BUSITEMA UNIVERSITY
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FACULTY OF ENGINEERING

DEPARTMENT OF MINING AND WATER RESOURCES ENGINEERING

WATER RESOURCES ENGINEERING PROGRAMME

FINAL YEAR PROJECT REPORT

DESIGN AND SIMULATION OF A REJECT WATER RECYCLING SYSTEM FOR THE REVERSE OSMOSIS PLANT

CASE STUDY: COCA-COLA CENTURY BOTTLING COMPANY–MBARARA PLANT.

BY

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A final year project proposal submitted to the Department of Mining and Water Resources Engineering as a partial fulfillment of the requirements for the award of a Bachelor of Science degree in Water Resources Engineering.

ABSTRACT

Reverse osmosis (RO), is a system that purifies water by removing about 98% of total dissolved solids, organics and heavy metals. However, it rejects large quantities of water with a raised content of minerals normally called concentrate (reject water). At present, RO technology has the actual producing water rate in the RO process as only about 50-75%, so it still faces serious discharge problem of rejected water (Shahalam, Al-rashidi and Abusam, 2010).

The main objective of this project was to design and simulate a recycling system for the reverse osmosis reject water for Coca-Cola Century Bottling Company-Mbarara branch. The project encompassed a review of literature about the reject water and recycling systems, characterizing and quantifying this reject water, design of the recycling system components for reject water, simulation of the recycling system and finally economic evaluation of the project.

The project was carried out using different engineering principles, methods and equations. The reject water was characterized using laboratory tests; the quantity was got from primary data as an average of several months. The system was designed per component where: water pump and distribution pipes were obtained using Darcy-Welsbach and continuity equation, the storage tank was sized using the peak discharge of reject water. The caustic soda dosing pump was obtained using the chemical dosage equation. The simulation was done in Arduino and Proteus. Finally, the economic evaluation was done using benefit cost ratio analysis and payback period method.

It was found out that the reject water parameters, total dissolved solids (127<500mg/l), electrical conductivity, turbidity (0.2<10NTU) were within the required national standards of portable water apart from PH () which indicated acidity. A PH correction system was put to neutralize the reject water with caustic soda. The average quantity of reject water discharged per day was $25m^3$ and peak discharge as $40m^3$, so the storage tank had a volume of $40m^3$. The project was found to be economically feasible since the benefit cost ratio was 2.58 greater than 1 and payback period of 2 years.

The design once implemented, it will correct the PH of reject water to portable water standards and eliminate the cases of corrosion in pipes and tank hence very safe for floor cleaning, car washing and toilet flushing. This will reduce on the mains water demand and costs for the plant.

DECLARATION

I **KEBIRUNGI STELLA** hereby declare that, this project report on design and simulation of R.O reject water recycling system, is a true work of my hands and has never been presented by any person or institution for an academic award

Signature: .....

Date: 29.05.17

APPROVAL

This project report has been submitted to the Faculty of Engineering for examination with approval of my supervisors mentioned below;

Main Supervisor

MR. JOSEPH DDUMBA LWANYAGA

Signature: .....

Date: .....

Co-supervisor

MRS. MARION ENGOLE

Signature: .....

Date: .....

DEDICATION

I dedicate this report to my dear mother, Jennifer Katto Monday who has always inspired me to reach this far. I love you and I pray that you live longer.

ACKNOWLEDGEMENTS

I am very grateful to the Almighty God for His amazing grace.
Sincere appreciation goes to my Supervisors Mr. Joseph Ddumba Lwanyaga and Mrs. Marion Engole who ensured that I acquired full knowledge and assistance where I needed.

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I appreciate my parents for the support they have extended to me in order to attain quality education. May the Almighty God bless the work of their hands.

Special thanks go to the staff of century bottling company-Mbarara branch for giving me an opportunity to carry out my research from the plant especially Mr Moses Ssebaale, the quality assurance manager, Mr Stephen Muyamba and Mr Baraka Ordrew for the knowledge I acquired from them.

Finally, I give credit to my fellow finalists who have always told me inspiring words of counsel and wisdom. May the Good Lord bless and reward them with success.

LIST OF ACRONYMS

R.O – Reverse Osmosis

CBC- Century Bottling Company

T.D.S- Total dissolved solids

E.C- Electrical conductivity

Mg/l- Milligrams per litre

NTU-Nephelometric units

NWSC-National Water and Sewerage Corporation

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CHAPTER ONE

1.1 Background of study

Reverse osmosis (RO), is a system that purifies water by removing about 98% of total dissolved solids, organics and heavy metals. The main application is for desalination, however it is also been used in filtration, removal of microorganisms, hardness, volatile organics and soluble organics in over 4000 land based plants(Treatment, 2005). However, it rejects large quantities of water with a raised content of minerals normally called the concentrate. At present, RO technology has the actual producing water rate in the RO process as only about 50-75%, so it still faces serious discharge problem of rejected water (Shahalam, Al-rashidi and Abusam, 2010)

To meet more stringent water quality regulations and high demand of beverage in Uganda, the Century bottling plant in Mbarara has two water treatment plants that is, conventional and reverse osmosis. National water and Sewerage Corporation is the only source of water for the plant as the borehole is no longer in use. The reverse osmosis plant uses a lot of water to meet the plants demand and drains about 25-50% reject water/ concentrate to waste water treatment plant using the activated sludge system. This has in turn increased the volume of wastewater treated by 25% leading to high costs of wastewater treatment. The waste water in the sludge reactor turns from the golden brown color to black indicating the failure of the system, that is to say the microorganisms die and definitely the plant starts to bring a hydrogen sulphide (rotten egg) foul. This is because the reject water exceeds the design flow, which was initially not there since the reverse osmosis plant is still new.

According to the survey conducted with the plant attendant, averagely $20m^3$ and even more of the concentrate is rejected per day. This reject has same sanitary qualities as portable water apart from the raised mineral content and unlike rain and the condensate(Liu, Wei and Lu, 2000); the RO will always reject water at a relatively constant quantity. The reject water has not been put to any effective use or recycled, which makes it very meaningful to develop highly-effective reject water recycling system to compensate the deficiencies of RO and realize water saving and wastewater treatment costs reducing. (David *et al.*, 2013)

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