BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

FINAL YEAR PROJECT REPORT

SIMULATION OF NUTRIENT LOAD AND IDENTIFICATION OF CRITICAL AREAS FOR BETTER WATERSHED MANAGEMENT USING SWAT MODEL

CASE STUDY: RIVER MANAFWA CATCHMENT

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A final year project report submitted in partial fulfillment of the requirements for the award of a Bachelor of Science degree in Water Resources Engineering at Busitema University

SIMULATION OF NUTRIENT LOAD AND IDENTIFICATION OF CRITICAL AREAS FOR BETTER WATERSHED MANAGEMENT USING SWAT MODEL CASE STUDY: RIVER MANAFWA CATCHMENT

Bachelor's Research Report by Kakala Joshua

REVISED SECTIONS

A revision of the final report was made and the Panel's comments and suggestions have been taken into account.

Response to The Comments from The Panel's Committee

Improve your Problem statement to point out more clearly the issues your research is addressing.

Response: The problem statement was rephrased to clearly indicate the issues my research is addressing. Page 2.

Your research should clearly address these three important questions; what information is already known about my research, what is the knowledge gap, what is my intervention?

Response: The information known is that river Manafwa is affected by pollution which originates from non-point sources around its catchment. The knowledge gap is that the non-point sources of pollution are really not known. My intervention is that my research helps in clearly identifying the non-point sources of pollution, it also estimates the amount of nutrient load deposited in the river and lastly my research identifies and suggests management practices that can be adopted to reduce the amount of nutrient load being deposited in the river.

Include another specific objective before modeling

Response: I included another specific objective, "To identify and prepare the data sets to use." Page 3.

Did you develop a model or used SWAT to analyze data.

Response: I used SWAT to develop a model for River Manafwa catchment.

Clearly indicate the methodology of assigning major nutrient hot spots (objective three).

Response: Specific objective 3 "To identify major nutrient hot spots in the catchment" was merged with specific objective 2 "To develop a model to simulate the nutrient load for the catchment" and its methodology is from Page 21 to Page 22.

Your results are not well articulated.

Response: The results are well articulate starting from Page 28 to Page 35.

Abstract

Nutrient deposition in water bodies is a major cause of pollution. Therefore, the need to do modelling of nutrient load at a watershed level is very vital. SWAT 2012 (Soil and Water Assessment Tool) was selected for the simulation of the nutrient load in River Manafwa Catchment in Uganda. The main objective of the study was to estimate nutrient load and identify critical areas for better watershed management. To set up the model for simulation, a DEM (Digital Elevation Model), land use map, soil map and weather data (temperature, solar radiation, wind speed, precipitation and relative humidity) was used. The stream flow data was available from 2000 to 2013. The model was calibrated using SUFI algorithm in SWAT-CUP by using the flow data from 2003 to 2007 and validated for 2008 and 2013. The model was not validated for nutrient load because nutrients data was not available. The performance of the model was evaluated by using a time series plots of observed and simulated value and the statistical measures of coefficient of determination (R2) and the Nash Sutcliffe Efficiency (NSE). The statistical analysis of calibration results showed agreement between observed and simulated daily values, with an R^2 value of 0.74 and NSE of 0.61. The R^2 and NS value for flow validation period was 0.61 and 0.53 respectively. The model identified subbasins 4,7,11,24 and 25 as the subbasins that generate the highest amount of nutrient load in the watershed and 2,6,18,19,20,22 and 23 as sub basins that contribute the least nutrient load to the in the watershed. The simulation results run with BMPs indicate that BMPs can greatly reduce on the amount of nutrient load generated from the watershed into the river. The simulation results run with BMPs indicated that grassed waterway with an overall reduction efficiency of 59.45% for TN and 67.30% for TP is the most efficient BMP to adopt for the entire watershed. Taking into consideration the influence of land slope, contouring with an overall reduction efficiency of 50.35% for TN and 60.06% for TP can be considered for implementation in the mountainous and hilly regions of the watershed. Terracing with an overall reduction efficiency of 51.95% for TN and 61.89% for TP can be adopted for implementation in the low land and relatively flat regions of the watershed. Generally, the model was capable of simulating nutrient load in River Manafwa Catchment.

Declaration

I **KAKALA JOSHUA** registration number **BU/UP/2014/573**, declare that all the material written in this report is original and has never been submitted to any institution for award of a degree.

Signature **Date**

.... 31st /5/2018

Approval

This is to certify that this project research has been carried out under my supervision and this report is ready for submission to the Board of examiners and senate of Busitema University with my approval.

MAIN SUPERVISOR: Mr. OKETCHO YORONIMO

SIGNATURE: ....

DATE: ....

CO-SUPERVISOR: Mr. MUGISHA MOSES

SIGNATURE: ....

DATE: ....

CO-SUPERVISOR: Mr. WANGI GODFREY MARIO

SIGNATURE: ....

DATE: ....

Dedication

This research is dedicated to my dear family; late Mr. Kakala Yusuf (RIP), Mrs. Kakala Jane, Mr. Kakala John, Ms. Muyama Grace and Ms. Nimurungi Jennifer Kayli for their support, heart calming and sensation words that encouraged me to move on in times of discouragement. May the almighty God bless the works of your hands.

Acknowledgement

I thank the Almighty God for giving me wisdom, knowledge, good health and guiding me throughout my studies.

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Special thanks go to my family members; the late Mr. Kakala Yusuf (RIP), Mrs. Kakala Jane, Mr. Kakala John, Ms. Muyama Grace, Ms. Nimurungi Jennifer Kayli and Mr. Kimera David for their support, heart calming and sensational words that encouraged me to move on in times of discouragement.

May the almighty God bless all of you abundantly.

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List of Acronyms

ARS	Agricultural Research Service
BMP	Best Management Practices
DEM	Digital Elevation Model
DWRM	Directorate of Water Resources Management
FAO	Food and Agricultural Organization
HRU	Hydrological Response Unit
MUSLE	Modified Soil Loss Equation
MWE	Ministry of Water and Environment
NARO	National Agricultural Research Organization
NSE	Nash-Sutcliffe Efficiency
ParaSol	Parameter Solution
PBias	Percentage Bias
R^2	Coefficient of Determination
SUFI	Sequential Uncertainty Fitting
SWAT	Soil and Water Assessment Tool
SWAT-CUP	SWAT Calibration and Uncertainty Programs
TN	Total Nitrogen
TP	Total Phosphorus
USLE	Universal Soil Loss Equation

CHAPTER ONE

Introduction

This chapter entails the background of the study, problem statement, justification, objectives and the scope of the study.

1.1 Background

Water is a renewable natural resource. It is important to individuals, society and natural ecosystems as life cannot exist without a dependable supply of suitable quality water and therefore it needs to be protected and nourished. Seventy percent of the earth's surface is covered by water. Oceans occupy most of the water (Naveen, 2012).

Water is delivered from the atmosphere in the form of rain, snow, hail, fog, and condensation and returns to the atmosphere by evaporation and transpiration. While on the earth, it runs over the ground to lakes, rivers, streams, and oceans and seeps into the ground to be taken up by growing plants to become a part of the ground-water reservoir, eventually discharging also to streams, rivers, lakes, or the ocean (Kabir, 2014).

The water in rivers plays an important role in meeting the essential requirements for the development of a country and serves as a source of water supply for domestic and industrial purposes, for agriculture, fisheries and hydro-power development (Jha, 2011). However, the quality of water is getting worse and worse because of population growth, the rapid development of industries, agriculture, animal husbandry, and nitrogen and phosphorus emissions. All of these pollution sources lead to deterioration and eutrophication in water quality, which put a threat to human life (Mandelker, 2014).

The intensification of agricultural practices in particular, the growing use of fertilizers and pesticides and the specialization and concentration of crop and livestock production have had an increasing impact on water quality. The main agricultural water pollutants are nitrates, phosphorus and pesticides (GEVAERT *et al.*, 2008).

Uganda is a landlocked country that occupies 241550.7 km2 of land. Open water and swamps constitute 41743.2 km2 of area, with about 16% of total land area of wetlands and open water, plus the annual water supply of 66 km3 in form of rain and inflows. One would therefore conclude that,

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