3rd European Conference on Copper in Plant Protection 15th-16th November in Berlin, Germany



BOLW MORE Bund Ökologische Lebensmittelwirtschaft EU GROU Julius Kühn-Institut ORGANIC Bundesforschungsinstitut für Kulturpflanzen

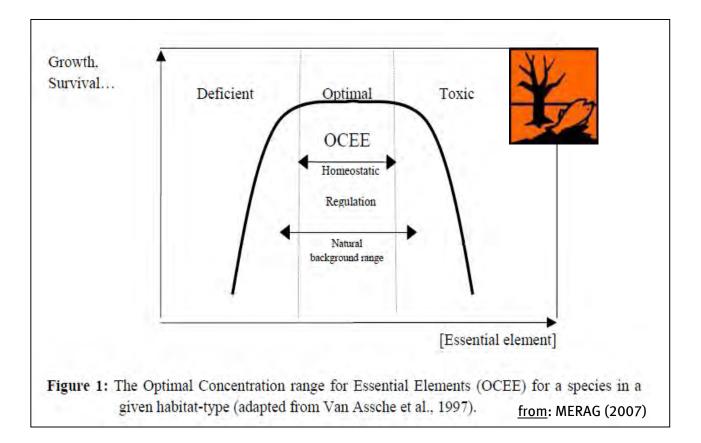
Umwelt 🌍 Bundesamt

The repeated dose makes the poison - assessing the risk of copper fungicides towards soil organisms

Tobias Frische German Environment Agency (UBA) Section Plant Protection Products

3rd European Conference on Copper in Plant Protection organized by BÖLW, IFOAM EU-Group and JKI Berlin, 15./16.11.2018 Copper fungicides - The repeated dose makes the poison (Frische, UBA)

The Dimorphic Character



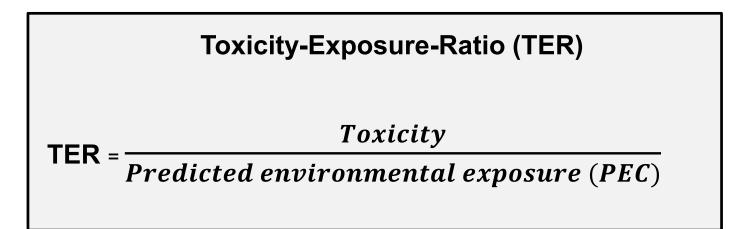
- essential element, however <u>persistent</u> and <u>toxic</u>...
- it's a question of the dose...

Precautionary Soil Protection

			Q
precautionary values for copper in soil (German Soil Protection Act, 1999)	soil type	mg/kg dw	
if exceeded: maximum permissible	sand	20	
additional input <u>360 g Cu/ha per year</u>	silt	40]
(∑ of all inputs)	clay	60	
]

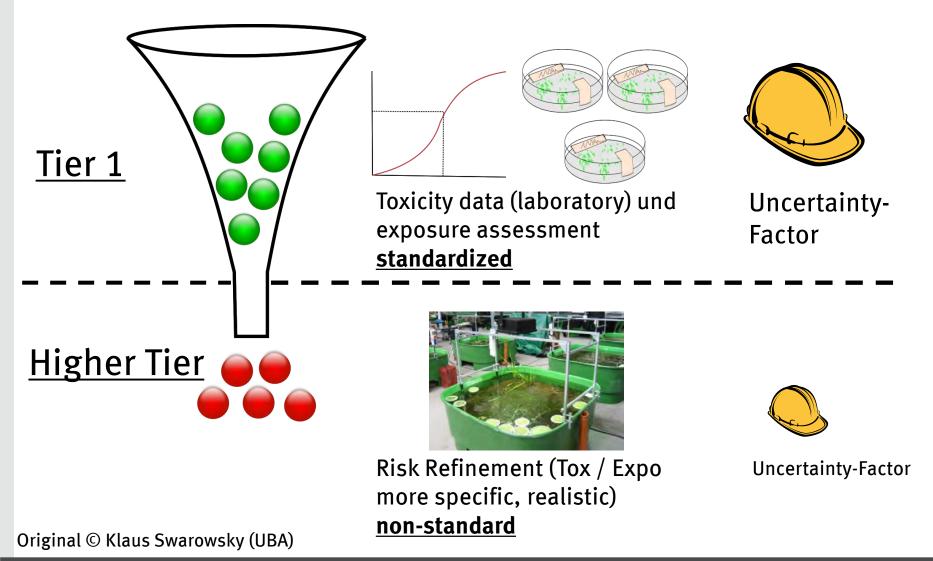
- in derivation considered: ecotox data, ~ bioavailability and natural background copper in German soils (8 – 42 mg/kg dw, median values)
- do not apply to agricultural soils regulatory coherence?
- copper pesticides: in-field soils are the major sink

Environmental Risk Assessment under 1107/2009/EC



- if TER at intended application rate above legally defined acceptability trigger (uncertainty factor) = risk acceptable
- BUT: relevant guidance document (SANCO 2002) not metalspecific (i.e. no consideration of soil accumulation and bioavailability)

Environmental Risk Assessment under 1107/2009/EC



15./16.11.2018

Exposure Assessment Copper Compounds (RAR 2017 + EFSA 2018)

Predicted environmental concentration, PEC_{soil} – e.g. <u>Grapes</u>:

- o application rate: 6000 g Cu/ha/year
- o soil layer: 5 cm
- soil bulk density: 1,5 g/cm³
- o no crop interception
- o no degradation, 10 years accumulation
- geo- and anthropogenic Cu background in soil (monitoring data vineyards soils: 10th Percentile 28 mg Cu/kg d.w. and 90th Percentile 160 mg Cu/kg d.w.)
- ▶ PEC_{plateau} (10 years, 10th Percentile soils): 108 mg Cu/kg d.w.
- ▶ PEC_{plateau} (10 years, 90th Percentile soils): 240 mg Cu/kg d.w.

Soil macro organism (earthworms and soil arthropods) – Tier 1

- o extensive set of acute and chronic toxicity data (lab studies)
- o chronic most relevant, earthworms most sensitive group

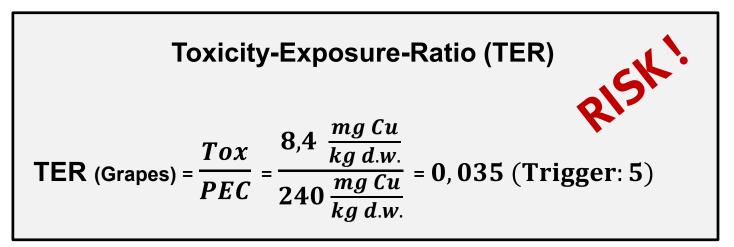
egulation (EU) I nex Part A, poi	Nº 283/2013, Anney			l nitrogen trans d Regulation (E		ubstance	Application method of	Time scale	End point	Toxicity (mg Cu/kg soil) ¹	Tes	t organism	Fest substance	Application	Time scale	End point	Toxicity (mg Cu soil) ¹	-	Test substance	1.1.1.1	Timesed	Pulsia	Territor (a. a.)		
Test organism	Test substance	Application	Time scale	End point	Toxicity (mg Cu/kg		test a.s./ OM ¹				ale	End point	Toxicity (mg (soil) ¹	Cu/kg				Test organism	1 est substance	method of test a.s./	Time scale	End point	Toxicity (mg Cu/ soil) ¹		
	1.00	method of test a.s./		5 m	soil)1	r salt	10%	Chronic 84 days	Growth	NOEC _g = 59.2			3011)		28 days	Reproduction	EC _{10, r} = 31 - 1 (21 values for	Folsomia	Copper chloride	OM ¹ 4.7%	21 days	Growth.	EC10 m (overall) =		
Earthworms	-	OM ¹		-		r chloride	10%	Chronic 28 days	Reproduction	$NOEC_{n(cp)} = 123.2$				_	28 days	Reproduction,	different soil ty EC _{50.r} (pH 6.0)	fimetaria				reproduction, mortality	828 EC _{10.m} (female) =		
Eisenia fetida	Copper oxychloride	OECD soil	Chronic 56 days	Reproduction	NOEC _{r(cp)} < 40.5	r chloride	10%	Chronic 84 days	Growth	EC ₅₀ > 100 NOEC ₂ = 62	5	Growth	35-day EC10, g			mortality	703.2 NOEC, (pH 6.0						519 EC _{10 m} (male) = EC ₁₀ , (overall)		
Eisenia andrei	Copper chloride	LUFA: 3.9%	Chronic 28 days	Reproduction	NOEC _{r(rp)} = 8.4 (LUFA 2.2 soil)	r chloride	-	Chronic 84 days	Mortality	NOEC _m = 162			63-day EC _{10. g} 451.7				203.2 NOEC _m (pH 6.) >3003.2						1090 EC ₁₀ , (overall) =		
		OECD: 10%			$\begin{split} &\text{NOEC}_{r(cp)} = 103.2\\ &(\text{OECD soil})\\ &\text{NOEC}_{r(p)} = 103.2\\ &(\text{OECD soil}) \end{split}$	r chloride	3.4-5.7%	Chronic 42 days	Growth, reproduction, mortality	NOEC ₁ = 54 NOEC ₁₀ = 54 NOEC ₈ = 131			42-day EC _{10, g} 322.7 70-day EC _{10, f} 465.7				EC _{50, r} (pH 5.0) 713.2 NOEC _r (pH 5.0						997 EC _{10,g} (overall) = 1242 EC _{10,g} = 352		
Eisenia fetida	Copper chloride	10%	Chronic 28 days	Reproduction	$NOEC_{r(p)} = 13.2$ (OECD soil) $NOEC_{r(p)} = 35.2$ (OECD soil) and	_			monany	NOEC _m = 131 NOEC _b = 63 NOEC _m = 136	2	Mortality, growth,	EC _{10, m} = 347 EC _{10, r} = 71				203.2 NOEC _m (pH 5.) 43.2 EC _{50,r} (pH 4.5)						EC ₁₀ > 2911 (hig background - historical Cu contaminated site		
				-	37.2 (LUFA 2.2 soil)	r chloride	9.8%	Chronic 294 days	Growth	$NOEC_g = 154$		reproduction	EC _{10, a} = 362 NOEC _m = 430			1.0	1483.2 NOEC, (pH 4.5	Folsomia fimetaria	Copper sulfate	4.5%	21 days	Reproduction			
Sisenia fetida	Copper chloride	4.7%	Chronic 21 days	Reproduction, growth	NOEC _g = 715 NOEC _t = 115	r chloride	0.5%	Chronic 110 days	Growth, mortality	NOEC _g = 76 NOEC _m = 153	_		$NOEC_x = 230$ $NOEC_x = 230$				1003.2 NOEC _m (pH 4.:	Folsomia fimetaria	Copper sulfate	4.5%	21 days		EC _{10, x} = 667		
Eisenia fetida	Cu oxychloride	10%	Chronic 28 days	Reproduction	NOEC _{r(cp)} = 83.2				mortanty			Mortality, grovin,	EC _{10, r} (soil 1) EC _{10, r} (soil 2)	= 107	4 lays	Reproduction,	≥3003.2 NOEC _r = 203.2	Isotoma viridis	Copper chloride	3.9%	56 days	Growth	NOEC ₅ (LUFA = 55.2 NOEC, (OECD)		
Eisenia fetida	Cu(NO3)2.3H2O	10%	Chronic 28 days	Reproduction	$NOEC_{t(cp)} = 28.2$	т sulfate	-	days	Meaning	$NOEC_m = 511$ $NOEC_{r(cp)} = 0.7$	-	represention	$E_{10,r}$ (soil 3) $E_{10,r}$ (soil 4)		2 lays	mortali	NOEC = 1003 NOEC = 803.1	Isopoda (Crustac	ar (athermoda)		-	-	403		
Eisenia fetida	Copper nitrate	10%	Chronic 56 days	Mortality, reproduction	LC ₅₀ = 555 NOEC _m = 202.4	_			reproduction	and a stepy	C		E 10, r (soil 5)		2 и 56 д	produ ion	OEC_g LUFA $(2) = 2$	Porcellio scaber	Copper chloride	1.	4 and 8	Growth	8-week LC ₅₀ = 2		
				reproduction	EC ₅₀ (cocoons) = 53.3 NOEC _{1(m)} = 12.4	τ sulfate	21.6%	Chronic 42 and 56 days	Orowan,	$OEC_g = 35.7$ NOEC _{r(cp)} = 80.7			NOEC : field transects: 418				(LUFA 2.2) = 4 56-day NOEC,	••			weeks		4-week EC _{10 g} (t mass gain) = 349		
	0		ct 0.23	-		r nitrate		Chronic 90	reproduction	NOEC _{n(cp)} = 100 (pH			689	10 2			(OECD) = 803.	Acari (Arachnica Platynothrus	Copper nitrate	3.9	90 days	Growth	NOEC _m ≥ 1498		
Eisenia fetida	Copper nitrate	10%	Chronic 21 days	Growth, reproduction, mortality	NOEC _{r(cp)} = 32.3 NOEC _g = 728.2 NOEC _m = 296.2	Tininate	7.7-11.7%	days	Reproduction	5.5) and 101.3 (pH 6.5)	1	Reproduction	EC ₅₀ (reprod., ≈ 70	11°C)			56-day NOEC, (OECD) = 403.	peltifer				Mortality and reproduction	$NOEC_g = 598$ $NOEC_g = 168$		
Eisenia fetida	Cu acetate		Chronic 28 days	Mortality	LC ₁₀ = 82.8 - 3717	r nitrate	7.7-11.7%	Chronic 120 days	Reproduction	4 month-NOEC (cocoon reduction)			EC_{50} (reprod., ≈ 160	18°C)	Not reported 21 days	Reproduction Growth	EC _{10, r} = 212 NOEC = 320 14-day EC _{10, r} =	Platynothrus peltifer	Copper chloride	3.9	70 days	Reproduction	NOEC ₁ = 68.2		
Eisenia fetida	CuCl ₂	-	Chronic 21 days	Growth, mortality	NOEC=300 (mortality and	r sulfate		Chronic 14		= 100 30 d - NOEC =153			EC_{50} (reprod., ≈ 180	25°C)	21 ways	reproduction, mortality	21-day EC _{10, r} = 21-day EC _{10, r} =	Hypoaspis aculeifer Hypoaspis	Copper chloride Copper chloride	3.9	21 days Not reported	Reproduction	EC ₁₀ = 179 EC _{10,7} = 2*		
Eisenia fetida	Copper chloride		Chronic 28	Reproduction	growth) EC _{10,r} = 54 - 324	1 Suitate	5.4-72%	and 30 days	Mortality	14 d - NOEC _m		Reproduction	EC10, r = 126.5				(male) = 850 21-day EC _{10, g}	aculeifer		3.0	.voi reponeu	Reproduction	NOEC ₁ = 320		
			days	Indicastan	(17 values for different soil types)					=1214	-	P 1.0	NOEC ₂ = 135 21-day EC _{10,2}	-			(female) = 547	Nematoda (Nema Plectus	Copper chloride	-			EC _{50, x(p)} = 165.		
Cisenia andrei	Unknown	3.7%	Chronic 28	Reproduction	EC10, = 159							Reproduction	180.2				21-day EC _{10, g} (juvenile) = 532	acuminatus	copper chierat		21 days	Reproduction	$NOEC_{n(p)} = 35.2$		
Eisenia andrei	Copper chloride	0.5%	days Chronic 28 days	Reproduction, mortality	NOEC ₁₀ = 192 NOEC ₁ = 192		crypti	cus			orted	Reproduction mortality	63-day EC _{10,r} EC _{10,r} = 55 EC _{10,m} = 62	= 90.2			(male and fema	NOEC and NOEC rep		OEC TOP NOEC	-197				

15./16.11.2018

3rd European Conference on Copper in Plant Protection

Earthworms – <u>Tier 1</u>

 Lowest toxicity endpoint: *Eisenia andrei* 28 d-NOEC (reproduction) = 8,4 mg Cu/kg d.w.

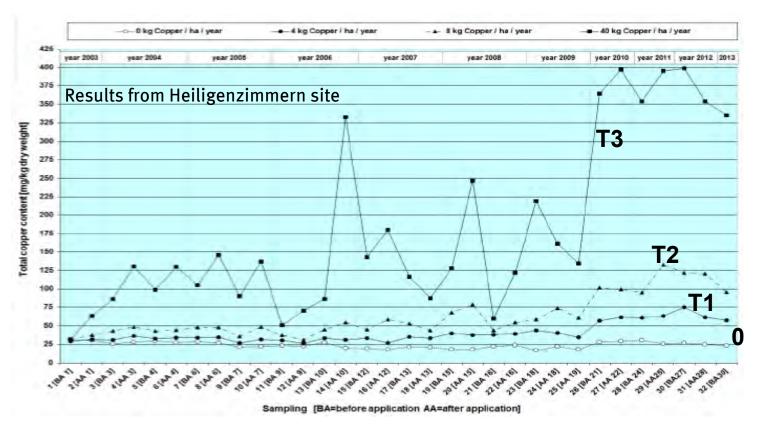


- BUT: Risk already at background soil copper !?
- BUT (as no guidance available): lab-to-field correction factor (4), normalization to reference soil (regression model), geomean approach, HC₅-SSD (species sensitivity distribution) proposed by notifier <u>not accepted</u>

Earthworms – Higher Tier (earthworm long-term field study)

- o 2 grassland-sites (SE Germany), start 11/2003 (data analysis: 10 years)
- o test substance: Copper Hydroxide WP (50%)
- o 3 applications per year (yearly treatment rate splitted)
- 3 treatments: 4 kg Cu/ha/y (T1) / 8 kg Cu/ha/y (T2) / 40 kg Cu/ha/y (T3), plus water control (negative) and reference toxicant (benomyl)
- 4 replicates per treatment
- o 4 samplings per replicate
- o 3 assessments per year
- Cu residue analysis (soil, earthworms)
- earthworm sampling (formalin extraction + hand sorting)
- o earthworm endpoints: abundance, species, biomass

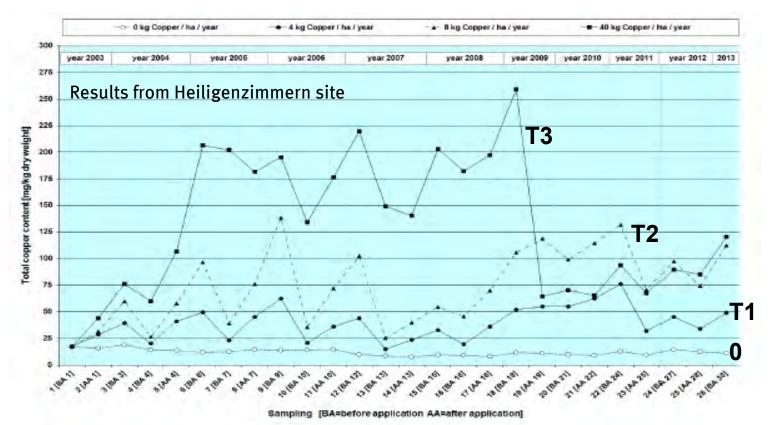
Earthworm long-term field study: Cu accumulation in soil (0-5 cm)



0 = Water (negative control)

T1 = 4 kg Cu/ha/year; T2 = 8 kg Cu/ha/year; T3 = 40 kg Cu/ha/year (stop in 2009)

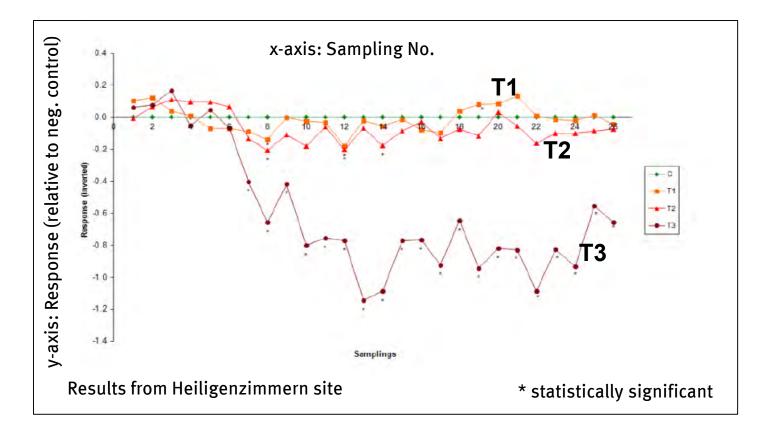
Earthworm long-term field study: Cu accumulation in earthworms



0 = Water (negative control)

T1 = 4 kg Cu/ha/year; T2 = 8 kg Cu/ha/year; T3 = 40 kg Cu/ha/year (stop in 2009)

Earthworm long-term field study: Community analysis (PRC)



T1 = 4 kg Cu/ha/year; T2 = 8 kg Cu/ha/year; T3 = 40 kg Cu/ha/year

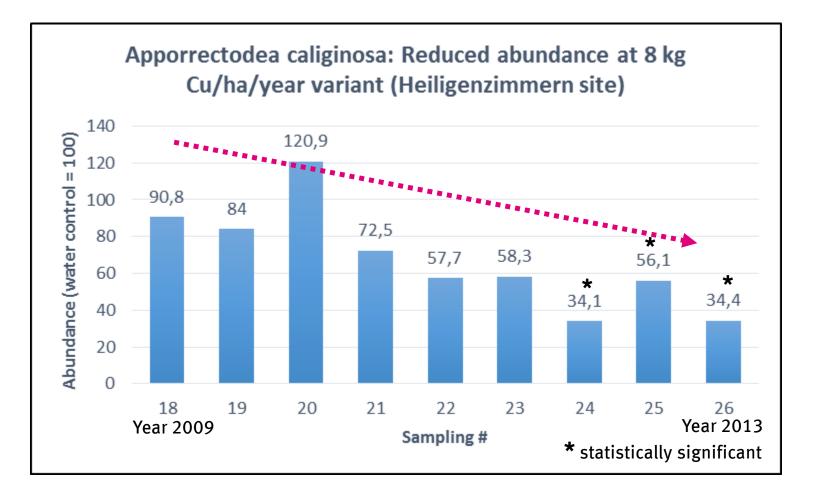
Earthworm long-term field study: Abundance (reduction compared to control)

reatment T1 (4 kg 1 2 opper/ha/year) 1 2 p. caliginosa . . chlorotica" . . rosea" .	3	4 5					_	_																															
p. caliginosa . chlorotica"	3	410		0	0	10 1	1 12	13	14 1	5 16	17	10 10	20	21	22		4 34	26	Result	s fr	0	m ł	Чe	ili	ge	en	Zİ	m	m	er	'n	Sİ	te						
. chlorotica"			0 /	ð	9	10 1	1 12	15	14 1	5 10	17	18 15	20	21	22 2	13 2	4 23	20							0														
			Π	(*)			(8)																																
rosea"	П		Π		\square																				_														
	Π		Π		П														T1	=	: 4	1 I	()	1 (С	LL.	/ł	าล	h	JE	22	٩r							
. terrestris	Π		\square		Π																		.5)	•				7	, ,									
. castaneus	Π		\square																						_														
. lacteum*	Π		Π		П									\square					T 2	? =	: 2	8 k	(0	1 (С	U	/r	1a	\	Ve	92	ar							
anylobous juveniles ⁿ	Π		\square																	-			12	,	Ū	•••			- J	, ,									
pilobous juveniles (*)																										_													
pigeic earthworms																			T3	5 =	- 4	40	k	C	(CI	U.	/h	a		Ve)a	r						
ndogeic earthworms				(*)			(8)				(*)											•••	-	J			• •••			2									
necic earthworms																																							
otal juvenile earthworms ⁿ																																							
otal adult earthworms				(*)			(*)																																
otal earthworms ⁿ																			G03N047N (Heiligen mmern)	_			_	_	_	_	_	Sam	plin	g	_		_	_		_	_	
																			treatment T3 (40 k <u>s</u> copper/ha/year)	1 2	3	4 5	6	7 8	9	10	11	12	13 1	4 1	5 10	5 17	18	19 2	20 21	22	23	24 25	5 26
G03N047N (Heiligenzimmern)								San	nplin;	3								-	Ap. caliginosa		Η		0	*) (*) (*)) (*)	(*)	(*)	*) (*	*) (°	<u> </u>) (*)	(*)	(*) (*)	*) (*) (*)	(*)	(*) (*) (⁸)
reatment T2 (8 kg	2	1 5	6 7		9	10 1	1 12	12	14 14	5 16	17 1	8 10	20	21	22.2	3 2	1 25	26	A. chlorotica ⁿ		+		++-	8 8	+	+	*	8	8 1	8 3	* *	*	*	*	8 *	*	*	* *	8
copper/ha/year)	3	4 5	0 /	0	9	10 1	1 12	15	14 1.	0 10	1/1	0 19	20	21	22 2	5 2	+ 25	20	A. rosea"				┼┼	+	+	+		+	+	+	+		H	+	+	\square	H	+	+
Ap. caliginosa			C	9 (*)		(*)	(*)							((*) (*	^r) (*) (*)	(*)	L. terrestris				C	*) (*	· · · ·		· · ·	(*) 8	8) (8	\$) ('	5	(*)	~	1.2		(*)		\bot	\Box
A. chlorotica"	Ħ	+	Ħ		Ħ		\top	\square					\square		+	t	\top		L. castaneus					C	기면	(*)	C	(9)			(*	1		(*)					
A. rosea"	Π		Π		П														O. lacteum"		Ħ		Ħ	+	+	\top			+	+	+		\square	+	+	\square	\square	+	+
L. terrestris	Π		(*	⁵)	Π								\square			Τ	\square	\square	tanylobous juveniles ⁿ		+		┼┼	+	+	+	\vdash	+	+	+	+	+	H	+	+	+	+	+	+
. castaneus		*) (*)		(*)	П		\square			\square			\square		\top	\top	\top		epilobous juveniles			(*)			(*)	(*)	(*)	(*) (*) (*	^{\$}) (1	[*]) (*) (*)	(*)	(*) (*) (*) (*)	(*)	(*) (*	²) (*)
D. lacteum ⁿ																			epigeic earthworms		Η		Ħ	(*	9 (*)) (*)	(*)	(*)	8 3	-	(*)	*	(*)	8 8	*	*	* *	
anylobous juveniles ⁿ																			endogeic earthworms		Π		C	*) (*) (*)	(*)	(*)	(*)	s) (*) (*	n (*	(*)	(*)	(*) (*) (*) (*)	(*)	(*) (*	") (*)
pilobous juveniles								((*)	(*)	(*)										+		e	*) (*	0 (*1	*	* (*)	8 (*) (8 8 *) (*	* × *) (*	* * *)	(*)	* (*)	8 1 (*)	8 *	(*)	*	* *	8
epigeic earthworms	(^{\$}) (^{\$})		(*)															anecic earthworms		+		Ц	1	*		Ľ	8		*	1	Ľ	1	~	+	Ľ	\square	+	+
endogeic earthworms				(*)		(*)		((*)		(*)			((*)				total juvenile earthworms ⁿ																				
anecic earthworms			(*	⁽)															total adult earthworms				0	*) (*	9 (*)	(1)	(*)	(*)	e) (9) (?	*) (*	(*)	(*)	(*) (*)	(*)	(*)	(*) (*) (°)
total juvenile earthworms ⁿ	\prod																		total earthworms ⁿ		+		\mathbb{H}^{3}	5 4	-	*	*	8	8 8	6 X	¢ *	*	*	*	5	*	*	* *	
otal adult earthworms				(*)		(*)	(*)				(*)								* significant for Tukey Test (p																				
otal earthworms"																			(*) significant for LSD Test (p n not evaluated because of lack		alie																		

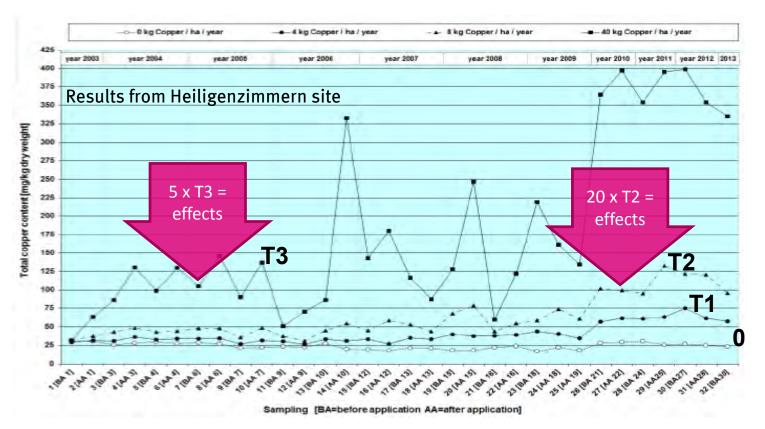
Earthworm long-term field study: Effects on Abundance (Ind./m²)

Results from Heiligenzimmern site	G03N047N (Heiligenzimmern)													Sa	mpl	ing															_																						
$\frac{\operatorname{engerhaven}{\operatorname{intervent}} + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 +$	treatment T1 (4 kg	,		, []		e l	ζ,	,	ö	0	10		10	12	14	15	16	17	10	10						4 4	15 /			Result	s f	ro	m	Н	lei	ili	ge	er	١Z	in	nr	n	er	'n	si	te)						
$\frac{h \cdot chronicar}{h \cdot creatrix} + \frac{h \cdot chronicar}{h \cdot creatrix} $	copper/ha/year)	1	4	" (°	1	2	0	1	ð	9	10	11	12	13	14	10	10	17	18	1B	1 21	2	1 2	4 4	5 4	4 1		20									0																
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Ap. caliginosa	Π		Τ				(*)				(8)								Γ	Τ		Τ		Τ	Τ																										
$\frac{L \ drents}{L \ drents} = \frac{1}{2} \ drents = $	A. chlorotica"	Π	T	T	T	T	T	T		1									\square	Γ	Γ	T	T	T	T	T	T										_																
$\frac{L \ drestrists}{D.\ drestrists}} = \frac{1}{D.\ drestrists} = \frac{1}{D$	A. rosea"	Π	T	T	T	T	T	T		1	1								Γ	Γ	Τ	T	T	T	T	T	╈	٦.		T1			Δ	k	C	1 (С		//	h	ิล	h	14	2	ar	1							
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	L. terrestris	H	T	t	T	╈	T	T	1	1	1			1					F	F	T	t	T	T	T	T	T		F				-	•••	.a		<u> </u>	^u			M	ני											
	L. castaneus	H	1	T	T	1	T	T		1	1								\square	T	T	t	T	T	T	T	T						_	-			_																
	O. lacteum"	Ħ	\top	T	T	+	T	T		+	1								\square	T	T	T	T	T	T	+	╈			. T2	2 =		8	k	C	(С	U	1/	h	a	h	le	22	ar	1							
endoger earthworns () () () () () () () () () (tanylobous juveniles ⁿ	H	T	t	T	╈	t	T	1	+	1			1					F	F	T	t	t	T	t	T	T				-		•	- 1	5						~				~ •								
endoger earlinvorns total juveniles earlinvorns total adult earlinvorns total adult earlinvorns total adult earlinvorns treatment T2 (8 kg copperha/var) Ac. caligniosa Ac. caligniosa Ac. caligniosa Ac. caligniosa A. chlorotica ^e A. c	epilobous juveniles	(*)	T	T	T	T	T											Γ	Г	Γ	T	T	T	T	T	T						_	_	-			_			_		-										
entoger entrivornis	epigeic earthworms	Π		Τ	T	T	T	T												Γ	Γ	Τ	T	T	T	T	T			T3	2 =		4	D	k	0	1 (С	U	ı/	h	a	h	Je	22	r	1						
total juvenile arthworms i </td <td>endogeic earthworms</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>(</td> <td>*)</td> <td></td> <td></td> <td></td> <td>(*)</td> <td></td> <td></td> <td></td> <td></td> <td>(*)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <th></th> <th></th> <th></th> <td></td> <td></td> <td>•</td> <td></td> <td></td> <td>J</td> <td>)</td> <td>-</td> <td></td> <td></td> <td>••</td> <td>~</td> <td></td> <td></td> <td></td> <td>••</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	endogeic earthworms							(*)				(*)					(*)															•			J)	-			••	~				••							
total adult earthworms I <thi< th=""> I I I</thi<>	anecic earthworms																																																				
total aarthworms* I <thi< th=""> I <thi< th=""> <</thi<></thi<>	total juvenile earthworms ^a																																																				
Treatment T2 (40 kg 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 25 25 25 26 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 <td>total adult earthworms</td> <td></td> <td></td> <td>Τ</td> <td>Τ</td> <td></td> <td></td> <td>(</td> <td>*)</td> <td></td> <td></td> <td></td> <td>(*)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Τ</td> <td></td> <td></td> <td></td> <td></td> <td></td> <th></th> <th></th> <th></th> <td></td>	total adult earthworms			Τ	Τ			(*)				(*)									Τ																															
G03N047N (Heiligenzimmern) Sumper/ha/year) I <th>total earthworms^a</th> <th></th> <th></th> <th>Τ</th> <th>Τ</th> <th></th> <th>Τ</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>2</th> <th></th> <th></th> <th></th> <th>_</th> <th>_</th> <th>_</th> <th></th> <th></th> <th>_</th> <th>_</th> <th>_</th> <th>_</th> <th>5</th> <th>sam</th> <th>plin</th> <th>g</th> <th>_</th> <th>_</th> <th>_</th> <th>_</th> <th></th> <th>_</th> <th>_</th> <th></th> <th>_</th>	total earthworms ^a			Τ	Τ																	Τ						2				_	_	_			_	_	_	_	5	sam	plin	g	_	_	_	_		_	_		_
GONMATN (Heligenzimmern) Understand I 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 12 23 2 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 12 23 24 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 12 23 24 25 3 4 4 4 4 4 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <th></th> <th></th> <th></th> <td>1</td> <td>2</td> <td>3 4</td> <td>5</td> <td>6 7</td> <td>8</td> <td>9</td> <td>1</td> <td>1</td> <td>1 1</td> <td>2 1</td> <td>3 1</td> <td>4 1</td> <td>5 1</td> <td>6 17</td> <td>18</td> <td>19</td> <td>20</td> <td>21</td> <td>22</td> <td>23</td> <td>24 2</td> <td>5 26</td>																															1	2	3 4	5	6 7	8	9	1	1	1 1	2 1	3 1	4 1	5 1	6 17	18	19	20	21	22	23	24 2	5 26
Interaction 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 12 23 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 12 23 2 1 4	G03N047N (Heiligenzimmern)	Г												Sar	npli	ing										7	5				╈	+	+		(*) (*) (*) (*) (*	0.0) (⁸	0.0	9 0	50	9 (*)	(181)	(*)	(*)	(*)	(*)	(*)	(*) (P) (*
Ap. caliginosa A. chlorotica" A. ch	treatment T2 (8 kg	1.1				<i>c</i>	2.	-			10		10			10		17	10	10	20			1.0		1.0						+	+		3	*	1					1	1	í li	1.	*	*	*	*	¥	*	*	4
Ap. caliginosa (*)	copper/ha/year)	1	2	3	4	5	0	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2.	22	2	4 2	5 2				╈	+	+			+	+	+	+	+	+	+	+	+	+	⊢	⊢	\vdash		+	+	+	+
A. chlorotica* A. rosea* A. rosea*<	Ap. caliginosa	Π		Τ	Τ		C	*) (*)		(*)		(*)										(*) (*) (*) (*	⁽⁾	9				1			(*		· · · ·		1	8	£1.	·) (*) (<u> </u>	<u> </u>	(*)	(*)			(*)		1	T
L. terestris L. de la la la la la la la la la la la la la	A. chlorotica"	Ħ	\uparrow	$^{+}$	$^{+}$	+	$^{+}$	$^{+}$	+	+	+	1	\neg	1					\vdash	\vdash	F							1		L. castaneus						C	계약	ηe	7C*	916	2			e	2		0						
L. terestris I <t< td=""><td>A. rosea"</td><td>Π</td><td></td><td>T</td><td>T</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Γ</td><td>Τ</td><td></td><th>1</th><th></th><th>O. lacteum"</th><td>Ħ</td><td>+</td><td>+</td><td></td><td></td><td>+</td><td>+</td><td>t</td><td>t</td><td>t</td><td>$^{+}$</td><td>$^{+}$</td><td>$^{+}$</td><td>$^{+}$</td><td>+</td><td>t</td><td>F</td><td></td><td></td><td></td><td>+</td><td>+</td><td>+</td></t<>	A. rosea"	Π		T	T																				Γ	Τ		1		O. lacteum"	Ħ	+	+			+	+	t	t	t	$^{+}$	$^{+}$	$^{+}$	$^{+}$	+	t	F				+	+	+
O. lacteum* I <th< th=""><th>L. terrestris</th><th>Π</th><th></th><th>Τ</th><th>T</th><th></th><th>(</th><th>*)</th><th>T</th><th>T</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>Γ</th><th>Τ</th><th>Τ</th><th>Τ</th><th>Τ</th><th>Τ</th><th>Τ</th><th>1</th><th></th><th></th><th>╈</th><th>+</th><th>+</th><th></th><th></th><th>+</th><th>+</th><th>+</th><th>+</th><th>+</th><th>+</th><th>+</th><th>+</th><th>+</th><th>+</th><th>⊢</th><th>⊢</th><th>\vdash</th><th></th><th>+</th><th>+</th><th>+</th><th>+</th></th<>	L. terrestris	Π		Τ	T		(*)	T	T											Γ	Τ	Τ	Τ	Τ	Τ	Τ	1			╈	+	+			+	+	+	+	+	+	+	+	+	+	⊢	⊢	\vdash		+	+	+	+
tanylobous juvenilesII	L. castaneus	Π		(⁽⁾)(*)	T	(*)												Γ	Τ	T		T	T		1		epilobous juveniles				(*)			(*) (*) (*	[:]) (*	•) (*) () (^h) (*	9 (*)	(*)	(*)	(*)	(*)	(*)	(*)	(*) (*) (*)
epilobous juvenilesIII	O. lacteum ⁿ	Π																							Γ			1		epigeic earthworms	+	+	+			(*) (*) (*) (*)(*)		۲	(*	9	*	(*)	8	*	*	*	*	
epilobous juveniles i	tanylobous juveniles ⁿ	\Box																												endogeic earthworms			\top		(*) (*) (*) (*) (*) (°	') (*) (°	9 (°	9 (*	9 (*)	(*)	(*)	(*)	(*)	(*)	(*)	(*) (²) (*)
epigeic earthworms (*) </td <td>epilobous juveniles</td> <td>П</td> <td></td> <td>Ι</td> <td></td> <td></td> <td>Ι</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>(*)</td> <td></td> <td>(*)</td> <td>(*)</td> <td></td> <td></td> <td></td> <td>Γ</td> <td></td> <td></td> <td>Γ</td> <td></td> <td></td> <th></th> <th></th> <th></th> <td>╈</td> <td>+</td> <td>+</td> <td></td> <td>0</td> <td>3 (*</td> <td>0.0*</td> <td>10</td> <td>) (*</td> <td>0.0</td> <td>0 (0</td> <td>2 0</td> <td>20</td> <td>* ×</td> <td>(*</td> <td>- 18 (10)</td> <td>* (*)</td> <td>8</td> <td>*</td> <td>*</td> <td>*</td> <td>*</td> <td>1 8</td>	epilobous juveniles	П		Ι			Ι								(*)		(*)	(*)				Γ			Γ						╈	+	+		0	3 (*	0.0*	10) (*	0.0	0 (0	2 0	20	* ×	(*	- 18 (10)	* (*)	8	*	*	*	*	1 8
change cardworms column col	epigeic earthworms			(₿) (*)		(*)																					anecic earthworms	++	+	+		Ì	1	*	1	1	1.	1	1	1	1	<u> </u>		Ľ			~	\rightarrow	_	+
total juvenile earthworms ^a	endogeic earthworms							((*)		(*)				(*)			(*)					(*)						total juvenile earthworms*																							
total juvenile earthworms* i i i i i i i i i i total adult earthworms (*)	anecic earthworms						(1	*)																						total adult earthworms					- C	9 (*) (*) (*) (*	9 (*) (*	9.0	9.0	9 (*	9 (*)	(*)	(*)	(*)		(*)	(*)	(*) (⁹) (*)
total adult earthworms (*) (*) (*) * significant for Tukey Test ($p \le 0.05$)	total juvenile earthworms ⁿ																														╀	+	+		8	: *	+	*	*	8	1	: ×	1	\$ X	* *	*	*	8		*	*	* :	1 8
total surface and the surface of th	total adult earthworms	Π	T	T	T		T	((*)		(*)		(*)					(*)													0.05)					_	_	-	-	-		_	-	-		-	-				_		_
total earthworms ⁿ (\forall) significant for LSD feet ($\beta \leq 0.05$) ⁿ not evaluated because of lack of normality		++	\rightarrow	+	_	_	_	_	_	-	_	_	_	_	_	_		-	-	-	+	+	+	-	+	_	_	-																									

Earthworm long-term field study: Effects on Abundance (Ind./m²)



Earthworm long-term field study: The repeated dose makes the poison



0 = Water (negative control)

T1 = 4 kg Cu/ha/year; T2 = 8 kg Cu/ha/year; T3 = 40 kg Cu/ha/year (stop in 2009)

Earthworm Risk Assessment – <u>Conclusion</u> RMS + EFSA (1):

"(...) taking into account all the effects observed (...) in the <u>field study</u> at 8 and 40 kg/ha/y, and the slight effects observed at 4 kg/ha/y, <u>a no observed adverse effect</u> <u>concentration (NOAEC) of 4 kg Cu/ha/y</u> <u>should be set for earthworms</u>."

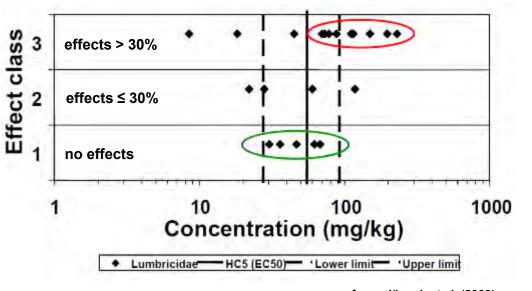
Earthworm Risk Assessment – <u>Conclusion</u> RMS + EFSA (2):

Available <u>field monitoring data</u>:

"Those studies give indication of an effect of copper content in soil on earthworm species abundance and diversity especially for endogeic earthworm's species, such as *Aporrectodea caliginosa* for soils with total copper content <u>> 100 mg Cu/kg d.w."</u>

Effect/ Risk Assessment Copper Compounds

Literature review (2009) commissioned by UBA



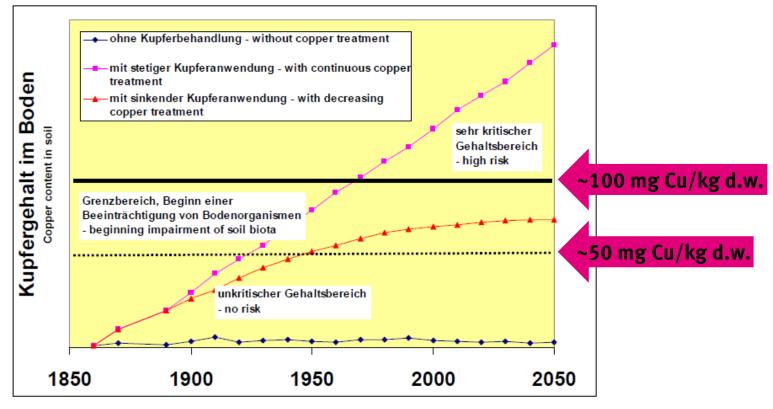




- field effects on earthworm populations (and other soil macro-organism)
- reduced abundance and species diversity at \geq 50 mg/kg

Copper fungicides - The repeated dose makes the poison (Frische, UBA)

Outlook "The repeated dose..."



copied from: Journal für Kulturpflanzen, Band 61 (4) 2009

• Where do we go in the upcoming (seven) years?

Thank you.

tobias.frische@uba.de

Umwelt 🎲 Bundesamt

Representative PPPs and intended uses

FUNGURAN OH 50 WP (Copper hydroxide), NORDOX 75 WG (copper oxide), CURENOX 50 WG (copper oxychloride), CUPROXAT SC (tribasic copper sulfate) POLTIGLIA CAFFARO 20 DF NEW (Bordeaux mixture)

Crop/ crop group	Application method	Spray volume [L/ha]	Maximum individual application rate [kg a.s./ha]	Number of applications	Application timing (growth stage)
Vineyards	Airblast sprayer	400-1000	1.25	8 (7-d interval)	BBCH 12-89
Vineyards	Airblast sprayer	400-1000	1.25	3 (21-d interval)	BBCH 91-11
Tomato	Foliar spraying	200-1000	0.85	8 (7-d interval)	BBCH 10-89
Cucurbits	Foliar spraying	200-1500	0.85	8 (7-d interval)	BBCH 10-89

Maximum total rate per year (kg Cu/ha/year)

- **Grapes: 6.0 (8.0)** = flexible dosing regime: max. 30 kg Cu/ha/year in any rolling 5 year period and 8 kg Cu/ha/year in any single year
- Tomato/Cucurbits: 6.0