Higher-tier Surface Water Exposure Modeling Approach at Watershed Scale of Veterinary Pharmaceuticals Administered to Beef Cattle

Isha Khanijo[1], Joshua Amos[1], Chris Holmes[1], Amy Ritter[1], Mark Cheplick[1], Marty Williams[1], Joe Robinson[2], Waterborne Environmental[1] and Zoetis[2]

Background and Objective

Current guidance for veterinary pharmaceuticals risk assessment uses the following calculation of estimating Predicted Environmental Concentrations (PEC) in surface water (VICH GL38 and Draft 10):

$PEC_{water}(max) = 0.011 \times PEC_{soil}$

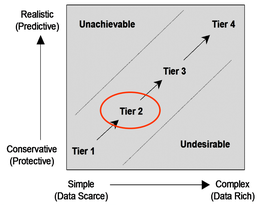
This approach lacks

1) long term (chronic) exposure estimates,
2) probabilistic exposure output
3) consideration of the combined effects of climate, topography and soils to estimate realistic estimate of exposure in surface water.

The objectives of this study is to develop a higher tier surface water modeling approach by simulating potential sources of veterinary pharmaceuticals using USEPA's Tier-2 drinking water pesticide exposure modeling framework.

USEPA Tier-2 Surface (Drinking) Water Exposure Assessment

- Higher tier (more realistic approach)
- Watershed level assessment
- 30 years of weather and repeated pesticide treatments
- ~128 regional crop/soil/weather scenarios
- evaluates the magnitude of pesticide concentrations in surface water and the frequency of occurrence (1 in a 10 year endpoint).



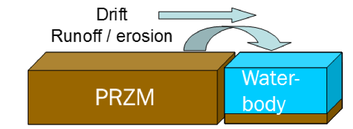
USEPA Tier-2 Drinking Water Exposure Modeling Framework

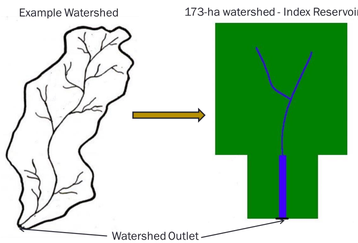
Agricultural field simulated by PRZM predicts edge-of-field chemicals loadings in runoff and erosion

Agricultural field scaled with Percent Cropped Area (PCA) factor to represent a watershed for drinking water assessment

Edge of field loadings and spray drift and get transported to waterbody simulated with EXAMS (or current regulatory model VVWM)

Index reservoir waterbody used for drinking water assessment represents a watershed





Conceptual Model and USEPA Framework Adaptation

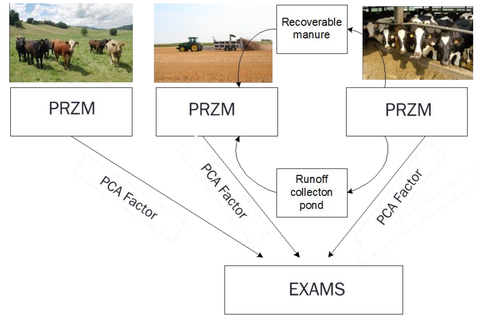
An extended release (up to 200 days) veterinary drug implanted to beef cattle was modeled. Three potential sources were identified for that could release drug into surface water.

- Feedlot where cattle implanted with the drug are kept
- Pasture where cattle implanted with the drug graze
- Cropland where manure scraped from feedlot and runoff collection pond water collected from feedlot is applied

Five potential areas of concern within the United States were determined and watersheds in those areas were selected based on climate and beef cattle density using GIS analysis (presented in another poster).

Three potential sources in each of potential watershed were modeled and PCA factors (also derived thru GIS analysis) were applied in modeling

Conceptual Model



Runoff and erosion flux from each of the three sources were modeled by PRZM. PCA factors were applied to fluxes to represent contribution of each source in a watershed. The scaled fluxes were input into waterbody to estimate PEC in drinking water.

Enhancement of PRZM

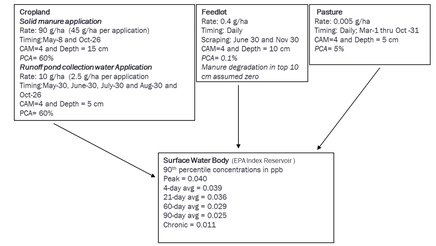
PRZM developed pesticide applications was enhanced to model daily application for a certain rate for duration of drug release from the cattle. This enhancement was done to model multiple daily excretion or "application" of the drug on a feedlot and pasture,
PRZM for feedlot was also modified such that user can specify the dates for scraping the feedlot and amount of manure to be scraped from feedlot surface.

Parameterization of PRZM Inputs for Three Sources

Recoverable solid manure generated from feedlots in the watershed was applied to cropland. Runoff from collection ponds was applied to cropland from feedlots >1000 head that are regulated to control runoff.
USEPA's standard corn scenario was used along with standard weather and soil as starting point. Soil, crop, runoff and erosion parameters were modified as described below. Crop changes include updating crop properties like canopy cover, root depth, and crop cycle dates.

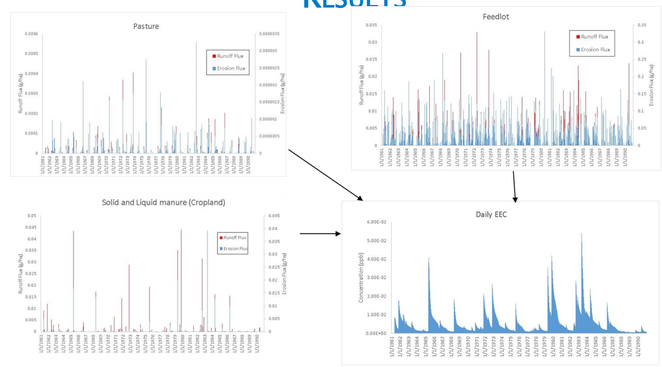
Parameter	Cropland	Pasture	Feedlot
Application rate	Based on daily drug release rate and P2O5 requirement for corn; Runoff pond collection water assumed to be 10% of total [1]	Based on daily drug release rate and stocking density (3.15 head/ac)	Based on daily drug release rate and stocking density (270 head/ac)
Application timing	Solid manure- once before planting and once after harvest Runoff Collection water- 4 times a year during cropping season with irrigation water	Daily for drug release period duration	Daily for 130 days until scraping; can be more than one cattle cycle
Chemical Application Method (CAM)	4 (uniform)	4 (uniform)	4 (uniform)
Depth of incorporation	Solid manure- 15.2 cm Runoff water – 5 cm	5 cm	10 cm (manure surface assumed to be top 10 cm
Crop	Corn (Std. EPA scenario)	Pasture grass	No Crop
Soil	Std. EPA scenario soil	Std. EPA scenario soil	Top 10 cm manure surface and 7 cm interface layer on top of soil layer[2]
Weather	EPA Standard weather (SAMSON Stations)	EPA Standard weather(SAMSON Stations)	EPA Standard weather (SAMSON Stations)
Runoff	Std. EPA scenario Curve numbers for corn	Std. EPA scenario Curve numbers for pasture	95 (compacted bare surface)
Erosion	MUSS equation	MUSS equation	Manure erosion equation from APEX model [3]
Slope	Std. EPA scenario	Std. EPA scenario	4 %

Example Calculations



Model was run using parameters described above. A soil half-life of 5 days and Koc of 1200 was assumed for these calculations. Degradation in top 10 cm manure surface was assumed to be zero since usually manure degradation studies are not available.

Results



- Feedlot manure surface is highly susceptible to runoff and erosion because of bare manure surface
- Feedlot is the biggest contributor of edge-of-field loadings (or runoff and erosion flux) compared to pasture and cropland as shown in the figure above,
- Only AFO < 1000 head cattle are not required to control runoff following NPDES guidelines. PCA factor used for feedlots (not controlling runoff) can highly impact the potential concentrations.
- Feedlot model assumes daily application which results in build of drug concentration
- No degradation is assumed in runoff collection pond or during manure storage

Conclusions

- All potential veterinary drug sources were considered to estimate exposure in drinking water by enhancing PRZM model to simulate feedlot and PRZM
- A robust and viable Tier 2 framework is presented which incorporates real world information but maintains conservatism
- Framework allows for 'higher-tier' exposure modeling as needed, but may not required for many submissions
- This methodology can also be adapted for non-extended release drugs

References

[1] Cole, N. A., A. M. Mason, R. W.Todd, M. Rhoades, and D.B. Parker (2009). Chemical Composition of Pen Surface Layers of Beef Cattle Feedyards. The Professional Animal Scientist 25: 541–552.
[2] Meilke, L.N., N.P. Swanson, and T.M. McCalla (1974). Soil Profile Concentration of Cattle Feedlots. J. Environ. Quality. Vol. 3, no. 1.
[3] Williams, J.R., W.L. Harman, M. Magre, U. Kizil, J.A. Lindley, G. Padmanabhan, and E. Wang. (2006). APEX Feedlot Water Quality Simulation. Transactions of ASABE 49 (1): 61–73.

WATERBORNE ENVIRONMENTAL

For more information please contact Isha Khanijo; E-mail: khanijoi@waterborne-env.com