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TOPIC OF RESEARCH:**IN-SITU STUDY OF LEACHATE RECIRCULATION AT AN ACTIVE
LANDFILL SITE IN WASTE DEGRADATION**

FINDINGS

This thesis investigates the potential of leachate recirculation as a sustainable management strategy for active landfills, focusing on its impacts on waste degradation and settlement at the Okhla landfill site in New Delhi, India. The study also examines seasonal and temporal variations in leachate characteristics. The research is set against the backdrop of India's severe waste management crisis, in which approximately 160,000 tons of municipal solid waste (MSW) are generated daily, with only about 50% treated, resulting in widespread environmental contamination.

The research is grounded in a stark reality. India's waste management system is characterised by significant structural deficiencies, including low community awareness, inadequate segregation at source, and poor implementation of existing legal frameworks. This results in over 31% of collected waste being unaccounted for and widespread open dumping. A key distinguishing feature of Indian MSW is its high organic fraction (approximately 50%) and moisture content (30-60%), which renders conventional thermal treatment methods such as incineration inefficient and increases the generation of highly polluted leachate. In Delhi alone, the three major landfills generate roughly 3,000 cubic meters of leachate daily, a complex effluent containing high levels of Chemical Oxygen Demand (COD), heavy metals (e.g., Lead, Chromium, Cadmium), and volatile organic compounds (VOCs), posing a severe threat to groundwater resources

The thesis is structured in four parts. The first part outlines the motivation, objectives, and literature review, highlighting the challenges of MSW management in India. It notes that Indian waste has a high organic content (~50%) and high moisture content, which complicates treatment. Leachate, a pollutant-rich liquid, poses significant risks to groundwater, with Delhi's major landfills generating about 3,000 m³ daily. The second part details field experiments at Okhla landfill, where two experimental cells—one with leachate recirculation (Active Cell) and one without (Reference Cell)—were monitored over two years. Leachate samples collected in pre- and post-monsoon seasons (2018 and 2022) showed a weakening trend in pollutant strength over time, attributed to landfill aging and reduced waste dumping. Key parameters like Chemical Oxygen Demand (COD) averaged 1,200 mg/L, with heavy metals such as lead and chromium exceeding permissible limits.

The experimental results demonstrated that leachate recirculation significantly enhances waste degradation and settlement. The Active Cell, receiving consistent moisture from recirculated leachate and rainfall, showed a more pronounced reduction in total organic carbon (from 463 g/kg to 138 g/kg) compared to the Reference Cell (from 515 g/kg to 291 g/kg). Cumulative settlement was markedly higher in the Active Cell (1.31 m, or 7.9% of cell height) than in the Reference Cell (0.32 m, or 1.92%), underscoring the role of moisture in accelerating biological decomposition and volume reduction.

The third part reviews existing models for predicting MSW settlement, including empirical, rheological, and mechanical approaches, noting their limitations in capturing complex nonlinear behaviors. In the fourth part, advanced modeling techniques—including Artificial Neural Networks (ANN), Support Vector Machines (SVM), and regression models—were applied to predict settlement. The ANN model outperformed others, achieving high accuracy ($R^2 = 0.926$, MAE = 0.051), highlighting its utility in landfill management planning.

The study concludes that leachate recirculation offers synergistic benefits: it reduces leachate pollutant strength, accelerates organic waste decomposition, and promotes faster landfill settlement, thereby extending landfill lifespan and mitigating environmental impacts. Recommendations include adopting leachate recirculation as standard practice, implementing systematic leachate quality monitoring, optimizing moisture levels, promoting waste segregation at source, and strengthening regulatory frameworks. This research provides actionable insights to improve landfill sustainability in India and similar contexts worldwide.

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