Anaerobic Digestion- Introduction to pH Effects, part 2

INTRODUCTION

Anaerobic digestion describes the process transforming wastes into biogas through methane producing microbes. Intermediates of this process include volatile fatty acids, which are then reduced to methane and carbon dioxide. In order for this process to work efficiently, the pH should remain between 6.8 and 7.2. This can be largely effected by the amounted of carbon dioxide produced within the biogas. Stability is increased by maintaining high alkalinity concentrations. Decreases in alkalinity may be due to accumulation of organic acid intermediates, often due to the presence of wastes that reduce the ability of methanogens to turn those wastes into biogas. Alkalinity is closely related to the release of amino acids that are chemically altered into ammonia. Bicarbonates are the primary buffer for balancing alkalinity with pH. When proteins are decomposed, the released carbon dioxide can form carbonic acid, carbonate alkalinity, or bicarbonate alkalinity. Ammonia released can create ammonium ions. This aids in buffering the system from drastic pH changes. However, sugars decompose into acetate and acetic acid, which contend with the alkalinity to drive pH values down. To ensure proper maintenance, alkalinity can be added at the beginning of the digestion batch. Alkaline additives include sodium bicarbonate, potassium bicarbonate, potassium carbonate, sodium nitrate, and anhydrous ammonia.

TASK(S)

Activity 1 (5-10 minutes)
Demonstration of carbon dioxide effect on pH
Activity 2 (20-30 minutes)
Relationship among carbon dioxide gas and pH
Activity 3 (10-15 minutes)
Relationship among ammonia concentration and pH

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ACTIVITY/PROCESS

Demonstration of carbon dioxide effect on pH

- Briefly review carbon dioxide production through aerobic respiration
- Obtain clear plastic cup of lye water and straw
- Add few drops of phenolphthalein indicator
- Measure pH using Lab Quest (Vernier)
- Exhale through straw until color change is seen
- Measure pH using Lab Quest (Vernier)

Relationship among carbon dioxide gas and pH

- Break students into previously arranged groups
- Each group obtain small scale digesters, previously started under differing pH treatments
- Measure the current pH of digestate and slurry using LabQuest (Vernier)
- Measure carbon dioxide concentration of captured biogas using Lab Quest gas chamber (Vernier)
- Create data table, scatterplot, and run ANOVA and correlation statistics to compare pH treatments, in Microsoft Excel

Relationship among ammonia concentration and pH

- Measure ammonium ion concentration of digestate and slurry using Lab Quest selective ion probe (Vernier)
- Create data table, scatterplot, and run ANOVA and correlation statistics to compare pH treatments, in Microsoft Excel

RESOURCES

Excerpt from The Microbiology of Anaerobic Digesters. Gerardi, M. John Wiley & Sons, Inc. Canada (2003). Chapter 16: Alkalinity and pH. pp99-104.

ASSESSMENT

- Identify strengths and weaknesses in data collection, graphing, and statistical analyses
- Using data collected, write brief summary of the relationship among pH with carbon dioxide and ammonium.
- Relate the effect that pH changes may have on viability of digestion and the processes that may contribute to those changes.