"Bioremediation of Food Wastes for Sustainable Bio-Cellulose Production: Developing Eco-Friendly Composites for Environmental and Biomedical Applications"

Fay Mohsin Almasahli, Fatima Khalid Koofan, Mazhar Ul-Islam*

Department of Chemical Engineering, College of Engineering, Dhofar University, Oman

Corresponding Author Email. mulislam@du.edu.om

The mismanagement and wastage of food resources present critical economic and environmental hazards, with approximately 30% of global food materials—including fruits, vegetables, juices, agricultural products, municipal and industrial wastes, and expired items—discarded. This leads to economic losses and creates breeding grounds for harmful microbes and pests, posing serious health risks. Our research addresses these issues through bioremediation, transforming food waste into valuable bio-products that contribute to environmental sustainability and economic growth in Oman.

Leveraging bioremediation principles, we aim to convert waste into bio-cellulose and other eco-friendly materials, which can be utilized in medical and environmental applications like wound dressings, facial masks, absorbent membranes, antimicrobial filters, and pollutant-degrading catalysts. In the first phase, we collected food wastes (e.g., fruit, sugarcane, coconut water, expired juices), assessed their sugar content, sterilized them, and developed them into bio-cellulose production media. This bio-cellulose demonstrated desirable morphological and mechanical properties, comparable to commercial standards, establishing the groundwork for a bio-cellulose industry in the region. Our findings, published in reputable journals and presented nationally, underscore the potential for environmental health benefits through sustainable waste management.

The study further explores the synthesis of novel biopolymer composites with both environmental and biomedical applications. Through ex-situ synthesis, we developed bacterial cellulose (BC) composites with various natural remedies including plants extract, polymers, nanomaterials etc for targeted environmental applications. BC-Chitosan composite demonstrated a strong capacity for heavy metal adsorption, achieving rates of 93.2%, 77%, and 26.5% for Fe (II), Cu(II), and Zn(II), respectively. Similarly, aloe vera gel incorporation enhanced the biocompatibility and strength of BC sheets. Such composite materials show promising applications in wastewater treatment, tissue engineering, and other biomedical fields, offering sustainable bioremediation solutions that address environmental challenges and support public health in the Gulf region.

Graphical Abstract