Evaluating a Plant-based Flocculant for Microalgae Biomass Harvesting

Marie D. Peralta[1] and Ann C. Wilkie[2]

[1]Biology Major, College of Agricultural and Life Sciences

[2] Faculty Mentor, Soil and Water Science Department, University of Florida-IFAS, Gainesville, Florida

Abstract

Establishing new feedstocks for renewable fuel is necessary to lessen our dependence on fossil fuels and mitigate global climate change. Energy crops for fuel production often displace opportunities for growing food, thereby increasing food prices. Cultivating microalgae for biofuel production is an innovative solution that does not compete with food crops. However, harvesting microalgae can be expensive and energy intensive. The press cake remaining after oil extraction from *Moringa oleifera* (MO) seeds has been used as a flocculant to purify water, and this non-toxic organic substance can displace expensive chemical additions. The research objective was to determine the effect of increasing MO concentrations on the flocculation of two different species of algae, *Chlorella minutissima* and *Scenedesmus* sp. Flocculation efficiency was evaluated in triplicate by measuring the optical density of the cultures before and after MO addition using spectrophotometry at 680nm. Aluminum sulfate (1% w/v) was used as a positive control to compare with increasing dosages of MO flocculant (0.05, 0.50, 1.0, and 1.5 g/L). Results demonstrated a positive correlation between increasing MO dosages and flocculation efficiency. A maximum flocculation efficiency of 91% was achieved with 1.5 g/L MO for *Chlorella minutissima* while only 40% efficiency was achieved for *Scenedesmus* sp.

Introduction

Flocculants can help overcome harvesting challenges including:

- *Energy intensive procedures:*
  - Regulating algae culture temperatures and aeration
  - Harvesting with high-speed centrifugation

Microalgae can produce carbohydrates, lipids, and proteins. These products can be used as possible sources of biofuel:

- ***Biodiesel*** from algae lipid
- ***Bioethanol*** can be made by fermenting the algae press cake remaining after taking the lipids
- ***Methane*** from anaerobically digesting algae biomass and press cake

How does flocculating algae occur?

Microalgal cells naturally repel each other due to identical surface charges. Flocculants can be used to bind under high pH conditions to block these surface charges. Once the flocculant is added, the algae aggregate into larger and heavier particles, accelerating sedimentation.

Why use *Moringa Oleifera* flocculant?

- This plant-based flocculant can be grown in drought conditions in tropical regions of the world.

Figure 1. Regions of Moringa growth globally (top); Moringa seeds and seed cake powder (bottom)

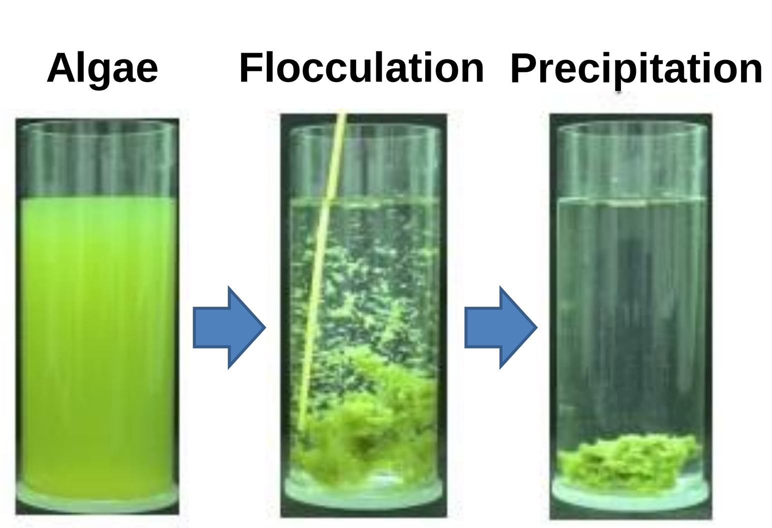
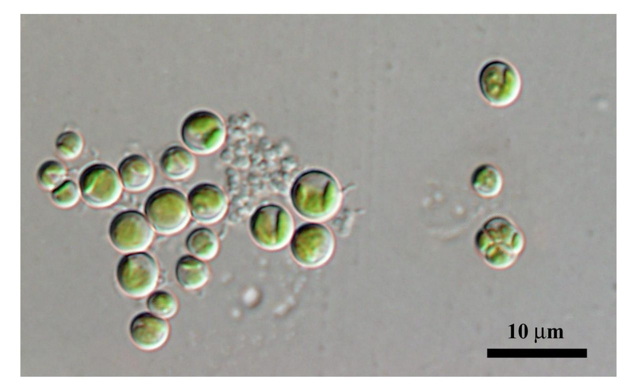


Figure 2. Algae Flocculation

Objectives

This project investigates the effect of flocculants *Moringa oleifera* seed cake and aluminum sulfate on microalgae *Chlorella minutissima* and *Scenedesmus sp.*, and whether flocculation increases over time with increasing flocculant dosages.



***Chlorella minutissima* under 100x magnification**

***Scenedesmus* sp. under 100x magnification**

Flocculating on different algae species or genuses will determine whether these flocculants perform consistently and independently of the type of algae harvested.

Materials & Methods[1]

- Mother cultures grown in BG-11 standard growth medium
- **The Jar Test[2]:**

Chlorella minutissima & *Scenedesmus* sp. under the following parameters:

  - **Flocculants**: MO seed powder (1% w/v) & aluminum sulfate (1% w/v)
  - **Flocculant Dosages**: 0.05 g/L, 0.50 g/L, 1.0 g/L, 1.5 g/L
  - **Flocculation Duration**: 15, 30, 45, and 60 minutes
  - **Spectrophotometry**: Optical density at 680nm[3] of 3 mL solutions taken before and after flocculation.

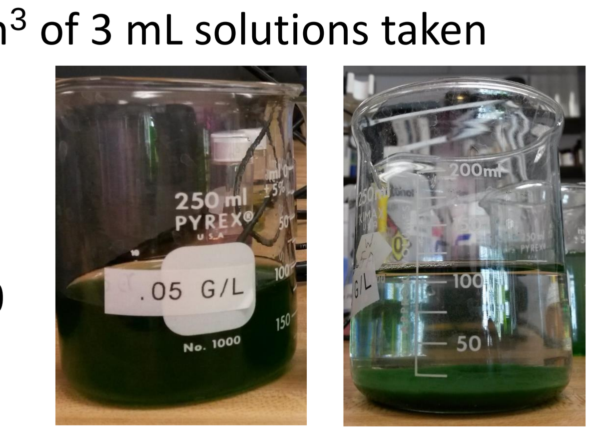
All tests performed in triplicate

- **Flocculation Efficiency:**

$$Flocculation\ efficiency\ (\%) = \frac{C_i - C_f}{C_i} \times 100$$

C_i= optical density at 680 nm of algae in medium before addition of flocculant

C_f= optical density at 680 nm of algae suspension after addition of flocculant



***Chlorella minutissima* culture in medium before flocculation (left) and after flocculation (right).**

Results

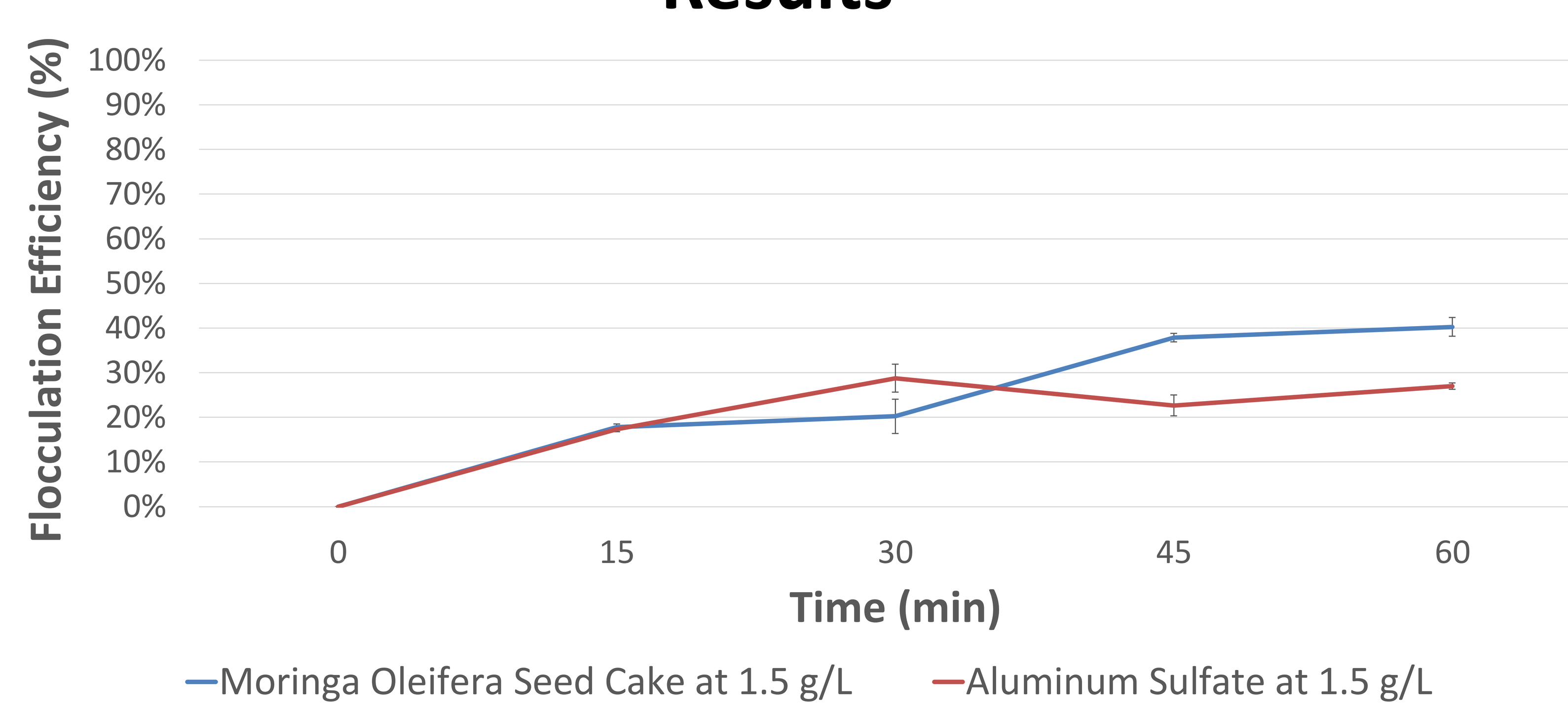


***Figure 3: Moringa Seed Powder* vs. Aluminum Sulfate with *Scenedesmus* sp.**

- MO seed powder flocculant provided higher flocculation efficiencies overall on *Scenedesmus* at a maximum of 40% at 60 minutes versus 27% efficiency with aluminum sulfate at 60 minutes.

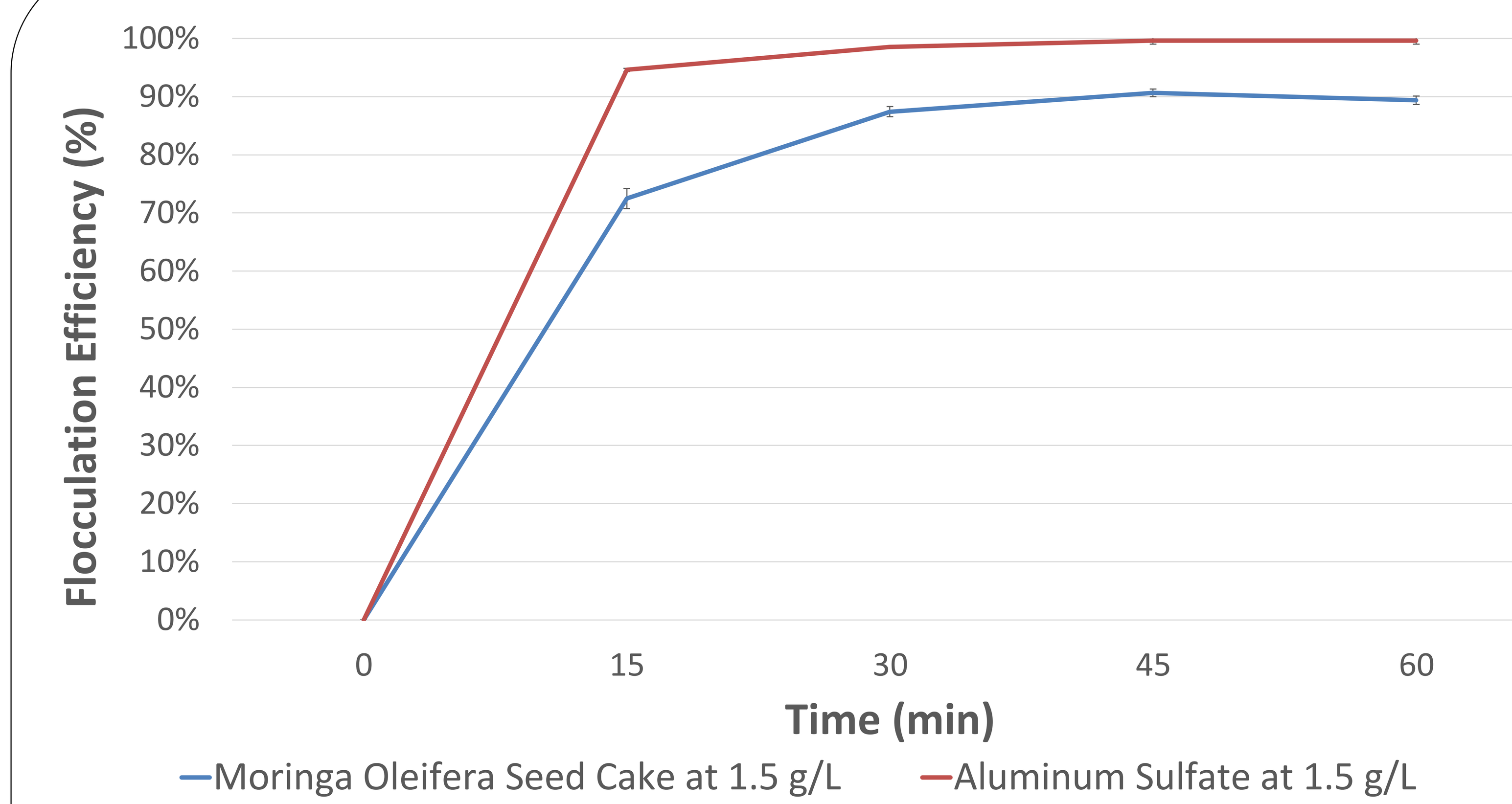


Figure 4: Moringa Seed Powder* vs. Aluminum Sulfate with *Chlorella Minutissima

- Aluminum sulfate flocculant provided higher flocculation efficiencies on *C. minutissima* at a maximum of 100% reached at 45 minutes versus MO flocculant at 91% efficiency at 45 minutes.

Conclusions

- An increase of flocculant dosages is positively correlated with flocculation efficiency over time.
- For Scenedesmus sp., MO flocculant provided better flocculation efficiencies while a higher efficiency was achieved with aluminum sulfate on Chlorella minutissima.
- This difference in performance may be attributed to the difference of algal cell size between the two microalgae; greater cell surface area may increase flocculant accessibility, increasing flocculation efficiency.
- Higher amounts of surface charges indicate a higher amount of algal cells.

Future Work

- Investigate different plant-based flocculants that have similar properties to MO flocculant.
- Evaluate the effect of MO flocculant on other algae species displaying different morphologies .

References

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3. Edmundson, S.J. and Wilkie, A.C. (2013). Landfill leachate – a water and nutrient resource for algae-based biofuels. *Environ. Technol.* 34(13–14):1849-1857.

Acknowledgements

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