SWAT+ vs PWC

A Comparative Analysis of Pesticide Transport Models

PWC

- **Chemicals**: Maximum 3 (1 parent + 2 metabolite generations)
- **Metabolite transport**: Full (volatilization, sorption, runoff, leaching, erosion, plant uptake)

SWAT+

- **Chemicals**: Multiple pesticides simultaneously
- **Metabolite transport**: Full (volatilization, sorption, runoff, leaching, erosion, plant uptake)
- **Evolution**: Classic SWAT (parent only) → SWAT+ metabolites (Rathjens et al., 2022) → plant uptake (Rathjens et al., 2025)

PWC: Field & Water Body

Field (PRZM/TPEZ):

- Sorption (Linear + Freundlich)
- Degradation (3-phase: aqueous/sorbed/gaseous)
- Volatilization (canopy resistance model)
- Transport: Runoff, erosion, leaching, plant uptake

Water Body (VVWM):

- Degradation, volatilization
- Settling, resuspension
- Benthic processes

SWAT+: HRU & Channel

HRU:

- Sorption (Linear only)
- Degradation (single-phase)
- Foliar/soil decay, washoff
- Transport: Surface runoff, lateral flow, tile drain, percolation, sediment

Channel:

- Reaction, metabolism (parent→daughter)
- Volatilization, settling/resuspension
- Diffusion, benthic reaction/burial

PWC: Application Methods

- **Foliar application**
- **Soil surface** (4cm layer)
- **Uniform incorporation** (any depth)
- **Specific depth** (user-defined)
- **T-Band** (2cm band)
- **Linear decrease** with depth
- **Linear increase** with depth
- **Custom** distribution

SWAT+: Application Methods

- **Foliar** (LAI-based interception)
- **Soil surface**
- **Soil incorporation** (uniform mixing)

PWC offers more refined application methods (8 vs 3)

PWC: Algorithm Detail

- **Volatilization**: Canopy resistance model (Henry's Law + boundary layer)
- **Sorption**: Linear + Freundlich; optional non-equilibrium
- **Numerical**: Predictor-corrector; sub-daily time steps; tridiagonal solver

SWAT+: Algorithm Detail

- **Volatilization**: Simplified aquatic flux
- **Sorption**: Linear only (equilibrium assumption)
- **Numerical**: Explicit Euler; daily time steps; 1st-order decay

PWC Output

- **Field scale**: Daily fluxes for runoff, erosion, volatilization, degradation, washoff, plant uptake
- **Water body**: Estimated Environmental Concentration (EEC)
- **Purpose**: Regulatory risk assessment

SWAT+ Output

- **HRU scale**: Mass balance for plant, soil, sediment, runoff, lateral flow, tile drain, percolation
- **Channel scale**: Dissolved/sorbed transport, reaction, metabolism, volatilization, settling
- **Purpose**: Watershed management analysis

Scenario Comparison

Scenario	SWAT+	PWC	Recommended
Watershed load	✓	✗	**SWAT+**
Risk assessment	△	✓	**PWC**
Management eval	✓	△	**SWAT+**
Regulatory compliance	✗	✓	**PWC**
Short-term events	△	✓	**PWC**
Long-term trends	✓	△	**SWAT+**
Spatial distribution	✓	✗	**SWAT+**
Multiple pollutants	✓	✗	**SWAT+**
Volatile pesticides	△	✓	**PWC**
Nonlinear sorption	✗	✓	**PWC**

Note: ✓ = Excellent, △ = Limited, ✗ = Not supported

PWC

- **Chemicals**: 1 parent + 2 metabolites
- **Scale**: Single point (field)
- **Volatilization**: Canopy resistance model
- **Sorption**: Linear + nonlinear (Freundlich)
- **Degradation**: Three-phase (aqueous/sorbed/gaseous)
- **Application**: 8 methods
- **Time step**: Sub-daily
- **Regulatory**: ✓ EPA accepted

SWAT+

- **Chemicals**: Multiple pesticides
- **Scale**: Distributed (watershed/HRU)
- **Volatilization**: Simplified aquatic flux
- **Sorption**: Linear only
- **Degradation**: Single-phase
- **Application**: 3 methods
- **Time step**: Daily
- **Regulatory**: ✗ Not EPA accepted

References

1. Rathjens, H., Kiesel, J., Miguez, M.B., Winchell, M., Arnold, J.G., Sur, R. (2022). Simulation of Pesticide and Metabolite Concentrations Using SWAT+ Landscape Routing and Conditional Management Applications. Water 14(9):1332. doi:10.3390/w14091332
2. Rathjens, H., Kiesel, J., Arnold, J., Reinken, G., Sur, R. (2025). Technical note: Extending the SWAT2012 and SWAT+ models to simulate pesticide plant uptake processes. Hydrol. Earth Syst. Sci. 29:6703–6714. doi:10.5194/hess-29-6703-2025

Thank You!