

Sludge has high nitrogen content.

Factors affecting biodigestion or generation of gas

The following are the factors that affect generation of biogas:

- (1) pH or the hydrogen-ion concentration
- (2) Temperature
- (3) Total solid content of the feed material
- (4) Loading rate
- (5) Seeding
- (6) Uniform feeding
- (7) Diameter to depth ratio
- (8) Carbon to Nitrogen ratio
- (9) Nutrients
- (10) Mixing or stirring or agitation of the content of the digester
- (11) Retention time or rate of feeding
- (12) Type of feed stocks
- (13) Toxicity due end product
- (14) Pressure
- (15) Acid accumulation inside the digester.

1. pH or hydrogen ion concentration. pH of the slurry changes at various stages of the digestion. In the initial acid formation stage in the fermentation process, the pH is around 6 or less and much of CO_2 is given off. In the latter 2-3 weeks time, the pH increases as the volatile acid and N_2 compounds are digested and CH_4 is produced. To maintain a constant supply of gas, it is necessary to maintain a suitable pH range in the digester.

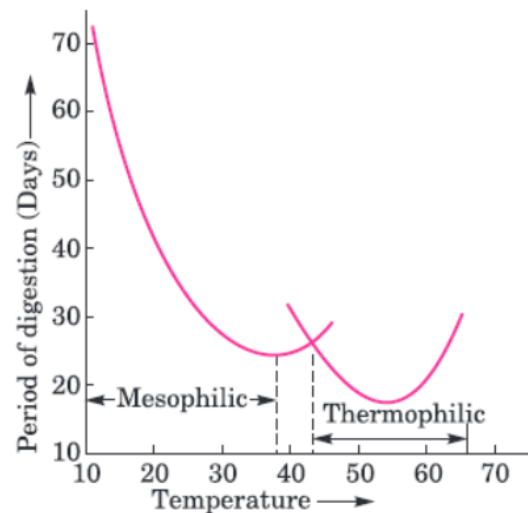
The digester is usually buffered if the pH is maintained between 6.5 to 7.5. In this pH range, the micro-organisms will be very active and biodigestion will be very efficient. If the pH range is between 4 and 6 it is called acidic.

Ideal PH is 7- 7.5

2. Temperature. Methane bacteria work best at a temperature of between 35° to 38°C . The fall in gas production starts at 20°C and stops at a temperature of 10°C . At one experiment 2.25 cu m of gas was produced from 4.25 m^3 , of cattle dung everyday when the digester temperature was 25°C . When the temperature was raised to 28.3°C , the gas production increased by 50% to 3.75 cu m/day.

There are two significant temperature zones in anaerobic digestion. These have been studied in some detail for digestion of sewage sludges for 90% digestion Fig. 17.5.1) shows the time required for 90% digestion at various temperatures, and the two temperature zones. It has been established that two types of micro organisms, mesophilic and thermophilic are responsible for digestion at the two temperature ranges. The optimum temperature lies at about 35°C , while the optimum thermophilic temperature is around 55°C . In temperate climates most of the sewage digestion tanks are heated to 35°C so as to reduce the time required for digestion and therefore the capacity of the tanks. The thermophilic range has not been put to use because of the problems associated with heating the tanks to such high temperatures. Heating of tanks designed mainly for collection of biogas may not be practicable, but it must be understood that temperature is a very important factor since it affects the bacterial activity directly. Any gross

deviation from a normal operating temperature may result in the unsatisfactory performance of the digester.



Effect of temperature on digestion.

3. Total Solid Content. The cow dung is mixed usually in the proportion of 1 : 1 (by weight) in order to bring the total solid content to 8-10%. The raw cowdung contains 80-82% of moisture. The balance 18-20% is termed as total solids. The adjustment of total solid content helps in bidegesting the material at the faster rate, and also in deciding the mixing of the various crop residues weeds plants etc. as feed stocks in biogas digester.

4. Loading Rate. Loading rate is defined as the amount of raw material (usually kg of volatile solids) fed to the digester per day per unit volume. Most municipal sewage treatment plants operate at a loading rate of 0.5 to 1.6 kg of volatile solids per m³ per day. Much higher rates are possible, but as with most aspects of digesters, the optimum situation is a compromise. If a digester is loaded with too much raw material at a time, acids will accumulate and fermentation will stop.

5. Seeding. Although the bacteria required for acid fermentation and methane fermentation are present in the cow dung, their numbers are not large. While the acid formers proliferate fast and increase in numbers, the methane formers reproduce and multiply slowly. It would be advantageous to increase the number of methane formers by artificial seeding with a digested sludge that is rich in methane formers. But beyond a certain seed concentration, the gas production will decrease, due to reduction of raw cow dung solids fed to the digester.

6. Uniform Feeding. One of the prerequisites of good digestion is the uniform feeding of the digester so that the micro-organisms are kept in a relatively constant organic solids concentration at all times. Therefore the digester must be fed at the same time everyday with a balanced feed of the same quality and quantity.

7. Carbon Nitrogen ratio of the input material. Besides carbon the quantity of N_2 present in the wastes is a crucial factor in the production of biogas. All living organisms require nitrogen to form their cell proteins from a biological view point, a digester is a culture of bacteria feeding upon and converting organic wastes. The elements of carbon (in the form of carbon hydrates) and nitrogen (as protein, ammonia nitrates, etc.) are the main food of anaerobic bacteria. Carbon is used for energy and nitrogen for building the cell structure. The bacteria use up carbon about 30 times faster than they use up nitrogen. Carbon and nitrogen should be present in the proper proportion. Other conditions (temperature, pH etc.) being favourable, a carbon, nitrogen (C/N) ratio of 30 (i.e., 30 times more carbon than nitrogen) will permit digestion to proceed at an optimum rate. When there is too much carbon in the raw wastes, nitrogen will be used up first and carbon left over.

8. Diameter to Depth Ratio. Research investigations reveal that gas production per unit volume of digester capacity was maximum when the diameter to depth ratio was in the range of 0.66 to 1.00. But reports from the field do not confirm this. Digesters of 16 ft depth and 4 to 5 ft diameter were reported to be working satisfactory. One reason may be that because in a simple unstirred single stage digester the temperature varies at different depths. The most actively digesting sludge is in the lower half of the digester and this is less affected by changes in night and day temperature.

9. Nutrients. The major nutrients required by the bacteria in the digester are, C, H_2 , O_2 , N_2 , P and S, of these nutrients N_2 and P are always in short supply and therefore to maintain proper balance of nutrients an extra raw material rich in phosphorus (night soil) and N_2 (chopped leguminous plants) should be added along with the cow dung to obtain maximum production of gas.

10. Mixing or stirring or agitation of the content of the digester.

Since bacteria in the digester have very limited reach to their food, it is necessary that the slurry is properly mixed and bacteria get their food supply. It is found that slight mixing improves the fermentation however a violent slurry agitation retards the digestion.

In sewage treatment plants, the digesters, especially the first tank in two stage digestion, are equipped for mixing the tank contents either by sludge recirculation pumps, or gas recirculation or by using one or more deep draft tubes with propeller mixers at the bottom.

11. Retention time or rate of feeding. The period of retention of the material for biogas generation, inside the digester is known as the retention period. This period will depend on the type of feed stocks and the temperature. Normal value of the retention period is between 30 and 45 days and in some cases 60 days.

By regulating the daily feed volume, the retention time can be controlled.

Periods for different materials to get well fermentation are:

(i) Cow and buffalo dung	50 days
(ii) Pig-dung	20 days
(iii) Poultry droppings	20 days
(iv) Night soil	30 days

The retention period of a digester is calculated by dividing total capacity of the digester by the rate at which organic matter is fed into it. Methanogenic bacteria multiply at the slower rate. Methane organisms become double in 2-4 days or even in more days. Retention time should not be less than 2-4 days, otherwise bacteria may come out with the slurry affecting the whole process of biogas production.

12. Type of feed stocks.

All plant and animal wastes may be used as the feed materials for a digester. When feedstock is woody or contains more of lignin, then biodigestion becomes difficult. This cow and buffalo dung, human excreta, poultry droppings, pig dung, waste materials of plants, cobs, etc. can all be used as feed stocks. To obtain an efficient biodigestion,

13. Toxicity.

The digested slurry, if allowed to remain in the digester beyond a certain time, becomes toxic to the micro organisms and might cause fall in the fermentation rate.

Biological systems need some trace elements like calcium, magnesium, potassium etc. Production of biogas is reduced when these elements are present in higher concentrations.

14. Pressure. Some work conducted at National Environmental, Engineering Research Institute (NEERI) Nagpur and other places indicated that the pressure on the surface of slurry also affects the fermentation. It has been reported to be better at lower pressures.

15. Acid accumulation inside the digester. Intermediate products such as acetic, propionic, butyric acids are produced, during the process of biodigestion. This causes a decrease of the pH, especially when fresh feed material is added in large amount. These acids may be converted into methane by addition of neem cake.

Classification of biogas plant

Biogas plants are mainly classified as:

- (1) Continuous and batch types (as per the process).
- (2) The dome and the drum types.
- (3) Different variations in the drum type.

1. Continuous and batch types

(a) Continuous plant. There is a single digester in which raw material are charged regularly and the process goes on without interruption except for repair and cleaning etc. In this case the raw material is self buffered (like cow dung) or otherwise thoroughly mixed with the digesting mass where dilution prevents souring and the biogas production is maintained. The continuous process may be completed in a single stage or separated into two stages.

Single stage process.