05/06/2011

Publication List Related to Total Maximum Daily Loads (TMDLs)

Publications and abstracts are listed in reverse chronological order. A limited number of reprints are available, and can be requested by referring to the NAEW number. Use your browser's "find" feature to search for words of interest. For more information, please contact:

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Shipitalo, M.J., J.V. Bonta, E.A. Dayton, and L.B. Owens. 2010. Impact of grassed waterways and compost filter socks on the quality of surface runoff from corn fields. Journal of Environmental Quality. 39(3):1009-1018. **(NAEW#465)**

Abstract:
Surface runoff from cropland frequently has high concentrations of nutrients and herbicides, particularly in the first few events after application. Grassed waterways can control erosion while transmitting this runoff offsite, but are generally ineffective in removing dissolved agrochemicals. In this study, we routed runoff from one tilled (0.7 ha) and one no-till watershed (0.8 ha) planted to corn into parallel, 30-m long, grassed waterways. Two, 46-cm dia., filter socks filled with composted bark and wood chips were placed 7.5 m apart in the upper half of one waterway and in the lower half of the other waterway to determine if they increased removal of sediment and dissolved chemicals. Automated samplers were used to obtain samples above and below the treated segments of the waterways for two crop years. The filter socks had no significant effect (P = 0.05) on sediment concentrations for runoff from the no-till watershed, but contributed to an additional 49% reduction in average sediment concentration compared to unamended waterways used with the tilled watershed. The filter socks significantly increased the concentrations of Cl, NO3-N, PO4-P, SO4, Ca, K, Na, and Mg in runoff from at least one watershed, however, probably due to soluble forms of these ions in the compost. The estimated additional amounts contributed by the socks each year ranged from 0.04 to 1.25 kg, thus were likely to be inconsequential. The filter socks contributed to a significant additional reduction in glyphosate (5%) and alachlor (18%) concentrations for the tilled watersheds, but this was insufficient to reduce alachlor concentrations to acceptable levels.

Shipitalo, M.J., Bonta, J.V. 2008. Impact of using paper mill sludge for surface-mine reclamation on runoff water quality and plant growth. Journal of Environmental Quality. 37(6):2351-2359. **(NAEW #458)**

Abstract:

Paper mills generate large amounts of solid waste consisting of a mixture of fibrous cellulose, clay, and lime. Paper mill sludge (PMS) can be used to improve reclamation of surface coal mines where low pH and organic matter levels in the soil material used to cover the spoil can inhibit reestablished of vegetation. When applied at high rates for this purpose, however, PMS may adversely impact the quality of surface runoff. Therefore, we applied PMS at two rates (224 and 672 Mg/ha) to 22.1 m long by 4.6 m wide plots (RCBD with 3 reps, plus 3 no PMS controls) at an active surface mine and monitored runoff amount and quality from April 2006 to Dec. 2006 and April 2007 to Sept. 2007. Control plots were mulched with hay and fertilized at planting, but the other plots were only amended with PMS. At both rates PMS reduced runoff 4- to 6-fold and decreased erosion from 46 Mg/ha to < 1 Mg/ha compared to the control plots, with most of the reduction occurring in the 2.5 months before the plots were planted. Flow-weighted average dissolved oxygen levels in runoff from plots at both PMS rates, however, were much lower (< 0.4 vs. 8.2 mg/L) and chemical oxygen demand (COD) was much higher for the 672 Mg/ha rate plots than in the control plots in the pre-plant period (7229 vs. 880 mg/L). Post planting there were few significant differences in water quality among treatments, but plant dry matter yields were greater for the PMS plots than for the controls. The 672 Mg/ha PMS rate did not increase COD or nutrient loads compared to the 224 Mg/ha rate and may have more persistent beneficial effects by increasing soil organic matter and pH to greater extent.

Eckstein, Y., Lewis, V.E., Bonta, J.V. 2007. Chemical Evolution of Acid Precipitation in Unsaturated Zone of the Pennsylvania Siltstones and Shales of Central Ohio. Hydrogeology Journal. 15(8):1489-1505. **(NAEW #455)**

Abstract:

The North Appalachian Experimental Watershed in Coshocton, Ohio has recorded over a 30-yr period average pH of precipitation of 4.7. The area lies within the Pennsylvanian siltstones and shale dominated by aluminosilicates and <5% calcite. A study was conducted to determine the evolution of acid deposition through an unsaturated to saturated zones composed of siltstone and shale in an isolated hill, precluding lateral flow and seepage. The results from water-rock chemical reactions modeled using PHREEQM demonstrate the percolating precipitation water is neutralized to pH 7.5 within the top 1.5 m. The model suggests that along with calcite, dissolution of albite, illite, and kaolinite are the dominant mechanisms of neutralization. The cation exchange capacity of the siltstone and shale, ranging 54.6 - 386 meq/100g, appears to be a function of high organic carbon content of 2.0 - 3.2%. While cation exchange is responsible for some of the Na+ in solution, it is not the primary source of Ca2+, Mg2+, or K+ ions. Exchange onto clays is occurring, but is secondary to exchange on organic

matter. Chemical composition of groundwater perched within a coal seam is controlled by oxidation and dissolution of pyrite, returning pH to approximately 4.0.

Morrison, M.A., Bonta, J.V. 2008. Development of Duration-Curve Based Methods for Quantifying Variability and Change in Watershed Hydrology and Water Quality [abstract]. Environmental Protection Agency. **(NAEW #452)***Only Available Online* http://www.epa.gov/nrmrl/pubs/600r08065/600r08065.pdf.

Abstract:

Little is known about effectiveness of land activities to control water quality. The objective was to explore the duration curve (DC) concept for comparing hydrology and water quality data from watersheds. DCs are plots of the percent of time that a given value of a variable (e.g., flow rate) is exceeded. DCs include the flow duration curve (FDC), concentration DCs, and load-rate DCs. DCs take into account natural variability and uncertainty in streamflow watershed response to land activities and precipitation events. Minimum number of samples, averaged streamflow data, and seasonal variation of concentrations were examined. It was found the smallest number of samples needed for relationships between streamflow (Q) and SO4 concentrations (C) ("C-Q relations") was 25-35. Little is gained with sample numbers larger than about 150-400 samples from the C-Q relations. However, differences between DCs developed from the C-Q data and flow DCs for different sample sizes suggest that 30-100 samples are adequate. Based on the combined approaches, 50 samples is the suggested minimum number of samples for this study. There is little benefit from using more than about 2% of the 2500 samples collected, a savings in money. An investigation of the use of readily available average daily flow data suggests that midrange and small instantaneous flow rates may be represented by average daily flows which are more readily available data, but errors are more pronounced at larger or smaller flows. An investigation of seasonal variation in NO3-N concentrations and loads showed C-Q equation form changed from a 2-part relation to a linear relation to no relation. An illustration was given on how the DC methodology can be used to quantify the decrease in load rates and the reduction in the percent of time a given load is exceeded (or reduced risk) due to a land-management change. This research project is a collaborative effort between the USEPA and ARS-Coshocton, funded by the USEPA. The research will benefit states and other stakeholders faced with assessing the performance and effectiveness of BMPs within a watershed management framework.

Vadas, P.A., L.B. Owens, and A.N. Sharpley. 2008. An empirical model for dissolved phosphorus in runoff from surface-applied fertilizers. Agriculture, Ecosystems and Environment 127 (1-2):59-65. **(NAEW #449)**

Abstract:

Dissolved phosphorus (P) in runoff from surface-applied fertilizers can be relatively great, but commonly used field or watershed-scale computer models often do not simulate direct transfer of fertilizer P to runoff. Using data from our own simulated

rainfall experiments and published runoff studies, we developed a simple model to predict fertilizer P release during rain and the concentration of dissolved P in runoff. The model operates on a daily time step and requires input data on the amount of fertilizer P applied, type of soil cover (bare, residue-covered, grassed) at application, and amount of rain and runoff for each storm during the simulated time period. The model applies fertilizer to the soil surface, adsorbs fertilizer P to soil before the first rain, releases P from fertilizer for each rain event, and distributes released fertilizer P between runoff and infiltration based on the runoff-to-rain ratio. Using data from seven runoff studies, we validated that our model accurately predicts dissolved P in runoff from surface-applied fertilizers. Validation data represented a series of runoff events for a variety of fertilizer types, soil conditions and subsequent fertilizer P adsorption amounts, storm hydrology conditions (i.e., runoff-to-rain ratio), and plot or field sizes (3 m2 to 9.6 ha). An analysis showed model predictions can be quite sensitive to rainfall and runoff data. However, the simplicity of our model should make it straightforward to incorporate into more complex P transport models, thus improving their ability to reliably predict P loss to the environment for a variety of agricultural land uses.

Bonta, J.V. and D. Wauchope. 2005. Agricultural BMPs and modeling for sediment. In: Schubauer-Berigan, J.P., Minamyer, S., Hartzell, E., editors. Proceedings of A Workshop on Suspended Sediments and Solids, July 11-12, 2002, USEPA, Cincinnati, OH. P. C-34-C-39. **(NAEW #436)**

Abstract:

Sustaining agricultural production for high commodity yields and quality has been a major goal of the agricultural community. One component of agricultural sustainability is the control of erosion and sediment transport on agricultural fields. Erosion degrades the soil resource and can affect nutrient and pesticide application rates, and transport through the soil profile and in direct runoff. This paper summarizes 17 broad classes of erosion control on agricultural lands, highlighting the positive and negative aspects of each. Newer erosion-control practices that have been investigated by the ARS are also briefly described. These include use of gypsum and polyacrylamide (PAM) as soil amendments, stiff grasses, and on-site erosion control using imprints. Gypsum and PAM enhance infiltration and stabilize the soil surface. Stiff grasses cause deposition of sediment upslope from a grass strip, but allow the water to flow through them. Imprinting controls sediment movement on a slope, while vegetation is established. Thirteen computer models developed by ARS are listed that can be used to simulate erosion and/or sediment yield from watersheds, along with three models for simulating weather for input to these models. The summary will be useful for land managers and regulatory agencies.

Owens, L.B. and M.J. Shipitalo. 2006. Surface and subsurface phosphorus losses from fertilized pasture systems in Ohio. Journal of Environmental Quality 35:1101-1109. (Available in PDF file.) **(NAEW #430)**

Abstract:

Phosphorus is an essential plant nutrient and critical to agricultural production, but it is also a problem when excessive amounts enter surface waters. Summer rotational grazing and winter feed beef pasture systems at two fertility levels (56 and 28 kg available P/ha) were studied to evaluate the P losses from these systems via surface runoff and subsurface flow using eight small (0.3 to 1.1 ha), instrumented watersheds and spring developments. Runoff events from a 14-yr period (1974-1988) were evaluated to determine the relationships between event size in mm, total-P (Tot-P) concentration, and Tot-P transport. Most of the P transported was via surface runoff. There were strong correlations (r2 0.45 to 0.66) between Tot-P transport and event size for all watersheds, but no significant (P= 0.05) correlations between Tot-P concentration and event size. Flow-weighted average Tot-P concentrations from the pasture watersheds for the 14-year period ranged from 0.64 to 1.85 mg L-1 with a few individual event concentrations as high as 85.7 mg L-1. The highest concentrations were in events that occurred soon after P fertilizer application. Average seasonal flow-weighted Tot-P concentrations for subsurface flow were <0.05 mg L-1. Applying P fertilizer to pastures in response to soil tests should keep Tot-P concentrations in subsurface flow at environmentally acceptable levels. Management to reduce runoff and avoidance of P fertilizer application when runoff producing rainfall is anticipated in the next few days will help reduce the surface losses of P.

Hauser, V.L., D.M. Gimon, J.V. Bonta, T.A. Howell, R.W. Malone, and J.R. Williams. 2005. Models for hydrologic design of evapotranspiration landfill covers. Environmental Science & Technology 39(18):7226-7233. **(NAEW #421)**

Abstract:

The technology used in landfill covers is changing, and an alternative cover called the evapotranspiration (ET) landfill cover is coming into use. Important design requirements are prescribed by federal rules and regulations for conventional landfill covers but not for ET landfill covers. There is no accepted hydrologic model for ET landfill cover design. This paper describes ET cover requirements, design issues, and assesses the accuracy of the EPIC and HELP hydrologic models when used for hydrologic design of ET covers. We tested the models against high quality field measurements available from lysimeters maintained by the Agricultural Research Service of the U.S. Department of Agriculture at Coshocton, Ohio and Bushland, Texas. The HELP model produced substantial errors in estimates of hydrologic variables. The EPIC model estimated ET and deep percolation with errors less than 7 percent and 5 percent, respectively, and accurately matched extreme events with an error of less than two percent of precipitation. The EPIC model is suitable for use in hydrologic design of ET landfill covers.

Bonta, J.V. and B. Cleland. 2003. Incorporating natural variability, uncertainty, and risk into water quality evaluations using duration curves. J. of the American Water Resources Association 39(6):1481-1496. **(NAEW #390)**

Abstract:

Quantifying natural variability, uncertainty, and risk with minimal data is one of the greatest challenges facing those engaged in water-quality evaluations, such as development of total maximum daily loads (TMDL), because of regulatory, natural, and analytical constraints. Quantification of uncertainty and variability in natural systems is illustrated using DCs. Duration curves (DCs) are plots that illustrate the percent of time that a particular flow rate (FDC), concentration (CDC), or load rate (LDC; "TMDL") is exceeded, and are constructed by using simple derived distributions. DCs require different construction methods and interpretations, depending on whether there is a statistically significant correlation between concentration (C) and flow (Q), and on the sign of the C-Q regression slope (positive or negative). FDCs computed from annual runoff data vary compared with a FDC developed by using all data. Percent exceedance for DCs can correspond to risk; however, DCs are not composed of independent quantities. Confidence intervals of data about a regression line can be used to develop confidence limits for the CDC and LDC. An alternate expression to a fixed TMDL is suggested as the risk of a load rate being exceeded and lying between confidence limits. Averages over partial ranges of DCs are also suggested as an alternative expression of TMDLs. DCs can be used to quantify watershed response in terms of changes in exceedances, concentrations, and load rates after implementation of best-management practices.

Bonta, J.V. 2002. Framework for estimating TMDLs with minimal data. Proceedings of the ASAE Conference on Watershed Management to Meet Emerging TMDL Environmental Regulations, Fort Worth, Texas. March 11-13, 2002. pp. 6-12. **(NAEW #372)**

Abstract:

Current regulations specify the derivation of total maximum daily loads (TMDLs) for surface waters. Yet these standards are often derived from incomplete information. In some cases these quantities are assigned to watersheds for which there are little data, and are established in terms of loads when only concentration data are available. Furthermore, they are often assigned under conservative conditions with no estimation of risk and uncertainty of the estimate. Flow-duration curves and regressions between flow rate and constituent concentration have historically been used to compute average total loads to determine water-quality trends. However, intermediate calculations in this methodology, not often used, have utility for TMDL estimation. From these intermediate calculations, one can determine the percent of time that a concentration and load (TMDL) will be exceeded, the duration of concentrations/loads, etc. The method can be used by itself or as a supplement to more complex watershed modeling. It is useful for determining the range of concentrations expected from a watershed, for characterizing actual in-stream conditions, and for tracking actual in-stream conditions after implementation of best-management practices. The method is simple to use, and is promising for areas where there are no flow data, and for which there are only a few samples. The concepts of the method are presented, along with those for using this method when data are scanty and for determining uncertainty in the TMDL estimates.