NUTRIENT REMOVAL FROM MUNICIPAL WASTEWATER USING WASTE ALUM SLUDGE

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Degree of Master of Science

Department of Civil Engineering
Faculty of Engineering

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Sri Lanka

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Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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Signature: Date: 05/08/2025

The above candidate has carried out research for the PhD/MPhil/Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

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Signature of the Supervisor: Date: 05/08/2025

Name of Supervisor: Prof. M.W. Jayaweera

Signature of the Supervisor: Date: 05/08/2025

UOM Verified Signature

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ABSTRACT

Nutrient Removal from Municipal Wastewater using Waste Alum Sludge

Phosphorus pollution in water bodies is a significant environmental concern, contributing to eutrophication and the degradation of aquatic ecosystems. Traditional phosphorus removal techniques, such as chemical precipitation and biological phosphorus removal (BPR), are effective but often costly and environmentally unsustainable. This study investigates the feasibility of using alum sludge, a byproduct of water treatment plants, as a cost-effective and sustainable adsorbent for phosphorus removal from wastewater.

Comprehensive characterization of alum sludge samples from three water treatment plants as Ambatale, Biyagama, and Kandana was conducted to evaluate their physical, chemical, and morphological properties. High aluminum content (19.51% to 29.52%) and amorphous structures were identified as key factors contributing to phosphorus adsorption, with moisture content affecting adsorption efficiency. The potential for phosphorus release was minimal, confirming the chemical stability of alum sludge and its suitability for reuse in wastewater treatment.

Phosphorus removal experiments using synthetic wastewater revealed that removal efficiency was highest at slightly acidic pH levels (6–6.5). Time-dependent studies indicated rapid adsorption within the first two hours, with equilibrium reached thereafter. Langmuir isotherm analysis demonstrated monolayer adsorption behavior, with Biyagama WTP sludge achieving the highest maximum adsorption capacity (7.96 mg/g), followed by Kandana (6.45 mg/g) and Ambatale (5.69 mg/g). These results underscore the influence of source-specific sludge characteristics on adsorption performance.

The findings highlight the potential of alum sludge as a low-cost, effective, and environmentally sustainable material for phosphorus removal in wastewater treatment. Further research is recommended to explore large-scale applications, hybrid treatment systems, and the regeneration of used sludges to enhance their viability. This study contributes to advancing circular economy principles by repurposing waste for environmental remediation.

Keywords: Alum sludge, Phosphorus, Adsorption, Synthetic Wastewater

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