

PUXIN DIGESTER: OPERATIONAL GUIDELINES

The Puxin digester that you have installed is one of the most robust digesters on the market and by just following a few basic principles, you will have many years running a successful sewerage management system/biogas production unit.

One of the first things to keep in mind is that a digester is a "live" system. The digestion/decomposition that takes place inside your digester is totally dependent on live micro-organisms. If the micro-organisms die for whatever reason, your system will fail. This will result in untreated sewerage being pushed out of your digester and no biogas being produced. Fortunately, due to the design of the Puxin digester, and by following a few basic rules, this very seldom happens.

To keep the micro-organisms happy, the following is required:

- * They need to be kept relatively warm
- * They need anaerobic conditions (NO oxygen)
- * They need neutral to slightly alkaline environment (pH of 6.8 to 7.5)
- * They need to be fed to keep them alive and healthy

The design of the digester takes care of keeping them warm and providing the required anaerobic conditions - feeding them is your responsibility!

Temperature control:

Microbes function optimally at 37 degrees Celsius, but can function at temperatures between 8 and 60 deg C. It is however more important to provide the microbes with a constant temperature rather than trying to reach a higher temperature which results in continuous temperature fluctuations.

An interesting fact in nature is that the earth maintains a constant temperature the minute you go more than a meter below the surface. In SA this temperature is maintained at approximately 15 deg C, which is quite sufficient for microbes to function effectively. The functioning part of your digester is well below a meter, thus operating in this ideally maintained temperature zone. Although this is not the optimal 37 deg, it is good enough for the microbes in the digester to keep producing biogas on a continuous basis throughout the year. So, temperature is taken care of as far as your digester's operational requirements are concerned.

Anaerobic conditions:

The fact that the digester is permanently filled with water provides the perfect anaerobic conditions for the microbes, as there is no free oxygen available under water. The unique design of the Puxin digester thus takes care of the anaerobic requirement for the methane producing microbes to function optimally.

pH Balance:

The methane bacteria like to breed in neutral or slightly alkaline environment, so the pH value of the liquid in the biogas plant should be controlled between 6.8 and 7.5. This is ensured by strictly following the rules on what and how much to feed the digester (see feeding requirements below).

Feeding your biogas digester is where you play a direct, active and very important function.

Start-up feeding requirements:

Your digester will digest and produce biogas from practically any form of organic material, provided there are live and active microbes present. You therefore need to establish a healthy microbial culture in the digester to get the process started. Once you have an established microbial presence, all you have to do is keep feeding the microbes with good food to keep them alive and multiplying.

The best type of organic material to kick start your digester is cow manure. Cows have 4 stomachs, so by the time manure is produced; the decomposition process is well on its way, with a healthy presence of methanogens (methane producing microbes). It is the presence of these microbes that is crucial for the successful operation of your digester.

4 Days after your digester has been cast and the gas dome has been put in place, load the digester with approx 700kg of fresh cow manure. The manure needs to be in the form of a slurry, so you will need to dilute and mix the manure with water. You can use a 20 liter container, fill it halfway with manure and the balance with water. Stir the mix to form a porridge like slurry and pour it into the inlet side of your digester. Keep repeating the process until all the manure is in the digester. Now fill the digester with water until the water level covers the gas dome and/or until the water level reaches the bottom of the outlet pipe (water will automatically keep flowing out of the outlet should you try to fill it above this level). Your digester is now ready for action!

Using cow manure as startup material is the best option, but should cow manure not be available, most other types of manure can be used. The only animal manure not suitable to start your digester is pure chicken manure due to the high concentration of ammonia present. Any combination of animal manures can be used as well. Your digester will not start if only vegetable matter is used, as there are no methanogens present in this matter. Should you not have any manure available or not sure what will work, please contact BiogasSA for advice.

It is important to keep your gas pipe valve open when you fill the digester with water to allow the trapped air in the gas dome to escape. Once the correct water level is reached, close the valve.

Depending on the type and combination of feed material used to prime the digester, it will start producing biogas after about 5 to 7 days. The biogas produced consists primarily of 2 types of gasses, methane (CH₄) and carbon dioxide (CO₂). Small quantities of other gasses are also present, of which the only significant one is sulphur dioxide (SO₂). It is the SO₂ that is responsible for the sulphur (rotten egg) smell of biogas. Methane as a gas is odorless, which could be dangerous should one forget to turn the gas off. It is for this reason that in applications where the biogas is used exclusively for cooking purposes, not to de-sulfurise (remove the SO₂) the biogas for safety reasons. However, in most applications the biogas is de-sulfurised due to the fact that the sulfur is a corrosive gas and will damage all metal appliances in a short period of time.

You can start testing to see if biogas is being produced after a couple of days by holding a match in front of the gas pipe and slowly opening the valve. Chances are that due to the initial low percentage of methane present, the biogas won't burn the first few times you try. To help increase the percentage of methane, open the valve and release all the accumulated gas the first few times the gas does not burn.

Once your digester has been up and running for a couple of months the percentage methane versus CO₂ should stabilize at a ratio of approx 60/40 and can even go up to 75/25. The higher the percentage methane, the higher the calorific value (combustibility) of the biogas. In order to run a biogas generator, for instance, one would need a methane percentage of at least 55% - this will only be reached after approximately 2½ to 3 months.

Daily feed quantities:

About 30 days after start-up, you can start adding manure/organic material on a daily basis. The 10m³ digester can accommodate approximately 200-250kg of slurry (50% manure/organic material and 50% water) every day. You can feed less, but NEVER feed more. Feeding more will result in undigested material being pushed out of the digester as well as inhibit your gas production - eventually this could lead to the microbes dying and the entire microbial process grinding to a halt. This will require the digester to be emptied out and the whole process starting from the beginning again. Starving your microbes will obviously also lead to the microbes dying and digestion process grinding to a halt. If your digester is connected to your sewerage system, the daily intake of sewerage will be sufficient to keep the microbes alive. Should you go on holiday for longer than 5 days and no sewerage enters the digester, it will be necessary to organize that it is fed during your absence - quantity depending on the duration of your absence.

If you are using your digester as a sewerage management system, you should also wait the required 30 days after start-up before connecting your sewerage system to the digester to allow the microbes to fully establish themselves. Your digester is designed to accommodate the sewerage of approximately 15 people if the black and grey water is separated - only 5-6 people if grey water and black water is allowed to enter the digester. If no additional material is fed into the digester except the sewerage (from say 4 people), only enough biogas will be produced to cook on for approximately 20 minutes. The 200kg quantity mentioned above is over and above the sewerage fed into the digester. It is important to note that the amount of biogas that can be produced in your digester is directly related to the amount of material fed into the digester. The more material you feed into the digester, the more biogas you are likely to produce (to a maximum of 200kg/day!). Optimally fed at a rate of 200kg/day, you can produce 5-6m³ of biogas over a 24-hour period.

Biogas production quantities:

The table below gives an idea of how much biogas can be produced from the different types of feed material.

Type	kg produced per day	Qty required to produce 1m ³ /day
Pig Manure	3.0	7.4 pigs
Cow Manure	15.0	2.1 cows
Chicken Manure	0.1	133 chickens
Human Manure	0.7	24 people
Sheep/Goats	0.5	32 sheep/goat
Grass	1.00	4.4 kg

It follows from the above table that one pig produces approx 3kg of wet manure per day and that it will require the manure of approx 7.4 pigs to produce one m³ of biogas. If only pig manure is available, one will have to collect the manure from approx 33 pigs (100kg/3) to reach the daily feed limit of a 100kg (plus a further 100 liter of water to make up the 200kg). This should produce in the region of 4.5m³ (33/7.4) of biogas per day.

It is important to note that the digester produces biogas 24/7, but the gas dome only holds 1.3m³ of biogas. In the scenario above where the 33 pigs will produce 4.5m³ of biogas over a 24 hour period, the gas should be used continuously if one does not want to lose the majority of the gas produced. Additional biogas storage is available by either building extra gas domes or installing biogas storage balloons (contact BiogasSA for further detail in this regard).

Any organic food waste from your kitchen is an ideal feeder material for your digester - the only requirement is that the waste must be mulched as fine as possible. Solid material will take a long period to digest and could block your pipes if too much of it is fed into the system.

VERY IMPORTANT: NO harsh chemicals of any kind should be fed into the digester - these will immediately kill the live microbes and the system will grind to a halt. As a guideline any rules that apply to a normal septic tank, also applies to your digester.

Avoid the following:

- * All bleaches (Handy Andy, Domestos, etc)
- * Non biodegradable washing powders (or any non biodegradable cleaning products)
- * Any type of pesticide, insecticide
- * Antibiotics
- * Any product containing heavy metal compounds or phosphorous

A biogas digester system is a live system and very much dependant on how, when and with what you feed it. Should you have any questions or even suggestions about the process, please do not hesitate to contact us and discuss - it is a lot easier to ask a question than to deal with a digester that has died down.

Trouble shooting:

Your digester produces biogas as a result of the action of billions of live microbes doing their thing. If for some reason or another the conditions become less than favorable, the microbes could slow down, stop working altogether or even die. There are a number of signs to look out for in order to prevent this from happening.

The major reason for the sudden decline or even total stoppage in biogas production, is acidification (tell tale sign is the yellowish colour of the digestate). Depending on the degree of acidification, there are different ways to treat the problem:

You will need a pH test kit or purchase a digital pH meter in order to check the pH.

- a) If the pH value is not below 6.0, the biogas digester can normally adjust its pH automatically over a period of time. Continue adding manure to the digester (100kg/day) on a daily basis and keep measuring the pH until biogas production is back to normal. It is very important that only prescribed feed material is used, as incorrect feed material was most likely the cause for the drop in pH level in the first place. Recovery will take a number of weeks.
- b) If the pH value has dropped below 6.0, you will have to remove some liquid (start with approximately a 1000 liter) by using a pump. Add approx 300kg of fresh manure slurry and refill the digester with water. At the same time add some lime or plant ash in the biogas plant to adjust the pH value to above 6.0.
- c) If the pH value has been adjusted back to 7.0 and the digester still does not produce biogas, it means that the microbes have died, normally as a result of some form of chemical substance that has entered the digester. If this happens you will have to empty out the entire digester and start the process from the beginning.
- d) If the pH value has been adjusted back to 7.0 and the digester now works normally but the gas production is very low, it means that in all likelihood there is a problem in the gas pipe system. Check for any leakages and ensure that there is no water trapped in the gas pipes somewhere.