Three-step Ammonia Removal System
University of California, Riverside
PI: Dr. Kelley Barsanti, Dr. Kawai Tam
Graduate Student: Christos Stamatis
Undergraduate Presenters: Maurice Armstrong, Maggy Harake, Joshua Milne, Partho Paul

Supporting People, Planet & Prosperity

Full Circle Engineering (FCE) is fully dedicated to using the principles of green engineering to remediate harmful ammonia (NH₃) emissions from the environment using a three-step NH₃ removal system. The system centers around the full circle mentality by using biochar, a sustainable and accessible filtration medium, which can be repurposed as an effective soil amendment upon saturation. Currently, FCE is working to create a full scale model of the three-step NH₃ removal system at Scott Brothers’ Dairy Farm located in Moreno Valley, California.

Three Steps to Removal

1. Absorption
   - Collection and subsequent scrubbing of gaseous NH₃ from agricultural point sources
   - Conversion of gaseous NH₃ to aqueous phase NH₃
   - Clean air is released as a byproduct of this process

2. Recycle
   - Water from biochar column is recirculated back into the scrubber column for further absorption
   - Biochar enriched with adsorbed NH₃ can be used as a soil amendment to propagate increased crop yield

3. Biochar
   - Aqueous NH₃ is pumped into a biochar column where NH₃ is removed from the water
   - Biochar serves as a granular medium which effectively adsorbs NH₃ from aqueous phase

Bench-Scale Design

Figure 1: Bench-scale schematic

Results and Developments

Biochar as an NH₃ Adsorbent - Removal Efficiency
The overall effectiveness of the biochar in removing ammonia (as NH₃) from the absorption column effluent was tested in a series of lab experiments. The initial ammonia concentration was determined from samples collected at the reservoir and the final concentration was determined using an ammonia phenolate analysis method. The water flow rate and biochar particle size were optimized, producing the results shown in Figure 3 and Table 1. The maximum ammonia removal efficiency was found to be 78% with an average of 60% ± 14% over multiple trials.

Biochar with NH₃ - Soil Amendment Properties
The ability of NH₃/NH₄⁺ saturated biochar to serve as a soil amendment was also tested using 3 other soil types for comparison. The results are summarized in Table 2. Romaine lettuce was used for its short maturation period of 3 weeks. The average leaf weight (Figure 4) and average number of leaves on each plant (Figure 5) were recorded over a 12 week period to allow for a robust statistical analysis.

Summary of Anticipated Outcomes

Anticipated Conclusions
Ultimately, this project encompasses the full circle mentality by converting hazardous waste into a valuable soil amendment for agricultural operations throughout the world. By remediating ammonia from farms, FCE will safeguard human health, preserve worker safety, improve community welfare, and protect the natural environment while boosting soil health, crop yield, and agricultural profits, while also reducing water use.