Paper 279

Operational Efficiency and Environmental Risk Analysis of Landfill Gas Collection Systems

With the rapid growth of urban solid waste, landfills remain a primary waste disposal method, and their operational management and environmental impacts have attracted increasing attention. During waste degradation, landfills generate significant amounts of landfill gas, primarily composed of methane (CH_4) and carbon dioxide (CO_2), which are combustible and potent greenhouse gases. Efficient landfill gas collection systems can reduce greenhouse gas emissions, mitigate environmental risks, and enable energy recovery, improving the resource utilization of landfills. However, in practical operation, collection systems often face challenges such as low collection efficiency, system leaks, and operational instability, directly affecting environmental safety and energy recovery potential.

The efficiency of landfill gas collection is influenced by multiple factors, including cover layer permeability, well network layout, suction pressure, waste mass structure, and degradation kinetics. Low collection efficiency not only results in methane release to the atmosphere, exacerbating greenhouse effects, but also poses safety hazards such as explosions and fires. Additionally, operational issues such as localized pressure fluctuations, well clogging, and equipment failure can further compromise system stability and environmental risk mitigation. Therefore, a systematic analysis of operational efficiency and environmental risks is crucial for the design optimization and safe management of landfill gas collection systems.

This study proposes a methodology for analyzing the operational efficiency and environmental risks of landfill gas collection systems. By developing coupled gas migration and collection kinetics models, the study simulates gas collection efficiency under varying well network layouts, suction conditions, and cover layer properties. Environmental risk assessment models are applied to evaluate methane emissions, greenhouse gas impact, and potential safety hazards. The results provide scientific guidance for optimizing landfill gas collection design, improving operational management, and implementing environmental control measures, achieving the integrated objectives of emission reduction, energy recovery, and safe operation.

The findings offer practical engineering insights for landfill operators and provide a technical reference for green and low-carbon urban solid waste management,

supporting resource recovery and sustainable environmental management.