

# BODEM ANDERS BEKEKEN

Maak het onzichtbare zichtbaar

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ARCHE Consulting

Dag van de bodemdeskundige 7 mei 2026



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# Waarom?



Huidige focus



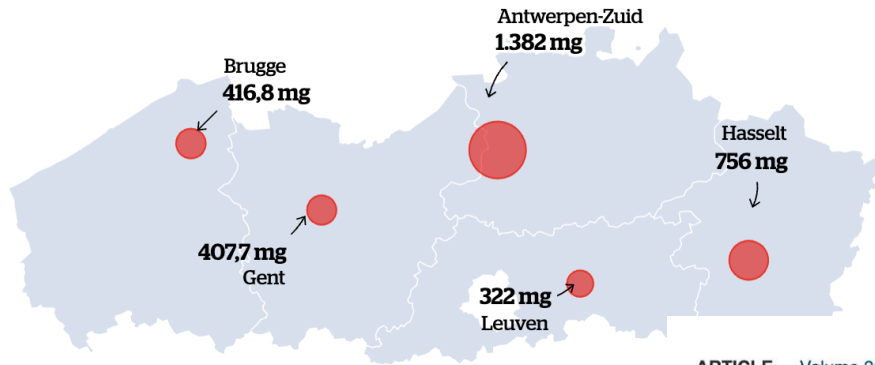
Gevolg van het Negeren van niet gereguleerde onbekende stoffen



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# Waarom?

## Cocaïnegebruik mg per 1.000 inwoners



Kaart: Het Laatste Nieuws • Kaartgegevens: © STABEL



ARTICLE · Volume 36, Issue 8, P2018-2027.E4, April 20, 2026 · [Open Access](#)

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## Cocaine pollution alters the movement and space use of Atlantic salmon (*Salmo salar*) in a large natural lake

[Jack A. Brand](#)<sup>1,2,10</sup> · [Daniel Palm](#)<sup>1</sup> · [Daniel Cerveny](#)<sup>1,3</sup> · ... · [Bryan W. Brooks](#)<sup>7</sup> · [Tomas Brodin](#)<sup>1</sup> · [Michael G. Bertram](#)<sup>1,8,9</sup> ... [Show more](#)

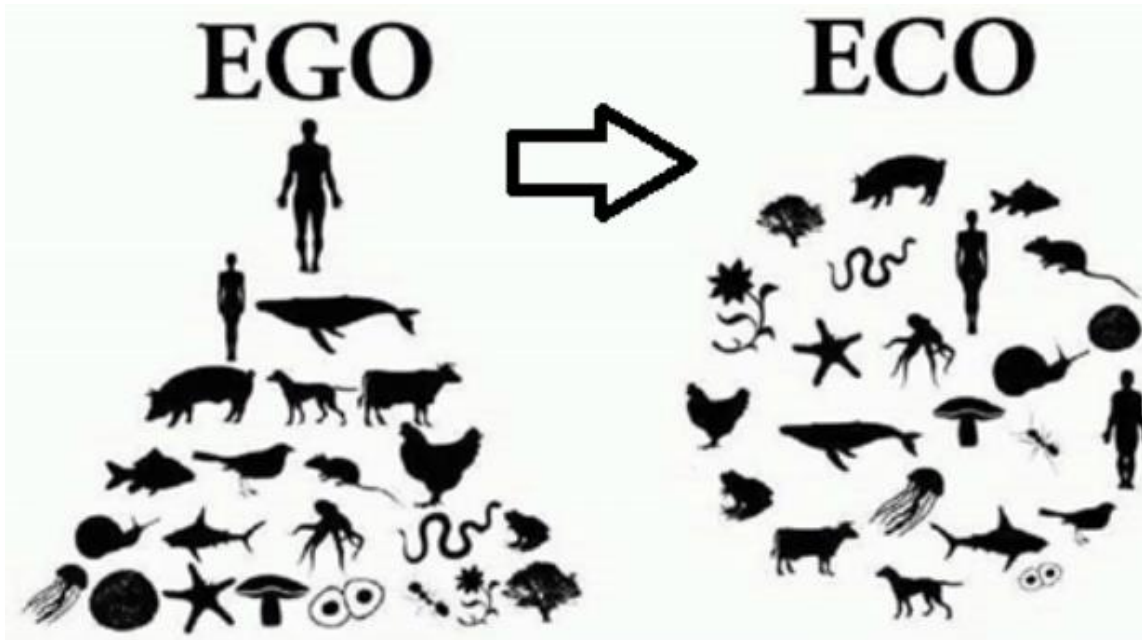
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### » Highlights

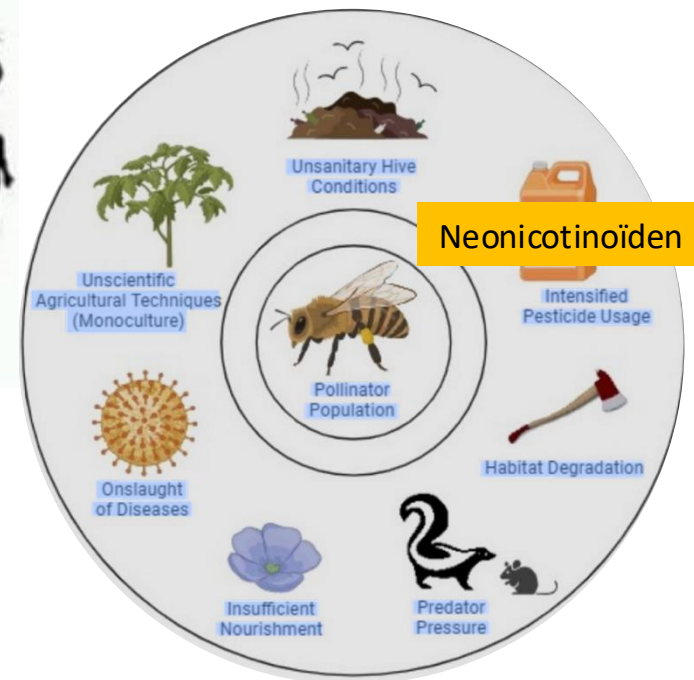
Show Outline

- Cocaine metabolite benzoylecgonine increased the movement of juvenile Atlantic salmon
- Exposed fish swam up to 1.9 times farther per week than control fish
- Benzoylecgonine increased dispersal by up to 12.3 km
- Cocaine-associated pollution altered salmon spatial ecology in a natural lake



(Diagram: S. Lehmann, 2010)

Colony Colapse Disorder  
honingbij (*Apis Melifera*)  
(Singh et al, 2025)



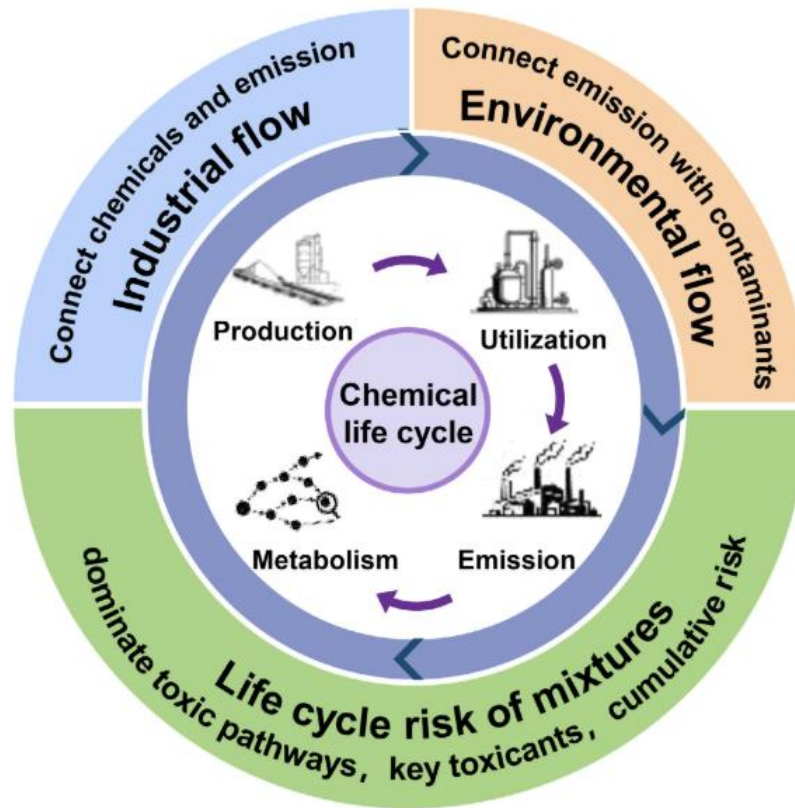
Lehman: et al , 2010.Green Urbanism: Formulating a Series of Holistic Principles  
October 2010 [Surveys and Perspectives Integrating Environment and Society](#) 3(2)

Singh, G., Rana, A. Honeybees and colony collapse disorder: understanding key drivers and economic implications. *Proc.Indian Natl. Sci. Acad.* **91**, 750–766 (2025).  
<https://doi.org/10.1007/s43538-025-00399-x>

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# Waarom?

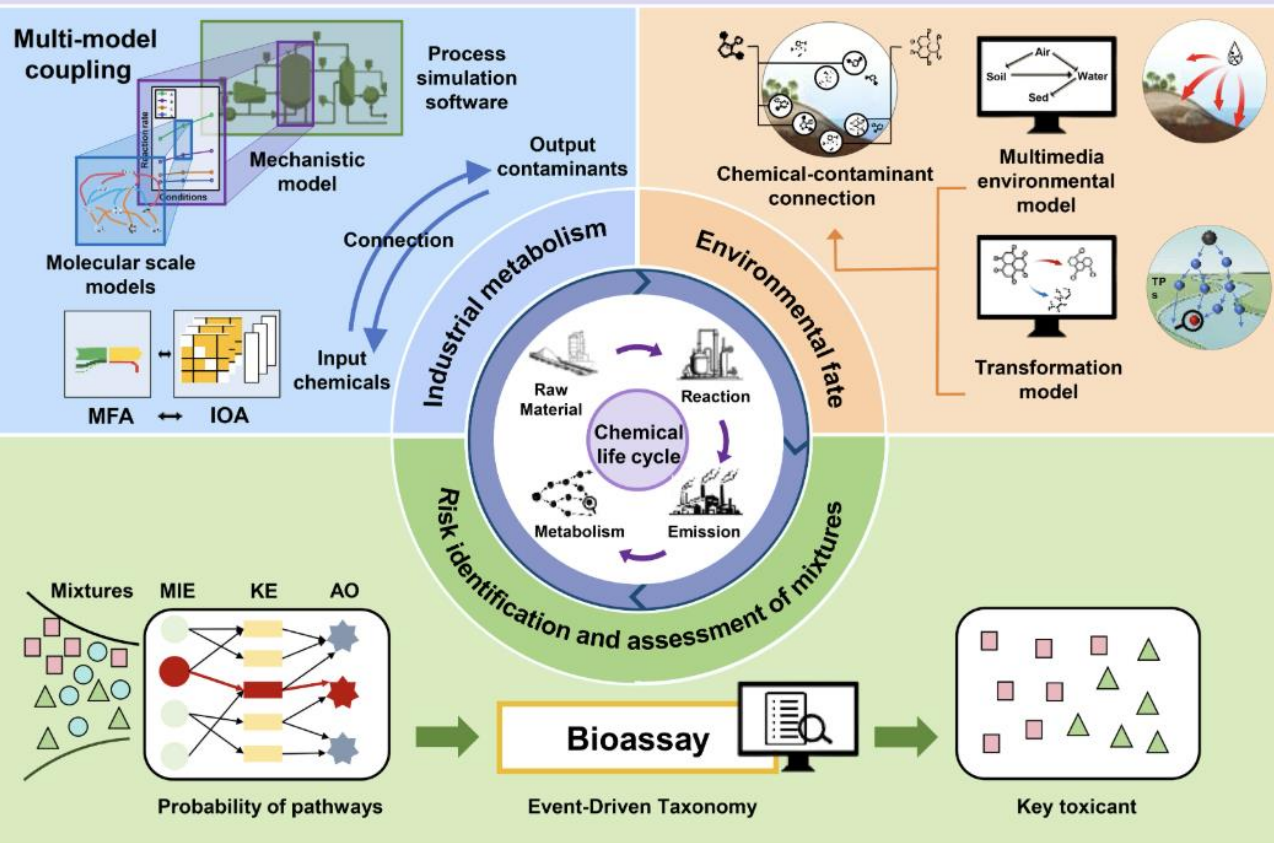


Zhang et al , 2026: Life cycle risk assessment and management of industrial chemicals: synergizing material metabolism and risk flow by 'emiss-ome'. <https://www.maxapress.com/article/doi/10.48130/newcontam-0026-0001>

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# Waarom?

## Emiss-ome: Life cycle risk assessment and management



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# Hoe maken we het onzichtbare, zichtbaar?



Effect gebaseerde monitoring  
(biotoetsen)

Gebruik van biodiversiteitsmetingen  
(MMIF, BSI, eDNA)

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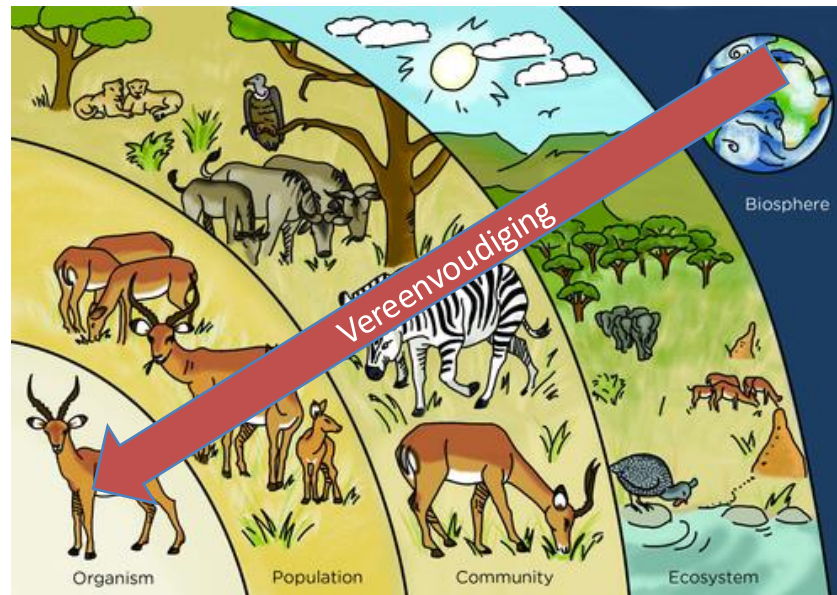
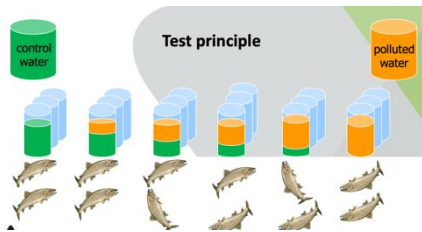
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# Ecologische risico beoordeling (ERA)

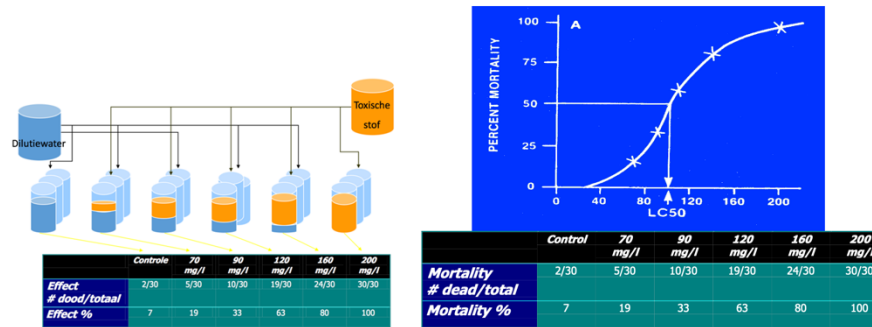
Studie van de effecten van chemische stoffen op het ecosysteem.

Ecotoxiciteitstesten



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# Principe ecotoxiciteitstesten



**EC50 (median effect concentratie)** is de concentratie van een chemische stof die naar schatting een specifiek effect (bv. fysiologisch gedrag) heeft in 50% van een populatie van een testsoort na een specifieke blootstellingsduur (bv. 24 of 48 uur).

**LOEC (Lowest Observed Effect Concentration)** is de laagste concentratie die een statistisch significant schadelijk effect heeft op de testorganismen in vergelijking met de controles in een specifieke test bij chronische blootstelling.

**NOEC (No Observed Effect Concentration)** kan worden gedefinieerd als de maximale concentratie van de teststof die geen statistisch significant schadelijk effect heeft op de testorganismen in vergelijking met de controle in een specifieke test bij chronische blootstelling.

**ECx** wordt tegenwoordig geprefereerd boven de NOEC om “geen effect” concentraties aan te duiden. Vaak wordt hierbij het effect niveau op 10-25 % geplaatst.

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# Bronnen ecotox data

**EPA ECOTOX-database:** De meest uitgebreide bron, met meer dan een miljoen testresultaten voor aquatische en terrestrische soorten. Deze wordt elk kwartaal bijgewerkt.

**ECHA CHEM (REACH-database):** De database van het Europees Agentschap voor chemische stoffen bevat gegevens uit REACH-registraties en biedt hoogwaardige ecotoxicologische gegevens die worden gebruikt bij beoordelingen in het kader van regelgeving.

**NORMAN Ecotoxicology Database:** Richt zich op opkomende milieustoffen en biedt experimentele eindpunten en kwaliteitsdoelstellingen (PNEC's).

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# Overzicht vaak gebruikte terrestrische ecotoxiciteitstesten

Soort	Type	Testduur	Eindpunt
<b>Bacteriën</b>			
Aanwezige microbiële gemeenschap	Bacteriën	Test afhankelijk	CO <sub>2</sub> -respiratie Enzym activiteit (zoals nitrificatie)
<b>Plant testen</b>			
<i>Lolium perenne</i>	Engels raaigras	14d	Kieming/groei
<i>Raphanus sativus</i>	Radijs	14d	Kieming/groei
<b>Invertebraat testen</b>			
<i>Eisenia foetida</i>	regenworm	2-8 weeks	Overleving/reproductie
<i>Folsomia candida</i>	Springstaart (Collembola)	2-4 weeks	Overleving/reproductie
<i>Enchytraeus albidus</i>	Enchytraeiden (potworm)	2-6 weeks	Overleving/reproductie

Testen moeten **GEVOELIG** zijn voor de onderzochte verontreiniging

Testen moeten **ROBUUST** zijn, d.w.z. reproduceerbaar en consistent bij verschillende bodems



[Folsomia candida](#)



*Enchytraeus albidus*



*Eisenia foetida*



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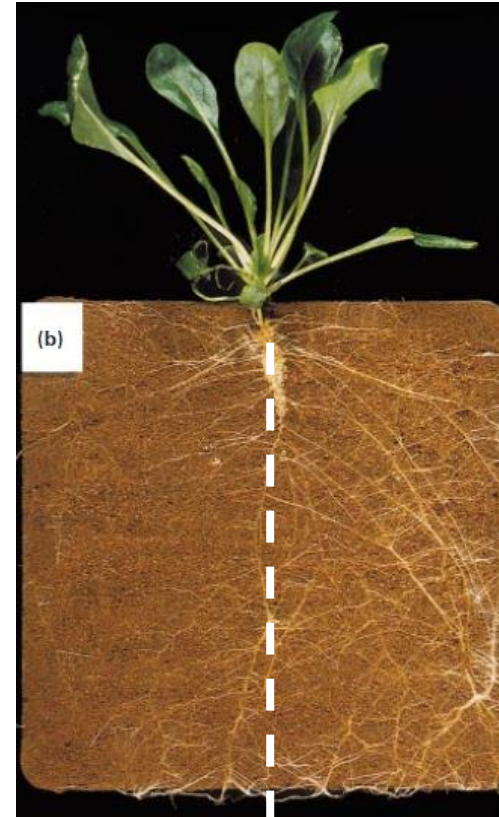
Vereniging Onafhankelijke Bodemkundige Advies- & Studiebureaus

# Planten aangepast aan verontreiniging



zinkviooltje

zinkboerenkers



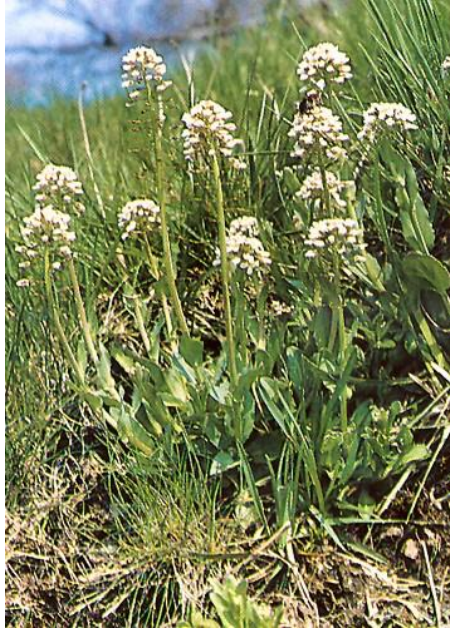
-zink

+ zink

verontreiniging

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# Metal hyperaccumulator planten



*Thlaspi caerulescens*  
(zinkboerenkers)

Trace element	Concentration criterion (% in leaf dry matter)
Antimony	□ 0.1
Cadmium	□ 0.01
Cobalt	□ 0.1
Copper	□ 0.1
Lead	□ 0.1
Manganese	□ 1.0
Nickel	□ 0.1
Thallium	□ 0.1
Zinc	□ 1.0



*Pycnantha acuminata*  
(endemische boomsoort uit New Caledonia): sap bevat 25% nikkel.

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# Wormen (Annelidae) (OECD 222)

- Eindpunt: overleving (14 d=acute test) & overleving en reproductie (28 d = chronisch)
- Species: compostworm (*Eisenia fetida* of *Eisenia andrei*)
- Uitvoering: 10 adulten/pot (750 g) met herhalingen (8 voor controle + 4 voor gedoseerde).  
Bodem: 'OECD standaardbodem' = 70% zand, 20% kaolinit, 10% veen. Meeste testen mét voedsel ('mest'), groei in cultuurkamer met licht.  
Bepalen van overleving na 14 d, aantal cocons na 28 d (typisch 10/adult na 28 dagen; bepaald door zieving) of aantal juvenielen na 56 dagen
- Rapportering: overleving (LC50) en reproductie (NOEC en EC<sub>x</sub>)
- Concentraties: meestal nominale waarden (organische stoffen)/gemeten waarden (metalen)



## Geldigheid van de test

Overleving  $\geq 90 \%$

$\geq 30$  juvenielen/container

CV voor reproductie  $\leq 30 \%$

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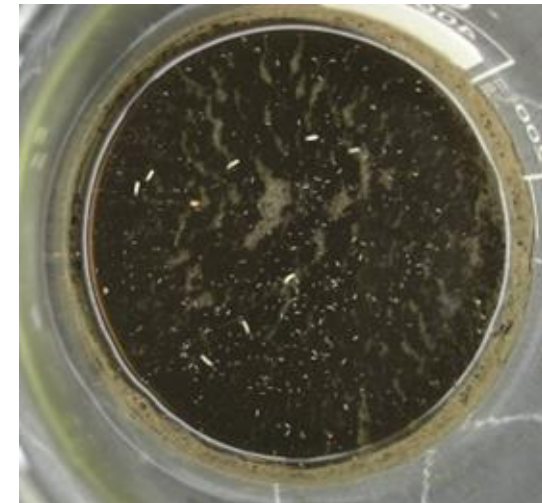


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# Springstaarten (collembola) (OECD 232)

- Eindpunt: reproductie(28 d = chronisch)
- Species: *Folsomia candida*
- Uitvoering: 10 gesynchroniseerde organismen/pot (30g) met herhalingen (8 voor controle + 4 voor gedoseerde).  
Bodem: 'OECD standaardbodem' =70 % zand, 20% kaolinit, 10% veen. Meeste testen mét voedsel (gist) groei in cultuurkamer met licht. Bepalen van aantal juvenielen (telling in suspensie, organismen drijven) en overlevende adulten na 28 d (typisch >500 juvenielen/adult na 28 dagen)
- Rapportering: overleving (LC50) en reproductie (NOEC en EC<sub>x</sub>)
- Concentraties: meestal nominale waarden (organische stoffen)/gemeten waarden (metalen)



## Geldigheid test

Overleving  $\geq 80 \%$

Minstens 100 instars/beker

CV voor reproductie  $\leq 30 \%$

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# Plantengroei (OECD 208, ISO 11269)

- Eindpunt: kieming en biomassa (scheut) na 14-21 dagen
- Species: vrije keuze (tarwe, koolzaad, klaver, boon,...)
- Uitvoering: gezeefde bodem, 3-10 zaadjes per pot (afhankelijk van plant), 4 herhalingen. Bepalen van aantal gekiemde planten en biomassa/pot. Variante: wortelengroei (4 d)
- Rapportering: NOEC en  $EC_x$
- Concentraties: meestal nominale waarden (organisch)/ gemeten (metalen)



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# Microbiële test: N-mineralisatie (OECD 216)

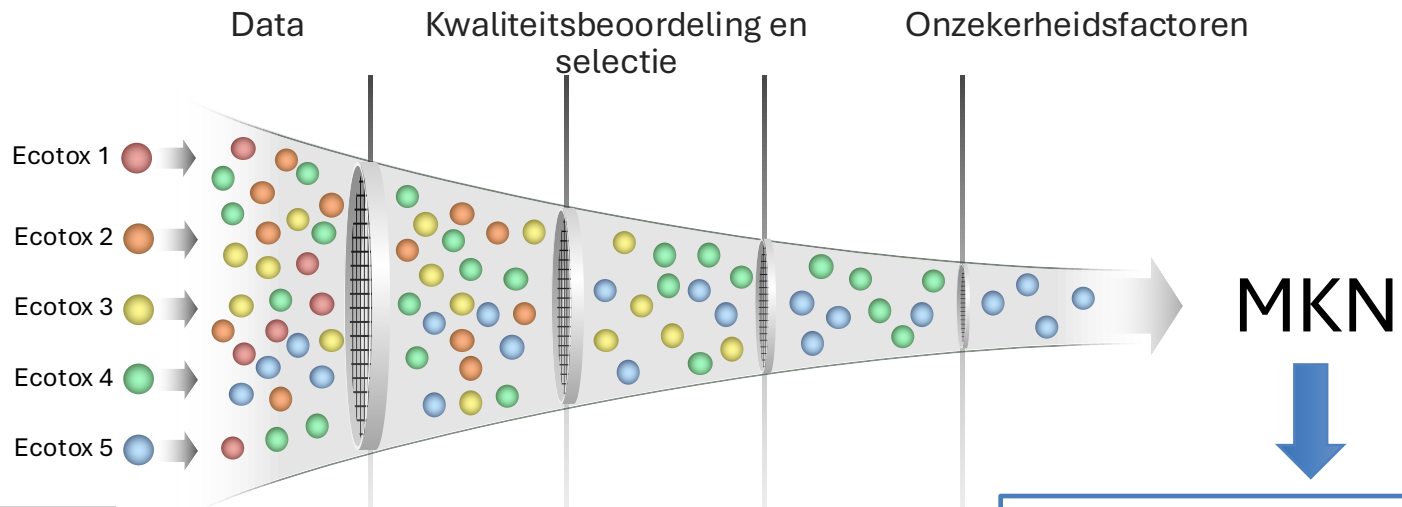
Eindpunt: nitraatproductie na 28 dagen

- Reactie: Organische-N  $\xrightarrow{\quad}$   $\text{NH}_4^+$   $\xrightarrow{\quad}$   $\text{NO}_3^-$
- Species: endogene populatie nitrificeerders in bodem
- Uitvoering: bodem pH 5.5-7.5, 0.5-1.5 Org C, 50-75% zand, preïncubatie, toevoegen van toxische stof, toevoegen van  $\text{NH}_4^+$ -oplossing of plantmateriaal met herhalingen (controle+gedoseerde).  
Bepalen van nitraat (KCl extract bodem)
- Rapportering: NOEC en Ecx
- Concentraties: meestal nominale waarden



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# Afleiding milieukwaliteitsnormen (MKN)



Ecotox	Substraat	Organisme	Concentratie	Effect (%)	Observatie	Opmerkingen
Ecotox 1	...	...	...	...	...	...
Ecotox 2	...	...	...	...	...	...
Ecotox 3	...	...	...	...	...	...
Ecotox 4	...	...	...	...	...	...
Ecotox 5	...	...	...	...	...	...

**NOEC**  
 Acuut EC50 LOEC  
 EC30 EC10  
 EC20  
 Chronisch

Chronisch  
 EC10  
 NOEC

**MKN**  
 ↓  
 Signaal functie:  
 Bij overschrijding = potentieel risico

↓  
 Veldonderzoek  
 Biotesten

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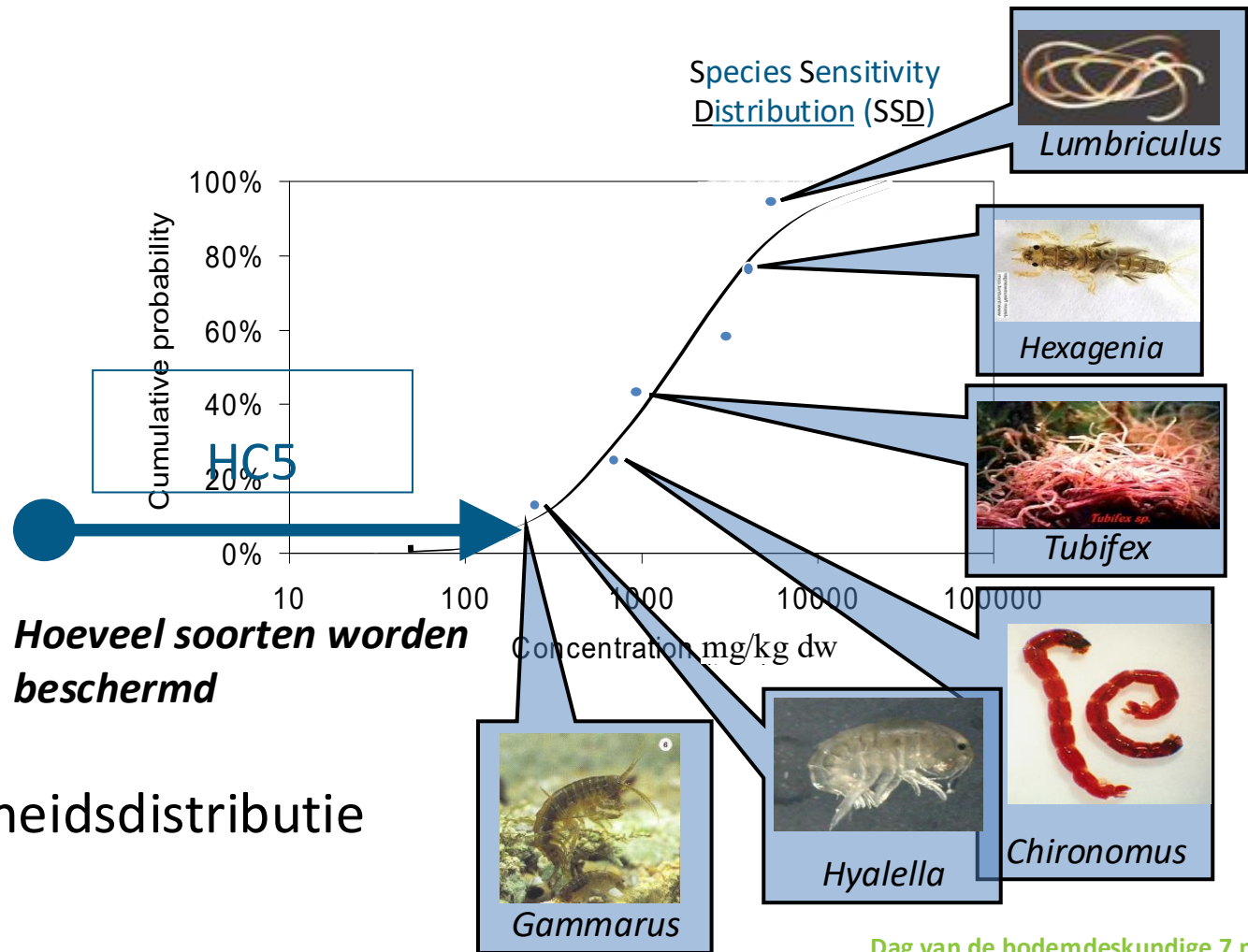
# Afleiding MKN data-arm

Beschikbare informatie	Beoordelingsfactor
Minstens 1 acute L(E)C50 (planten, regenwormen micro organismen)	1000
1 chronische NOEC /EC10 waarde (vb. planten)	100
2 chronische NOECs/EC10 waarden van soorten die 2 trofische niveaus omvatten	50
Chronische NOEC/EC10 waarden voor minstens 3 soorten die representatief zijn voor 3 trofische niveaus	10

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# Afleiding MKN data-rijk



Soortengevoeligheidsdistributie (SSD)

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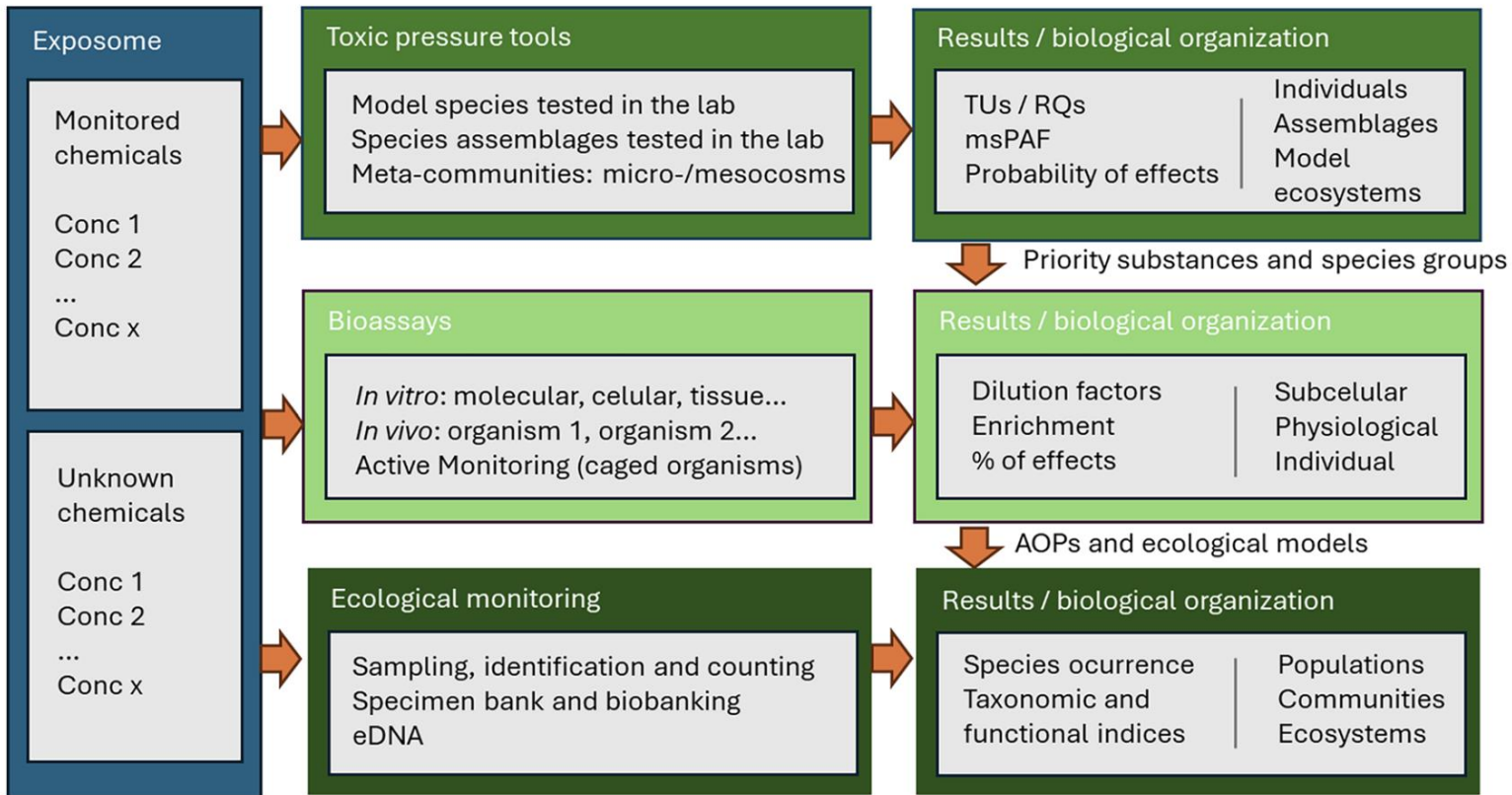
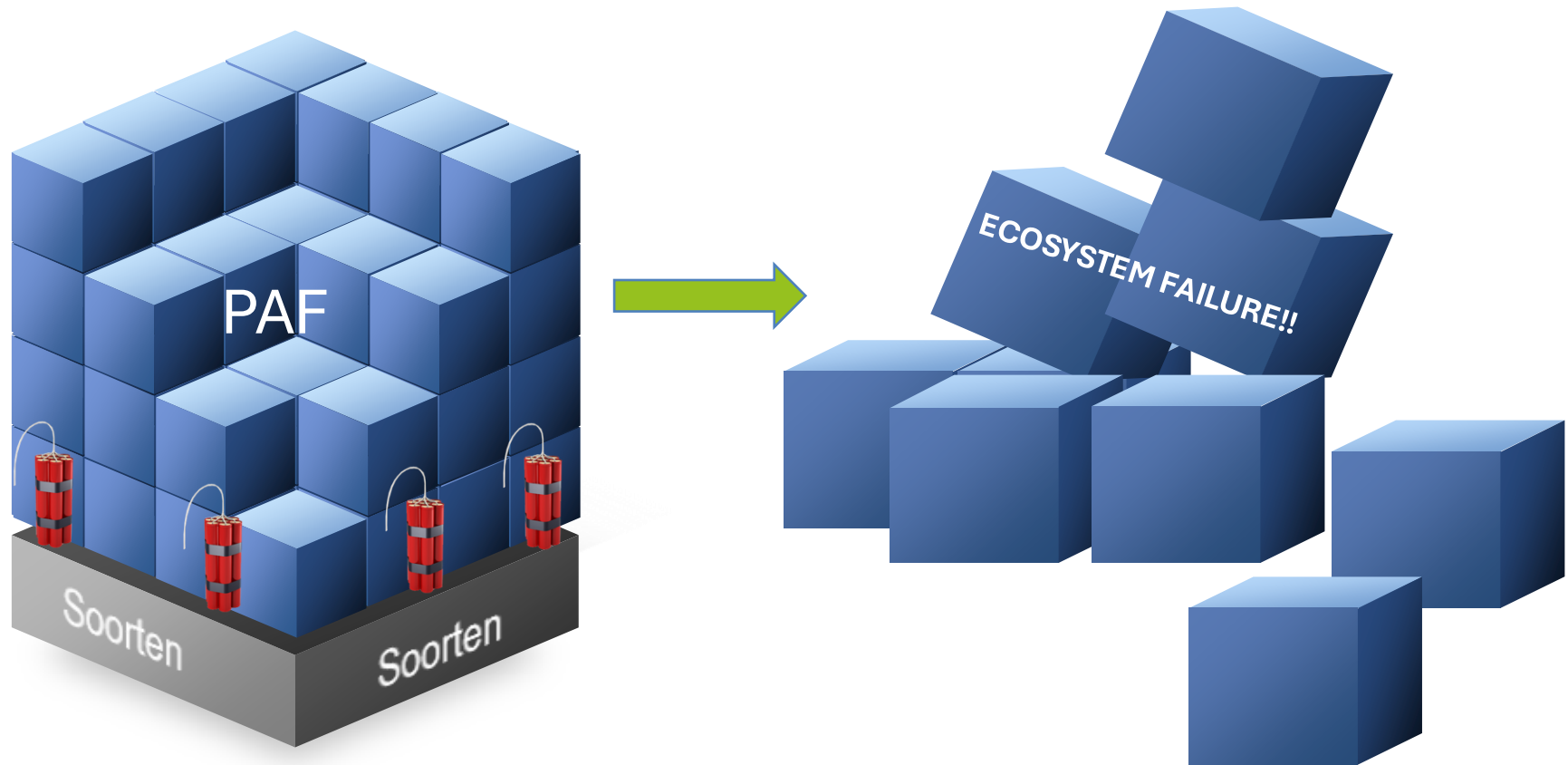


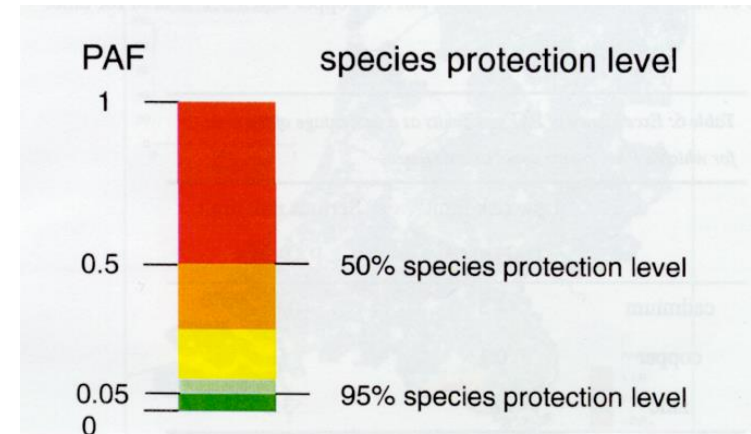
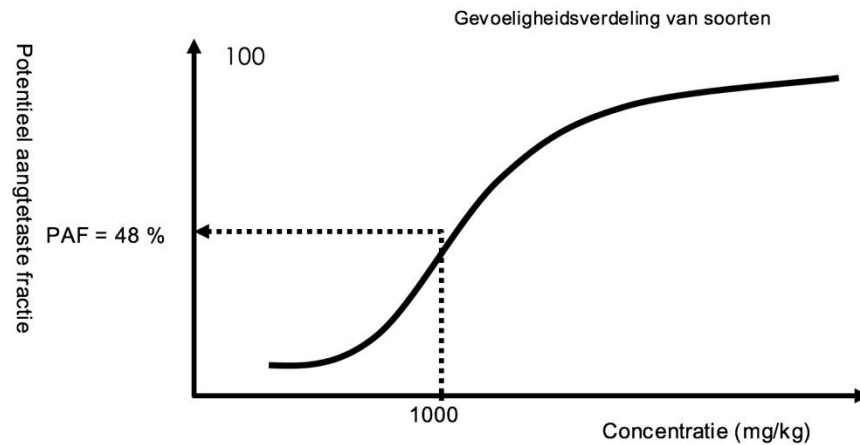
Figure from Rico, A., Hommen, U., Escher, B.I. *et al.* The use of diagnostic tools to assess the risks of chemicals to freshwater ecosystems: towards a unified evaluation framework. *Environmental Management* (2025). <https://doi.org/10.1007/s00267-025-02265-4>

# Berekenen van de toxische druk a.d.h.v Potentieel aangetaste fractie- PAF concept



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# Potentieel aangetaste fractie- PAF concept



Figuur 1: Berekening van de Potentiële Aangetaste Fractie (PAF) tengevolge van de loodverontreiniging.

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# Voorbeeld multi-substance PAF (msPAF)

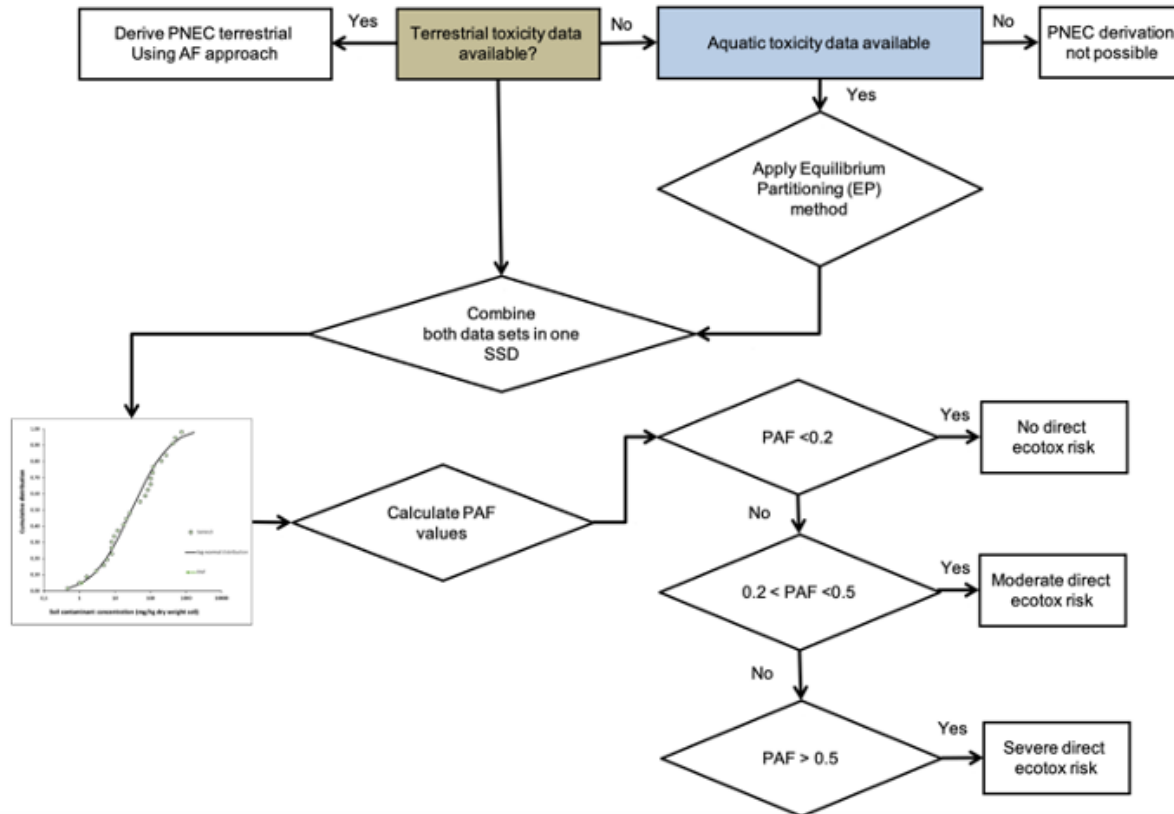
$$msPAF = (1 - \prod (1 - PAF_i))$$

Mengsel contaminant	Bodem concentratie (mg/kg dw)	Potentieel aangetaste fractie (PAF) (%)
Pb	350	4.1
Cd	5	3.4
Zn	220	3.9
Ni	35	3.4
<b>Multi substance Potentieel aangetaste fractie (msPAF)</b>	$= 1 - ((1 - 0.041) \times (1 - 0.034) \times (1 - 0.039) \times (1 - 0.034))$ $= 0.14 = 14 \% \text{ aangetast}$	

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# Aanpak en resultaten generieke ERA



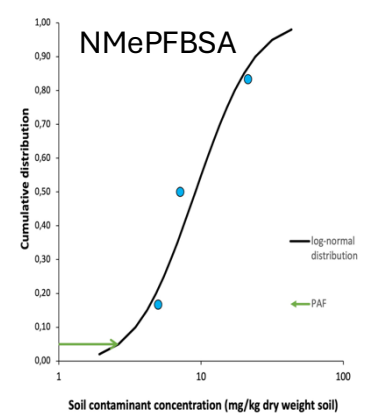
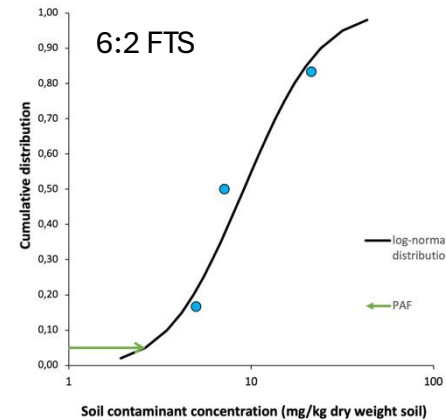
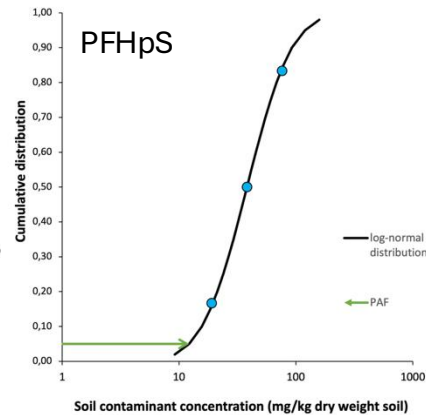
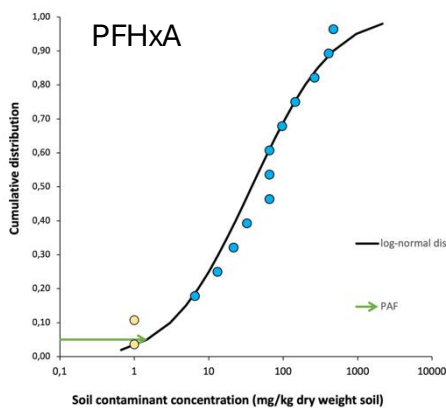
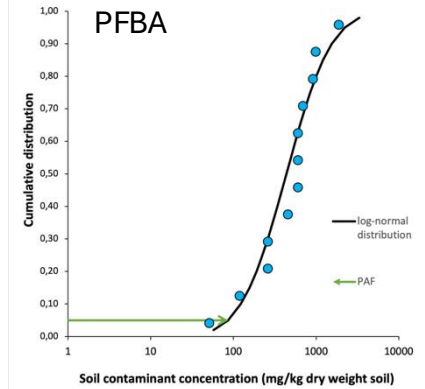
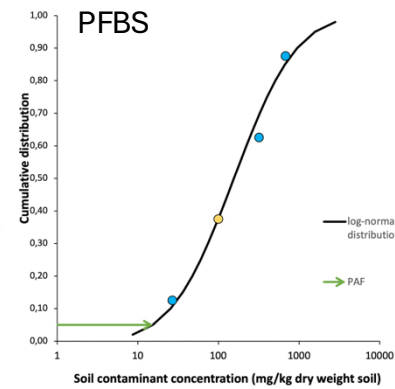
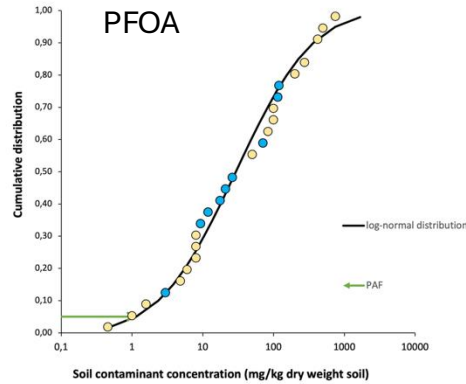
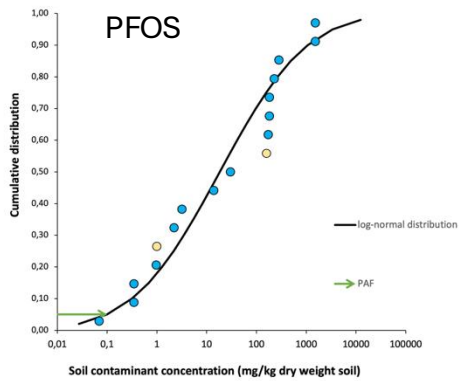
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# Aanpak PFAS BBO 3M Zwijndrecht



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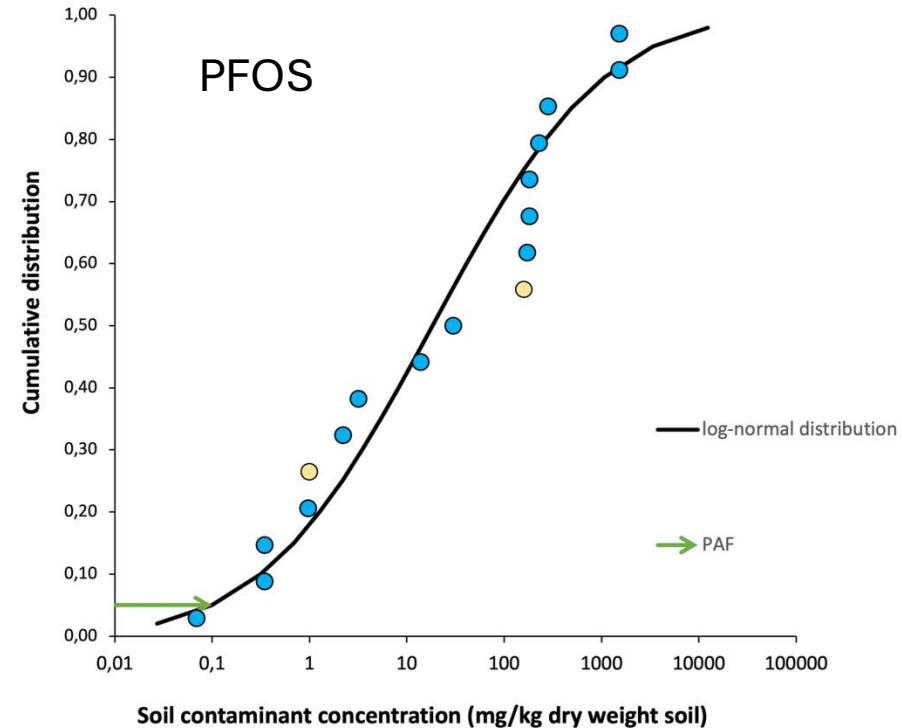


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# Aanpak PFAS BBO 3M Zwijndrecht

PFAS substance: PFOS			
PNEC derivation terrestrial compartment			
Species	Effect level & parameter	mg/kg dw	
<i>Aporrectodea caliginosa</i> Earthworm	40d-NOEL Growth (weight)	1 <sup>(1)</sup>	
<i>Eisenia fetida</i> Earthworm	14d-NOEL Survival	750	
PNEC – soil data-based	AF of 100 on lowest chronic value	0.010 mg/kg dw = 10 µg/kg dw	
PNEC derivation aquatic compartment - Conversion from mg/L to mg/kg dw is based on Kd of 34.3 L/kg			
	Effect level & parameter	mg/L	PAF conversion mg/kg dw
<i>Pseudokirchneriella subcapitata</i> Green alga	endpoint not reported	5.3 <sup>(2)</sup>	182.5
<i>Chlorella vulgaris</i> Green alga	endpoint not reported	8.2 <sup>(2,3)</sup>	282.4
<i>Navicula pelliculosa</i>	endpoint not reported	44 <sup>(4,5)</sup>	1515.1
<i>Anabaena flos-aquae</i>	endpoint not reported	44 <sup>(5)</sup>	1515.1
<i>Lemna gibba</i>	endpoint not reported	6.6 <sup>(2,3)</sup>	227.3
<i>Myriophyllum sibiricum</i> Watermilfoil	endpoint not reported	0.092 <sup>(6)</sup>	3.17
<i>Daphnia magna</i> Waterflea	endpoint not reported	5.3 <sup>(4)</sup>	182.5
<i>Moina macrocopa</i> Waterflea	endpoint not reported	0.4 <sup>(7)</sup>	13.8
<i>Pimephales promelas</i>	endpoint not reported	0.028 <sup>(2,8)</sup>	0.96
<i>Lepomis macrochirus</i>	endpoint not reported; unbounded LOEC/NOEC	0.87 <sup>(9)</sup>	29.96
<i>Danio rerio</i>	malformation in F1	0.01 <sup>(10)</sup>	0.344
<i>Xenopus laevis</i>	endpoint not reported	5 <sup>(9)</sup>	172.2
<i>Chironomus tentans</i>	emergence; unbounded LOEC/NOEC	0.002 <sup>(11)</sup>	0.069
<i>Enallagma cyathigerum</i>	endpoint not reported; unbounded LOEC/NOEC	0.01 <sup>(12)</sup>	0.344
<i>Monoporeia affinis</i>	endpoint not reported; unbounded LOEC/NOEC	0.064 <sup>(13)</sup>	2.204
PNEC <sub>aquatic</sub> <sup>(1)</sup>	AF of 10 on lowest chronic value	0.2 µg/L	

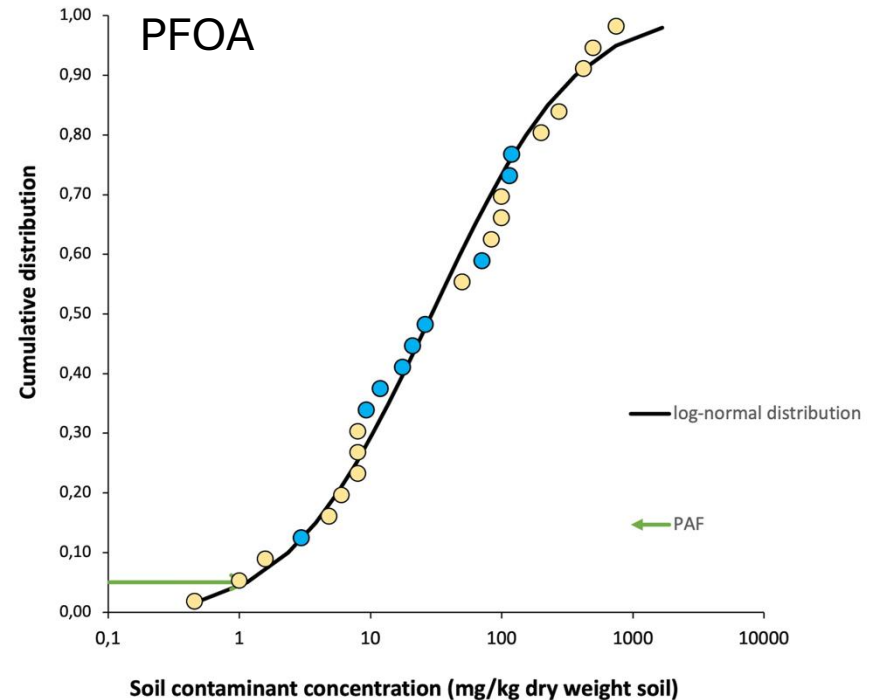


PAF HC<sub>5</sub>: 0.0997 mg/kg dw  
 PAF surrogate PNEC<sub>soil</sub> = 0.0997/5 =  
 0.02 mg/kg dw = 20 µg/kg dw

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# Aanpak PFAS BBO 3M Zwijndrecht

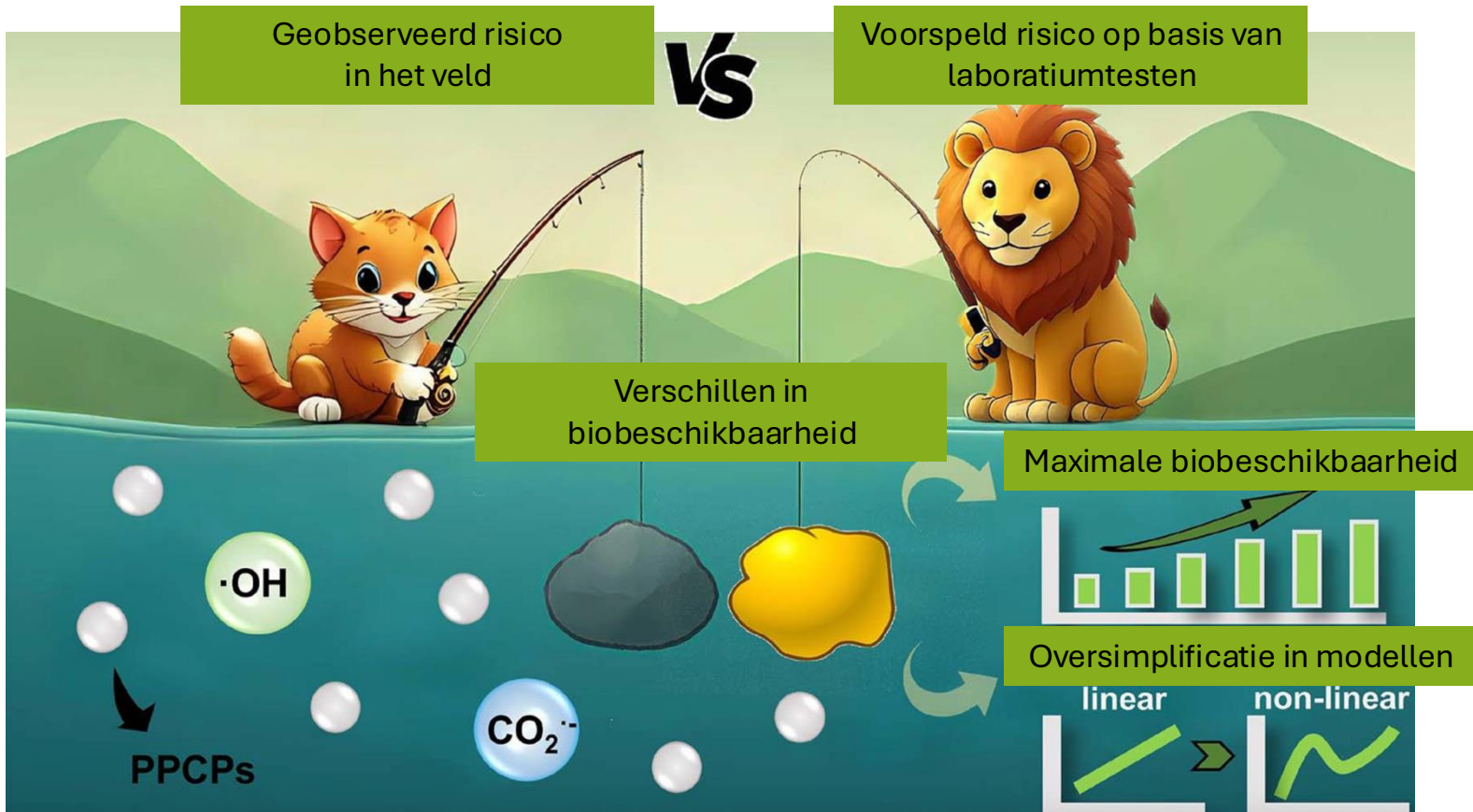
PFAS substance: PFOA			
PNEC derivation terrestrial compartment			
Species	Effect level & parameter	mg/kg dw	
<i>Ambystoma tigrinum</i> Tiger salamander	30d-NOEL Survival	8 <sup>(1)</sup>	
<i>Anaxyrus americanus</i> American toad	30d-NOEL Survival	8 <sup>(1)</sup>	
<i>Aporrectodea caliginosa</i> Earthworm	40d-NOEL Growth (weight)	1 <sup>(2)</sup>	
<i>Brassica chinensis</i> Chinese cabbage	7d-EC10 Growth (length)	99.8 <sup>(3)</sup> Geomean	
<i>Caenorhabditis elegans</i> Roundworm	1d-NOEL Reproduction	100 <sup>(4)</sup>	
<i>Cucumis sativus</i> Cucumber	60d-NOEL Growth (biomass)	4.82 <sup>(5)</sup>	
<i>Eisenia andrei</i> Earthworm	7d-NOEL Survival	500 <sup>(4)</sup>	
<i>Eisenia fetida</i> Earthworm	14d-NOEL Survival	750 <sup>(6)</sup>	
<i>Eremias argus</i> Lizard (Mongolia racerunner)	60d-NOEL Survival	1.58 <sup>(7)</sup> Geomean	
<i>Folsomia candida</i> Springtail	28d-NOEC Reproduction	50 <sup>(4)</sup>	
<i>Lactuca sativa</i> Lettuce	30d-NOEC Growth (weight)	0.455 <sup>(8)</sup> Geomean	
<i>Lithobates pipiens</i> Northern leopard frog	30d-NOEL Survival	8 <sup>(1)</sup>	
<i>Lobelia sokamensis</i> Collembole	5d-NOEL Survival	420 <sup>(4)</sup>	
<i>Oryza sativa</i> Rice	21d-NOEC Growth	200 <sup>(4)</sup>	
<i>Sorghum bicolor</i> Great millet	3d-EC10 Growth (length)	5.98 <sup>(9)</sup>	
<i>Triticum aestivum</i> Common wheat	28d-EC10 Growth (height)	83.8 <sup>(10)</sup>	
<i>Vigna radiata</i> Mung bean	21d-EC10 Growth	273.8 <sup>(4)</sup>	
PNEC – soil data-based	AF of 10 on lowest chronic value	0.046 mg/kg dw = 46 µg/kg dw	
PNEC derivation aquatic compartment - Conversion from mg/L to mg/kg dw is based on Kd of 2.84 L/kg			
Species	Effect level & parameter	mg/L	PAF conversion mg/kg dw
<i>Pseudokirchneriella subcapitata</i> Green alga	3-4d NOEC Growth rate	38.7 <sup>(11,12,13)</sup> (aeomean)	115.0 (aeomean)
<i>Myriophyllum spicatum</i> Watermilfoil	35d-EC10 Root length	8.8 <sup>(14)</sup>	26.2
<i>Myriophyllum sibiricum</i> Watermilfoil	35d-EC10 Growth (length)	23.7 <sup>(14)</sup>	70.5
<i>Daphnia magna</i> Waterflea	21d-EC10 Reproduction	7.02 <sup>(15)</sup>	20.9
<i>Moina macrocopa</i> Waterflea	7d-NOEC Reproduction	3.13 <sup>(16)</sup>	9.29
<i>Brachionus calyciflorus</i> Rotifer	4d-NOEC Intr. rate of population increase	4 <sup>(17)</sup>	11.9
<i>Bufo gargarizans</i> Frog	30d-EC10 Survival	5.89 <sup>(15)</sup>	17.5
<i>Oncorhynchus mykiss</i> Rainbow trout	85d-NOEC Growth (length)	40 <sup>(12)</sup>	118.9
<i>Oryzias latipes</i> Japanese rice fish	28d-NPEC/EC10	1 <sup>(16)</sup>	3.0
<i>Pimephales promelas</i> Fathead minnow	30d-NOEC/EC10	100 <sup>(12)</sup>	297.3
<i>Pseudorasbora parva</i> Stone moroko	30d-EC10 Survival	11.78 <sup>(15)</sup>	35.0
PNEC <sub>soil</sub> <sup>(2)</sup>	AF of 10 on lowest chronic value	0.10 mg/L = 100 µg/L	



PAF HC<sub>5</sub>: 1.15 mg/kg dw  
 PAF surrogate PNEC<sub>soil</sub>: 1.15/5 = 0.23 mg/kg dw  
 = 230 µg/kg dw

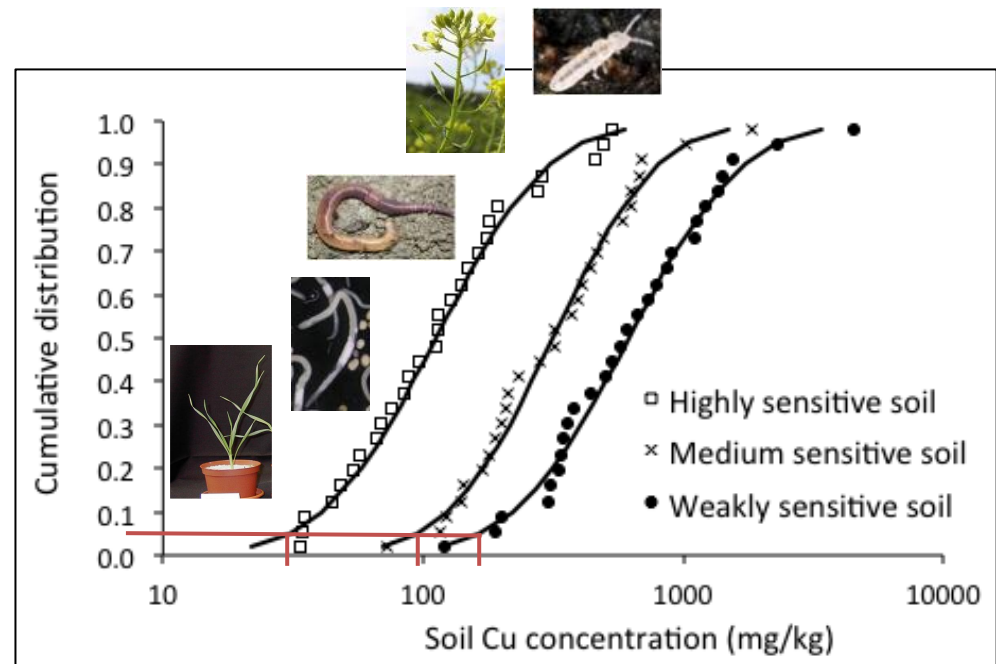
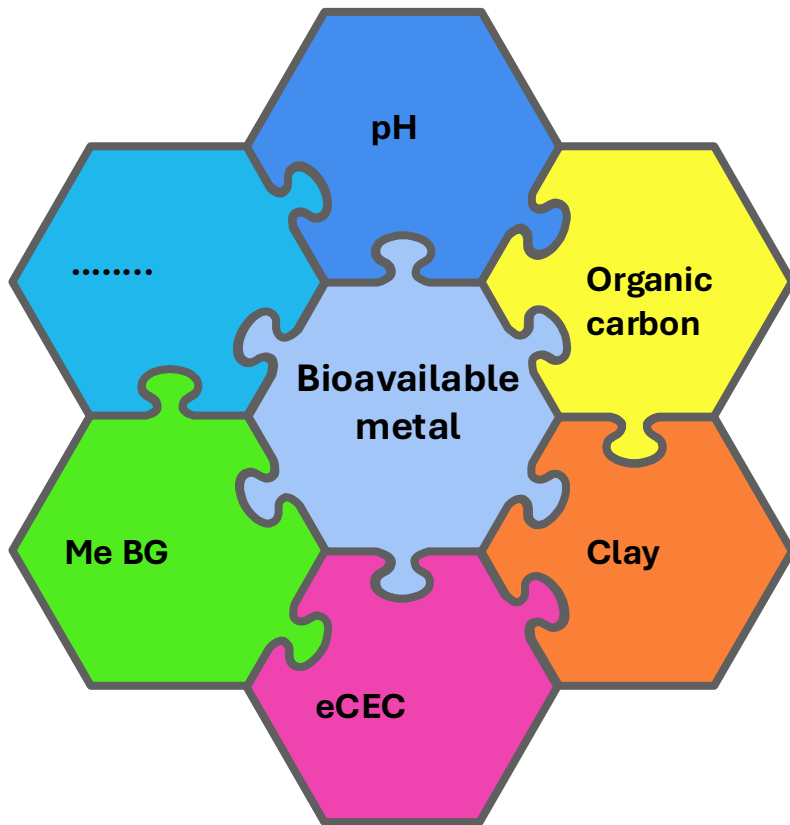
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# Verschuil tussen lab en veld observaties



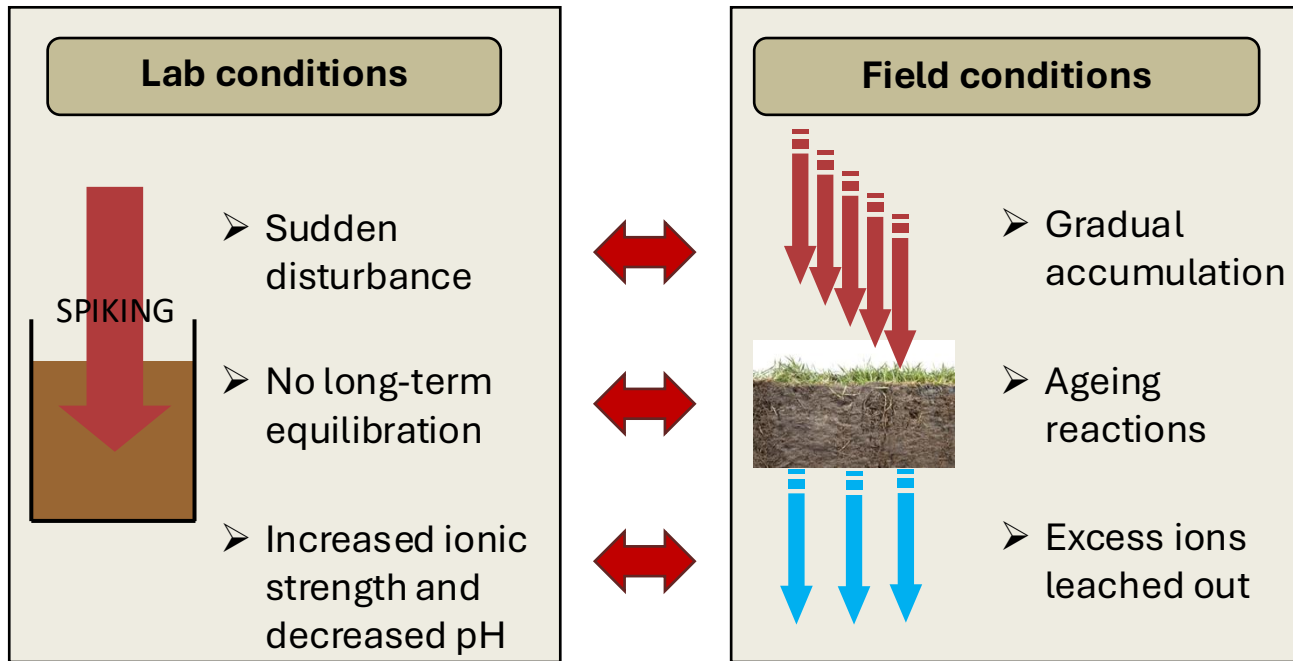
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# Incorporatie biobeschikbaarheid metalen



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# Biobeschikbaarheid bodem: verschillen tussen labo en veld condities



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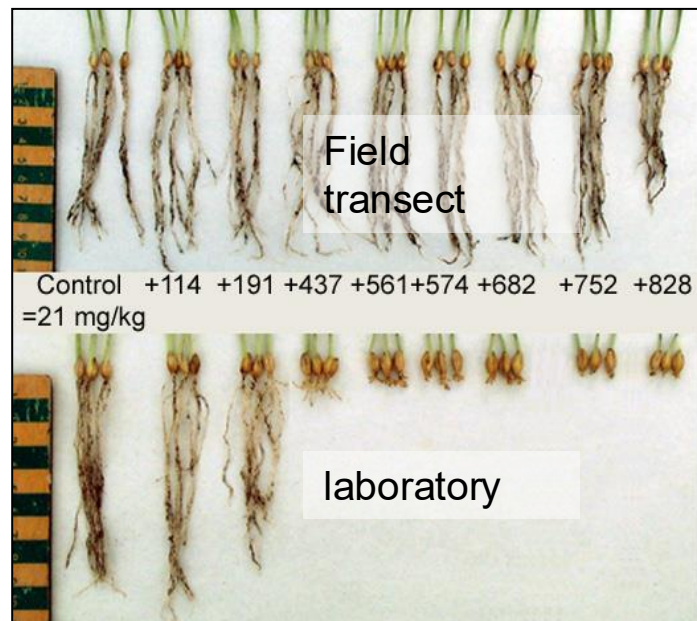


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Advies- & Studiebureau

# Biobeschikbaarheid bodem: verschillen tussen labo en veld condities

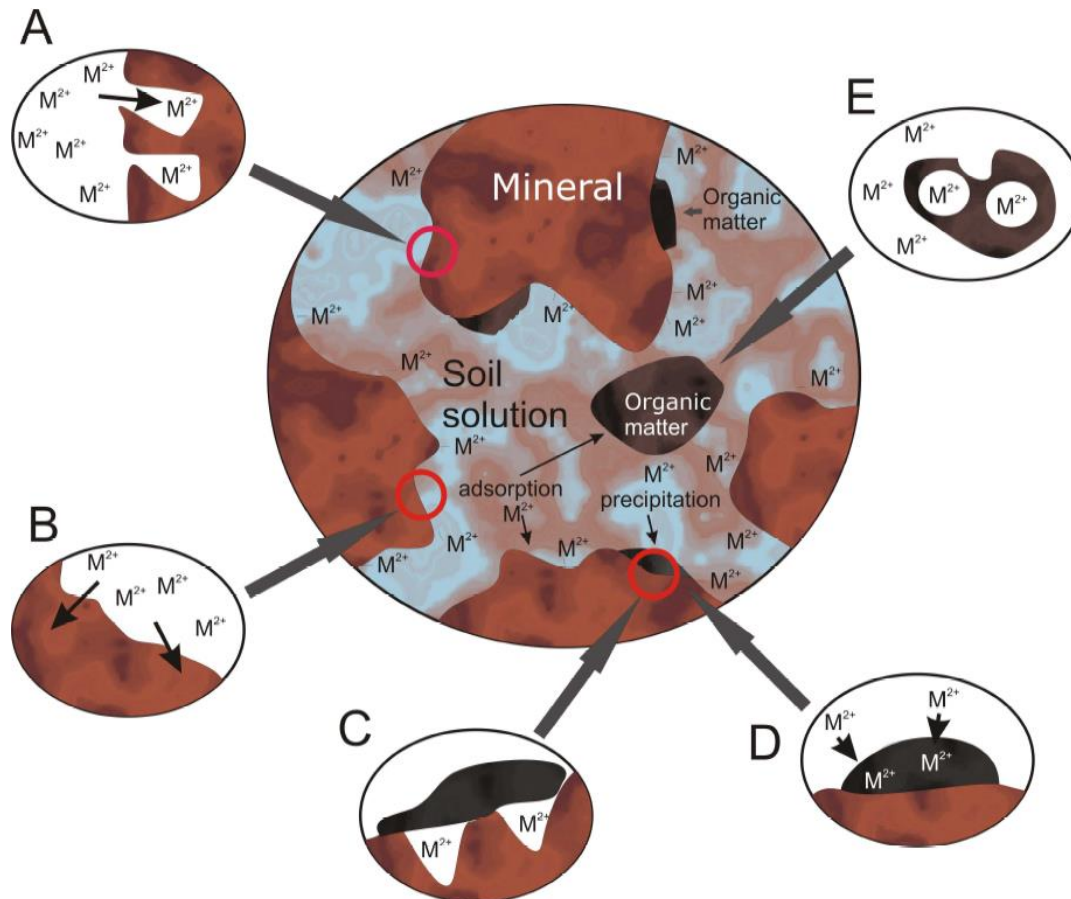


Er is een duidelijk verschil tussen de metaal toxiciteit die in het laboratorium wordt gemeten in pas verrijkte monsters en gelijkaardige concentraties van in in het veld verontreinigde bodems

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# Verouderingsprocessen

## Ageing reactions



- A. Diffusion in micro-pores
- B. Inclusion in crystal structure of soil minerals
- C. Occlusion by precipitates
- D. Precipitation on soil surface
- E. Occlusion in organic matter

# Soil threshold calculator V3.1

- Released November 2013, frequently updated. Last update feb 2026 Arsenic included
- Available at <http://https://arche-consulting.be/en/tools/threshold-calculator-for-metals-in-soil>



PNEC and Risk Characterisation Ratio (RCR) for:

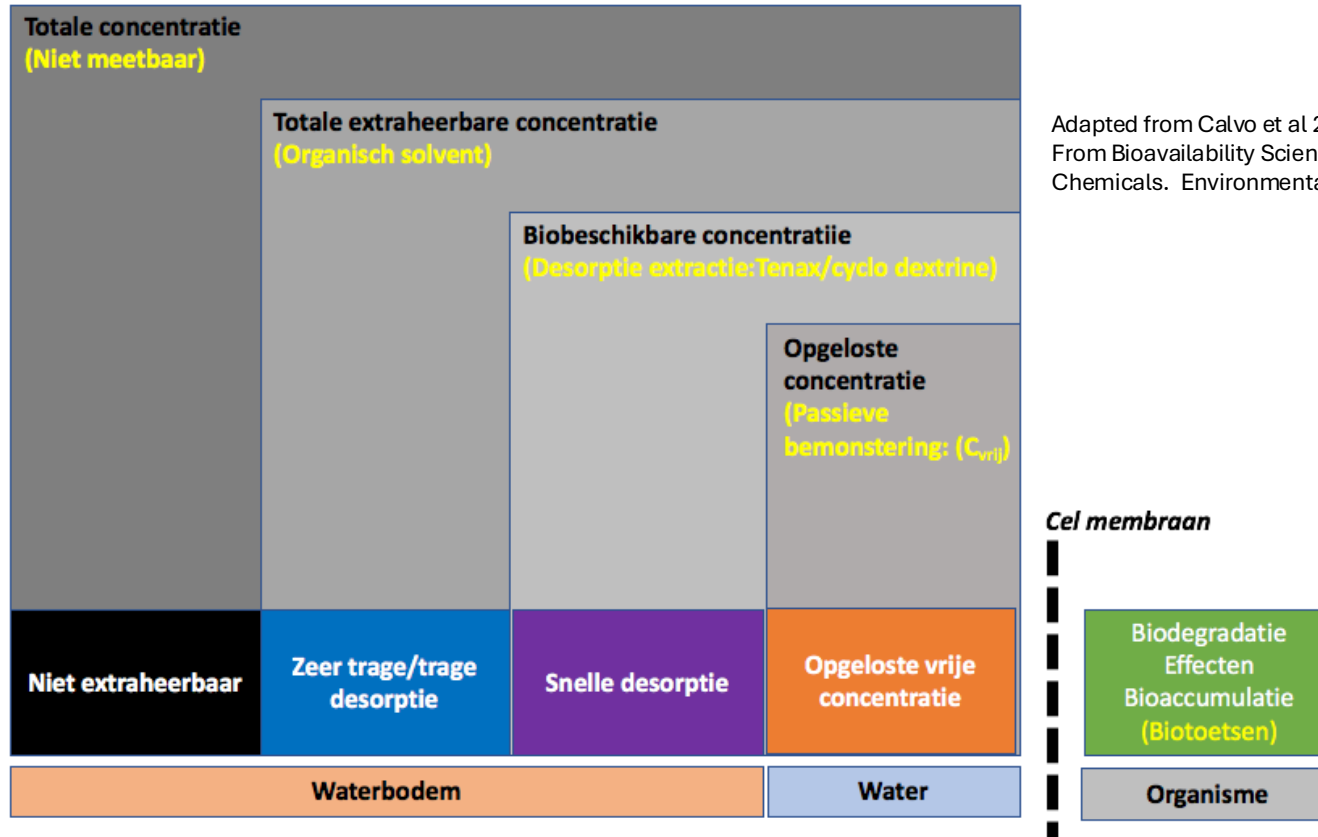
	PNEC (mg/kg)	PEC (mg/kg)	RCR /	PAF %
<b>Copper</b> <span style="float: right;">Back To Input</span>				
Results for site specific information: eCEC= 12.04 cmolc/kg, pH= 7, Org. C= 2 %, Clay= 10 %				
ADDED approach PNECadded,site specific	52.8	75	1.42	11.5
TOTAL approach PNECtotal,site specific	71.1	100	1.41	12.0

PNEC: Predicted No Effect Concentration of the metal, concentration below which exposure to the metal is not expected to cause an adverse effect  
PEC: Predicted (or in this case usually measured) Environmental Concentration of the metal of interest in the soil  
RCR: Risk Characterisation Ratio – the PEC divided by the PNEC  
PAF: Potentially Affected Fraction, the fraction of terrestrial species predicted to be affected at the metal concentration (PEC) entered

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# Biobeschikbaarheid organische stoffen



Adapted from Calvo et al 2015  
 From Bioavailability Science to Regulation of Organic Chemicals. Environmental Science & Technology, 49 (17)

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# Wat brengt de toekomst?



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# Soil monitoring Law Proposal (2023)



## European Commission proposal for a Soil Monitoring Law

Technical Briefing on  
Introducing relevant soil biodiversity descriptors for soil monitoring

### Policy recommendations for improvements needed in EC proposal

- The mandatory soil biodiversity descriptor 'soil basal respiration' in Annex I should be replaced with the following two soil biodiversity descriptors of which Member States should choose at least one:
  - Community-level physiological profiling (CLPP) and
  - Metabarcoding (eDNA).Annex I should also require the application of a suitable biodiversity index, such as the Shannon-Wiener Index, to evaluate soil biodiversity.

The Commission should be empowered to adopt delegated acts to amend Annex I and adapt it to newest scientific and technical progress, specifically on soil biodiversity.
- Member States should be required to set criteria for at least one of these biodiversity descriptors after the first soil measurements are performed, at the latest four years after date of entry into force of the Directive. These criteria can be set either at Member State- or at soil district-level.
- Member States should be required to monitor at least one of the above-mentioned soil biodiversity descriptors and include the results of this monitoring in the assessment of the soil health.



### III. Which biodiversity descriptors and monitoring methods are suitable

The proposed descriptor on soil basal respiration is not suited to provide a qualitative of soil biodiversity. The descriptor is scientifically as well as technologically not up to date. Respiration does not provide information about communities and species, or data for an index. Soil biodiversity experts regard it as one of the least effective methods for the of soil biodiversity<sup>16</sup>. It predominantly measures soil activity from bacterial respiration, a fungal or other sources and is very easily manipulated (i.e. via manure application, potent in misleading positive outcomes due to the activity of low biodiverse microbiomes).

Methods that put soil respiration into a wider context are more powerful<sup>15</sup> and have proven as indicators of soil microbial functions and functional diversity<sup>16</sup>. The descriptors to monitor soil biodiversity should accurately portray the (functional) diversity of soil<sup>17</sup> describe soil biodiversity's loss or development. Well established scientific literature suggests two core methodological approaches to achieve this:

- Community-level physiological profiling<sup>17</sup> (CLPP) and
- Metabarcoding<sup>18</sup> (eDNA).

CLPP approaches collect information about the soil's functional biodiversity whereas eDNA (environmental DNA) collects information mainly about the soil's taxonomic biodiversity. In both cases, the information can be operationalized by standard biodiversity indexes, for example the (3) Shannon-Wiener Index<sup>19</sup>. After standardization and cross-validation, an approach based on CLPP and eDNA can thus lead to a harmonized assessment of soil biodiversity at EU level as well as facilitate the setting of criteria at soil district or Member State level, taking into consideration land use.

More information on the approaches and methods mentioned above:

#### (1) Community-level physiological profiling (CLPP)

Community-level physiological profiling (CLPP) analysis is a technique used to characterize the metabolic activity of microorganisms in a mixed microbial community. By examining a community's ability to use a range of carbon sources, it gives insights into its overall functional versatility. In ecological studies, EcoPlates<sup>21</sup> are employed to measure the consistency of a standard microbial group and to identify and evaluate shifts when an environmental factor emerges. Those shifts in microbial populations frequently signal upcoming changes in the overall health and stability of the environment. Two main methods are widely acknowledged to evaluate microbial soil condition: MicroResp<sup>TM22</sup> and Biolog EcoPlate<sup>TM23</sup>.

#### (2) Metabarcoding (eDNA)

Regarding soil ecosystem biodiversity analyses via metabarcoding, eDNA methodologies offer an efficient, reproducible, and scalable solution to characterise biodiversity, establish diversity thresholds, understand food web dynamics and monitor community changes as a result of diversity, management decisions, or restoration programs. In this context, the use of eDNA methodologies has enabled the classification of the major biotic components of soil microbiomes in agricultural systems<sup>24</sup>. The Global Soil Biodiversity Conservation Network also recommends analytical methodologies based on eDNA to develop new ecological indicators for tracking soil health and biodiversity<sup>25</sup>.

#### (3) Shannon-Wiener Index

The Shannon-Wiener index is a key indicator used to evaluate biodiversity in ecology. However, it is important to understand differences and similarities in its application in both CLPP and eDNA methods. In both cases, the index is used to quantify biodiversity, taking into account the number and abundance of species (in the case of eDNA) or metabolic patterns (in the case of CLPP). In both cases, the Shannon-Wiener index allows for assessing the complexity of an ecosystem, where higher values indicate greater biodiversity. For CLPP, the index is based on metabolic profiles, which indicate the ability of microorganisms to utilize various carbon substrates. For eDNA, the index is based on the

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The Commission should be empowered to adopt **delegated acts to amend Annex I** and adapt it to newest scientific and technical progress, specifically on soil biodiversity.
2. Member States should be required to **set criteria for at least one of these biodiversity descriptors after the first soil measurements are performed**, at the latest four years after date of entry into force of the Directive. These criteria can be set either at Member State- or at sub-district-level.
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# eDNA Metabarcoding



Molecular technique that uses **DNA** extracted from environmental samples to **identify multiple organisms simultaneously** through **high-throughput sequencing**.



Environmental DNA (eDNA) is extracted from **soil, sediment, water, snow, biofilms,** others.



Specific **genetic markers** (barcodes) are amplified (e.g. 16S, 18S, ITS), sequenced and **compared to reference databases** for **taxonomic identification**



It captures diverse organisms, including **prokaryotes and eukaryotes**, without the need for visual identification.



Used for **detecting biodiversity** in every environmental compartment.

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# eDNA bemonstering



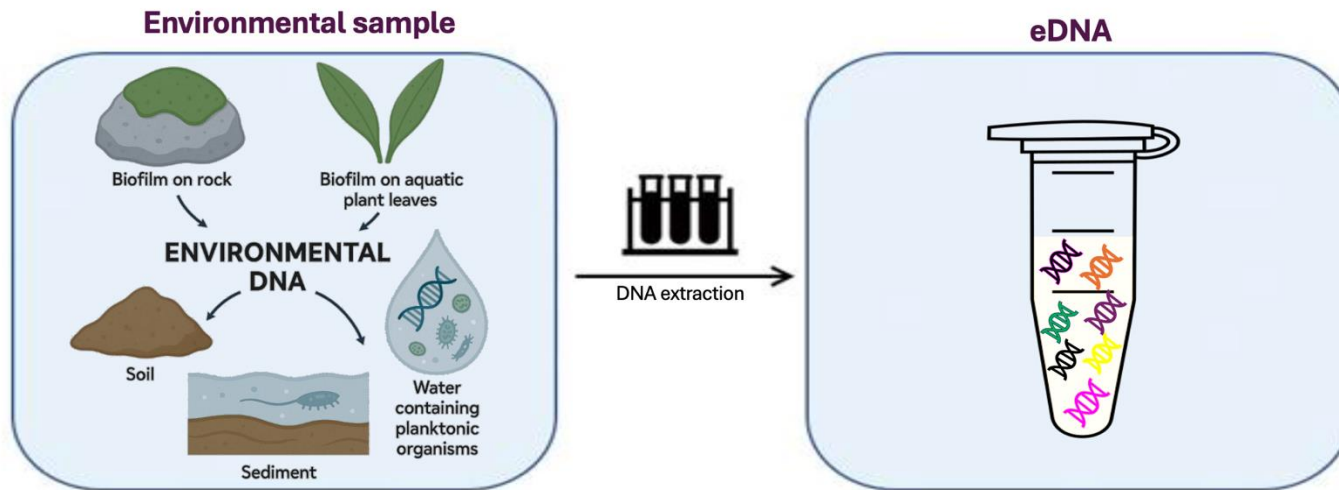
- **Soil:** Samples are collected using a sterile trowel, ensuring minimal surface contamination.
- **Sediment:** A corer is used to collect surface sediment layers from aquatic environments, targeting the top few centimetres rich in microbial and eukaryotic DNA.
- **Water:** Water samples are filtered using a vacuum filtration system. Filters retain suspended eDNA for subsequent extraction in the lab.
- **Biofilm:** Biofilms are scraped from surfaces (e.g., stones, aquatic plants) using a sterile toothbrush to recover attached communities for analysis.

Depending on the chosen **genetic marker**, it is possible conducting **broad** community surveys (e.g., 18S for eukaryotes, 16S for prokaryotes) or **targeted**, taxon-specific analyses (e.g., RbcL for diatoms)

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# eDNA extractie

**Pool of DNA molecules** present in an environmental sample (eDNA) → DNA of **different organisms** belonging to different taxonomic groups.



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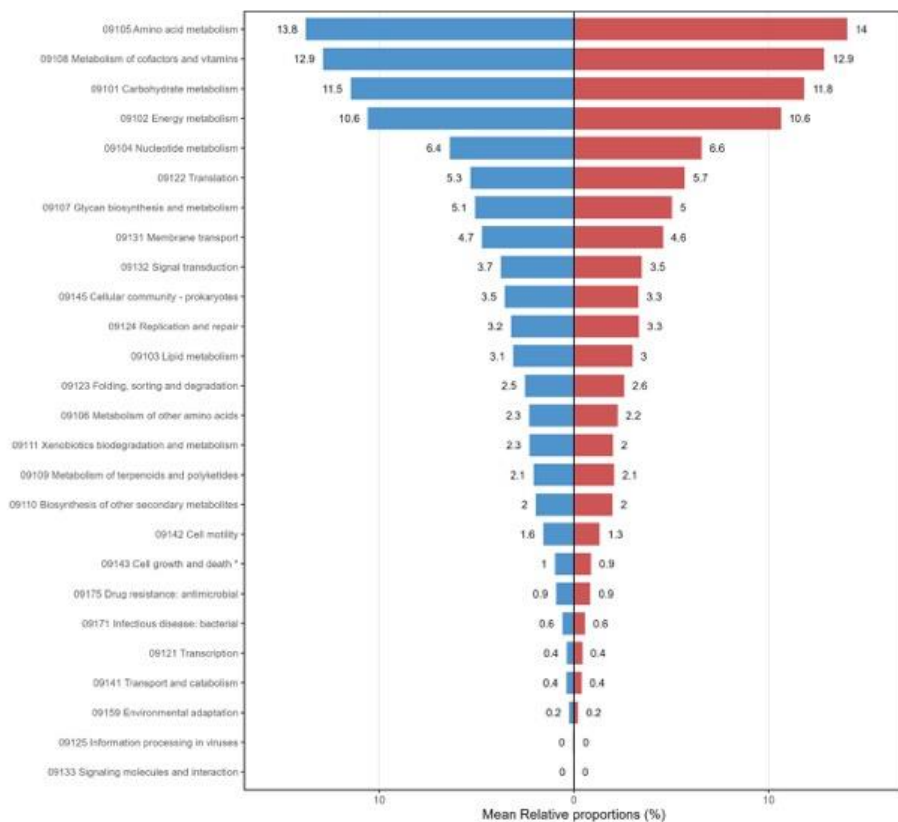


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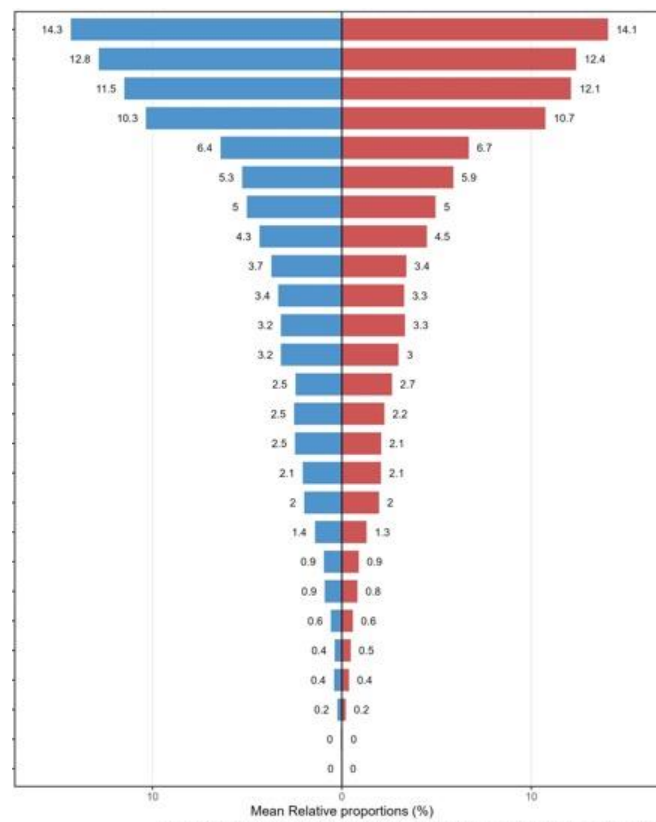


# Sediment preliminary Predicted Functional Profile

Molse Nete | Downstream Scheppelijke Nete vs Upstream Scheppelijke Nete



GN | Downstream Molse Nete vs Upstream Molse Nete



No significant differences (ALDEx2; p.BH > 0.05) were detected between pairwise comparison for any predicted metabolic pathway

# DEB-IBM populatie modellen

## Theory of the dynamic energy budget (DEB)

Metabolic theory:

- Describing the energy flows within the organism
- Growth, maturation and reproduction used to predict life history traits (IBM model)

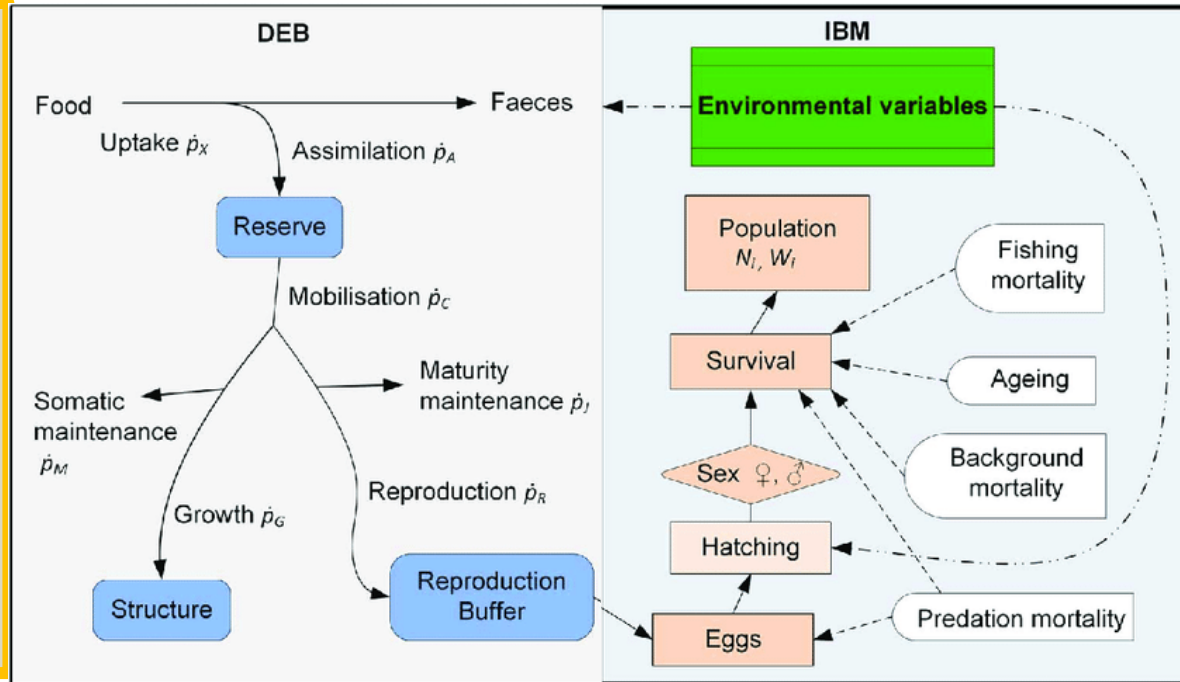
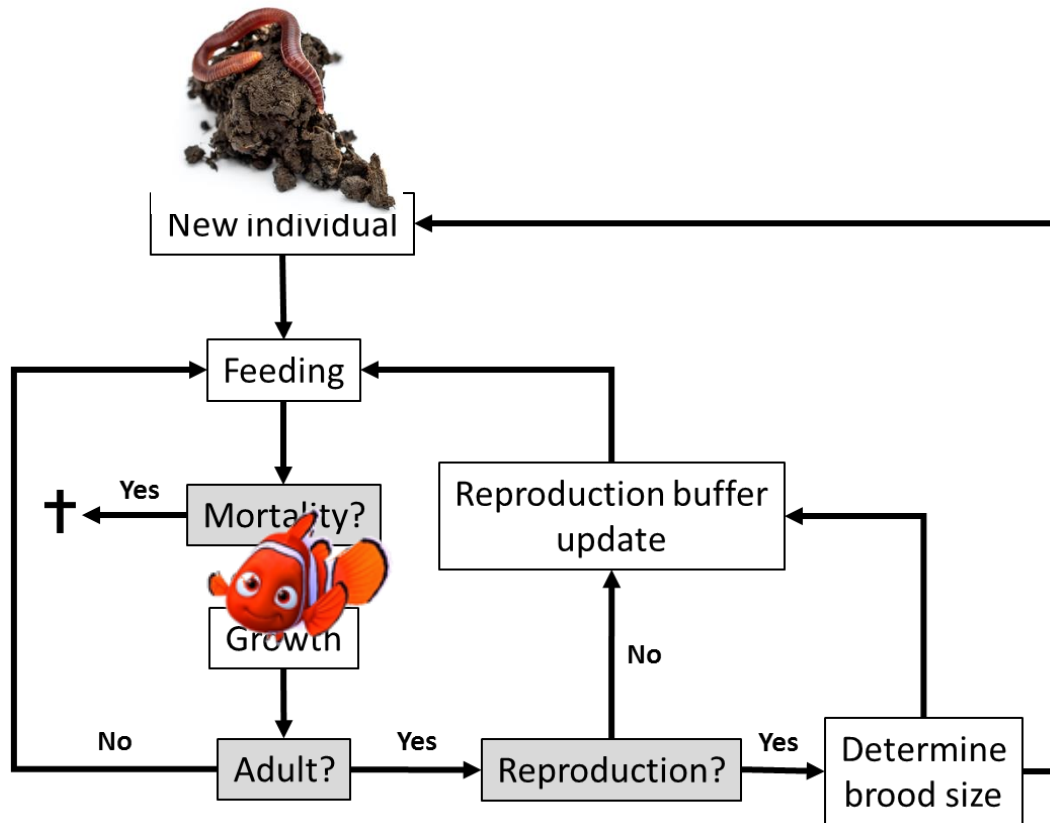


Figure Harry Gorfine

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# DEB-IBM populatie model

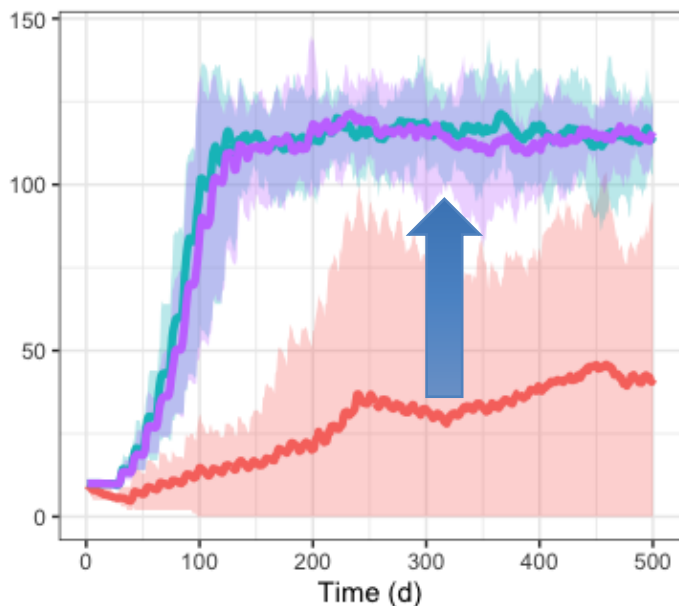


Chemical stressors, changing environmental conditions leading to sublethal effects

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# Vb toepassing DEB-IBM populatie model

Grote Laak - Cd



**Historical metal pollution in river sediment and soils in Flanders:**  
Excavation of polluted sediment would lead to complete destruction of the local environment (i.e., complete loss of nature and biodiversity)

→ **LIFE NARMENA project**

**N**ature-based Remediation of **M**etal pollutants in **N**ature Areas to increase water storage capacity

**Non-invasive, Nature-Based soil and sediment Remediation (NBR):**

- Bacteria-assisted phytoremediation (BAP)
- Constructed wetlands (CW)

**Ecological modelling to compare different risk management scenarios:**

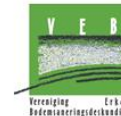
- Mathematically model impact of heavy metals (As, Cd, and Cr) on *Lemna minor*, and populations of *Daphnia magna* and *Hyaella azteca*
- Comparison between conventional and nature-based remediation



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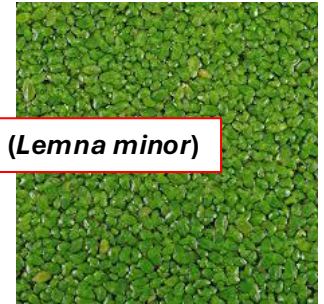


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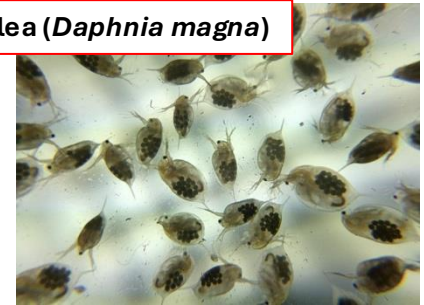


# Eco-modelling tool

- **DEB-IBM modelling framework developed for 3 indicator species**
- **Different scenarios included:**
  - No remediation (situation before remediation)
  - Excavation (complete removal of heavy metal contamination)
  - NBR (Grote Laak, Grote Calie, Winterbeek)
  - User-defined (set your own metal + concentration in water and sediment compartment)
  - Predict impact at the population level



Duckweed (*Lemna minor*)



Water flea (*Daphnia magna*)



Amphipod (*Hyalella azteca*)

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Setting up and running the model  
Record output

The screenshot shows the NetLogo interface for the DEBIBM\_NARMENA\_v5.1 model. The top window title is "NetLogo — DEBIBM\_NARMENA\_v5.1 (/Users/arche/Dropbox (Arche)/Projects/OVAM/NARMENA/04 Working documents/Population Modelling/Final model)". The interface includes a menu bar (File, Edit, Delete, Add, abc Button), a toolbar with "RecordD..." and "MC" buttons, and a main workspace with several panels:

- SETUP:** Includes "GO" and "MC" buttons.
- OutputFile:** "OutputFileName" is set to "simulation.txt".
- Remediation scenario:** "stressor-present?" is "On", "stressor" is "Chromium", "location" is "Grote Laak", and "remediation\_scenario" is "User-defined".
- Exposure conditions:** "sediment-concentrat..." is 3500 µg/kg dw, "water-concentration" is 100 µg/L, "terr.bioavailabil..." is 1 %, and "aq.bioavailabil..." is 50 %.
- Population-level plots:** Six plots are shown:
  - Daphnia - Population abundance:** Shows abundance (#) over 300 days. A red line represents the average prediction, surrounded by a red shaded area for the min-max prediction. A dashed horizontal line indicates the control prediction.
  - Daphnia - Population biomass:** Shows biomass (mg) over 300 days. An orange line represents the average prediction, surrounded by an orange shaded area. A dashed horizontal line indicates the control prediction.
  - Hyalella - Population abundance:** Shows abundance (#) over 300 days. A blue line represents the average prediction, surrounded by a blue shaded area. A dashed horizontal line indicates the control prediction.
  - Hyalella - Population biomass:** Shows biomass (mg) over 300 days. A purple line represents the average prediction, surrounded by a purple shaded area. A dashed horizontal line indicates the control prediction.
  - Lemna - Biomass:** Shows biomass (mg dw/m<sup>2</sup>) over 354 days. A green line represents the average prediction, surrounded by a green shaded area. A dashed horizontal line indicates the control prediction.

Setting the simulated scenario:  
What metal (Cr, As, Cd)?  
Location (Grote Laak, Winterbeek, Grote Calie)?  
Remediation (no remediation, excavation, NBR)

Sediment and water concentrations are set  
Soil and water bioavailability of each metal is set as well

Population abundance

Only biomass for Lemna

Population biomass

Lines represent an average prediction  
Shaded area is min-max prediction  
Dashed lines are the control prediction  
(no contamination)





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Vereniging Nederlandse  
Arbeiders van de  
Rijkswateringen

# Vragen?



Tuesday, June 9, 2026

Dag van de bodemdeskundige 7 mei 2026





[www.arche-consulting.be](http://www.arche-consulting.be)

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Director

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