ENVIRONOMICS LLC

Methane Generation Biology

Interspecies Hydrogen Ion Transfer

or, Good Neighbors Getting Along

Methane generation, while a complicated process, all boils down to many bacteria cooperating. Long before organism used oxygen, "bugs", including methanogens, were hard at work taking advantage of any food or energy source available. Where does a methane bug get its food? It eats the excrement of its neighbor. The stable anaerobic system depends on symbiotic biological relationships like this.

Large numbers of different types of bacteria are present in a digestion vessel. Typically, they are divided into three groups. See Biogasworks (http://www.biogasworks.com/Index/AD%20Intro.htm) for more discussion. Anaerobic system organisms are generally categorized as:

Hydrolyzers of complex organics	Acid formers	Methane formers

While this is certainly true, in reality, many different organisms comprise each of these three groups. Viewing this arrangement from a different perspective better prepares anaerobic system operators.

Methane Bugs Are Not Very Forgiving To Changes In Their Environment

A designer and operator of an anaerobic system would do well to keep in mind: anaerobic systems are not very forgiving to changes in its environment because methane bacteria are the final step in a long chain of neighborly relationships. Here is the rest of the story.

Each organism, humans included, take in food and give off waste as a normal requirement of life. Food (i.e., energy and basic building blocks of life) comes into us, we extract the value for our bodily needs and we release wastes (feces, urine, and exhaled carbon dioxide). These wastes will accumulate, choking us in our own discards, our own excreta, unless the wasteproducts are removed from the surroundings. Similarly, as we consume food in our immediate surroundings until depleted, we will starve unless new supplies become available. As with humans, many organisms, have mobility to escape build ups of the by-products of living. And as humans may be mobile, traveling to a store or other source of foodstuffs to address our hunger, organisms have limited or no ability to move towards new food supplies. Moreover, all organisms can travel, but can only relocate so far, before escape is no longer an option.

Accumulated wastes choke a system

Methane bacteria and other organisms in the anaerobic digester worked out a better way to coexist. Organisms in an anaerobic environment arrange themselves so each will consume the waste of the other. Each organism is able to extract and use for its own needs, the energy remaining in the neighbors' waste. Each organism sets up its own shop of enzymes to act on its food source. That is to say, the waste of one organism does not build up as that waste becomes food for the next group

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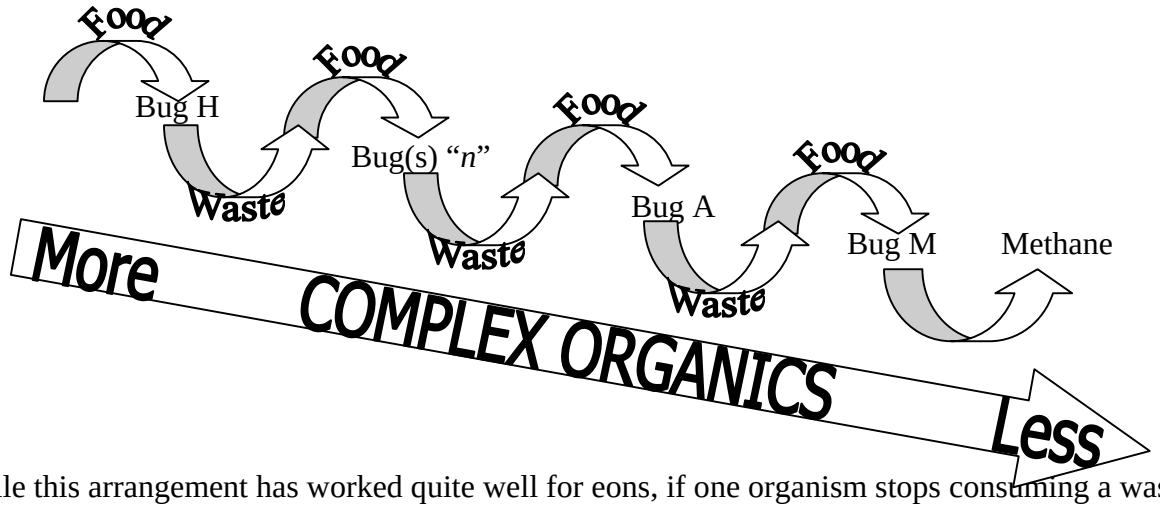
of organisms. The excreta of one is the rice and potatoes for the next. The final energy exhalation is methane.

Manure, food processing waste, sewage sludge, or other complex organic compounds are subject to breakdown by a series of organisms, each consuming what they consider food, extracting metabolic needs, and excreting unneeded, undesired by-products. As the food moves through the arrangement of organisms, the organic compounds become less complex: starting with a kernel of waste corn and ending with methane gas and bacterial mass. We exhale carbon dioxide, this system exhales methane.



While this arrangement has worked quite well for eons, if one organism stops consuming a waste of its neighbor, that waste begins to accumulate. As the waste accumulates, the neighbor fails to perform at peak performance, becoming sluggish, choked in material it cannot process. Suffocating in by-product, unable to function, it is unable to consume food (waste) produced by **its** neighbors. Essentially, as one organism slows its participation on the process, the entire system slows and there is build up of product that would otherwise have been consumed/removed.

The final step in the process is the methane producing bug. They exhale methane. Their food is largely volatile fatty acids. When upset or food/acid production exceeds methanogen consumption, pH drops, impacting all organisms in the population. When organic acids accumulate, stink results.

Why are they so sensitive? Methanogens are unusual. They exhale or excrete high energy content methane as the by-product of their own metabolism. To harvest the energy they need to live, they produce and give off methane. For every 100 calories of energy these unique bacteria consume as food, they exhale 90% of that energy in the methane they are producing, leaving little energy for their own internal bodily needs. There is little energy left to move about, or invest in reproduction, or creation of new sets of enzymes necessary to adapt to changes in their environment. This is a problem. But a problem that has existed for billions of years, as these are some of the oldest known organism. The system eventually works out a new metabolic pathways, a new energy flow, a new way to flush the system of waste products. **However**, stable constant feed or environment is best for the organisms.

Cooperating neighbors profit one from the other

Storage basins stink and digesters sour because the methane bugs are unable to consume the wastes produced by their neighbors. Cooperating neighbors each profit from the waste of the other.
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