A Statistical Model Predicting Daily Pesticide Load In the Sacramento River, California

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Abstract

Transport of pesticides by surface runoff during rainfall events is a major process contributing to pesticide contamination in rivers. This study presents a statistical model that relates pesticide loading over time in the Sacramento River with the precipitation and pesticide use in the Sacramento River watershed. The model simulated closely the observed pesticide loading in the Sacramento River during 1991-2000 winter storm events, indicating that precipitation and pesticide use are the two major factors affecting dynamics of pesticide transport into the surface water in the watershed. The validity of the model is further proven by the completely independent prediction of diazinon loading in 2001, which not only matched the magnitude, but also the over time trend on a daily basis. The capability of the statistical model to provide time series estimates on pesticide loading in rivers is unique and may be useful for total maximum daily load assessments.

Objectives

- Explore the relationship of pesticide loading in rivers with the dominant environmental variables
- Establish an empirical equation to describe the relationship

Watershed Description

- Area: about 5000 sq. miles
- Precipitation: highly variable (18" to 40" annually)
- Land use: agriculture with limited urban areas
- Temperature: low 40s F to upper 90s F

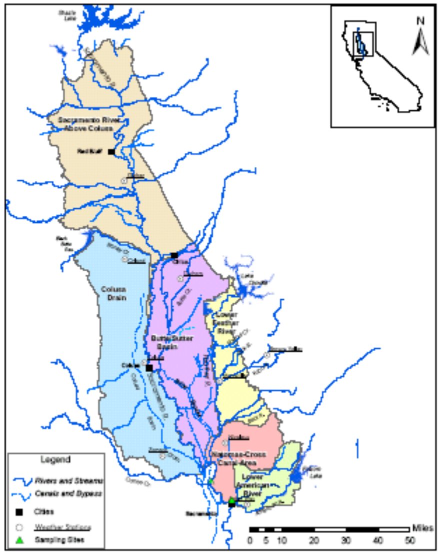

Figure 1. Sacramento River watershed and its subbasins - the Sacramento Valley

The Regression Model

General model

$$Y = a(P-b)^n U$$

Y: pesticide load (lb/d)
P: precipitation (cm/d)
U: pesticide use (lb/d)
a: regression coefficient
b: minimum precipitation for runoff
n: exponential constant

Single basin model:

$$Y = a(\sum_{j=1}^{M} P_j - b)^n \sum_{k=3}^{N} U_k$$

Subbasin model:

$$Y = \sum_{i=1}^{L} a_i (\sum_{j=1}^{M} P_{ij} - b)^n \sum_{k=3}^{N} U_{ik}$$

Data Sources

- Surface water monitoring data collected by:
  * United States Geological Survey (USGS)
  * California State Water Resources Control Board
  * California Department of Pesticide Regulation (DPR)
  * California Central Valley Regional Water Quality Control Board
  * Sacramento River Watershed Program (SRWP)

- Pesticide Use Data: Pesticide Use Report of DPR
- Precipitation: California Weather Database of the University of California, Davis
- Streamflow Data: USGS

Methods

- Pesticide load at two integrated sites analyzed
  * I Street Bridge
  * Alamar Marina Dock
- Weekly moving average of daily load used as independen variable
- Model parameters estimated by Lenvenberg-Marquardt procedure
- Global optimazation approximated by MonteCarlo analysis

Results

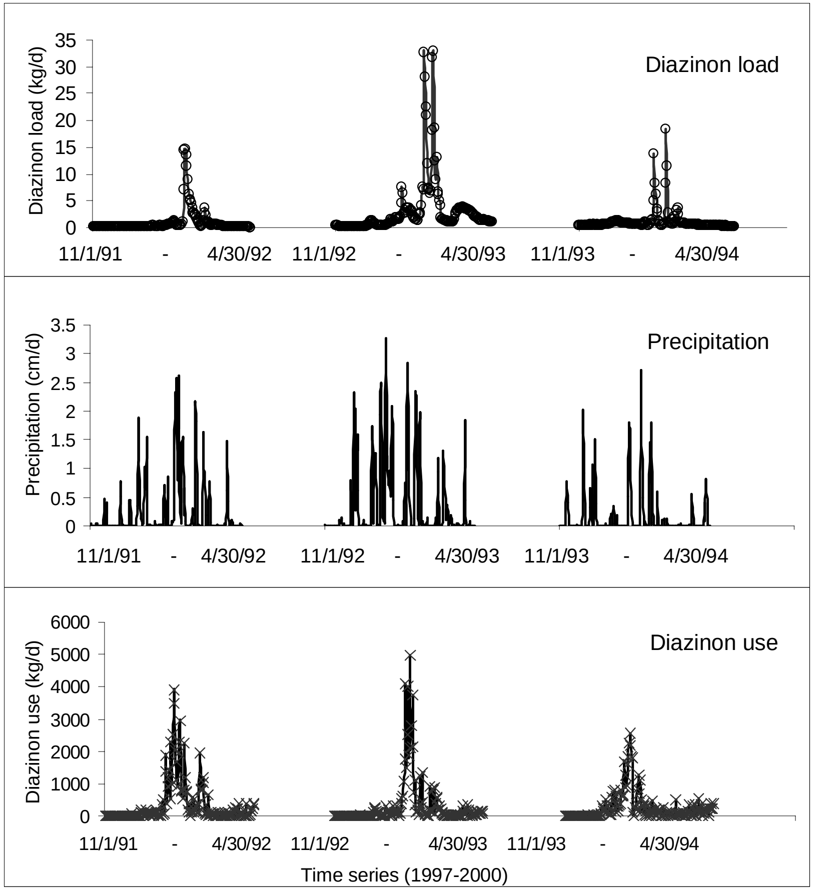

Figure 2. Time series of diazinon load in the Sacramento River, precipitation, and diazinon use in the Sacramento River watershed during 1991-1994 winter storm seasons.

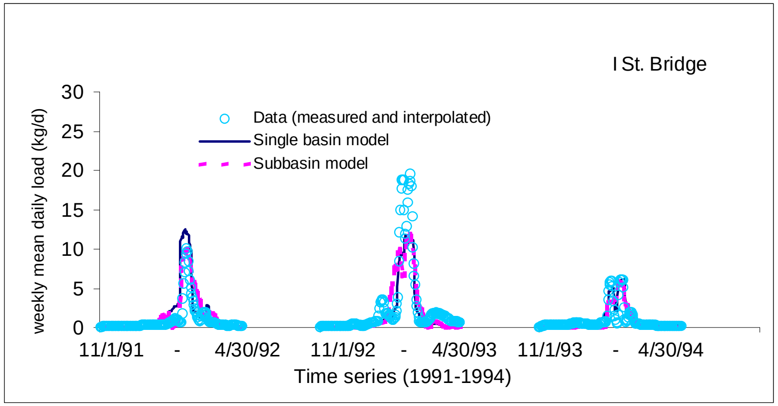

Figure 4. Comparison of observed and regression model fitted weekly moving average of diazinon daily load for the Sacramento River.

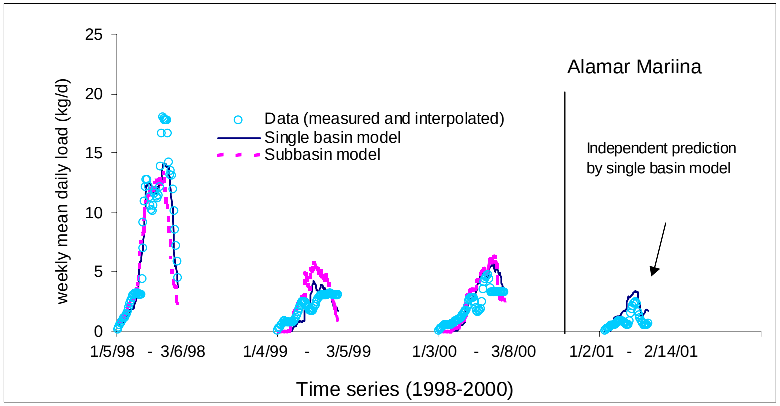

Figure 5. Comparison of observed, regression model fitted, and independent predicted weekly moving average of diazinon daily load for the Sacramento River.

Results (cont.)

Table 1. Estimated rgression model parameters for pesticide load in the Sacramento River

model	parameter	Location	
		I St. Bridge	**Alamar Marina**
single basin	T	7	7
	a, cm^{-n}	2.285E-04	3.857E-05
	b, cm	5.204	1.752
	n	0.124	0.815
	M	12	28
	N	33	35
	r^2	0.674	0.907
	P[a]	<0.001	<0.001
subbasin	T	7	7
	a_1, cm^{-n}	1.362E-04	2.275E-04
	a_2, cm^{-n}	3.408E-05	1.321E-04
	a_3, cm^{-n}	3.305E-05	1.101E-04
	a_4, cm^{-n}	3.479E-05	1.461E-04
	a_5, cm^{-n}	1.000E-07	1.000E-07
	a_6, cm^{-n}	5.095E-04	
	b, cm	2.665	1.397
	n	0.583	0.421
	M	23	19
	N	29	31
	r^2	0.595	0.726
	P[a]	<0.001	<0.001

* The significance level P was based on measured and interpolated data

Conclusions

- The proposed statistical model described very well the observed pesticide loading in the Sacramento River, indicating that P and U are the two major factors affecting dynamics of pesticide transport into the surface water in the watershed

- The validity of the model is further proven by the completely independent prediction of diazinon loading in 2001, which not only matched the magnitude, but also the over time trend on a daily basis

- As a statistical model, its capability of providing time series information on loading is unique, and can be especially useful for TMDL (Total Maximum Daily Load) assessments

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Further Reference

The whole paper can be found in Environ. Sci. Technol. 2004, 38:3842-3852. Corresponding author phone: 916-324-4186; e-mail: lguo@cdpr.ca.gov.