Spatial Distribution of Fluoride in Ground Water and Spread of Dental Fluorosis in Vavuniya South, Sri Lanka

By

W. M. A. V. Rajakarunanayake

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

DECLARATION OF THE CANDIDATE

I do hereby declare that work described in this thesis was carried out by me under the supervision of Mr. C.L.K Nawarathna and Dr. H.M. Ranjith Premasiri, and report on this thesis has not been submitted in whole or in part to any University or any other institution for another Degree/Diploma.

Date 20th March 2016 .....

W.M.A.V.Rajakarunanayake

ACKNOWLADGEMENT

I am grateful for my supervisor Mr. C.L.K Nawarathna, Dean, Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura. Whenever I was in a tight corner, he guided me.

My deep gratitude is offered to Dr. H.M. Ranjith Premasiri, Senior Lecturer, Department of Earth Resources, Engineering, University of Moratuwa. He guided me to think in terms of the chemical patterns of the earth.

I have greatly benefited from their guidance and encouragement in academic matters. They keenly followed my progress, pointed weaker areas and helped to overcome unexpected difficulties in the field research.

I thank Professor (Dr.) R.M.K. Ratnayake and, Mr. Prabath Malavige for all the support and guidance given to me throughout the M.Sc program in GIS and Remote Sensing. I am grateful to all the lectures who shared their knowledge with us in this program.

Emirates Professor of Geology C. B. Disanayake, Dr. C.S Weeraratna, former Professor of Soil and Water and Dr. Tanuja Aryinanada for their guidance and sound advice. They shared their valuable experience and pointed out questionable areas.

Mr. M.S. Janaka, Divisional Secretary and Mrs. T. Manokaraj, Assistant Director of Planning, Vavuniya granted me the official permission to conduct the field research. Mrs Manokaraja helped me beyond the call of her duty.

Dr.Sajeevan Sivaguru, Dental Surgeon/Managing Director, International Dental Care, Dr. Jeevanthan, Regional Dental Surgeon of Vavuniya and Dr. (Mrs.) P. Senthil Kanthan, Senior Dental Surgeon and Dr Jesli, Dental Surgeon; Base Hospital Vavuniya were very helpful. They sacrificed their time to patiently explain the situation of Dental Fluorosis and their professional experience in the district.

Dr. Amila Piyathilaka for taking time to question my questioner sharply. Mr. Roshan Dalababandara provided a comfortable unoccupied house at Anuradhapura to use during my research period.I thank the Water Resources Board for the Chemical Test Report.

All the support given by the Vavuniya staff of the Lanka Rainwater Harvesting Forum is greatly appreciated.

Mr. Asoka Dias and Mrs. Manouri Dias helped me by suggesting necessary software and always supporting for my education and in personal life from childhood.

My mother accompanied me for my field research. My father was immensely helpful to take the samples to the laboratory and doing many other personal errands. I thank my parents for their love and support.

Non-academic staff of the Geography Department was very cooperatively helpful. I appreciate them.

LIST OF ABBREVIATIONS

CKDu - Chronic kidney disease of unknown etiology

DSD- Divisional Secretariat Divisions

F^-- Fluoride

GIS - Geographical information system

GND -Grama Niladhari Divisions

GPS- Global Positioning System

IDW - Inverse distance weighted

NWSDB- National Water Supply and Drainage Board

RDHS -Regional Director of Health Service

RWHS – Rain Water Harvesting Systems

SLS- Standards of Sri Lanka

UNICEF- United Nations International Children's Emergency Fund

WHO - World Health Organization

TDS-Total Dissolved Solids

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

Spatial Distribution of Fluoride in Ground Water and Spread of Dental Fluorosis Diseases in Vavuniya South, Sri Lanka

W. M. A. V. Rajakarunanayake

ABSTRACT

This thesis presents the connection between the ground water and dental fluorosis through spatial distribution of fluoride in Vavuniya South, Sri Lanka. The main objective is to gain insight into the spread of dental fluorosis and geo chemistry parameters of ground water in the relevant region. This research is a multi-disciplinary in four levels. After spatial analysis of geo chemical pattern and spread of the patients, dental fluorosis patients were geo tagged. Dug well water quality comparison with geo statistics was the final step. The field survey was conducted in all nineteen villages of the study area. A questioner was given to 100 families, totalling 415 people. Dean's fluorosis index was used for dental fluorosis categorization. Water samples were collected from drinking water sources. A meter was used for pH, Electrical conductivity (EC) and Total Dissolved Solids (TDS). Final water testing was done at the laboratory of Water Resource Board. Geospatial analysis of the various geological and hydro chemical datasets indicate Fluoride concentration in ground water is between 0.15 and 2.55 mg/L. 21 water samples exceed the permissible limit of Fluoride as 1 mg/L. Including 30 children, 76 dental fluorosis cases were identified. The geology map of the South Western part of the surveyed area shows Hornblende biotic genesis, Magnesium and Fluoride rich rocks. Northern Eastern sector compress more acidic silica rich rock formations. The ground water quality zonation map reveals 35% of the study area does not reach up to the accepted drinking water quality levels. It indicates safe piped water or rain water harvesting is an urgent requirement for Agbopura, Puthubulankulam, Mahamylamkulama, Madukanda, Avusthapitiya, Periyaulukulam, Awaranthulawa and Rankethgama.

Key words: Ground water, Fluoride, Fluorosis, GIS

CHAPTER ONE

INTRODUCTION

1.1 Background

High level of fluoride in the ground water is a global issue. United Nations International Children's Emergency Fund (UNICEF, 2012) estimates that fluorosis is endemic in at least 25 countries including India, South Africa and China. The fluoride ion level recommended by the World Health Organization (WHO, 2006) is below 1.5 mg/L. Greater than the recommended level will lead to health problems. According to potable water standards of Sri Lanka (SLS) 614:2013 stipulated by the Sri Lanka Standards Institution, the permissible fluoride level in drinking water is 1.0 mg/L.

Correct intake levels of fluoride ion is beneficial to both bone and dental structure. Lack of fluoride in childhood prevents the proper formation of teeth and weak born structures. Specific bacteria in dental plaque, ferment carbohydrates to produce acids that can demineralize tooth enamel. Excessive fluoride contained in drinking water during calcification can cause discoloration of children's teeth. If fluoride concentration is less than 0.5 mg/L, dental caries may be the result. Since children's tissues are free from the fluorides, their skeleton tissues can absorb the fluorides more easily. Continuous intake of high level fluoride can result in skeletal fluorosis. Skeletal and non-skeletal fluorosis creates pains in bone and joints, stiff back, burning sensations, muscle weakness, chronic fatigue, gastro intestinal problems and lack of appetite. This research is limited only to the dental fluorosis.

The first hydro chemical map in Sri Lanka was developed by Dissanayaka and Weerasooriya in 1985. It has indicated that ground water of some areas in Sri Lanka contains high concentrations of toxic materials such as arsenic / cadmium / nitrates / fluorides. The fluoride level of ground water map was updated by Chandrajith *et al.* in 2012. This map has been developed by using approximately 14,000 ground water samples. High level of fluoride was indicated in many districts of Sri Lanka.

Anuradhapura, Polonaruva, Ampara, Moneragala and Vavuniya districts belong to the harmful upper fluoride category.

According to the findings of Chandrajith *et al.* (2012), 8 million people in Sri Lanka are affected in consuming high fluorinated drinking water. This leads the school children and adults to a serious health risk.

Many researchers have identified the areas and exact locations where fluoride is high. A few locations of water sources are geo tagged. Until this study was completed in March 2016, there was no other dental fluorosis related multi-disciplinary research combined with GIS techniques to identify the geological aspect has been published. Most of the medical or geological researches were done in Anurdhapura District. In Sri Lanka, there are more than 30,000 bore wells (known as tube wells) within dry zone. More than 90% of ground water aquifers are municipal well fields and private boreholes in Jaffna, Batticaloa, Mannar, Vavuniya and Puttalam areas (Panaboke, 2006).

The research was focused on the spatial distribution of geology, land use patterns and the drinking water para meters. The ground survey was mainly focused on fluoride in ground water and spread of dental fluorosis in Vavuniya South. Combining all the above mentioned layers and using Inverse Distance Weighted was used to analyse the drinking water quality of the research area.

1.2 The Research Problem

Sri Lanka has 3 climatic zones as wet, intermediate and dry zone. 65% of the land falls in to the dry zone; Vavuniya district where the study was carried out also belongs to the dry zone. The dry zone water table is deep and very often bore wells reach down to the saturated water level. The depth of the bore wells differ from village to village depending on the geological features. According to the communities of the area all the wells are deeper than 20 feet.

The corns of mineralized water get infiltrated with the fresh water. The study area is boarded to the north central province where there is mineral apatite enriched occurrence at Eppawala. The fluoride concentration in ground water sources in Eppawala varies from 0.96 mg/L to 2.81 mg/L (Nandasena *et al*, 2011). It indicates the interchange of fluoride and hydroxyl ions. Administrative districts are divided on surface geological