(Annexure-I)

# Abstract

Municipal Solid Waste (MSW) management is a critical environmental challenge, with legacy waste contributing to greenhouse gas emissions, leachate production, and soil contamination. This study explores the stabilization of **Municipal Solid Waste Fines (MSWF)** using **biopolymers such as Xanthan Gum (XG) and Agar Gum (AG)** as eco-friendly alternatives to lime and cement. The research assesses the impact of biopolymers on **geotechnical properties, long-term durability, and environmental sustainability** of MSWF for civil engineering applications.

MSWF samples were collected from various depths of a legacy waste dumpsite and tested for **Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR), specific gravity, and structural stability** after biopolymer treatment. The study found that **UCS increased by 2419% with AG (reaching 3654.88 kPa), cohesion improved by 492.7%, and long-term stability was maintained** beyond 90 days. Biopolymer-treated MSWF exhibited **enhanced compaction properties and reduced leachability of heavy metals**, making it a promising construction material.

Environmental analysis showed that **lime stabilization emitted 102 kg CO2e per ton, while XG emitted 17.76 kg CO2e, and AG was carbon-negative at -2.53 kg CO2e per ton**, demonstrating significant sustainability benefits. Optimized pavement design using **biopolymer-treated MSWF reduced bituminous layer thickness by 25.7%**, leading to material savings and improved performance.

This study establishes **biopolymer stabilization as a viable, durable, and environmentally sustainable solution** for MSWF treatment. The findings highlight **the potential of biopolymers in circular economy applications**, offering a sustainable alternative for waste utilization in geotechnical engineering.