Environmental Quality Standards under the Water Framework Directive

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What I plan to cover

What are EQSs and how are they used?

How do we derive EQSs?

Focus on biota standards

A role for passive samplers?
What are EQSs?
WFD - Purpose

- Prevent deterioration and enhance status of aquatic ecosystems & associated wetlands
- Promote sustainable water use
- Reduce pollution from priority substances
- Prevent deterioration/reduce pollution of groundwater
- Contribute to mitigating effects of floods/droughts
What are EQSs?

- **Environmental Quality Standard**
- Threshold below which we do not expect adverse effects to occur
- Hazard-based
- Usually for individual chemicals
- Only meaningful when we compare them to environmental concentrations (measured or predicted) → Risk
How are EQSs used?

✈ Controlling discharges to the environment
   - EQSs translated into discharge limits
   - Assess compliance - sampling and chemical analysis

✈ Monitor ‘state of the environment’
   - Benchmark e.g. trends in exceedances

✈ Classification
   - ‘Good’ status requires compliance with EQSs for Specific Pollutants
   - EQS exceedances trigger further investigation or remediation

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Sampling and chemical analysis to determine EQS compliance
WFD Pollutants

Selected at EU level

- Priority Substances (ANNEX X)
- Priority Hazardous Substances (ANNEX X)

Selected by MSs

- Specific Pollutants (ANNEX VIII)
How do we derive EQSs?
What receptors and pathways do we need to consider?

- **Sediment biota**
- **Prey organism (water column)**
- **Predator**
- **Humans**

Pathways:
- **QSsediment**
- **QSwater,eco**
- **QSbiota,secpois**
- **QSwater,dw**

Diagram shows the flow of contamination from **WATER** through sediment biota, water column, and to humans via predation.
Deriving an EQS

Aquatic and sediment toxicity data
Field and mesocosm data
Mammalian/avian toxicity
Physico-chemical data
Bioaccumulation, bioconcentration, biomagnification

Select for relevance and reliability

Data analysis and extrapolation

To make allowances for what we don’t know e.g. sensitivity of untested species, short-term data v long-term exposure

EQS Technical Guidance finalised 2011

To make allowances for what we don’t know e.g. sensitivity of untested species, short-term data v long-term exposure
Extrapolation

% of species at risk

Log concentration

AF = 10-1,000

AF = 1-5

HC5 (concentration corresponding to 5% of species at risk)

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Implementing EQSs
Points of protection

- **Point of Production**
  - Controls on raw materials, processes

- **Point of Emission**
  - Limits on emissions e.g. discharge permits
  - Limits in ambient environment
  - Water (and sediment) standards - may be translated into controls at point of emission
  - Biota standards - may be translated into water column standards

- **Point of Contact**
  - Limits on body residues

- **Internal Dose**
May be more than one EQS for a substance

Maximum Allowable Concentration (based on acute toxicity data)

Annual Average Concentration (based on chronic toxicity data)
EQSs for saltwaters and freshwaters

- Additional AF applied when estimating SW EQS (assumes more biodiversity) unless exclusively marine taxa represented in dataset - contentious
- SW EQSs are usually more stringent (lower) than FW EQSs

- Separate EQSs for saltwaters and freshwaters
- Based on separate analyses of FW and SW ecotoxicity data ...unless evidence that they can be pooled

Biota standards – no distinction between FW and SW

Adopt SW EQS for TRaC waters (>5 ppt salinity)
Biota standards
Setting standards – routes of exposure

- For many substances, the main risk to plants and animals is through direct toxicity in water → water column EQS

- But for lipophilic substances that bioaccumulate, the main risk is to predators (and possibly humans) exposed to the chemical via the food chain → biota EQS
Deriving biota standards (secondary poisoning of wildlife)

Extrapolation to account for:
- converting dose to diet conc
- duration of tox study
- interspecies variation
- lab food - natural food

QS_{biota} → BCF/BAF → BMF → no-effect dose from feeding study (usually mammals or birds)
Biota standards

- For some substances, EQS Directive 2008/105/EC offers biota (and/or sediment) EQSs instead of water standards for classifying chemical status.

- \( QS_{\text{biota}} \) is expressed as a concentration in body tissue of prey organism. Using bioaccumulation data, can be converted to corresponding concentration in water.

- WFD biota standards for lipophilic priority compounds (Hg, HCB, HCBD) – more proposed (January 2012).
Sampling and analysing wild-caught biota (1)

- Cannot guarantee ‘catch’ (species, age class, tissue)
- Where have they been?
- Depletes native biota
- Survey in UK - unable to determine EQS compliance or to identify trends with confidence – very large sample sizes required
- Some MSs have established biota monitoring programmes (+’biobanks’), but different species
Sampling and analysing wild-caught biota (2)

- Variability resulting from different species
  - lipid content$^1$
  - feeding strategy$^{2,3}$
  - tissues used for analysis$^2$
  - fish age$^1$

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1 Boscher et al (2010), Chemosphere 78, 785-792
2 Christoforidis et al (2008), Chemosphere 70, 694-702
3 Kim et al (2012), 89, 1360-1368
Assessing compliance with a biota standard - what are the options?

- **Biota**
  - Wild-caught biota
  - Caged biota
  - Passive sampler (as ‘surrogate’ biota)

- **Water**
  - Water sampling
  - Passive sampler (to estimate water conc)

**Biota EQS**

Corresponding water concentration back-calculated from biota EQS using BMF/BAF
Assessing compliance with biota standards – a role for passive samplers?
Passive samplers as ‘surrogate biota’ (1)

- Can we infer biota concentrations from the accumulation of substances by passive sampling devices (PSD)?
- Range of PSDs available covering wide spectrum of physico-chemical properties
- Simple to deploy
- Promote consistency across MSs?

BCF
Partition coefficient

[Graph showing range of PSDs and log Kow values]
Passive samplers as ‘surrogate biota’ (2)

EQS_{biota} for HCB = 10 \, \text{ug/kg}

3. Passive samplers as ‘surrogate’ biota (3)

- UK study compared residues of range of lipophilic organics accumulated by PSDs and fish (3-4 week deployment of SPMDs vs caged chub, *Leusiscus idus*)

- Few meaningful relationships

- Possible reasons
  - between-fish variability in biota (variability between PSDs?)
  - metabolism by biota (PAHs)
  - fouling of PSDs
  - role of ingestion of contaminants by biota?
  - deployment period (equilibrium not attained)?

Benzo-b-fluoranthene: caged fish vs SPMD
Passive sampling to estimate water concentration

- Can we assess compliance with EQS back-calculated from biota EQS?
- Effectively use PSD as “concentrating” device; need partition co-efficients to estimate twa in ambient water
- Some research experience\(^1\) e.g. comparing SPMDs, sediments and caged fish to estimate bioavailable concs of PAH, PCB and organochlorines in water
- PSDs take up dissolved fraction - not directly comparable with conventional ‘spot’ sampling
- Back-calculated water concentration may be subject to high uncertainty (choice of BAF/BCF factor\(^2\)) ... how reliable is it?

\(^2\) Moermond and Verbruggen (2012) IEAM 10, 1351
Where do we go from here?

- Biota standards potentially offer a more reliable measure of environmental exposure than water samples for substances that bio-accumulate.
- Biota can act as a composite sample
- However, biota standards require serious attention before we can use them to assess waterbody status with confidence
- High risk of inconsistency in approach (and bias) between MSs
- Biota monitoring is well-established in marine environment (e.g. OSPAR) but not in freshwaters. Align marine and freshwater methods?
- Do PSDs have a role to play?

**Opportunities to align R&D to these regulatory issues?**
Biota standards and PSDs – possible research

- Biota standards and PSDs
- Biota EQS
  - Biota
    - Wild-caught biota
    - Caged biota
    - Passive sampler (as ‘surrogate’ biota)
  - Water sampling
  - Passive sampler (to estimate water conc)

- Review current practice - use of different species, tissues etc
- Analyse possible bias
- Is food ingestion underestimated in caged biota and PSDs?
- Explore use of other species e.g. filter feeding molluscs
- Useful relationships PSD vs biota? Compare residues in PSDs and biota sampled at same location and time - existing data and de novo R&D
- Analyse reasons for poor correlations
  - Which PSDs?
- Analyse food ingestion underestimation in caged biota and PSDs?
- Review ‘state of the art’ wrt analytical LOQs
- Review robustness of back-calculated water EQS
- Trials to compare predicted biota concs with actual biota residues
Thank you for your attention

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