DEFLUORIDATION OF POTABLE WATER IN CKDu PREVALENT AREAS ENRICHED WITH HARDNESS USING MODIFIED-FLY ASH FUNCTIONALIZED WITH IRON OXIDE

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DECLARATION

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Name of the co-supervisor: Dr. (Ms.) W. B. Gunawardana

Signature of the supervisor: Date:

Abstract

Chronic Kidney Disease of Unknown Etiology is a major health issue reported in countries around the equator including Sri Lanka, Tunisia, Andra Pradesh India, and El Salvador. In Sri Lanka, CKDu is prevalent in the North-Central Province and now it is being progressed in the dry zone. The exact causal factor for the disease is not known yet where scientists now mainly suspect that the multiple ion interaction in potable groundwater may be the root cause for the disease. Further, fluoride ion concentration is higher in CKDu prevalent areas and the interaction of fluoride ion with other constituents (Cd, As, Al, hardness) is mainly suspected as the cause for the disease. The synergistic effect of hardness and fluoride on the CKDu had been discussed in many studies worldwide where the prevalence of other ions is very less, and it is below the WHO maximum allowed concentrations. The hardness and fluoride distribution are relatively higher in CKDu prevalent areas in Sri Lanka and the nephrotoxicity of hardness and fluoride in their mutual presence is proven by experiments with mice. Our preliminary studies found that there is no CKDu when the hardness and fluoride concentrations of water are below 200.00 mg/L and 0.47 mg/L, respectively. Therefore, this study was carried out to remove the hardness and fluoride concentrations of water to the level of 200.00mg/L and 0.47mg/L, respectively. Initially, a divalent cation exchange column was designed using a commercially available cation exchange resin, ECO A, to remove excessive hardness level up to 200.00mg/L. The eluent from the cation exchange column was further treated for defluoridation. Coal derived fly ash was further modified using the hydrothermal method. The Modified Fly Ash (MFA) was further treated with Fe (III) Chloride to generate positive charges on the surface. FTIR, SEM, EDX, confirmed the incorporation of Fe into MFA and, the defluoridation ability of Fe functionalized MFA. FTIR spectra ($400cm^{-1}$ – $600cm^{-1}$ region) showed the incorporation of Fe into MFA. The average crystalline size obtained from XRD analysis was 23.3nm and the synthesized material was in nanoscale. The batch experiments showed that 1.3g of the Fe functionalized MFA resulted in the maximum defluoridation for a 100.00 ml of water sample containing 200.00 mg/L hardness and 2.00 mg/L fluoride within 40 minutes of contact time at pH 6. The material gave optimum defluoridation at pH 6 and therefore there is no need of altering the pH of water for the defluoridation. The adsorption data fitted with the Langmuir adsorption isotherm where the maximum adsorption capacity was 10.00mg/g. The separation factor for the Langmuir adsorption was 1.23 and therefore the Langmuir adsorption is favorable. The reaction followed pseudo second order kinetics. Regeneration studies of the Fe functionalized MFA showed that

NaOH was the best regeneration agent and the material was exhausted after two regeneration cycles. The material synthesize cost to purify water for a five-member family for three months was LKR 6923.07 (37.52USD) and the cost for the regeneration was LKR 174.46 (0.95USD). Therefore, the synthesized material is ideal and cost effective to remove fluoride in potable ground water in CKDu prevalent areas.

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Key Words: CKDu, Functionalized Modified Fly Ash (FMFA), Defluoridation, Fluoride, Hardness, Adsorption, Iron Oxide

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LIST OF ABBREVIATIONS

Abbreviation	Description
CKD	Chronic Kidney Disease
CKDu	Chronic Kidney Disease of unknown etiology
CFA	Coal Fly Ash
MFA	Modified Fly Ash
FMFA	Iron oxide Functionalized modified Fly Ash
(FMFA) opt	Optimized Iron oxide Functionalized modified Fly Ash
IC	Ion Chromatography
GFR	Glomerular filtration rate
SL	Sri Lanka
NCP	North Central Province
FTIR	Fourier-transform infrared spectroscopy
SEM	Scanning electron microscope
EDX	Energy-dispersive X-ray spectroscopy
XRD	X-ray Diffraction Analysis