Abstract

In this study, a three-dimensional hydrodynamic and water quality model code was developed to simulate the circulation pattern and the trophic level of reservoirs with highly variable bathymetry in Taiwan. As reservoirs in Taiwan are characterized by the rapid changes in bathymetry and the transient variations of the storage volumes (i.e., surface elevations), which presents various challenges for the modelers.

Preliminary model results obtained for the Feitsui Reservoir show that the transient variation of the storage volume can be reproduced by the model, as whereby the dynamic fluctuation of the surface elevation at the dam site is replicated by the model for a two-year period (from 1999 to 2000). Subsequent tests conducted using the model include hydrothermal simulations of the reservoir to ensure the accurate predictions of the spatial and temporal variations of temperature in the reservoir, with particularly focus on matching the thermocline structure during the summer stratification period. Results of the temperature simulation reveal that there is a stratification phenomenon occurring during summer and early autumn in 1999 and 2000, and subsequently this lead to an overturn phenomenon happened. The hydrodynamic results derived will then be used to run the water quality model.

An eutrophication model that can simulate eight water quality parameters was also developed in this study. Biological variables were incorporated, including four groups of phytoplankton such as Cyanobacteria, green algae, diatom, and all the others. The hydrodynamic and water quality simulation uses the same grids and time...
steps in order to handle the geometry of the reservoir. Simulation results of model simulation indicate that the temperature, light, and nutrient are the growth limiting factors for phytoplankton. A new temperature function shows that a bell shape equation is suitable for phytoplankton temperature-limiting phytoplankton simulation. Both the field data and model simulation results also showed that each algae has its own growing period. It was found that phosphorus is the nutrient limiting factor for most phytoplanktons, except for diatom, which is controlled by both phosphorus and nitrogen relatively. Lastly, the carbon-phosphorus-nitrogen ratio for the four groups of phytoplankton is made distinct so that in order to emphasize the interaction of nutrients could be emphasized.

Keywords: Feitsui Reservoir, eutrophication, three-dimensional numerical model, algae dynamics.

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CHAPTER 1 INTRODUCTION

1.1 Background

Reservoirs are man-made water bodies and are usually formed by constructing a dam across a flowing river. They are usually built to address one or more specific water needs. These needs include, such as augmenting municipal and drinking water supplies, irrigating agricultural fields, irrigation, and supplying the industry with industrial and cooling water supplies. Alternatively, they are also used for power generation, flood control, sports or commercial fisheries, recreation, aesthetics and navigation purposes.

In contrast to flowing water, reservoirs and lakes were not given much attention in the early years of water quality modeling. This is because, with the exception of large navigable systems like the Great Lake, historically, they have not been the major focus of urban development, with the exception of large navigable systems like the Great Lake. Starting in the 1970s, however, it was…
CHAPTER 2 – LITERATURE REVIEW

In the real world, three-dimensional flows can be found occurring everywhere. The ultimate aim of fluid dynamic studies is to investigate such phenomena. With the rapid progress and development of computer science and technology, the simulations of such complex flows in the real world become possible.

The fundamental bases of any CFD (Computational Fluid Dynamics) problem are the Navier-Stokes equations, which define any single-phase fluid flow. The development of such methods in fluid computation has been progressing over the last few decades. Frankel (1950) presented the first version of the successive over-relaxation (SOR) scheme for solving Laplace's equations. Early efforts at solving flows with shock waves adopted either the Lax approach or the artificial viscosity scheme introduced by von Neumann and Richtmyer (1950). Peaceman and Rachford (1955) and Douglas and Rachford (1956) then developed a new family of implicit methods for solving parabolic and elliptic equations in which the sweep directions were alternated and an unrestricted step size was allowed.
unrestricted. Alternating direction implicit (ADI) schemes were also developed (Peaceman and Rachford, 1955; Douglas and Rachford, 1956) and were extended to the

CHAPTER 4 - Results of Model Simulation

The hydrodynamic model was first developed. In order to ensure that the hydrodynamic model can provide reliable information on regarding the physical transport processes to the water quality system, two years of data of regarding the water level and temperature were used in this model. The water quality data obtained from the administration of Feitsui Reservoir were also used to calibrate the model. In addition, the phytoplankton biomass measured in a field survey carried out by Wu (Wu, 2000) was used to verify the ecosystem model.

CHAPTER 5 Summary and Conclusions

5-1 Summary and Conclusions

The main purpose of this study was to build a three
three-dimensional numerical model for which can deal with a highly variable bathymetry reservoir with highly variable bathymetry. An orthogonal and z-coordinate grid was generated as the physical domain. Some GIS tools were also used to automatically create the mesh. Continuity and momentum equations with hydrostatic assumptions, together with the equation of states were applied to solve the hydrodynamic transportation equations. The mass-balance equation of the water quality state variables were then applied to simulate the concentrations of phytoplanktons, organic nitrogen, ammonium nitrogen, nitrite-nitrate nitrogen, organic phosphorus, inorganic (ortho) phosphorus, bio-chemical oxygen demand, and dissolved oxygen.

5-23 Suggestions for Future Research

There are unsolved questions and improvements which can be done carried out in the future in order to gain a more comprehensive insight into toward the water quality and ecological system of the Feitsui Reservoir.

There are two reasons for the existence of the thermocline; one is the increase of air temperature in a period, and the other is the temperature
difference experienced between day and night. Even though, in a matter of fact, the temperature in a day changes with time during the day, but there is only one recorded daily value in the record-field data. In this model, we only consider one input temperature was considered per day for this model. This is only its good enough to simulate the long-term thermocline caused by the increase of air temperature, and it would be but not be sufficient good enough to simulate the temperature difference exhibited between the day and night. The hydrodynamic coefficient would be more reliable if the temperature data were more comprehensive detailed.