the green waste composting facilities in the San Joaquin Valley. The result of the survey indicates an average stockpile time of 3.85 days, and ranged from 0-21 days. The Site X stockpile EF was based on sampling at day 45, and is not representative of stockpiling in the San Joaquin Valley. As such, the Site X stockpile test was not included in the stockpile EF. The test at CIWMB (Modesto) contained no stockpile data and does not factor into the green waste stockpile EF. The test at CIWMB Tierra Verde contained no uncontrolled stockpile data and does not factor into the green waste stockpile EF.

2.) Green Waste Windrow EF

On March 2, 2015, CARB published *ARB Emissions Inventory Methodology for Composting Facilities*[1] for estimating emissions from composting operations. The emission factor is an average of 9 different green waste source tests, summarized in the table below.

[1] https://ww3.arb.ca.gov/ei/areasrc/composting_emissions_inventory_methodology_final_combined.pdf

Table 3: Green Waste Windrow EFs for VOC and $NH_3$

| Summary of CARB Green Waste Composting Emissions Test Data | | | |
|---|---|---|---|
| **Site** | | **VOC (lb/wet ton)** | **$NH_3$ (lb/wet ton)** |
| 1 | SCAQMD Inland (Winter) | 1.56 | 0.26 |
| 2 | SCAQMD Inland (Fall) | 2.25 | 0.63 |
| 3 | CIWMB (Modesto) | 0.85 | N/A |
| 4 | CIWMB<br>(Modesto - 15% by weight food waste) | 1.95 | N/A |
| 5 | Site X | 6.30 | 2.34 |
| 6 | Jepson Prairie | 5.65 | 0.24 |
| 7 | Northern Recycling (Zamora) | 10.03 | 0.45 |
| 8 | City of Modesto | 1.50 | N/A |
| 9 | City of Modesto (15% by weight food waste) | 2.20 | N/A |
| **Average** | | **3.58** | **0.78** |

Please note, the values are based on the input material (as wet tons), not finished material. The green waste windrow composting EF is based on a typical active + curing phase composting life cycle (minimum 60 days). The active phase has been defined at a minimum 22 days for District purposes. The District has also examined the VOC profile split over the course of a windrow cycle. The results are summarized below.

Table 4: Green Waste Windrow VOC EF Active-Phase vs Curing-Phase.

| Windrow Phase | Overall EF Active + Curing (lb-VOC/wet ton) | VOC Profile Split (%) | Phase EF (lb-VOC/wet ton) |
|---|---|---|---|
| Active-Phase | 3.58 | 90% | 3.22 |
| Curing-Phase | | 10% | 0.36 |

### *B. Food Waste Composting EFs*

The District has not been able to identify an emission factor for uncontrolled food waste composting. Source tests from controlled composting operations have yielded emission factors ranging from 3.4 lb VOC per ton food waste composted (micropore cover) to 37.1 lb VOC per ton food waste composted (Ag Bag). In addition to the wide range of values observed, it is also unlikely that emissions from a covered system would accurately represent emissions from the open windrow commonly used by facilities in the District. This is because covered systems offer many process control advantages including weather protection and water retention.

Source testing was conducted at the City of Modesto compost facility as a field test study for the California Integrated Waste Management Board (CIWMB). Two goals of this test were to determine VOC emissions from green waste composting and food waste composting. The food waste composting windrows contained approximately 15% food waste (from local food processing plants (e.g. peppers, tomatoes, peaches, and syrup) and 85% ground green waste. The resulting EFs were 0.85 lb-VOC/ton and 1.95 lb-VOC/ton for green waste and food waste respectively. As predicted, the food waste EF was higher than the green waste EF, 2.3 times higher for this test site. Since the average green waste EF has been established at 3.58 lb-VOC/ton, the District considers the food waste EF to be too low to be usable as a stand-alone food waste composting EF since it would be lower than the green waste EF. However, if more data were to become available for food waste composting, the food waste EF from the City of Modesto test site may be used in combination with the new data.

For these reasons, the District will use the green waste composting emission factor to represent this feedstock until a more representative emission factor can be identified.

### *C. Grape Pomace Composting EFs*

The District has not been able to identify an emission factor for grape pomace composting. Therefore, the District will use the green waste composting emission factor to represent this feedstock until a more data is available.

### *D. Biosolids, Animal Manure, Poultry Litter, and Co-Composting EFs*

1.) Biosolids, Animal Manure, Poultry Litter, and Co-Compost Stockpile EF

The VOC and $NH_3$ emission factors for stockpiling of biosolids, manure, and poultry litter were based on emissions testing at Los Angeles County Sanitation District's (LACSD) Joint Water Pollution Control Plant, which was published as "Assessment of Air Emissions From Fresh and Aged Biosolids", by Thomas R. Card and Charles E. Schmidt, October 2007.

Table 5: Biosolids, Animal Manure, Poultry Litter, and Co-Compost EF

| Summary of District Stockpile Emission Factor | | |
|---|---|---|
| **Stockpile Type** | **Emission Factors (lb/wet ton/day)** | |
| | **VOC** | **$NH_3$** |
| Biosolids, Animal Manure, Poultry Litter, and Co-Compost | 0.2 | 0.02 |

2.) Biosolids, Animal Manure, Poultry Litter, and Co-Composting Windrow EF

Biosolids and animal manure composting emission factors were taken from source tests conducted by the South Coast Air Quality Management District (SCAQMD) in support of their Rule 1133 (Emission Reductions from Composting and Related Operations). These emission factors were calculated as an average of emissions from three co-composting facilities (SCAQMD, 2002) as presented in the Table below.

The District has not been able to identify an emission factor for poultry litter composting. The District will use the biosolids composting emission factor to represent this feed stock until a more representative emission factor can be identified.

Table 6: Biosolids, Animal Manure, Poultry Litter, and Co-Composting EFs.

| Summary of Co-Composting Emission Factors Developed by SCAQMD | | |
|---|---|---|
| **Location** | **Emission Factors (lb/wet-ton)** | |
| | **VOC** | **$NH_3$** |
| RECYC Inc | 0.53 | 2.70 |
| EKO Systems | 1.70 | 3.28 |
| San Joaquin Composting | 3.12 | 2.81 |
| **Average** | **1.78** | **2.93** |

## Summary

The District's composting EFs are summarized in the table below.

Table 7: Summary of District Composting EFs.

| **Operation Type** | **Emission Factors** | |
|---|---|---|
| | **VOC** | **$NH_3$** |
| Organic Waste Stockpile* | 0.2 lb/wet ton/day | 0.02 lb/wet ton/day |
| Biosolids, Manure, Poultry Litter, and Co-Compost Stockpile | 0.02 lb/wet ton/day | 0.001 lb/wet ton/day |
| Organic Waste Composting** | 3.58 lb/wet ton | 0.78 lb/wet ton |
| Biosolids, Manure, Poultry Litter, and Co-Composting** | 1.78 lb/wet ton | 2.93 lb/wet ton |

* The organic material stockpile EF shall be used for the following types of organic material stockpiles: green waste, 15% food waste, and grape pomace.
**Emission Factors represent the entirety of the composting cycle, i.e. start of the active phase through completion of the curing phase.

## References

1. "Organic Material Composting and Drying focusing on Greenwaste Compost Air Emissions Data Review", by Thomas R. Card and Charles E. Schmidt, June 2008

2. "Northern Recycling Zamora Compost Facility Air Emissions Source Test", by Thomas R. Card and Charles E. Schmidt, May 2009

3. "Assessment of Air Emissions from Fresh and Aged Biosolids", by Thomas R. Card and Charles E. Schmidt, October 2007