



The Fate of Nutrients and Pathogens During Anaerobic Digestion of Dairy Manure

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Patrick A. Topper, Agricultural Research Technologist

Robert E. Graves, Professor of Agricultural Engineering

Thomas Richard, Associate Professor of Agricultural Engineering

On farm anaerobic digestion of dairy manure is being used for power production and odor reduction. During the digestion process, much of the organic matter in manure is converted to volatile fatty acids (VFA's) by acidogenic bacteria, and these VFA's are then consumed by methanogenic bacteria to produce methane, carbon dioxide and a few other gases. Nitrogen, phosphorus, and potassium are transformed by these microbial processes, but these nutrients are not destroyed. Some nutrients, like sulphur, are converted into different compounds during the digestion process; in this case, hydrogen sulfide gas is produced. This fact sheet will explain the fate of the major nutrients in dairy manure plus Johne's and pathogens as they pass through an anaerobic digester. General information about anaerobic digestion can be found at: <http://www.biogas.psu.edu/>

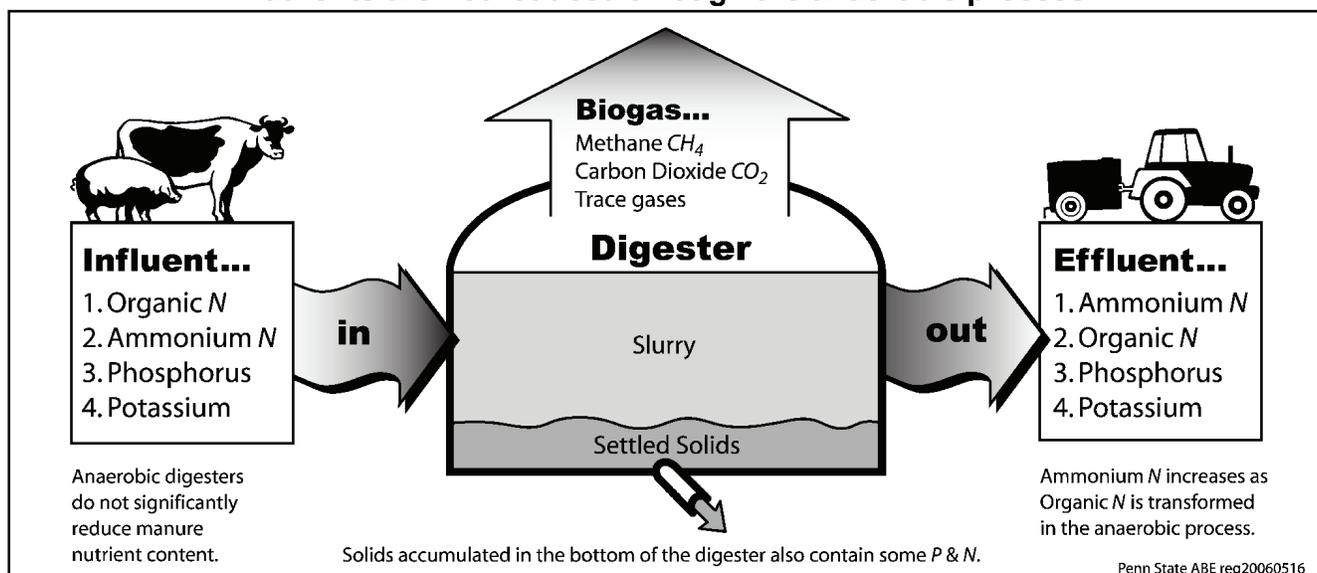
formed from the reaction of the urease enzyme in the feces with the urea in the urine. Ammonium formation is fairly rapid, with about 95 % of the reaction complete in the first 12 hours, often before the manure is collected. Ammonium is not destroyed during the digestion process, but rather, organic N is converted to ammonium during protein degradation. Hence, the ammonium level in the digester effluent is typically higher than raw manure. A negligible amount of ammonia gas will escape with the biogas. It should be stressed that total nitrogen into the digester will equal the total nitrogen leaving the digester. This is different than most other manure management practices, which lose nitrogen through volatilization. As a result, the digester effluent ammonium content can be up to two times higher than in stored manure.

When digester effluent is field applied, much of the ammonium will be released as a gas (ammonia) unless it is incorporated into the soil. When incorporated, microorganisms can convert the ammonia to nitrite, which is then rapidly converted to nitrate, the nitrogen form most readily taken up by plants.

Nitrogen, Phosphorus, Potassium (NPK)

Nitrogen in the manure enters the digester mainly in two forms: ammonium or organic N. Ammonium is

Nutrients are not reduced through the anaerobic process.



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There is always some solids retention in a digester, especially in plug flow designs. In the digester, solid nutrients can settle. These settled solids make it look as though the nutrient concentration decreased as manure passed through the digester. Phosphorus (P) and potassium (K) measurements often illustrate this effect. The microorganisms in the digester do not consume P and K. Some P can be converted to ortho P (a soluble form) in the digester, but the total mass remains constant. The total P and K flowing into a digester equals the P and K in the effluent plus the amount that has settled out. These settled solids, which include both organic matter and other non-digestible solids such as sand, must be periodically cleaned out of the digester, when the associated nutrients will “reappear”.

pH

As the manure undergoes the anaerobic digestion process, organic solids are reduced to VFA's, and as these organic acids accumulate the pH initially tends to decrease. Manure usually contains enough alkalinity to prevent these acids from decreasing pH too much, but if the pH gets below 6.5, the methane producing organisms suffer. As those methanogenic microorganisms convert VFA's to methane, these acids are destroyed and the pH of the effluent will increase. Farmers using digester effluent on their fields have reported an increase in soil pH with a corresponding reduction or complete elimination in liming requirements.

Johne's and Pathogens

Johne's disease, *Mycobacterium avium*, subspecies *paratuberculosis*, can live in manure for long periods of time outside of the cow's body, including living in the soil. An anaerobic digester, operating at 99°F and having a 20 day retention time, has shown a dramatic reduction in Johne's bacteria in the digester effluent. Digesters that operate in the thermophilic range, (135°F), have shown complete elimination of Johne's bacteria in hours. Most thermophilic digesters operate with a 5 day retention time.

Escherichia coli O157:H7, Salmonella, Cryptosporidium and other pathogens are all found in manure and all are potentially harmful to humans. An anaerobic digester has a pathogen-reducing effect.

It has been shown that a 95% pathogen reduction can be achieved using a 20 day retention time mesophilic digester in the 95 to 105°F temperature range. Higher rates of pathogen reduction are achieved with thermophilic digestion.

A Special Note Concerning BSE

The exact cause of Bovine Spongiform Encephalopathy (BSE) or Mad Cow Disease is not known, but it is generally accepted by the scientific community that the likely cause is infectious forms of a type of protein called prions. In cattle with BSE, these abnormal prions initially occur in the small intestines and tonsils. In later stages of the disease these prions are commonly found in the central nervous tissues, such as the brain and spinal cord. These abnormal prions are resistant to common food disinfection treatments, such as heat, so it is difficult to reduce or eliminate their infectivity or presence. **The operating temperatures of an anaerobic digester in the thermophilic (135°F) or mesophilic range (99°F) are not sufficient to destroy prions or BSE.** An anaerobic digester cannot be used as a treatment for BSE infected animals or their wastes.

Infectious Diseases

Animals and their manure that are diagnosed with an “Infectious Disease” in Pennsylvania are under the regulatory control of the Bureau of Animal Health and Diagnostic Services of the Pennsylvania Department of Agriculture. <http://www.agriculture.state.pa.us/> Contact this bureau before making any plans for handling or disposal of such materials. For other states, contact your state veterinarian office. Any practicing veterinarian should be familiar with the diagnosis, notification and handling procedures required for animals with infectious diseases.

More information about animal diseases is available at the PSU College of Agricultural Sciences, Department of Veterinary and Biomedical Sciences at: <http://www.vetsci.psu.edu>

For further information visit:
www.abe.psu.edu/extension/extensionindex.html

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