BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

INVESTIGATING THE EFFICIENY OF TAMARIND SEED POWDER IN DEFLUORIDATION OF WATER.

CASE STUDY: OSUKURU SUBCOUNTY.

NAME: AJOK PASKA

REG NO. BU/UP/2012/622

SUPERNISORS

MAIN SUPERVISOR: MS MARION ENGOLE

CO-SUPERVISOR: MR WANGI MARIO

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EXECUTIVE SUMMARY

This paper begins with an overview of the origin, magnitude, geographical distribution and health consequences of fluoride contamination problem around the world and particularly in osukuru Sub County.

Tamarind seed, a household waste from the kitchen is used for the sorptive removal of fluoride from synthetic aqueous solution as well as from field water samples. The main aim of this study was to investigate the efficiency of tamarind seed powder for defluoridation of ground water. Various current defluoridation technologies are discussed and this paper mainly focused on adsorption.

Batch sorptive defluoridation was conducted under variable experimental conditions such as agitation time, initial fluoride concentration, and sorbent dose. Maximum defluoridation was achieved in within 80minutes. Defluoridation capacity increased with increase in sorbent dose and equilibrium was reached when increase in sorbent dose gives no appreciable change in the amount of fluoride removed, moreover defluoridation decreases with increase in initial fluoride concentration. The optimum efficiency for both synthetic and field water samples was found to be 96% and 90% respectively. For domestic application, defluoridation with 100% achievement was reached.

Key words | batch adsorption, defluoridation, domestic application, Tamarind seed

DECLARATION

I **AJOK PASKA** hereby declare that, this report is a true work of my hands and has never been presented by any person or institution for an academic award

Signature: ……………………………………

Date: ……27/05/2016…………

APPROVAL

This piece of work has been approved by;

Main Supervisor

MS. ENGOLE MARION

Signature…………………………………………………

Date………………………………………………………..

Co-supervisor

MR. MARIO WANGI

Signature…………………………………………………

Date………………………………………………………..

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LIST OF ACRONYMS/ ABBREVIATIONS

W.H.O	World Health Organization
PH_{zpc}	Zero point charge
UV	Ultra-violent light
POU	Point of Use
Ft	Feet
Cm	centimeter
%ads	percentage adsorption
IFS	International fluoride society
NaF	Sodium Fluoride
C_f	Dilution factor
K_1	pseudo-first order rate constant, min±1
k	pseudo-second order rate constant, g sorbent/mg pollutant min
q_e	equilibrium mass of pollutant sorbed on sorbent, mg pollutant/g sorbent
q_t	mass of pollutant sorbed at time t, mg pollutant/g sorbent
t	contact time, min
C_a	Adsorbed fluoride
TS	Tamarind seeds
C_o	Initial fluoride concentration
M	Mass
Q	Adsorption capacity
O&M	Operation and Maintenance cost

CHAPTER ONE

1.0 INTRODUCTION

This chapter includes the following; back ground to the study, statement of the problem, purpose of the study, objectives of the study, scope of the study.

1.1 BACKGROUND

Fluorine (F_2) due to its high electronegative and reactivity cannot be found in natural environment in elemental form. Fluoride (F^-) is a fluorine anion which has a great tendency to behave as ligand and easiness to form a great number of different organic and inorganic compounds in soil, rocks, air, plants and animals. These compounds are quite soluble in water, so fluoride is present in surface and groundwater as an almost completely dissociated fluoride ion (WHO. 2002).

There are numerous fluoride "belts" throughout the world where ground waters contain unsafe levels of fluoride. These belts span over 14 countries in Africa, 8 countries in Asia, and 6 countries in the Americas that all having water considered unsafe by the World Health Organization (Tekle-Haimanot, *et al.*, 1995). One of the regions of the world most affected by fluorosis is East Africa, specifically, the East African Rift Valley. Possibly because fluorotic minerals are often carried by water, it is more common to find fluoride rich soils in lowlands and valleys. T (Bardsen, *et al.*, 1995). With over 61% of East African water sources having more than 1 mg of F /l (the recommended amount), 20% having more than 5 mg/l, and 12% having over 8mg/l (Chilton, *et al.*, 2006).

In Uganda High fluoride concentrations (greater than the WHO guideline value of 1.5 mg/l) are found in the Rift Valley of western Uganda and in the volcanic areas of the east (Mbale, Elgon, Moroto areas). The incidence of fluorosis is known to be high as a result. The crater lakes of western Uganda often have high concentrations (e.g.4.5 mg/l F in Lake Kikongo; Mungoma, 1990) and concentrations in ground waters having interaction with these lake waters are likewise expected to be high (and the waters correspondingly saline).

High fluoride concentrations are particularly noted in ground waters from the Rwenzori Mountains on the western border and the Osukuru Hills in eastern Uganda (WRAP, 1999). In the Sukullu Hills, fluoride may also be associated with occurrences of phosphate minerals which are currently being investigated for mining development. (British Geological Survey, 2001)

Drinking water is the major source of fluoride daily intake and continuous consumption of drinking water with heightened fluoride concentrations (>1.5 mg/L) can cause varying degrees of health problems (Harrison, 2005). At drinking water concentrations between 0.9-1.2 mg/L, fluoride may give rise to mild dental fluorosis. Values of 1.5-2 mg/L of fluoride in drinking water gives rise to higher chances of dental fluorosis, while values exceeding 2 mg/L may have very high chances of dental and skeletal fluorosis (WHO, 1994). In Osukuru there are high cases of dental fluorosis but few cases of skeletal fluorosis.

In an effort to combat this public health problem, various technologies have been explored in both the developing and developed world, these methods can be broadly classified into three basic types namely adsorption, precipitation and membrane processes. In the precipitation methods there is high probability of contamination of drinking water due to unwanted chemicals. On the other hand membrane processes involve constant maintenance and heavy prices, which has made them less popular Hence, more attention is focused on adsorption (Feenstra *et al*, 2007). Plant materials are reported to accumulate fluoride and hence application as defluoridating agents has been suggested. Examples of such biosorbents are serpentine (Maruthamuthu & Venkatanarayana Reddy,1987a), Tamarind gel (Maruthamuthu & Venkatanarayana Reddy 1987b), Duck weed Spirodela polyrrhiza (Shirke &Chandra 1991), Hydrilla Verticillata (l.f) Royale plants (Sinha et al. 2000) Aloe vera (Murugan & Subramanian, 2002). However, the applicability of these low cost methods is limited either due to their low efficiency or lack of public acceptance. Therefore, it is of paramount importance to identify materials with high rate of removal, economically, socially and technically feasible for applications in rural communities.

Tamarind seeds is a household material and is left as waste after removing Tamarind pulp for food preparation. It mainly consists of polysaccharides with fats, tannins, proteins and amino acids in minimum proportion. The surface of Tamarind seed is positive at a neutral pH since its pHzpc is 7.44. Hence, there may be electrostatic interaction between the fluoride ion and Tamarind seed (Meltzer 1976). Since this material is familiar in eastern Uganda an attempt is made to use it for defluoridation of drinking water. Using both laboratory aqueous solution and ground water field samples,

REFERENCES

"Fact Sheet: Tamarindus indica" (PDF). University of Florida. Retrieved July 22, 2012.

"http://www.appropedia.org/index.php?title=Water_defluoridation&oldid=247305

Abukakar, MG; Ukwuani, AN; Shehu, RA (2008). "Phytochemical Screening and Antibacterial Activity of Tamarindus indica Pulp Extract". Asian Journal of Biochemistry 3 (2): 134–138.

Anamika Satle et al. (2012) Solubility Enhancement Potential of Tamarind Seed Polysaccharide as Pharmaceutical Excipient

Bårdsen, K. B. a. A. (1995). USE OF ACTIVATED CLAY FOR DEFLUORIDATION OF WATER. 1st International Workshop on Fluorosis Prevention and Defluoridation of Water, Ngurdoto, Tanzania, the International Society for Fluoride Research.

Bjorvatn, A. B. a. K. (1997). DENTAL FLUOROSIS IN SUBJECTS EXPOSED TO FLUORIDE CONTAINING DRINKING WATER AT DIFFERENT AGE. 2nd International Workshop on Fluorosis Prevention and Defluoridation of Water, Nazreth, Ethiopia, the International Society for Fluoride Research.

British Geological Survey (2001), ground water quality Uganda

Chikte, A. J. L. a. U. M. E. (1997). FLUORIDE AND FLUOROSIS: THE STATUS OF RESEARCH IN SOUTH AFRICA. 2nd International Workshop on Fluorosis Prevention and Defluoridation of Water, Nazreth, Ethiopia, the International Society for Fluoride Research.*

Christman, S. "Tamarindus indica". Flori Data. Retrieved January 11, 2010.

Dahi, L. Fewtrell and Y. Magara. (2006) World Health Organization (WHO). Fluoride in Drinking-water by J. Fawell, K. Bailey, J. Chilton, E. ISBN: 1900222965. Published by IWA Publishing, London, UK.

Diallo, BO; Joly, HI; McKey, D; Hosaert-McKey, M; Chevallier, MH (2007). "Genetic diversity of Tamarindus indica populations: Any clues on the origin from its current distribution?" African Journal of Biotechnology 6 (7).

Doughari, J. H. (December 2006). "Antimicrobial Activity of Tamarindus indica". Tropical Journal of Pharmaceutical Research 5 (2): 597–603. Doi: 10.4314/tjpr.v5i2.14637.

Dr Xiang Quanyong, (2003) Effect of fluoride on intelligent children, Department of Occupational Health, School of Public Health, Fudan University (Formerly Shanghai Medical University), Shanghai,

Fluoride and Fluorides (1984): Environmental Health Criteria 36; World Health Organization (WHO): Geneva, Switzerland, 1984.

Fluorides—Environmental Health Criteria 227; World Health Organization (WHO): Geneva, Switzerland, 2002.

Harrison, P.T.C. Fluoride in water: A UK perspective. J. Fluor. Chem. 2005, 12

Ho, Y.S., McKay, G., 1998b. A comparison of chemisorption kinetic models applied to pollutant removal on various sorbents. Process Saf. Environ. Protect.

J. Fawell, K. B., J. Chilton, E. Dahi, and L. F. a. Y. Magara (2006). Fluoride in Drinking-water. London, IWA Publishing.

Khaled AbuZeid, Ph.D. P.E, PMP, Water Resources Programme Manager (CEDARE)

L. Feenstra, L. V., J. Griffioen (2007). Fluoride in groundwater: Overview and evaluation of removal methods. Utrecht, the Netherlands, International Groundwater Resources Assessment Centre: 25.6, 1448–1456.

Lama El Hatow,M.Sc, Program Assistant, Water Resources Management Programme (CEDARE)

M C Rwenyonyi, K. B., J M Birkeland and O Haugejorden (1997). DENTAL FLUOROSIS IN RELATION TO ALTITUDE AND FLUORIDE IN DRINKING WATER IN UGANDA. 2nd International Workshop on Fluorosis Prevention and Defluoridation of Water, Nazreth, Ethiopia, the International Society for Fluoride Research

M Wandera, M K Malde & K Bjorvatn. Assessment of the fluoride content of weaning food items in western Uganda.

M. Murugan and E. Subramanian (1998) Defluoridation of water by Tamarind seed Journal

Marutamuthu, M. & Venkatanarayana Reddy, J. 1987a a native index of defluoridation by Serpentine. Fluoride 20, 64–67. Figure 10 | SEM images of (a) free Tamarind seed and (b) fluoride-loaded Tamarind seed. (X 2000 magnification).460

Marutamuthu, M. & Venkatanarayana Reddy, J. 1987b Binding of fluoride with Tamarind gel. Fluoride 20, 109–112.

Morton, Julia F. (1987). Fruits of Warm Climates. Wipf and Stock Publishers. pp. 115–121. ISBN 0-9653360-7-7.

*Mungoma, S. 1990. The alkaline, saline lakes of Uganda: a review. Hydrobiologia, **208**, 75-80*

O, Y.S., McKay, G. (1998a). Sorption of dye from aqueous solution by peat. Chem.Eng. J

Popenoe, W. (1974). Manual of Tropical and Subtropical Fruits. Hafner Press. pp. 432–436.

Prerna Kumari, PG Scholar (2015) Environmental Science & Engineering Group Birla Institute of Technology, Mesra, Ranchi (India),

R Tekle-Haimanot, A. F., B Bushera and Y Mekonnen (1995). FLUORIDE LEVELS IN WATER AND ENDEMIC FLUOROSIS IN ETHIOPIAN RIFT VALLEY. 1st International Workshop on Fluorosis Prevention and Defluoridation of Water, Ngurdoto, Tanzania, the International Society for Fluoride Research.*

Shirke, P. A. & Chandra, P. 1991 Fluoride uptake by Duck-Weed Spirodela Polyrrhiza. Fluoride 24, 109–112.

Subramanian & Ramalakshmi (2010): Polyaniline-coated tamarind seed powder for defluoridation journal of Scientific & Industrial Research

Valdez-Jiménez, L.; Soria Fregozo, C.; Miranda Beltrán, M.L.; Gutiérrez Coronado, O.; Pérez Vega, M.I

WRAP, 1999. The annual yearbook of the water resources management department. Water Resources Assessment Project, ed: Azza, N.G.T., Uganda.British

Y. S. HO and G. McKAY (FELLOW) Department of Chemical Engineering, Hong Kong University of Science and Technology, Kowloon, Hong Kong,