**OPEN BURNING - YARD WASTE - LEAF AND BRUSH SPECIES**

***a. Source Category Description***

Open burning of yard waste is the purposeful burning of leaf and brush species in outdoor areas. Criteria air pollutant (CAP) and hazardous air pollutant (HAP) emission estimates for leaf and brush waste burning are a function of the amount of waste burned per year.

For this source category, the following SCCs were assigned:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCC** | **SCC Level 1** | **SCC Level 2** | **SCC Level 3** | **SCC Level 4** |
| 2610000100 | Waste Disposal, Treatment, and Recovery | Open Burning | All Categories | Yard Waste – Leaf Species Unspecified |
| 2610000400 | Waste Disposal, Treatment, and Recovery | Open Burning | All Categories | Yard Waste – Brush Species Unspecified |

***b. Activity Data***

The amount of household MSW burned was estimated using data from EPA’s *Advancing Sustainable Materials Management: 2013 Fact Sheet*.1,2 The report presents the total mass of waste generated from the residential and commercial sectors in the United States by type of waste for the calendar year 2013. According to the 2010 version of the EPA report, residential waste generation accounts for 55-65 percent of the total waste from the residential and commercial sectors.3 For the calculation of per capita yard waste subject to burning, the median value of 60 percent was assumed. This information was used to calculate a daily estimate of the per capita yard waste of 0.36 lbs/person/day. Of the total amount of yard waste generated, the yard waste composition was assumed to be 25 percent leaves, 25 percent brush, and 50 percent grass by weight.4

Open burning of grass clippings is not typically practiced by homeowners, and as such only estimates for leaf burning and brush burning were developed. Approximately 25 to 32 percent of all waste that is subject to open burning is actually burned.4 A median value of 28 percent is assumed to be burned in all counties in the United States.

The per capita estimate was then multiplied by the 2014 population in each county that is expected to burn waste. Since open burning is generally not practiced in urban areas, only the rural and like rural population in each county was assumed to practice open burning. Like rural population is defined as the population of urbanized areas and urban clusters with population densities equal to or less than the maximum rural population density value for all counties. The ratio of rural and like rural to total population was obtained from 2010 U.S. Census data.5 This ratio was then multiplied by the 2014 U.S. Census Bureau estimate6 of the population in each county to obtain the county-level rural population for 2014.

The percentage of forested acres from Version 2 of BELD2 within BEIS was used to adjust for variations in vegetation. The percentage of forested acres per county (including rural forest and urban forest) was then determined. To better account for the native vegetation that would likely be occurring in the residential yards of farming States, agricultural land acreage was subtracted before calculating the percentage of forested acres. Table 1 presents the ranges that were used to make adjustments to the amount of yard waste that is assumed to be generated per county. All municipios in Puerto Rico and counties in the U.S. Virgin Islands, Hawaii, and Alaska were assumed to have greater than 50 percent forested acres.

**Table 1. Adjustment for Percentage of Forested Acres**

|  |  |
| --- | --- |
| **Percent Forested Acres per County** | **Adjustment for**  **Yard Waste Generated** |
| < 10% | 0% generated |
| >= 10%, and < 50% | 50% generated |
| >= 50% | 100% generated |

***c. Controls***

Controls for residential MSW burning are generally in the form of a ban on open burning of waste in a given municipality or county. However, literature suggests that burn bans are not 100% effective. It was therefore assumed that approximately 25% of the residents that may burn trash in the yard would burn waste even if a ban is in place. For counties that have burn bans, the assumption was applied by multiplying .25 by the number of persons estimated to practice open burning. For example, the State of Colorado implemented a state-wide ban on open burning, and this method was employed for all counties in Colorado.

***d. Emission Factors***

Emission factors are specific to yard waste type and are reported in Tables 2 and 3 below. Emission factors for CAPs were developed by the U.S. Environmental Protection Agency (EPA) in consultation with the Eastern Regional Technical Advisory Committee.7 For leaf burning, emission factors for PM2.5 were calculated by multiplying the PM10 leaf burning emission factors by the PM2.5 to PM10 emission factor ratio for brush burning (0.7709). Emission factors for HAPs are from an EPA Control Technology Center report.8 Forest fire simulation emission factors were used to estimate emissions for 17 dioxin congeners.9

***e. Emissions***

County-level criteria pollutant and HAP emissions were calculated by multiplying the total amount of yard waste (either leaf or brush) burned per year by an emission factor. Emissions for leaves and residential brush were calculated separately, since emission factors vary by yard waste type.

***f. Example Calculations***

VOC emissions in Autauga County, Alabama from open burning of leaf waste:

Population of Autauga County in 2010 = 55,395

Rural fraction of Autauga County population = 0.42

Per capita waste yard waste generated (lb/person/day) = 0.35

Leaf fraction of waste = 0.25

Fraction of rural population that burns yard waste = 0.28

Adjustment factor based on % forested acres = 1

Number of days in a year = 365

Factor to convert from lbs to tons = 1/2000

2014 leaf burning activity in Autauga County = 55,395 \* 0.42 \* 0.35 \* 0.25 \* 0.28 \* 1 \* 365 \* 1/2000

2014 leaf burning activity in Autauga County = 240 tons

VOC emissions = tons of leaves burned \* VOC emission factor

VOC emission factor = 28 lb/ton

VOC emissions from leaf burning in Autauga County in 2014 = 105 tons \* 28 lbs/ton \* 1 ton/2000 lbs

VOC emissions from leaf burning in Autauga County in 2014 = 1.5 tons

***g. Changes from 2011 Methodology***

The main change to the methodology as compared to the 2011 NEI was the use of population density to determine the number of people likely to burn waste in a county. In the previous methodology, an 80% urban no-burn threshold, based on the ratio of urban to rural *population,* indicated that a county would have zero emissions from yard waste burning. In the current methodology, this no burn threshold was replaced by the use of population density to determine rural and like rural populations for each county. Additionally, the current methodology assumes that 25% of people likely to burn in counties with bans will do so, even with bans in place.

***h. Puerto Rico and US Virgin Islands Emissions Calculations***

2014 Census Data does not exist for the US Virgin Islands. Emissions are calculated using the same method described above using 2010 data.

***i. References***

1. U.S. Environmental Protection Agency, [*Advancing Sustainable Materials: 2013 Fact Sheet*, "Table 1](https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf). Generation, Recovery and Discards of Materials in MSW, 2013(in millions of tons and percent of generation of each material)," February 2014, (accessed May 2019).

2. U.S. Environmental Protection Agency, [*Advancing Sustainable Materials: 2013 Fact Sheet*](https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf), "Table 2. Generation, Recovery and Discards of Materials in MSW, 2013(in millions of tons and percent of generation of each product)," February 2014, (accessed May 2019).

3. U.S. Environmental Protection Agency, [*Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010—Fact Sheet*](https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management-0)," p. 4, December 2011, (accessed May 2019).

4. Two Rivers Regional Council of Public Officials and Patrick Engineering, Inc. “Emission Characteristics of Burn Barrels,” prepared for the U.S. Environmental Protection Agency, Region V. June 1994.

5. U.S. Census Bureau, Decennial Censuses, [2010 Census: Summary File 1](https://www2.census.gov/census_2010/04-Summary_File_1/),

6. U.S. Census Bureau. [*Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014, 2014 Populations Estimates*](https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2014_PEPANNRES&prodType=table)*,* (accessed May 2019).

7. Huntley, Roy, U.S. Environmental Protection Agency, “state\_comparison ERTAC SS\_version7\_3 Oct 20 2009 [electronic file],” November 5, 2009.

8. U.S. Environmental Protection Agency, *Evaluation of Emissions from the Open Burning of Household Waste in Barrels*, EPA-600/R-97-134a, Control Technology Center. November 1997.

9. Gullet, B.K. and T. Abderrahmne, “PCDD/F Emissions from Forest Fire Simulations,” *Atmospheric Environment*, Vol. 37, No. 6, pp. 803-813. February 2003.

**Table 2. Emission Factors for Open Burning of Leaf Species (SCC 2610000100)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pollutant** | **Pollutant Code** | **Emission Factor**  **(lb/ton)** | **Emission**  **Factor**  **Reference** |
| 1,2,3,4,6,7,8-heptachlorodibenzofuran | 67562394 | 5.08E-08 | Reference 9 |
| 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin | 35822469 | 3.32E-07 | Reference 9 |
| 1,2,3,4,7,8,9-heptachlorodibenzofuran | 55673897 | 6.12E-09 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzofuran | 70648269 | 3.34E-08 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin | 39227286 | 1.136E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzofuran | 57117449 | 1.428E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin | 57653857 | 2.14E-08 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzofuran | 72918219 | 2.22E-09 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin | 19408743 | 3.46E-08 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzofuran | 57117416 | 1.268E-06 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzo-p-dioxin | 40321764 | 7.66E-09 | Reference 9 |
| 2,3,4,6,7,8-hexachlorodibenzofuran | 60851345 | 1.962E-08 | Reference 9 |
| 2,3,4,7,8-pentachlorodibenzofuran | 57117314 | 2.02E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzofuran | 51207319 | 1.396E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzo-p-dioxin | 1746016 | 2.3E-09 | Reference 9 |
| CO | CO | 112 | Reference 7 |
| Cumene | 98828 | 0.01325 | Reference 8 |
| Ethyl Benzene | 100414 | 0.048 | Reference 8 |
| Nitrogen Oxides | NOX | 6.2 | Reference 7 |
| Octachlorodibenzofuran | 39001020 | 2.06E-08 | Reference 9 |
| Octachlorodibenzo-p-dioxin | 3268879 | 1.328E-06 | Reference 9 |
| Phenol | 108952 | 0.115 | Reference 8 |
| PM10-FIL | PM10-FIL | 22 | Reference 7 |
| PM10-PRI | PM10-PRI | 22 | Reference 7 |
| PM25-FIL | PM25-FIL | 16.96 | 0.7709 \* PM10 |
| PM25-PRI | PM25-PRI | 16.96 | 0.7709 \* PM10 |
| Styrene | 100425 | 0.1015 | Reference 8 |
| Sulfur Dioxide | SO2 | 0.76 | Reference 7 |
| VOC | VOC | 28 | Reference 7 |

**Table 3. Emission Factors for Open Burning of Brush Species (SCC 2610000400)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pollutant** | **Pollutant Code** | **Emission Factor**  **(lb/ton)** | **Emission**  **Factor**  **Reference** |
| CO | CO | 140 | Reference 7 |
| Nitrogen Oxides | NOX | 5 | Reference 7 |
| PM10-PRI | PM10-PRI | 19.73 | Reference 7 |
| PM10-FIL | PM10-FIL | 19.73 | Reference 7 |
| PM25-PRI | PM25-PRI | 15.21 | Reference 7 |
| PM25-FIL | PM25-FIL | 15.21 | Reference 7 |
| Sulfur Dioxide | SO2 | 1.66 | Reference 7 |
| VOC | VOC | 19 | Reference 7 |
| 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin | 35822469 | 3.32E-07 | Reference 9 |
| 1,2,3,4,6,7,8-heptachlorodibenzofuran | 67562394 | 5.08E-08 | Reference 9 |
| 1,2,3,4,7,8,9-heptachlorodibenzofuran | 55673897 | 6.12E-09 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzofuran | 70648269 | 3.34E-08 | Reference 9 |
| 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin | 39227286 | 1.136E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzofuran | 57117449 | 1.428E-08 | Reference 9 |
| 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin | 57653857 | 2.14E-08 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzofuran | 72918219 | 2.22E-09 | Reference 9 |
| 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin | 19408743 | 3.46E-08 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzofuran | 57117416 | 1.268E-06 | Reference 9 |
| 1,2,3,7,8-pentachlorodibenzo-p-dioxin | 40321764 | 7.66E-09 | Reference 9 |
| 2,3,4,6,7,8-hexachlorodibenzofuran | 60851345 | 1.962E-08 | Reference 9 |
| 2,3,4,7,8-pentachlorodibenzofuran | 57117314 | 2.02E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzofuran | 51207319 | 1.396E-08 | Reference 9 |
| 2,3,7,8-tetrachlorodibenzo-p-dioxin | 1746016 | 2.3E-09 | Reference 9 |
| Cumene | 98828 | 0.01325 | Reference 8 |
| Ethyl Benzene | 100414 | 0.048 | Reference 8 |
| Octachlorodibenzofuran | 39001020 | 2.06E-08 | Reference 9 |
| Octachlorodibenzo-p-dioxin | 3268879 | 1.328E-06 | Reference 9 |
| Phenol | 108952 | 0.115 | Reference 8 |
| Styrene | 100425 | 0.1015 | Reference 8 |