FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES ENGINEERING

A HYDRO INFORMATICS SYSTEM FOR REAL-TIME OPTIMAL OPERATION OF A SURFACE WATER TREATMENT PLANT

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A project report submitted to the department of water resources and mining engineering in partial fulfilment of the requirement for the award of the bachelor of science in water resources engineering of Busitema University

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ABSTRACT

The need for clean drinking water in the sub-Saharan Africa is on a rapid increase due to the fact that the existing surface water bodies are facing a problem of pollution resulting from both urban and industrial developments which are on a rise in most African countries.

Water treatment plants have been adapted to avail the people with water that is clean and safe for drinking and other related uses, but as a result of increasing pollution of surface water sources, these plants are facing challenges related to operation. This project, therefore, was inclined towards optimizing the operation of surface water treatment plants through the use of a real time hydro informatics system to effectively monitor the parameters right from the surface water source to the final treatment unit. Deep learning and Arima models were developed for the forecasting of available water and raw water parameters, for which the deep learning models had better performance based on their high coefficient of determination values and were adopted. Also, three tools were used in developing the prediction models of the effluent water unit parameter outputs. These included multilinear regression, deep learning and support vector machines. The deep learning modals had better prediction accuracy based on their slightly higher values of coefficient of determination and hence were adopted during the optimization. The optimization was carried out using the genetic algorithm tool of MATLAB and the results indicated better parameter control when compared with a real-world system. An Arduino based IoT system was also developed which was used for system monitoring and control, and this proved to be an easier and better way of treatment system monitoring and parameter control.

Key terms: Surface water treatment plant, Hydro-informatics, models, genetic algorithms, optimization, IoT

DECLARATION

I, KARUGABA SWIZEN, KATO HUSSEIN, CHELIMO BRUNO hereby declare that all the work material portrayed in this project proposal is my original work except where explicit citation has been made and it has not been presented to any Institution of higher learning for any academic award.

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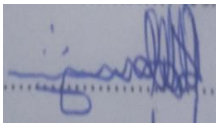

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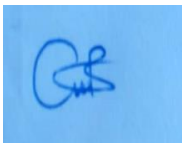
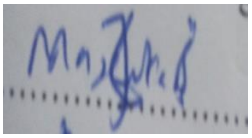


Date: 22.05.2023

APPROVAL

This is to certify that the project proposal under the title “A hydro informatics system for real-time optimal operation of a water treatment plant.” has been done under the best of our efforts and is now ready for examination

Mr. Maseruka Benedicto
Department of Water Engineering
Sign



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ANN: Artificial Neuron Network

IoT: Internet of Things

LS SVM: Least Square Support Vector Machine

ML: Machine learning

NTU: Nephelometric turbidity units

NWSC: National water and sewerage corporation

ORP: Oxidation Reduction potential

PH: Potential Hydrogen

SWAT: Soil and Water Analysis Tool

TDS: Total dissolved solids

UIDs: Unique Identifiers

WASP: Water Analysis and Simulation Program

WHO: World health organization

WIFI: Wireless fidelity

WQM: Water quality monitoring

WQMS: Water quality monitoring systems

WSN: Wireless sensor network

CHAPTER ONE: INTRODUCTION

This chapter includes the background of the study, the problem statement, the purpose of the study, the scope which includes conceptual scope, geographical scope and time scope of the study, and finally the justification.

1.1 Background

Water is the most abundant resource on earth, however, only about 3% of the total available water is fresh water, out of which nearly 69% is captured in glaciers, 30% is hosted in karst and porous aquifers, and the rest is in surface water reservoirs such as lakes, rivers, streams, and marshes. Fresh water is the basic substance of life on earth and is increasingly in short supply (Katsanou & Karapanagioti, 2017). As the world's population continues to grow, coupled with its effects like urbanization and industrialization, the water quality of these limited surface water sources continues to dwindle due to pollution (Khanyi et al, 2022).

Water treatment plants have been adapted to treat this water for human consumption. They follow a train of processes ranging from determination of abstraction points, raw surface water parameter determination, screening, aeration, coagulation, flocculation, sedimentation, filtration, and finally disinfection before supplying it to the consumers(Kaleeswari et al., 2018). Due to the high rate of increasing pollution plant operators are facing challenges related to operation, which include; errors in carrying out calculations, neglecting timely parameter testing, under-dosing, and over-dosing among others which also consume a lot of time and hence leading to drudgery during plant operation. These practices are also mainly based on the operator 's expertise and intuition depending on the quality of the incoming raw water. These operation practices also lead to high expenses in terms of chemicals needed for dosing, and power usage and also may pose a risk to the lives of the consumers.(Nshemereirwe et al., 2022)

This challenge is more pronounced in Africa's developing countries which are constrained by low levels of technology. In Uganda, over 7 million people lack access to safe water and 28 million do not have access to improved sanitation facilities. Further, due to disparities in water access in Uganda, urban people living in poverty pay as much as 22 percent of their income to access water from water vendors (Uganda's Water Crisis - Water in Uganda 2022 | Water.Org, n.d.). National Water and Sewerage Cooperation, (NWSC), a Public Utility Company, completely owned by the

BIBLIOGRAPHY

dos Santos, F. C. (2017). Inteligência artificial aplicada ao controle da dosagem de coagulante em plantas de tratamento de água.

Gagnon, C. (1997). Modelling of coagulant dosage in a water treatment plant.

J, S. M. (2015). Modelling And Simulation Of Water Treatment Plant For Optimum Coagulant Dosage Based On Hammerstein-Wiener Model.

Khaled, Y. (2021). The application of unsupervised machine learning to optimize water treatment membrane selection.

Mostafa, K. S. (2015). Optimization of conventional water treatment plant using dynamic programming.

Wang, D. (2020). Model predictive control for chlorine dosing of drinking water treatment based on support vector machine model.

Zhao, Z. (2019). Optimization and modeling of coagulation-flocculation to remove algae and organic matter from surface water by response surface methodology.

Zimoch, I. (2014). The optimization of chlorine dose in water treatment process in order to reduce the formation of disinfection by-products.

Nations, U. (2019). World population prospects 2019. In Department of Economic and Social Affairs. World Population Prospects 2019.

Palaniappan, M. (2008) Review of Decision-Making Support Tools in the Water, Sanitation, and Hygiene Sector About the Organizations.

Lowe, M. (2022) A Review on Machine Learning, Artificial Intelligence, and Smart Technology in Water Treatment and Monitoring.

Kaleeswari, K. (2018) Analysis of fuzzy logic-based control model for water treatment plant in Indian scenario.

dos Santos, F. C. (2017). Inteligência artificial aplicada ao controle da dosagem de coagulante em plantas de tratamento de água.

Gagnon, C. (1997). Modelling of coagulant dosage in a water treatment plant.

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Gagnon, C. (1997). Modelling of coagulant dosage in a water treatment plant.

J, S. M. (2015). Modelling And Simulation Of Water Treatment Plant For Optimum Coagulant Dosage Based On Hammerstein-Wiener Model.

Khaled, Y. (2021). The application of unsupervised machine learning to optimize water treatment membrane selection.

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Zimoch, I. (2014). The optimization of chlorine dose in water treatment process in order to reduce the formation of disinfection by-products.