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Engineering Performance Evaluation of Urban Stormwater Runoff Pollution Reduction Technologies

With the rapid pace of urbanization, urban stormwater runoff has significantly increased, carrying a variety of pollutants into rivers, lakes, and urban drainage systems. These pollutants include suspended solids, heavy metals, nitrogen and phosphorus nutrients, organic matter, and pathogenic microorganisms, which pose serious risks to water quality and urban ecosystems. Conventional stormwater drainage systems prioritize rapid runoff discharge and often fail to effectively reduce pollutant loads, exacerbating water pollution issues in urban areas. Therefore, developing and evaluating technologies for stormwater runoff pollution reduction is of great engineering and environmental significance.

Current urban stormwater pollution reduction technologies include green infrastructure, such as rain gardens, permeable pavements, and green roofs; retention and sedimentation facilities, such as sedimentation basins and pollutant interceptors; and chemical or biological treatment units, including constructed wetlands and biofiltration systems. The performance of these technologies varies under different rainfall events and discharge conditions and is significantly affected by rainfall intensity, runoff water quality, pollutant types, and system scale. To ensure the engineering feasibility and environmental effectiveness of urban stormwater management systems, it is necessary to systematically evaluate the engineering performance of these technologies and optimize their design and operation.

This study proposes a comprehensive engineering performance evaluation methodology for urban stormwater runoff pollution reduction technologies. By developing pollutant load calculation models and hydraulic process simulations, the removal efficiency, retention capacity, and operational stability of different technology units are analyzed under typical urban rainfall events. Additionally, economic cost and maintenance requirements are considered to evaluate optimized technology combinations, providing guidance for the planning and design of urban stormwater management systems. The approach enables quantification of pollutant reduction capabilities and adaptability of various technologies, supporting stormwater resource utilization, pollution mitigation, and ecological protection objectives.

The results provide technical guidance for urban drainage and water environment management and offer engineering references for the development of green infrastructure, stormwater governance policies, and sustainable urban development, promoting the coordinated improvement of water quality and urban ecological functions.