Spatial Analysis of Geochemical and Physiographical Parameters on Chronic Kidney Disease in Medawachchiya Divisional Secretariat Division

By

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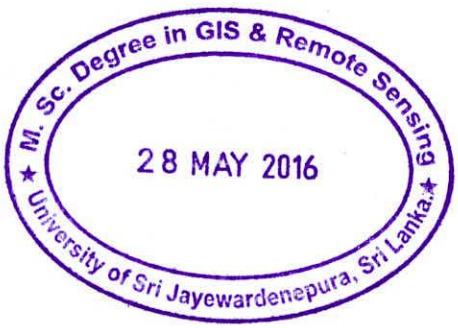

Thesis Submitted to the Faculty of Graduate Studies University of Sri Jayewardenepura for the Partial Fulfilment of Master of Science Degree in GIS and Remote Sensing on 20th March 2016

DECLARATION BY THE CANDIDATE

The work described in this thesis was carried out by me under the supervision of Mr. C.L.K. Nawarathna (Dean, Faculty of Humanities and Social Sciences, University of Sri Jayawardenepura) and Dr. Ranjith Premasiri (Senior Lecturer, Department of Earth Resources Engineering, University of Moratuwa) and a report on this has not been submitted in whole or in part to any University or any other institution for another Degree/Diploma.

..... 20-03-2016

K.A.K.C.Sriyani Date

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude and sincere thanks to Mr.C.L.K. Nawarathna and Dr. Ranjith Premasiri for their invaluable guidance and advices offered to me during my research. The knowledge share with my by them provided me the driving force and motivation to complete my work. The extensive hours that they spent explaining various aspects to me made me move ahead with confidence.

I also would like to express my sincere gratitude to Prof. R.M.K. Rathnayake for providing me with immense support, guidance and motivation during my research. Further I am very much grateful to Mr.Prabath Malavige, Mr.S. Sivanantharajah and all lectures of M.Sc. in GIS and Remote Sensing for the invaluable guidance, motivation, comments and reviews. I shall further extent my gratitude to all non-academic staff for providing me with immense support in various aspects.

I further shall express my sincere thanks to Dr. Asanka Ranasingha (Department of Health, North Central Province), Eng.R.S.Wijeseakara (General Manager, Water Resource Board), Eng.R.M.S Rathnayake (Regional Support Centre-North Central, National Water Supply and Drainage Board), Eng.K.M. Premathilake (Assistant General Manager, Ground Water Section, National Water Supply and Drainage Board) and consultant staff of "Anuradhapura North Water Supply Project" for providing invaluable data and information.

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LIST OF ABBREVIATIONS

As	-	Arsenic
Ca	-	Calcium
CAD	-	Computer Aided Drafting
CBO	-	Community Based Organization
Cd	-	Cadmium
CKD	-	Chronic Kidney Disease
CKDu	-	Chronic Kidney Disease of Unknown Aetiology
Cl	-	Chloride
DEM	-	Digital Elevation Model
DSD	-	Divisional Secretariat Division
F	-	Fluoride
Fe	-	Iron
GIS	-	Geographic Information System
GND	-	Grama Niladari Division
IDW	-	Inverse Distance Weighted
K	-	Potassium
km	-	Kilo Meter
km^2	-	Square Kilo Meter
Mg	-	Magnesium
mg/kg	-	Milligram per Kilogram
mg/l	-	Milligram per Litres
MOH	-	Medical Officer of Health
Na	-	Sodium
NCP	-	North Central Province
Po_4	-	Phosphates
ppb	-	Part Per Billion
SLD99	-	Sri Lanka Datum 99
So_4	-	Sulphate
SQL	-	Structured Query Language
TB	-	Terra Bite

TDS	-	Total Dissolved Solids
TIN	-	Triangulated Irregular Network
WHO	-	World Health Organization
WRB	-	Water Resources Board

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K.A.K.C.Sriyani

ABSTRACT

CKD has been recorded in different forms in different parts of the world. Though diabetes and high blood pressure have been identified as the general causes for the illness, the form of disease found in tropical countries has not shown any correlation with either of those causes. CKD in those parts of the world is often termed as "Chronic Kidney Disease of Unknown Aetiology (CKDu)" because of its' unknown origin. In the Sri Lankan context, worst conditions have been recorded from Anuradhapura district. It has been identified that the occurrence of the illness is significantly influenced by excessive levels of Total Hardness, Fluoride, Arsenic and Phosphate in drinking water. Increased levels of those parameters in ground water sources are found to be created due to extensive usage of agro chemicals. The research investigated the impacts of geochemical and physiographical parameters on CKDu. The influences of ground water flow were analysed by comparing the ground water flow model and the spatial distribution of heavy metal particles in ground water.

Spot analysis test results with respect to above mentioned water quality parameters and the actual locations of recorded CKDu patients in Medawachchiya DSD were used as the indicative data for the analysis. Interpolation of spatial distributions of each water quality parameter and preparation of "Ground Water Flow Model (Hydrologic Model)" were done using appropriate GIS tools. The analysis revealed that the level of CKDu vulnerability has increased in the downstream direction of the ground water flow. Areas with high densities of agricultural fields were not always the most critical ones and the areas located in the downstream direction of ground water flow paths have more often indicated worst CKDu vulnerabilities. The results indicated increasing patterns for heavy metal concentrations in ground water sources, in the direction of the ground water flow path. Transportation of heavy metals via ground water and accumulation of heavy metals in downstream areas have created ascending orders of CKDu vulnerability in the downstream direction of ground water flow, which would occur in parallel to the topographic slope of the land.

Keywords: CKDu; Total Hardness; Fluoride; Arsenic; Phosphate; Geochemical and Physiographical Parameters; Ground Water Flow Model (Hydrologic Model)

CHAPTER ONE

INTRODUCTION

1.1. Introduction

Chronic Kidney Disease has been identified as one of the burning health issues in Sri Lanka. The fatal nature of the disease and the unknown aetiology has drawn attention of many medical researchers to conduct various kinds of researches and investigations on the health hazard. It is reported that 80% of these patients eventually die from kidney failure within first two years.

The disease has been recorded in different forms in several parts of the world. The sort of disease found in Europe and North American regions, is identified to occur mainly due to diabetes and hypertension. However, it is found that above mentioned reasons are not the major causes for the disease in Asian and Central American regions. The disease in such regions has been distinguished as a different variety for which the major causes are yet to be precisely identified. Hence the disease in those regions of the world is often referred to as "Chronic Kidney Disease of Unknown Aetiology (CKDu)". Over the recent few decades, the disease with unknown aetiology has emerged as a major health concern in Sri Lanka also. The usual factors such as long-standing diabetes and hypertension are not found to be the leading causes for CKDu in Sri Lanka. The communities in the dry zone of the country, where there exists agriculture based socio economic conditions have been severely affected by the illness. Accordingly, North Central Province in Sri Lanka reports the highest number of CKDu patients and mortality rates. It has been identified that the illness occurs as a result of some combined effects of several adverse environmental conditions and such conditions are all found to be created by human interventions. Majority of the community in those areas fulfil their domestic water needs by using ground water sources.

It has been found that the form of disease prevailing in Sri Lanka has mainly occurred due to some unique hydro geochemistry conditions of the drinking water. Many investigations have revealed that the adverse hydro geochemical conditions are created

due to the extensive usage of agro chemicals in the agricultural fields. The fatal nature and the possible interrelation between drinking water and the illness demand intensive studies to be conducted with a view to identify suitable counter measures as well as preventive measures against the widespread health hazard.

When considering about the spatial distribution of the illness over the island, some localized areas (especially concentrated to the dry zone of the country) having high density of CKDu victims have been identified. With the male people becoming victims of the disease, almost all CKDu victimised families have faced so many financial crises.

Many researchers have revealed a direct link between the heavy metal molecules (Cadmium, Arsenic, Zinc, Lead, Aluminium, Chromium, etc.) and the illness. Chandrajith (2010) has mentioned that even though no single geochemical parameter could be clearly and directly correlated with the aetiology of CKDu, the unique hydro geochemistry of the drinking water is closely associated with the incidence of the disease.

Another cause of CKDu as explained by Chandrajith *et al.*, (2011) is higher ratios of Sodium/Calcium in drinking water with high levels of Fluoride. Similarly some researchers have also stated that the cause for the disease may be associated with Fluoride levels and hardness of water, while some other researchers have stated that the cause for the disease is due to a complex chemical formed by a combination of the above chemicals.

However majority of the findings of the previous researches lead to the conclusion that heavy metal molecules are the major cause for the illness. Many case studies have been conducted over the recent past in order to find out possible ways of intrusion of heavy metal particles in to the human body. Groundwater is the main drinking water resource and more than 85% of the drinking water requirements for the rural communities are obtained from shallow and deep wells (Lasantha, 2008). With the prevalence of well-established irrigation tanks covering almost the entire dry zone, the shallow groundwater sources are known to be benefited by seepage from small tank cascade systems located upstream (Panabokke, 2003).

After many years of researches, it has been found that heavy metal molecules enter to the human body, mainly via drinking water. In most of the areas affected by CKDu, people use ground water (in most of the cases by means of either shallow wells or deep wells as described before) as their major source of drinking water and it has been figured out that the presence of heavy metal particles in ground water sources has become the major origin of the disease.

The probable causes for the illness in Sri Lanka have been identified during the time of the literature review and those are explained in the following chapter of this report. This research has been carried out based on the assumption that CKDu occurs due to the presence of heavy metal particles in drinking water. In that context, it is important to identify the correlation between the disease and ground water quality. Thus for this particular research, the concentration of heavy metal particles in ground water were used as indicative data for CKDu vulnerability.

Since the illness was severely recorded during the recent decade or so, it has been figured out that the intrusion of heavy metal particles in to the natural water sources was not purely a natural phenomenon. Thus it has been revealed that the intrusion of heavy metal particles in to the water sources has happened mainly due to some human interventions. It has been found that agrochemicals continue to leach out to streams and shallow wells, contaminating drinking water sources in the areas affected by chronic kidney disease of multifactorial origin (CKD-mfo) (Sussett. and Grathwohl. 2011; Thompson *et al.*, 2009). Many investigations and case studies have also revealed that long term usage of agro chemicals (weedicides and pesticides) as well as chemical fertilizer has created increased levels of heavy metal concentrations in drinking water. Furthermore, excessive amounts of agro chemicals used in agricultural fields have been found to reach the water sources by means of ground water seepage as well as of direct surface runoff. Being similar to other diseases, prevention is more important than curing for CKDu also. Even after several years of research studies, medical industry is yet to invent medicine which could cure the illness. That has created an inevitable necessity for the introduction of proper preventive measures against the health hazard. Such situation has demanded many investigations to be conducted even beyond boundaries of medical and environmental disciplines.