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# Global Environmental Engineering for and with Historically Marginalized Communities

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**Abstract**

Marginalized communities lack full participation in social, economic, and political life, and they disproportionately bear the burden of environmental and health risks. This special issue of *Environmental Engineering Science*, the official journal of the Association of Environmental Engineering and Science Professors (AEESP), reports research on the unique environmental challenges faced by historically marginalized communities around the world. The results of community-based participatory research with an Afro-descendant community in Columbia, Native American communities in Alaska, United States, villagers in the Philippines, disadvantaged communities in California, United States, rural communities in Mexico and Costa Rica, homeless encampments in the San Diego River (United States) watershed entrepreneurs in Durban, South Africa, and remote communities in the island nation of Fiji are presented. The research reported in this special issue is transdisciplinary, bringing engineers together with anthropologists, sociologists, economists, and public health experts. In the 13 articles in this special issue, some of the topics covered include inexpensive technologies for water treatment, novel agricultural strategies for reversing biodiversity losses, and strategies for climate change adaptation. In addition, one article covered educational strategies for teaching ethics to prepare students for humanitarian engineering, including topics of poverty, sustainability, social justice, and engineering decisions under uncertainty. Finally, an article presented ways that environmental engineering professors can engage and promote the success of underrepresented minority students and enable faculty engaged in community-based participatory research.

***Keywords:*** community-based participatory research; environmental justice; marginalized populations; sustainable development; WaSH

The global economy is organized in such a way that ~60% of humanity is left unable to meet basic needs (Hickel, 2020). Accordingly, some of the most vexing and consequential environmental challenges are concentrated in the world's poorest regions. More than 10% of humanity continue to live on less than the international poverty line of US$1.90 per day (World Bank, 2020) and lack access to basic services and economic opportunity. More than 4.2 billion people still lack access to adequate sanitation services (UNICEF and WHO, 2019), ~1 billion are without electricity (World Bank, 2019), and >3 billion people rely on household energy sources that produce dangerous indoor air pollutants (WHO, 2018). Unsafe air and water rank among the major contributors to disease and death worldwide (WHO, 2016).

The global majority of individuals lack full participation in social, economic, and political life in the way that is enjoyed by the minority at the top of the socioeconomic–political hierarchy. As a result, the vast majority of global citizens are marginalized and disproportionately bear the burden of environmental and health risks. For example, the rich countries of the Global North are responsible for 92% of greenhouse gas emissions overshoot and associated damage due to climate change. However, low- and middle-income countries of

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the Global South currently bear 82% of the costs of climate change, and this figure is expected to increase to 92% by 2030, reaching $\sim$1 trillion dollars annually (Hickel, 2020).

This special issue of *Environmental Engineering Science*, the official journal of the Association of Environmental Engineering and Science Professors (AEESP), reports research contextualized by the unique environmental challenges and the resource and economic constraints faced by historically marginalized communities in the United States and around the world. Many of the articles report community-based participatory research, reflecting the importance of collaborative partnerships between researchers and members of the communities that the researchers wish to serve. Much of the research reported in this special issue is transdisciplinary, spanning anthropology, sociology, economics, and public health, in addition to environmental engineering and science.

The articles in this special issue address many of the Grand Challenges documented in the NASEM Report, *Environmental Engineering for the 21st Century* (National Academies of Sciences, Engineering, and Medicine, 2019): Sustainably Supply Food, Water, and Energy; Adapt to the Impacts of Climate Change; Design a Future Without Pollution or Waste; Create Efficient, Healthy, Resilient Cities; and Foster Informed Decisions and Actions.

The studies presented in this special issue reflect the authors' ''keen awareness of the needs of people who have historically been excluded from environmental decision-making, such as those who are socioeconomically disadvantaged, members of underrepresented groups, or those otherwise marginalized.'' We hope this special issue will serve as a bellwether for the emerging interest within the environmental engineering and science scholarship community to play a role in the transition to an environmentally sustainable, just, and peaceful world.

Brief summaries of the articles included in this special issue are provided hereunder.

Montoya *et al.* (2021) noted that Black, Hispanic, and Native American students and faculty are largely underrepresented in environmental engineering programs in the United States. These authors summarized a 2019 AEESP workshop in which environmental engineering professors examined systemic racism in academia. This article presents a strategic plan for expanding the horizons of students and fostering faculty careers in a way that advances equity in our profession.

Kearns *et al.* (2021) examined strategies for improving the efficacy of biochar adsorbents to remove organic chemical pollutants from water. They devised simple measurements that would make it easy to quantify the treatment capacity of biochar by measuring dissolved organic matter using ultraviolet light detection. This study provides valuable information for strategies for purification of surface waters, groundwater, dump leachate, and wastewater.

Orner *et al.* (2021) quantified the environmental and economic sustainability of four animal manure management and resource recovery scenarios in rural Costa Rica using life cycle assessment methods. Their results reveal that carbon neutrality was primarily achieved through energy recovery. The study provides clarity on how small-scale farmers in low-resources settings can utilize resource recovery technologies while improving environmental and economic performance of manure management.

Bielefeldt *et al.* (2021) presented the perspectives of engineering faculty as to the ethical and societal issues that should be taught and the pedagogies that are used to prepare students for global/humanitarian engineering. The ESI topics that were found to be particularly congruent include poverty, sustainability, social justice, and engineering decisions under uncertainty.

Peguero *et al.* (2021) examined a viscous heat treatment technology for pasteurizing fecal sludge before digestion using black soldier fly larvae, which can then be used for animal feed or biodiesel, whereas the sludge can be used for compost. Heat treatment inactivated *Escherichia coli*, total coliform, and somatic coliphage to below detection limits and had little impact on black soldier fly larvae growth. The findings could better guide the microbial safety aspects of fecal sludge management and conversion of sludge into value-added products.

Velez-Torres *et al.* (2021) undertook a transdisciplinary and participatory research approach to study the Afro-descendant community El Tiple in Columbia. The research provided valuable information to strengthen the community's small-scale farming activities, which are seriously affected by land transformation, pollution, and biodiversity loss. Together with community members, this team designed, constructed, and analyzed a greenhouse hydroponic cultivation system to restore local production of food and medicinal plants.

Mattos *et al.* (2021) investigated seasonal variation in household water access and waste management practices in two remote Alaskan Native communities. Interviews were conducted in addition to water sample collection to characterize potential health risks. The study found that many households have inadequate water and sanitation infrastructure to protect themselves and the environment. The study highlights the value of multidisciplinary and longitudinal data collection to capture water and sanitation practices.

Nabong *et al.* (2021) used focus group discussions and interviews in the Philippines to study perspectives on climate change and strategies for adaptation. This study found significant differences in the prioritization of adaptation strategies between villagers and the municipal government. Contributing factors included education levels, social or economic class, accessibility to resources, sources of information, and past experience with hazards.

Tariqi *et al.* (2021) investigated the relationship between nitrate levels in drinking water and the health of disadvantaged communities in California. The areas studied are those that experience socioeconomic, health, and environmental hardships. The study showed a statistically significant correlation between nitrate levels in water and the incidence of thyroid cancer in the study population.

Verbyla *et al.* (2021) assessed the challenges and potential solutions for water and sanitation services to homeless encampments in the San Diego River (CA, United States) watershed. Water samples upstream and downstream of three homeless encampments showed that there was insufficient evidence that the encampments contaminated the river. Interviews with service providers from public and nonprofit sectors confirmed the challenges of providing water and sanitation service to those in the encampments.

Workman *et al.* (2021) outlined how anthropologists and allied social scientists can provide a guide to a more holistic understanding of water, sanitation, and hygiene (WaSH),

thereby assisting engineers. They hypothesize that their approach would result in more equitable and successful implementation of WaSH projects for marginalized and diverse groups.

Mostafa *et al.* (2021) developed and evaluated a novel piped water treatment system to provide potable water in a rural community in Chiapas, Mexico. Their system achieved the multiple objectives of providing high-quality water while avoiding taste and odor problems for users.

Byrne *et al.* (2021) measured drinking water quality in remote Fijian communities and evaluated chlorine disinfection of harvested rainwater as a strategy to protect drinking water quality. The intervention was developed using a ''design with'' community members approach, and then a successful pilot project was executed. Chlorination of stored rainwater in addition to regular gutter and tank maintenance was recommended, along with capacity building and strengthening stakeholder relationships.

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