



University of Natural Resources and
Applied Life Sciences, Vienna
Department of Water, Atmosphere and
Environment

Biology, Chemistry and Microbiology for Civil Engineering

811.357

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Important



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- Please be punctually (esp. In the LABs)
- Time in the chemical Lab (tuesday, wednesday): 9:00 – 12:30
- Presentation of the groups: CEN/ISO: Friday 10.6.11:30

Content



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- Chemical and physical parameters
- Chemical and physical processes
- Investigation of water samples
 - Sampling
 - Analyses
- Guidelines (DW, aquatic environment, waste water, sewage sludge)
- Characteristics of natural waters
- Quality assessment of water, waste water and sewage sludge

- Practical exercises
- Presentation by the groups

<http://on.to/sig>
(Institutshomepage)



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Chemistry for Civil Engineering

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Teil: **Introduction**

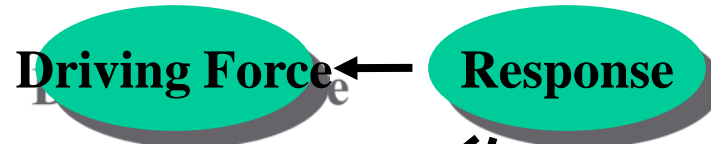
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Holistic approach: water



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Contamination sources
 natural, anthropogenic



Risk management

- prevention, ban
- technical measures
- national und international limit values and regulations

Emissions

- contamination monitoring and reduction
- technical measures



Effects on humans and the environment

Risk assessment

State of the water
 • drinking water
 • surface water

Water related EU regulations



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Irrigation water requirements - microbiological and chemical parameters
Bathing Water Directive - microbiological parameters
Drinking Water Directive - microbiological and chemical parameters
WHO Drinking Water Guidelines 3rd Edition 2004
WFD (surface and groundwater)- biological and chemical status

EU-Water quality standards



Intergrated water
quality management



EU - emission limits

UWWT (91/271/EEC)- eutrophication and oxygen depletion
IPPC (96/61/EEC)- chemical parameters
Nitrate Directive (91/676/EEC) - chemical parameters
Plant Protection Products (91/414/EEC)- chemical parameters
REACH (EG) Nr. 1907/2006 (REACH-Verordnung) Registration, Evaluation, Authorisation of Chemicals

Strategies of regulations



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- Precautionary principle (minimisation):
 - Zero or no increase
 - No analytical detection with established method
 - Natural background

- Risk based (WHO and WFD)
 - No perceivable damage level
 - Defined risk

Strategies of regulations



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- Based on technical or economical feasibility
 - Best available technology (BAT)
 - Best environmental practices (BEP)
 - The benefit should be higher than the costs
 - The costs should be socially acceptable

Hazard/risk



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- Hazard: qualitative
 - damage factor could possibly cause a damage
- Risk: quantitative
 - intensity of the damage (dose)
 - probability and magnitude of a hazard

the magnitude of the potential loss ,
and the probability p that the loss will occur



Steps of a risk assessment

- Hazard identification
- Dose response relationship
- Exposure assessment
- Risk characterisation



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Pollutant identification (WHO)



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Substances with threshold value

No effect below a threshold value–
NOAEL, LOAEL

Substances without threshold value

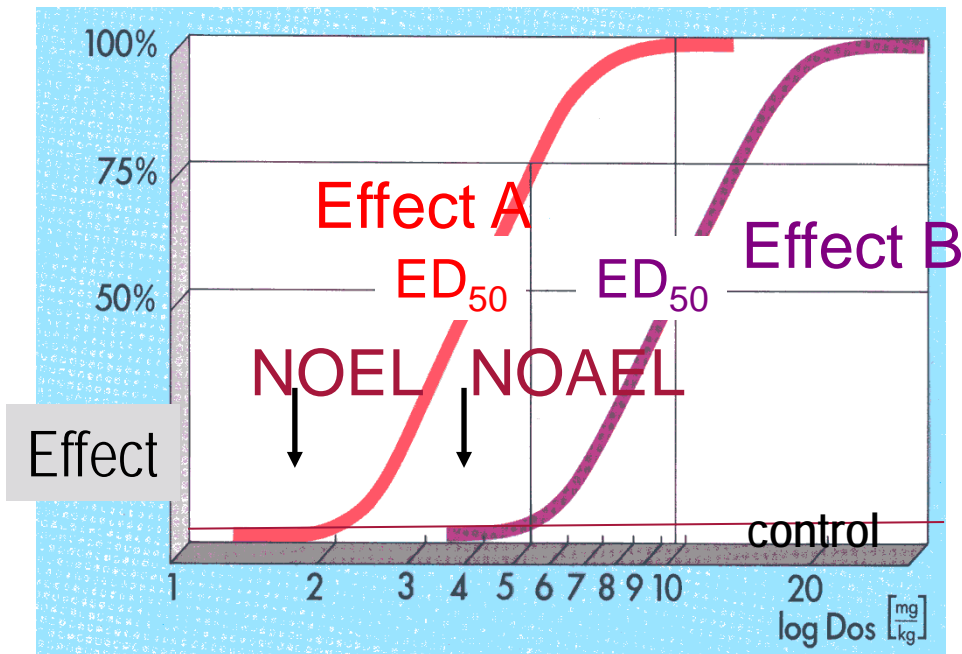
Irreversible effects
(cancerogenic, mutagenic, genotoxic effects
CMR-substances)

Dose response relationship



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Substances with threshold value



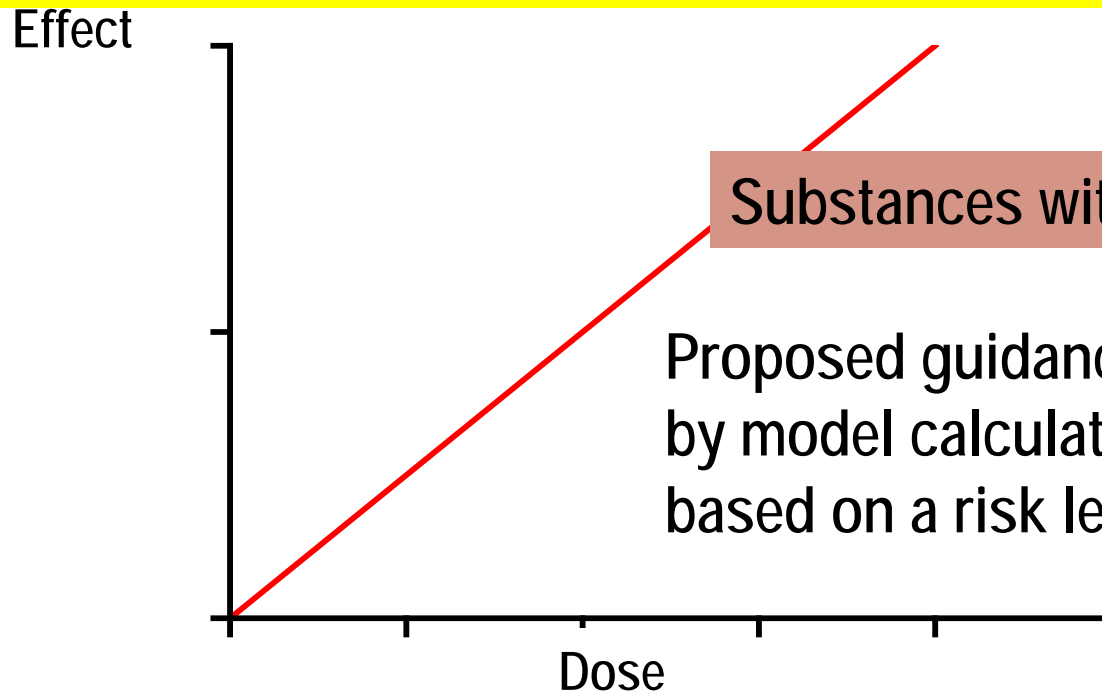
- Determines the relationship between the magnitude of exposure and the probability of occurrence of health effects
 - Dependent on the toxokinetics
 - Absorption, dispersion, metabolism, excretion
 - and the toxicodynamics
 - Binding, interaction and induction of the effects

Experimental and model data:



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The dose to effect relationship for substances with irreversible effects (e.g. teratogenic and cancerogenic) is linear



Substances without threshold value

Proposed guidance values are derived by model calculation based on a risk level of 10^{-5} or 10^{-6}

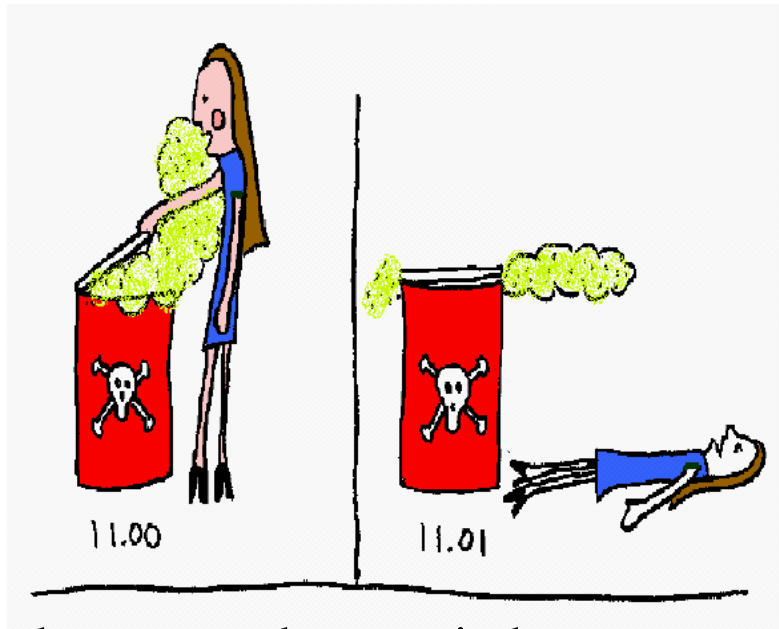
This means: effect "0" only at "0,, dose

Exposure: frequency and duration



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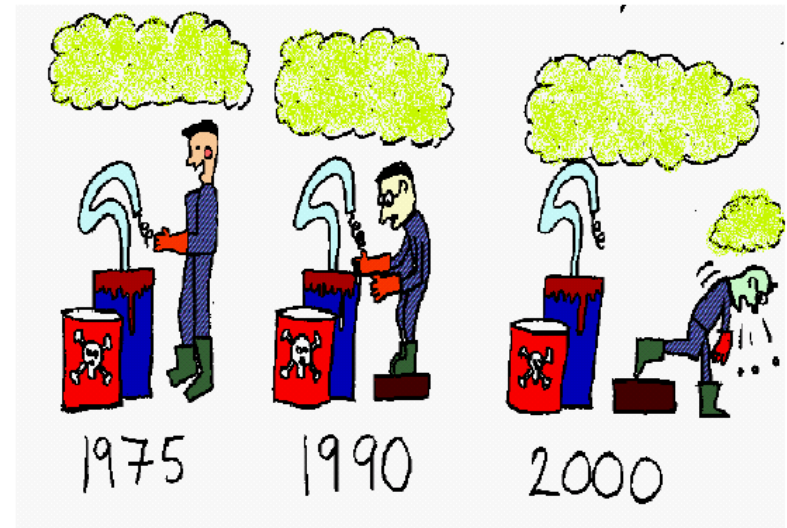
Acute Toxicity



- High dose
- Rapidly visible reaction
- Poisoning symptoms
- Antidote

- Low dose over a long period
- No visible effect at short term
- The effects cannot be easily attributed
- NO antidote

Chronic Toxicity



Acute and subchronical toxicity



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Substances with threshold value

- LD_{50} : lethal dose for 50% of the laboratory animals (24 h)
- LC_{50} : lethal concentration (4 h in the air)

- NOEL No Observed Effect Level
- NOAEL No Observed Adverse Effect Level
- LOAEL Lowest Observed Adverse Effect Level
- MTD Maximum Tolerated Dose (lifelong exposure)
- ADI Acceptable Daily Intake
- TDI tolerable daily intake

Risk assessment for human health risks

(WHO, 2004) http://www.who.int/water_sanitation_health/dwq/guidelines/en/



esp. Chapter 4 and 8

Substances with threshold value

TDI (tolerable daily intake)

$$\text{TDI} = \frac{\text{NOAEL oder LOAEL}}{\text{UF}}$$

NOAEL = no-observed adverse effect level

LOAEL = lowest observed adverse effect level

UF = Unsicherheitsfaktor (10 - 10000)

Assumption:

- 60 kg body weight; 2 l water consumption/day, 70 years
- 10 kg body weight; 1 l water consumption/day
- 5 kg body weight; 0.75 l water consumption/day



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WHO Guideline Value (GV)

(WHO, 2004)



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Substances with threshold value

$$GV = \frac{TDI * BW * P}{C}$$

TDI = tolerable daily intake

BW = body weight

P = for drinking water fraction

C = daily water consumption

Substances without threshold value

Risk level 10^{-4} - 10^{-6}

Comparison between

Exposure

e.g. water concentration,
environmental concentration

Effect

Calculated concentration /or
guideline value (GV)

DALY = Disability Adjusted Life Years

(WHO, 2004)



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The disability adjusted life year (DALY) is a composite measure of years of life lost because of premature mortality and equivalent years lost because of lower 'quality of life' as a result of serious injury and disability.

DALY = Severity of health effects * duration * number of people affected
↪ 0 (normal good health) 1 (death).

DALY = years of life lost by premature mortality (YLL) and years of healthy life lost in states of less than full health, i.e., years lived with a disability (YLD)

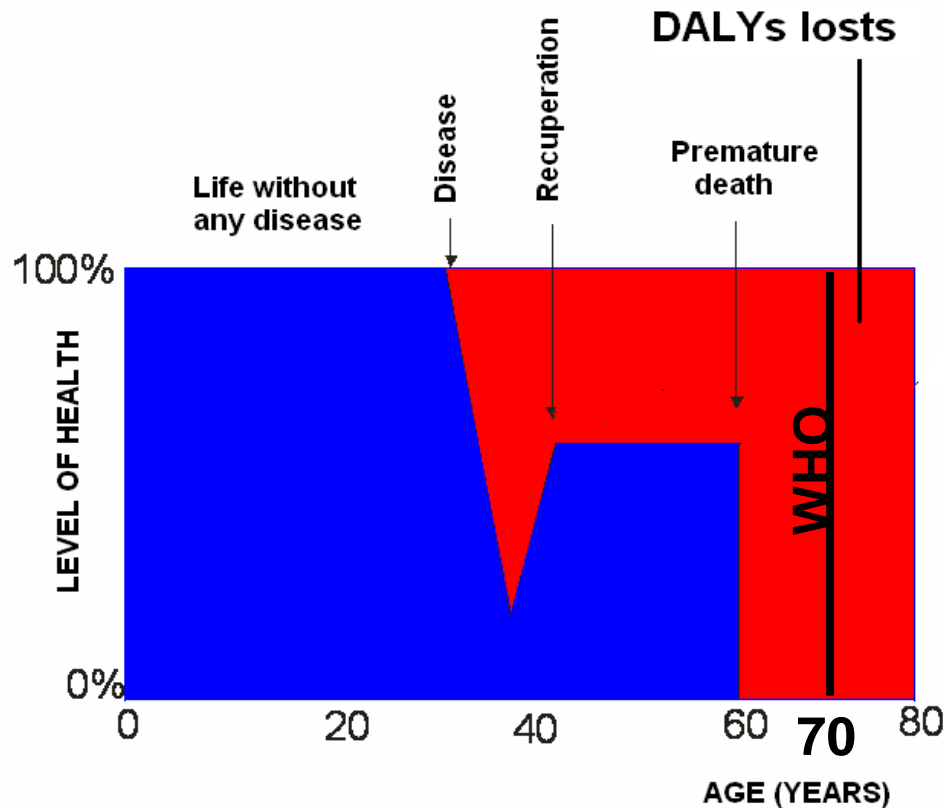
$$DALY = YLL + YLD$$

Definition of the tolerable risk



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Disability Adjusted Life Years- DALYs



To standardize the acceptable risk caused by different agents in different norms (Drinking water a risk of 10^{-5} for cancer while in irrigation a risk of 10^{-3} for diarrheas)

Risk assessment in the environment

Predicted environmental concentration PEC

Exposure estimation

Use pattern

Pathways

Distribution characteristics

Behavior in the environment

- persistence
- degradation
- bioaccumulation

Chemical analytics

Predicted no effect concentration PNEC

Effect estimation

Ecological effects

- Acute toxicity
- Chronic toxicity

Toxicity to humans
and the ecosystems

- Bioaccumulation
(secondary poisoning)

Risk estimation



Probability of occurrence

Risk assessment

Criteria for identification of **PBT** (persistent, bioaccumulative, toxic) and **vPvB** very persistent, very bioaccumulative, substances

The table contains two sets of criteria, one for persistent, bioaccumulative and toxic (**PBT**) substances and a second category for so-called very persistent and very bioaccumulating substances (**vPvB**).

Criterion	PBT criteria	vPvB-criteria
P	Half-life > 60 d in marine water or > 40 d in freshwater* or half-life > 180 d in marine sediment or > 120 d in freshwater sediment*	Half-life > 60 d in marine- or freshwater or >180 d in marine or freshwater sediment
B	BCF > 2,000	BCF > 5,000
T	Chronic NOEC < 0.01 mg/l or CMR or endocrine disrupting effects	Not applicable

* For the purpose of marine environmental risk assessment half-life data in freshwater and freshwater sediment can be overruled by data obtained under marine conditions.

(4) L(E) C50; NOEC - no observed effect concentration;
CMR - carcinogenic, mutagenic or toxic to reproduction
BCF biocentration factor.

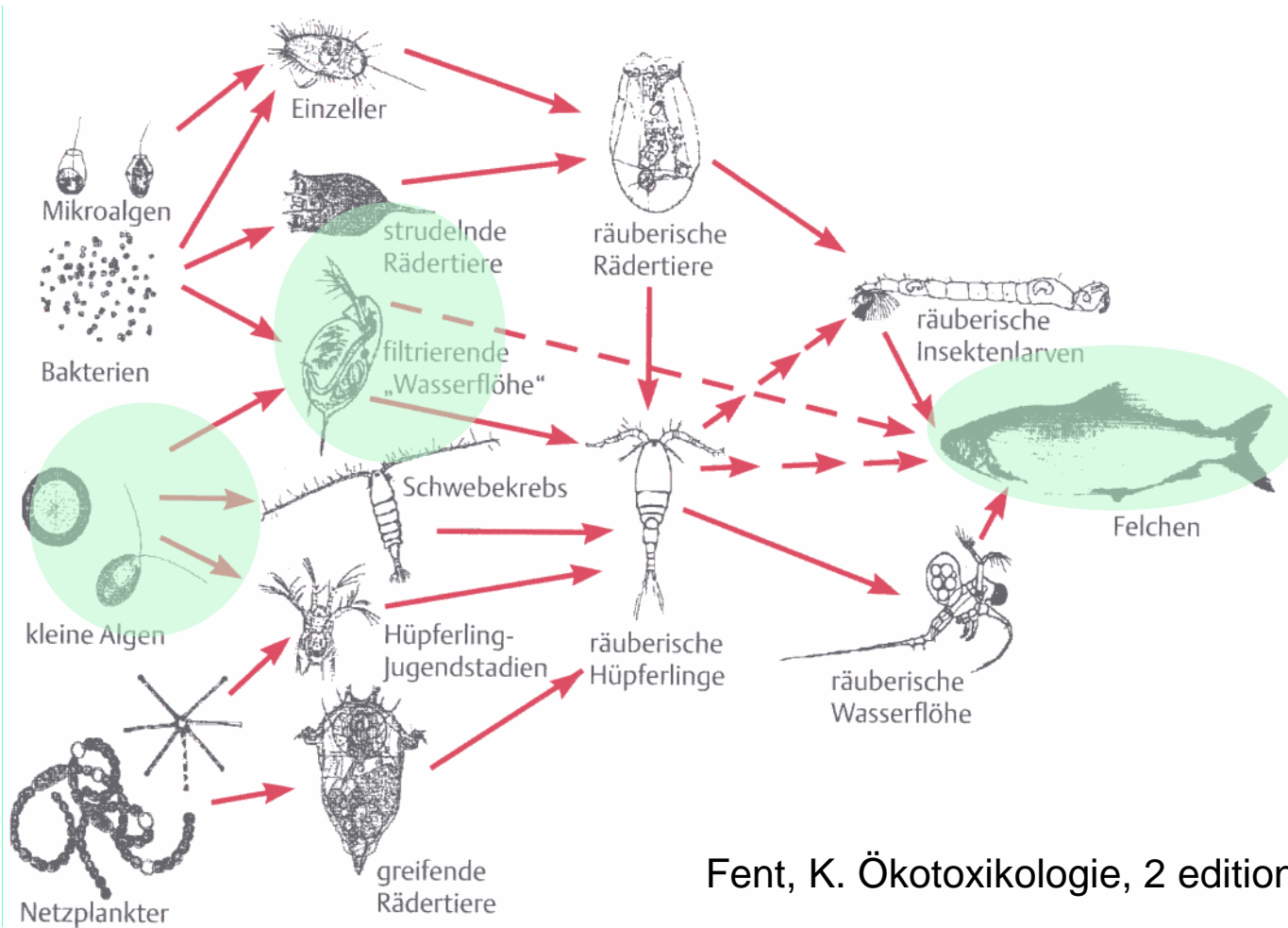
Protection of ecosystem



Complexity in ecotoxicological risk assessment: consideration of organisms of different trophic levels



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Fent, K. Ökotoxikologie, 2 edition., 2003

Assessment factors to derive a $PNEC_{\text{aquatic}}$



Available data	Assessment factor
At least one short-term L(E)C50 from each of three trophic levels of the base-set (fish, Daphnia and algae)	1000 ^{a)}
One long-term NOEC (either fish or Daphnia)	100 ^{b)}
Two long-term NOECs from species representing two trophic levels (fish and/or Daphnia and/or algae)	50 ^{c)}
Long-term NOECs from at least three species (normally fish, Daphnia and algae) representing three trophic levels	10 ^{d)}
Species sensitivity distribution (SSD) method	5-1 (to be fully justified case by case) ^{e)}
Field data or model ecosystems	Reviewed on a case by case basis ^{f)}

Concept of the ecotoxicological risk analysis



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Pattern of use



Dispersion
Persistence



Environmental
Concentration PEC

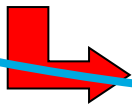
Effects



Toxicity
Assessment factors



Effect concentration
PNEC



PEC/PNEC



PEC predicted environmental concentration

PNEC predicted effect concentration

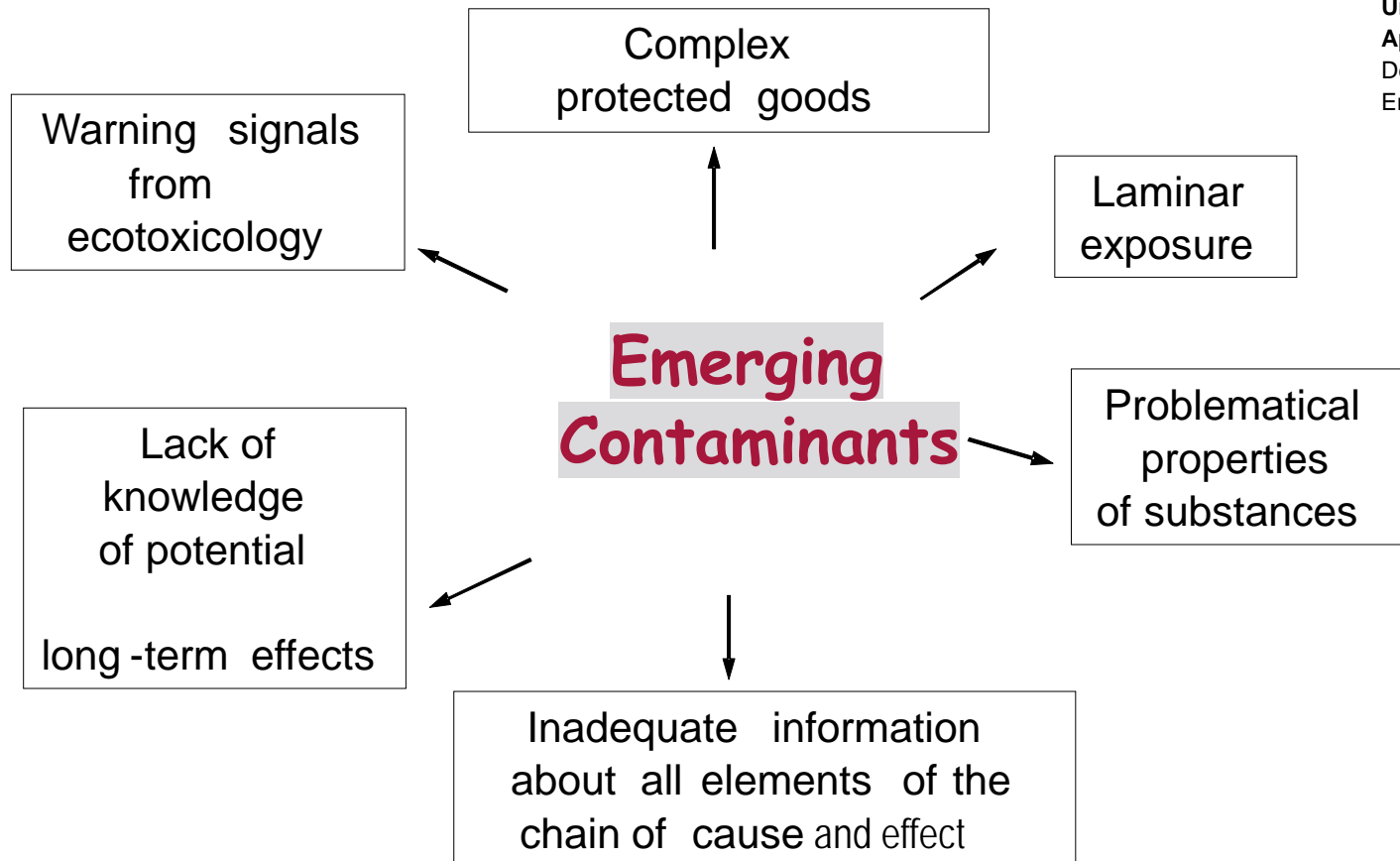
>1 risk assessment required

< 1 no risk assessment needed

Emerging Contaminants (EC) (Grummt, 2010)



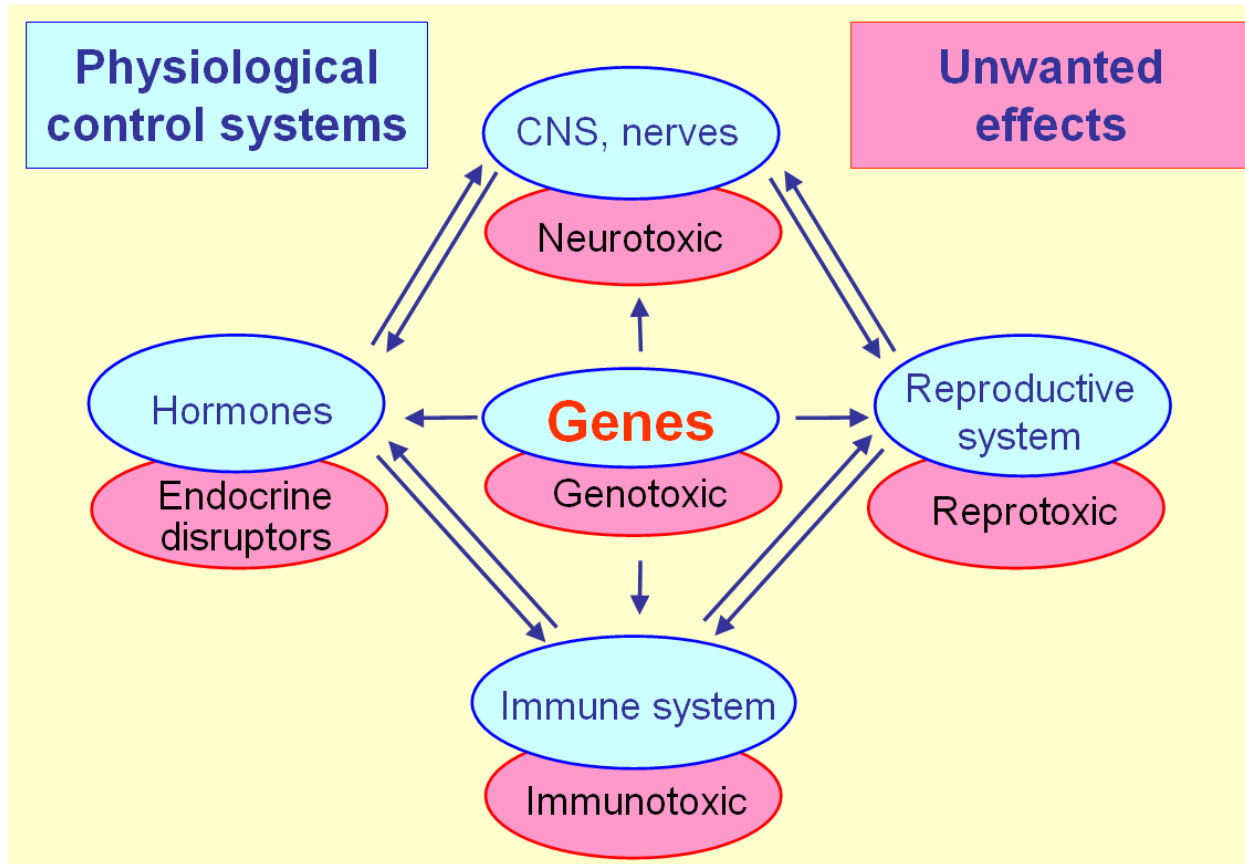
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Neuer Ansatz für EC (Grummt, 2010)



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Further reading



- http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html
- <http://ecb.jrc.ec.europa.eu/tgd/>
- <http://icm.eionet.europa.eu/>
- <http://www.as-search.at/norm-kann-mehr/normen-entwickeln/normungsgremien>
- <http://ris1.bka.gv.at/>
- http://ec.europa.eu/environment/water/water-drink/index_en.html