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| **Excellence in Research: Hybrid Ceramic Membrane Bioreactor and Reverse Osmosis Processes for the removal of Micro and Nano plastics from Municipal Wastewater** |
| Sponsor | National Science Foundation |
| Investigators | Raghava Kommalapati with Hongbo Du and Nabila Shamim (PVAMU) |
| Project Dates | 09/22-08/25 |
| Amount Awarded | $500,000  |
| Project Description: |
| The goal of this research is to generate the fundamental knowledge required to establish an innovative hybrid process for the removal of microplastics (MPs) and nanoplastics (NPs) from municipal wastewater using ceramic membrane bioreactors (CMBR) followed by reverse osmosis (RO). This research will investigate the use of anaerobic CMBR utilizing flat-sheet ceramic microfiltration membranes and aerobic CMBR equipped with tubular ceramic ultrafiltration membranes through lab experiments and implicit modeling of computational fluid dynamics (CFD) and explicit modeling of molecular dynamics (MD). The product water at the final would be clean enough and would be qualified as potable water. The efficiency of MP and NP removal will be evaluated, and the mechanisms of membrane fouling will be investigated by analyzing the cake layer deposited on the membrane surface. CFD simulations will be conducted to optimize CMBR design and to help understand the mechanisms by which ceramic membranes are fouled by pollutants in municipal wastewater containing NPs and MPs. Classical explicit MD simulations at the atomic level will be carried out to understand the fundamentals of removing MPs and NPs from water with ceramic membrane filtration. The environmental and economic impacts of the proposed technologies will be evaluated through life cycle assessment and life cycle cost analysis. The ultimate outcome of this project will be an innovative approach for cost-effective removal of NPs and MPs from municipal wastewater.**Intellectual merit:** Municipal wastewater effluent is the primary source of MPs and NPs entering the aquatic environment because there is currently no cost-effective treatment approach for effectively removing all MPs and NPs from municipal wastewater. While there has been increased interest in the use of membrane bioreactors using polymeric micro- or ultra-filtration membranes as tertiary treatment, these polymeric membranes suffer from increased fouling in the presence of MPs and NPs, and they can contribute to MP pollution when damaged or abraded. The proposed work would be the first study to investigate the use of ceramic membrane bioreactors to remove NPs and MPs from municipal wastewater and to understand the fundamental of removing MPs and NPs from water with ceramic membranes. This research will generate a critical understanding of the efficacy, fouling behavior, and mechanisms of both aerobic and anaerobic CMBR for the removal of NPs and MPs along with other pollutants from municipal wastewater through laboratory experiments, CFD modeling, and MD simulations. The fundamentals of removing MPs and NPs from water will be clarified with explicit MD simulation. Life cycle assessment and life cycle cost analysis will provide a rigorous analysis of the environmental impacts and economic viability of these novel treatment approaches. This work will be conducted by a team of investigators from Prairie View A&M University with expertise in membrane processes for water treatment, filtration technology, materials engineering, and life cycle analysis.**Broad impacts:** Microplastic pollution of rivers, lakes, and oceans is an increasing concern due to its potential impact on the environment and human health. The development of effective, efficient, and robust processes for removing MPs and NPs from wastewater will provide the municipal water industry with a safe and affordable alternative for treating water that will be discharged into the aquatic environment. The innovative processes to be investigated could eventually be scaled up and used for other applications in surface water and industrial wastewater treatment. PVAMU is the home of the Center for Energy and Environmental Sustainability (CEES), an NSF-funded CREST Center that focuses on a range of environmental themes, including wastewater treatment. This project will further strengthen that area of very active research at an HBCU with a strong record of graduating African American engineers. It will also help build the research program of a tenure-track woman professor in Chemical Engineering at PVAMU. A total of 3 graduate and 6 undergraduate students, many of them from underrepresented groups, will be engaged in the proposed research over the course of the project, and our research results will be incorporated into the curriculum for teaching graduate and undergraduate students. Ultimately, this project will help increase the number of underrepresented students pursuing careers in engineering and water treatment-related fields. Research results will be disseminated via professional conferences, journal publications, discussions with stakeholders, and our website. |