College of Arts and Sciences
PhD in Materials Science and Engineering (MSE)

Waqas Ahmad

BS, University of Engineering and Technology Peshawar, Pakistan | MS, National University of Sciences and Technology Pakistan

Dissertation:Potential of Co-Feeding Pyrolysis in Arid Regions for Energy Production, Carbon Sequestration and Soil Amendment

Supervisors: Dr. Fatin Samara, Dr. Yassir Taha Makkawi

Abstract:

Co-pyrolysis can convert mixed organic residues into fuels and soil functional carbon, yet practical rules for temperature and blend that satisfy energy, agronomy and safety at the same time remain unclear. This study establishes temperature-resolved mono-feed baselines for food waste (FW), sewage sludge (SLG), Salicornia (SA) and date-palm residues (DP) at 400-600 °C, then quantifies how co-feeds (FW-SLG, SA-DP) shift product yields, oil and gas energy, biochar performance (summarized as energy and acidity, stability and nutrient-thermal profile) and safety (PAHs/TEQ and metal-risk indices), with a plant-growth screen in alkaline sandy soil. In FW-SLG, liquid quality and quantity diverge with severity: FW rich blends produce the most energy-dense oils at lower temperature, mid temperature maximizes total liquids and high temperature favors permanent-gas energy. In the SA family, the 50% SA+DP co-feed yields oils that are more energy-dense than either parent, and at lower temperature its oil yield also exceeds the single feeds. GC-MS confirms a compositional shift from oxygenate-rich spectra (fatty acids/esters/phenolics) at low severity to less-oxygenated hydrocarbons (olefins/alkyl aromatics) at high severity. Biochar functions map to soil context: low-temperature FW-SLG chars maintain mildly acidic to near-neutral reactions with higher exchange capacity, aligning with nutrient-poor alkaline sands; SA-DP chars are strongly alkaline and saline, suited to acid-soil correction and best blended or rinsed before use in neutral to alkaline soils. Stability increases with temperature (lower H/C and O/C; higher thermal recalcitrance), while mass-based carbon-sequestration efficiency peaks near 400 °C and declines as char yield falls, defining a stability yield trade-off. Safety is met for organics across identified windows; metal risk depends on feed and blend. The 25% FW+SLG char keeps all regulated metals within soil-use standards and sits one ecological-risk class lower than the 50% blend, where exceedances (e.g., Ba, Se, Ni) and Cd/Cu driven risk appear. Overall, the work delivers an operating map: select ~400 °C for sequestration, ~500 °C for liquids (FW-SLG), ≥600 °C for gas energy; choose 25% FW+SLG for alkaline sandy soils and SA-DP for acid-soil correction linking temperature and blend to energy, agronomy, and safety in one framework.

Tahir Nawaz

BS, University of Engineering and Technology Peshawar, Pakistan | MS, National University of Sciences and Technology Pakistan

Dissertation: Functional Multi-Principal Element Alloys: Mechanical, Magnetic and Electrochemical Properties
Supervisors: Dr. Mehmet Egilmez, Dr. Wael Abuzaid

Abstract:

Functional multi-principal element alloys (MPEAs) have emerged as a transformative class of materials due to their vast compositional freedom, tunable defect chemistry and coupled physical phenomena. However, despite extensive progress in their structural applications, the composition-structure-property relationships governing their mechanical, magnetic and electrochemical functionality remain insufficiently understood. This thesis systematically investigates two families of MPEAs to establish fundamental links between alloy chemistry, microstructural evolution and functional response. The first part of this work examines FeMnAlNi-based shape memory alloys alloyed with vanadium. Through cyclic heat treatment and controlled aging, abnormal grain growth and a dominant BCC superelastic phase were achieved, enabling recoverable strains up to ~6% and transformation stress of 1GPa with stable hysteresis. The second part explores disorder-driven ferromagnetism in equiatomic NiCoFeCr high- entropy alloy. Magnetic measurements reveal a complex interplay between itinerant magnetism and chemical disorder, with a suppressed Curie temperature ($T_c \approx 92$ K) and a secondary magnetic anomaly at 125 K, consistent with cluster freezing. Critical exponent analysis confirms deviation from mean-field behavior, aligning with a three- dimensional Heisenberg model. The final part investigates CoNiFe(Cr/V)-based MPEAs as bifunctional electrocatalysts. V incorporation reduces charge transfer resistance and enhances hydrogen evolution kinetics, achieving competitive overpotentials in both alkaline and acidic media. Collectively, this work establishes compositionally tunable pathways to engineer multifunctional MPEAs, advancing their potential in adaptive structures, spin-based technologies and energy conversion systems.