SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

ANAEROBIC DIGESTION OF CARDBOARD AND PAPER WASTE

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Introduction

The United States produces over 254 million tons of municipal solid waste (MSW) annually. Paper and paperboard are the largest constituents of MSW before recycling (27.0%) (Figure 1). Paper and paperboard include containers and product packaging, newspaper, and direct mail advertisements. Only 67.0% is recycled; the rest is either landfilled or incinerated (EPA, 2015). Due to landfill location restrictions and rapidly decreasing capacity as well as concerns regarding the environmental impact of incinerators, anaerobic digestion is becoming an increasingly popular alternative for both degradation of waste and production of energy (CH_4 gas) (Meng, 2015). Some states have even gone as far as to ban containers/paper from their landfills (Van Haaren, 2010). Despite its relative abundance and molecular composition, substrates containing lignocellulose, such as paper and paperboards, are often touted as difficult to degrade anaerobically (Baba, 2013). However, the chemical treatment that is applied to these types of paper and paper boards for different purposes (e.g. meal packaging), could have a positive impact on their anaerobic biodegradability. This work evaluates the biomethane potential of different types of paper and paper boards. Monod parameters were calculated as well.

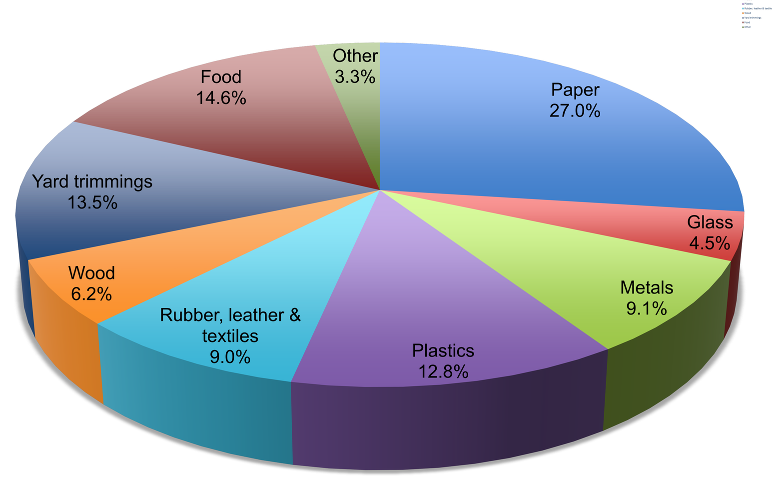

Figure 1. Breakdown of material found in US municipal solid waste (EPA, 2015)

Methodology

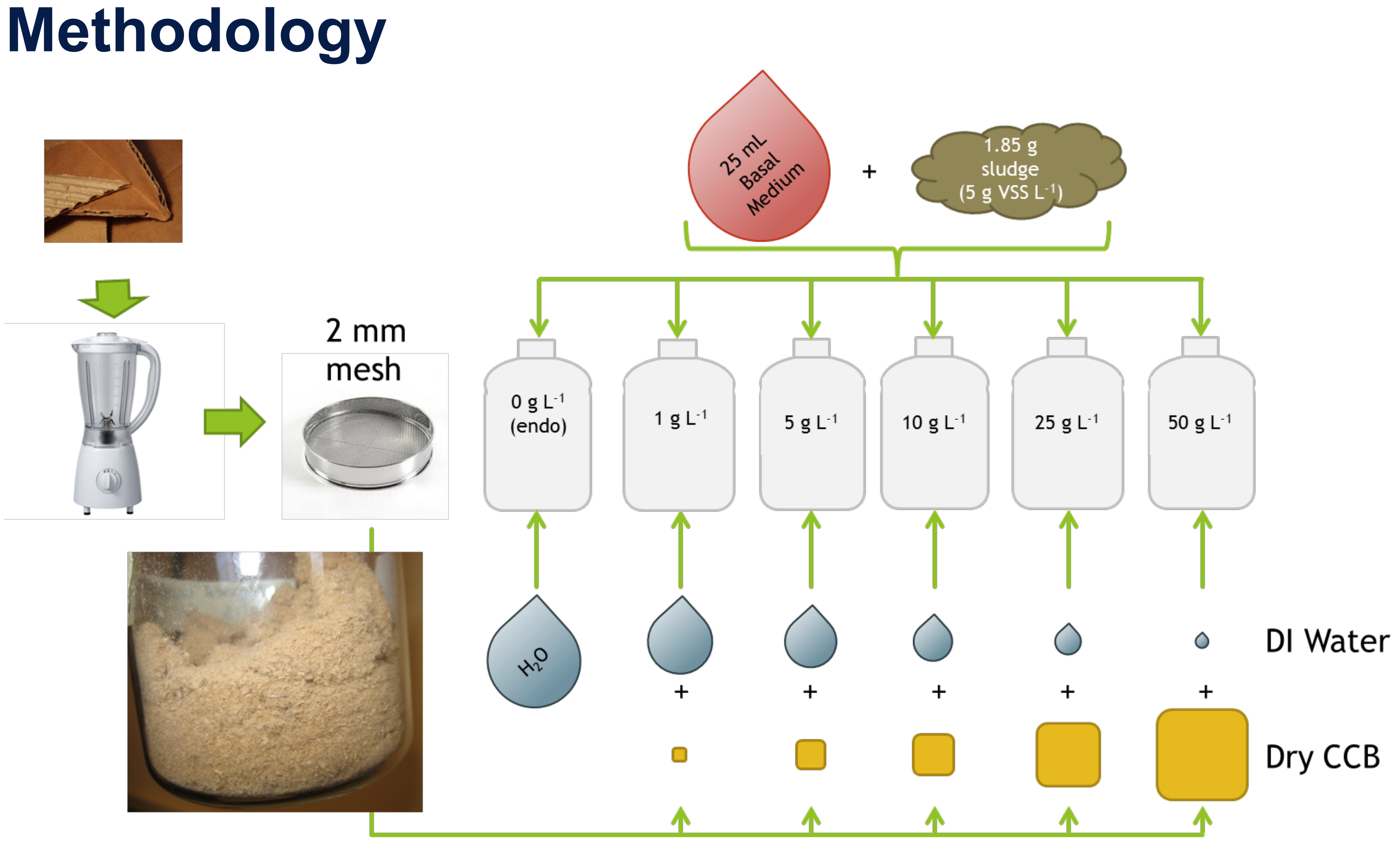

Figure 2. Preparation of substrates and subsequent loading of serum bottle batch reactors

Methodology

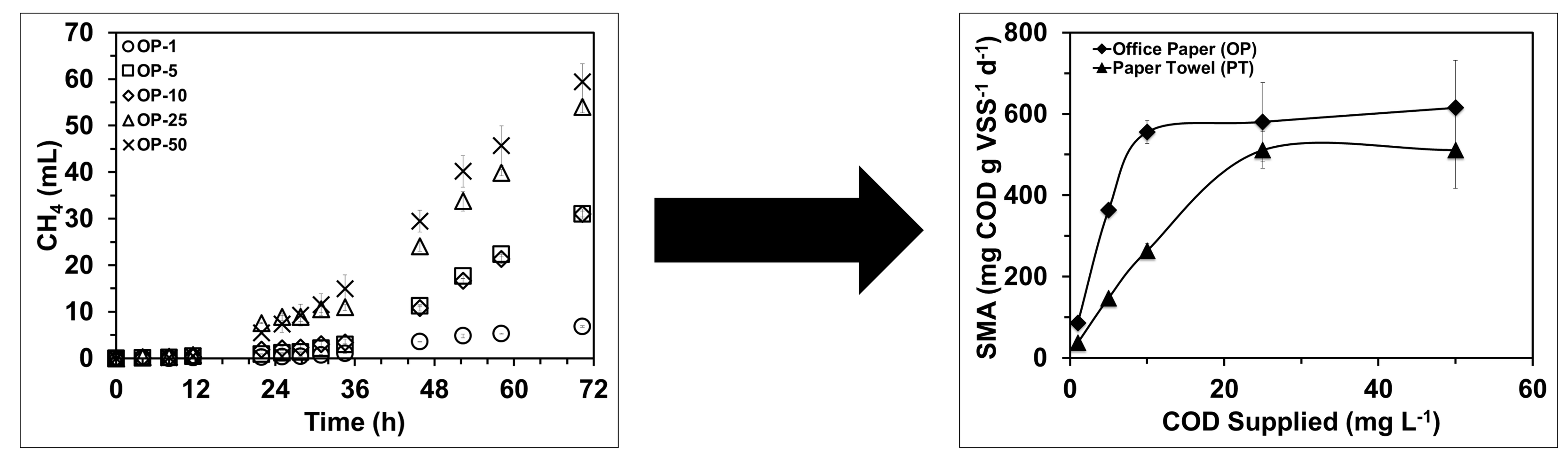

Figure 3. Visual representation of data analysis

$$SMA = SMA_{max} \frac{S}{K_S + S} \quad (1)$$

Kinetic parameters, SMA_{max} and K_s, are calculated using Equation 1.

Hypothesis

Materials that have been pretreated (e.g. SBB and OP) will have higher specific methanogenic activity (SMA) due to faster hydrolysis.

Results

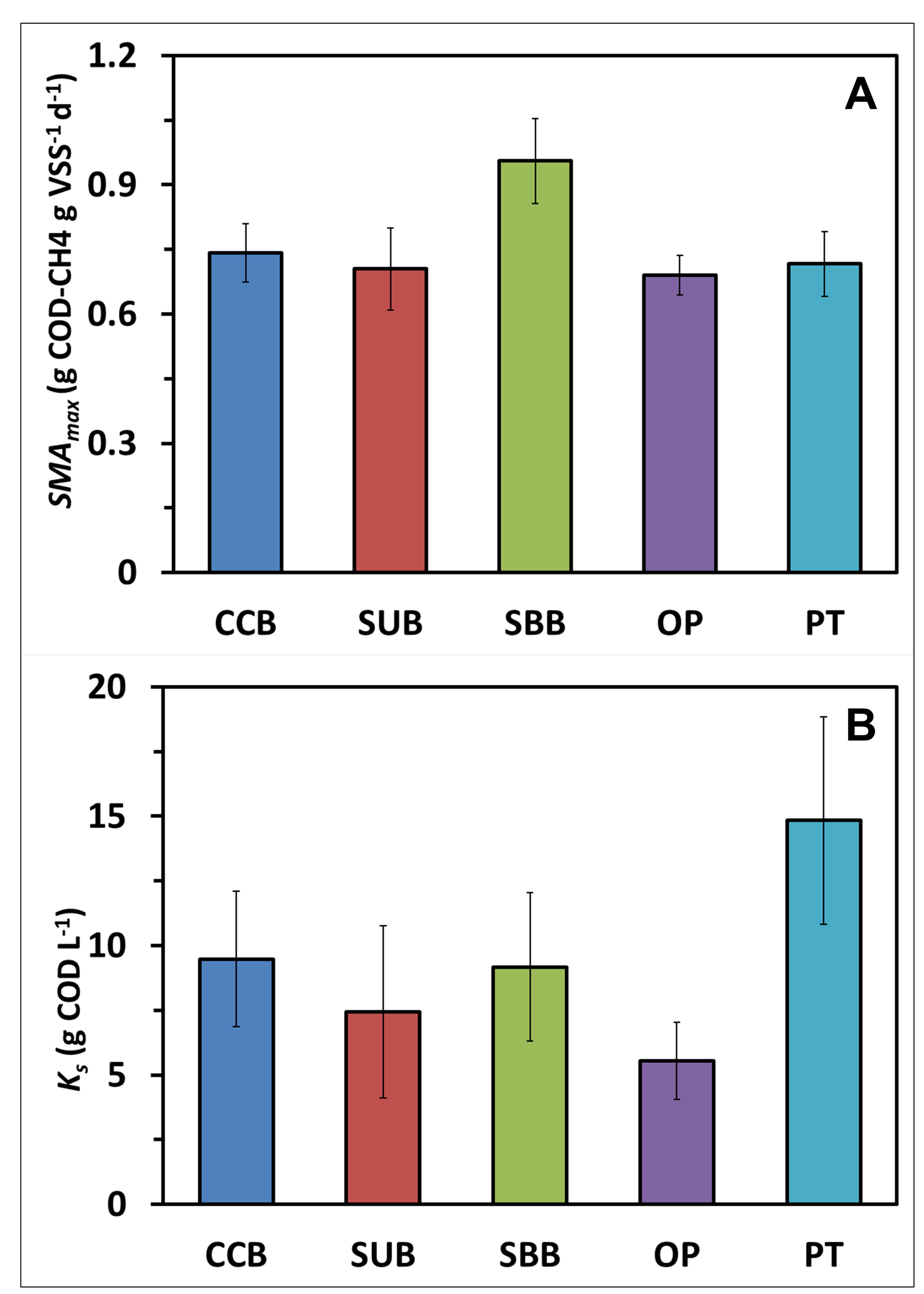

Figure 4. (A) Maximum specific methanogenic activity (SMA_{max}) for the following substrates: corrugated cardboard (CCB), solid unbleached board (SUB), solid bleached board (SBB), office paper (OP), and paper towel (PT); (B) Half-velocity constant (K_s) for each substrate

Results

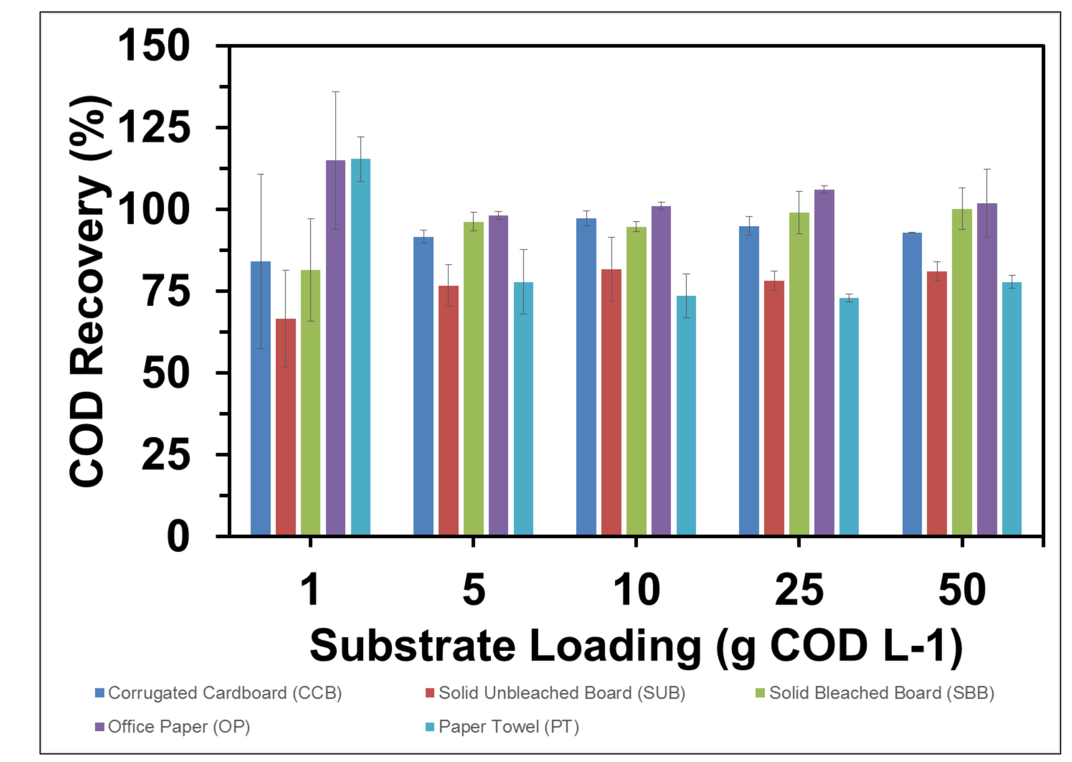

Figure 5. COD recovery as methane for each substrate

Conclusions

As hypothesized, solid bleached board (SBB) had a significantly higher SMA_{max} than the other substrates indicating that the microbiological community is able to utilize this feed source at a faster rate than the others. The half-velocity constant (Ks) was highest for paper towel, but did not show a distinct trend amongst the other substrates. All substrates yield a high recovery of methane (>80%) at the screened concentrations.

Current & Future Work

- Characterize % of lignocellulose, cellulose, and structural carbohydrates
- Fit data to modified Gompertz equation (Li, 2015) to quantify lag phase duration
- Evaluate the effect of particle size on digestibility rate
- Screen hydrolysis accelerating enzymes
- Immobilize enzyme on compatible support matrix
- Scale up process for use in a continuous system with hollow fiber membrane and upflow anaerobic sludge digester

Acknowledgements

Funding provided by United States Air Force as part of the Basic Expeditionary Airfield Resources (BEAR) – Energy Saving Technologies (EST) program.

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