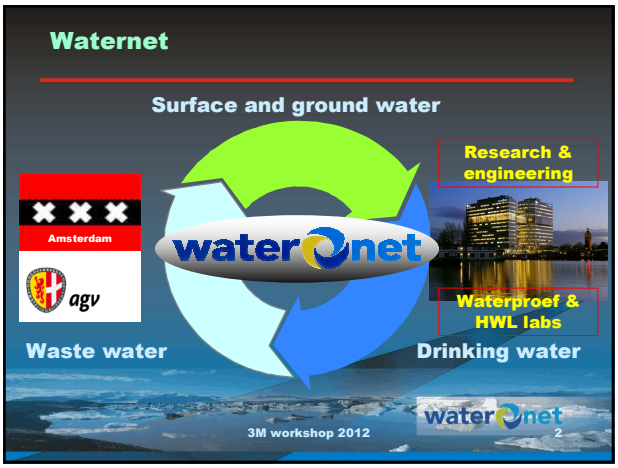

3M workshop, KWR Nieuwegein, 18-19 June 2012
A PERSPECTIVE ON ALTERNATIVE REGULATORY APPROACHES AND MONITORING STRATEGIES
Ron van der Oost
waternet


Waternet
Surface and ground water
Amsterdam
agv
waternet
Research & engineering
Waterproef & HWL labs
Waste water
Drinking water
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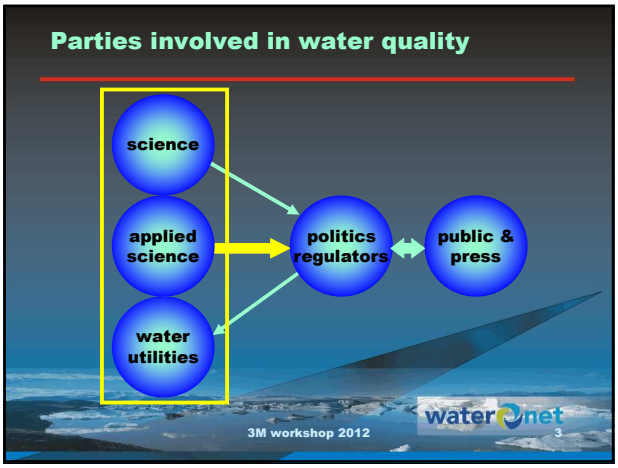
Parties involved in water quality
science
applied science
water utilities
politics regulators
public & press
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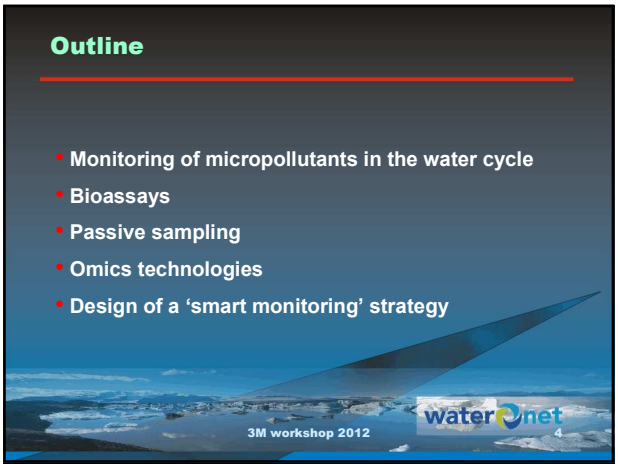
Outline
Monitoring of micropollutants in the water cycle
Bioassays
Passive sampling
Omics technologies
Design of a 'smart monitoring' strategy
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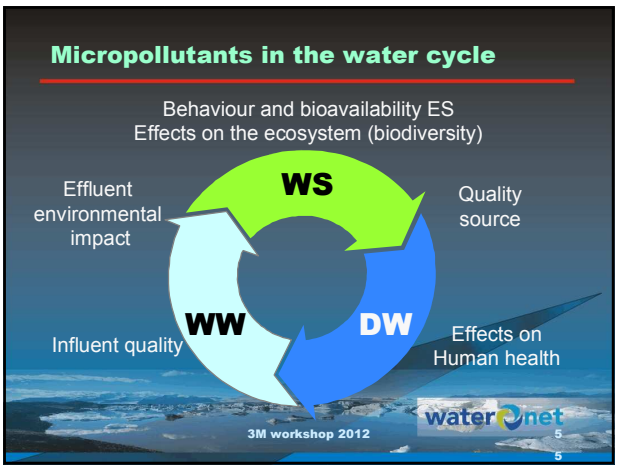
Micropollutants in the water cycle
Behaviour and bioavailability ES
Effects on the ecosystem (biodiversity)
Effluent environmental impact
WS
Quality source
WW
DW
Influent quality
Effects on Human health
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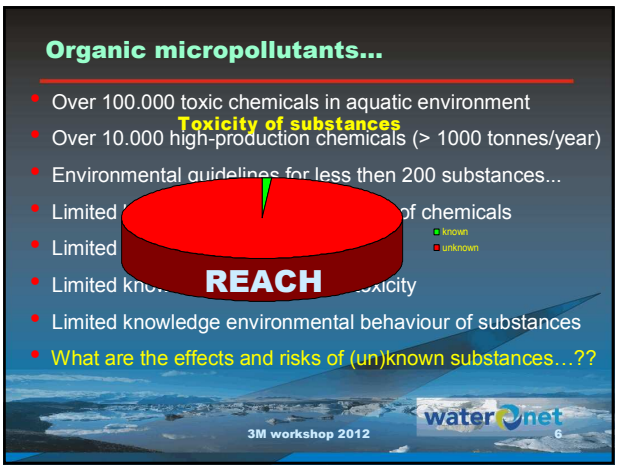
Organic micropollutants...
Over 100.000 toxic chemicals in aquatic environment
Over 10.000 high-production chemicals (> 1000 tonnes/year)
Environmental guidelines for less then 200 substances...
Limited
of chemicals
Limited
Limited kn
xicity
Limited knowledge environmental behaviour of substances
What are the effects and risks of (un)known substances…??
Toxicity of substances
known
unknown
REACH
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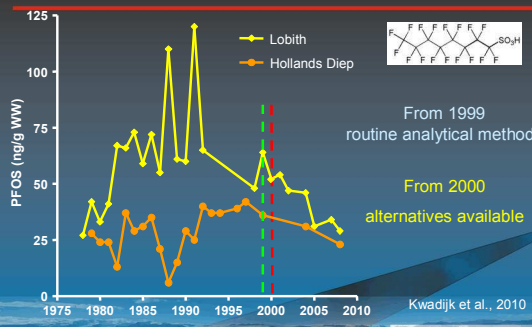
PFOS in eel (historical sample bank)



WFD monitoring

Non-chemical factors: habitat, hydromorphology microbiology, predation, etc

guidelines

Chemical status: 33+ priority pollutants

link?

Ecological status: groups populations

Measures to improve the water quality have to be taken if monitoring indicates no good chemical or ecological status!

WFD splits: human health

Ecotoxicity vs. human toxicity

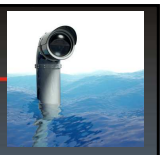
Chemical status: 33+ priority pollutants

- Choice of priority pollutants based on ecological effects
- Threaths for drinking water (polar compounds) are not included
- Lobbies WW ('guidelines too strict') versus DW ('not strict enough')

Limitations of WFD monitoring

- No information on human risks (drinking water)
- Limited information on environmental risks
- No knowledge on cause of ecological impacts
- Which effective measures should be taken…?
- **Difficult to reach the WFD objectives of good chemical and ecological status in 2015….!**

Smart monitoring



Alternatives for WFD monitoring:

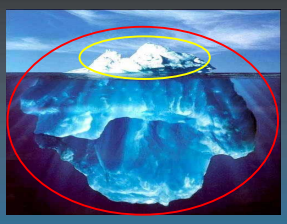
- Integrated monitoring (chemistry, biology & toxicology)
- Time-integrated monitoring (passive sampling)
- Toxic *in vitro* screening to identify risks and 'hot spots'
- Risk analysis of most relevante micropollutants (TIE, EDA)
- Application of innovative techniques ('omics')

Goal: more information on water quality for less €$!

Outline

- **Monitoring of micropollutants in the water cycle**
- **Bioassays**
- **Passive sampling**
- **Omics technologies**
- **Design of a 'smart monitoring' strategy**

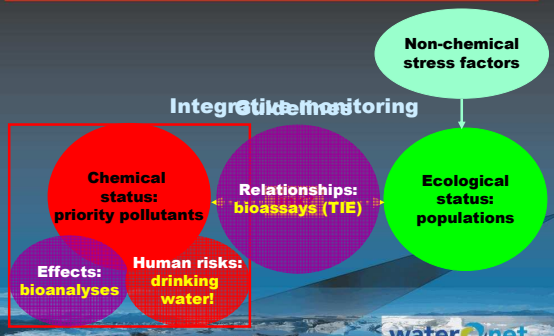
Monitoring substances or effects?



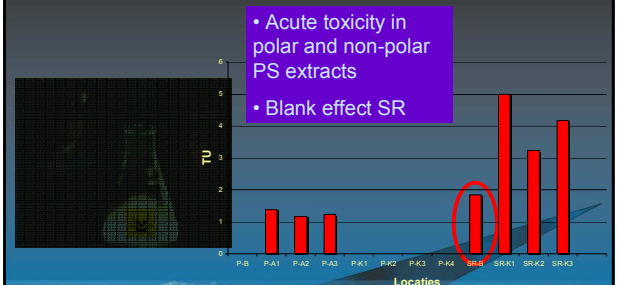
- **Substances**:
  - selected priority pollutants (e.g. 33 for EU WFD)
- **Effects**:
  - General toxicity: effects of total mixture of pollutants
  - Specific toxicity: effects of substances with a similar mechanism of toxic action; high sensitivity!
  - Unknown cause of effect (TIE/EDA needed)

More reliable risk assessment by use of toxic screening prior to relevant chemical analyses

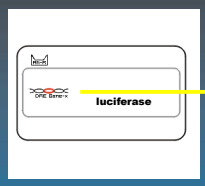
Alternatives for WFD monitoring



Microtox: general acute toxicity



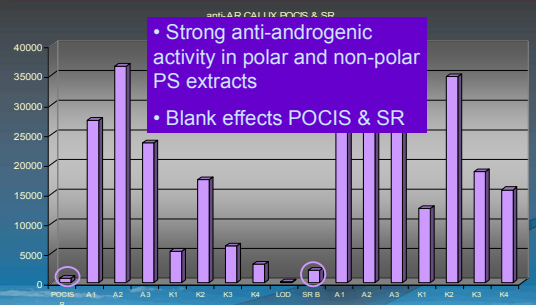
CALUX reporter gene assays



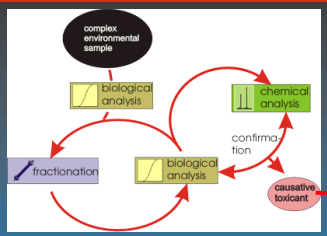
- dioxins & PAHs
- estrogens
- androgens
- thyroids
- glucocorticoids
- oxidative stress
- genotoxicity
- …

Chemical **A**ctivated **Luc**iferase gene e**X**pression BioDetection Systems (BDS)

AR-CALUX: anti-androgenic activity



Effect directed analyses (EDA)



Effect monitoring, fractionation and chemical analyses of emerging substances that have potentially harmful effects on ecosystems and human health (in vitro => in vivo, ADME)

Monitoring substances or effects?

Toxicity:
- Limited amount of assays can give a cost-effective and reliable risk assessment
- Low substance specificity
- Bioavailability included
- Mixture toxicity included
- Metabolites included
- Unknown substances included
- Chronic exposure is difficult and expensive **So what??**
- No accepted classification available
- Biomagnification not included
- No effects ☞ no worries
- ….

Chemistry:
- Search for a needle in a haystack: obligatory analysis of more then 200 substances in drinking water
- Many analyses are yet impossible (e.g. matrix effects)
- Not enough toxicity data available for risk assessment (ERA)
- No information on bioavailability
- No information on mixture toxicity
- Direct comparison to substance-directed legal guidelines
- Low concentrations ☞ still worries
- Surrogate security and accuracy
- ….

Dr. De Zwart (RIVM, Netherlands)

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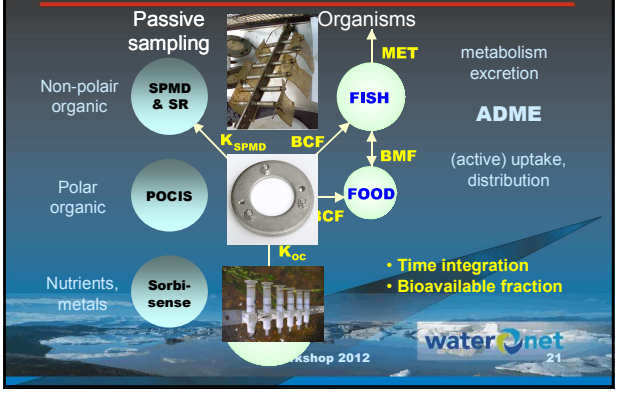
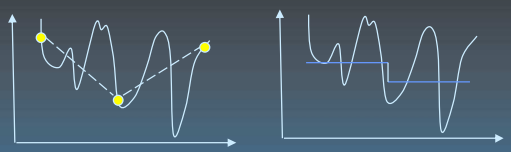
Passive sampling

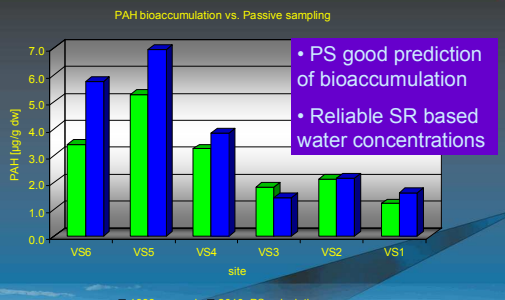


Passive sampling: time integration



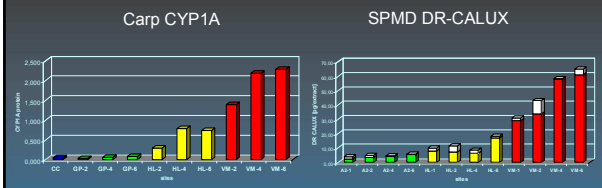
- Grabsamples are 'snapshots'
- PS is better for trends & time weighed average
- Lower sampling frequencies needed with PS

Passive sampling: bioavailability



- PS good prediction of bioaccumulation
- Reliable SR based water concentrations

PS-bioassay combination vs. fish



- Good correlation between time-responses of carp CYP1A activity and SPMD DR-CALUX (after acid silica)

Passive sampling: pro's & con's

- ☺ Bioavailable dissolved fraction of specific groups of chemicals
- ☺ Time integration: Time weighted average concentrations
- ☹ Different uptake rates for chemicals with different properties => changed composition of environmental mixture
- ☹ Uptake rate depends upon temperature, flow rate, biofouling...
- ☺ PRC (performance reference compounds) => water levels
- ☺ Reliable measurements of very low concentrations (<0.01 ng/L)

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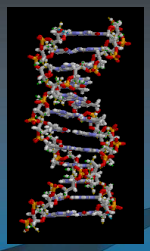
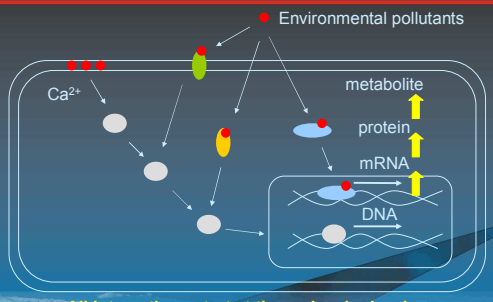
Innovative techniques ('omics')

- Genetical code: DNA has a unique basepair sequence for every organism
- Determination of species and indiviuals possible with specific DNA recognition techniques, instead of labor-intensive microscopic research
- Responses on DNA expression: biomarkers of effects & exposure

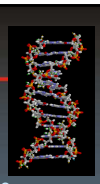


Genomics



All interactions start at the molecular level

Relationships 'omics' techniques



GENOMICS DNA: what's possible?

↓

TRANSCRIPTOMICS mRNA: what's happening?

↓

PROTEOMICS Proteins: what's the result?

↓

METABOLOMICS Metabolites: what's the consequence?

↓

Fenotype: condition, appearance, development, behaviour, etc.

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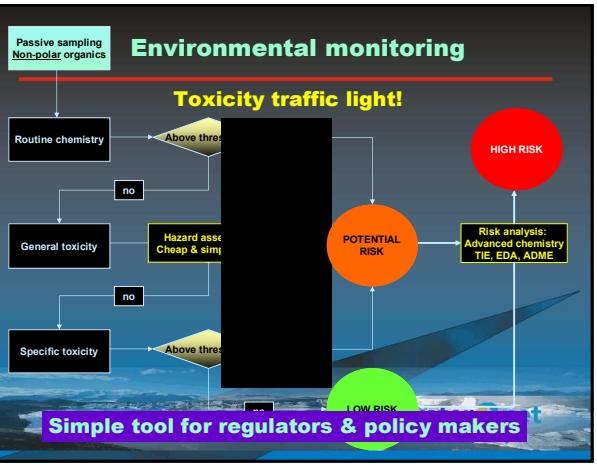
Vision on future monitoring

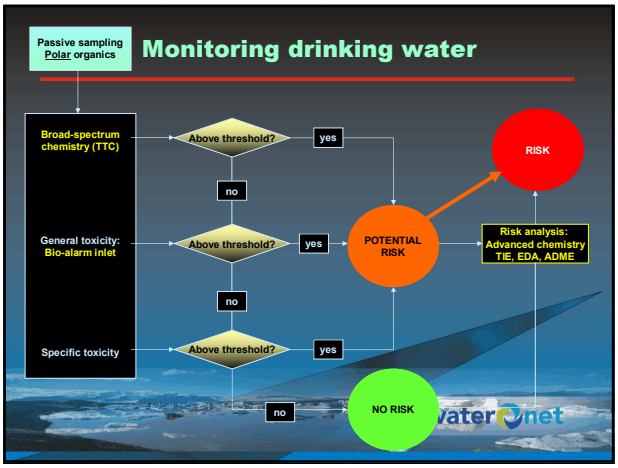
- Chemical analyses will always be needed, but they are most useful if you know what you are looking for…
- For an overall risk assessment the use of chemical analyses alone is insufficient, but a combination of chemical and toxicological monitoring is necessary, and may be less expensive!
- Comparable strategies should be designed for all water cycle compartments

Environmental monitoring

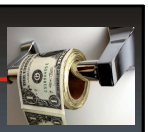


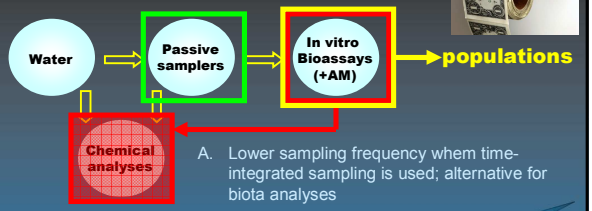
Simple tool for regulators & policy makers

Monitoring drinking water



Cost reductions on monitoring





A. Lower sampling frequency whem time-integrated sampling is used; alternative for biota analyses
B. Only advanced chemical analyses after responses in tox-screening
C. Bioassay screening and innovative DNA testing to reduce costs for ecological testing

What needs to be done…?

- Additional research on integrative monitoring
- Further calibration of polar organics passive sampling
- Design of guidelines for classification of effects
- Design of more 'simple' bioassays for effect measurement
- Design of less expensive EDA/TIE procedures
- Develop simple tools for regulators/policy-makers

Paradigm shift: substances ➡ risks!

Thanks!

Research & Innovation Steering Committee

Questions for tomorrow…?

- Ideas on using bioassays for assessment of mixture toxicity?
- Ideas on using passive sampling for monitoring?
- Ideas on design of bioassays threshold (guideline) values?
- Ideas on potential application of omics techniques?

Extrapolating *in vitro* to *in vivo* effects

Responses of *in vitro* assays do not account for the impact of absorption, distribution, metabolism and excretion (ADME)

→ Make corrections for absorption an metabolism

- **Metabolism:** the impact of metabolites can be analysed by addition of an enzymatic S9 mixture te the assay mixture (common with genotoxicity assays)
- **Oral uptake:** absorption can be simulated by passing the sample trough a monolayer of Caco-2 cells (of intestine epithelium cells)
- **Aquatic uptake:** use of passive samplers to assess the fraction that is bioavailable