Urban BMPs Can Protect Water Quality: Non-Pesticides as Models for Pesticides

Cohen, S.Z., and Q. Ma. August 19, 2009
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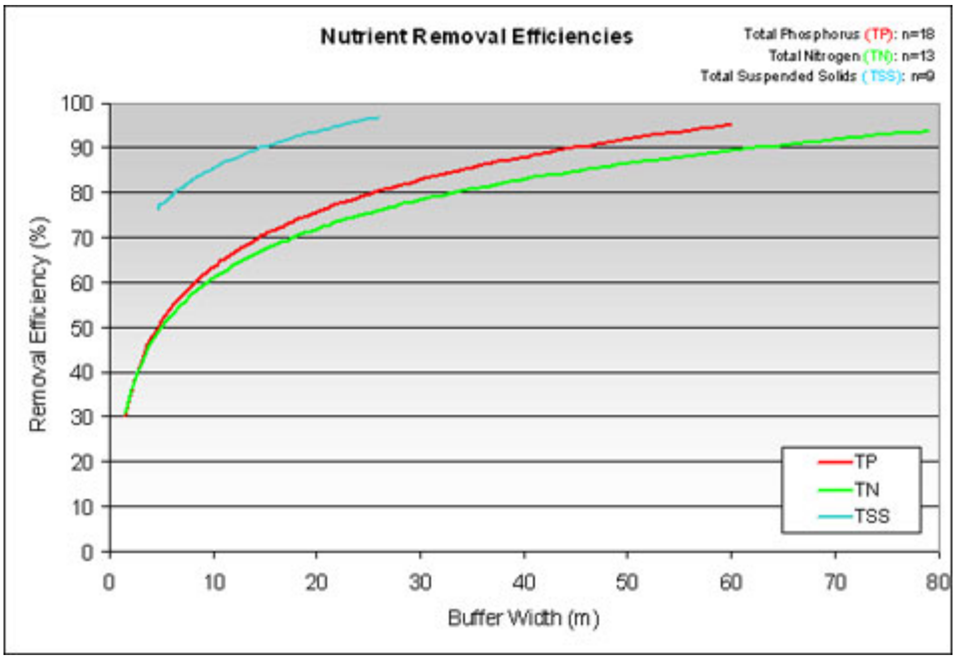
Abstract

Residential/urban developments are typically designed and built with BMP features. Examples are detention basins, sand filters, wetlands, porous pavers, infiltration basins, and wet ponds. This practice has been standard operating procedure in most counties in the US for several decades. One objective of these BMPs is the control of peak storm flow to control erosion. Of greater interest for this symposium is the other key objective, the protection of water quality. Civil engineers and urban planners are familiar with this standard of care for urban environments, but pesticide scientists and regulators are generally not. Many studies have been done on contaminant attenuation by urban BMPs. For example, the International Stormwater BMP Database contains data from over 300 studies. Most analytes in BMP studies are not pesticides, e.g., TSS, nitrate, lead, and P. However, this extensive amount of data could be used to guide risk assessment and risk reduction discussions and investigations for urban pesticides.

Buffer Widths and Nutrient and Sediment Removal Efficiencies (2008)

Baris, R.D., Q. Ma, S.Z. Cohen. 2008.
Buffer Widths and Nutrient and Sediment Removal Efficiencies. Presentation at the American Water Resources Association, 2008 Summer Specialty Conference: Riparian Ecosystems and Buffers: Working at the Water's Edge, Virginia Beach, VA.



Abstract: Vegetative buffers, as one type of Best Management Practices (BMPs), can serve many roles – preventing drift of turf chemicals, providing riparian habitats, and reducing contaminant loading from stormwater runoff via natural filtration. Most jurisdictions have either explicit or de facto regulations or guidelines for stream and wetland buffers. This paper provides an analysis of contaminant removal efficiency of vegetative buffers and critical buffer widths. Key parameters of concern are total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). All three parameters can have significant impacts on wetland and freshwater systems. The literature was reviewed to determine the relationship between buffer width and pollutant removal efficiency. In addition, the relationship between buffer width and the onset of concentrated flow was examined. Plots of contaminant removal efficiency (RE) vs. buffer width (B) followed logarithmic relationships, i.e., RE(%)=a(lnRE)+b, R2 = 0.63, 0.57, and 0.42 for the TP, TN, and TSS relationships, respectively. (All relationships were significant at $p = 0.01$, except for TSS ($p=0.058$).) This indicates buffer width is a key factor but not the only factor. The second derivative of these plots can be used to estimate the 'point of diminishing returns', i.e., the approximate B at which a large increase in B results in only a relatively small increase in RE. These numbers were 18 m, 20 m, and 15 m, for TP, TN, and TSS, respectively. We suggest that these distances are governed by the transition from overland/sheet flow to concentrated/channelized flow. Calculations are done to demonstrate that the distances to reach

concentrated flow in very short grass are 10.7 m, 15 m, and 21.6 m for slopes of 0.005, 0.01, and 0.02, respectively. Another key consideration for this type of analysis would be the extent to which stormwater runoff is treated with other BMPs prior to entering the vegetative filter strips.

Pesticide and Nutrient Modeling (2008)

Cohen, S.Z., Q. Ma, N.L. Barnes, and S. Jackson. 2008.
Chapter 8: Pesticide and Nutrient Modeling, In: Water Quality and Quantity Issues for Turfgrasses in Urban Landscapes, A Proceedings of CAST series, Special Publication No. 26, Council for Agricultural Science and Technology (CAST), Ames, IA.

Introduction
The main purposes of this paper are to summarize briefly the key practices and research regarding the techniques and applications of mathematical models that can predict the offsite transport of turfgrass chemicals to water resources and to offer suggestions for improvement. These models are important tools for risk assessment and risk management of turfgrass chemicals, but their use also has strong potential to produce results that deviate significantly from reality. To put the subject area in context, the first discussion indicates the significant extent to which turfgrass is managed with chemicals in the United States. After that, a definition of mathematical models in the current context provides a basis for the rest of the paper. Examples of the implications of using inappropriate input parameters are given.

Quantitative Analysis of Over 20 Years of Golf Course Monitoring Studies (2010)

Baris, R.D., S.Z. Cohen*, N.L. Barnes, J. Lam and Q. Ma
Environ. Tox. and Chem., 29(6):1224–1236.

Abstract: The purpose of the present study was to comprehensively evaluate available golf course water quality data and assess the extent of impacts, as determined by comparisons with toxicologic and ecologic reference points. Most water quality monitoring studies for pesticides have focused on agriculture and often the legacy chemicals. There has been increased focus on turf pesticides since the early 1990s, due to the intense public scrutiny proposed golf courses receive during the local permitting process, as well as pesticide registration evaluations by the U.S. Environmental Protection Agency under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Results from permit-driven studies are frequently not published and knowledge about them is usually not widespread. Forty-four studies involving 80 courses from a 20-year period passed our quality control and other review criteria. A total of 38,827 data entries (where one analysis for one substance in one sample equals a data entry) from pesticide, pesticide metabolite, total phosphorus, and nitrate analyses of surface water and groundwater were evaluated. Analytes included 161 turf-related pesticides and pesticide metabolites. Widespread and/or repeated water quality impacts by golf courses had not occurred at the sites studied, although concerns are raised herein about phosphorus. Individual pesticide database entries that exceed toxicity reference points for groundwater and surface water are 0.15 and 0.56%, respectively. These percentages would be higher if they could be expressed in terms of samples collected rather than chemicals analyzed. The maximum contaminant level ([MCL]; 10 mg/L) for nitrate-nitrogen was exceeded in 16/1,683 (0.95%) of the groundwater samples. There were 1,236 exceedances of the total phosphorus ecoregional criteria in five ecoregions for 1,429 (86.5%) data entries. (This comparison is conservative because many of the results in the database are derived from storm flow events.) Thus, phosphorus appears to present the greatest water quality problem in these studies. Pesticides detected in wells had longer soil metabolism half-lives (49 d) compared with those not detected (22 d), although the means were not significantly different.

Environmental Chemistry in an Environmental Risk Assessment Context: Case Studies of Dibromochloropropane, Pentachloronitrobenzene, and Organoarsenical Pesticides (2007)

Cohen, S.Z. October 23, 2007.
Environmental Chemistry in an Environmental Risk Assessment Context: Case Studies of Dibromochloropropane, Pentachloronitrobenzene, and Organoarsenical Pesticides. Presentation before the Department of Chemistry & Biochemistry, University of Maryland, Baltimore County.

Abstract: Environmental risk assessment of organic chemicals requires a consideration of toxicity and exposure. The mechanism of toxicity can help focus the exposure assessment on particular sensitive receptors (e.g., trout, humans) and potential exposure pathways (e.g., runoff to cold water streams, leaching to aquifers that supply water to wells). A characterization of exposure requires an understanding of chemical mobility and persistence. The latter requires an understanding of multiple potential pathways for chemical degradation as well as metabolism to potentially toxic degradates. 1,2-Dibromo-3-chloropropane (DBCP) was a mobile and persistent chemical that is still present in drinking water aquifers years after last use. The molecular structure of pentachloronitrobenzene (PCNB) might lead one to initially believe that it bioaccumulates and it is extremely persistent, but lab and field data indicate otherwise. Organoarsenical (R-As) herbicides contain arsenic, but they have low acute toxicity and they are not carcinogenic. However, the regulatory risk assessment focus on the potential for conversion to toxic inorganic arsenic has introduced many complications to the exposure assessment of R-As.

Prediction of Pesticide Toxicity to Amphibians: Testing a Preliminary Screening Equation and EPA's 'ICE' Equations with New Data (2006)

Lam, J. and S.Z. Cohen. November, 2006.
Poster presented at SETAC (Society of Environmental Toxicology and Chemistry) North America 27th Annual Meeting, Montreal, Quebec, Canada.

There is a general consensus that amphibian populations are declining globally, and concern of an increase in the rates of malformations. Many possible causes have been suggested for these declines including: changes in predation and/or habitat, endoparasite infestation and disease (chytridiomycosis), ultraviolet radiation, mineral depletion, and natural or man-made chemicals, including pesticides. Extensive pre-registration testing of pesticides for environmental risks does not include amphibians, but does usually include cold water fish species. To help satisfy this data gap for ecological risk assessments, we previously proposed a two-step, simple equation to predict amphibian toxicity from more readily available rainbow trout data (Reid, et al., 2000). The equation uses acute toxicity data to predict MACs that would protect amphibians from acute, delayed toxic, and chronic effects. It involves a regression equation that uses rainbow trout LC50 data to predict western chorus frog LC50, and from that an MAC is derived for amphibians by multiplying the latter value by 0.03. At the time, minimal data were available to test the equation. Earlier work indicated that trout and amphibians both appear to have a mixed-function oxidase detoxification system less active than in mammals. We now use more recent data to evaluate the extent to which the equation predicts an MAC that is protective of amphibians for toxic effects. We are currently evaluating 58 combinations of pesticides, species, and toxic endpoints. This includes 12 pesticides, 10 species, and 15 endpoints. To date, the equation has only lacked adequate conservatism for the only two organometallic pesticides in the data set (mancozeb and triphenyltin) plus the herbicide endosulfan. The use context of this equation has been amphibian risk assessment at the watershed scale for proposed golf course and housing developments. It may be useful for future national pesticide regulatory risk assessments.

The Pesticide Module of The Root Zone Water Quality Modeling (RZWQM): Testing and Sensitivity Analysis of Selected Algorithms for Pesticide Fate and Surface Runoff (2004)

Ma, Q., R.D. Wauchope, K.W. Rojas, L.R. Ahuja, L. Ma and R.W. Malone. 2004. The Pesticide Module of the Root Zone Water Quality Model (RZWQM): Testing and Sensitivity Analysis of Selected Algorithms for Pesticide Fate and Surface Runoff. *Pest Mgmt. Sci.* 60:240-252.

Abstract: The Root Zone Water Quality Model (RZWQM) is a one-dimensional, numerical model for simulating water movement and chemical transport under a variety of management and weather scenarios at the field scale. The pesticide module of RZWQM includes detailed algorithms that describe the complex interactions between pesticides and the environment. We have simulated a range of situations with RZWQM, including foliar interception and washoff of a multiply applied insecticide (chlorpyrifos) to growing corn, and herbicides (alachlor, atrazine, flumetsulam) with pH-dependent soil sorption, to examine whether the model appears to generate reasonable results. The model was also tested using chlorpyrifos and flumetsulam for the sensitivity of its predictions of chemical fate and water and pesticide runoff to various input parameters. The model appears to generate reasonable representations of the fate and partitioning of surface- and foliar-applied chemicals, and the sorption of weakly acidic or basic pesticides, processes that are becoming increasingly important for describing adequately the environmental behavior of newer pesticides. However, the kinetic sorption algorithms for charged pesticides appear to be faulty. Of the 29 parameters and variables analyzed, chlorpyrifos half-life, the Freundlich adsorption exponent, the fraction of kinetic sorption sites, air temperature, soil bulk density, soil-water content at 33 kPa suction head, and rainfall were most sensitive for predictions of chlorpyrifos residues in soil. The latter three inputs and the saturated hydraulic conductivity of the soil and surface crusts were most sensitive for predictions of surface water runoff and water-phase loss of chlorpyrifos. In addition, predictions of flumetsulam (a weak acid) runoff and dynamics in soil were sensitive to the Freundlich equilibrium adsorption constant, soil pH and its dissociation coefficient.

The Special Case of Pesticides: Science and Regulation (2004)

Stuart Z. Cohen, Ph.D., CGWP
Environmental Claims Journal, 16(1/Winter):55-68 (2004)

Abstract: Pesticide regulation is a data-intensive activity that is strongly controlled at the federal level. The pesticide law FIFRA controls pesticide sale, use, and disposal. Normal use of pecticides is excluded under RCRA and CERCLA. There are approximately 1,000 pesticide active ingredients with highly diverse functions ranging from insecticides to disinfectants and pheromones (insect sex attractants). There is a relatively large database on many pesticides, which helps reduce uncertainty in risk assessments. Witnesses subject to Daubert should be familiar with the data as well as the computer models designed for pesticides. "Inert" ingredients that are formulated with the pesticide active ingredients can become issues in torts cases. Federal courts have ruled both in favor and against FIFRA preemption, i.e., the ability of a plaintiff to seek relief in a torts case may be blocked by FIFRA. Golf course permitting provides a special land use whereby fundamental pesticide risk and regulatory issues are debated at the level of local planning and zoning commissions.

Risk Assessments for Golf Course Pesticides: 1. Special Considerations for Modeling (2002)

Stuart Z. Cohen, Ph.D., CGWP
Poster presented at 10th IUPAC International Congress on the Chemistry of Crop Protection, Basel, Switzerland. (2002)

Abstract: There are approximately 17,100 golf courses in the USA (NGF, 2002), and 5,900 courses in Europe (EGA, 2002). The closely mown, heavily traveled turf makes it susceptible to insect, weed, and disease pests that can require intensive chemical management. Golf courses are also often located close to wetlands, surface water features, and/or over shallow ground water, raising environmental risk concerns during the land use approval process. The results of computer simulation modeling can be used to aid pesticide registration decisions and approval decisions on specific sites/watersheds, as well as inspire the design of risk mitigation measures (Best Management Practices). Standard risk assessment/modeling methods focus on row crop agriculture, but the turf system is unique and requires special considerations. Golf courses consist of natural areas, roughs, fairways, tees, and greens, in order from less intensive to more intensive management. Thus a typical U.S. golf course site is approximately 56 ha, but the percent turfgrass area (PTA) for greens, tees, and fairways is typically only 31% and 3.4%, as a function of the whole golf course and the watershed, respectively. More fungicides are applied more often to greens than other areas, but more herbicides are applied to fairways. Turf is a unique system in that it contains a dense canopy (verdure), a dense bioactive root system, and a surficial organic mat called thatch. The thickness of thatch typically varies between 0.3 cm and 2.0 cm, depending on the area of the course and its age. Its organic carbon content is very high (20%-40%), which slows pesticide migration, but its pesticide sorption capability is not as efficient as soil organic matter due to the aging and higher surface area to volume ratio of the latter. The key hydrologic parameters field capacity, wilting point, and bulk density are also different for thatch than most other cropping systems. Dissipation half lives in turf are usually shorter than in bare ground studies. Greens and tees are generally well drained, which influences the runoff curve numbers chosen for these turf surfaces. Fairways are usually not built on runoff-prone soils. A two-tier modeling system is suggested, using rules-of-thumb, the runoff curve number method, TurfPQ, PRZM, and SWAT.

Risk Assessments for Golf Course Pesticides: 2. New Methodologies to Estimate Amphibian Toxicity to Turfgrass Chemicals (2002)

Reid, S., S.Z. Cohen, J. Julian, S. Julian, J. Ferrigan, and J. Howard
Poster presented at 10th IUPAC International Congress on the Chemistry of Crop Protection, Basel, Switzerland. (2002)

Abstract: Recently there has been concern raised over the decline of amphibian populations around the world and the increased rate of amphibian deformities. Over the past several years there has been increased research on the cause of these declines and deformities. Pesticides and nitrogen fertilizers have been identified as possible causes, among others. Golf courses, which regularly receive pesticide and fertilizer applications, can be home to a variety of wildlife including amphibians. Golf courses typically make suitable sites for amphibian habitats because of their vast open tracts of land, many water sources, and wooded areas. Amphibian toxicology studies are generally not required by regulatory agencies. Therefore, we developed a three-step methodology to calculate maximum allowable concentrations (MACs) for a variety of pesticides commonly used on golf courses for an amphibian risk assessment. We have also recently developed nitrate-N criteria for two frog species. First, western chorus frog (Pseudacris triseriata) toxicities were estimated based on readily available rainbow trout toxicity data (frequently required as part of pesticide registration). Second, interspecies sensitivities were compared using new toxicity data from Howard (2001) and Julian et al. (2001) to determine if the estimated western chorus frog toxicity could be compared side-by-side with other species of amphibians. Finally, chronic MACs were derived that were protective of all relevant amphibian species, but with a focus on the spotted salamander (Ambystoma maculatum). This was done by analyzing the Howard (2001) and Julian et al. (2001) data for sub-chronic and chronic effects to calculate a conservative factor that was multiplied by the estimated western chorus frog toxicity. A more straightforward approach was used to calculate nitrate MACs for frog species in California and Utah, USA. To our knowledge, this is the first time aquatic amphibian criteria have been calculated for turf pesticides and fertilizers.

GLEAMS, OPUS, PRZM2 and PRZM3 Simulations of Atrazine Runoff Compared to Field Observations from a Loamy Sand Soil under High-Intensity Rainfall Conditions (2000)

Ma, Q.L., R.D. Wauchope, J.E. Hook, A.W. Johnson, C.C. Truman, C.C. Dowler, G.J. Gascho, J.G. Davis, H.R. Sumner, and L.C. Chandler.
Soil Sci. Soc. Am. J. 2000, 64:2070-2079.

Abstract: High-intensity storms that occur shortly after chemical applications have the greatest potential to cause chemical runoff. We estimated how effectively current transport models GLEAMS, OPUS, PRZM2, and PRZM3 could predict water runoff and runoff losses of atrazine [6-chloro-N-ethyl-N-(1-methylethyl)-1,3,5-triazine-2,4-diamine] under such conditions, as compared with observations from a controlled field runoff experiment. The experiment was conducted for 2 yr using simulated rainfall on two 14.6- by 42.7 m plots within a corn (Zea mays L.) field on Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) under conventional tillage practices. For each plot-year, atrazine was applied as surface spray immediately after planting and followed by a 50-mm, 2-h simulated rainfall 24 h later. A similar pre-application rainfall and four subsequent rainfalls during the growing season were also applied. Observed water runoff averaged 20% of the applied rainfall. Less runoff occurred from freshly tilled soil or under full canopy cover; more runoff occurred when nearly bare soil had crusted. Observed total seasonal atrazine runoff averaged 2.7% of that applied, with the first posttreatment event runoff averaging 89% of the total. GLEAMS, OPUS, PRZM2, and PRZM3 adequately predicted water runoff amounts, with normalized root mean square errors of 29, 29, 31, and 31%, respectively. GLEAMS and PRZM3 predicted atrazine concentrations in runoff within a factor of two of the observed concentrations. OPUS adequately predicted atrazine concentrations in runoff when it was run with an equilibrium adsorption submodel, but significantly underestimated atrazine concentrations when it was run with a kinetic sorption submodel.

Water Quality Impacts by Golf Courses (1999)

Cohen, S.Z., A. Svrjcek, T. Durborow, and N.L. Barnes
J. Env. Qual., 1999, 28(3):798-809.

Abstract: Interest in water quality impacts by golf courses has grown significantly over the last 10 years due mostly to the intense public scrutiny proposed golf courses receive during the local permitting process. Results from permit-driven studies are frequently not published nor is there usually widespread knowledge about them. Seventeen studies (36 golf courses) passed our quality control and other review criteria and were incorporated into a detailed data review. A total of 16,587 data points from pesticide, metabolite, solvent, and nitrate analyses of surface water and ground water were reviewed. There were approximately 90 organics analyzed in the surface water database and approximately 115 organics in the ground water database. Widespread and/or repeated water quality impacts by golf courses are not happening at the sites studied. None of the authors of the individual studies concluded that toxicologically significant impacts were observed, although HALs, MCLs, or MACs were occasionally exceeded. No solvents were detected in any of the studies. The percent of individual pesticide database entries that exceeded HALs/MCLs for ground water and surface water were 0.07% and 0.29% respectively. The percentages would be somewhat higher if they could be expressed in terms of samples collected rather than chemicals analyzed. The MCL (10 mg/L) for nitrate-nitrogen in surface water was not exceeded, and only 31/849 (3.6%) of the samples exceeded the MCL in ground water; however, most of the nitrate MCL exceedances were apparently due to prior agricultural land use. There was a slight trend for detected pesticides to be more persistent and more mobile than pesticides that were not detected, but the trend was not statistically significant. There are major data gaps in this review, particularly in the midcontinent area.

Water Runoff and Pesticide Transport from a Golfr Course Fairway: Observations vs. OPUS Model Simulations (1999)

Ma, Q.L., A.E. Smith, J.E. Hook, R.E. Smith, and D.C. Bridges.
J. Environ. Qual., 1999, 28:1463-1473.

Abstract: Frequent pesticide applications to golf courses cause concerns that surface water may become contaminated. We hypothesized that runoff potential of these pesticides could be predicted by the recently developed OPUS model. We conducted a 3-yr field study measuring surface runoff of water and dimethylamine salts of 2,4-D [(2,4-dichlorophenoxy) acetic acid], dicamba (3,6-dichloro-2-methylphenoxy-benzoic acid), and mecoprop [(+)-2-(4-chloro-2-methylphenoxy)-propanoic acid]. Twelve 7.4- by 3.7-m plots of 'Tifway 419' bermudagrass (Cynodon dactylon L.) Pers. x C. transvaalensis Burtt Davy) were managed as a golf course fairway. Simulated rainfall was applied at an average intensity of 29 mm h-1 1 d before and 1, 2, 4, and 8 d after pesticide application for 0.92, 1.75, 1.75, 0.92, and 0.92 h, respectively. Average annual runoff loss was 9.13, 15.41, and 10.82% of applied 2,4-D, dicamba, and mecoprop, respectively. Both mass and concentration of pesticide runoff decreased rapidly with time, with the first posttreatment event runoff averaging 74.5, 71.7, and 73.0% of the total runoff of 2,4-D, dicamba, and mecoprop, respectively. The OPUS model adequately simulated runoff [R2 = 0.897 and normalized root mean square error (NRMSE) = 24.6%.] The 2,4-D in runoff was better simulated by complete-kinetic sorption (R2 = 0.876, NRMSE = 60.2%) than by equilibrium sorption submodel (R2 = 0.848, NRMSE = 68.2%). OPUS did not accurately simulate 2,4-D over all runoff events, but simulated 2,4-D in the first posttreatment runoff event within a factor 2 of those measured.

Offsite Transport of Pesticides in Water: Mathematical Models of Pesticide Leaching and Runoff (1995)

S. Z. Cohen, R.D. Wauchope, A. W. Klein, C. V. Eadsforth, R. Graney
[with acknowledgements to J. Lin (Bayer-USA), T. Durborow (E&TS-USA) and R. D. Jones (EPA-USA)]
Pure & Appl. Chem., 1995, 67(12):2109-2148.

Abstract: The process of modeling the leaching and runoff of pesticides is simple in concept but complex in execution. Models are physical, conceptual, or mathematical representations of reality. Screening-level models are an appropriate first step for examining pesticide leachate and runoff potential, as long as conservative input assumptions are used. They may consist of comparisons of certain mobility and persistence properties with numerical criteria, or they may require pencil, paper, and a hand calculator. At a higher level of sophistication, a wide variety of computer models are available that can quantitatively simulate pesticide leaching and runoff in the aqueous phase. It is important to pick a model that has been validated in more than one study, has good user support, requires an amount of data input appropriate for the application, and has a history of producing results acceptable to scientists and regulatory authorities. Considering these various criteria for acceptability, EPA's PRZM2 model and the German modification, PELMO, would be appropriate for evaluating leaching potential. The GLEAMS, LEACHM, and CALF models are also scientifically acceptable, but have not been as widely used. The GLEAMS model is appropriate for quantifying runoff potential in simple, field-scale drainage patterns. The more complex SWRRBWQ model is more appropriate for watershed-scale assessments. The most appropriate use of these computer simulation models is to rank the contamination potential of a particular pesticide at several sites or rank several pesticides at one site. Another excellent application of these models is to calibrate them to fit the results of an intensive field study at one site, and extrapolate to other points in time and space for the same pesticide. One should always recognize the variability in natural processes and field conditions, and use probabilistic (stochastic) analysis whenever possible. More model validation and calibration is needed in tropical climates and in special situations such as turf, forests and orchards.

Ground Water Monitoring and Computer Simulation Modeling of Triasulfuron – an Integrated Approach for Predicting Leaching Potential (1994)

Cohen, S.Z., T.E. Durborow, K. Balu, and J.A. Senita

Abstract: One of the biggest challenges facing pesticide scientists and regulatory agencies has been the reliable prediction of the environmental behavior of pesticides. Field studies are useful, but they are also costly in terms of time and money. Thus the principal focus has been on studying the basic mechanisms of persistence and mobility in the laboratory, with limited attempts to conduct the studies in a site-specific context. Yet regulatory decisions frequently require risk assessments on a site-specific basis. This is especially true for ground water concerns. Our recommended approach to ground water risk assessments is to intensively study the pesticide at a limited number of sites, calibrate a computer simulation model to the specific site(s) and study conditions, and use the model to predict subsurface behavior at other sites and under different conditions. This cost-effective but scientifically valid approach was applied successfully to the new herbicide triasulfuron (CGA-131036, the active ingredient in Amber®, a low volume sulfonylurea compound used for post-emergent weed control in wheat and barley. Thus the purposes of this poster are to briefly summarize the ground water monitoring study and the model calibration of the monitoring results, and demonstrate how the calibrated model can be used to predict leaching patterns in other field scenarios.

Environmental Chemistry of Ethylene Dibromide in Soil and Ground Water (1990)
(Table of Contents)

J.J. Pignatello and S.Z. Cohen
Rev. Environ. Contam. Tox., 1990, Vol. 112.

Monitoring Ground Water for Pesticides

Cohen, S.Z., C. Eiden, and M. Lorber
Chapter 10, In: Garner, W.Y., R.C. Honeycutt, H.N. Nigg (Eds.), Evaluation of Pesticides in Ground Water, American Chemical Society, Washington DC. 1986.

At least 17 pesticides have been found in ground water in a total of 23 states as a result of agricultural practice. These results have been obtained through three different types of monitoring studies: (1) large-scale retrospective, (2) small-scale retrospective, and (3) small scale prospective. The first two types of studies survey areas where the pesticides(s) in question has already been used. The third type of study is an intensive field study where the pesticide is applied and monitoring begins at time zero. Often, soil core data are at least as important as ground-water data. The ability to draw meaningful conclusions from large-scale studies is greatly diminished unless the studies have a statistical, stratified design. The purpose of this paper is threefold: to describe the three study types; suggest guidelines for ground-water sampling, soil sampling and well construction; and update the data summary of pesticides in ground water from agricultural practice.