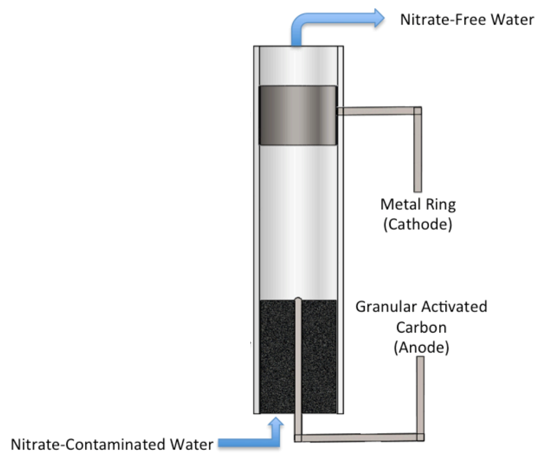
Southern California World Water Forum – College Grant Proposal

NiTreat:

A Sustainable Approach to Nitrate Removal from Drinking Water Resources



<u>Project Strand:</u> Technology-Local

<u>University of California Riverside</u>

Bourns College of Engineering

Department of Chemical and Environmental Engineering

<u>Faculty Director</u>

David Jassby, Ph.D.

<u>Student Manager</u>

Hira Yoshihara-Saint

December 18, 2015

Project Summary

The NiTreat team's objective is to develop an electrochemical packed-bed granular activated carbon (GAC) reactor with the purpose to significantly reduce nitrate contamination from drinking water. The proposed prototype is a cost-effective filtration system that relies on the electrochemical transformation of nitrates on the surface of GAC. The continual increase of nitrate concentrations in drinking water has been linked to certain types of cancers, thyroid disorders and blue-baby syndrome. The team's suggested design has the potential to generate safer drinking water for communities impacted by high levels of nitrates in their drinking water at a lower cost. The long-term goal of the NiTreat team is to develop a flexible and scalable treatment technology with the potential for both small-scale point-of-use, as well as a water treatment facility integration.

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3.A

Application Strand	Technology
LOCAL Project Name	NiTreat: A Sustainable Approach to Nitrate Removal from Drinking Water Resources
GLOBAL Project Name	

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3.E. **PROJECT MANAGEMENT TEAM**

Identify the team members of the project (i.e., budget, research, technology etc.). Add rows, as needed.

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3.E. **MEMBER AGENCY(IES) / LOCAL WATER AGENCY(IES)**

	NAME	TITLE / ORGANIZATION	ADDRESS	PHONE & EMAIL
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2				
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Organizational Background – University of California, Riverside

Established in 1989, the Bourns College of Engineering (BCOE) at the University of California, Riverside has risen up in the ranks as one of the top 100 engineering colleges. Serving a wide-range of undergraduate and graduate students, BCOE continue to innovate in the field of engineering and technology. The premier research facilities serve both undergraduate and graduate research in an attempt to further expand and improve current technology.

The Bourns College of Engineering is steadfastly committed in generating engineers with a strong theoretical foundation coupled with adaptive skillsets to dominate in a rapidly evolving technology industries. Due to the Bourns College of Engineering's premier research facilities, undergraduate students are encouraged to apply their theoretical knowledge through research opportunities, student design competitions and STEM outreach events. Bourns College of Engineering currently comprise of four research facilities: Bourns College, Winston Chung Global Energy Center, Material Science Building and the Center of Environmental Research and Technology. The availability of these facilities to undergraduate student research has produced a distinct undergraduate student body who is motivated to pursue graduate school.

The integration of the Chemical and Environmental Engineering programs is due to the close association between the Chemical and Environmental program curriculum. This has allowed a diverse curriculum for the Chemical and Environmental engineering students. Moreover, the integrated department has heightened environmental awareness from chemical engineering students.

The overall mission of the Chemical and Environmental Engineering department is to facilitate and provide the necessary foundations for its students to excel and develop the current available technologies. Additionally, the Bourns College of Engineering's objective for is to maintain a top-notch educational and research programs for students in preparations for the leading the development of their chosen industries.

Project Description

Project Overview

The rising levels of nitrate concentrations in water resources is an escalating problem. The upsurge of nitrate contamination in ground and surface waters has been correlated to the overuse of nitrogen-based fertilizers, improper animal waste disposal, and the discharge of insufficiently treated industrial and domestic wastewater[8,11,12]. Affected populations are mostly agricultural and low-income communities, which rely on private well water and have no emergency drinking water substitute if high levels of contamination occur[9,10,17]. For instance, larger communities, such as the city of Des Moines, IA, which draw their water from rivers that border agricultural lands, are suffering from increasing treatment costs associated with nitrate contaminations[4,20]. In the case of Des Moines, the city has recently filed a lawsuit against counties located upstream on the Raccoon River, alleging that mismanagement of agricultural runoff from fields is leading to the contamination of one of the city's major water sources with nitrates, which is increasing the costs associated with the provision of drinking water to the city's residents[5]. Alarmingly, high levels of nitrate ingestion have been linked to certain types of cancers, thyroid disorders and methemoglobinemia (blue-baby syndrome) [10,16-18]. This has led the US EPA to set a maximum contaminant level (MCL) of 10mg/liter for nitrates[6]. Unfortunately, drinking water from private wells is not federally regulated, and consumers are often unaware of the contamination, and rarely have the means to address it. In California alone, 4181 private wells have exceeded the EPA MCL standard for nitrates back in 2007 (Figure 1)[6,9]. The high treatment cost associated with treating nitrate-contaminated drinking water has financially strained water treatment facilities. For instance, the De Moines water treatment facility spent over $900,000 for treating nitrate-contaminated water back in 2013[5]. Unfortunately, the projected cost for 2015 could exceed that value, which would prove to be detrimental to the well-being of the Des Moines population. Therefore, there is a growing need to create an environmentally sustainable and low-cost water treatment technology that would effectively reduce nitrates in drinking water.

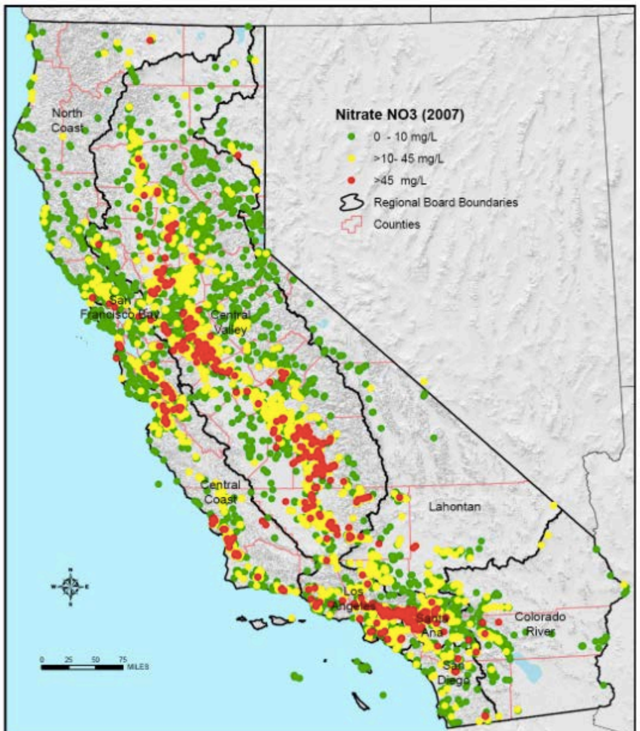

Figure 1: Private well nitrate levels[14].

The difficulty associated with the removal of nitrate from water resources is due to nitrate's high solubility and stable properties, which lower its capability for coprecipitation or adsorption[10]. Current approaches towards nitrate removal from drinking water result in high treatment costs and often require additional regulation of the treatment's byproducts. Current methods of nitrate removal are reverse osmosis (RO), ion exchange (IX), or biological and catalytic transformation[10,14]. Although these methods are effective at removing nitrates from water resources, facility costs and regulated treatment of byproducts present economic and environmental challenges. RO and IX denitrification methods have been proven to be effective, but costly. Additionally, these methods produce brine byproducts that require additional treatment for proper disposal[10]. Biological denitrification is currently implemented in wastewater treatment, but the fear of possible bacterial contamination has inhibited its use for treating nitrates in drinking water[10]. Catalytic transformation of nitrates, although effective, uses expensive metal catalysts and pure hydrogen gas[10]. Moreover, the presence of carbonates in the water reduces the rate of catalytic reactions, requiring longer contact time and lowering output rates[10]. Thus, the increasing rate of nitrate-contamination in drinking water has to be met with a cost-effective, and sustainable treatment system.

This novel filtration system, if implemented at a small-scale point-of-use, could alleviate the detrimental health effects of high levels of nitrate ingestion from contaminated water. Additionally, since activated carbon has been extensively studied in the field of wastewater treatment, making its use highly familiar to end-users. Previous studies have reported an 80-95% reactivation efficiency of GAC by electrochemical regeneration method[22]. Thus, GAC utilization is an ideal candidate for wastewater treatment systems due to its regenerative quality, which minimizes treatment waste streams. Moreover, due to the modular nature of our technology, water treatment facility integration with lessened waste streams could assuage the current water treatment method's byproducts. Therefore, using the world water forum funding, we propose to further study the capability of our filtration technology with a long term goal of constructing a prototype that could efficiently reduce nitrate concentrations in drinking water.

Research and Preliminary Data Collection

The encompassing expected output of the NiTreat team is to construct an operational prototype unit with the ability to significantly reduce nitrate concentrations in drinking water. The team's main objective would be in conjecture of successfully executing the team's projected goals of optimization, full-scale construction, and the operational cost-analysis of the technology.

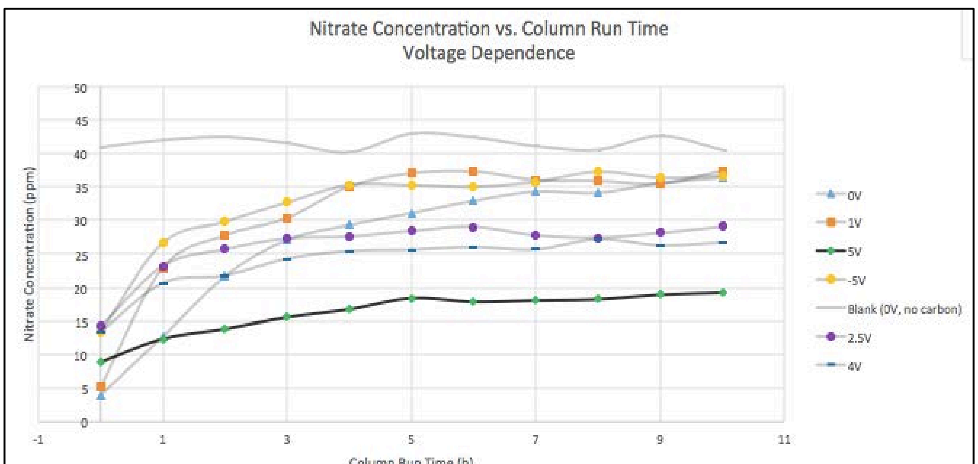

Figure 2: Nitrate concentrations in column effluent over time as a function of applied potential.

The optimized results of the lab-scale prototype are expected to be similar to the experimental data acquired. The system is expected to produce nitrate concentrations below the MCL standard with an inflow concentration above 10 mg/liter. The different supply of electric potential was observed in the preliminary data to be a critical parameter in nitrate reduction. To test for varying electric potential, sodium nitrate solution will be pumped through the column with GAC loading of 4.5 g and an inflow rate of 1 ml per min (Figure 2). At 0V normal adsorption of the GAC was observed with breakthrough concentration reduction taking place after several hours. However, decreasing HRT breakthrough time was observed with increasing anodic potential, with the main breakthrough at 5volts (Figure 2,◆). The original nitrate concentration (40-ppm) was observed to reduce to 14-ppm, a 65% reduction within 2 minutes of HRT. Thus, the team expects a nitrate reduction to be within the range of the 65% with the same HRT efficiency. Most importantly, the team does not expect harmful byproducts, either gaseous or aqueous, to be present in the effluent. Preliminary data of the NO_x analyzer showed ambient level of NO_x, indicative of zero NO_x produced by the system (Figure 3). However, a more detailed study needs to be conducted to conclusively claim that there is no formation of harmful byproducts in small concentrations. A calculated power consumption of a 1-ton GAC loading required 45 watts to efficiently reduce nitrates in drinking water without sacrificing the systems material durability. Therefore, the team expects a low power requirement for the in-home filtration device. Additionally, the team expects an inflow limitation involved with different water sources, flow rates and nitrate concentrations. The small-scale prototype is expected to handle normal household faucet flow rate of 2.0-3.0gal$\cdot$ min^{-1} with little performance lost. A cost-analysis of the prototype will concentrate on household integration cost and prospective water treatment facility integration.

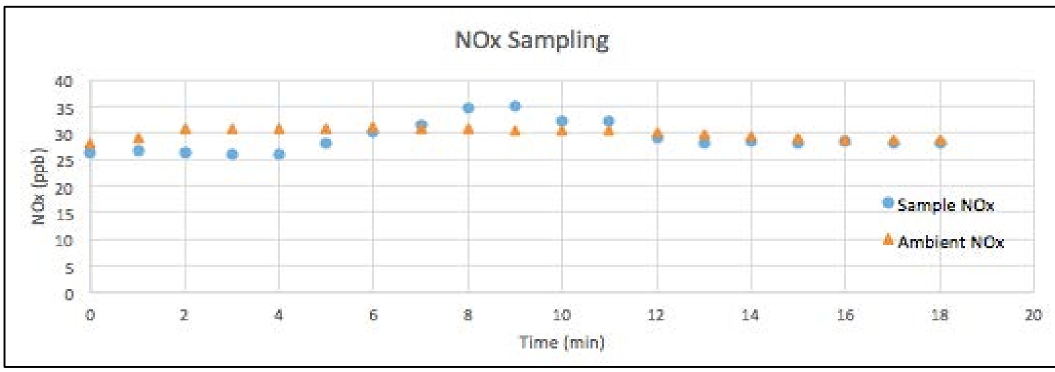

Figure 3: NO_x concentrations comparison between sampled and ambient

<u>Lab-Scale Design</u>

The project proposes an electrochemical filtration system that relies on the *oxidative* transformation of nitrates through an electrochemical packed-bed activated carbon column. Previous studies have observed nitrate reduction to nitrogen gas with ammonia being a significant byproduct[2,14]. Our preliminary results demonstrate that the only transformation product of the electrochemical oxidation of nitrate is nitrogen gas. Our technology's capability to induce transformation of nitrate to nitrogen gas without ammonia, NOx, or nitrite generation is hypothesized to occur via a nitrate radical mechanism (Figure 4).

The filtration system will utilize a 4-16 mesh-size granular activated carbon packed at the bottom of the column. A titanium wire carries the anodic charge to the GAC and a titanium metal ring, located above the GAC, acts as the cathode, which completes the electrochemical circuit (Figure 4). Titanium metal was chosen due to its resistance to corrosion in low-voltages. A solution of sodium nitrate (40-ppm) and sodium chloride (0.01 M) will be pumped through the filtration system to find its nitrate elimination capability. In addition to nitrate, the water will contain ion species and organic matter at concentrations typical of hard groundwater, with the goal of identifying and addressing any potential interference from background electrolytes. The measurement of nitrogenous species in the reactor effluent will be conducted using an ion chromatograph (IC) and total nitrogen (TN) analyzer. A NO_x analyzer (NO_x-box) will be use to analyze gasses evolving from the reaction. Preliminary results obtained using the NO_x-box indicate that no NO_x is produced during the electrochemical transformation of nitrate on the GAC anode. X-ray photoelectron spectroscopy (XPS) was used to determine whether nitrate (or other nitrogenous species) were attached to the GAC as a result of the electrochemical reactions. However, no difference in XPS spectra was detected between fresh and used GAC, indicating that neither nitrate nor transformation products were adsorbed or covalently attached to the GAC surface.

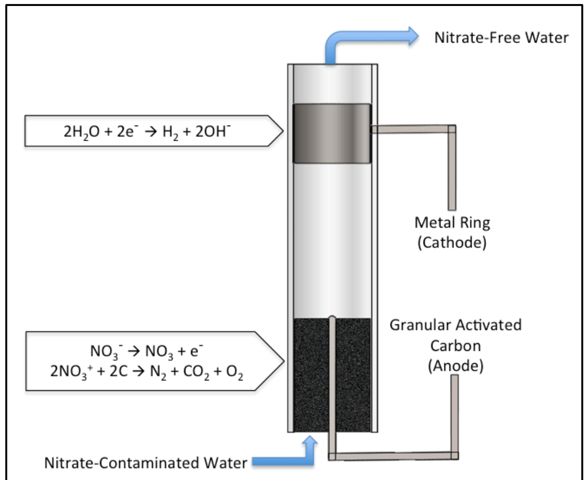

Figure 4: GAC packed column used to *oxidatively* transform nitrates to nitrogen *via* nitrate radical mechanism (Lab-scale model)

Analysis of the reactor effluent (at 5 V with GAC acting as anode) using IC revealed a single peak, with a retention time associated with nitrate. Thus, the only ionic species detected in the reaction effluent was nitrate. TN analysis of the reactor effluent yielded a TN value that was statistically identical to the nitrate concentrations measured using the IC. Therefore, it was concluded that no dissolved, non-ionic nitrogen species (such as chloramines or *N*-nitrosodiamine) resulted from the electrochemical transformation of nitrate either. Based on the above-mentioned experimental results (nitrate is the only ionic species, TN results match nitrate concentrations, no NO_x detected, no nitrogen adsorbed/bonded on GAC) we speculate that the only transformation product is nitrogen gas, which is difficult to detect due to its atmospheric abundance. However, further research is needed to completely identify transformation products as well as determine a reasonable transformation pathway.

The unique technology of the filtration system is due its simplistic design with the notable efficiency in removing nitrates from drinking water. Due to the technology's modular design, this provides it with the flexibility for both small-scale point of use applications and water treatment facility integration.

Project Management

To establish the feasibility of the NiTreat filtration unit, all optimization tests and construction of the lab-scale and small-scale prototypes will be completed within the Bourns College of Engineering at the University of California, Riverside under the team's faculty director, David Jassby, Ph.D. Additionally, Dr. Jassby will provide the necessary laboratory facilities and his expertise in water treatment technologies to ensure the team's project completion.

The NiTreat team from the University of California, Riverside is composed of three undergraduate students: Thania Flores-Soto, Carlos Gutierrez and Hira Yoshihara-Saint. Thania Flores-Soto is an Environmental Engineering student whose technical concentration involves water treatment technology. Additionally, Thania's internship for the California State Senate has acquainted her with water district facilities and regulations. Due to her internship experience, she has developed a passion towards addressing environmental injustices in the inner cities. Thus, she will lead the outreach and projected community impact of the project.

Carlos Gutierrez, a Chemical Engineering student, will be undertaking mass balances and optimal parameter calculations throughout the design process. His previous coursework of fluid mechanics, mass transfer and thermodynamics have equipped him with a strong chemical and mathematic skill set. Therefore, he will be the lead for the construction of both lab-scale and full-scale prototypes. In addition, he will be the point person for current published research connected to the NiTreat technology.

The team's second Chemical Engineering student is Hira Yoshihara-Saint. Her chemical engineering coursework focuses on biochemical engineering processes. She also has experience in using Java, C++, and C#, and she is currently learning MATLAB modeling program. Furthermore, her undergraduate research position under Dr. Charles Wyman and Dr. Charles Cai on the Co-Solvent Enhanced Lignocellulosic Fraction (CELF) for biofuel production has built her proficiency with the laboratory skills necessary for this project. Included in her laboratory skill sets are biomass compositional analysis techniques, analyzing Agilent chromatography data and optimization of pressure and temperature driven bioreactors. Due to her specific coursework and skillset, she will be responsible for analyzing the possible chemical mechanism of the reaction, byproduct formations and the optimization of the prototype.

Anticipated Outcome

The anticipated outcome of our project is to construct a low-cost operational filtration prototype capable of significantly reducing nitrate concentrations for safer drinking water. Our research is expected to produce two benefits: reduces water treatment costs and provide safer drinking water to communities affected by high levels of nitrates in their drinking water.

Improves equitable access of safer drinking water through nitrate reduction	714,000 people in Tulare Lake Basin and Salinas Valley alone.
Reduces Water Treatment Cost	Full-scale treatment facility: In the range of $10,000-$3000/day (nitrate-loading dependent) Small-scale point-of-use: $150-200/year

The small-scale water treatment prototype is projected to alleviate high levels of nitrate concentrations for low-income and agricultural communities. In California alone, there are registered 2 million agricultural workers, not including their family members. Specifically, extensive study has been conducted for the high nitrate contamination in the Tulare Lake Basin and Salinas Valley. The increasing nitrate levels in their drinking water are due to private well-water uses around agricultural area, which imposes an increased human health cost. Additionally, the communities affected by high levels of nitrate contamination are frequently economically disadvantage. A reported 45% (585,000 people) of the Tulare and Salinas populations who are affected by high levels of nitrate in their drinking water are below the poverty level[9]. Current in-house water treatment systems such as reverse osmosis (RO) which cost an average of $300, are an unlikely investment for families with significant financial difficulties. The NiTreat's team water filtration system is projected to cost less than the current available water treatment systems on the market. This is due to its novel single-filter housing design, and regenerative characteristic of GAC. Moreover, since nitrogen gas is the main byproduct of this novel filtration system, maintenance and operational costs are projected to be lower than the RO system. However, funding is needed to construct an operational filtration unit to formally report estimated marketable price.

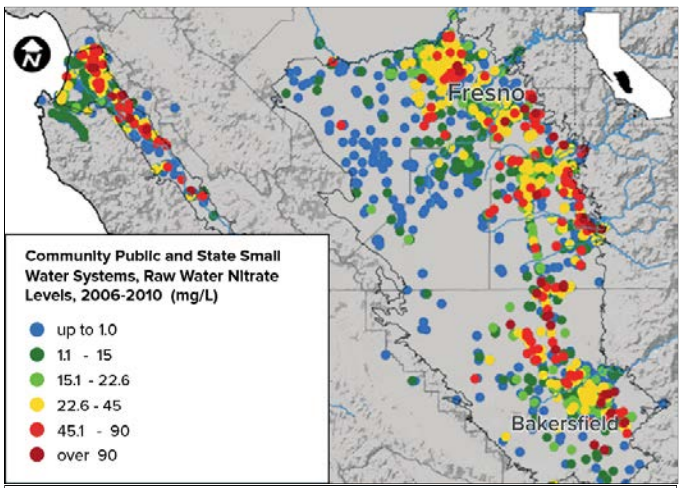

Figure 5: High Susceptibility Households in the Tulare Lake Basin and Salinas Valley[9].

The modular nature of the filtration technology has the potential for water treatment facility integration. The growth of nitrogenous fertilizer usage has led to an increased cost for water treatment facilities in reducing nitrate concentrations in drinking water. A 2012 Inland Empire Utilities Agency report showed the cost of treating 150-ppm of nitrate concentration in drinking water to be $15,750/day for reverse osmosis and $3250/day ion exchange water treatment methods[1]. Our technology, if integrated in water treatment facilities, is projected to be between these price range. However, current methods used in treating nitrate in drinking water produce brine as a treatment byproduct. This inevitably requires additional permit cost for brine disposal to mitigate environmental pollution, which further increases treatment cost. Our preliminary data does not show brine byproducts. Additionally, initial results have shown nitrogen gas to be the only byproduct of the filtration system. However, additional research must be conducted to formally determine that even small concentrations of contaminant byproducts are not formed.

The extensive health cost of high nitrate contamination in drinking water not only poses a local problem, but a considerable global threat. The potential global impact of a low-cost and efficient nitrate water treatment technology could mitigate the detrimental health effects of nitrate ingestion through drinking water. The prospective impact of this filtration unit is correlated to the continual growth of fertilizer use in almost all agricultural communities around the globe (Figure 6). Due to the high cost of water treatment facilities, most developing nations lack the financial stability to run a 24-hour nitrate treatment system[13]. More concerning are the rural communities, which compromise 70% of the world's poverty population, who have no access to safe drinking water[19]. Thus, if our technology is to be implemented both on a local and global scale, the human health cost of high levels of nitrate ingestion could potentially be mitigated.

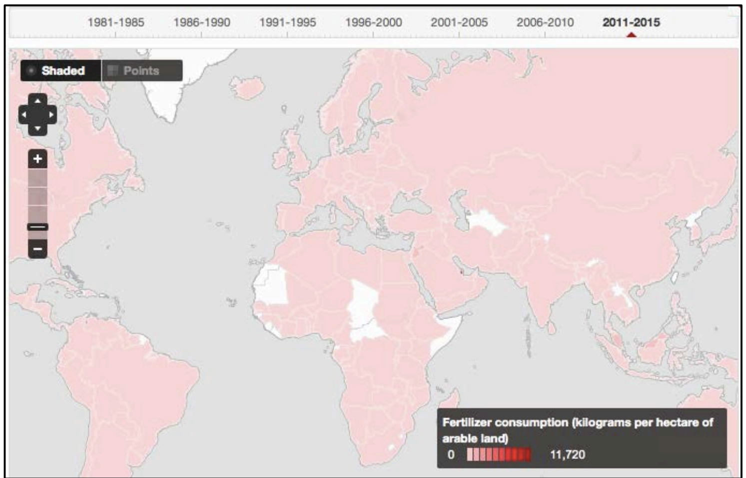

Figure 6: Global Fertilizer Consumption[19]

Outreach Plan

The proposed outreach plan will educate farmers of the hazards and adverse health effects of high nitrate concentrations in drinking water. The University of California, Riverside's NiTreat team will conduct outreach by attending agricultural expositions, specifically the 2016 Sustainable Ag Exposition in San Luis Obispo, CA on the 16th and 17th of November. Furthermore, low-income communities plagued with high nitrate levels in their water resources will be educated through K-12 school STEM programs. Bulletins and newsletters funded by the grant will be distributed in both agricultural expositions and schools. The project outreach will not only encompass nitrate contamination, but also include water conservation and remediation techniques. Additionally, the NiTreat team will offer and encourage community leaders and homeowner associations to schedule community presentations about the hazards of nitrate contaminated water. The project will engage students by showcasing the prototype at STEM events at UCR. UCR K-12 STEM outreach will also be utilized by live demonstrations of the prototype, bringing awareness to the need for safer drinking water and water filtration technologies. These exposition trips, presentations, and community forums are planned activities of the NiTreat team to promote better understanding of the dangers of nitrates in drinking water.

Project Timeline

Year	Month	Goal	Description
2016	January-March	- Continue literature review. - Laboratory research on systems byproducts	
2016	April-May	- Grant recipient announcement - Construction of lab-scale device	Receive grant; Purchase materials and begin lab and small-scale prototype construction.
2016	June-August	- Carry out experiments and develop small scale prototype	-Identify optimization parameters -Draft small-scale prototype design
2016	September-December	- Finalize optimized small-scale prototype -WWF staff on site visit and complete project - Attend Sustainable Ag Exposition (November 16-17: San Luis Obispo)	Finalize optimized parameters for final report
2017	January-March	- Prepare presentation for WWF Exposition - Operate a simulation of normal household water consumption (2 Months)	
2017	March-April	- MWD exposition presentation	

Budget Justification

DIRECT COSTS						
	COMPUTATION					
BUDGET ITEM DESCRIPTION	**PRICE/RATE**	**UNIT**	**QTY**	**MWD/ WWF**	**College**	**TOTAL COST**
SALARIES AND WAGES						
Undergraduate Student Researchers				$0	$2,500	$2,500
Subtotal			**Subtotal**	$0	$2,500	**$2,500**
TRAVEL						
Airfare\Lodging (not allowed)						
Subtotal	2500		**Subtotal**	0	0	0
SUPPLIES/MATERIALS - Describe all major types of supplies/materials, unit price, # of units, etc., to be used on this assisted activity.						
Lab Scale Device						
Impact Resistant Polycarbonate Tube	**$16**		**9**	$144.00		**$144.00**
Extended-Life Inline Circulation Pump (<10 gpm)	**$225**		**2**	$450.00		**$450.00**
Adjustable Current Limiting Power Supply	**$235**		**1**	$235.00		**$235.00**
Ultra-Corrosion Resistant Titanium Shim	**$78**		**1**	$78.00		**$78.00**
Ultra-Corrosion Resistant Titanium Wire (1/8-lbs coil)	**$72**		**1**	$72.00		**$72.00**
Quick-Check Flow Transmitter (0.1-5 gpm)	**$123**		**1**	$123.00		**$123.00**
Quick-Check Adjustable Switch (0.1-5 gpm)	**$255**		**1**	$255.00		**$255.00**
Tubings, end-pipes, sealants etc.	**$200**		**2**	$400.00		**$400.00**
Sample collection bottles, chromatography trays etc.	**$150**			$150.00		**$150.00**
Fisher Scientific Activated Carbon (6-14 mesh) Case of 4EA	**$690**			$690.00		**$690.00**
Sigma-Aldrich Sodium Nitrate (99% Purity)	**$78**		**3**	$234.00		**$234.00**
Sigma-Aldrich Sodium Chloride (99% Purity)	**$72**		**2**	$144.00		**$144.00**
Small-Scale Prototype						
Plastic Filter Housing	**$98**		**3**	$294.00		**$294.00**

Tubings, end-pipes, sealants etc.	**$100**		**2**	$200.00		**$200.00**
Ultra-Corrosion Resistant Titanium Shim stock	**$78**		**1**	$78.00		**$78.00**
Ultra-Corrosion Resistant Titanium Wire (1/4-lbs coil)	**$95**		**1**	$95.00		**$95.00**
Water Storage Tank	**$250**		**1**	$250.00		**$250.00**
Fisher Scientific Activated Carbon (6-14 mesh)	**$190**		**2**	$380.00		**$380.00**
Sample Analysis Cost						
Ion Chromatography Analysis Cost	**$2,000**			$2,000.00		**$2,000.00**
Total Nitrogen Analyzer and Nox-Box Test	**$1,000**			$1,000.00		**$1,000.00**
Outreach Materials: Pamphlets, Flyers, Posters and demonstration materials for K-12 UCR-STEM outreach event and Sustainable Ag Exposition				$600.00	0	**$600.00**
Exposition Registrations: 3 Students will attend and participate in the Sustainable Ag Exposition in San Luis Obispo	$126		3	$378.00	0	**$378.00**
Office Supplies: Presentation materials				$300.00	0	**$300.00**

Subtotal			**Subtotal**	$8,550.00	$0.00	**$8,550.00**
CONTRACTUAL/ CONSTRUCTION						
Subtotal			**Subtotal**	$0.00	$0.00	**$0.00**
TOTAL DIRECT COSTS:				**$8,550.00**	**$2,500.00**	**$11,050.00**
INDIRECT COSTS -						
Indirect Costs @ 10% total				**$855.00**	**$0.00**	**$855.00**
Subtotal				**$855.00**	**$0.00**	**$855.00**
TOTAL INDIRECT COSTS				**$855.00**	**$0.00**	**$855.00**
TOTAL ESTIMATED PROJECT/ACTIVITY COSTS:				**$9405.00**	**$2,500.00**	**$11,905.00**

The University proposes a match of 25% of the amount requested (i.e., $2,500) in the form of volunteer time. We estimate that undergraduate students participating in this project will contribute more than 200 hours of effort, and we will track this activity. Student effort is valued at $12 per hour or more.

References

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8. SIGNATURE BLOCK

	NAME / TITLE	SIGNATURE	DATE
Faculty Project Manager	David Jassby Assistant Professor		12/14/15
College Contracts Officer / Administrator	Teeny Ellis Sr. Contract & Grant Officer	Teeny Ellis	12/17/2015
Student Project Manager	HIRA YOSHIHARA-SAINT		12/14/15


Certificate of Participation
presented to
Kawai Tam
University of California, Riverside
Thank you for participating in the
Southern California World Water Forum
College Grant Program
on October 16, 2015.
worldwaterforum
Metropolitan Water District of Southern California College Grant Program
SANITATION DISTRICTS OF LOS ANGELES COUNTY
Converting Waste Into Resources
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
water for people
Friends of the United Nations

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

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P.O. Box 9020 • Chino Hills, CA 91709
TEL (909) 993-1600 • FAX (909) 993-1985
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December 14, 2015

Selection Committee
World Water Forum College Grant Program

To Whom It May Concern:

The Inland Empire Utilities Agency (IEUA) provides regional water and wastewater treatment for nearly 850,000 people in the southwestern portion of San Bernardino County. IEUA operates several treatment facilities that are essential to meeting public health needs within our service area. Over the last several decades, IEUA has implemented various programs and projects to address groundwater cleanup within the underlying Chino Groundwater Basin. Specifically, nitrate contamination has limited safe access to drinking water and has driven the development of millions of dollars in local investments to protect our scarce water supplies. IEUA is always looking for innovative and effective ways to remove nitrates from wastewater, groundwater and surface water sources.

This letter is written in endorsement of the University of California-Riverside's NiTreat team's application to the World Water Forum College Grant Program. We believe that the NiTreat team's goal of finding a sustainable approach towards nitrate removal aligns with the IEUA's mission in providing all communities with quality drinking water. The IEUA supports the University of California-Riverside's NiTreat team in pursuing external funding to construct a prototype designed to reduce nitrates from drinking water.

Please call me at 909-993-1762 or email me at cberch@ieua.org if you have any questions.

Sincerely,

Chris Berch,
Executive Manager of Engineering/
Assistant General Manager

Water Smart – Thinking in Terms of Tomorrow