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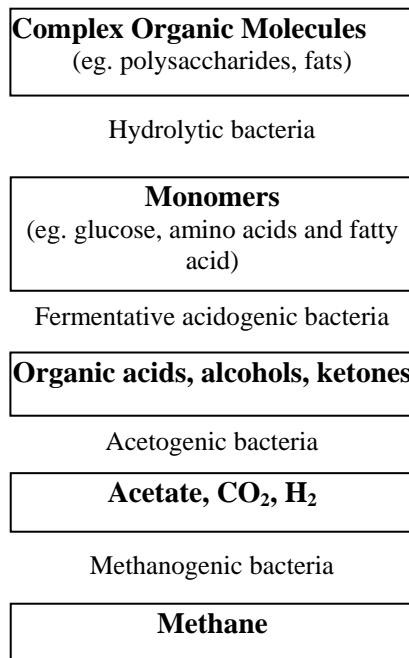
The Role of Anaerobic Digestion in an Integrated Biosystem.

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Introduction

Integrated biosystems, in which waste from one enterprise is used in another enterprise instead of just being disposed of, can include a wide range of systems. Existing examples range from small family units (as seen in countries like Vietnam) through corporate enterprises (for example Monteforte Boys Town in Fiji) to regional scale (such as occurs to some extent locally, where food grown on the Adelaide Plains is consumed in Adelaide, whose wastes are treated at Bolivar then the solids land spread in agricultural areas and the water used for irrigation in the Virginia horticultural area which is producing food for Adelaide).

Anaerobic digestion is a naturally occurring bacterial process that produces methane and carbon dioxide from decaying organic matter in the absence of oxygen. AD occurs in streams, lakes, swamps, land fill and saturated soil as well as the digestive tracts of animals (particularly ruminants). The breakdown of complex organic matter (proteins, fats and carbohydrates) is a multi stage process involving a large variety of bacteria, see Fig 1. In the final stage, which is of interest to us, methanogens work by two paths, some reducing carbon dioxide to methane and others converting acetic acid to methane (Cobb and Hill 1992).



Source: Gabriel Bitton, 1994, *Wastewater Microbiology*, Wiley-Liss, NY.

Fig 1: Anaerobic breakdown of complex organic matter

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Methane is a greenhouse gas causing 23 times more atmospheric warming than carbon dioxide and is also a clean burning fuel, the major constituent of natural gas. It has been suggested that methane ignited by lightning strikes, or other means, may be responsible for the "will o' the wisp" and possibly also for legends about dragons.

In a world struggling to deal with increasing volumes of waste material and an increasing demand for energy anaerobic digestion provides a possible solution to both problems and has been used in both western industrialised countries and in developing countries. In some systems the main emphasis may be on waste reduction (reducing the BOD/COD level of a waste stream to facilitate further treatment and reuse) with the energy produced being regarded as a by product. On the other hand the emphasis may be on energy production, with the reduction of pollution as an added bonus.

Alternatives to Anaerobic Digestion

The alternatives to anaerobic digestion are aerobic digestion, direct composting, incineration and gasification. Aerobic digestion requires a large amount of energy and produces larger quantities of bacterial sludge than anaerobic digestion. Direct composting is also an aerobic process that may be used to provide low grade heat as well as solids useful as soil conditioners. Incineration is another method of waste disposal that provides heat as a by product while gasification produces combustible gas. Both these latter methods may be suitable for dry residues and destroy organic matter, leaving only ash with little fertiliser value

Anaerobic Digesters

Many different types of digester are available, some better suited to certain applications.

Upflow Anaerobic Sludge Blanket digesters are suited to low solids waste streams and can handle variations in flow rate fairly well due to the biomass retained as granulated sludge. They are high rate and require the development of suitable sludge granules during startup.

Many agricultural digesters are Continuous Flow Stirred Tank types, which are high rate if properly heated and agitated.

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Fig 2 The CFST digester at Roseworthy Campus

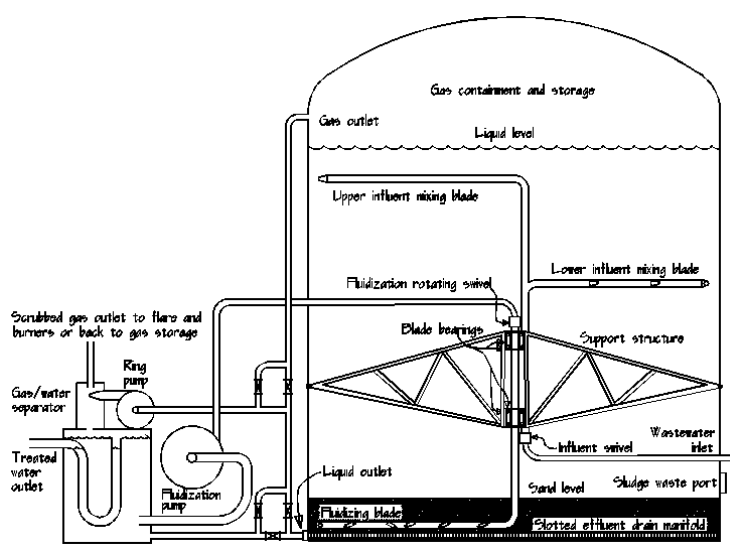


Fig 3 High Rate Digester by “NewBio”

Plug Flow digesters may be high rate or of very simple, low cost design

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Fig 4 Plug Flow Digester by “Practically Green”



Fig 5 "Poly" plug flow digester

With any digester the amount of biogas (approx 60% methane and 40% carbon dioxide with traces of ammonia, hydrogen sulphide, water and other volatiles) given off is a function of the amount of degradable solids added to the digester and the residence (or retention) time of the solids. The retention time is greatly influenced by temperature as the bacterial growth rate approximately doubles for each 5C increase in temperature. A model proposed by (Chen and Hashimoto 1978) was used to develop the graph in Fig 6.

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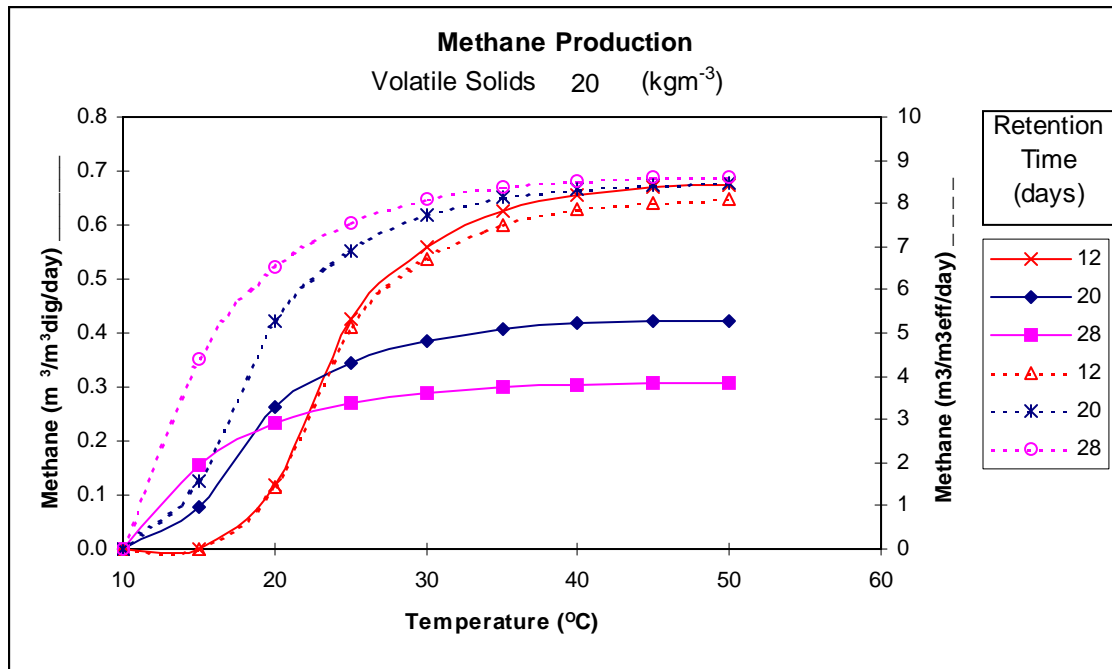


Fig 6 Relationship between Temperature and Retention Time

Advantages and Disadvantages of Anaerobic Digestion

Wastes treated anaerobically have reduced pathogen levels (how much reduction depends on the pathogen being considered, the temperature of operation and the retention time of the waste(Larsen, Munch et al. 1994; Sarapatka 1994, White and Horn 1998)). Treated wastes are easier to handle (White and Horn 1998) and do not adversely affect vegetation when land spread direct on to pastures, although the build up of heavy metals may be a problem with some wastes in the longer term. Another advantage of anaerobic digestion over aerobic digestion is the reduced production of bacterial sludge due to the slower growth rate possible under anaerobic conditions compared to aerobic digestion.

The main disadvantages of anaerobic digestion are the slow growth rates obtained, which require longer retention times and hence larger facilities, and the inability to effectively utilise lignin and cellulose (which are also not properly broken down by aerobic digestion).

Design Philosophy

In developing any integrated biosystem for agricultural application (and I suggest that there is an almost infinite number of possible combinations) there are two guiding principles that I think should be kept in mind.

- A simple system will be easier to build, maintain and operate. This means that low technology solutions must be sought for each component and that every extra bit added (both equipment and enterprises) should be easily justifiable by making a reasonable improvement to the total system performance.

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- The harder a system is pushed the more unstable it will become. Each enterprise needs to be designed with reasonable reserve capacity, rather than being pushed to the limit of performance as a lightly loaded (natural) system should need little operator intervention in monitoring, control or maintenance as it will be more stable (Rose 1999).

Conclusion

In conclusion anaerobic digestion can provide a reasonably low technology approach to primary waste treatment which results in energy production and better fertiliser properties than the raw waste, but must be seen as part of a system as the digester effluent is only partially treated for most purposes.

References

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