

Forecasting Physical, Chemical and Biological Water Quality
Parameters of Kotmale, Victoria, Randenigala and Rantambe
Reservoirs Using DYRESM-CAEDYM Model

by

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award of the Degree of Master of Philosophy in Zoology
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DECLARATION

The work described in this thesis was carried out by me under the supervision of Prof. S. Piyasiri and Prof. K.D.W. Nandalal and a report on thesis has not been submitted in whole or in part to any University or any other institution for another Degree/Diploma.



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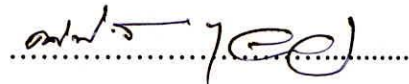


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DEDICATION

TO

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ABBREVIATIONS

NH ₄	- Ammonia
CAEDYM	- Computational Aquatic Ecosystem DYNamics Model)
DO	- Dissolved Oxygen
DYRESM	- DYnamic REservoir Simulation Model
EWS	- Emissivity of a water surface
LEC	- Light extinction coefficient
MARE	- Mean absolute relative error
MAW	- Mean albedo of water
NO ₃	- Nitrate
PO ₄	- Orthophosphorus
RMSE	- Root mean squared error

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Forecasting Physical, Chemical and Biological Water Quality Parameters of Kotmale, Victoria, Randenigala and Rantambe Reservoirs Using DYRESM-CAEDYM Model.

K.G.A.M.C.S. Abeysinghe

ABSTRACT

The Mahaweli is the longest river (335 km) in Sri Lanka with an annual discharge of $8878 \times 10^6 \text{ m}^3$ of water into the sea. Several dams have been built across the river for the purpose of irrigation and hydroelectric power generation. The four major reservoirs of the “Accelerated Mahaweli Project” are Kotmale, Victoria, Randenigala and Rantambe.

Strong thermal stratification in a reservoir may result in oxygen depletion along the vertical profile downwards leading to their eutrophication. Several reservoirs in the Mahaweli Project experienced water quality linked problems in recent times. A one-dimensional reservoir hydrodynamic model DYRESM was calibrated and validated for the Kotmale, Victoria, Randenigala and Rantambe reservoirs to predict water level, temperature, salinity and density in it. Calibration and validation are strengthened by calculating several goodness-of-fit statistics. After calibration and verification of hydrodynamic model DYRESM for the Kotmale reservoir, it was coupled with ecological model CAEDYM. The coupled model DYRESM-CAEDYM simulates water level, temperature, salinity, density and 5 water quality constituents (NO_3 , NH_4 , PO_4 , pH, and DO).

The model enables the prediction of thermal stratification and water quality in the reservoir body using data that can be collected easily, such as climatological data and reservoir inflow quantity and quality. This can minimize huge cost involved in monitoring water quality in the reservoir body.

The calibrated and verified hydrodynamic model (DYRESM) was used to run different operational scenarios which useful to make decisions for improving water quality in the Mahaweli reservoirs (Kotmale, Victoria, Randenigala and Rantambe). Simulations were developed to evaluate the stratification cycle during a period of 3 years; impact of the withdrawal quantity on stratification; and simulations also were developed to assess the impact of the withdrawal level on stratification.

The three year long (1997-1999) simulations of Kotmale, Victoria, Randenigala and Rantambe reservoirs showed that the annual cycle of stratification clearly. Thermal stratification is strong during the relatively warm period of March-August in all the three years. Thermal stratification in a reservoir determines the water quality in it and thus the model enables predicting adverse effects with respect to water quality in the reservoir. Thermal stratification and other water quality are affected by the change in the release quantity. When release was decreased by 25% for the period of three month (at the onset of stratification period) in all the three years, reservoir stratification has slightly decreased and thus DO concentration has slightly improved in the Kotmale reservoir. However, the improvement in the reservoir during the warm period is trivial. Victoria, Randenigala and Rantambe reservoirs follow the same results with the same operation. The outlet elevation affects the thermal stratification and water quality in the reservoir. When water is released through both outlets (upper outlet 75% of water and

lower one 25% of water) for the period of three month (during the onset of stratification period), the thermocline has becomes deeper. The surface temperature and other water quality have not changed, but the bottom water quality has improved considerably. This suggests the possibility to change the strong stratification in the Kotmale, Victoria, Randenigala and Rantambe reservoirs by manipulating the releases.

Reservoir managers will be able to take precautionary measures by controlling stratification in the reservoir by manipulating withdrawals. The study, based on two different withdrawal patterns, shows that stratification in these reservoirs could be altered by manipulating the withdrawal. Thus, the impact of many alternative operational patterns on thermal stratification in the reservoir could be studied with the help of the model in advance to avoid adverse water quality conditions in the reservoir as well as supplied from the reservoir.

Results from this study will provide reservoir management with information to better understand how changes in hydrology and water quality in the basin affects water quality in the reservoir. With this information, managers will be able to more effectively manage their reservoirs.