Development of the reservoir eutrophication model (REM) for South African reservoirs

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Abstract

The reservoir eutrophication model (REM) is commonly used to simulate the trophic status of South African reservoirs. Uncertainty analysis is usually not included in such modelling. This is unfortunate because a false sense of model accuracy may result. Uncertainty analyses conducted in this study suggest that the conventional REM model is too simple and too inflexible to accurately characterise the behaviour of individual South African reservoirs. A more accurate reservoir specific eutrophication model (RSEM) has therefore been developed. The RSEM model is more complicated in that it takes account of more variables and has to be calibrated individually for each reservoir. But the improvement in model accuracy, for predicting both historical and future data justifies this complication. In the case of Hartbeespoort Dam the newly developed RSEM model has been compared to the conventional REM model using Monte Carlo simulation. This simulation was designed to test the effect of a 20% decline in the inflow of point source phosphorus. The RSEM model predicts that the effect of this management strategy is an average reduction in chlorophyll of 25%. The REM model predicts only an average 7% reduction in chlorophyll.

Introduction

Eutrophication is the enrichment of water bodies with plant nutrients, mainly phosphorus and nitrogen, which leads to excessive growth of aquatic plants to such levels that it interferes with the desirable uses of the water. Over the last ten years, the word "eutrophication" has been used more and more to denote the artificial and undesirable addition of nutrients and the effect this has on a water body. The effect of eutrophication is visible in excessive growth of algae and aquatic plants. Consequences of such increased growths include taste and odour problems in treated drinking water from eutrophied sources, reduced oxygen which is detrimental to fish and impairment of recreational use of the water.

In this paper we develop empirical models in order to estimate eutrophication. These empirical models can be used to simulate the eutrophication levels that can be expected as the result of different water quality management strategies for the control of point source phosphorus. In this paper we consider the effect of a 20% reduction in the inflow of point source phosphorus for Hartbeespoort Dam. The empirical models derived in this study indicate that the effect of this management strategy would be an average reduction in chlorophyll of 25%. This suggests that large-scale point source removal of phosphorus would have a substantial effect on eutrophication at Hartbeespoort Dam.

The reservoir eutrophication model (REM)(Grobler 1985a; 1985b; 1986) was used to assess the future trophic status of South African reservoirs (Grobler, 1988). This model assumes that only phosphorus limits eutrophication and that chlorophyll concentration is a suitable measure for assessing trophic status of a water body. Three submodels are used in the REM model: a phosphorus export model, a phosphorus budget model and a chlorophyll concentration model. The REM model simulates the export of non-point source and point source phosphorus from catchments, the phosphorus mass balance for the reservoir and resulting chlorophyll concentrations in the reservoir. The REM model is illustrated by the schematic in Fig. **1**.

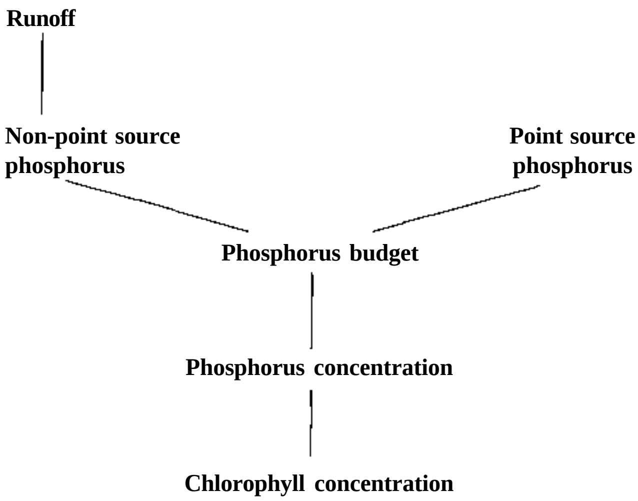

Figure 1
Schematic for the REM Model

This paper describes how each of the three REM submodels was evaluated using South African data. The high degree of uncertainty found to be associated with the REM models for individual reservoirs suggests that the application of the REM procedure may lead to incorrect conclusions regarding the impact of proposed water management strategies for phosphorus control. New models have therefore been developed which address the characteristics of South African reservoirs more closely and hence simulate their behaviour more accurately.

Model evaluation

In this study models are evaluated according to bias, R^2 and error standard deviation. Bias measures the mean prediction error and

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