ASSESSING ANAEROBIC DIGESTION MODEL NO.1 (ADM1) TO DETERMINE THE EFFECT OF CERTAIN PARAMETERS ON MODEL OUTCOMES

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ENVE4198 GRADUATION PROJECT

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AIM

The goal of this study was to be able to thoroughly understand and apply the **ADM1 model**, to determine the effect of organic loading rate and substrate composition in terms of carbohydrates, proteins and fats on the model outcomes and to form a basis for comprehensive studies to be carried out in this field.

INTRODUCTION

The ADM1 model is a systematic representation of the key processes involved in converting complex organic substrates into **methane**, **carbon dioxide**, and **inert** byproducts.

Model is composed of biochemical and physico-chemical processes. In biochemical processes, the model examines a variety of substrates and bio-conversion processes. The model incorporates the decomposition of complex materials into components such as carbohydrates, proteins, and lipids. Physico-chemical processes are not mediated biologically and include ion association/dissociation and gas-liquid transfer.

Substrate uptake processes are assessed through Monod type kinetics and biomass growth is implicit in substrate uptake. Bio-chemical processe including death of biomass is represented by first order kinetics.

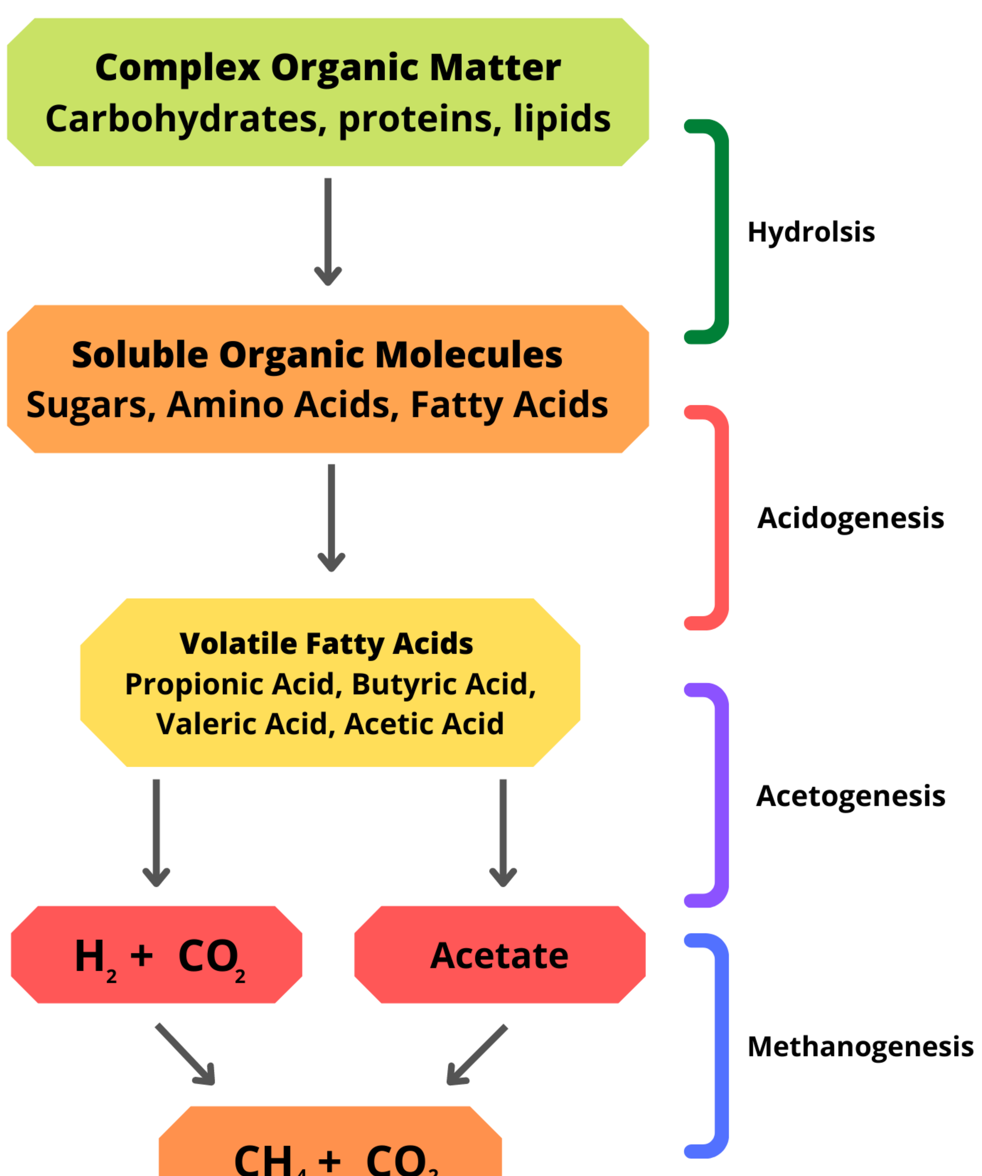

Fig.1: Conversion processes in anaerobic digestion as used in the model.

MATERIAL AND METHODS

Liquid phase physico-chemical processes are expressed either as **algebraic** or **kinetic rate equations** and the program is implemented based on these rate equations.

The rate equations for the gas phase are very similar to the rate equations for the liquid phase, with the exception that there is no advective influent flow.

An **anaerobic digestion system** typically consists of a **liquid-volume reactor** with a sealed gas headspace at atmospheric pressure, with the gas evacuated for downstream use. A completely stirred reactor with a single input and output stream and constant liquid volume is the system to be presented here. **ADM1 model** was impemented in **MATLAB**. The mass balance for each state component in the liquid phase is as shown in Equation 1:

$$\frac{dS_{liq,i}}{dt} = \frac{q_{in}S_{in,i}}{V_{liq}} - \frac{S_{liq,i}q_{out}}{V_{liq}} + \sum_{j=1-19} \rho_j \nu_{i,j}$$

Equation 1

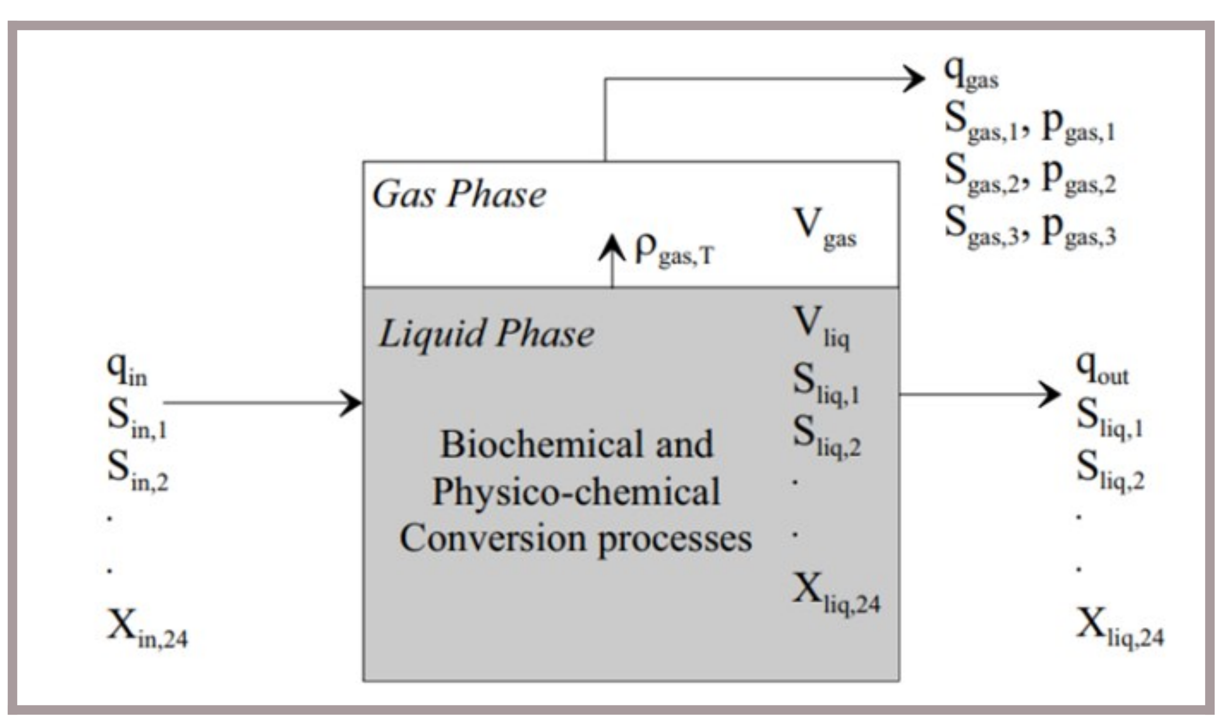

Fig.2: Schematic of a typical, single-tank digester.

RESULTS AND DISCUSSION

Table1: Initial Distribution of Influent Concentrations

	X_xc (Composite)	X_ch (Carbohydrates)	X_pr (Proteins)	X_li (Lipids)
kgCOD/m^3	2	5	20	5
Percentage, %	6.25	15.625	62.5	15.625

Using the initial values in Table 1, different scenarios were created by keeping three of the influent concentrations of composite materials, carbohydrates, lipids and proteins constant and one changing, and the following results were observed.

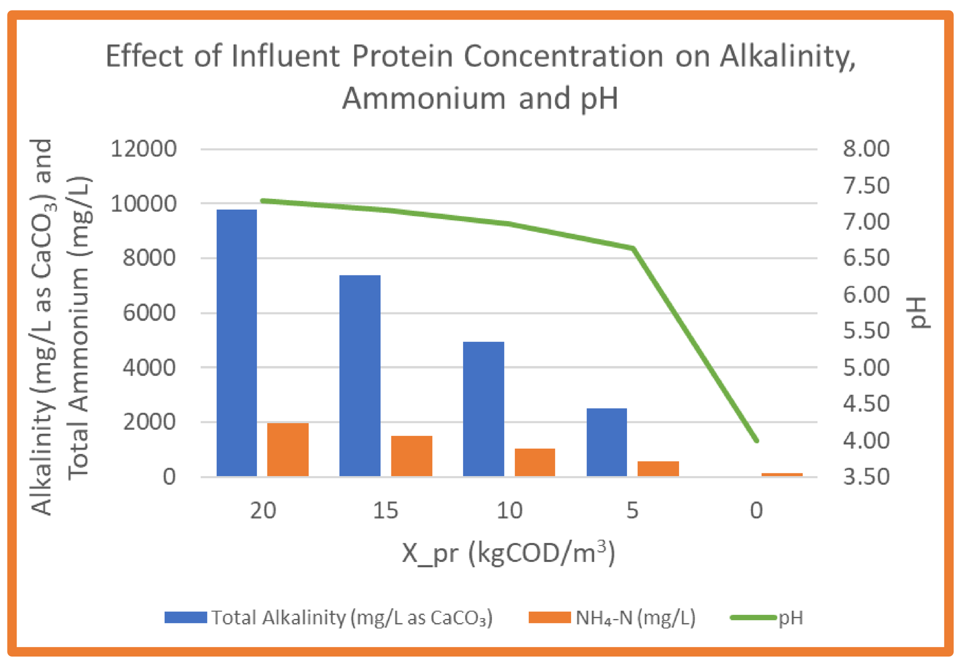

Figure.3: Effect of Influent Protein Concentration on Alkalinity, Ammonium

- In the scenario where the lipid concentration was gradually reduced from 5 to 0 kg COD/m^3, a 15 percent decrease was observed
- In the scenario where the carbohydrate concentration was gradually reduced from 5 to 0 kg COD/m^3, gas production decreased by 18 percent.
- In the scenario where the protein concentration was gradually decreased from 20 to 0 kg COD/m^3, significant changes were observed in alkalinity, total VFA amounts and methane production as seen in Figure 3,4,5.

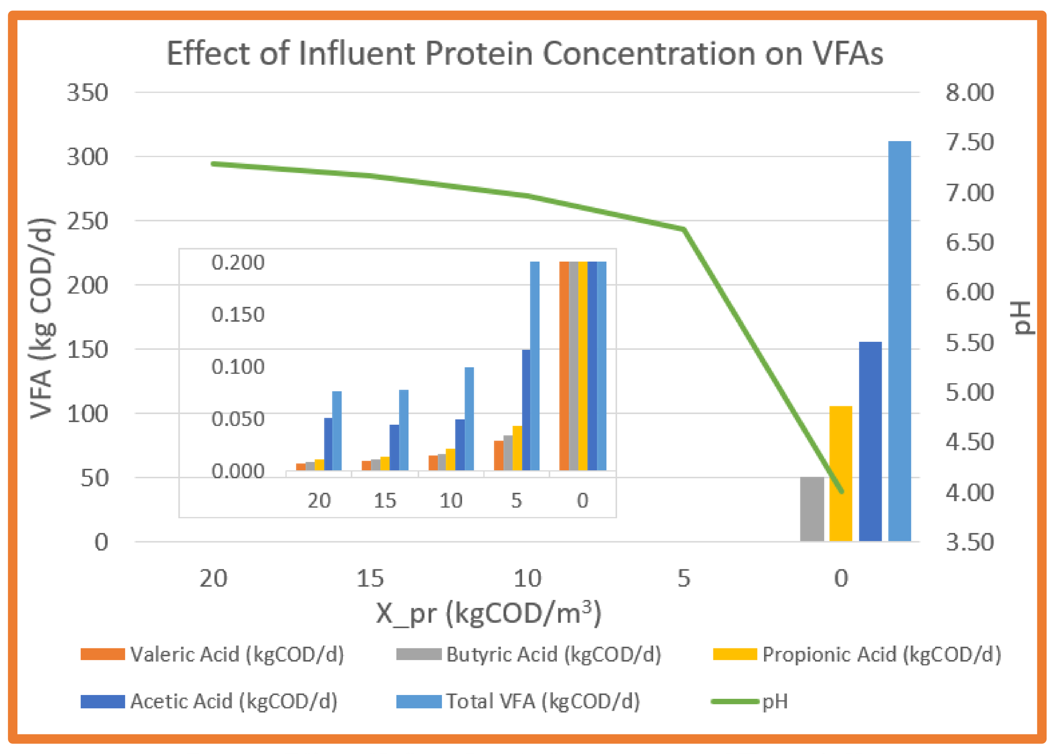

Figure.4: Effect of Influent Protein Concentration on VFAs and pH

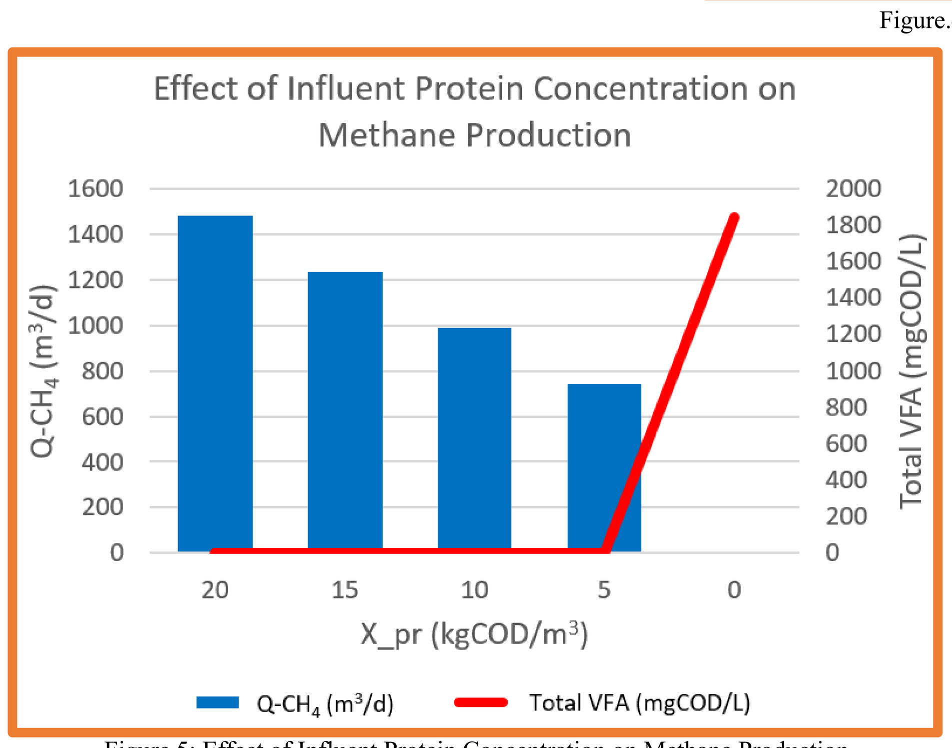

Figure.5: Effect of Influent Protein Concentration on Methane Production

- The model outcomes revealed that in the absence of protein in the feed, methane production did not occur, which was as a result of significant decrease in alkalinity and pH. As a result of cessation of methanogenesis, VFA accumulation was observed in the system.

CONCLUSION

In this project, the effects of the influent composition on gas production, alkalinity, VFA production, pH, NH_4-N at the steady state were investigated with different scenarios using the ADM1 model.

As a result, it was concluded that the most influential influent parameter on these outputs is proteins. Basically the deficiency or absence of proteins in the feed results in decrease of alkalinity and thus pH, which adversely affects the methanogenesis process. Cessation of methanogenesis then results in accumulation of VFAs, which results in further decrease of pH. The outcomes of this model revealed that the carbohydrate, protein and lipid ratio is important in terms of efficient functioning of anaerobic digestion

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