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Analysis and Characterization of Sludge from Water Treatment Plants: Implications for Environmental Management

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Background: Water treatment plants (WTPs) generate significant quantities of sludge, which, if improperly managed, pose environmental and public health risks. In Sri Lanka's North Central Province, data on the physicochemical properties of sludge and its reuse potential are limited, highlighting the need for location-specific studies to inform sustainable waste management strategies.

Objective: This study aimed to analyze and characterize the physical and chemical properties of sludge from Mahakanadarawa, Nuwarawewa, and Thuruwila WTPs and to evaluate its potential for agricultural reuse and brick manufacturing.

Methods: At each plant, eight subsamples with a weight of 500g in each sample (four corners, top and bottom) were homogenously composited into representative top and bottom sludge samples. Chemical parameters (pH measured with a calibrated pH meter, Electrical Conductivity and total dissolved solid measured with a portable EC/TDS meter, nitrate determined by UV-Vis spectrophotometry, and major nutrients, inorganic ions, and heavy metals quantified by X-ray fluorescence spectroscopy) and physical parameters (ash content determined by gravimetric analysis) were analyzed using standard laboratory procedures. Results are reported as the mean of two replicate tests. Results were compared with the World Health Organization (WHO) limits for land application.

Results: The pH values (7.54–8.23) and EC (136–298 $\mu\text{S}/\text{cm}$) were within WHO limits. Phosphorus (18,700–24,700 mg/kg) and potassium (11,700–42,600 mg/kg) indicated strong fertilizing potential, while calcium (69,100–91,500 mg/kg) supported soil structure enhancement. However, sulfur levels (30,400–42,300 mg/kg) exceeded recommended limits, and magnesium was critically deficient. Nitrate levels varied, with some top samples exceeding WHO limits, indicating eutrophication risks. Heavy metals, especially nickel (315–656 mg/kg) and arsenic (83–196 mg/kg), exceeded WHO limits, while other heavy metals like Pb, Cr were within the recommended range and Cd was not detected. The study concluded that untreated sludge is unsuitable for direct agricultural application. However, Layer based segregation allows for reuse with proper modification with the top layer for agricultural use with nutrient adjustments, proper settling heavy metals may leach to the bottom layer and the bottom layer for brick production as high-temperature firing converts metals into stable compounds.

Conclusion: These finding highlight reuse potential, leachability, and the importance of layer-based segregation to enhance environmental safety and resource recovery.

Keywords: Environmental Safety, Sludge Regeneration, Heavy Metals