Department of Pesticide Regulation
Environmental Monitoring Branch
1001 I Street
Sacramento, California 95812

Review of the SeawaveQ Model and Challenges of its Application in California

Dan Wang, PhD
November, 2015

1. Review of the SeawaveQ Model

The SeawaveQ (seasonal wave with streamflow adjustment) model, developed by Vecchia et al., (2008) at the U.S. Geological Survey, is a parametric regression model for analyzing pesticide concentration trends in stream. The log-transformed daily concentration variable is regressed against a seasonal wave (which represents the seasonal variability of concentration in response to the seasonality of application rates), streamflow anomalies (which are the deviation of concurrent daily streamflow from short- and mid-term average conditions), and a trend (which represents long-term or inter-annual changes in concentration). The model was validated using environmental monitoring data from the Midwest.

The model was further developed for estimating the daily concentration in streams and the annual maximum concentration for historical years with monitoring data or the probability of exceeding a specified benchmark concentration for a random unmonitored year (Vecchia et al., unpublished, reviewed by Dan Wang). The regression equation was coupled with a stochastic model that described the deviations from the regression equation. The stochastic model parameters include a correlation time scale, the variance of the stochastic component, and the variance of the noise. The model was validated using simulated data. The components of the model are displayed in equation (1).

$$\log\{C(j)\} = \beta_0 + \beta_1 W(j) + \beta_2 A_{MT}(j) + \beta_3 A_{ST}(j) + \beta_4(t_{\{j\}} - t_m) + \omega(j)X(j)$$

Equation (1)

Where $C(j)$ is the daily pesticide concentration;
$W(j)$ is the pesticide signal in the watershed, i.e., the seasonal wave;
$A_{MT}(j)$ and $A_{ST}(j)$ are the mid- and short-term stream flowrate anomaly;
$\beta_4(t\{j\} - tm)$ *is the* long-term trend;
$\omega(j)X(j)$ is the stochastic component that is assumed to take the form of a weighted time-series.

2. Challenges of Applying the SeawaveQ Model in California

2.1 The applicable scenario

The model can only be applied to individual sites with daily flowrate measurement and 18–24 pesticide measurements spread through the entire year. Not many monitoring sites in California meet this data requirement (Johnson et al., 2011).

2.2 The model structure

The seasonal wave, *W(j)*, is predetermined assuming that the release of the pesticide from fields follows its seasonal application rate. This seasonal wave pattern is fixed for all years considered in the model. However, when the seasonal application rate and irrigation pattern change due to drought or newly proposed regulations, the seasonal wave would change (Ficklin et al., 2009; Ryberg et al., 2015).

The model assumes that the long-term trend is steady and linear. However, when a regulation is proposed, a significant drop in the pesticide use is typically observed that would disrupt the linear trend (Ryberg et al., 2015).

2.3 The model validation approach

The validation for the original model is based on monitoring data from the Midwest where agriculture relies on natural rainfall. The situation in California is more complex. In addition to the natural hydrologic processes of rainfall runoff, snowmelt, and base flow from groundwater discharge, flows in California are highly managed and affected by reservoir releases, water diversions, irrigation return flows, and sometimes diversions through bypasses (CVRWQCB, 2004). Such complexity would affect the seasonal wave determination and the model performance.

The validation for the updated model is based on simulated datasets that were governed by the proposed model structure (Equation 1). Actual monitoring datasets, however, may deviate from that structure.

2.4 Exceedance definition

The exceedance rate in the model is defined on an annual basis, i.e., if there are one or more samples in a year that exceed the benchmark, this year will have an exceedance rate of 1. This definition does not distinguish the years when different numbers of samples exceed the benchmark. Obviously, a year with more samples exceeding the benchmark posts higher risk than a year with fewer samples exceeding the benchmark. The model has the capacity to calculate the daily exceedance rate using the predicted daily concentration. However, the model's performance on this task has not been evaluated. Such an evaluation in California is required before the model is used in California.

3. Conclusion

The SeawaveQ model can only be used on individual sites with sufficient flowrate and pesticide measurements. Such sites are scarce in California and cannot represent the conditions in the entire state. For those few sites with sufficient data, the current model can be used with modifications. Two possible modifications are: (1) use actual pesticide use rate (available in DPR's Pesticide Use Reporting Database, http://www.cdpr.ca.gov/docs/pur/purmain.htm) as input instead of using a predetermined seasonal wave with a fixed pattern, and (2) validate the model using actual monitoring data from California sites with daily pesticide and flowrate measurements (such data are available in Cryer et al., 2001).

Reference

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