ØKOTOKSIKOLOGISKE JORDKVALITETSKRITERIER

20 års stilstand i Danmark

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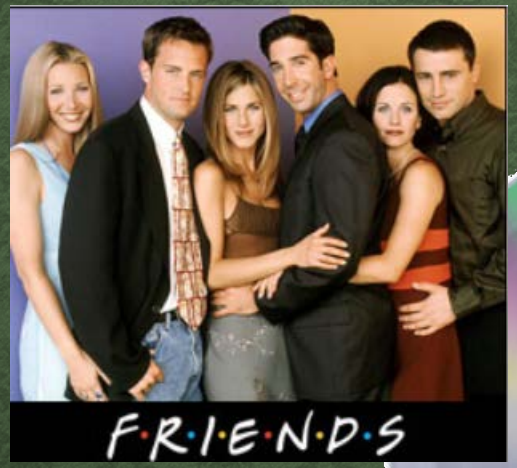
Miljøvurdering af forurenede grunde Del I

THOSE WERE THE DAYS.....



Short
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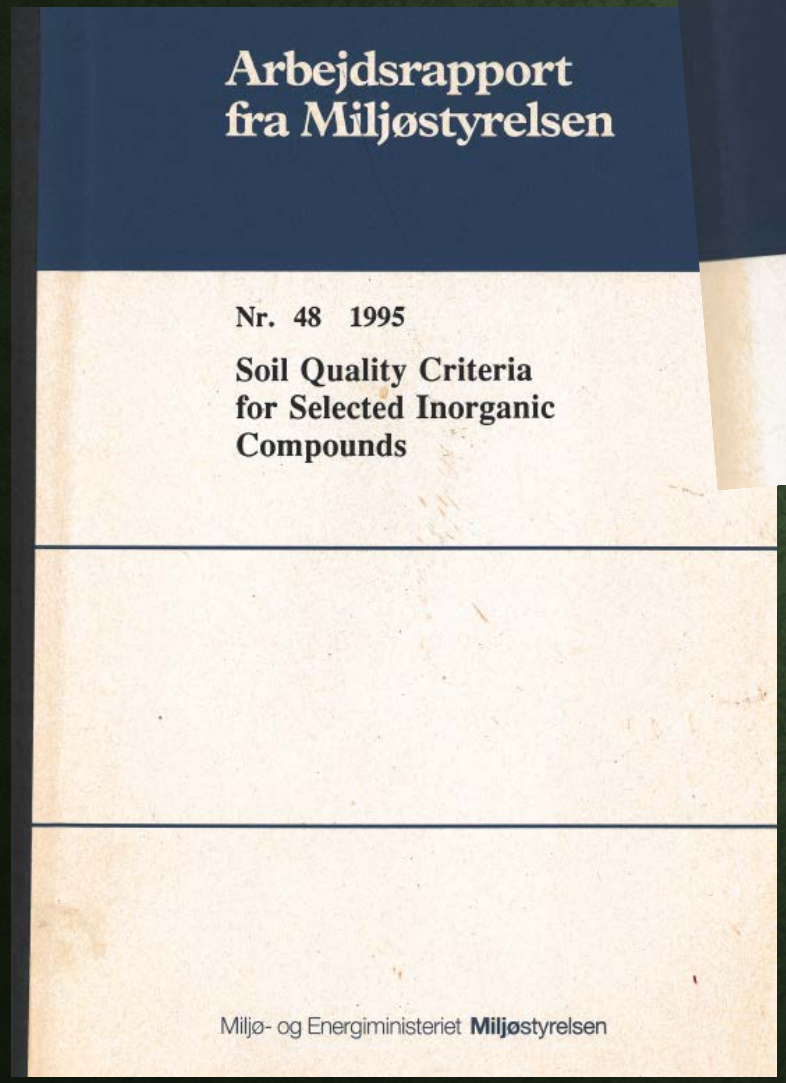
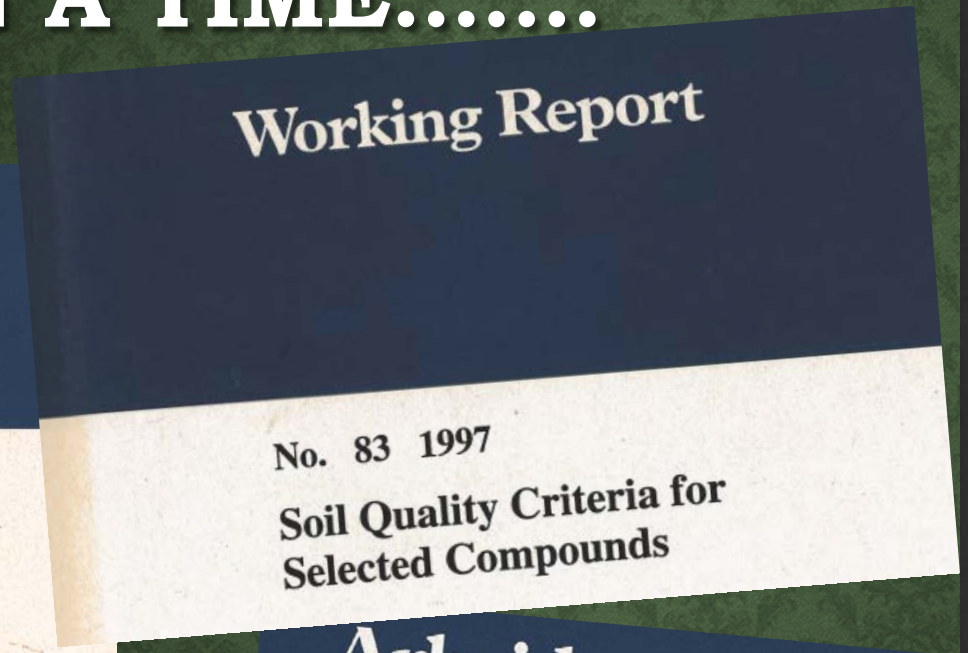
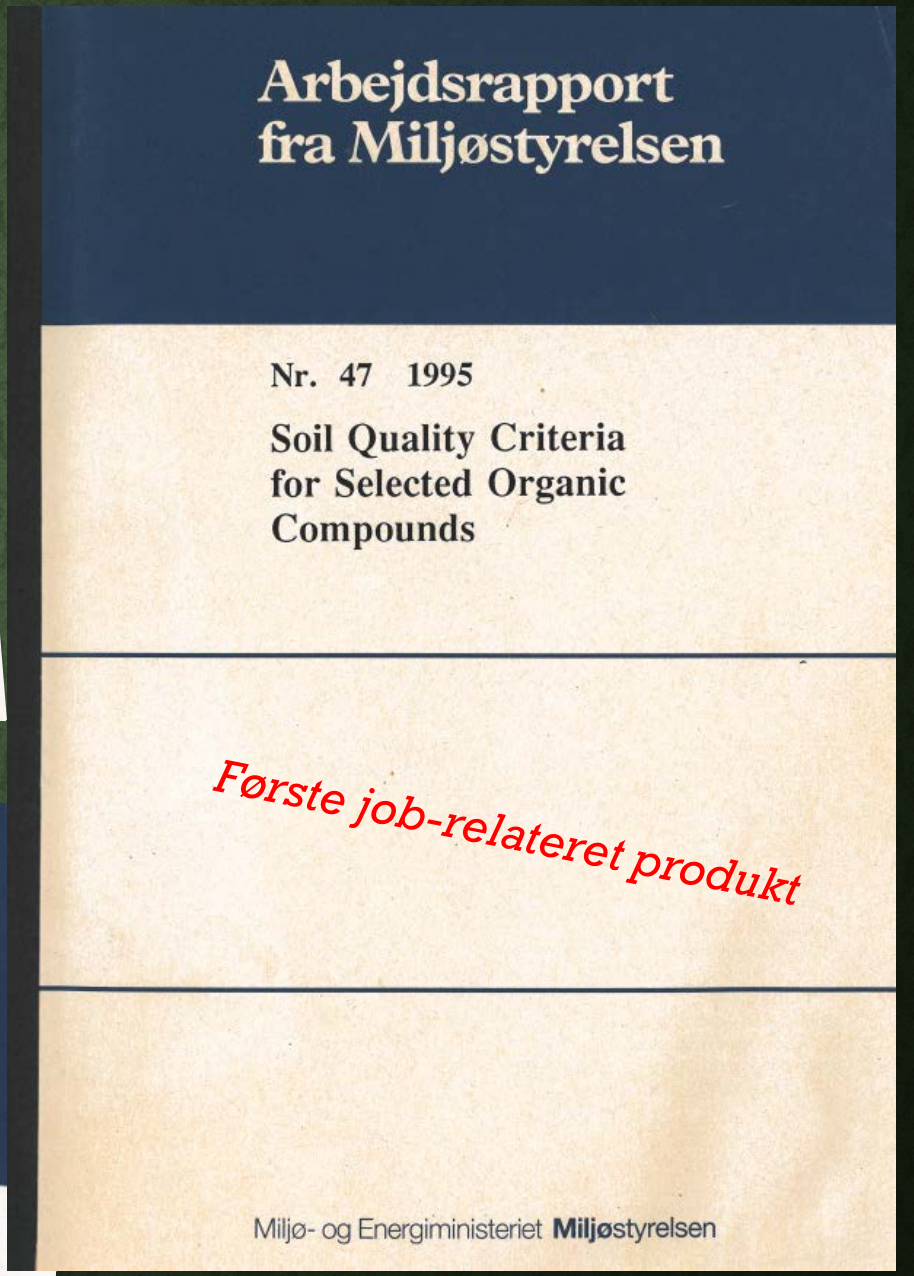
ONCE UPON A TIME.....







DK - FIRST MOVERS

- Udvikling af JKK blev i starthalvfemserne drevet af bl.a. Holland (RIVM)
- Danmark fulgte trop og samarbejdede med bl.a. RIVM
- De første udgaver af SSD (mere følger) var bl.a. udviklet af Hans Løkke (DMU)
- Hovedfokus var spildevandsslam og landbrugsjord og i mindre grad forurenede grunde
- Første runde (1995) inkl. metaller, LAS, PAH, B(a)P og klorphenoler
- Anden runde (1997) inkl. flere metaller, PCB, klorbenzener, nonylphenol og phthalater
- Holland introducerede to økotoksikologiske JKK: Target Value og Intervention Value
- Danmark fravalgte at udvikle et miljøbaseret afskæringskriterium

JKK OG SPILDEVANDSLAM

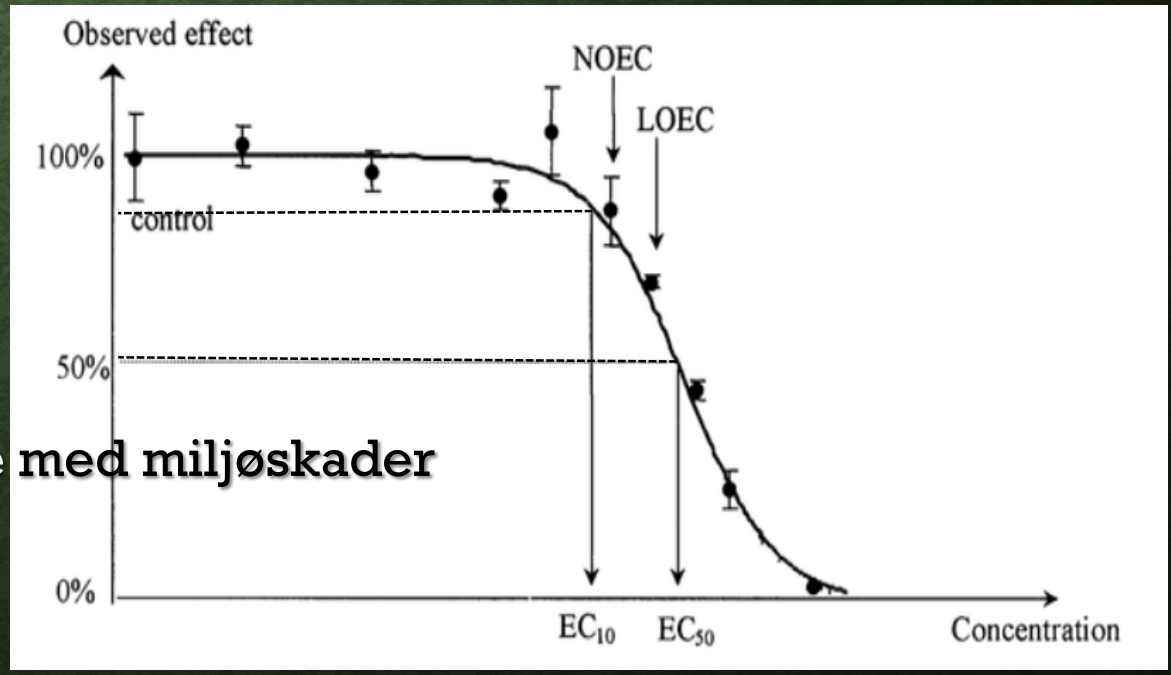
- Afskæringsværdi for LAS i slam er baseret på JKK
- Afskæringsværdi for PAH i slam er baseret på optag i afgrøder
- JKK for NP og DEHP er udviklet efter at afskæringsværdier i slam var fastsat

MILJØKVALITETSKRITERIER
MILJØKVALITETSKRAV

Hvordan fastsættes de?

MILJØKVALITETSKRITERIER/KRAV

- Økotoksikologiske data fra simple test med arter eksponeret til en koncentrationsserie
- Målparametre skal have påvist effekt på populationsniveau
- Typisk få ”laboratorie” arter testet
- Ekstrapolation nødvendig for at beskytte de mange naturlige arter i økosystemer
- MKK fastsættes på baggrund af såkaldt PNEC
- PNEC fastsættes ved én af to metoder
- Udgangspunkt er ”nul-effekt” doser
- ”Nul-effekt” ≈ EC10 / NOEC
- En overskridelse af JKK er IKKE ensbetydende med miljøskader



TESTORGANISMER I JORD















Måleparametre:

- Død
- Reproduktion
- Vækst / Biomasse
- N/C omsætning

OECD/OCDE

232

Adopted:
7 September 2009

OECD GUIDELINES FOR TESTING CHEMICA

Collembolan Reproduction Test in Soil

OECD/OCDE

220

Adopted :
13 April 2004

OECD GUIDELINES FOR THE TESTING OF CHEMICALS

Enchytraeid Reproduction Test

OECD/OCDE

216

Adopted:
21st January 2000

OECD GUIDELINE FOR THE TESTING OF CHEMICALS

Soil Microorganisms: Nitrogen Transformation Test

OECD/OCDE

208

Adopted:
19 July 2006

OECD GUIDELINES FOR THE TESTING OF CHEMICALS

Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test

OECD/OCDE

222

Adopted :
13 April 2004

GUIDELINE FOR THE TESTING OF CHEMICALS

Earthworm Reproduction Test (*Eisenia fetida/ Eisenia andrei*)

MILJØKVALITETSKRITERIER/KRAV

- Få data = Stor usikkerhed → Brug af faktormetoden (AF metode)
- Data fra mange arter = Mindre usikkerhed = rimelig forståelse af arternes følsomhedsfordeling → SSD metoden
- Akvatiske arter er ofte velundersøgte
- Jordlevende arter er ofte sporadisk undersøgte
- Sedimentlevende arter er som oftest dårligt undersøgt

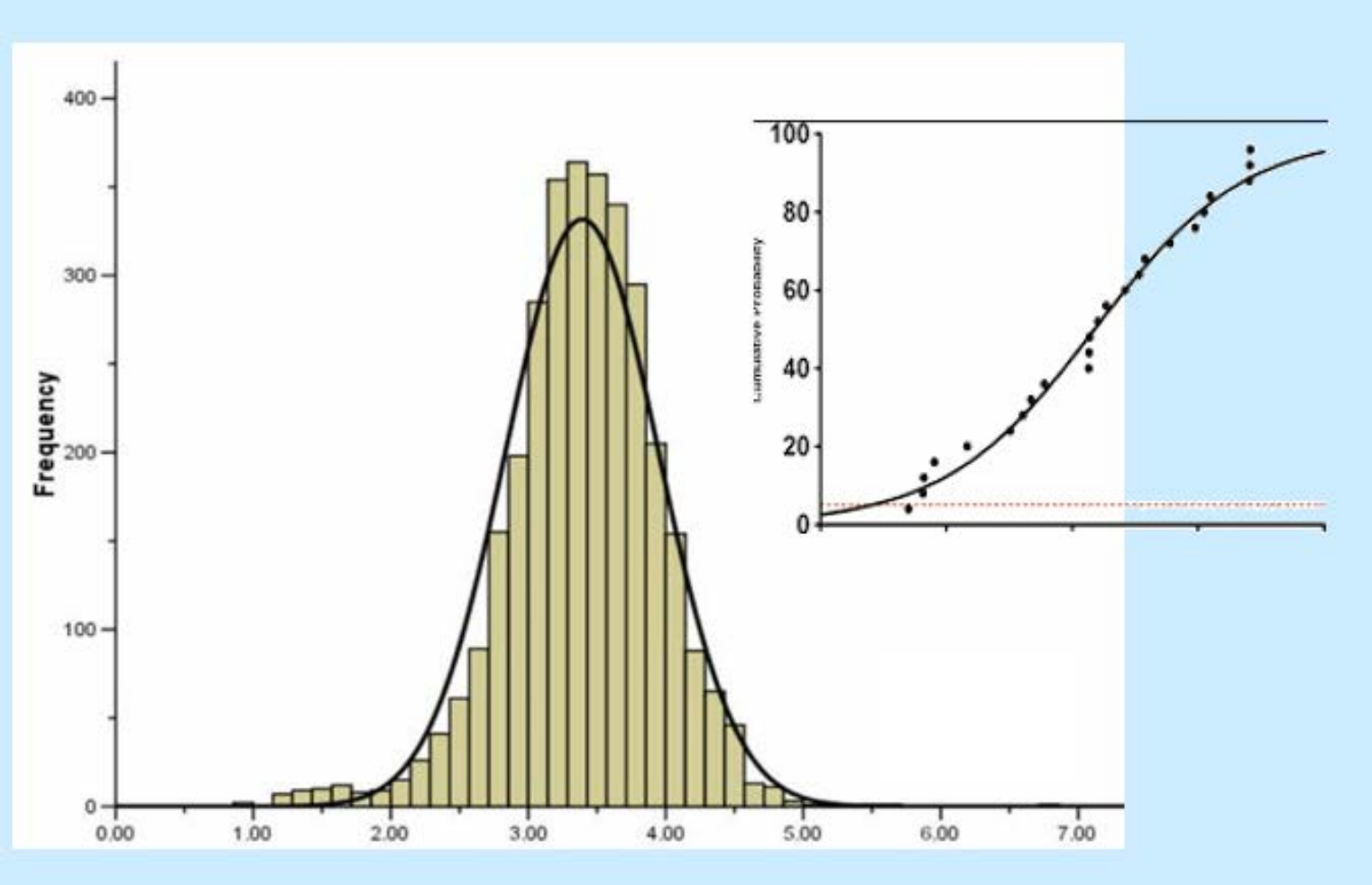
PREDICTED NO-EFFECT CONCENTRATION

$$JKK = PNEC = \frac{LCx/ECx}{AF}$$

Table R.10-10 Assessment factors for derivation of $PNEC_{soil}$

Information available	Assessment factor
L(E)C50 short-term toxicity test(s) (e.g. plants, earthworms, or microorganisms)	1000
NOEC for one long-term toxicity test (e.g. plants)	100
NOEC for additional long-term toxicity tests of two trophic levels	50
NOEC for additional long-term toxicity tests for three species of three trophic levels	10
Species sensitivity distribution (SSD method)	5 – 1, to be fully justified on a case-by-case basis (cf. main text)
Field data/data of model ecosystems	case-by-case

SPECIES SENSITIVITY DISTRIBUTION



ETX 2.2 by rivm

Normal Distribution based
Hazardous Concentration and Fraction Affected

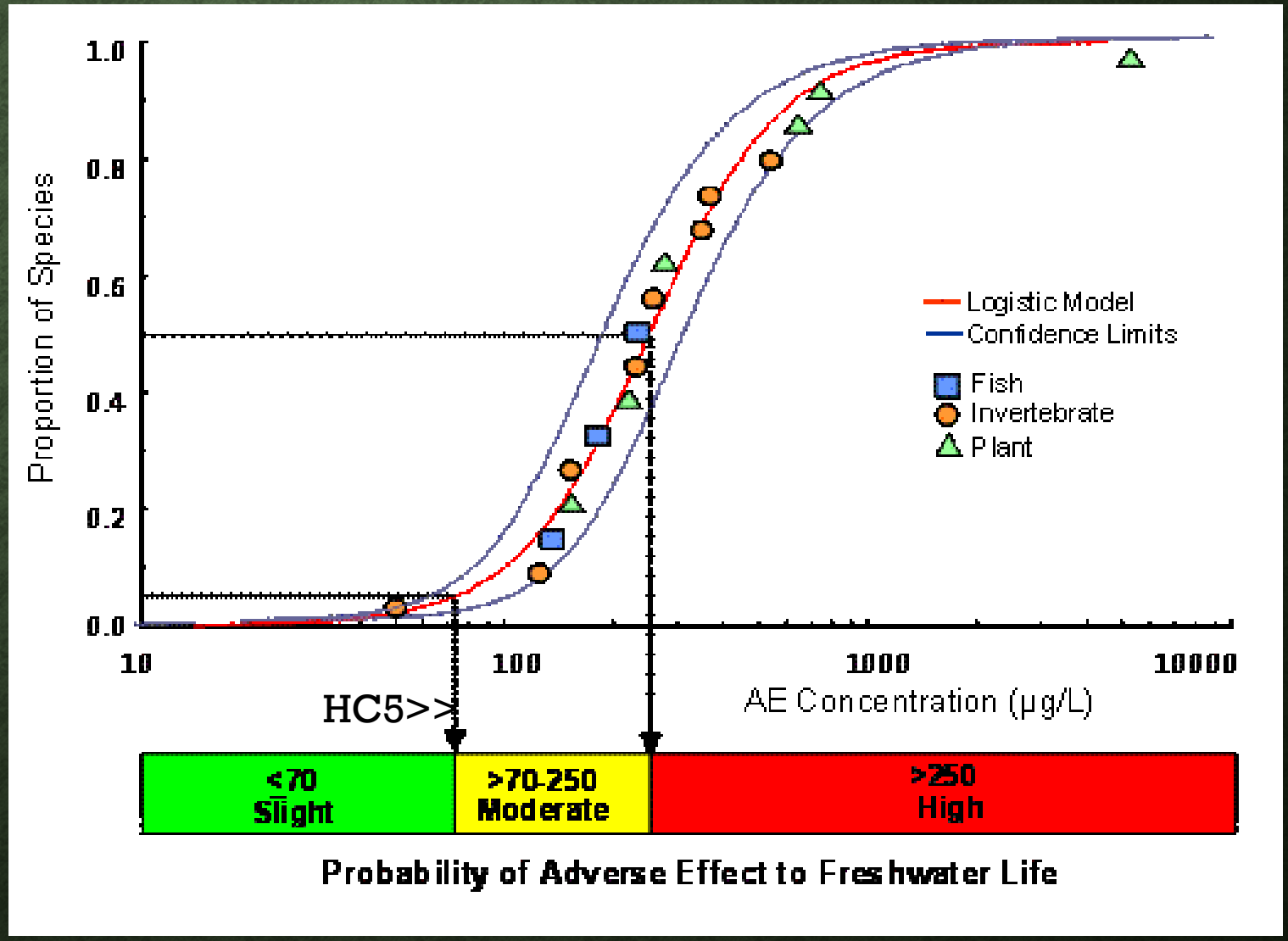
Companion software to Aldenberg and Jaworska (2000) and Aldenberg and Luttik (2002)

Design and idea	Tom Aldenberg, Peter van Vlaardingen, Theo Traas
Design and programming	Arjen Wintersen
License	The ETX software is free of charge. The software itself may not be sold or traded.
Copyright	RIVM 2017

Start

SPECIES SENSITIVITY DISTRIBUTION

JKK = PNEC = HC5/AF
AF = 1-5



EKSEMPLER

PAH, kobber & zink

JKK FOR PAH - GENBESØGT

- Upræcist JKK på ∑1,0 mg/kg
- Human JKK på ∑ 4/40 mg/kg
- Flere nye studier i start 00'
- Line Sverdrup, PhD; DMU
- Steven Droge, PhD; UvA
- EU RAR 2008

Tabel 0.1. Økotoksikologiske jordkvalitetskriterier (mg/kg tørvægt) som de er foreslået i denne rapport samt den publicerede PNEC-værdi i EUs risikovurdering af PAH-stoffer (EU-RAR 2008)

Sektion	PAH	PNEC i EU-RAR* (mg/kg)	Forslag til jordkvalitetskriterium (mg/kg)
3.1	Acenaphthen	0,038	0,03
3.2	Acenaphthylen	0,29	0,2
3.3	Anthracen	0,13	0,05
3.4	Benz(a)anthracen	0,079	--
3.5	Benz(ghi)perylen	0,17	--
3.6	Benz(a)pyren	0,053	8,5
3.7	Benz(b+j+k)fluoranthen	0,28+	--
3.8	Chrysen	0,55	--
3.9	Dibenz(a,h)anthracen	0,054	--
3.10	Flouren	1,0	0,8
3.11	Fluoranthen	1,5	1,3
3.12	Indeno(1,2,3-cd)pyren	0,13	--
3.12	Naphthalen	1,0	1,1
3.13	Perylen	---	--
3.14	Phenanthren	1,8	2,3
3.15	Pyren	1,0	0,8

+ *Benz(b)fluoranthen*
* *Se appendix A*

Miljøministeriet
Miljøstyrelsen

Økotoksikologiske jordkvalitetskriterier for PAH

John Jensen

Aarhus Universitet
Institut for Bioscience

Miljøprojekt Nr. 1394 2011

FLUOREN

- Laveste EC10 = 7,7 mg/kg
- Tre trofiske niveauer: AF=10
- PNEC = 7,7 / 10 = 0,77 mg/kg
- JKK = 0,8 mg/kg
- EU RAR: PNEC= 1,0 mg/kg (2% OC)

Tabel 3.2. Effektværdier for fluoren.

Art	Toksicitetsmål	Værdi, mg/kg	Reference
1. Mikroorganismer	Nitrifikation, EC10	33	Sverdrup m.fl. 2002
2. Rødkløver	Biomasse, EC20	76	Sverdrup m.fl. 2003
3. Rajgræs	Biomasse, EC20	350	Sverdrup m.fl. 2003
4. Enchytraer	Reproduktion, EC10	25	Sverdrup m.fl. 2002
5. Springhale	Reproduktion, EC10	7,7	Sverdrup m.fl. 2002

PYREN

- Laveste EC10 = 10 mg/kg
- Laveste NOEC = 5 mg/kg
- Tre trofiske niveauer: AF=10
- PNEC = 7,5 / 10 = 0,75 mg/kg
- JKK = 0,8 mg/kg
- EU RAR: PNEC= 1,0 mg/kg (2% OC)

Tabel 3.5. Effektværdier for pyren

Art	Toksicitetsmål	Værdi, mg/kg	Reference
1. Mirkoorganismer	Nitrifikation, EC10	130	Sverdrup m.fl. 2002
2. Rødkløver	Biomasse, EC20	56	Sverdrup m.fl. 2003
3. Gul sennep	Biomasse, EC20	810	Sverdrup m.fl. 2003
4. Enchytraer	Reproduktion, EC10	11	Sverdrup m.fl. 2002
5. Springhale (*F. fernitaria*)	Reproduktion, EC10	10	Sverdrup m.fl. 2002
6. Springhale (*F. candida*)	Reproduktion, NOEC	5*	Herbert m.fl. 2004
7. Springhale (*F. candida*)	Reproduktion, EC10	11,3*	Droge m.fl. 2006
8. Regnorm	Reproduktion, NOEC	40	Brown m.fl. 2004

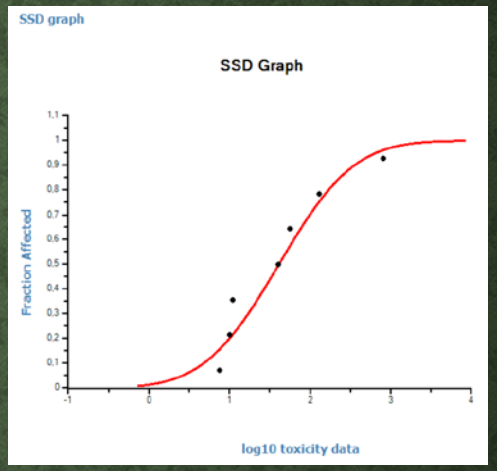
**Da det antages, at EC10 og NOEC værdier er sammenlignelige, hvorved den geometriske middelværdi på 7,5 mg/kg fra de to studier med springhalen* F. candida *bruges i den videre fastsættelse af jordkvalitetskriteriet.*

PYREN – ALTERNATIVE TAKES

- PNEC = laveste NOEC = 5,0 /10 = 0,5 mg/kg
- PNEC = HC5/AF = HC5/5 = 2,23/5 = 0,45 mg/kg
- PNEC = LLHC5 = 0,14 mg/kg
- JKK = 0,5 mg/kg

Input toxicity data

Data no.	Toxicity data
1	130
2	56
3	810
4	11
5	10
6	7,5
7	40



HC5 results

Name	Value	log10 (Value)	Description
LL HC5	1,356E-1	-8,678E-1	lower estimate of the HC5
HC5	2,234E0	3,491E-1	median estimate of the HC5
UL HC5	8,733E0	9,411E-1	upper estimate of the HC5
sprHC5	6,441E1	1,809E0	spread of the HC5 estimate

Toxicity data

Anderson-Darling test for normality

Sign. level	Critical	Normal?
0,1	0,631	Accepted
0,05	0,752	Accepted
0,025	0,873	Accepted
0,01	1,035	Accepted

AD Statistic: 3,70E-1
n: 7

Note: below n=8, this test may not perform well.

Kolmogorov-Smirnov test for normality

Sign. level	Critical	Normal?
0,1	0,819	Accepted
0,05	0,895	Accepted
0,025	0,995	Accepted
0,01	1,035	Accepted

KS Statistic: 6,26E-1
n: 7

Note: below n=20, this test may not perform well.

Cramer von Mises test for normality

Sign. level	Critical	Normal?
0,1	0,104	Accepted
0,05	0,126	Accepted
0,025	0,148	Accepted
0,01	0,179	Accepted

CM Statistic: 3,64E-2
n: 7

Note: below n=20, this test may not perform well.

KOBBER

- DK JKK = 30 mg/kg (1995)
- DK Human JKK = 500 / 1000 mg/kg
- Voluntary RAR = Ingen konsensus i EU

EU VOLUNTARY RAR - 2008

European Union Risk Assessment Report

VOLUNTARY RISK ASSESSMENT OF COPPER, COPPER II SULPHATE PENTAHYDRATE, COPPER(I)OXIDE, COPPER(II)OXIDE, DICOPPER CHLORIDE TRIHYDROXIDE

CAS No: 7440-50-8, 7758-98-7, 1317-3-1, 1317–38–0, 1332-65-6
EINECS No: 231–159–6, 231–847–6, 215-270-7, 215–269–1, 215-572-9

Responsible for this voluntary risk assessment : European Copper Institute (ECI)
Contact person: Dr. Katrien Delbeke, European Copper Institute, Brussels, Belgium
e-mail: kmd @eurocopper.org

Review country for this voluntary risk assessment : Italy
Contact person: Dr. Roberto Binetti , Istituto Superiore di Sanità, Rome, Italy
e-mail: binetti@iss.it

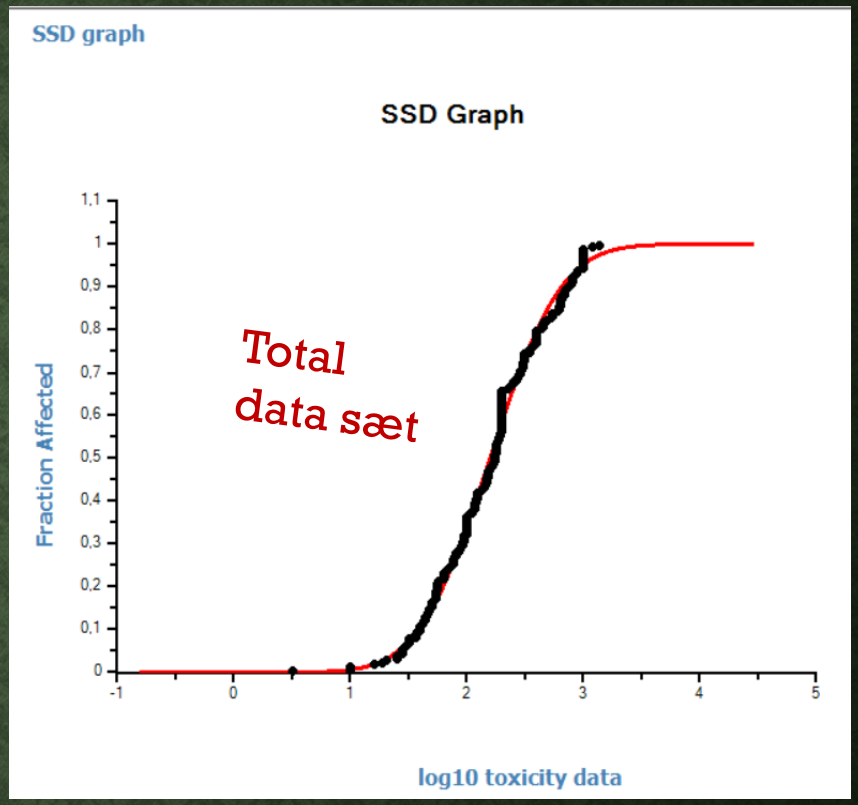
KOBBER

Kæmpe data set i EU RAR

- Plants: 68 NOEC/EC10 values, 9 different species and 5 different families
- Invertebrates: 105 NOEC/EC10 values, 12 different species and 6 different families
- Microbial processes : 78 NOEC/EC10 values; 9 endpoints: 6 different functions representing the C- and N-cycle

KOBBER

- SSD total data vs. SSD ét data per art
- HC5 (total) = 25,7 mg/kg
- AF = 2
- PNEC = 12,86 mg/kg
- JKK = 13 mg/kg



- Middelkoncentration i danske landbrugsjorder = 11,7 (+- 3,9) mg/kg

National monitoring study in Denmark finds increased and critical levels of copper and zinc in arable soils fertilized with pig slurry☆

John Jensen*, Martin Mørk Larsen, Jesper Bak

Department of Bioscience, Aarhus University, Denmark

KOBBER

DK JKK = 30 mg/kg

EU RAR:

- NOEC normaliseres ift. biotilgængelighed i forskellige jordtyper
- AF = 1
- HC5 = PNEC = 73,1-172,8 mg/kg
- Ikke anerkendt af alle EU medlemmer (herunder MST)

For the normalisation of the ecotoxicity data, first the leaching-ageing factor (of x2) was applied on all added NOEC/EC10 values. These adjusted values were subsequently normalised to representative EU soils using the relevant regression models, generating so soil type specific HC5-50 values.

A Species Sensitivity Distributions was constructed using the normalised NOEC/EC10 data. Using the SSD fitting model which results in the smallest uncertainty around the HC5, the median fifth percentile (HC5-50) was derived. The HC5-50 values ranged between **73.1 and 172.8 mg Cu/kgdw** for the defined soil types using the best-fitting model and between 78.9 and 172.8 mg Cu/kgdw using the log-normal model.

ZINK

- DK JKK (1995) = 100 mg/kg
- DK Human JKK = 500/1000 mg/kg

EU RAR

- PNEC er beregnet som tilført zink (dvs. foruden baggrund)
- PNEC beregnet på baggrund af SSD
- Separate SSD for mikroorganismer og planter/invertebrater
- PNEC = HC5/AF
- AF = 2 for planter/invertebrater
- AF = 1 for mikroorganismer
- PNEC = 26 mg/kg

ZINK

Table 3.98 NOEC values for soil microbial processes that are used as input values for deriving the 5th percentile values as a basis for the soil $PNEC_{add,\ terrestrial}$.

Microbe-mediated processes	NOEC values (Cn, in mg/kg d.w.) (n=97)
C-mineralization (respiration), including mineralization of specific substrates * (n=39)	17; 17; 30; 30; 38; 50; 50; 50; 55; 80; 100; 100; 100; 100; 100; 100; 100; 110; 110; 120; 150; 150; 165; 200; 240; 300; 300; 300; 303; 327; 400; 469; 600; 600; 800; 1300; 1300; 1400; 1400
N-mineralization (n=26)	38; 50; 50; 50; 75; 75; 100; 100; 100; 100; 100; 109; 150; 150; 164; 164; 164; 164; 206; 233; 257; 300; 300; 400; 424; 1000
Enzyme activities (n=32)	30; 30; 48; 52; 64; 67; 70; 76; 105; 109; 140; 145; 151; 160; 164; 164; 164; 200; 200; 460; 500; 508; 590; 728; 820; 820; 1341; 1640; 1640; 1640; 2353; 2623

* C-Mineralization of specific substrates (e.g. acetate or plant residu): also referred to as "substrate induced respiration" (SIR).

HC5 results

Name	Value
LL HC5	1,925E1
HC5	2,665E1
UL HC5	3,512E1
sprHC5	1,824E0

N = 97
HC5 = 26,7
PNEC = 26,7

Table 3.99 Individual and "species mean" NOEC values for plants and invertebrates that are used as input values for deriving the 5th percentile values as a basis for the soil $PNEC_{add,\ terrestrial}$.

Taxonomic groups	Individual NOECs (Cn, in mg/kg d.w.) (n=74)	"Species mean" NOECs (Cn, in mg/kg d.w.) (n=20)
Oligochaetes * (n=27)	85; 97; 100; 115; 161; 180; 180; 180; 183; 199; 223; 237; 320; 320; 320; 350; 350; 350; 414; 484; 553; 560; 560; 560; 600; 1000; 1000	280; 320; 600
Insects ** (n=18)	32; 100; 275; 300; 300; 300; 300; 314; 320; 320; 320; 320; 366; 399; 560; 620; 1000; 1000	320
Plants *** (n=29)	32; 32; 32; 32; 32; 33; 83; 84; 100; 100; 100; 100; 100; 200; 200; 200; 200; 200; 200; 200; 200; 215; 300; 300; 300; 400; 400; 400; 400	32; 45; 89; 100; 140; 170; 200; 200; 200; 200; 200; 300; 300; 400; 400; 400

* 3 species of Oligochaetes; ** 1 insect species; *** 16 plant species

HC5 results

Name	Value
LL HC5	3,382E1
HC5	5,783E1
UL HC5	8,352E1
sprHC5	2,469E0

N = 20
HC5 = 57,8
PNEC = 28,0

ZINK

IKKE ACCEPTABLE DATA FOR SSD

Toxicity data

Anderson-Darling test for normality

Sign. level	Critical	Normal?
0,1	0,631	Rejected
0,05	0,752	Rejected
0,025	0,873	Accepted
0,01	1,035	Accepted

AD Statistic: 7,66E-1
n: 20

Note: below n=8, this test may not perform well.

Kolmogorov-Smirnov test for normality

Sign. level	Critical	Normal?
0,1	0,819	Rejected
0,05	0,895	Rejected
0,025	0,995	Accepted
0,01	1,035	Accepted

KS Statistic: 9,41E-1
n: 20

Note: below n=20, this test may not perform well.

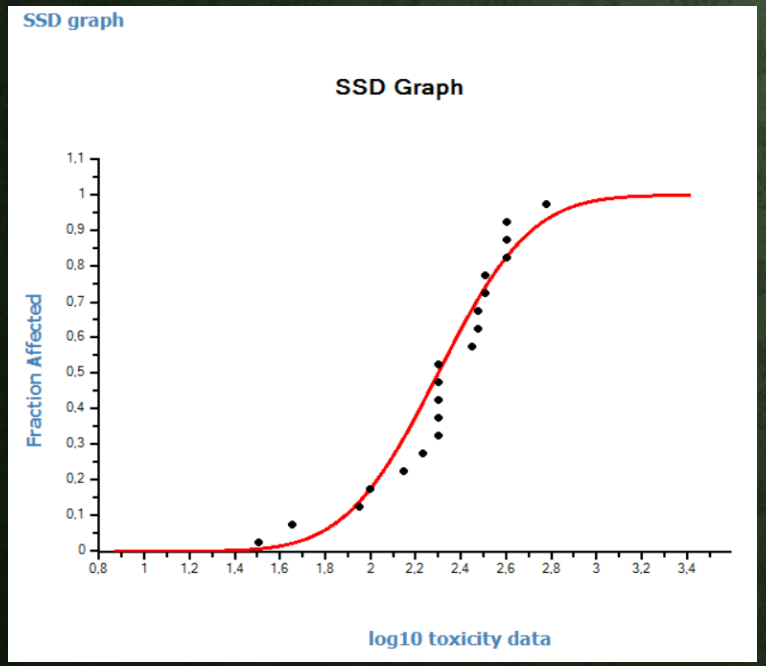
Cramer von Mises test for normality

Sign. level	Critical	Normal?
0,1	0,104	Rejected
0,05	0,126	Accepted
0,025	0,148	Accepted
0,01	0,179	Accepted

CM Statistic: 1,23E-1
n: 20

Note: below n=20, this test may not perform well.

SSD graph



P+I

Toxicity data

Anderson-Darling test for normality

Sign. level	Critical	Normal?
0,1	0,631	Rejected
0,05	0,752	Rejected
0,025	0,873	Rejected
0,01	1,035	Rejected

AD Statistic: 1,05E0
n: 97

Note: below n=8, this test may not perform well.

Kolmogorov-Smirnov test for normality

Sign. level	Critical	Normal?
0,1	0,819	Rejected
0,05	0,895	Rejected
0,025	0,995	Rejected
0,01	1,035	Rejected

KS Statistic: 1,25E0
n: 97

Note: below n=20, this test may not perform well.

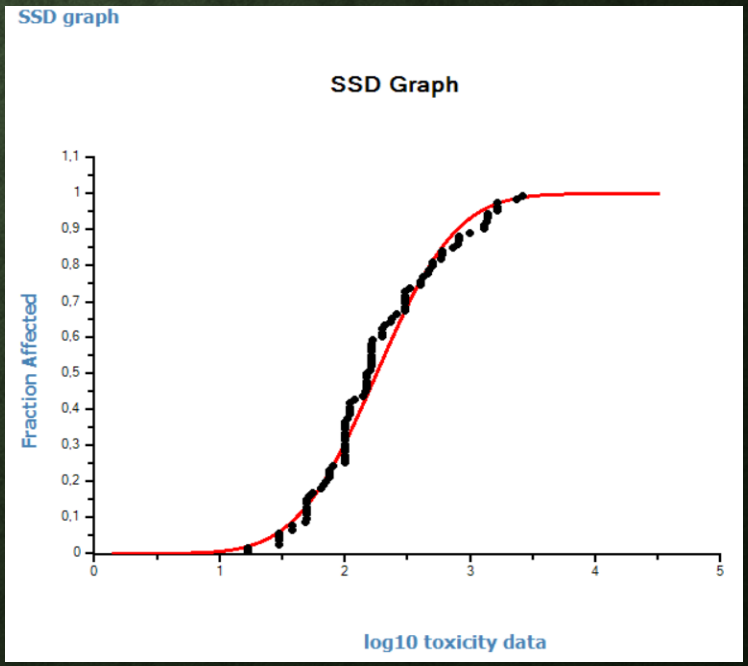
Cramer von Mises test for normality

Sign. level	Critical	Normal?
0,1	0,104	Rejected
0,05	0,126	Rejected
0,025	0,148	Rejected
0,01	0,179	Rejected

CM Statistic: 1,84E-1
n: 97

Note: below n=20, this test may not perform well.

SSD graph



Micro

ZINK

Kombineret datasæt

- HC5 = 30,1
- AF = 2
- PNEC = 15 mg/kg

Baggrundkoncentration: Ler : 37 mg/kg; Sand = 10,1 mg/kg

- PNEC(ler) = 52 mg/kg
- PNEC(sand) = 25 mg/kg
- Gennemsnit danske landbrugsjorder = 47,7 mg/kg

HC5 results

Name	Value
LL HC5	2,278E1
HC5	3,007E1
UL HC5	3,819E1
sprHC5	1,676E0

Toxicity data

Anderson-Darling test for normality

Sign. level	Critical	Normal?
0,1	0,631	Rejected
0,05	0,752	Accepted
0,025	0,873	Accepted
0,01	1,035	Accepted

AD Statistic: 6,70E-1
n: 117

Note: below n=8, this test may not perform well.

Kolmogorov-Smirnov test for normality

Sign. level	Critical	Normal?
0,1	0,819	Rejected
0,05	0,895	Accepted
0,025	0,995	Accepted
0,01	1,035	Accepted

KS Statistic: 8,92E-1
n: 117

Note: below n=20, this test may not perform well.

Cramer von Mises test for normality

Sign. level	Critical	Normal?
0,1	0,104	Rejected
0,05	0,126	Accepted
0,025	0,148	Accepted
0,01	0,179	Accepted

CM Statistic: 1,07E-1
n: 117

Note: below n=20, this test may not perform well.

National monitoring study in Denmark finds increased and critical levels of copper and zinc in arable soils fertilized with pig slurry*

John Jensen*, Martin Mørk Larsen, Jesper Bak

Department of Bioscience, Aarhus University, Denmark

KONKLUSIONER

- De danske jordkvalitetskriterier til miljøbeskyttelse er forældede
- For PAH er der udarbejdet et opdateret sæt af JKK
- Nye data og nye metoder kalder for nye JKK
- JKK kan **kun** bruges som screeningsværktøj

< JKK = ingen risiko for miljøskade

> JKK er IKKE ensbetydende med miljøskade, da:

  - Ældning nedsætter biotilgængeligheden
  - Økosystemer er ofte mere robuste end forventet
  - Adaptation/øget tolerance kan forekomme

> JKK kræver en lokalitets-specifik risikoevaluering, fx baseret på TRIAD (part 2)