Anaerobic Digestion for Low Income Households:

How to make better fertilizers and provide household energy from wet organic wastes

A recent scientific paper has highlighted simple methods for recycling organic wastes in low-income countries[1]. If the household needs the organic waste for energy, nutrient rich wastes can be fed into an anaerobic digester to produce biogas, an alternative clean energy source. However, action may be needed to reduce or meet water requirements, especially for dry feedstocks, and to reduce financial costs, labour and nutrient losses from the bioslurry.

Nitrogen

The optimal carbon (C) to nitrogen (N) ratio in the digester is 20–35. Below 20, when N is too high, the bioslurry smells of ammonia; above 35, biogas production drops. Low C:N ratio can be corrected by adding rice straw, biochar, soil or coir dust; high C:N with poultry manure, collected urine or N-fixing wild plants.

				Factors that limit use			
C:N	Description	Solutions	Effectiveness	Finances	Feedstock	Labour	Water
<20	Excess N Bioslurry smells of ammonia	Co-digest with high C:N feedstock or turn-in during composting (e.g. rice straw)	High		Limits use		
		Absorb nutrients using biochar, carbonate, clay minerals or coir dust	Medium		Limits use		
20-35	Ideal range						
>35	Too little N Low biogas production	Co-digest with low C:N feedstock (e.g. poultry manure, food waste)	High		Limits use		
		Collect urine and add to digester	High		Limits use		
		Co-digest with N-fixing under-utilised wild plants	Medium				

Bulk density

Feedstock bulk density should ideally be 0.6–0.8 g cm^{-3}. Below this range, large or bulky materials can clog the digester; above it, overly dense feedstocks may not decompose well, reducing biogas production. Bulk density can be adjusted by chopping or pounding the waste. However. this adds labour or requires additional equipment.

[1] *Smith et al., 2026. Environ. Res. Commun. 8, 042002* https://doi.org/10.1088/2515-7620/ae59f6

Bulk density	Description	Solutions	Effectiveness	Factors that limit use: Finances	Feedstock	Labour	Water
<0.6 g cm^{-3}	Low bulk density Feedstock clogs the digester	Pound feedstocks in the mixing tank	High			Limits use	
		Chop large pieces of organic waste	Medium	Limits use		Limits use	
0.6 – 0.8 g cm^{-3}	Ideal range						
>0.8 g cm^{-3}	Low biogas production	Pound with water to disperse	High			Limits use	

Lignin

Woody materials and stiff crop residues have high lignin levels. When lignin exceeds about 7.5%, biogas production falls. Yields can be improved by pre-treating feedstock with cattle urine, manure, rumen fluid or white-rot fungi from decaying wood. These methods are low-cost but require extra labour.

Lignin	Description	Solutions	Effectiveness	Factors that limit use: Finances	Feedstock	Labour	Water
<7.5%	Low lignin	No need for pre-treatment					
>7.5%	High lignin Low biogas production	Pre-treatment with alkali, such as cattle urine.	Medium			Limits use	
		Pre-treatment with white-rot fungi from decaying wood	Medium			Limits use	
		Pre-treatment with rumen fluid from slaughtered animals	Medium			Limits use	
		Pre-treatment with cattle manure	Low			Limits use	

Acidity

Anaerobic digestion occurs by different processes; those that breakdown the feedstock into smaller molecules and those that convert the small molecules into methane (biogas). Methane producers work best at a pH of 6.8–7.4, while the first breakdown stage can handle more acidic conditions. Outside this pH range, biogas production slows. If pH drops below 6.8, the slurry smells sour. It can be raised by adding alkaline materials, such as cattle manure, lime, wood ash or biochar. If pH goes above 7.4, acidic materials, such as food waste, pine needles or citrus peel can be added.

pH	Description	Solutions	Effectiveness	Factors that limit use: Finances	Feedstock	Labour	Water
<6.8	Too acidic Bioslurry smells sour Low biogas production	Co-digest with high pH feedstock (e.g. cattle manure) while also adjusting C:N to ideal ratio ~32.5	Low		Limits use		
		Add lime	High	Limits use			
		Add wood ash	Medium		Limits use		
		Add biochar	Medium		Limits use		
		Two-vessel system - low pH vessel 1, higher pH vessel 2	High	Limits use			
6.8–7.4	Ideal range						
>7.4	Too alkali (1) Low biogas production	Co-digest with acidic feedstock (e.g. food-waste, pine needles, citrus peel	High		Limits use		
		Two-vessel system - low pH vessel 1, higher pH vessel 2	High	Limits use			

Water

Anaerobic digestion works best with a water content of 85–95%. Below 85%, it is too dry and biogas production drops. This can be fixed by adding wetter feedstocks, water (rainwater or reused household water), recycled bioslurry or small amounts of urine without adding too much nitrogen. Above 95%, biogas production also falls because the slurry moves through the digester too quickly. This can be corrected by adding drier materials.

Water content	Description	Solutions	Effectiveness	Factors that limit use			
				Finances	Feedstock	Labour	Water
<85%	Too dry Low biogas production	Co-digest with wetter feedstocks to achieve the moisture content over 85%	High		Limits use		
		Add more water	High				Limits use
		Divert urine into digester (take care to avoid excess N or alkalinity)	High				
		Domestic water recycling	Low				
		Rainwater harvesting	Medium	Limits use			
		Filter bioslurry and recycle water back to digester	High				
85% - 95%	Ideal range						
>95%	Too wet Low biogas production Retention time less than 40 days	Co-digest with drier feedstocks to achieve the moisture content below 95% (e.g. most animal manures)	High		Limits use		

Temperature

The best temperature for anaerobic digestion is 35–45 °C. Fixed-dome digesters are built underground to buffer against temperature extremes, but this increases construction costs. Cheaper designs, such as floating-drum or simple fixed-dome digesters, can use insulation or solar heating to raise temperatures, and shading to reduce overheating.

Temperature	Description	Solutions	Effectiveness	Factors that limit use			
				Finances	Feedstock	Labour	Water
<35°C	Too cold Low biogas production	Build digester underground	High	Limits use			
		Insulate digester (e.g. with crop residues, leaves, red soil, clay or charcoal)	Medium				
		Solar water heating system	High	Limits use			Limits use
		Solar gain using a greenhouse canopy	Medium	Limits use			
		Solar gain using a black bag	Low				
35°C - 42°C	Ideal range						
>42°C	Too hot Low biogas production	Build digester underground	High	Limits use			
		Shading to avoid direct sunlight	Medium				

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