INTRODUCTION

Accounting for the bioavailability of metals in routine water monitoring represents a step-change in the way regulators assess the potential risks of metals in the aquatic environment. Guidance on how bioavailability may be incorporated into compliance assessments, classification and local risk assessment are included in the recent EU Technical Guidance for deriving Environmental Quality Standards (EQS) under the European Water Framework Directive (WFD). The guidance supports the use of a tiered compliance assessment regime for metals (Figure 1) that incorporates bioavailability and recommends using Biotic Lignoid Models (BLM).

The bioav project has developed an online resource (www.bio-met.net) that includes a user-friendly software tool (User-friendly BLM) for calculating the bioavailability of copper, nickel and zinc and assessing EQS compliance in European freshwaters.

However, a reasonable question remains before widespread adoption of this new approach: “How will the pattern of EQS exceedances differ from conventional assessments when bioavailability is taken into account?”

This poster gives three examples of EQS compliance for copper, nickel and zinc when bioavailability is accounted for. For two examples, how this compliance changes from existing standards to accounting for bioavailability is also shown. The examples are from Sweden, France and Austria.

THE TIERED APPROACH AND PROCESSING DATA

To determine compliance with an EQS regulators will usually monitor the metal concentration at a site over a period of at least a year. 1. The mean dissolved metal concentration is compared to the generic EQS 

\[ \text{EQS}_{\text{generic}} \]

Some European Member States will also assess the “confidence off failure” as this stage using guidance given in ISO/WD 5667-20. If the EQS is exceeded the assessment passes to tier 2

2. pH, dissolved calcium and dissolved organic carbon data are used in the user-friendly BLM to account for site-specific bioavailability. The outputs of these calculations include a local bioavailable metal concentration (which can be compared to the EQS_{local}), a local EQS_{bioavailable} (which can be compared to local dissolved concentrations of metals) and also a local risk characterisation ratio. As per stage 1, some Member States in Europe will assess the “confidence in failure”. If the EQS is exceeded the assessment passes to tier 3

3. Tier 3 allows for local issues, including ambient background concentrations.

The input data for the examples below are available freely from European Environment Agency website or directly from the Member State Regulator. The EQS_{bioavailable} for the metals are 1 µg Cu l^{-1}, 10.9 µg Zn l^{-1} and 4 µg Ni l^{-1}. The first tier are proposed Annex VIII EQS in the UK. The EQS_{bioavailable} for nickel is proposed at EU level, but is not finalised.

SWEDISH MONITORING DATA

Table 1 shows the compliance assessment results for a series of Swedish rivers and lakes. These data were made directly available from KEM and cover the period 2000-2008. These data are not annual averages at sites, but represent a “face value” assessment with samples, which tends to be more precautionary than a full compliance assessment.

For copper and zinc an additional comparison is made between EQS failure using the existing EQS (for zinc this is hardness-based) with the one that fully accounts for bioavailability. These data show that the EQS failure rates after accounting for bioavailability are lower when bioavailability is not considered. The existing zinc EQs in Sweden is an “added” value, although no ambient background has been included here.

The waters in this dataset have a mean pH of 6.5, but a median dissolved organic carbon of 4.9 mg l^{-1}. This means these waters are relatively insensitive to exposures of copper, nickel and zinc which is supported by the low levels of EQS failure observed after bioavailability is accounted for.

FRENCH MONITORING DATA

Table 1 shows the compliance assessment results for monitoring data from Northern France for the decade 2000-2009 obtained from the Environmental Agency’s website. There are relatively few sites, but each site has been sampled between 8 and 12 times over the period. The number of metal exceedances at each site varied with fewer sites recording dissolved copper and zinc. The waters in this dataset have median dissolved organic carbon of 3.6 mg l^{-1} and pH (mean = 7.9). The mean calcium concentrations for these sites is 74 mg l^{-1}. The Table clearly shows the relatively high exceedance rates for zinc and especially Cu using existing hardness based standards, as compared to accounting for bioavailability. The levels of nickel exceedance are also relatively low when bioavailability is considered.

AUSTRIAN MONITORING DATA

Table 1 shows the compliance assessment results for Austrian monitoring data for 2006, obtained from the SWAD database. There are about 150 sites, but each site had been sampled multiple times over the year. At each site, pH, DOC, total water hardness, alkalinity and the total and dissolved fraction of copper, nickel and zinc was measured. The waters in this dataset have a high pH (mean = 8.0). Average DOC is 2.5 mg l^{-1} and total hardness averages 10.7 °dH. Overall, there are relatively few EQS failures for copper, nickel and zinc. For copper and zinc, an additional comparison is made between EQS failure using the existing EQS with the one that fully accounts for bioavailability. These data show that the EQS failure rates after accounting for bioavailability are equal for Cu and higher for Zn than when bioavailability is not considered. Also, the location of the exceedances changes when considering DOC and pH in addition to hardness (results not shown here).

Table 1. Monitoring data from Sweden used to account for bioavailability.

Table 2 shows the compliance assessment results for monitoring data from Northern France for the decade 2000-2009 obtained from the Environmental Agency’s website.

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Table 3. Monitoring data from Austria used to account for bioavailability.

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CONCLUSIONS

- Data are available to undertake bioavailability assessments, even at a screening level.
- There are relatively few EQS failures for copper, nickel and zinc, although it is not clear as to whether the metals are dissolved or total.
- Bio-availability based EQS give robust and realistic assessments of potential metal risks.
- The number of EQS exceedances may change little, or decrease compared to existing generic or hardness based standards, but it is likely that the location of exceedances will change when accounting for bioavailability.

Figure 1. A tiered approach to account for metal bioavailability in regulatory compliance assessment.