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PRO DAIRY Education & Applied Research

HYDROGEN SULFIDE REMOVAL FROM BIOGAS
Part 1A: Hydrogen Sulfide and Biogas - Basics

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WHAT IS HYDROGEN SULFIDE?

Hydrogen sulfide (H_2S) is a colorless gas that is immediately recognizable for its "rotten egg smell". H_2S is found in biogas, with concentrations in dairy manure-derived biogas generally varying from 600 to sometimes over 7,000 ppm.

In addition to its characteristic smell, H_2S is also corrosive, flammable, poisonous, and heavier than air; the last two make H_2S a particularly dangerous gas from a human health perspective.

HOW IS HYDROGEN SULFIDE FORMED?

H_2S is formed during the anaerobic digestion of organic material. Because sulfur is an essential element for life, and a macronutrient in plant nutrition, organic material contains sulfur, sometimes significant quantities.

In the absence of oxygen, sulfur reducing bacteria obtain their energy by breaking down organic material and use sulfur (sulfate) rather than oxygen as the terminal electron acceptor.

Methanogenesis, the formation of methane (CH_4) by microbes, depends on the presence of organic sulfur cofactors, without which the methanogenic bacteria could not form CH_4.

The concentration of H_2S in biogas is influenced by a number of factors, including the sulfur content of the farm water, diet/ feed additives of the cows, and co-digestion of additional organic materials.

EFFECTS OF HYDROGEN SULFIDE

In addition to posing a hazard to human and animal health on-farm, H_2S can have negative effects on farm equipment.

Corrosion: H_2S will cause corrosion of metal such as iron and galvanized parts and rapid corrosion of non-ferrous metals such as brass, copper and aluminum. Care must be taken to ensure valves, pressure regulators, sensors and other components in the gas flow path are compatible with H_2S.

Besides direct corrosion from H_2S, when biogas is burned in an engine-generator set or boiler, sulfur dioxide (SO_2) is formed. When SO_2 reacts with water it forms sulfuric acid which is very corrosive of metal parts. Moisture is present in biogas, ~4% (unless reduced/removed pre-combustion), in combustion air, and is formed during combustion.

The formation of sulfuric acid is exacerbated when engines are started and stopped frequently. Exhaust systems and metals exposed to exhaust (galvanized structures, etc.) are particularly susceptible

SO_2 and water can also dissolve in the engine oil, making it acidic and less able to lubricate components. For this reason, the properties of the engine oil need to be closely monitored and the oil changed at a greater frequency when biogas H_2S concentrations are high.

HYDROGEN SULFIDE REMOVAL

Because of the negative effects of hydrogen sulfide on farm buildings, biogas handling, and end use equipment, it is often advised to treat biogas or "scrub" H_2S from the biogas.

Several techniques are commonly used for H_2S removal that fall into two general categories: in vessel and separate vessel.

In Vessel

Air Injection

In an air injection system, a small amount of oxygen is directly injected into the headspace of the anaerobic digester. Similarly to the biological trickling filter, microbes convert the H_2S into elemental sulfur, which builds up on the surface area intentionally provided in the reactor gas head space. Accumulated sulfur falls off and becomes part of the digester effluent.

Digester Additives

Digester additives are iron containing chemicals that are added to the digester influent. These chemicals in turn react with the hydrogen sulfide directly, binding them up and remain in this state as part of the digester effluent.

Separate Vessel:

Biological Trickling Filters

Biological trickling filters work by encouraging microbes that "fix" or use the sulfur in biogas. Ultimately the sulfur is flushed out of the system by system washwater.

Iron Sponge

In an iron sponge system, the H_2S reacts with iron impregnated in a bark media. Once the media has reacted with the H_2S it can be regenerated through the addition of oxygen; however, regeneration is not 100% and ultimately the media requires regular replacement and disposal.

Additional information is available from other fact sheets in this series specific to each method.

HYDROGEN SULFIDE SAFETY CONCERNS

Because H_2S is heavier than air, it can collect in low lying areas and enclosed spaces; coupled with its toxic properties it can pose severe risk to both human and animal health in certain conditions.

It is generally recommended that when working around manure storages, workers wear an H_2S personal gas monitor. The monitor can detect the presence of H_2S and alert the wearer when dangerous conditions are encountered.

Though the presence of H_2S can be readily detected at low concentrations through its characteristic odor, sensitivity to the odor is quickly lost when exposed to elevated concentrations, making it particularly dangerous to rely on smell alone for detection.

OSHA states that concentrations above 100 ppm are considered immediately dangerous to life and health. Inhaling a single breath of H_2S with a concentration above 1,000 ppm can lead to immediate collapse with a loss of breathing.

For more information on on-farm hydrogen sulfide safety concerns please refer to:
"Conducting a Safety Walk-Through on a Farm: Hazards of the Manure Handling System, Anaerobic Digester, and Biogas Handling System"[1]

[1] http://www.manuremanagement.cornell.edu/Pages/General_Docs/Papers/Self_assessment_Safety_Walk_through_Manure_Systems_2007.pdf

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