
**World Water Forum College Grant Program
2017-2019 Grant Proposals**



College	UC RIVERSIDE
Faculty	Dr. Barsanti & Dr. Tam
Project #018	Reducing Ammonia Emissions and Conserving Water Quality



Southern California World Water Forum | College Grant Proposal
Project Strand: **Technology-Local**

Designing for the Future: Reducing Ammonia Emissions and Conserving Water Quality

December 15th, 2017

University of California Riverside
Bourns College of Engineering
Department of Chemical and Environmental Engineering

Faculty Director: Kelley Barsanti, Ph.D.

Student Manager: Taylor Turner

Project Members: Hannah Keife, Jourdan Joyner, Thania Flores, Daniel Zaragoza

PROJECT SUMMARY

Agricultural producers are primary contributors to atmospheric ammonia pollution throughout the United States. California, in particular, contributes significantly more ammonia emissions than any other state; with the largest contribution coming from dairy facilities. Chemical-based scrubbers have been used in dairy facilities to remove ammonia from the atmosphere; however, such scrubbers are prone to clogging and require large amounts of water that is not reused or recycled. An improved design is required given the pressing need to reduce ammonia emissions, but also maintain water quality and quantity. A three-step scrubber has been proposed that maintains functionality in reducing emissions and improves sustainability by allowing water reuse and repurposing of collected ammonia. The three steps are 1. An absorption unit in which ammonia is scrubbed from the intake gas by a clean water sprayer; 2. An adsorption unit in which aqueous ammonia is sent through a biochar filter; and 3. An air stripping unit that removes any residual aqueous ammonia. This three-step design will minimize ammonium salt clogging, and the ammonium saturated biochar can be used as a fertilizer. Most importantly, the three-step design will allow water to be reused; thus achieving significant advancements in environmental and economic sustainability.

Application Strand	Region
LOCAL Designing for the Future: Reducing Ammonia Emissions and Conserving Water Quality	Moreno Valley, Riverside County, California

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CONTACT INFORMATION

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Student Project Manager	Taylor Turner
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Department	Dept. of Chemical and Environmental Engineering
Overview/History	See: Page 5
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	NAME	TITLE / ORGANIZATION	ADDRESS	PHONE & EMAIL
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4	Hannah Keife	Undergraduate – Research Lead	2647 Scenic Crest Lane, Corona CA 92881	(951) 847 - 4426 hkeif001@ucr.edu
5	Daniel Zaragoza	Undergraduate - Co-Construction Lead	32150 Thompson Rd, Winchester CA 92596	(951) 987 - 1124 Lzara001@ucr.edu

OVERVIEW/HISTORY-UNIVERSITY OF CALIFORNIA, RIVERSIDE

Established in 1989, the Bourns College of Engineering (BCOE) at the University of California, Riverside has risen as one of the top 100 engineering colleges in the United States. Serving a wide-range of undergraduate and graduate students, BCOE continues to innovate in the field of engineering and technology. The premier research facilities serve both undergraduate and graduate students, whose research expands current and creates new technologies.

The Bourns College of Engineering (BCOE) is steadfastly committed to producing engineers with a strong theoretical foundation coupled with adaptive skill to excel in a rapidly evolving technological world. Facilitated by BCOE's premier research facilities, undergraduate students are encouraged to apply their theoretical knowledge through research opportunities, student design competitions and STEM outreach events. BCOE has four research facilities: Bourns College, Winston Chung Global Energy Center, Material Science Building and the Center of Environmental Research and Technology (CE-CERT). The availability of these facilities to undergraduate student researchers has produced a distinct undergraduate student body who is highly-trained and well-motivated to apply their research experiences in government, non-profit, academic, and industrial sectors.

While unique, integration of the Chemical and Environmental Engineering programs is logical and successful due to the close association between the curriculum requirements and fundamental knowledge and skills required for both fields. This has allowed a diverse curriculum for the Chemical and Environmental engineering students, as well as the opportunity for students to work in interdisciplinary teams. Moreover, the integrated department facilities heightened environmental awareness in chemical engineering students.

The overall mission of the Chemical and Environmental Engineering department is to facilitate and provide the necessary foundation for its students to excel upon graduation and become leaders in the development of technical solutions to address our most pressing problems and environmental challenges. Additionally, BCOE's objective is to maintain the finest educational and research programs for students as they prepare for and gain experience in their chosen careers.

PROJECT DESCRIPTION

This innovative scrubber will reduce ammonia emissions coming from dairy farms while simultaneously allowing water reuse and promoting decreased costs for implementation and costs. As shown in Figure 1 below, a water based air scrubbing unit is used in the first step to absorb the gas phase ammonia entering the system (S-2). The second phase uses adsorption to collect ammonium ions and pass water to phase 3 with largely reduced ammonium concentrations (S-5). In the third step, a fresh air feed (S-7) is used to strip any remaining ammonia from the water. Following all three steps the water is recycled back into the system (S-8), while the ammonium can be used to create a biochar fertilizer (S-4). This system reduces ammonia emissions, which improves air quality for human health and provides a sustainable approach to water usage, addressing the drought California is currently experiencing.

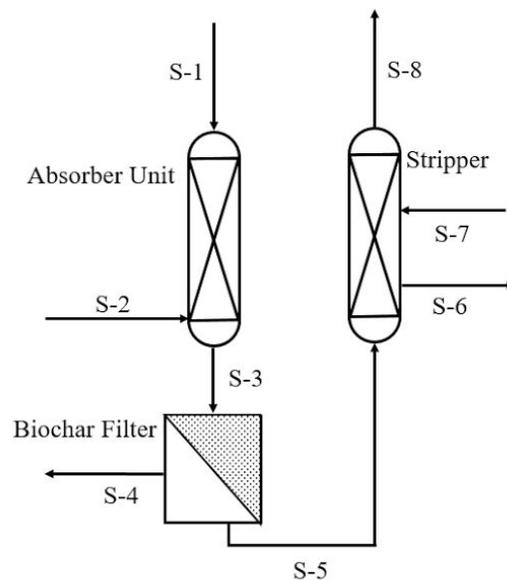


Figure 1. Streams of Three-Step Scrubber Design

This project is a local focus. Our team will be partnering with Scott Brothers Dairy Farm in Moreno Valley, California. This is a short drive (30 minute) from UC Riverside. We plan on using our three-step ammonia scrubber to treat ammonia emissions from their milking house wastewater.

We chose the technology content strand as the research focus for creating this project. We saw a problem in the existing technology that dairy farms use to reduce ammonia emissions. They are very costly and use hundreds of thousands of gallons of water every day. From our research so far, we found that the second step of the design effectively removes ammonium ions from water with an efficiency of about 67%. We plan on designing the full system and implementing it at the Scott Brothers Dairy Farm next year.

Research will be taking place at the Bourns College of Engineering Center for Environmental Research & Technology (CE-CERT) in Riverside, CA. The team will be working out of PI, Dr. Kelley Barsanti's lab. Along with this, samples and data will also be collected from Scott Brothers Dairy Farm in Moreno Valley, CA, where the team plans to install a field-scale scrubber to obtain real, actionable data that will be used to optimize the full-scale ammonia scrubber.

The anticipated outcome of this research is to reduce ammonia emissions while also minimizing fresh water consumption. This will allow industry scrubbers to operate more efficiently and reduce the amount of water consumption needed for operation, without compromising performance. This process pushes for sustainability because it reduces the overall ammonia emissions produced from dairy farms while keeping fresh water use at a minimum by introducing a recycling stream that recycles a majority of the original effluent. In regard to the qualitative benefits to people and the planet, the design contributes to a cleaner and environmentally sustainable planet with its innovative use of a water-based absorber unit (rather than chemically based) and a manure-based biochar filter to reduce ammonia concentrations. In initial bench-scale tests, removal efficiency as high as 67% were demonstrated. The three-step process is designed to reduce the overall ammonia pollution from dairy facilities that would otherwise enter the environment in an uncontrolled fashion and cause significant health risks to surrounding populations. At Scott Brothers Dairy farm, the goal will be to remove and measure the ammonia gas being released from the farm at the outflow point shown in the Figure 2 below.



Figure 2: Outflow Emissions at Scott Brothers. Dairy

With the increasing challenge to maintain a sustainable freshwater supply to support the growing population of California, it has become important for residents and agricultural producers to reduce their water usage and implement systems to use water more efficiently, and maintain water quality. Agriculture contributes to 80% of the water consumption in California and since the dairy facilities are a primary consumer, the implementation of our Three-Step Ammonia Removal System for agricultural producers is sure to be beneficial in the reduction of freshwater use in ammonia removal systems.¹ Our sustainable design will allow for a cleaner and healthier environment for current and future populations. Chemical scrubbers are a common technique used by most modern day dairy facilities to reduce ammonia emissions. The issue with these current chemical scrubbers is the abundant amount of freshwater used to scrub the ammonia emissions. These methods are not conducive to the current water scarcity in the state of California since the techniques require 10,080 gallons of water per day to perform correctly.² On the other hand, water-based air scrubbers are used to separate ammonia from a contaminated air stream; ammonia is quite soluble and easily moves from the contaminated air stream and to the water, creating an aqueous ammonia solution. Regarding step two, various filtration techniques exist on the current market, and recent studies have demonstrated that manure-based biochar is one effective filter medium in the adsorption of ammonia, as well as an environmentally friendly dairy farm product.³ Our biochar filter removes ammonium from the wastewater stream via adsorption to create ammonia-rich biochar. This biochar then serves as an effective fertilizer and a potential revenue stream for the dairy farm, thus reducing the economic and environmental costs of effluent disposal. We estimate our water based scrubber will only use 1,781 gallons of water a day which is a significant reduction from the 10,080 gallons of water per day by a chemically-based scrubber. After one year of operation (365 days), a chemical scrubber would use 3,679,200 gallons of water compared to our scrubber which would use 650,065 gallons of water. This is a net savings of 3,029,135 gallons of water per year. There are 325,851 gallons per acre foot, so 9.3 acre-feet of water per year would be saved using the three-step ammonia scrubber over a traditional one-step chemically-based scrubber.

The Scott Brothers Dairy currently does not have an ammonia reduction system in place, thus the reduction in ammonia emissions would provide an economic benefit to Scott Brothers Dairy and ultimately other facilities. The AQMD has a threshold of 200 lbs of ammonia per year, fees are imposed on emissions above the 200 lbs per year. Based on AQMD emission factors, the 2100 cows at the Dairy emit a total of 51 lbs of ammonia per cow per year.⁴ At a cost of \$0.03/lb, the Dairy currently pays an annual fee of \$3,207. Based on design calculations and the bench-scale lab results, our three-step scrubber system will remove 70% of the gas-phase ammonia by absorption to water stream; the biochar adsorption then removes 67% of the aqueous ammonium, yielding a 53% reduction in total ammonia emitted. This 53% reduction in emissions would system save the Dairy \$1504 in AQMD fees per year. The relatively high removal efficiency achieved demonstrates that the second step design is an effective and environmentally contributive method for removing ammonia from dairy operations. Our innovative design will satisfy the overarching goal of preventing large emissions of ammonia into the atmosphere which contribute to pollution-induced health risks; while also significantly reducing the water consumption of agricultural operations in comparison to existing ammonia removal methods.

To establish the feasibility of ammonia scrubber, all optimization tests and construction of the prototype will be completed within CE-CERT at the University of California, Riverside under the team's faculty director, Kelley Barsanti, Ph.D. Dr. Barsanti initiated this project with a different group of students in 2015 and has been working with new incoming members to complete the project's goals. Her expertise in air quality pollution makes her the ideal faculty mentor for this project. The team meets with her weekly, where short term goals are established, issues are discussed, and all members are up to date with the project's advancement.

The team from the University of California, Riverside is composed of five undergraduate students: Taylor Turner, Hannah Kiefe, Jourdan Joyner, Thania Flores-Soto and Daniel Zaragoza. Taylor Turner, a chemical engineering undergraduate, has been part of this project since 2016 and is currently the team lead. As the student manager he will be organizing meetings, track the budget, be in charge of training new members, and be the main contact and responder to all outside parties.

Jourdan Joyner and Daniel Zaragoza will be sharing the lead role of prototype construction. Jourdan is an undergraduate chemical engineer who transferred into the university in 2016. Jourdan has previous research experience working in a lab, has programming skills and communicates clearly. Daniel is an undergraduate environmental engineering student with prior military service and experience in construction work, programming, and laboratory techniques and procedures. The pairing of Jourdan and Daniel will enable the team to have clear protocols to successfully test and build the ammonia scrubber.

Hannah Keife is an Environmental Engineering undergraduate who has the technical capabilities to perform experiments in a laboratory setting, calculations, while also having excellent communication and organizational skills. Her strengths come from her experience in all her undergraduate STEM courses, work experience and key role as President of Kappa Kappa Gamma. She will lead the research aspect of this project to ensure it has accurate results and innovative ideas.

Thania Flores-Soto is an Environmental Engineering student whose technical concentration involves water treatment technology. Thania has extensive internship and work experience, where she closely worked with surrounding communities. She has developed a passion towards addressing environmental injustices in low-income communities. Additionally, she is talented in making posters, presentation, flyers, and other outreach materials. Thus, she will lead the outreach and projected community impact of the project.

A key partnership for the project's completion includes Michael Bagtang, project engineer, from Agricultural Waste Solutions/Scott Brothers Dairy. His role in this project is to facilitate the testing of the prototype in the Scott Brothers Dairy. It should be noted that the scrubber will be initially tested in lab then once optimized it will gather real time data at the dairy.

PROJECT SCHEDULE

Year	Month	Goal	Description
2017	November-December	-Recruit a 3 rd year student -Propose a final design	New member (3rd year student) will be the lead for the 18'-19' team
2018	January-March	- Propose a final design -Start testing biochar materials	
2018	April-May	- Grant recipient announcement - Begin prototype construction -Recruit and train new members	Receive grant; Purchase materials and begin prototype construction.
2018	June-August	- Finalize prototype -New members are fully trained	Optimize parameters via lab tests
2018	September-December	-WWF staff on site visit and complete project report	Finalize optimized parameters for final report
2019	January-March	- Prepare presentation for WWF Exposition	
2019	March-April	- MWD exposition presentation	

FINANCIAL CRITERIA

DESCRIPTION	AMOUNT	NOTES
GRANT FUNDS REQUESTED	\$9,888.78	This amount includes UCR's 10% overhead fee
ADDITIONAL SOURCE OF FUNDS	N/A	N/A
PROJECT TOTAL	\$9,888.78	Total amount requested

The University proposes a match of 25% of the amount requested (i.e., \$2,500) in the form of volunteer time/effort by the faculty advisor Dr. Kelley Barsanti which is valued at a minimum of \$2,500.

BUDGET BREAKDOWN

Budget Description	Computation			WWF	COLLEGE	TOTAL COST
	Price/Rate	Unit	QTY			
Supplies and Materials						
Custom Lab Scale Ammonia Scrubber	\$ 3,000.00	1		\$ 3,000.00		\$ 3,000.00
Vinyl Tubing 3ft.	\$ 3.00		9	\$ 27.00		\$ 27.00
Ammonia Gas Sensor	\$ 762.00	2		\$ 1,524.00		\$ 1,524.00
Odor Masks	\$ 12.00	1	5	\$ 60.00		\$ 60.00
Mask Filters	\$ 7.00		4	\$ 28.00		\$ 28.00
Heavy-duty Gloves	\$ 40.00		2	\$ 80.00		\$ 80.00
Probe-PC Connections	\$ 140.00	1		\$ 140.00		\$ 140.00
Electrode/ Probe Supports	\$ 10.00		2	\$ 20.00		\$ 20.00
Air Pump	\$ 2,619.00	1		\$ 2,619.00		\$ 2,619.00
Water pump	\$ 850.00	1		\$ 850.00		\$ 850.00
Solar power generator	\$ 217.00	1		\$ 217.00		\$ 217.00
Other Office/Presentation Supplies	\$ 200.00			\$ 200.00		\$ 200.00
Round Trip to Scott Bros. Dairy	\$ 22.47		10	\$ 224.70		\$ 224.70
Total Cost of Supplies						\$ 8,989.70
UCR Overhead Fee						\$ 898.97
Total Budget						\$ 9,888.67

REFERENCES

1. Cohen, R.; Wolff, G.; and Nelson, B. (2004) Energy Down the Drain: The Hidden Costs of California's Water Supply. Natural Resources Defense Council and Pacific Institute, O5.National Atmospheric Emissions Inventory. (n.d.). Pollutant Information: Ammonia. Retrieved November 20, 2015. Oakland, CA, August.
2. California Regional Water Quality Control Board Central Valley Region. 10 November 2005. California Water Boards. Web
3. Spokas, Kurt A., et al. "Biochar's Role as an Alternative N-Fertilizer: Ammonia Capture." *Plant and Soil*, vol. 350, 2012, pp. 35–42.
4. Occupational Health & Safety Guideline for Ammonia. Guideline. N.p.: Occupational Health & Safety Administration, 1992. Print.

LETTERS OF INTENT/SUPPORT

John V. Rossi
General Manager

Robert Stockton
Division 1

Thomas F. Evans
Division 2

Brenda Dennstedt
Division 3

Donald D. Gallesino
Division 4

S.R. "Al" Lopez
Division 5



Securing Your Water Supply

Metropolitan Water District of Southern California
C/O: Dr. Adrian Hightower
Education Unit Manager
PO Box 54153
Los Angeles, CA 90054-0153

Dear Dr. Hightower,

As one of Metropolitan Water District of Southern California's member agencies, Western Municipal Water District is honored to recommend a team of students from the University of California Riverside (UCR), lead by Dr. Kelley Barsanti, for the World Water Forum (WWF) program.

The students are applying for the WWF program to assist financially with research funding for their water-reuse project. The project entails the implementation of a three phase water-based ammonia air scrubber, that will implement a process for the reuse of dairy wastewater. The first phase consists of a water-based air-scrubbing (gas absorbing) unit. The second phase uses a novel clinoptilolite filter to collect ammonium from the waste stream, cleaning the water for reuse. This second phase eliminates the requirement for waste disposal of the water-ammonia effluent. Phase three uses an air stripper to further reduce the ammonia concentration from the water. The water can then be reused and the process of reclamation than be implemented once again.

The students have already partnered with Scott Brothers Dairy in Moreno Valley, which demonstrates the seriousness of their commitment to the project implementation. The project is a sustainable and affordable way to treat wastewater containing high amounts of ammonia. They are currently working with the dairy to install a prototype design of their project to test wastewater.

Should you have further inquiries regarding the eligibility of the UCR team please feel free to contact me at RMcGuire@WMWD.com or 951-571-7255. I appreciate your consideration for the UCR students during the World Water Forum selection process.

A handwritten signature in blue ink, appearing to read "Rachel McGuire".

Rachel McGuire
Communications Manager

CERTIFICATE OF ATTENDANCE

Certificate of Participation
presented to

TAYLOR TURNER

UNIVERSITY OF CALIFORNIA, RIVERSIDE

Thank you for participating in the

**Southern California World Water Forum
College Grants Program on Innovative Conservation Technology,
Communication and Policy.**

October 13, 2017



SIGNATURE BLOCK

*Signatures are found in the hard copies.

UC Riverside (local)

Budget Description	Computation			WWF	COLLEGE	TOTAL COST
	Price/Rate	Unit	QTY			
Supplies and Materials						
Custom Lab Scale Ammonia Scrubber	\$ 3,000.00	1		\$ 3,000.00		\$ 3,000.00
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Mask Filters	\$ 7.00		4	\$ 28.00		\$ 28.00
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