Ontario Rural Wastewater Centre

Info Sheet

Université de Guelph Campus d'Alfred

Background on Anaerobic Digestion at the Farm

A. Crolla and C. Kinsley[1]

Introduction

Over the past several years there has been significant interest in adopting on-farm manure anaerobic digesters in Ontario. The potential for sustainable energy production, while reducing greenhouse gas (GHG) emissions, mitigating pathogens and odours, and increasing ionized nutrients in the digestate, has made anaerobic digestion an attractive option for manure management. The biogas produced from the anaerobic digester can be used to fuel an electric co-generator, where the electricity produced is sold to the grid and waste heat recovered to be used on the farm. The co-digestion of manure with organic rich substrates can offer significantly increased biogas yields. Other advantages associated with the digestion of manure include improving the fertilizer value of the digested substrates (digestate), along with reduced odours and pathogens.

Credit: Heinzle Family

Figure 1. Terryland Farms Digester (St. Eugene, ON)

Process of Anaerobic Digestion

Anaerobic digestion is a biological process in which microorganisms metabolize organic matter (measured as volatile solids (VS)), in the absence of air, and produce biogas as a by-product. Typical biogas mixtures produced from dairy manure consist of 55-70% methane (CH_4) and 30-45% carbon dioxide (CO_2) [1, 2], with traces of inorganic gases that can include carbon monoxide (CO), hydrogen (H_2), hydrogen sulphide (H_2S), ammonia (NH_3), nitrogen (N_2) and nitrous oxide (N_2O) [3]. The anaerobic microbes necessary for anaerobic digestion exist naturally in livestock manure; therefore, the digester's function is to provide suitable operating conditions for the microbes (Table 1).

Table 1. Optimum Operating Conditions

Temperatures [2, 4, 5]	35-40°C (Mesophilic) 55-63°C (Thermophilic)
pH [3, 6]	6.8-7.2
Carbon:Nitrogen (C:N) Ratio [2, 7, 8]	20:1-30:1
Hydraulic Retention Times (HRTs) [7]	12-25 days (Dairy Manure) 15-35 days (Cattle Manure)
Organic Loading Rates (OLR) [7, 9]	3.5-5.5 kg VS/m^3/day

Biogas Yields from Digestion of Manure with Co-substrates

The co-digestion of manure with other substrates such as energy crops, industrial wastes, or food industry wastes can result in numerous benefits. The addition of co-substrates to manure can improve the C:N balance resulting in a stable digestion process with good digestate fertilizer quality [10]. Co-digestion also improves the flow qualities of the co-digested substrates [1]. Perhaps the most important drivers for co-digestion of manure with other substrates are the financial benefits associated with the increased biogas yields and income generated from tipping fees when wastes are used as co-substrates.

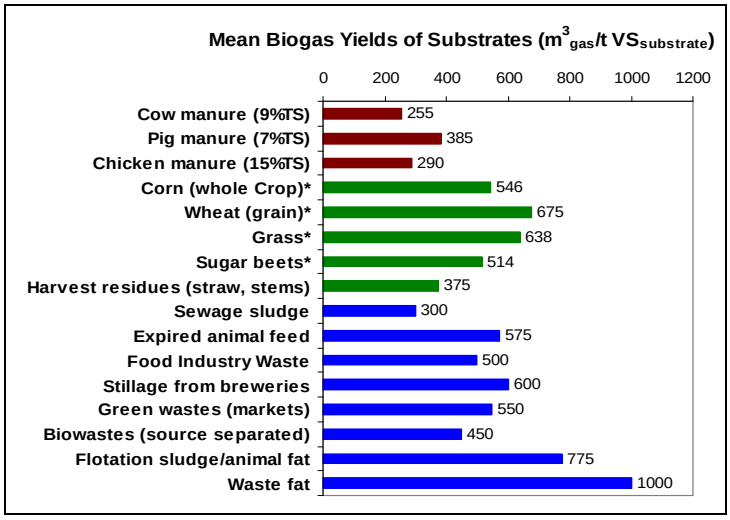

Figure 2. Potential Biogas Yields of Various Substrates for Co-digestion (Assumes biogas with 60% methane)
[Compilation of data from 10, 11, 12]

Credit: Terrence Sauvé

Figure 3. Various Co-substrates
(left to right: whey, corn syrup, grease trap waste, dissolved air flotation, waste glycerine)

A number of crops demonstrate good biogas potentials. Many varieties of grass, clover, cereals and corn, including whole plants, as well as rape or sunflower have shown to be suitable for methane production. Typically all C4-plants have very good growth yields. Recent German experience has shown mean methane yields of 330 m^3 CH_4/t for corn and 350 m^3 CH_4/t for barley [11], whereas methane yields from the digestion of cow manure alone will average a methane yield of 176 m^3 CH_4/t [12]. In Ontario there is a growing interest in the use of organic rich wastes as co-substrates in manure digestion for enhanced biogas production. There are a number of organic rich substrates that are easily degradable. Among these substrates are slurries, sludges, oils, fats and whey. Some of these substrates (e.g. source separated municipal bio-waste, food leftovers, waste grease, expired food, market wastes) would require pre-treatment to reduce particle size, remove indigestible components or to sterilize/pasteurize the substrates [10]. Readily degradable substrates, like fats and proteins, yield the highest percentages of methane [1].

Environmental Impacts Associated with Digestate

The anaerobic digestion of manure (and co-substrates) has been shown to:

1. Reduce CH_4 gas emissions from storage reservoirs holding digestate;
2. Reduce N_2O gas emissions from the land application of digestate;
3. Reduce odours in both storage reservoirs and during land application;
4. Reduce pathogens and weed seeds in the digestate;
5. Improve the fertilizer value of the digestate by transforming nutrients into more readily available inorganic forms.

Although nutrients in the digestate are in a form more easily available for plant uptake, this can also translate into nutrient losses if crops are not available for the uptake. Cover crops can be used to hold the nutrients.

Credit: ORWC

Figure 4. Land Application of Digestate

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[1]Ontario Rural Wastewater Centre, Université de Guelph-Campus d'Alfred, Alfred, Ontario, Canada.
Contact: a.crolla@alfredc.uoguelph.ca

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