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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Applying SWAT to predict orthophosphate loads and trophic status in four reservoirs in the upper Olifants catchment, South Africa" *by* J. M. Dabrowski

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Author Response to Reviewer 3:

Study Site Description:

The "Study Area" description has been updated to address comments rasied by the reviewer. In summary:

The reservoirs are regulated, with Loskop providing water to the second largest irrigation scheme in South Africa, while the other reservoirs supply water for domestic and industrial use.

Dryland agriculture is located primarily in the mid to upper reaches of the catchment, consisting mainly of maize production, which is the primary source of nonpoint source pollution, particularly during summer storm events

STWs contribute a volume of approximately 7 % of mean annual runoff to the catchment (DWAF, 2004). (DWAF (Department of Water Affairs and Forestry): National Water Resource Strategy. Pretoria, South Africa, 2004.).

Figure 5:

For all reservoirs, measured OP concentrations were not well simulated by the model from 2008 onwards, with measured concentrations being considerably lower than simulated predictions. No obvious modelling errors could be detected that could account for this difference. The discrepancy could possibly be related to the inability of the model to simulate nutrient cycling associated with the production of algal blooms in the reservoir. For example the first large algal bloom recorded in Loskop Reservoir was in 2007, after which time blooms have re-occurred on an annual basis (Dabrowski et al., 2013). Subsequent monitoring in the reservoir revealed very low concentrations of OP associated with algal blooms – presumably due to uptake of OP to facilitate growth of algae (Dabrowski et al. 2013). The fact that these blooms occurred near the inflow of the reservoir (in the lacustrine zone) and that monitoring takes place at the dam wall could suggest that algal blooms may intercept OP concentrations and deplete levels before they reach the dam wall. None of the other reservoirs were studied in as sufficient detail to determine whether similar processes occur. As all reservoirs showed very similar declines in OP concentrations, analytical error can also not be ruled out (This explanation has been included in the revised version of the manuscript).

Dabrowski, J., Oberholster, P. J., Dabrowski, J. M., Le Brasseur, J., and Gieskes, J.: Chemical characteristics and limnology of Loskop Dam on the Olifants River, in light of recent fish and crocodile mortalities, Water SA, 39, 675-686, 2013.

Figure 8.

This is not a serial correlation. The figures estimate OP concentrations (y) in the reservoirs (dependant variable) as a function of OP loading (x) that occurs upstream in the catchment (independent variable). While concentrations in the reservoirs are dependent on loads, the SWAT model takes many other factors into account (such as the volume of water in the reservoir, settling out of nutrients, etc.).The graphs do not estimate loads into the reservoir as given from OP concentrations in the reservoir. The graphs estimate concentrations in the reservoir given from OP loads generated in the catchment.

The Vollenweider equations/models can be used to determine trophic status based on knowledge of P loading (normalised by surface area), reservoir depth and residence time. Based on these input parameters the P concentrations can also be estimated (Nielsen et al. 2013). Under these specific equations, it would be important to use units as specified by the reviewer (mg/m2/year). The Vollenweider model is a relatively simple approach used to make assessments of P concentrations and trophic status. The Vollenweider models also makes use of benchmark total phosphate concentrations (or guidelines) against which to determine trophic status (e.g. < 10 ug/l = oligotrophic; 10 -20 ug/l = mesotrophic, 20-50 ug/l = eutrophic). While the guideline values we have used here are slightly different (and applicable to ortho-phosphate as opposed to total phosphate), the approach used is essentially the same – this paper simply uses SWAT to estimate OP loading and OP concentrations in the reservoir (which takes a number of other factors into account, such as residence time, reservoir surface area, reservoir volume, nutrient settling etc.) as opposed to using the Vollenweider equations. Considering the study was performed in South Africa, it made sense to use guidelines relevant to South Africa. While this is specific to South Africa, the approach adopted here can be applied throughout the world using appropriate guidelines.

Nielsen, A., Trolle, D., Me, W., Luo, L., Han, B.-P., Liu, Z., Olesen, J.E. and Jeppesen, E.: Assessing ways to combat eutrophication in a Chinese drinking water reservoir using SWAT, Mar. Freshwater Res., 64, 475-492, 2013.

The units referred to by the reviewer are very specific to the Vollenweider equations and there are a number of other studies that report P loading in reservoirs as a function of total mass (as opposed to mass per surface area). Furthermore, one of the main messages of this paper is the reduction in loads that would be required to meet a specific trophic status. In terms of catchment management, it is very useful to quantify the total amount of P loading permissible so as to achieve a particular trophic status. For example in Bronkhosrtspruit reservoir it is evident that OP loads would need to be reduced by 4000 kg annually so as to bring OP concentrations within the mesotrophic range. Expressing loads as a unit of weight is the most useful manner in which to communicate this message and provides managers with meaningful targets by which to reduce OP loads at STWs. If loading was expressed as weight per unit surface area of the reservoir, it would in any event be necessary to calculate a total load (expressed as mass only, based on the reservoir surface area) so as to estimate by how much OP loading would need to be reduced further up in the catchment.

While it would be ideal to have all graphs in the same scale the large differences in OP loading per reservoir would make the graphs for the smaller reservoirs impossible to read. However, to alert readers to the difference in scale additional text has been added to the caption for the revised version: i.e. (note the difference in scale on the x axis)

The guidelines for hyper-eutrophic conditions have not been indicated as the guideline value is 0.25 ug/l. Therefore adding this trophic level would significantly impair the readability and appearance of the figures. However, knowing the threshold level (0.25 ug/l) it would be possible to calculate the predicted loads for a hyper-eutrophic status by using the regression equations for each reservoir.

Seasonal Variation

OP variation in the reservoirs is predominantly as a result of stream flow changes. The model does not simulate nutrient cycling in reservoirs, which has been mentioned in the revised version of the manuscript. See response to Figure 5 above.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 13635, 2013.