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Manipulation of the SWAT Code to Model Veterinary Antibiotics in the Environment

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USDA ARS United States Department Of Agriculture Agricultural Research Service

Usage of VAs around the world:

1. China: 6000 tons annually (Zhao et al., 2010)

   Momensin, Salinomycin, destomycin, bacitracin, colistin, and kitasamysin, enramycin, and virginiamycin

1. United States (USDA, 2006)
2. United Kingdom & European Union: (Directive 70/524/EEC+(EU Directive 70/524/EEC, 1970)
3. New Zealand: 57% of nearly 93000 kg of antibiotics use.
4. Africa: (Mitema et al. (2001) 14600 kg of antimicrobials beween 1995 to 1999 ex tetracyclines& sulfamides. No antibiotics
5. Korea: acetaminophen, diclofenac, ibuprophen, sulfathiazole, and chlortetracycline in wastewater influents (Park. J, 2006)

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AAs registered for use as growth promoters/feed efficiency in Australia, Denmark, (EU), Canada and the USA:

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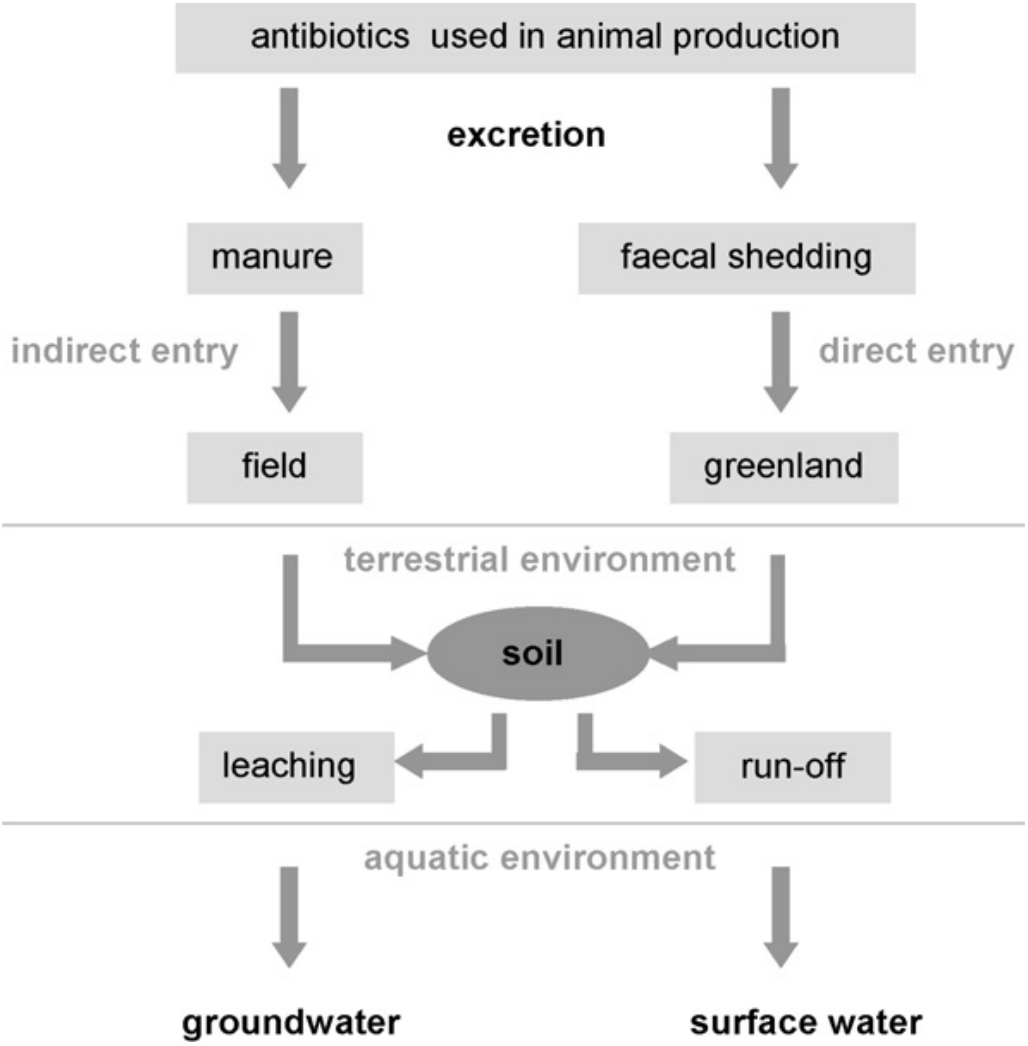
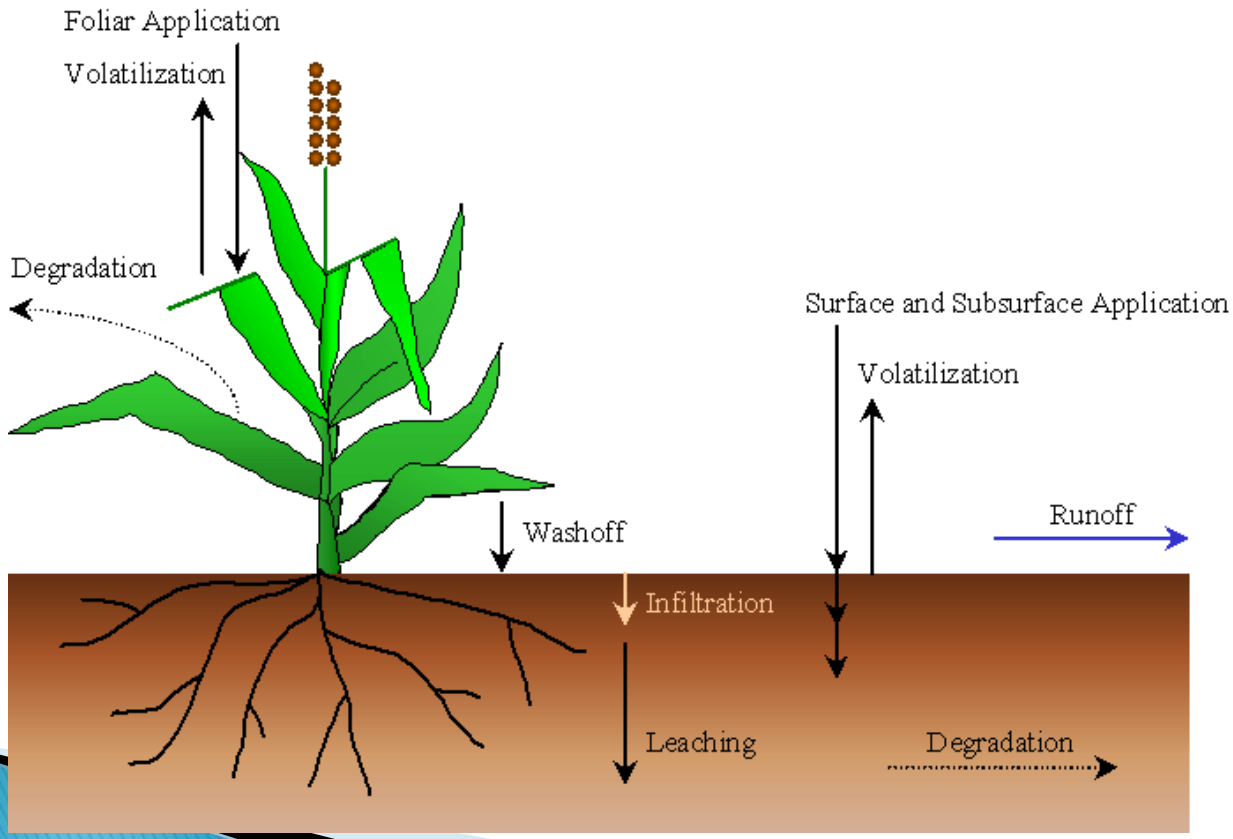
Fate of VAs in the Environment (Albrechts.C, 2007)



Theoretical Framework (Overall process follows the pesticides fate and transport in SWAT (SWAT Manual 2009):



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Modeling Fate and Transport of VAs:

- Most commonly used models :

1. PhATE (Pharmaceutical Assessment and Transport Evaluation)model (Anderson et al. 2004-(V.L. Cunningham, 2008)

2. GREAT-ER (Geo-referenced Regional Exposure Assessment Tool for European Rivers) model that was mainly developed to predict the distribution of concentrations of consumer products in surface waters (Feijtel et al 1997-V.L. Cunningham)

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Study Objective:

Use of the Soil and Water Assessment Tool (SWAT) model to model a list of veterinary pharmaceuticals (VPs) in agricultural dominated watersheds.

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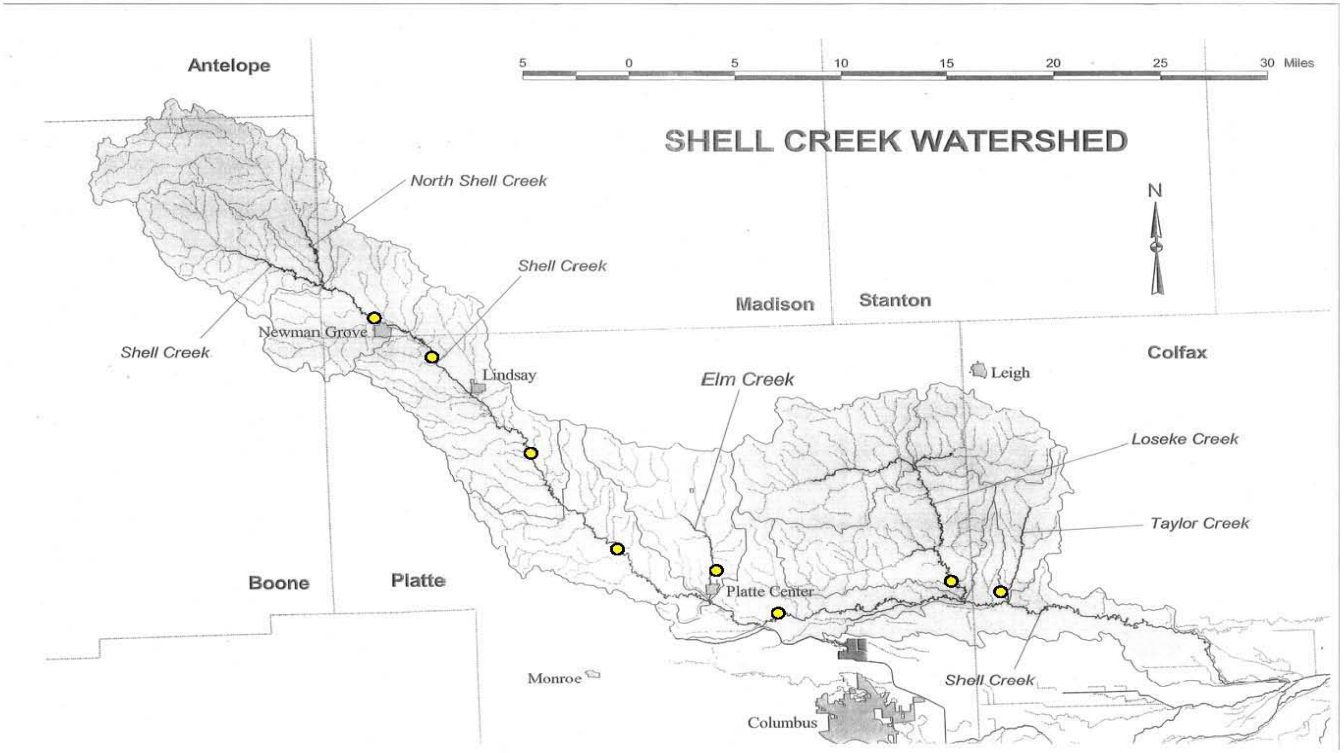
Shell Creek Watershed:

Draft 7/10/08

Attachment 1: Map of Shell Creek Watershed (Yellow circles denote approximate continuous sampling locations)



Shell Creek Watershed:

- Location: Northeastern Nebraska and drains an area of 1214 square km in parts of Boone, Colfax, Madison, and Platte Counties.
- Landuse: agricultural with steep-sloped pastures, rolling pivot-irrigated hills, and gravity-irrigated flood plains (1700 landowner/operators).
- Precipitation &runoff: 735 & 50 mm.
- WQ issues: Erosion and sedimentation, nitrogen, and phosphorus, pharmaceuticals.
- Animal operations: Cattle and swine.
- Land cover types : corn (48%), soybean (28%), range (19%), alfalfa (3%), and misc. (2%).
- Soils: deep, silty loams and silty clay loams; soil series include the Nora (49%), Hobbs (27%), Belfore (19%), Moody (4%) and Gibbon (1%).

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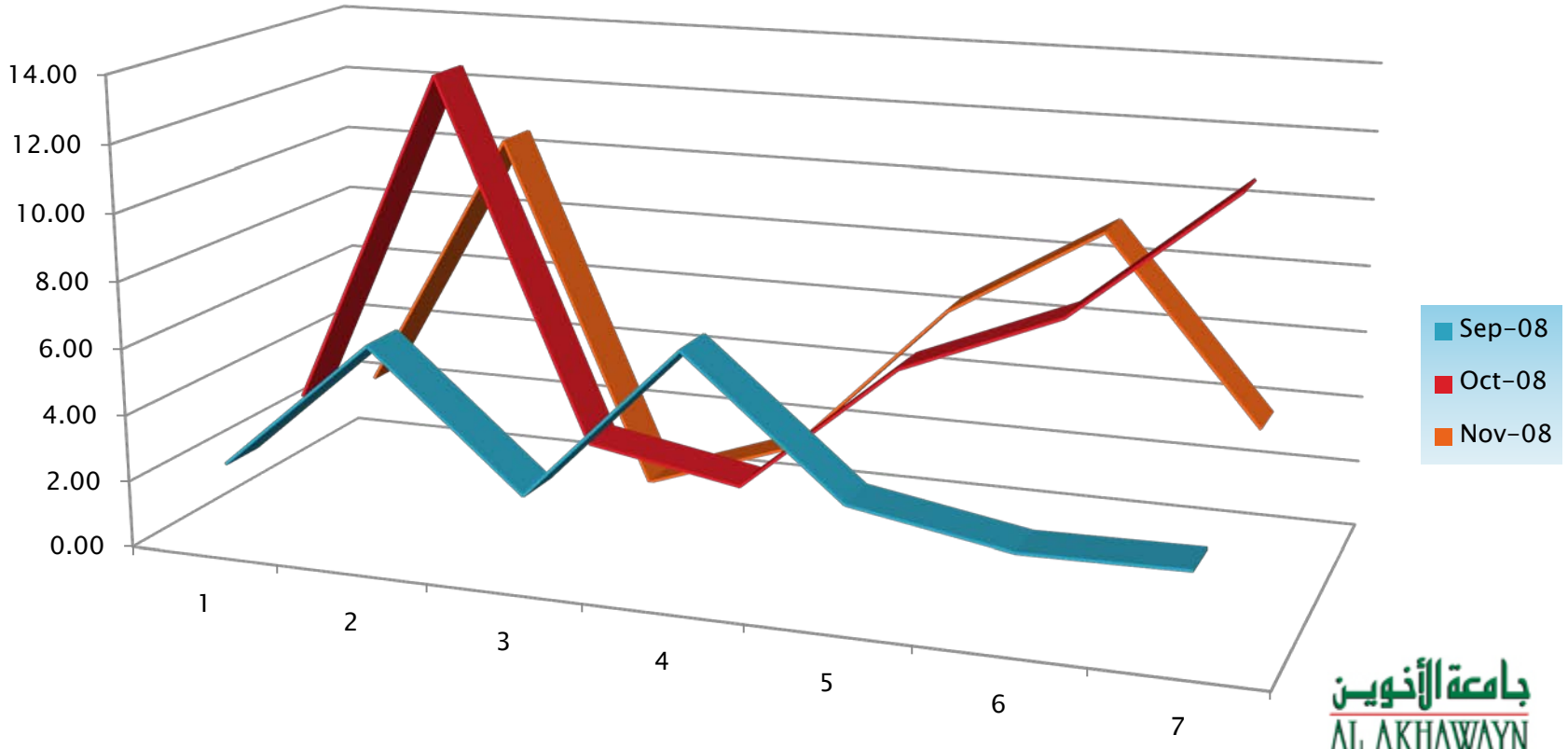
Sulfamethazine Concentration (ng/L) in 2008-Shell Creek:



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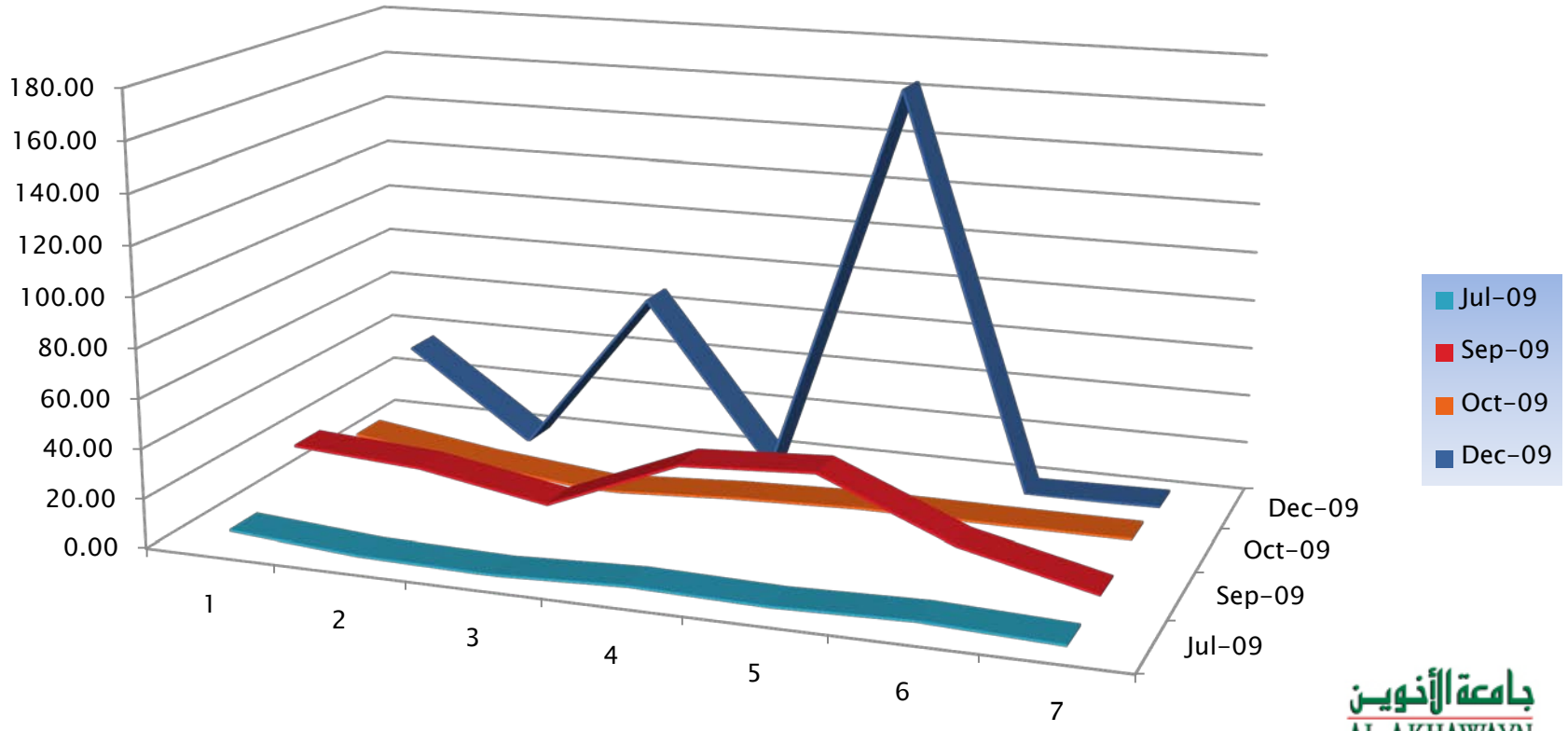
Sulfamethazine Concentration (ng/L) in 2009-Shell Creek:



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Theoretical Framework used for Modeling VAs using SWAT (Aga, 2008):

Special characteristics of VMs:

1. Molecular structure
2. Ionization
3. Dissociation constant
4. Octanol water distribution coefficient and
5. Sludge sorption/desorption (kb)

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Molecular Weight/Ionization/Dissociation Constant:

1. Molecular weight: very complex

2. Ionization: charged molecules that are influenced by soil and solution pH.

3. Dissociation constant: effect of pKa and pH on solubility.

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Octanol/Water Distribution Coefficient & Sludge Sorption-Desorption (Kp):

- Dow=(Concentration in n-octanol)/(concentration in water)

  Log Dow <1 (VM is unlikely to sorb into organic matter)

  Log Dow >=3 (VM will absorb into organic matter)

- Koc=(chemical sorbed /chemical in solution at equilibrium) /(% organic carbon)

  Kb=foc * Koc

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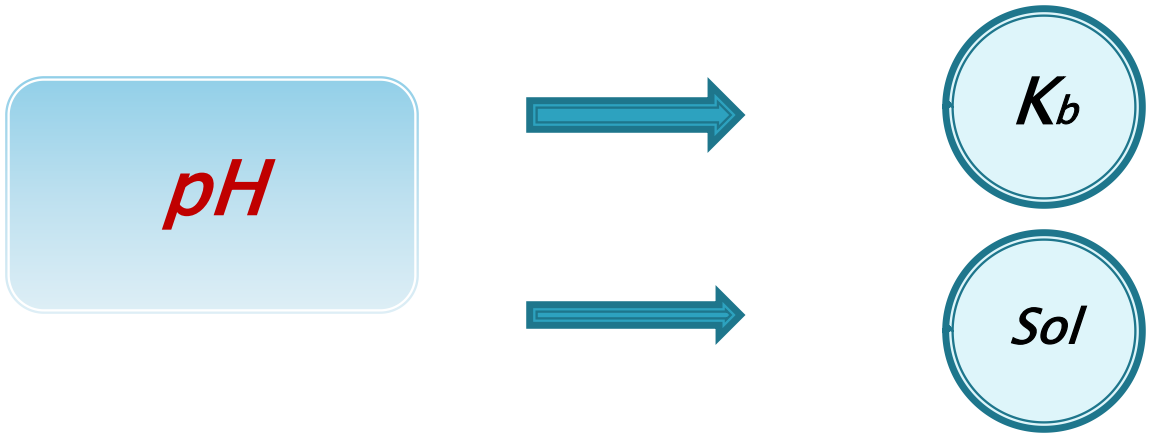
Dependent Variables in(Pharm) Subroutine:



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On going /Future work:

- Sensitivity analysis on critical parameters.
- Incorporation of various additional variables identified as critical to modeling fate and transport of VAs.

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