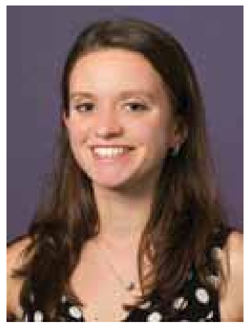
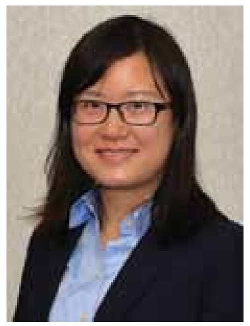
Essays by the 2016 NEWEA Student Scholarship Recipients



Maya Swope
Macalester College, **Non-Environmental Student Scholarship**



Yan Li
University of Connecticut, **Graduate Student Scholarship**

Jessica Zielinski Meffert
University of New Haven, **Undergraduate Scholarship**

Essay Question: *Wipes, plastics, and pharmaceuticals/personal care products are examples of modern industrial challenges to wastewater treatment and water quality. What can people in your field of study do in the future to ease the burden of these products on the environment?*

Modern environmental problem solving requires the successful convergence of scientific knowledge, politics, and culture. The disciplines of Geography and Environmental Studies provide a framework to do just that. People in this field study the way that people and societies interact with their environment from the perspective of a spatial, geographical analysis. One component of studying geography that is especially useful in this instance is Geographic Information Systems (GIS), which can be used to map out the distribution of where pollution from wipes, plastics, and pharmaceuticals originates and where it ends up. GIS allows us to create a map layer of measured instances and locations of water pollution by these materials. Then, adding information about the flow of rivers or the density of populations in given locations allows us to both analyze potential sources of pollution and predict consequences and complications as the pollution moves further downstream. We can also overlay that with a map layer indicating the cultural or socioeconomic class of residents in a given location, for example. This is important from an environmental justice perspective

Swope (continued) because all too often it is the poorest members of our communities who experience a greater burden of pollution in their neighborhoods. Maps created through this GIS process can also serve as an educational tool for industries, community members, and policymakers. They can accurately communicate large amounts of data in a quick and intuitive manner.

Geography and environmental studies both also emphasize the importance of systematic thinking approaches to problem solving. In the context of the aforementioned consumer products that are creating problems for water treatment and water quality, my studies of consumerism and of the psychology of sustainable behavior are especially applicable. Geographers and environmentalists alike aim to better understand what drives the consumption and subsequent disposal of these products. The GIS programs that I use for analysis and predictions are driven largely by quantitative data, so it is integral that these other aspects of the discipline are included in my evaluation of this particular water pollution problem.

It is the very nature and interdisciplinarity of geography and environmental studies that make them both great problem-solving areas of study and aptly suited to this particular problem of wipes, plastics, and pharmaceuticals/personal care products in our waterways. As I continue my education and begin my career, the concrete knowledge and the frameworks that I have learned for asking and answering relevant questions will allow me and others to better understand and devise solutions to this problem and similar environmental issues.

Essay Question: *Water, energy and food systems are tightly interconnected. Increasing human population and urbanization, water pollution, and increasing energy demand pose fresh challenges to scientists, engineers, and law makers. Please discuss the relationship between food, water, and energy, and discuss what role you could play, as an engineer, to help foster secure and efficient use of water resources.*

As the critical factors for human activities, water, energy, and food are tightly interconnected with the aid of bacteria. Water and energy are the indispensable consumption in food processing, while food wastes rich in organic compounds and bacteria can be converted to clean energy in biochemical processes such as microbial fuel cells (MFC) and anaerobic digesters (AD). Environmental engineers should understand environmental challenges, apply novel biotechnology, turn wastes into beneficial products, and integrate food, energy, and water.

As a PhD student of environmental engineering, I have conducted frontier research on energy-positive wastewater treatment using bioelectrochemical systems (BESs). One major achievement is to identify new applications of MFCs for heavy metal and nutrient removal in wastewater. The MFC concept has drawn global attention in the past decade due to the distinct advantage of converting wastewater to electricity by intrinsic anaerobic electrogenic bacteria in wastewater. But the typically low power generation of MFCs has hindered real-world usage. I have discovered a novel feature of MFCs through harvesting electrical energy produced from spontaneous reactions (e.g., Cr^{6+} reduction) to power non-spontaneous reactions (e.g., Ni^{2+} reduction), so that self-sustaining wastewater treatment can

Yan Li (continued) be achieved. Lab-scale tests have demonstrated well the simultaneous removal of multiple heavy metals in MFCs without external power supply, which reveals an alternative low-cost treatment technology. Moreover, I have developed short-cut nitrification/autotrophic denitrification (SNAD-MFC) to overcome the critical problems of high aeration costs, high carbon requirements, and long retention times in traditional biological nutrient removal (BNR) processes. By utilizing an aerobic cathode for short-cut nitrification and an anoxic cathode for autotrophic denitrification, the SNAD-MFC system accelerates the nitrogen removal rate without extra energy/chemical requirements, and achieves energy-positive BNR, which can be used for diverse food wastewater treatment. My MFC research has drawn attention in the environmental field, and has been published in top engineering journals (e.g., Applied Energy, Bioresource Technology and Journal of Power Sources).

Another focus of my research is the optimization of AD systems for biomass energy and nutrient recovery from food wastes. Conventional AD systems only target biogas production from organic wastes. In fact, biogas production is closely correlated with fermentation liquid components (e.g., fatty acids, ethanol) and biomass solids (e.g., microbial population, nutrients). If harvested properly, fermentation liquid and biomass solids are high quality energy sources and fertilizers, which have enormous economic value and environmental benefit. My goal is to renovate the engineering and scientific understanding of AD systems and enhance sustained, economically attractive AD performance with food waste as the starting point. The breakthrough of my study is to integrate the gas/liquid/solid phases as a whole bioenergy/nutrient recovery system, and to optimize AD systems through novel monitoring technology. Optimizing AD systems will have a great impact on bioenergy production, water reclamation, and food availability.

My vision of self-sustaining, new generation wastewater treatment technology has been considerably broadened throughout my PhD research. I have clearly recognized the correlation of food, energy, and water, and learned effective strategies to tackle environmental contamination, convert wastes to clean energy/nutrient sources, and bring the most benefit to the environment.

The relationships among food, water, and energy, especially when considered in the context of our 21st century world, can be complex. However, understanding their nexus is critical for maintaining healthy communities, both built and natural. In built environments, examples of water-energy-food interrelatedness play out through: water and energy inputs required for food production; energy inputs for water acquisition, treatment and delivery; and water inputs required for energy extraction, refining, and cooling needs. This interplay illustrates the cyclical manner in which water, energy, and food resources are interdependent for obtaining desired outcomes. When considered alongside the challenges of population growth, urbanization trends, water pollution, and increasing energy demand, this interdependence reveals the need for diverse stakeholder collaboration to achieve creatively integrated solutions for community health and sustainability.

Many studies argue that human populations have exceeded or will soon exceed the sustainable resource capabilities of our biosphere. This excess results in water pollution, as well as food and energy insecurity. In order to sustain increasing populations, our water-energy-food systems will need to

Meffert (continued) become more efficient. Human populations are also becoming more urbanized; in some ways, this produces more efficient outcomes across water-energy-food systems, but usually with new sets of challenges. Ever-growing human populations intensify these challenges, resulting in dramatic increases in energy demand and water pollution, potentially negating efficiency and efficacy gains achieved in recent decades. Another driver and passenger alike in this trio, food production serves up a confounding link. Considering the magnitude of this link (an estimated 15.7-percent of national energy use in 2007* and 80-percent of national freshwater use in 2015† were expended in food-related processes), it becomes clear that addressing any one of these constraints will require solutions across the water-energy-food nexus.

As a scientist, my role in fostering secure and efficient use of water resources will depend on effective implementation of research and best practices through collaboration with diverse stakeholders involved across the water-energy-food nexus. As a researcher both at the University of New Haven and with the Environmental Protection Agency, I have begun seeking these collaborations, most notably in the field of green infrastructure. Green infrastructure is a valuable component of plans to address water-energy-food conundrums. One reason for this value is green infrastructure's versatility in meeting multiple goals over a range of scales, often simultaneously addressing triple-bottom-line constraints. These qualities produce both cost-benefit optimization and strategically critical buy-in from varied stakeholders. In addition to promoting green infrastructure, I have also partnered with others on waste reduction initiatives. Increasing system efficiency, when coupled with minimizing wasteful use of system outputs, realizes truly improved outcomes. As a young scientist, I look forward to furthering my knowledge of green infrastructure, waste minimization, and other capabilities, as well as working with a variety of stakeholders to explore and implement these synergistic solutions. Such solutions will help ensure current and future generations have access to the food, energy, and water resources essential to their health and quality of life.

* U.S. Department of Agriculture's Economic Research Report 94 (2010).
† U.S. Department of Agriculture's Economic Research Service Irrigation and Water Use Reporting (2015).