Parameterisation of PRZM for the Mitigation of Runoff and Erosion by In-field Measures

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York 2022 – Pesticide Behaviour in Soils, Water and Air

Introduction – Runoff and Erosion

Images: Surface runoff – Wikipedia; accessed: 17 Aug 2021

Objectives

How effective is the use of infield runoff and erosion measures in reducing pesticide discharge from sloped fields?

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- Evaluation of maize field trails to quantify the effect of micro-dams and conservation tillage on the reduction of runoff and erosion
- Derivation and adaptation of specific model parameters to consider mitigation measures in the simulation of runoff and erosion with PRZM
- Quantifying the effect of these mitigation measures on EU regulatory exposure concentrations

Methods – Farm Machinery to control Runoff and Erosion

Micro-dam –
commercially available plough

„Micheltand” for conservation tillage

Methods – Plot Characteristics in Belgium

Set-up: Micro-dams (MD) / conservation tillage (CsT) vs. conventional tillage (CvT)

	Trial 2018	Trial 2019	Trial 2013
Soil type	Silt loam (clay 15%, silt 74%)		
Crop	Maize (no irrigation)		
Plot length [m]	24	18	24
Plot area [m^2]	72	54	72
Slope [%]	9		9 & 16
Precipitation [mm]	173	337	268

Methods – Runoff Curve Number

Run-off Q [mm] is calculated in the PRZM model (Young and Fry, 2014) based on the precipitation P [mm] using:

$$Q = \frac{(P \ - \ 0.2\ S)^2}{P \ + \ 0.8\ S}$$

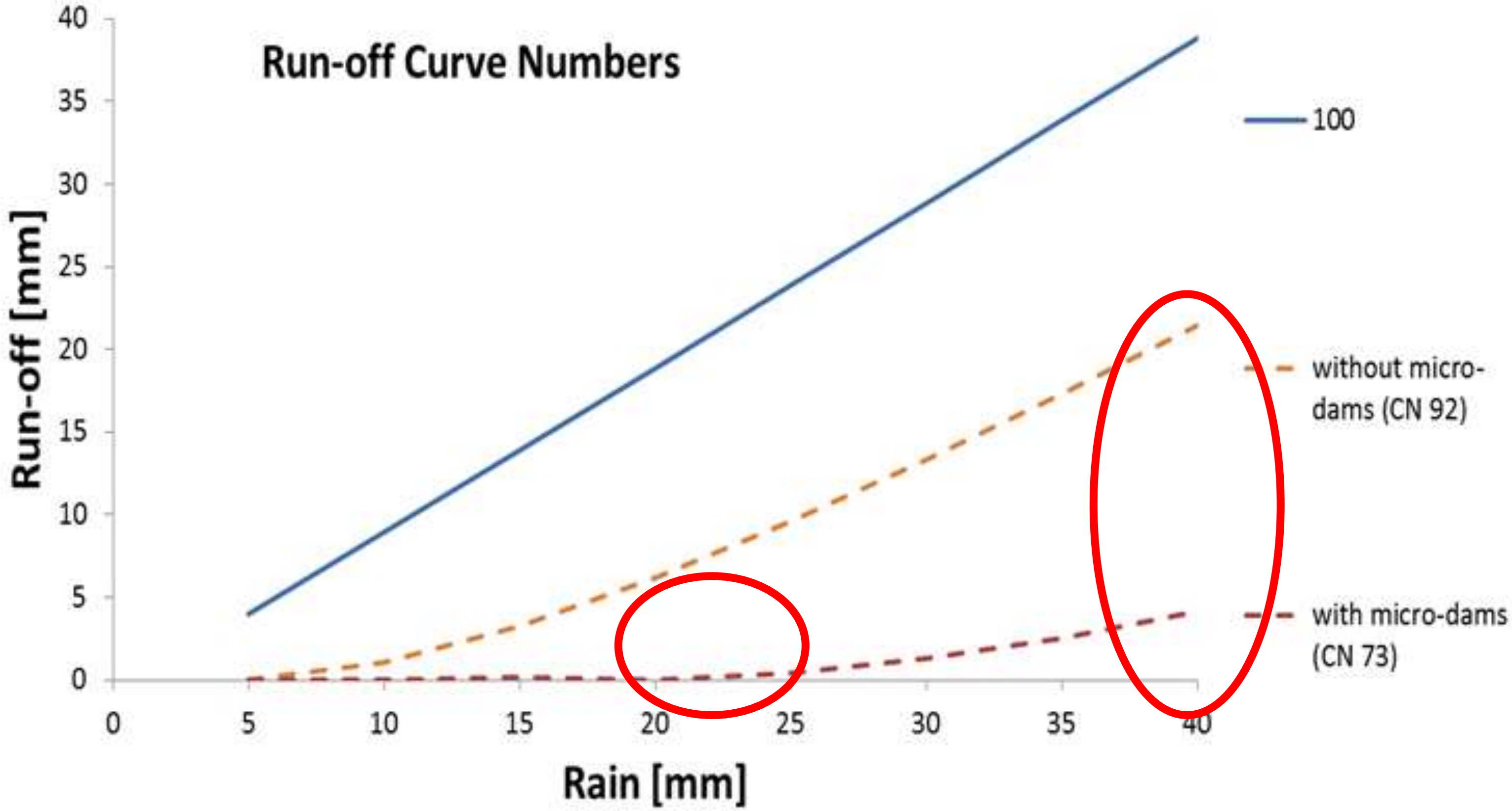
The corresponding daily watershed parameter S [mm] is set into relation with the (dimensionless) curve number CN, being the quantification in risk assessment:

$$S = 25.4\ (\frac{1000}{CN} - 10)$$

Young, D.F., and M.M. Fry. 2014. “A Model for Predicting Pesticide in Runoff, Erosion, and Leachate: User Manual.” U.S. Environmental Protection Agency

Methods – Runoff Curve Number

Relationship of precipitation and runoff quantified by curve numbers



Methods – MUSS Erosion Equation

The MUSS equation (Williams, 1995) is a modification of the universal soil loss equation (USLE; Wischmeyer and Smith 1960) used for the calculation of erosion in PRZM:

$$X_e = 0.79\,(V_r\, q_p)^{0.65}\, A^{0.009}\, K\, LS\, C\, P$$

X_e: the event soil loss

V_r: volume of daily runoff event

q_p: peak storm runoff rate

A: field size

K: soil erodibility factor

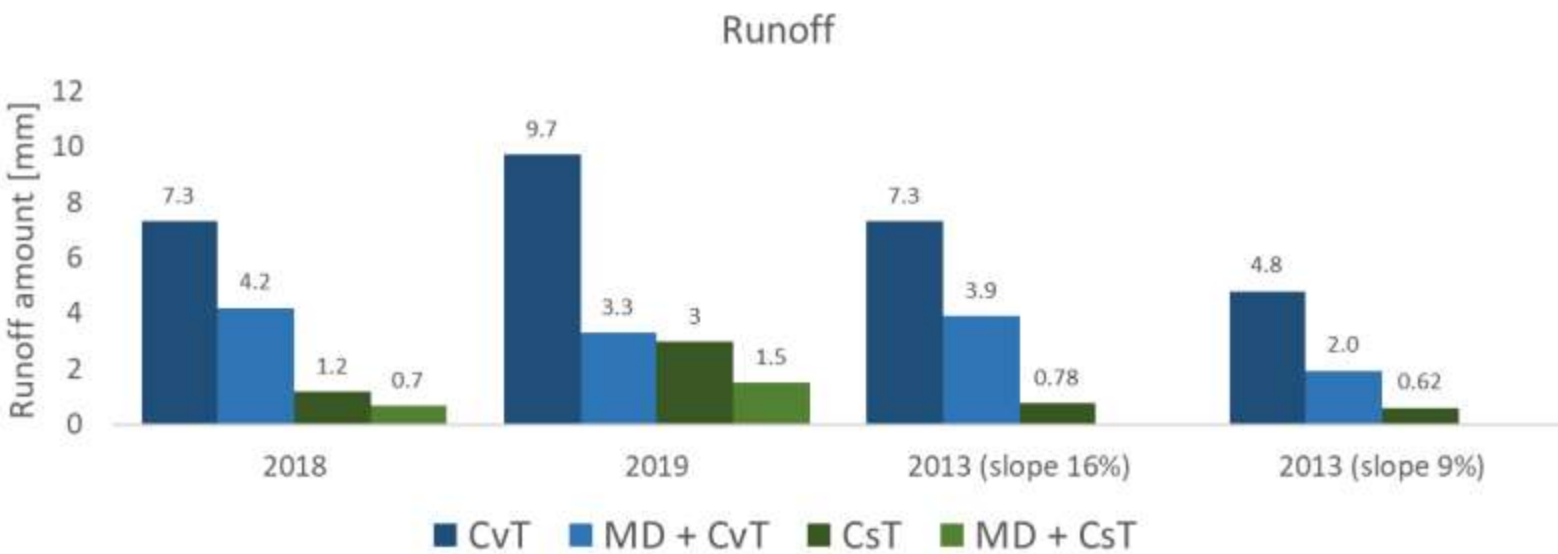
LS: length-slope factor

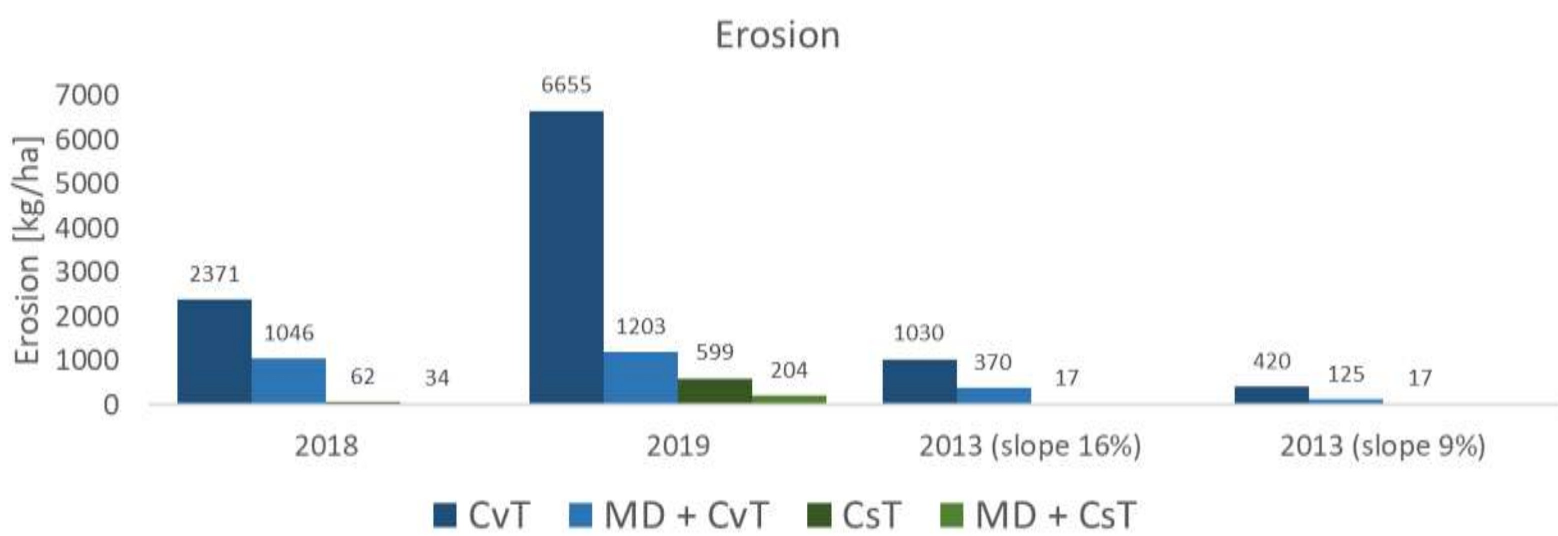
***C*: soil cover factor, combining crop type and tillage method in contrast to fallow and tilled land**

P: conservation practice factor

Williams, J.R. 1995. “The EPIC Model. Pages 909-1000 in Singh, V.P. Computer Models of Watershed Hydrology.” Water Resources Publications, Highland Springs, Colorado USA.
Wischmeier, W.D., and D.D. Smith. 1960. “A Universal Soil-Loss Equation to Guide Conservation Farm Planning.” Trans. Int. Congr. Soil Sci., 7th, 418–25.

Results – Quantitative Reductions (measured)





Results – Quantitative Reductions (measured)

Runoff

Micro-dams (MD): 24–71%

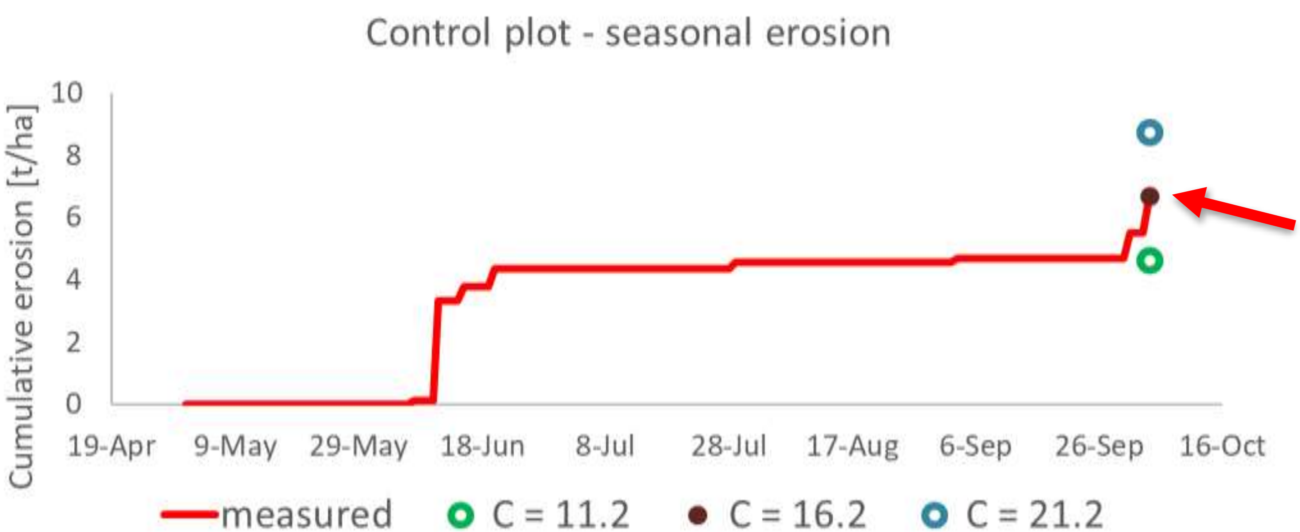
Conservation Tillage (CsT): 69–89%

Erosion

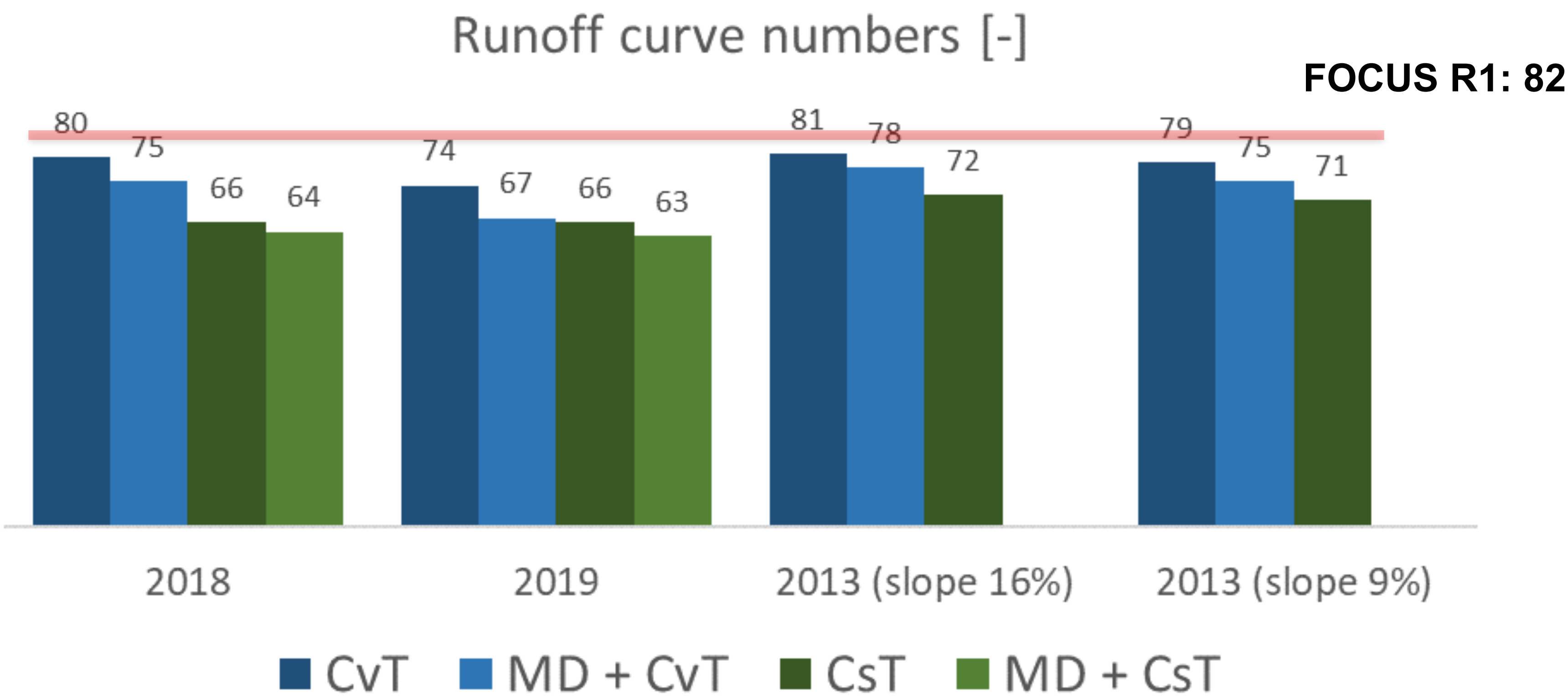
Micro-dams (MD): 59–82%

Conservation Tillage (CsT): >90%

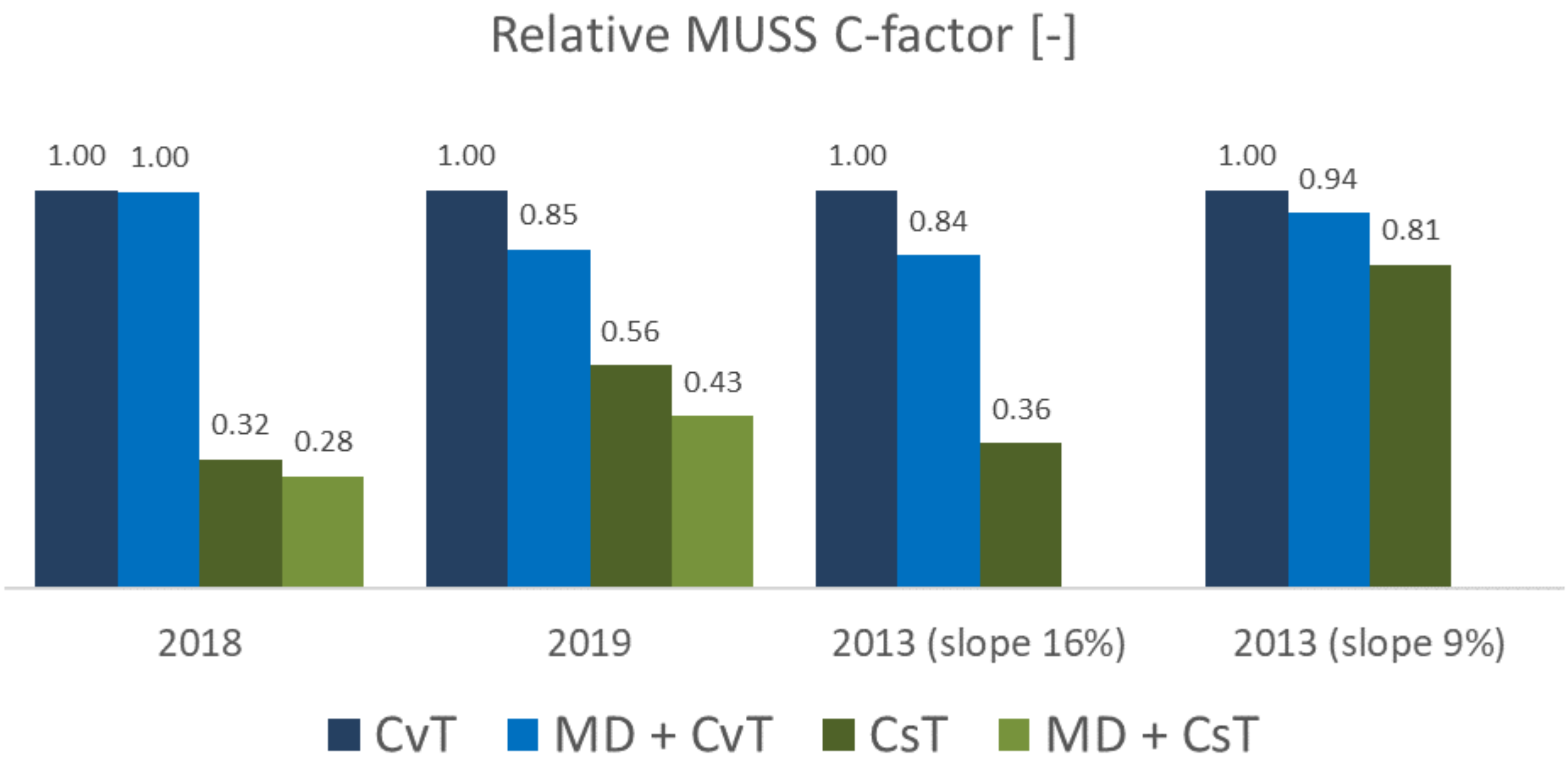
Results – Simulations with PRZM – Trial of 2019



Results – Fitted CN



Results – Fitted C-Factors, relative to Conventional Tillage



Results – Example PEC Calculations – FOCUS R Scenarios

knoell worldwide registration

Application of FFA (240 g/ha at emergence):

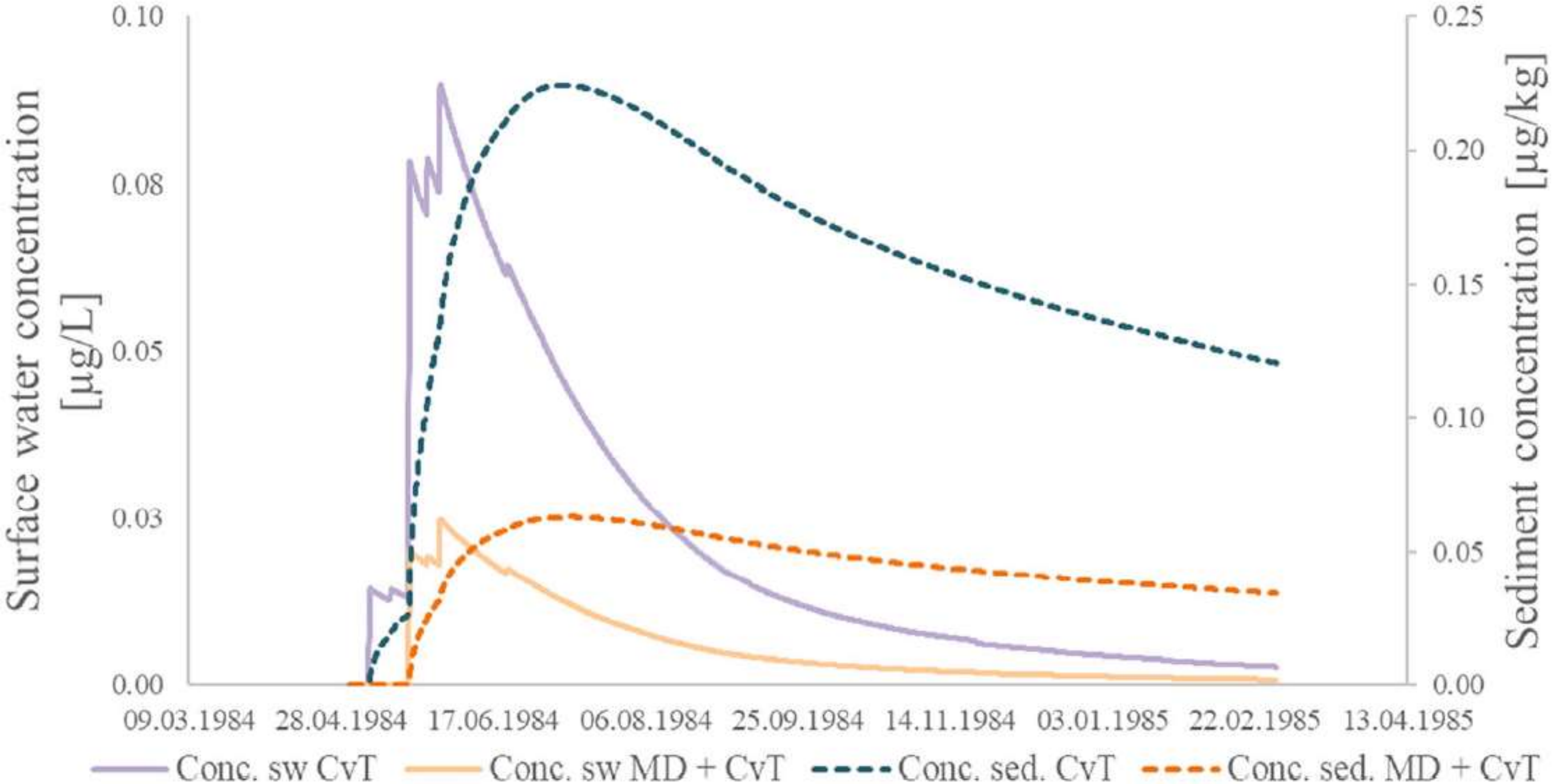
Relatively immobile – k_{om}: 125 l/kg; DT50 soil/water/sediment: 18 d/50 d/1000 d

Drift disabled to showcase runoff reduction

	PECsw (µg/L)					PECsed (µg/kg)				
	CvT	MD + CvT	Red. (%)	CsT	Red. (%)	CvT	MD + CvT	Red. (%)	CsT	Red. (%)
FFA (215 g/ha)										
R1 pond	0.090	0.025	72	3.5E – 03	96	0.22	0.063	72	9.0E – 03	96
R1 stream	2.7	6.8E – 03	100	0.037	99	0.61	0.35	44	0.10	83
R2 stream	1.8	0.34	81	0.14	93	0.51	0.25	51	0.14	72
R3 stream	0.88	0.028	97	1.1E – 03	100	0.25	0.040	84	5.3E – 03	98
R4 stream	7.2	3.1	58	0.58	92	2.4	2.1	12	1.3	46

Results – PEC Dynamics Example R1 Pond

knoell worldwide registration



Summary + Conclusions

- Micro-dams and conservation tillage are powerful mitigation measures to effectively reduce run-off and erosion and hence to reduce the exposure of surface water to pesticides
- By adjusting two parameters (CN & C), the reduction effect of the mitigation measures can be properly reproduced when simulating runoff and erosion with PRZM
- Recommendations for the implementation into the regulatory pesticide exposure assessment with PRZM using adapted runoff curve numbers and values for the parameter C in the MUSS erosion equation:
  - → micro-dams: CN 6% reduction, C-factor reduction of MUSS 10%
  - → conservation tillage: CN 12% reduction, C-factor reduction of MUSS 48%

Publications

Sittig, S., Sur, R., Baets, D. and Klaus Hammel (2020): “Consideration of Risk Management Practices in Regulatory Risk Assessments: Evaluation of Field Trials with Micro-Dams to Reduce Pesticide Transport via Surface Runoff and Soil Erosion.”

Environ Sci Eur 32 (1): 86.

https://doi.org/10.1186/s12302-020-00362-1.

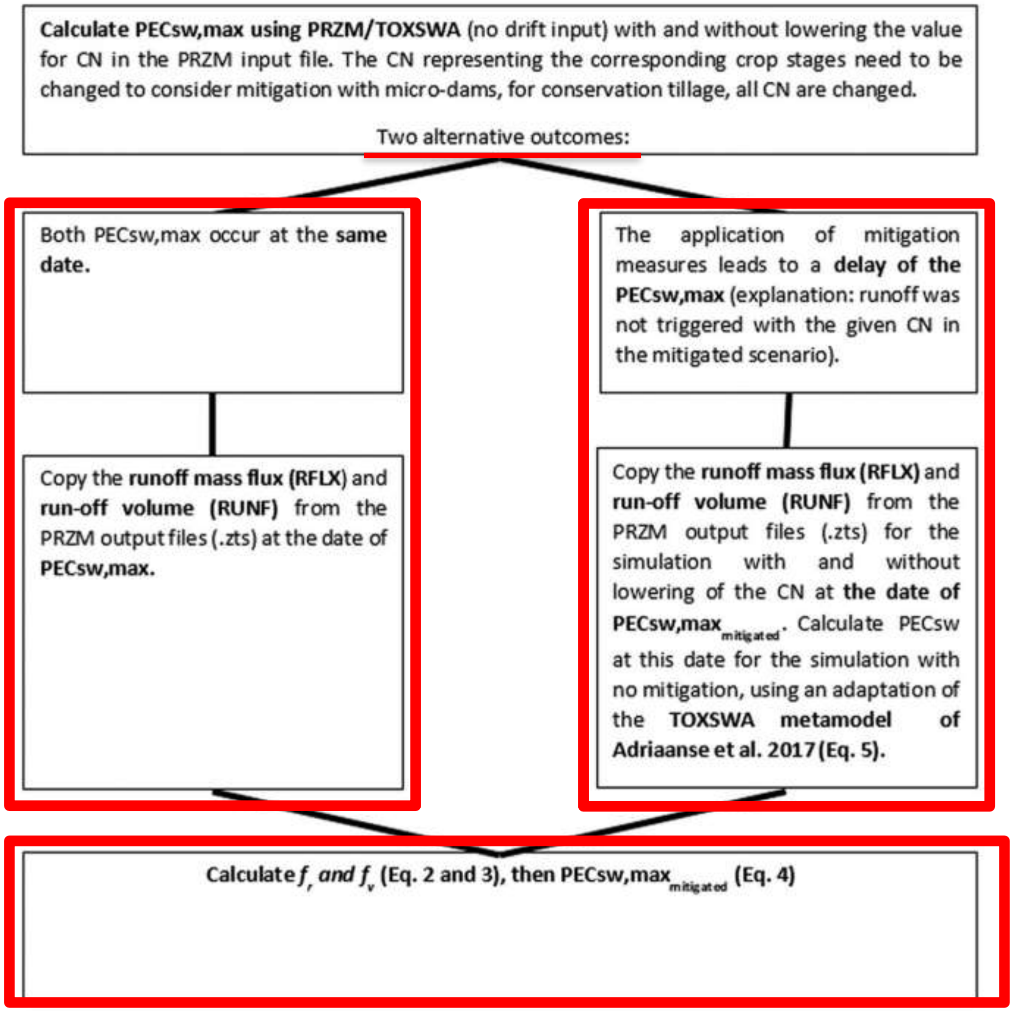
Sittig, S., Sur, R., and Dirk Baets (2021): “Runoff mitigation via micro-dams and conservation tillage-numerical modelling of runoff and erosion from maize field trials.”

Integr Environ Assess Manag. 2021: 1-16.

https://doi.org/10.1002/ieam.4546

Thank you for your kind attention

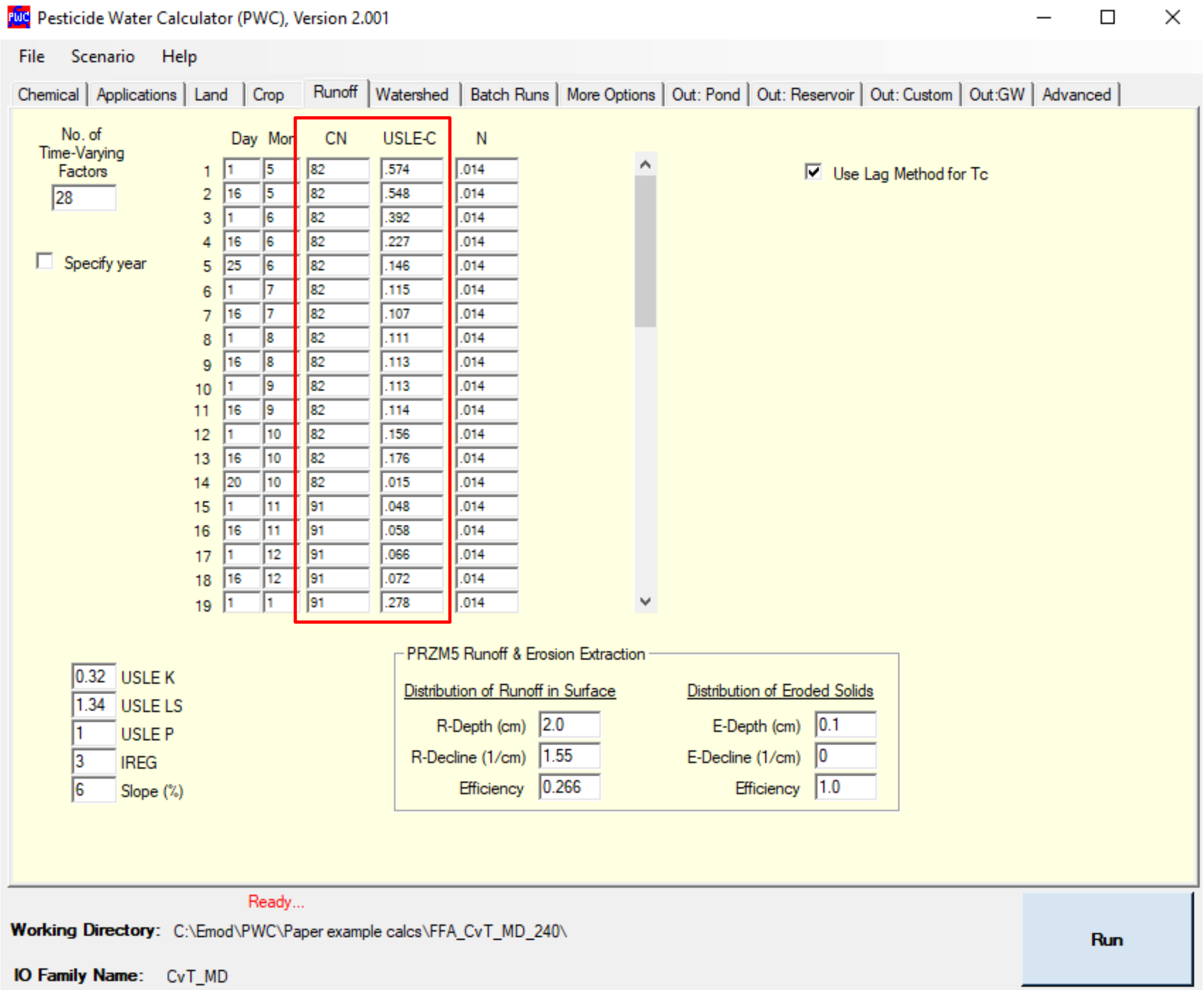
Methods – Workflow PEC Calculation



Regulatory relevant concentrations (PEC) can be calculated with adapted parameters derived from the results of the field trials.

Sittig, S., Sur, R. and Baets, D. (2022), Runoff mitigation via micro-dams and conservation tillage—Numerical modeling of runoff and erosion from maize field trials. Integr Environ Assess Manag. https://doi.org/10.1002/ieam.4546

Methods – EEC calculation with PWC



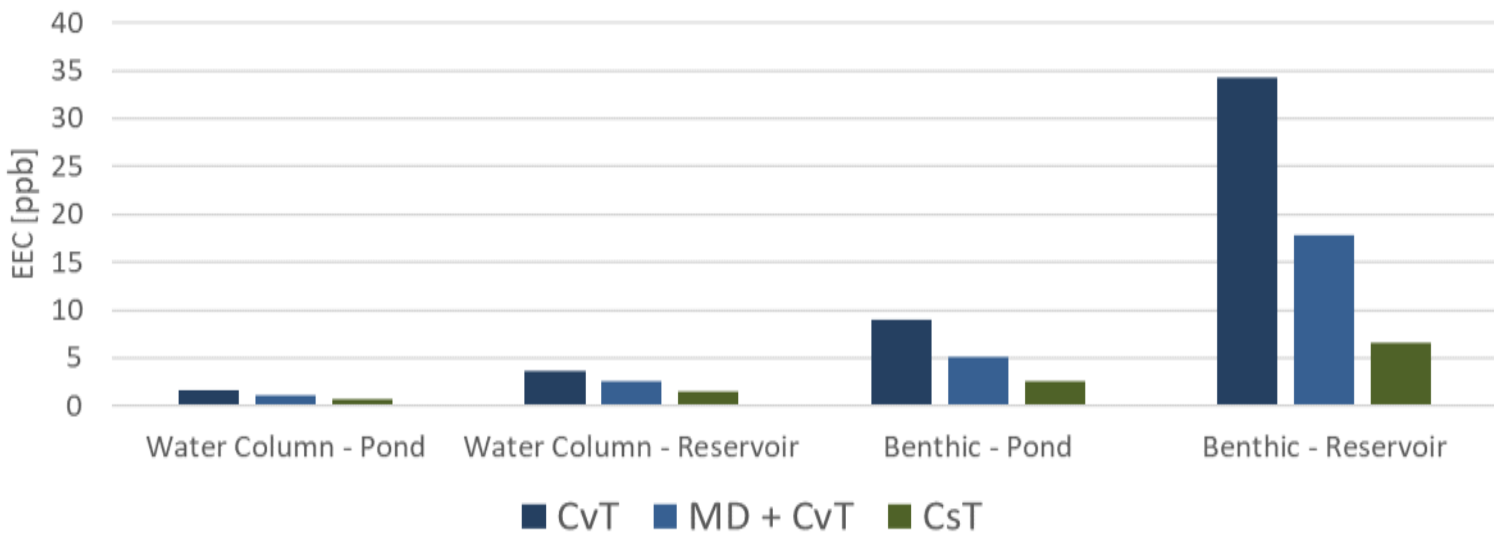
Regulatory relevant concentrations (US: EEC; EU: PEC) can be calculated with adapted parameters derived from the results of the field trials

For US calculations: “Illinois corn” as benchmark scenario shown here

Results – Example EEC Calculations – Illinois corn

Application of FFA (240 g/ha at emergence):

Relatively immobile – k_{om}: 125 l/kg; DT50 water/sediment: 50 d/1000 d



<u>EEC reductions</u>

Water column – MD + CvT: 30–33%; CsT: 57–61%

Benthic – MD + CvT: 43–48%; CsT: 71–81%

Sittig, S., Sur, R. and Baets, D. (2022), Runoff mitigation via micro-dams and conservation tillage—Numerical modeling of runoff and erosion from maize field trials. Integr Environ Assess Manag. https://doi.org/10.1002/ieam.4546

Results – Erosion Reductions in "Il corn"

In "Illinois corn", the mass of eroded sediment is considerably reduced

Average soil loss per year in the 30-year simulation period:

CvT: 49 t/ha

MD + CvT: 38 t/ha

CsT: 29 t/ha

→ Soil loss reduced with MD by 23% and with CsT by 41%