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HYDROGEN SULFIDE REMOVAL FROM BIOGAS
Part 1e: Hydrogen Sulfide and Sulfur Emissions

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WHAT IS SO_X?

SO_x or oxides of sulfur, are sulfur compounds found in the exhaust gases following the combustion of biogas, or other fuels containing sulfur compounds (diesel, coal, etc.).

The most common component is sulfur dioxide (SO_2), but other oxides include:

SO, SO_3, SO_4, S_2O, S_2O_2, S_6O_2, S_7O_2, S_nO.

EFFECTS OF SO_X

SO_x poses a hazard to both human and animal health, as well as to the environment and farm equipment. SO_2 is the primary component of concern within SO_x.

Human and Animal Health Effects

Direct exposure to SO_2 and other sulfur oxides can cause irritation of the eyes and nose, throat and lungs, and inflammation of the airways.

SO_x can also react with other compounds in the atmosphere to form small particulate matter that can accumulate in the lungs, causing additional long-term health problems.

Environmental Health Effects

SO_2 and the other oxides of sulfur are corrosive and can directly damage plant material, reducing crop growth/productivity.

When SO_2 reacts with water vapor in the atmosphere it forms sulfuric acid, which is a major component of acid rain. Acid rain has negative effects on forests, soils, freshwater bodies (lakes, rivers, etc.), and even human structures such as corroding metal bridges, and weathering stonework.

Farm Equipment Effects

SO_2 can react with water vapor in the exhaust from an engine-generator or boiler burning biogas, to form sulfuric acid. Sulfuric acid is highly corrosive and can damage metal biogas and farm equipment, including structures with metal roofs, siding or beams.

HOW IS SULFUR DIOXIDE FORMED?

SO_2 is formed during the combustion of biogas containing hydrogen sulfide (H_2S).

$$2\ H_2S + 3\ O_2 \rightarrow 2\ H_2O + 2\ SO_2$$

REDUCING SO_X EMISSIONS FROM ON-FARM BIOGAS UTILIZATION EQUIPMENT

Because the main source of SO_x from the combustion of biogas is hydrogen sulfide (H_2S), reducing the concentration of H_2S in the biogas before it is combusted is the most effective way to reduce the production of SO_x.

Concentrations of H_2S in raw biogas commonly range from 600 to as high as 7,000 ppm.

Several different techniques are available for the removal of H_2S from biogas, and several are outlined in other fact sheets in this series, including, iron sponge, biotrickling filters, and in-vessel air injection.

Table 1 illustrates the effects of reducing H_2S concentration in biogas on the emissions of SO_2 as a function of farm size and co-digestion of additional organic wastes. Values were estimated using the National Pollutant Release Inventory (NPRI) calculators[1].

Table 1. Mass of SO_2 emissions avoided per year due to removal of H_2S from biogas.

Farm Size (LCE)[1]	Co-digestion[2]	Biogas Production (CF/day)	Mass (lbs) SO_2 removed per year when [H_2S] reduced (ppm)[3]					
			500	1,000	1,500	2,000	2,500	3,000
100	Manure only	7,900	239	478	717	956	1,195	1,434
	+10 % Whey	8,690	263	526	789	1,051	1,314	1,577
	+10 % FOG	12,874	389	779	1,168	1,558	1,947	2,337
250	Manure only	19,750	597	1,195	1,792	2,390	2,987	3,584
	+10 % Whey	21,725	657	1,314	1,971	2,629	3,286	3,943
	+10 % FOG	32,185	974	1,947	2,921	3,894	4,868	5,841
500	Manure only	39,500	1,195	2,390	3,584	4,779	5,974	7,169
	+10 % Whey	43,450	1,314	2,629	3,943	5,257	6,572	7,886
	+10 % FOG	64,370	1,947	3,894	5,841	7,788	9,736	11,683
1,000	Manure only	79,000	2,390	4,779	7,169	9,559	11,948	14,338
	+10 % Whey	86,900	2,629	5,257	7,886	10,514	13,143	15,772
	+10 % FOG	128,741	3,894	7,788	11,683	15,577	19,471	23,365
1,500	Manure only	118,500	3,584	7,169	10,753	14,338	17,922	21,507
	+10 % Whey	130,350	3,943	7,886	11,829	15,772	19,715	23,658
	+10 % FOG	193,111	5,841	11,683	17,524	23,365	29,207	35,048
2,000	Manure only	158,000	4,779	9,559	14,338	19,117	23,897	28,676
	+10 % Whey	173,800	5,257	10,514	15,772	21,029	26,286	31,543
	+10 % FOG	257,481	7,788	15,577	23,365	31,154	38,942	46,731
2,500	Manure only	197,500	5,974	11,948	17,922	23,897	29,871	35,845
	+10 % Whey	217,250	6,572	13,143	19,715	26,286	32,858	39,429
	+10 % FOG	321,852	9,736	19,471	29,207	38,942	48,678	58,414
3,000	Manure only	237,000	7,169	14,338	21,507	28,676	35,845	43,014
	+10 % Whey	260,700	7,886	15,772	23,658	31,543	39,429	47,315
	+10 % FOG	386,222	11,683	23,365	35,048	46,731	58,414	70,096
4,000	Manure only	316,000	9,559	19,117	28,676	38,234	47,793	57,352
	+10 % Whey	347,600	10,514	21,029	31,543	42,058	52,572	63,087
	+10 % FOG	514,963	15,577	31,154	46,731	62,308	77,885	93,462

[1] Lactating Cow Equivalent

[2] Whey and FOG (Fats, Oils and Greases) co-digested with manure at 10% on a Volatile Solids Basis

[3] Assuming a 98% conversion efficiency of H_2S to SO_2

[1]NPRI, 2003. Tools for calculating and reporting emissions. https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/tools-calculating-emissions.html#n2

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