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EPA/EREF Research Project Quantifies Landfill Gas Emissions

ABSRACT: The quality of raw gas from municipal solid waste landfills is 10 to 1,000 times lower than previously reported in AP-42 with 5 compounds not detected (acrylonitrile, ethyl mercaptan, carbonyl sulfide, Freon-21, and methyl mercaptan). MSW landfill owners and operators can use the data from this research project fro Clean Air Act regulatory compliance, which may result in some landfills being excluded from regulatory compliance.

Concerns have been expressed to the Environmental Protection Agency (EPA) by industry and others regarding the need for more up-to-date landfill gas emission factors that are contained in the document *Compilation of Air Pollutant Emissions Factors* commonly referred to as AP-42 (*http://www.epa.gov/ttn/chief/ap42/ch02/index.html*). These emission factors are used by regulators in establishing air permits, developing national and regional emission inventories, and evaluating residual risk. Most of the existing data used by EPA to develop the landfill gas emission factors was from sites tested in the 1980's prior to the development of the new federal regulations under Subtitle D of the Resource Conservation and Recovery Act (RCRA) in 1991.

Through a Cooperative Research and Development Agreement (CRADA), EPA and the Environmental Research and Education Foundation (EREF) formed a partnership in 2001 to collect comprehensive air emissions data at newer municipal solid waste (MSW) landfills because the data were thought to be much different than the data at older landfills and reported in AP-42. The purpose of the research project was to collect and analyze:

- MSW landfill gas pre-combustion, which represents uncontrolled air emissions from landfills; and
- MSW landfill gas combustion device emissions, which represents combustion equipment efficiency and the byproducts of landfill gas combustion.

The landfill gas combustion devices evaluated included enclosed flares, turbines, reciprocating internal combustion engines (RICE) and boilers.

Average results for the raw landfill gas testing (i.e., pre-combustion) are shown in Table 1. Of the 48 AP-42 compounds analyzed for, more than half of the compounds were at least an order of magnitude less (10^{-1}) than the listed AP-42 values. In summary, the raw landfill gas test results showed that:

- 14 compounds were one order of magnitude less (10^{-1}) than their respective AP-42 value;
- 7 compounds were two orders of magnitude less (10^{-2}) than their respective AP-42 value; and
- 2 compounds were three orders of magnitude less (10^{-3}) than their respective AP-42 value.

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Table 1. Constituent Concentrations and AP-42 Default Values (ppmv)

Compound	AP-42 Default Value	Average Concentration
1,1,1-Trichloroethane	0.48	0.0073
1,1,2,2-Tetrachloroethane	1.11	0.0059
1,1-Dichloroethane	2.35	0.2450
1,1-Dichloroethene	0.20	0.0172
1,2-Dichloroethane	0.41	0.0130
1,2-Dichloropropane	0.18	0.0013
Isopropyl Alcohol	50.10	2.1480
Acetone	7.01	8.3880
Acrylonitrile	6.33	ND
Bromodichloromethane	3.13	0.0027
Butane	5.03	10.034
Carbon Disulfide	0.58	0.1476
Carbon Tetrachloride	0.004	0.0089
Ethyl Mercaptan	2.28	ND
Carbonyl Sulfide	0.49	ND
Chlorobenzene	0.25	0.2826
Chloroethane	1.25	6.7360
Chloroform	0.03	0.2918
Chloromethane	1.21	0.3152
1,4-Dichlorobenzene	0.21	0.2624
1,3- Dichlorobenzene	0.21	0.2090
1,2- Dichlorobenzene	0.21	0.0067
Freon-12	15.70	0.7316
Freon-21	2.62	ND
Methylene Chloride	14.30	2.1352
Dimethyl Sulfide	7.82	0.1440
Ethane	889	8.8400
Ethanol	27.20	0.1576
Ethybenzene	4.61	3.4780
1,2-Dibromoethane	0.001	0.0058
Trichloromonofluromethane	0.76	0.2012
Hexane	6.57	1.9035
Hydrogen Sulfide	35.50	97.24
Total Mercury	253.0E-6	125.2E-6
2-Butanone	7.09	3.3660
2-Hexanone	1.87	0.1997
Pentane	3.29	7.2140
Tetrachloroethylene	3.73	0.6106
Methyl Mercaptan	2.49	ND
Propane	11.10	19.66
t-1,2-Dichloroethene	2.84	0.0214
Trichloroethylene	2.82	0.2316
Vinyl Chloride	7.34	0.5077
m/p-Xylene	12.10	7.904
o-Xylene	12.10	2.776
Benzene	1.91	0.8082
NMOC as Hexane	595.00	1567.4
Toluene	39.30	13.93

In fact, five compounds (acrylonitrile, ethyl mercaptan, carbonyl sulfide, Freon-21, and methyl mercaptan) were not detected in any sample. This is significant because MSW landfills had been identified as the largest source of acrylonitrile in EPA's urban air toxics program. Based on the data collected, modern MSW landfills appear to generate lower concentrations of organic compounds then older sites.

The research also collected data on post–combustion emissions of landfill gases from various combustion devices and the average data is shown in Table 2. In general, combusted gas test results showed that:

- Oxygen (O_2), carbon dioxide (CO_2), and nitrogen oxides (NO_x) were highest from RICE;
- Total hydrocarbons and polyaromatic hydrocarbons (PAH) were highest for RICE and may be the result of the MSW landfill accepting petroleum cleanup wastes;
- Total dioxin and furans were primarily below the detection limits of the analytical instruments except for boilers; and
- Heavy metals emissions were low, except from boilers.

EPA will be using the data collected under this research program along with other submitted industry data to update the AP-42 values. In addition, EPA intends to update the gas collection efficiency data. The agency is unsure when the updated AP-42 values will be available and has stated that MSW landfill owners and operators can use the data from this research project for Clean Air Act regulatory compliance, which may result in some landfills being excluded from regulatory compliance.

The final report titled *Field Test Measurements at Five Municipal Solid Waste Landfills with Landfill Gas Control Technology* including reports for the individual landfills is available on EPA website at *http://epa.gov/ORD/NRMRL/publications.html*.

For further information on the project, contact Dr. Edward Repa, EREF's Vice President of Environmental Programs, at 703-299-5139 extension 11 or *erepa@erefdn.org*. ◆

Table 2. Emissions from Control Technologies

Parameter		Flare	Rice	Boiler
O_2 (%v/v)	Range	12.5 -16.4	2.3-7.6	7.2-7.9
	Average	14.2	5.1	7.5
CO_2 (%v/v)	Range	2.9-6.4	12.8-16.5	12.1-12.
	Average	5.3	14.6	12.3
Moisture (%v/v)	Range	5.8-10.3	11.3-18.3	11.6-14.1
	Average	7.5	14.6	12.6
CO (ppmv)	Range	11-92	549-585	ND-14
	Average	45	564	9
SO_2 (ppmv)	Range	ND-8	ND-39	41-68
	Average	3.5	17.5	9
NO_x (ppmv)	Range	7.7-12	142-3150	3-21
	Average	9.8	1448	13
Total Hydrocarbon as Propone (ppmv)	Range	ND-35.6	645-994	ND
	Average	19.1	835	ND
Total Hydrocarbon as Hexane (ppmv)	Average	ND-17.8	323-497	ND
	Range	9.6	418	ND
Total Dioxins (x10-3 ng/dscm)	Average	<34.7	<33.8	341l
Total Furans (x10-3 ng/dscm)	Average	156	13.9	300
Total Dioxins/Furans	Average	190	<47.6	640
Total PAH (ng/dscm)	Average	7,930	43,400	7,960
HCl (ppmv)	Range	0.9-1.4	2.7-14.3	1.3-1.6
	Average	1.2	7.4	1.4
Arsenic (ug/dscm)	Average	2.7	3.1	2.3
Cadmium (ug/dscm)	Average	0.19	0.47	1.2
Lead (ug/dscm)	Average	0.33	3.31	6.0
Manganese (ug/dscm)	Average	8.1	9.5	4.0
Mercury (ug/dscm)	Average	ND	ND	0.46
Nickel (ug/dscm)	Average	3.3	13.8	47