Biodigestion Alternative

A Cool Way of Raising Pigs

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Since 1992 the anaerobic digestion of pig waste has been quite popular in Vietnam. Here urine and feces are flushed periodically during the day and routed to biodigesters that generate methane. This solution to the disposal of pig waste, at first glance, sounds quite positive, but it demands closer examination.

This practice involves a great deal of pumping. Even a small pig farmer is forced to pump and treat tens of thousands of liters of water each year. In many cases, the water that is pumped is not fresh but re-circulated water. This re-circulated water is not free of pathogens, and it often serves as a vector of disease. The pig is raised in a damp, wet and humid environment where conditions are ideal for the proliferation of disease.

In order to flush, a concrete floor is required. But concrete floors have a very negative impact on the bone structure of the pig. When pigs are brought to slaughter after having spent their entire lives on a concrete floor, they have great difficulty walking. It can be forcefully argued that it is inhumane to raise pigs on such a hard surface.

A biodigester is always producing gas, and this, in many cases, necessitates the construction of a large gas storage vessel. Such storage vessels are generally located in close proximity to kitchens, sometimes even within kitchens. If ever they should leak, there is the very real danger of explosion and fire. Piping methane from the biodigester to the storage device and from the storage device to the stove is often risky and unsafe.

Anaerobic digestion is far from being a complete waste treatment solution. It leaves behind both a solid and a liquid that require further treatment. Before it can be incorporated into the soil, the raw sludge has to be composted or otherwise amended. The effluent from the biodigester is too rich in NPK to be released into the environment and is often treated in duckweed ponds.

Recent experiments have been conducted in Vietnam and Laos that show the effectiveness of rice hull biochar in cleaning up biodigester effluent. But to produce biochar, gasifiers are needed, and the primary product of these gasifiers (in terms of economic value) is not biochar but syngas. This syngas should not be wasted or flared, but fully utilized as fuel. Since this syngas can be used by pig farmers for household cooking and the distillation of rice wine, it undermines the need for biogas.

So in the production of fuel, gasifiers can seamlessly replace biodigesters. Here we are talking about top-lit, updraft gasifiers that are constructed completely out of stainless steel and that sell for about $35 USD (700,000 VND). They can easily fulfill the energy needs of the average pig farmer in Vietnam.[1]

[1] On gasification, see: http://dl.dropbox.com/u/22013094/Paper/Presentations/Gasification.ppsx
The 150 gasifier in operation: http://www.youtube.com/watch?v=vnM5Itk7wlQ

The syngas produced in these gasifiers does not have to be stored. Rather it is produced on the spot only as needed. Instead of utilizing pig feces rich in nutrients that can be reintegrated into the feed/food chain, the farmer utilizes nutrient-poor, low-grade, lingo-cellulosic biomass. At the same time the farmer plays an active role in recycling low-grade biomass that all too often is thoughtlessly dumped in rivers or burned. Even when purposefully burned as a source of fuel, this biomass releases enormous pollution into the air.

But what alternative to the anaerobic digestion of pig waste does the Vietnamese farmer have?

One of the most exciting ways to dispose of pig waste is to raise the pig on soft bedding comprised of sawdust, shredded straw, coconut dust, coffee husks or some other form of dry biomass. The feces deposited onto the bedding by the pig is collected once or twice a day and placed in nearby mesophilic bins[2] or biopods.[3] Both devices are ideal for growing black soldier fly (BSF) larvae.

BSF larvae are some of the most voracious eaters within the natural world. They can effect as much as a 20-fold reduction in the weight and volume of some forms of putrescent waste in a period of less than 24 hours. In an area of only one square meter, they can eat up to 30 kg of putrescent waste per day. And for each 100 kg of putrescent waste, there can be as much as 20 kg of nutrients of a high protein (42%) and fat (34%) content. Live larvae sell for about $500 US dollars or 10.5 million VND per ton. Dry larvae have roughly the same value as Menhaden fishmeal valued at about $1,200 US dollars or 25.2 million VND per ton.

If a mesophilic bin is used to grow larvae, the larvae are destined primarily for chickens. At night mature prepupae crawl through the aeration holes of the mesophilic bin and fall onto the ground. They then seek refuge under leaves and other debris around the base of the bin. The following morning, chickens have no problem finding and eating them.

But if a biopod is used to grow larvae, the larvae self-harvest into a bucket. This leaves the farmer free to feed larvae to whatever he wishes: chickens, fish, frogs, shrimp and so forth. In the picture above left, we see BSF larvae grown in the Mekong on nothing other than pig feces. In the picture above right, we see the biopods in which they were cultivated.

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[2] On mesophilic composting, see:
http://dl.dropbox.com/u/22013094/Paper/Presentations/Mesophilic%20Composting.ppsx

[3] On BSF and redworm technology, see:
http://dl.dropbox.com/u/22013094/Paper/Presentations/BSF%20and%20Redworm%20Bioconversion.ppsx

The residue of the mesophilic bins or biopods is then fed to red worms. Red worms grow 2 to 3 times faster on BSF residue than on partially decomposed food waste.[4] BSF larvae digest fresh putrescent waste, something that red worms cannot do, and red worms digest the more recalcitrant cellulosic materials, something that larvae cannot do. Together they form a perfect partnership, recovering all possible nutrients. Red worm residue (or castings) constitutes one of the best growing mediums for plants. It effects an enormous reduction in the amount of fertilizer required to grow plants.[5] Vermicompost sells in Vietnam for about $500 US or 10.5 million VND per ton.

In this pig-on-bedding concept, urine simply drains into the dry bedding and is absorbed by it. Biochar and effective microorganisms (EM) can be incorporated into the bedding and are quite efficient in preventing the escape of ammonia. When urine comes into contact with the bedding, beneficial mesophilic microorganisms proliferate. These microorganisms compete with and eliminate a broad variety of swine pathogens. As pigs walk, play and root on and within the bedding, they keep it well aerated. The bedding also functions as a soft cushion for the pig.

This approach to the processing of pig waste is somewhat similar to the processing of human waste described in another essay.[6] But in the case of humans, urine is diverted away from feces (while feces remains on site), and in the case of pigs, feces is diverted away from urine (while urine remains on site). In both cases, it is important that the two types of waste not be processed together.

In the picture above on the right, we see the collection of pig feces with a dustpan and small spade. This collection has to be done but once or twice a day, and the entire procedure takes less than five minutes. In the picture on the left, we see the sieving of feces right before it is deposited into a biopod. A single 4-foot biopod can easily serve 20 pigs.

Since the floor of the pig pen is not flooded with water, everything remains aerated, dry and sanitary. This

[4] Professor Tran Tan Viet of the University of Forestry and Agriculture in HCMC has carefully studied the mutually beneficial relationship between BSF larvae and red worms in disposing of putrescent waste.
[5] "A study in Connecticut (Lunt and Jacobson, 1944) reported worm castings increase the nutrient availability of the soil by 1.4 fold for calcium (Ca), 3.0 fold for magnesium (Mg), 11.2 fold for potassium (K), 7.4 fold for phosphorus, and 4.7 fold for nitrate-nitrogen (NO3--N)." See: http://www.scribd.com/doc/30909297/Biochar-Article
[6] See: https://dl.dropbox.com/u/22013094/Paper/Summaries/Human%20Waste.docx

translates into far less disease and mortality. When properly managed, the bedding has a fresh, pleasant, compost smell. Since the bedding does not smell, filth-bearing flies and rodents are not attracted to it. The pig pen stays remarkably free of flies and rodents.

In the same time that the pigs walk and play on it, the bedding is slowly transformed into a mesophilic compost of considerable value (at least $50 US or one million VND per ton). Unlike anaerobic sludge, this compost does not have to be amended in any way prior to incorporation into the soil. This bedding can also be made available to red worms and converted into vermicompost.

Just as it does not make sense to make ethanol out of corn, it does not make sense to make methane out of nutrient-rich pig feces. What can be easily transformed into a valuable feed should not be transformed into a less valuable fuel. This is especially true in Vietnam where rice hulls and coffee husks are abundant and can be inexpensively gasified. At the same time the problem of the efficient and rapid disposal of these two forms of cellulosic biomass is squarely addressed.

But note that in gasifying rice hulls and coffee husks the pig farmer is not simply disposing of biomass, but he is also earning a substantial profit. One ton of rice hulls or coffee husks has, for example, a combined value in gas and biochar of almost $300 USD (6.3 million VND). In the case of rice hulls, the by-product (rice hulls) often has a greater value than the paddy rice from which it was derived.

Pig farmers in Vietnam are quite resourceful in collecting food waste from restaurants and feeding this waste to pigs.[7] This collection takes place within all major cities within Vietnam. In the two pictures below we see the informal collection of food waste right in Hanoi.[8]

Pig farmers can also be taught how to ferment fruit waste, vegetable waste, fish byproducts, fish mortalities, slaughterhouse waste, shrimp shell waste and so forth.[9] Furthermore, the pig farmer can grow taro and other plants rich in protein to ferment and feed them to his pigs. Conventional pig feed produced by Cargill and other feed companies constitutes as much as 70% of the cost of raising pigs in Vietnam, and the Vietnamese pig farmer can be easily taught to produce all of the feed he needs to raise his pigs.

In feeding his pigs, the pig farmer should buy nothing from feed companies, and in growing the plants needed to feed his pigs, he should buy nothing from fertilizer companies. He should become strong, independent, and no longer subject to the fluctuations and uncertainty of the global marketplace. Since 98% of the Vietnamese people eat pork, *the pig farmer*

[7] Of course such food waste should always be pasteurized. Here gasifier heat can be used to kill pathogens.
[8] These pictures were taken on July 8, 2012 at the end of Tong Duy Tan street in Hanoi.
[9] See: https://dl.dropbox.com/u/22013094/Paper/Presentations/Fermentation.ppsx

becomes a key player in assuring the security of the supply of food within Vietnam.

There was a time in Vietnam when it made a lot of sense to process pig waste in a biodigester. This solution was far better than simply discharging pig waste into ditches, streams and rivers. But with the advent of living bed technology, BSF and redworm bioconversion, and the availability of low-cost gasifiers, the logic of the biodigestion of pig waste is not as compelling as it once was.

It's a question, not of doing away with the biodigestion of pig waste, but of making more options available to the pig farmer. Some pig farmers might like to get involved in selling larvae, red worms and vermicompost as an additional source of income. Some might want to take things a bit further and grow larvae and red worms to feed to catfish or shrimp which they might culture in ponds located on their pig farms. Some might not have sufficient space to construct biodigesters and duckweed ponds. Some might feel a bit uneasy about storing methane in close proximity to a kitchen and might prefer the safety of cooking with gasifier heat. Some might need cured bedding and vermicompost laced with biochar to fertilize their vegetable gardens. This list goes on and on.

In producing the four basic components of food, fuel, feed and fertilizer as described in this essay, the Vietnamese pig farmer can make far more money than ever before, and he can accomplish all of this in a thoroughly sustainable manner.