Sediment quality criteria (SQC) derivation method

Sediment quality criteria (SQC) can be used for sediment quality assessment by comparing environmental concentrations of the target substances with the corresponding quality criteria. The derivation of SQC is largely based on the EU Technical Guidance for Deriving Environmental Quality Standards (TGD), published by the European Commission in 2018 (EC 2018) [1]. The derivation process includes the following steps (Figure 1):

1. Search for acute toxicity data (LC/EC50), chronic toxicity data (NOEC) and field/mesocosm data. When sediment toxicity data are not available, water column toxicity data can be used (see step 3).
2. Data quality evaluation: the collected data are assessed for relevance and reliability [2,3].
3. SQC derivation: three different approaches are available depending on data availability:

Derivation using the **"Species Sensitivity Distribution" (SSD) method**. All the relevant and reliable toxicity data available on the different species are ranked and plotted (the lowest effect concentration per species and endpoint), and the hazardous concentration representing the concentration protective of 95% of all species (HC5) is calculated. This method can be applied when preferably more than 15, but at least 10 effect data from different species covering at least 8 taxonomic groups are available. To derive quality standards for protecting pelagic species, the following taxa would normally need to be represented (EC 2018): one fish species and a second family in the phylum Chordata, a crustacean species, an insect, a phylum other than Anthropoda or Chordata, an order of insect or any phylum not already represented, algae or cyanobacteria, and a higher plant. Guidance on the use of SSD for the derivation of sediment thresholds is currently not available; preliminary recommendations are provided in ECHA (2014) [4]. To account for residual uncertainty, the HC5 is divided by an AF. An AF of 5 is used by default but may be reduced based on the uncertainties associated with HC5 derivation (quality of the database, diversity and representativeness of the database, goodness of fit).

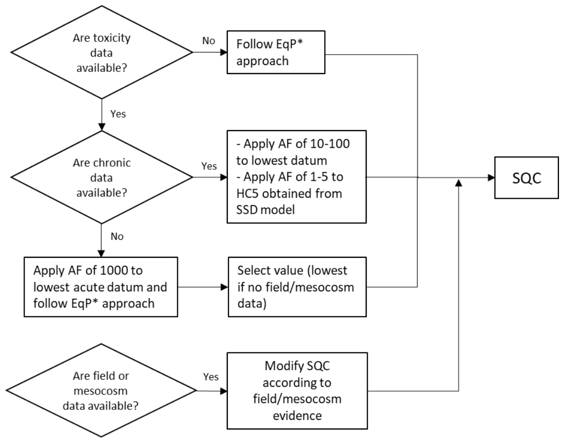

*Figure 1: Process for the derivation of SQC (EC 2018) [1]. * indicates that the application of an additional AF of 10 is required for substances with log Kow > 5.*

Derivation using the **Assessment Factor (AF)** method. The lowest reliable and relevant effect datum is selected (preferably a NOEC or EC10 from a chronic test) and divided by an AF. The AF (Table 1) varies between 10 and 100 according to the number of data available on other species, representing different taxa and feeding behaviors (e.g. epibenthic grazers, sediment-ingesting worm, benthic filter-feeder). If only results from short-term tests with sediment-dwelling organisms are available, an assessment factor of 1000 is applied to the lowest reliable value. In such situations, a quality criterion should also be derived using the Equilibrium Partitioning approach and the lowest value

Derivation using the **"Equilibrium Partitioning" (EqP) method** and toxicity data from water column exposures. The EqP approach, which is based on the method developed by Di Toro et al. (1991) [5] for deriving sediment quality guidelines, assumes that the toxicity of a non-ionic organic chemical in sediment is proportional to its concentration in pore water.

The SQC can be calculated as follows:

$$SQC_{EqP} = QC_{fw,eco} \times K_{OC}$$

where $QC_{fw,eco}$ is the quality criterion or standard for surface waters based on long-term tests and K_{OC} is the partition coefficient of the chemical to sediment organic carbon. For this method, it is necessary to find the most precise partitioning coefficient for the chemical compound.

Table 1: Assessment factors for the derivation of quality criteria for sediments (after EC 2018) [1].

Available data	**Assessment factor (AF)**
Only short-term toxicity tests (LC50 or EC50)	1000
One long-term test (NOEC or EC10)	100
Two long-term tests (NOEC or EC10) with species representing different life histories and feeding behaviors	50
Three long-term tests (NOEC or EC10) with species representing different living and feeding conditions	10

4. Comparison of the obtained values derived through the different methods with **field or mesocosm data** (if available).

Because of the relatively limited sediment toxicity database for some substances, the application of relatively high AF is required to account for residual uncertainties in the derivation of SQC. There is the possibility that the proposed SQC are too low, making compliance assessment difficult. For this reason, SQC are classified as definitive (D) or preliminary (P) according to the number of effect data used in their derivation: SQC are considered definitive if the AF applied is ≤ 50. If the AF applied is > 50 or the SQC is derived solely from water toxicity data through the EqP approach, SQC are considered provisional.

Effect data from tests where bioavailability is maximized are preferred because they represent a worst case scenario and therefore would lead to the derivation of more protective values. For substances for which the bioavailability is dependent on the total organic carbon (TOC) of the sediment, the variability introduced by the presence of toxicity values generated at different TOC concentrations can be accounted for by normalizing each effect datum to a standard sediment with a default TOC content. The 'standard' EU sediment has a default TOC content of 5%. The 'standard' Swiss sediment representing a worst case scenario has been set at 1% TOC (approx. a 10^{th} percentile of OC content measured in Swiss sediments).

In general, for organic compounds SQC are derived for sediment with 1% TOC as a worst case. Measured environmental concentrations should be normalized to the TOC content in sediment before comparison with the corresponding SQC as follows:

$$MEC_{norm} = \frac{MEC}{f_{TOC}}$$

Where:

MEC_{norm} = measured environmental concentration normalized to 1% TOC

MEC = non-normalized measured environmental concentration

f_{TOC} = fraction of total organic carbon in the sediment being assessed in %

Normalization is recommended for TOC content between 1 and 10 %. This normalization approach is a simplification which assumes a linear relationship between the concentration of TOC and bioavailability, which determines toxicity. Outside of the 1-10% TOC range, there is some uncertainty associated with normalization which must be taken into account in the assessment.

References

[1] European Commission, «Guidance No 27 - Deriving Environmental Quality Standards - version 2018,» European Commission Publications Office, Brussels, 2018.

[2] Moermond C, Kase R, Korkaric M, Ågerstrand M. (2016) CRED: criteria for reporting and evaluating ecotoxicity data. Environmental Toxicology and Chemistry 35: 1297-1309.

[3] Casado-Martinez MC, Mendez-Fernandez L, Wildi M, Kase R, Ferrari BJD, Werner I. (2017) Incorporation of sediment specific aspects in the CRED evaluation system: recommendations for ecotoxicity data reporting. SETAC Europe 27th Annual Meeting, Brussels.

[4] ECHA, European Chemical Agency. 2014. Principles for environmental risk assessment of the sediment compartment: proceedings of the topical scientific workshop. Helsinki (FI): ECHA. 81 p.

[5] Di Toro DM, Zarba CS, Hansen DJ, Berry WJ, Swartz RC, Cowan CE, Pavlou SP, Allen HE, Thomas NA, Paquin PR. (1991). Technical basis for establishing sediment quality criteria for nonionic organic chemicals using equilibrium partitioning. Environmental Toxicology and Chemistry 10: 1541-1583.