

**ALTERNATIVE PHOSPHORUS SOURCES IN LAKE
BOTTOM SEDIMENTS AROUND EPPAWALA
PHOSPHATE DEPOSIT, SRI LANKA**

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Degree of Master of Philosophy

Department of Earth Resources Engineering

University of Moratuwa

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Thesis submitted in partial fulfillment of the requirements for the degree of
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DECLARATION

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ABSTRACT

Jaya-Ganga is a water canal constructed bisecting the phosphate deposit in Eppawala, Sri Lanka. It nourishes three lakes around the vicinity of Eppawala Phosphate Deposit (EPD). With a view to prospect for unconventional phosphate sources, surface and core sediment samples from three lakes were evaluated, especially to determine the P_2O_5 concentrations and phosphate solubility. Additionally, surface sediments were analyzed by X-ray fluorescence, X-ray diffraction and laser particle analyzer to evaluate geochemical, mineralogical and textural variations, respectively. Furthermore, selected core samples were subjected to C14 age dating to determine the sedimentation rates, mass accumulation rates and Phosphorus accumulation rates in lakes. $P_2O_5\%$ in the surface lake sediments varied from 0.12 to 1.91 and from 0.33 to 1.24 in upstream and downstream, respectively. In upstream core sediment samples, $P_2O_5\%$ varied between 0.03 and 1.89, however, in downstream core samples, $P_2O_5\%$ varied from 0.01 to 2.22. The solubility of phosphates in lake sediments is typically assessed with respect to 2% citric acid solubility (by P_2O_5). Aligning with aforesaid, the performed solubility percentage upstream showed 14 to 37 in surface samples and from 4 to 71 in core samples. The corresponding percentages for the downstream samples fluctuated from 8 to 58 and from 1 to 50, respectively. Moreover, geochemical analyses of the surface sediments in both upstream and downstream lakes revealed higher contents of P_2O_5 , TiO_2 , Al_2O_3 , Fe_2O_3 and MnO and, low levels of SiO_2 , MgO , Na_2O , K_2O and CaO compared with the norms of Upper Continental Crust (UCC) values. The significantly positive anomaly of P_2O_5 in downstream sediments against UCC comparison is noteworthy. The geochemical classification divulged the chemical immaturity and mineralogical instability of the surface sediments in both areas. Meanwhile, the average Chemical Index of Alteration (CIA) values in upstream and downstream suggested the extreme chemical weathering conditions in the source area. Mineralogical analyses revealed the presence of phosphate-bearing minerals, such as fluorapatite, crandallite and millisite in downstream surface sediments, which are the weathered products of the EPD. Textural studies of surface sediments delineated the nature of material deposition through solid suspensions and favorable depositional condition, in downstream lake. Furthermore, downstream lake showed higher sedimentation rate, Mass Accumulation Rate (MAR) and Phosphorus Accumulation Rate (PAR) over upstream lakes. Interestingly, PAR of downstream is more than five times that of upstream lakes. Overall, results of the study reflected the contribution of the EPD as a phosphate source to the downstream lake and the potential of secondary phosphate mineralization in downstream sediments. High solubility values facilitated the applicability of downstream lake sediments as a low-grade phosphate additive/fertilizer. Continuous nourishment of phosphate-bearing materials via Jaya-Ganga, into the downstream lake sediments, steadily increase the quantity of the phosphate content in downstream sediments and the minable quality of the lake sediments as an economically viable phosphate source in the future.

Key words: Lake sediments, Phosphates, Weathering, Erosion, Eppawala Phosphate Deposit, Phosphate solubility

**DEDICATED TO SRI LANKANS WHO CONTRIBUTED FOR FREE
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LIST OF ABBREVIATIONS

AAS - Atomic Absorption Spectrophotometer
AMS - Accelerator Mass Spectrometry
BP – Before Present
CIA - Chemical Index of Alteration
EPD - Eppawala Phosphate Deposit
ERP - Eppawala Rock Phosphate
GPS - Global Positioning System
GSD - Grain Size Distribution
HERP - High-grade Eppawala Rock Phosphate
IR - Infrared
LOI - Loss-on-Ignition
LPA - Laser Particle Analyzer
MAR - Mass Accumulation Rate
PAR - Phosphorus Accumulation Rate
SSC - Sand-Silt-Clay
SSP - Single Super Phosphate
TP - Total Phosphorus
TSP - Triple Super Phosphate
UCC - Upper Continental Crust
UV - Ultra Violet
Vis - Visible
XRD - X-ray Diffraction
XRF - X-ray Fluorescence