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

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Degree of Master of Philosophy

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Philosophy in Earth Resources Engineering

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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 EDUCATION

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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