Beginners Guide to Biogas

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Designing a small Anaerobic Digester

(If you use this information in a project for assessment please give proper reference to the source!)

Disclaimer

This information is provided as a guide, since there have been a number of enquiries, and should be verified before undertaking construction. All care has been taken but no responsibility can be accepted because of the large number of variables in each different situation. In fact the most accurate information you can get will be obtained by building and running a small digester under local conditions, bearing in mind any effects of scale such as a greatertemperature range, and possibly better mixing in a small digester.

Please be aware of the **SAFETY** aspects of running a digester project!

There are number of ways to approach the design, I have chosen to assume the digester is supplying gas to a small household and work backwards from the use to the input required and finally to the digester size. The calculations below are approximate, as I am an engineer and cannot see the sense in a high degree of accuracy when there are so many variables.

Gas Requirement

On average 26 litres of gas are required to boil 1 litre of water (Rodriguez, Preston and Dolberg, 1996 in An et al, 1997), so approximately 200 litres of gas per day is required to cook three meals (An, Rodriguez, Sarwat, Preston and Dolberg, 1997). If this gas is 60 % methane (this is reasonable to achieve and biogas must be at least 50% methane to burn) we need about 120 litres of methane per day. Methane has an energy content of about 39 MJ per cubic metre.

Waste Requirement

One kg of "Volatile Solids" (the biologically degradable portion of wastes) produces 0.5 cubic metres of methane (McCarty, 1964 in Hill, 1983), but only about half the VS added to a digester will be broken down. (This will vary, hence the disclaimer above.) This means approximately 0.5 kg of VS must be added to the digester per day to produce 120 litres of methane.

The VS content of various wastes is given below, taken from ASAE Standard D384.1DEC93 (ASAE, 1998)

Fresh Maure Production (kg per day per 1000 kg liveweight)

Animal	Dairy	Beef	Veal	Pig	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total	86	58	62	84	40	41	51	64	85	47	110
% VS	10	7.2	2.3	8.5	9.2	na	10	12	17	9.1	19

Ram, 1993 gives human waste as 3% VS, but no production figures.

For example a 60 kg pig will provide the 0.5 kg VS needed per day in 5 kg of manure. 15 litres of water must be added to this amount of solid to avoid scum formation (An et al, 1997), who also says 4-5 pigs are needed to provide the gas for a family of 4-5. (This may be because of dietry differences, decomposition of effluent outside the digester and difficulty in collecting all the manure.)

Digester Size

Waste must be held in the digester for a period of time for digestion to occur, just how long depends on temperature. It is also worth considering that a longer retention time will release more of the potential gas, is likely to be more stable and does allow for future increases in demand (you can increase the loading rate a bit without fear of failure) BUT you do need a larger digester to hold the effluent long enough.

Temperature (°C)	Retention Time (days) minimum recommended	Retention Time (days) recommended
10	60	120
20	22	44
30	9	18

For 20°C operating temperature and a retention time of 44 days 20 litres per day input gives an operating capacity of 880 litres.

As the digester needs to be 5 to 10 times longer than its diameter it is possible to come up with a range of suitable dimensions for this capacity, allowing at least 10% extra volume for the gas head space.

For 1:5 proportions Diameter = cube root (4 x Volume / 5 / pi) and for 1:10 proportions Diameter = cube root (4 x Volume / 10 / pi) and pi = 3.14 or 22/7
eg. For an operating volume of 880 litres (or 0.88 cubic metres) plus 10% for head space gives 0.97 cubic metres volume required. For a 1:5 digester Diameter = 0.63 m (with a length of 3.2 m) or a 1:10 digester the diameter becomes 0.5 m (with a length of 5 m). A larger volume digester will extract more gas, be more robust and allow some room for extra manure if necessary.

For any diameter of digester the required length can be found by Length = 4 x Volume / pi / Diameter squared. Knowing the Flat Width of a poly "tube" (which is half the circumference) Diameter = 2 x FlatWidth / pi

If you want to investigate this further I can e-mail you an EXCEL(5/95) model of a Continuous Flow Stirred Tank

digester.

Images are also available.

REFERENCES

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4. Ram, M. S., L. Singh, et al. (1993). "Effect Of Sulfate and Nitrate On Anaerobic Degradation Of Night Soil." Bioresource Technology 45(3): 229-232.