Title of thesis: Advancement of Underground Waste Management Systems in Mongolia

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Abstract

This thesis presents the design, analysis, and feasibility assessment of an **advanced underground waste compactor system** tailored to the environmental and operational conditions of **Ulaanbaatar, Mongolia**. The project addresses persistent challenges in the city's waste management system, including limited collection capacity, poor sanitation, inefficient logistics, and severe winter constraints. By integrating mechanical design, hydraulic analysis, and smart sensor technologies, the study proposes a solution that aligns with Mongolia's long-term sustainability and urban modernization goals.

A **mixed-method research design** was adopted, combining quantitative and qualitative approaches. The quantitative component focuses on **engineering modeling and performance evaluation**—including hydraulic force calculations, compaction pressure analysis, structural verification, and energy demand estimation. The selected hydraulic cylinder (100 mm bore, 16 MPa working pressure) generates approximately **125 kN of compaction force**, achieving up to a threefold reduction in waste volume. Analytical modeling confirmed that the resulting mean pressure (≈196 kPa) lies within the optimal range for municipal solid waste compaction, and structural assessments showed all stresses remain within safe limits for both the galvanized steel container and reinforced concrete pit. The qualitative component interprets **contextual and environmental factors** specific to Ulaanbaatar—such as soil freezing depth, extreme temperatures (down to –35 °C), and local maintenance constraints—to ensure that the system is practical, maintainable, and resilient under real-world conditions.

The results indicate that the proposed system can **increase storage efficiency by nearly twofold**, significantly reducing waste collection frequency, transportation costs, and fuel consumption. Integration of ultrasonic fill-level and temperature sensors enables **smart monitoring**, allowing data-driven waste collection planning and early detection of fire or overheating. The system's modular design, with separate compartments for general, recyclable, and ash waste, supports Mongolia's waste segregation objectives and enhances recycling potential.

Economically and environmentally, implementing this system represents a major step toward **modern, cleaner, and more sustainable waste infrastructure** in Ulaanbaatar. It offers tangible reductions in operational costs and CO_2 emissions while improving hygiene, aesthetics, and public satisfaction in urban areas.

In conclusion, this study demonstrates that a properly engineered underground compactor system is **technically feasible, economically viable, and environmentally beneficial** for Mongolia's urban context. It establishes a robust engineering foundation for pilot implementation and future upgrades—such as solar-assisted power units, advanced corrosion protection, and real-time IoT integration. More broadly, the project exemplifies how localized engineering innovation can drive **sustainable infrastructure transformation** in developing cities facing rapid urbanization and harsh climatic conditions.