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Hydrology and Earth System Sciences Discussions

Interactive comment on "Distributed hydrological modeling of total dissolved phosphorus transport in an agricultural landscape, part II: dissolved phosphorus transport" *by* W. D. Hively et al.

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We thank the anonymous referee for his/her useful comments regarding our paper.

The reviewer makes a particularly good point regarding the potential transport of P through shallow lateral flow in the vadose zone. Certainly, recent research has pointed to preferential flow pathways as significant sources of P. Our hydrologic model (SMDR) does account for horizontal transport through matrix flow (unlikely to transport significant P) and through preferential flow in macropores using a depth dependant multiplier (typical range of 2 to 10) to modify the average hydraulic conductivity of the soil layer (see Gérard-Marchant et al. 2005a - Part I of this paper). However, in practice macropore flow is highly variable, and the data does not exist to accurately validate P transport through macropores.

Although it is true that *"shallow subsurface flow is potentially active throughout the watershed"* while *"variable source overland flow often occurs close to toeslope"*, we would suggest that water transported horizontally through macropores has one of four possible fates: 1) percolation into the subsoil, 2) contact with tile drainage, 3) conversion to surface runoff in the form of seepage and springs, and 4) direct transport into the stream channel. In the case of percolation, this is accounted for by our present model. Tile drainage, however, might well be a confounding factor. During grabsampling of runoff on the study watershed (Hively 2004), we found P concentrations in flow from tile drains to be consistently elevated in comparison to concentrations observed in overland flow from field areas. Additional work that was done on the farm (Scott et al., 1998) observed that approximately 1/3 of total annual P lost from a grazed pasture was transported through tile drains. Accordingly, it might be worth while to attempt to incorporate tile drainage pathways into future versions of our model.

In the case of conversion to surface runoff, which we believe to be the dominant fate of vadose zone macropore flow, this will tend to occur at slope breaks, toe slopes, and areas of converging groundwater flow pathways. In this case, we assume that soil P concentrations and land use at the point of surface runoff production control the concentration of P in runoff, as accounted for in our present model. It is worth while to note, however, that hydrologically active areas such as springs have unique P source area properties, due to the frequency of runoff production. In particular, a simulated rainfall experiment conducted in the study watershed (Hively et al, 2005) demonstrated that P concentrations in runoff from a permanent wet area within an intensively managed area of tilled maize production were lower than expected, and soil test P was 50% lower than soil test values from the surrounding corn field. This data seemed to indicate that P leaching from the spring area, which had received manure and tillage in the springtime, had been significant, leading to low P source potential by summertime. Unfortunately, simulating the spatial distribution of permanent wet areas consisting of springs originating from faults in the bedrock is only possible with prohibitively intensive data collection. Finally, in the case of direct flow from the vadose zone into the stream, this is expected to comprise a small portion of the total flow from the watershed, and it is accounted for by the calibrated baseflow concentration used in our model.

Perhaps a more serious point is the referee's *"suspicion that the model... can hardly be validated"* and that the *"overall agreement between observed and predicted time series of TDP load could only be very site- and data-specific"*. Certainly, there is an element of truth in the latter statement, since each landscape behaves in its own particular way according to the highly variable nature of soil, bedrock, topography, vegetation, and farm management that control hydrologic and P loading processes. Variability and replicability of the hydrological predictions are addressed in the first part of this paper (Gérard et al. 2005a). In translating the hydrology to P transport we have attempted to rely upon relationships derived from physical processes, in order to make the model have the largest range of possible application. The manure-related P loading function is likely highly transferable, and is in fact based upon data from manure extraction studies in Pennsylvania (Gérard-Marchant et al., 2005b). Users must estimate an initial manure P concentration and monitor the amount of rainfall and timing of application. In the case of surface runoff, the initial relationship between soil test P and P concentrations in runoff was, in fact, derived on a site specific basis from simulated rainfall data (Hively et al., 2005). However, this is a necessary evil. Considerable research has demonstrated that the relationship between soil test P and P in runoff is consistent, but only within soil types, and it is recommended that this relationship be established on a local basis (Kleinman et al, 2000; Sharpley et al., 2002, 2003). Such, unfortunately, appears to be the nature of soil P loading processes, due to the inherent effects of particle size distribution and iron/aluminum content upon soil charge and P sorption capacity. That said, the coefficients derived in our model are likely applicable to soils throughout the Catskill landscape that comprises the New York City watersheds. Regarding validation, the first difficulty is that if hydrology is not accurately simulated, P loading, which is directly dependent on hydrologic estimates, will be inaccurate. Therefore, our measures of fit were significantly better for days when hydrology was simulated within

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20% of measured flow. That aside, the observed dataset is one of the most complete available in the nation, and provides an excellent daily estimate of actual P loads. Although it is certainly difficult to aggregate landscape source factors for comparison with loads measured at a single outlet, this is a difficulty faced in common by all models. Our main strength in this case is that the estimated concentrations were carefully derived from a wide variety of on site measurements (Hively, 2004), and the validation data is therefore as good as any.

References

[1] Gérard-Marchant P., W.D. Hively and T.S. Steenhuis. 2005a. Distributed hydrological modelling of total dissolved phosphorus transport in an agricultural landscape, part I: distributed runoff generation. Hess

[2] Gérard-Marchant, P., M.T. Walter and T.S Steenhuis, 2005b. Two simple models for phosphorus loss from manure in runoff. J. Environ. Qual. 34: 872-876

[3] Hively, W.D. 2004. Phosphorus Loading from a Monitored Dairy Farm Landscape. Ph.D. Dissertation. Cornell University, Ithaca, NY.

[4] Kleinman, P.J.A, R.B. Bryant, W.S. Reid, A.N. Shaprley, and D. Pimentel, 2000. Using soil phosphorus behavior to identify environmental thresholds, Soil Sci., 165(12):943-950.

[5] Scott, C.A., L.D. Goehring, and M.F. Walter. 1998. Water quality impacts of tile drains in shallow, sloping, structured soils as affected by manure application. Applied Engineering in Agriculture. 14(6):599-603.

[6] Sharpley, A.N., P.J.A. Kleinman, R.W. McDowell, M. Gitau, and R.B. Bryant, 2002. Modeling phosphorus transport in agricultural watersheds: Processes and possibilities, J. Soil and Water Conservation, 57(6):425-439

[7] Sharpley, A.N., and P.J.A. Kleinman. 2003. Effect of rainfall simulator and plot scale on overland flow and phosphorus transport. Journal of Environmental Quality 32(6):

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 1581, 2005.