FATE AND TRANSPORT OF GLYPHOSATE AND DEGRADATION BYPRODUCTS: IMPLICATIONS FOR REMEDIATION AT CKDu ENDEMIC AREAS IN SRI LANKA

Abesinghe Arachchige Shankani Uthpala Gunarathna

(158008R)

Degree of Master of Engineering

Department of Civil Engineering

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Thesis submitted in partial fulfillment of the requirements for the degree Master of Engineering in Civil Engineering

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DECLARATION

"I declare that this is my own work and this thesis 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.

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The above candidate has carried out research for the Masters thesis under my supervision.

Name of the co-supervisor: Prof. J. M. A. Manatunge

Signature of the supervisor: Date:

Abstract

Glyphosate, which is commercially available as Roundup®, was the widely used herbicide in Sri Lanka until 2015 and is suspected to be one of the causal factors for Chronic Kidney Disease of unknown etiology (CKDu). This research, therefore, focuses on investigation of glyphosate and Aminomethylphosphonic acid (AMPA), the major degradation product of glyphosate, immobilization in top soil and subsequent mobilization to water and their effective and efficient removal. A field study and a series of mesocosm studies were performed to investigate the immobilization of glyphosate in the top soil and the mobilization of glyphosate and AMPA to water. Further, a long term batch experimental study was carried out to study the degradation of glyphosate in water in the absence and presence of hardness, for 240 days. Finally, the applicability of Ozonation process for glyphosate removal from water was studied using batch experiments. Glyphosate and AMPA were analyzed using LC/MS and GC/MS. It was evident that glyphosate persistence in the environment was high, especially due to the sorption of glyphosate to soil. Mobilization of glyphosate to water was minimal and it was catalyzed by the event of first precipitation after the application of glyphosate and application of Triple Super Phosphate (TSP) to the soil. Furthermore, glyphosate degradation was hindered and its persistence was increased due to the presence of hardness in water and surfactants in commercial grade glyphosate. Ozonation process rapidly degraded the glyphosate present in water both in the absence and presence of hardness to levels less than 700 µg/L which is the USEPA Maximum Contaminant Level for drinking water. In conclusion, this study provides the insight that the dominant mechanism of glyphosate in the environment is adsorption of glyphosate to the topsoil and mobilization to water is minimal. Further, Ozonation is an effective and efficient method to remove glyphosate in water in CKDu prevalent areas despite the presence of hardness and surfactants.

Key words: Adsorption, AMPA, Desorption, Hardness, Ozonation.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AMPA	Aminomethylphosphonic acid
CKDu	Chronic Kidney Disease of unknown etiology
EPSP	5_enolpyruvylshikimate_3_phosphate synthase
EPSPS	Enolpyruvyl shikimate-3-phosphate synthase
GC/MS	Gas Chromatography/Mass Spectrometry
GFR	Glomerular filtration rate
LC/MS	Liquid chromatography/Mass Spectrometer
PEP	Phosphoenolpyruvate
POEA	Polyethoxylated tallowamine
S3P	5-hydroxyl of shikimate 3-phosphate
TFAA	Trifluoro-acetic anhydride
TFE	Trifluoroethanol
TSP	Triple Super Phosphate
UCSC	Unified Soil Classification System
USEPA	United States Environmental Protection Agency