

# Evaluation of Effects Based Methods for Regulating Metals in Aquatic Ecosystems

*Kevin Brix\*, Stijn Baken, Jelle Mertens, Chris Cooper*



# Water Framework Directive (WFD)



- Maintain waterbodies that have good a Chemical & Ecological status,
- improve all of those that do not.



## Chemical Status

- 'Priority Substances'  
(Ni, Pb, ...)

[Pass or fail]



## Ecological Status

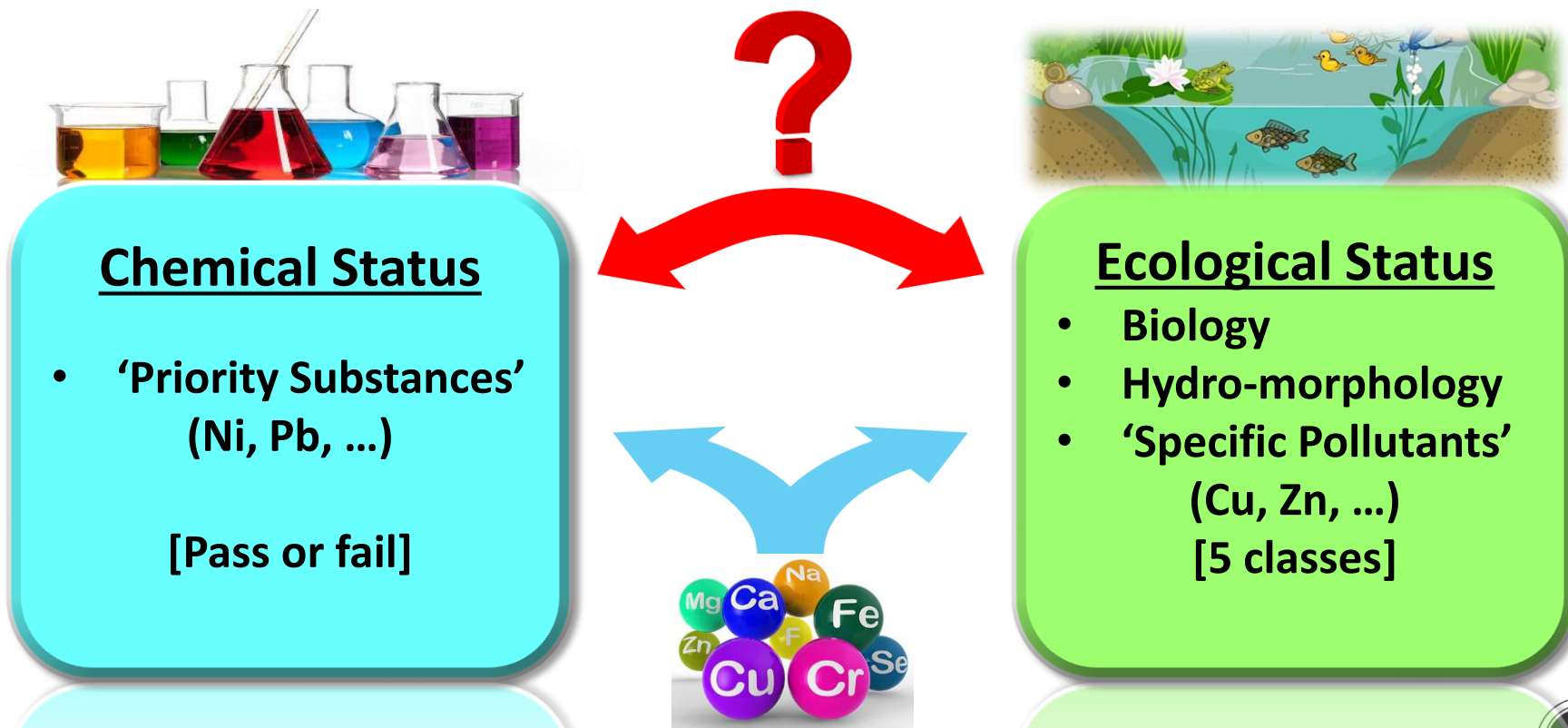
- Biology
- Hydro-morphology
- 'Specific Pollutants'  
(Cu, Zn, ...)  
[5 classes]



# Water Framework Directive (WFD)



- It's good, but it's not perfect...
  - Link between Chemical and Ecological status?
  - Based on single substances, what about mixtures?



# Water Framework Directive (WFD)



- Can Effect Based Methods (EBMs) bridge the gap?
  - Group chemicals according to their Mode of Action (MoA)...
  - Consider exposure to multiple chemicals?
  - Link between chemical exposure and biological effect?

## Chemical Status

- 'Priority Substances'  
(Ni, Pb, ...)

[Pass or fail]



## Ecological Status

- Biology
- Hydro-morphology
- 'Specific Pollutants'  
(Cu, Zn, ...)  
[5 classes]



# EBM EU Comm. Working Group



- Objective:

“Examine the possible implementation of Effect Based Methods for monitoring and assessment in the WFD context, alongside traditional chemical analysis”
- Work plan:
  - Final draft report completed (beginning of 2019).
  - Approved by WG Chemicals and SCG.
  - Final report to be published and disseminated soon.
- Drafting group:
  - Activity chairs: Sweden, Italy, Switzerland, JRC.



# What are EBMs??



- Lab-based assays, chemical compounds with the same MoA, that have higher level implications (population, ecological, ...).

Table I.2 : Recommended modes of action (MoA) for inclusion in the WFD monitoring.

EBM=Effect-Based-Method, SOP=Standard Operating Procedure, EBT=Effect-Based-Trigger-value, SW= Surface Water, WW=Waste Water, DW=Drinking Water

MoA with proven relevance	Protection aim/reasoning	Effect based method (EBM)	Reference compound	Standardised SOP	Defined effect based trigger value (EBT) to	Known applicability
Relevant MoA	<p><b>MoA = Activation of Estrogen receptor</b></p> <p><b>EBM = e.g. ER GeneBLAzer.</b></p> <p><b>Reference compound = 17-beta-estradiol.</b></p> <p><b>High level effect = Effects on reproduction.</b></p>					
Activation of estrogen receptor						SW, WW, DW, sediments
		MELN		Validity for ISO 19040-3 to be demonstrated	0.557 ng/l E2-equivalence	



# EBMs – metals?



- For some organics, the MoA is well-defined and there are, in some cases, EBMs developed that are MoA-specific.
  - Endocrine disruptors, pesticides.
- What about metals...?





# EBM metal taskforce



- Stijn Baken (ECI).
- Jelle Mertens (EPMF).
- Chris Cooper (IZA).
- **Kevin Brix (EcoTox).**





# EBM for metals - Criteria



- A number of potentially metal-relevant MoA were selected.
- 13 MoAs/EBMs, 3 criteria:
  - 1. Specificity**
    - To just metals, or other toxicants?
  - 2. Sensitivity**
    - Effects at environmentally relevant concentrations or near metal EQS?
  - 3. Link to higher levels of biological organisation**
    - Evidence in literature?

Ion Homeostasis  
Oxidative Stress  
Lysosomal Membrane Stability  
DNA Damage  
Deformities  
In Vivo Testing  
Cytochrome P450  
Acetylcholinesterase  
Urease  
Bacteria Reporter Assay  
ALAD  
Metallothionein  
eDNA



# EBM for metals - Evaluation



**Table 1. Summary of Sensitivity, Specificity, and Linkage to Individual/Population Effects for Metal EBMs**

<i>Mode of Action</i>	<i>Metal Specificity</i>	<i>Other Toxicants</i>	<i>Metal Sensitivity</i>	<i>Link to Individual/Population Effects</i>
<i>Ion Homeostasis</i>	Na: Ag, Cu, Pb Ca: Co, Cd, Pb, Zn Mg: Ni	Pesticides, Pharmaceuticals, Salinity	Mixed: Effects detectable at concentrations near EQS in some cases but not all	Strong – Demonstrated links to survival and growth, but no links to reproduction demonstrated

**For each MoA:**

**(E.g. Oxidative Stress; EBM = ↓ anti-oxidants (superoxide dismutase, glutathione peroxidase, ...))**

- **Metal Specificity** (As, Cd, Co, Cr, Cu, Zn, ....)
- **Other toxicants** (Pesticides, PAHs, PCBs, salinity, temp.).
- **Metal Sensitivity** (near EQS for *some* metals).
- **Higher level effects** (Weak: No studies link to individ./pop.).



# EBM for metals - Evaluation



Mode of Action	Metal Specific?	Metal Sensitivity?	Population/Ecological?
Ion Homeostasis			
Oxidative Stress			
LMS			
DNA Damage			
Deformities			
Cytochrome P450			
AChE			
Urease			
Bacteria Reporter Assay			
ALAD			
Metallothionein			
eDNA			
In Vivo testing			



# EBM for metals - Evaluation



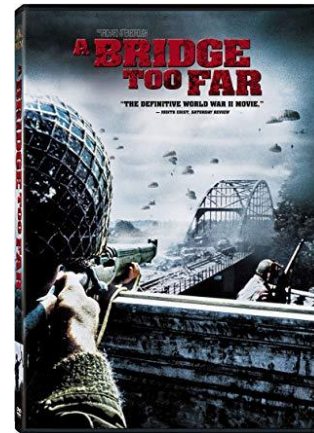
Mode of Action	Metal Specific?	Metal Sensitivity?	Population/Ecological?
Ion Homeostasis	N	Some	Strong
Oxidative Stress	N	Some	Weak
LMS	N	One	Moderate
DNA Damage	N	~x10 EQS	Weak
Deformities	N	Some	Strong
Cytochrome P450	N	~x10 EQS	Weak
AChE	N	One	Strong
Urease	N	Some	Moderate
Bacteria Reporter Assay	Y	Some	Weak
ALAD	Y	One	Weak
Metallothionein	N	Some	Weak
eDNA	N	Yes	Strong
In Vivo testing	N	Some	Strong



# Conclusions (1/2)



- For those MoAs/EBMs selected for metals:
  - No EBM met all 3 criteria.
  - ALAD and the bacteria reporter assay = only EBM that are specific to metals.
  - Not representative of population/ecological level effects..
- So, for metals, continue with traditional methods.
  - Routinely measured.
  - Relatively easy & cheap.



# Conclusions (2/2)



- EBM's work well for some groups of substances.
  - Endocrine disruptors, plenty of literature.
- Some countries use EBM's as a weight of evidence approach.
- Relatively cost effective.
- Future for EBM's?
  - Use as a screening tool.
  - Integrate into the Ecological Status.





# Thank you for your attention!

*Kevin Brix (Ecotox).*

## Metals Environmental Research Associations

# MERA



European Precious Metals  
Federation



**RioTinto**

