



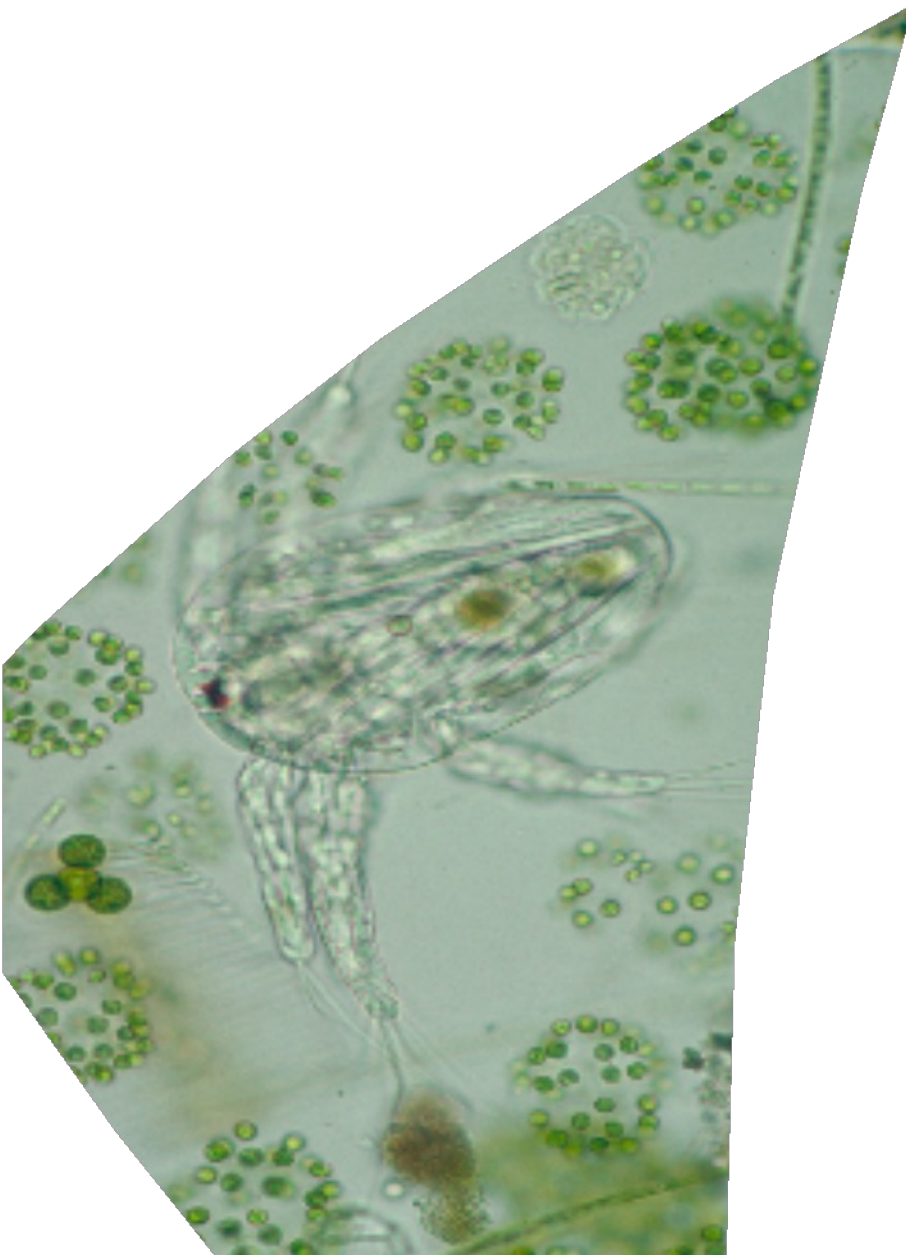
Sediment quality assessment at small streams affected by different types of anthropogenic pressures

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Méthodologie pour l'évaluation de la qualité des sédiments

La stratégie d'évaluation de la qualité des sédiments en Suisse comprend des procédures d'échantillonnage et de traitement des échantillons pour l'analyse chimique des sédiments dans les cours d'eau et les lacs, pour l'évaluation de la charge en micropolluants. Elle contient en outre une liste de substances proposées pour la surveillance. Des critères de qualité écotoxicologique des sédiments (EQSsed) ont été élaborés pour ces substances. Le système d'évaluation proposé dans la stratégie s'inspire du système modulaire gradué. La stratégie est conçue pour une utilisation de routine dans la surveillance des eaux et s'appuie sur des méthodes déjà utilisées dans les cantons.

Note : Cette publication n'est pas une aide à l'exécution de la Confédération mais un rapport d'experts.

Strategy for sediment quality assessment in Switzerland

Technical report prepared for the Federal Office of the Environment

December 2021 (Updated 2022)



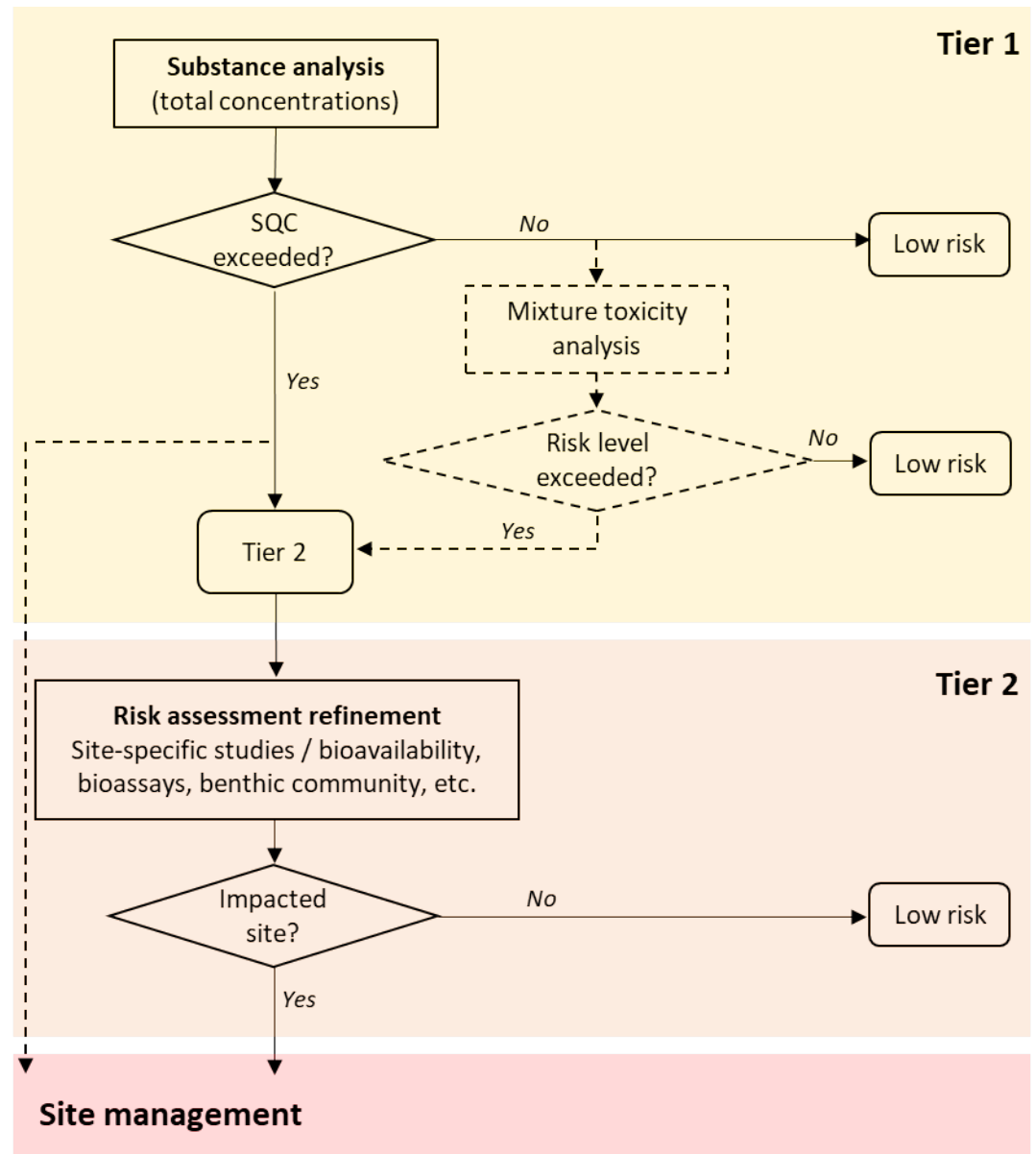
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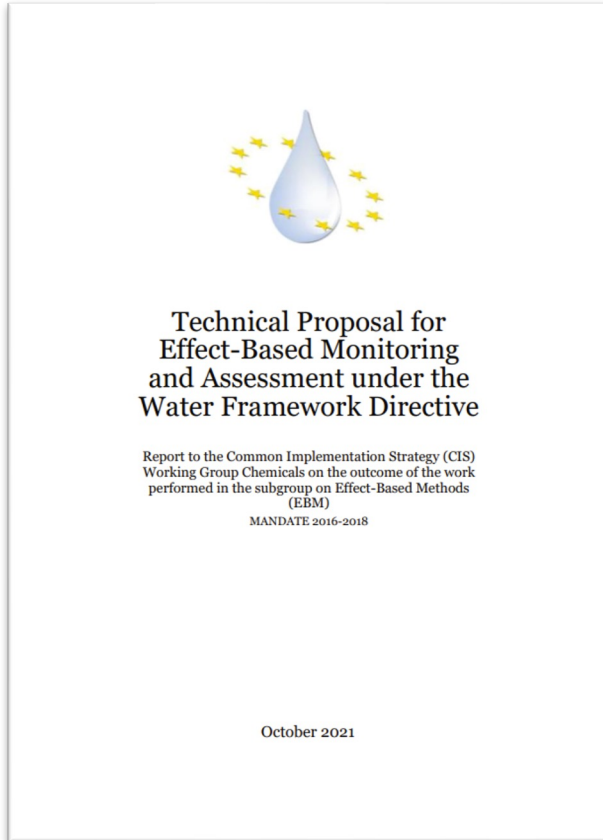


SQC (EQS_{sed})
recommended as
screening tools



Effect-Based tools have great potential for use

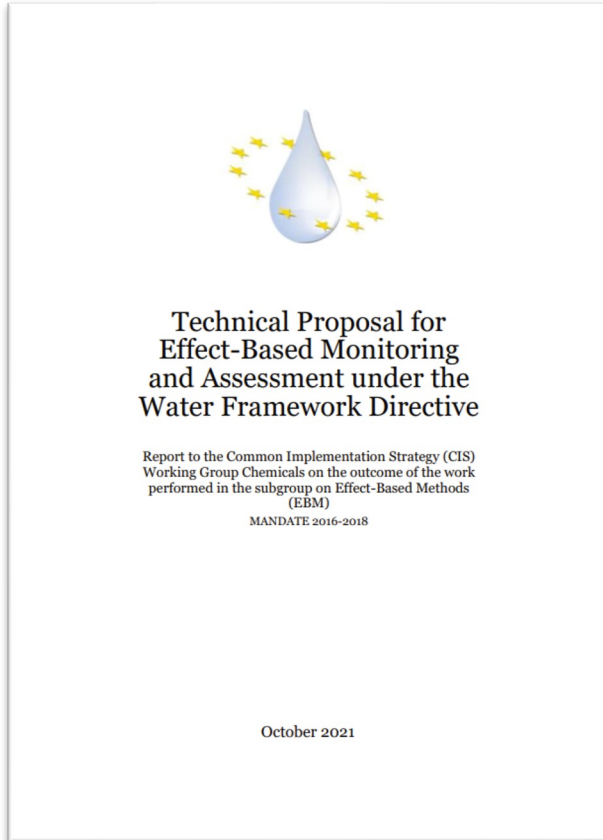
- **As screening tools**, as part of the pressures and impacts assessment (surveillance monitoring) to aid in the prioritisation of water bodies to study further;



(Carere et al. 2021)



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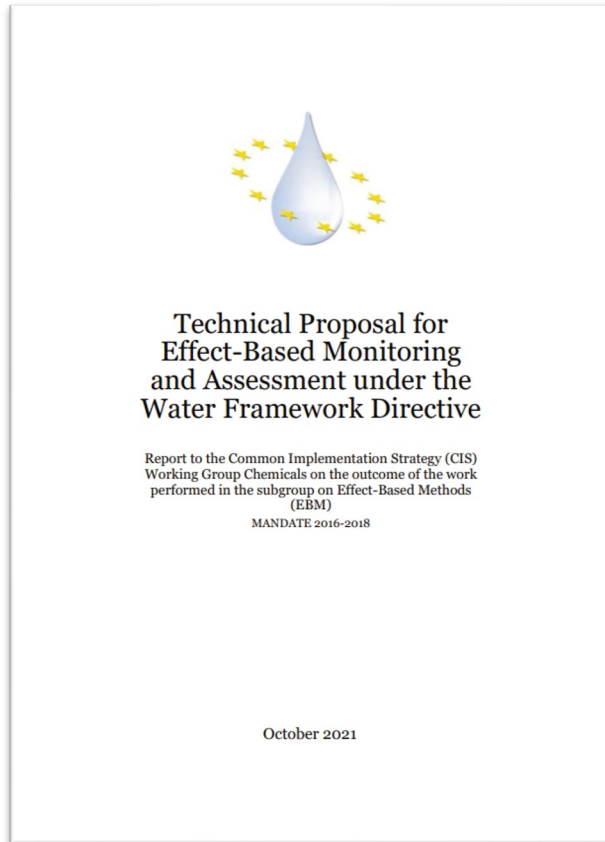


(Carere et al. 2021)

- As screening tools, as part of the pressures and impacts assessment (surveillance monitoring) to aid in the prioritisation of water bodies to study further;
- To establish **early warning systems**, to prioritise further studies in areas that are not concluded to be at risk because they are located far from known local sources;



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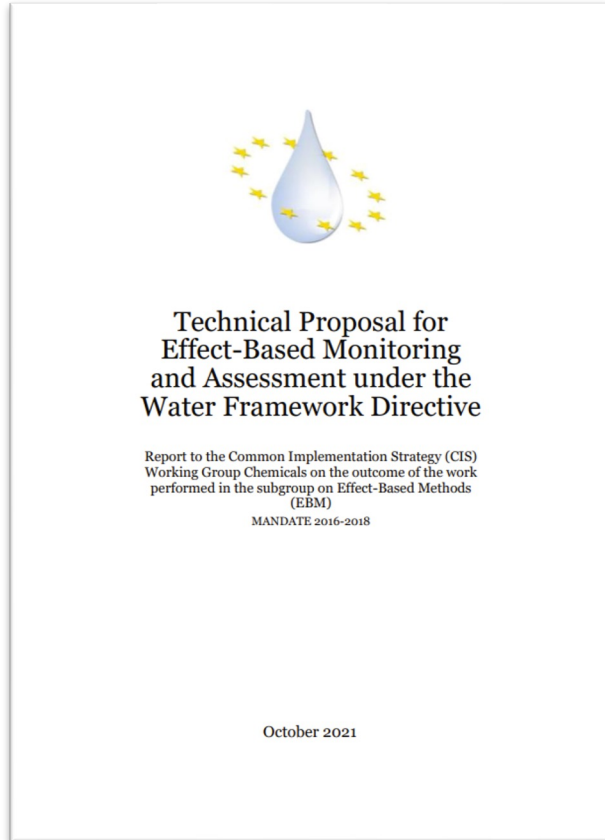


(Carere et al. 2021)

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- To establish **early warning systems**, to prioritise further studies in areas that are not concluded to be at risk because they are located far from known local sources;
- To take the effects from **mixtures of pollutants or not routinely analysed chemicals (“unknowns”)** into account (e.g. to support investigative monitoring where causes of a decline of specific species are unknown);



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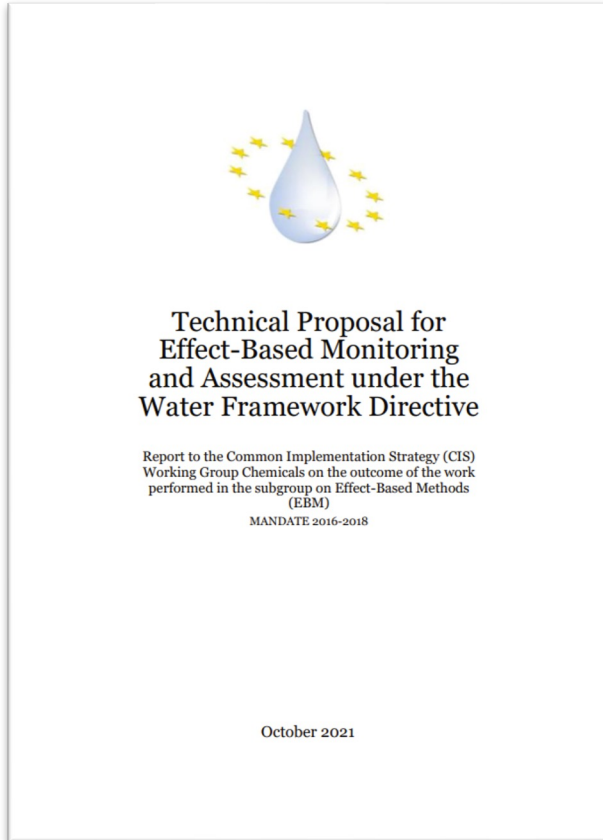


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- To take the effects from **mixtures of pollutants or not routinely analysed chemicals (“unknowns”)** into account (e.g. to support investigative monitoring where causes of a decline of specific species are unknown);
- To provide **additional support** in water and sediment quality assessment.



Specifically for sediments

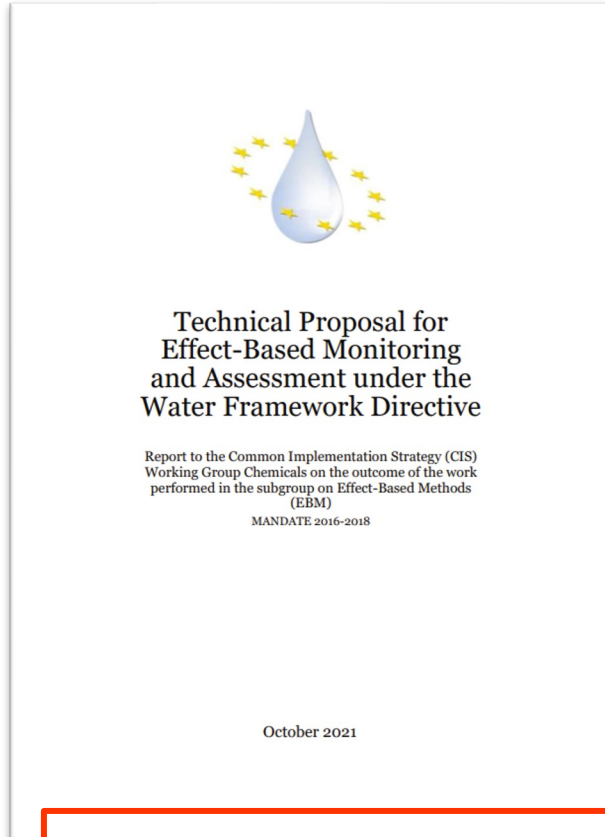


- A battery of *in vivo* bioassays would be useful in the **analysis of pressures and assessment of impacts** under the WFD, for investigative monitoring to take complex mixtures into account, and in general to **evaluate sediment quality**.

(Carere et al. 2021)



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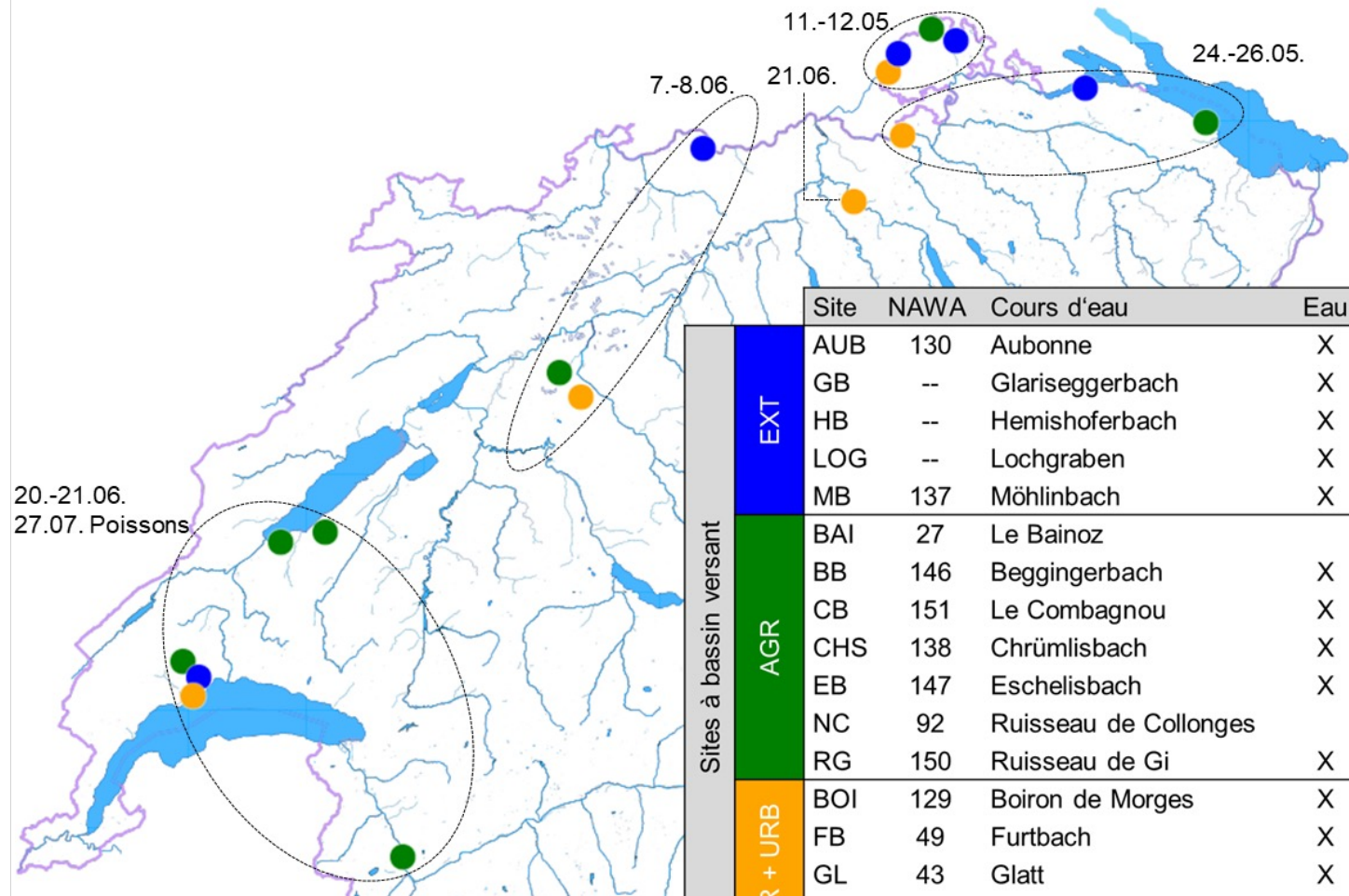


- A battery of *in vivo* bioassays would be useful in the **analysis of pressures and assessment of impacts** under the WFD, for investigative monitoring to take complex mixtures into account, and in general to **evaluate sediment quality**.
- For **future development**, it was concluded that a **guidance document** would be useful
 - to help identify a suitable battery of tests depending on the types of pressure, and
 - to facilitate the assessment of the results.

Pilot project to test a battery of bioassays at small streams affected by different levels and types of contamination.



Sampling sites



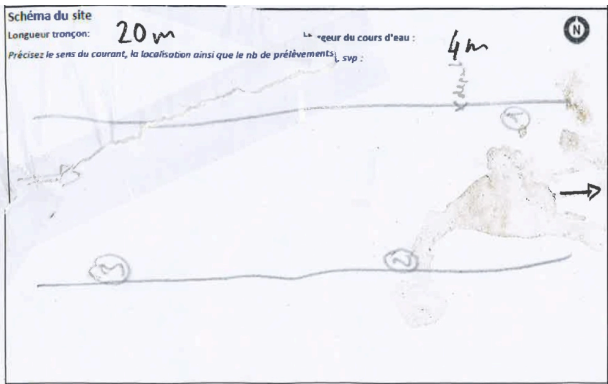
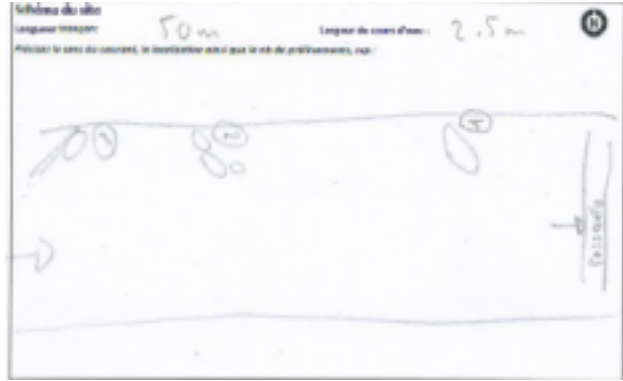
- Less impacted sites (EXT)
- Sites under agricultural pressure (AGR)
- Sites under agricultural and urban pressure (AGR+URB)

| | Site | NAWA | Cours d'eau | Eau | Sediment | Poissons | |
|------------------------|------|------|-----------------------|-----------------|----------|----------|---|
| Sites à bassin versant | EXT | AUB | 130 | Aubonne | X | | X |
| | | GB | -- | Glariseggerbach | X | X | X |
| | | HB | -- | Hemishoferbach | X | X | X |
| | | LOG | -- | Lochgraben | X | X | X |
| | | MB | 137 | Möhlinbach | X | X | X |
| | AGR | BAI | 27 | Le Bainoz | | X | |
| | | BB | 146 | Beggingerbach | X | | X |
| | | CB | 151 | Le Combagnou | X | | X |
| | | CHS | 138 | Chrümlisbach | X | X | X |
| | | EB | 147 | Eschelisbach | X | X | X |
| AGR + URB | NC | 92 | Ruisseau de Collonges | | X | | |
| | RG | 150 | Ruisseau de Gi | X | X | X | |
| | BOI | 129 | Boiron de Morges | X | X | | |
| | FB | 49 | Furtbach | X | X | | |
| | GL | 43 | Glatt | X | | | |
| | LAG | 145 | Landgrabe | X | X | | |
| | URT | 902 | Urtenen | X | X | | |

Sediment sampling



Sampling just after surface water sampling



1 to 3 points with fine sediment deposits, always submerged



1 composite sample sieved at 2 mm



Sub-sampling



Surface water parameters



Battery of *in vivo* bioassays

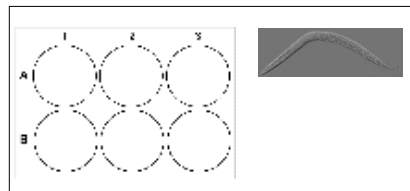
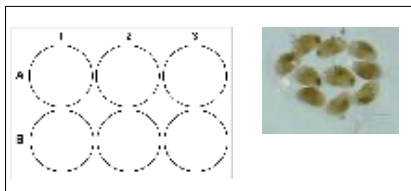
- No bioassay/species represents benthic invertebrate diversity

| Test species | Taxonomic group | SOP | Endpoint | Toxicity classification | | |
|---------------------------------|----------------------|--------------|--------------------------------------------------|-------------------------|--------------------|------------------|
| | | | | No significant effect | Moderate effect | Severe effect |
| <i>Heterocypris incongruens</i> | Crustacean, ostracod | ISO 14371 | Mortality Growth* (inhibition) | 0-20 % 0-35 % | 20-30 % 35-70 % | > 30 % > 70 % |
| <i>Chironomus riparius</i> | Insect, chironom | AFNOR 90-339 | Emergence (inhibition) | 0-32 % | 32-64 % | > 64 % |
| <i>Caenorhabditis elegans</i> | Worm, nematode | ISO 10872 | Growth (inhibition) Reproduction (inhibition) | 0-25 % 0-50 % | 25-50 % 50-75 % | > 50 % > 75 % |

Ecotoxicological quality classification based on toxicity thresholds

| Quality | Effects in bioassays |
|---------|----------------------------------------------------------------------------|
| Good | No effects |
| Medium | At least one endpoint with moderate effect, none with severe effects |
| Poor | At least two species with moderate effects or one with severe effects |
| Bad | At least one species with severe effects and another with moderate effects |

* Growth is only assessed if mortality is lower than 30 %.





Physico-chemical characterisation

- **Descriptive parameters:** grain size, total organic carbon and organic matter, major elements.
- **Metal concentrations,** including total mercury.
- **Organic pollutants** (16 PAHs, 6 PCBs, 91 pesticides or metabolites, 10 organophosphate flame retardants, 9 UV filters, 12 musks and fragrances).

Quality classification system based on sediment quality criteria (SQC)

| Definitive SQC | Preliminary/ <i>ad hoc</i> SQC | Quality | Definition | Meaning |
|----------------|-----------------------------------|-----------|-------------------|------------------|
| | | Very good | $QR < 0,1$ | SQC not exceeded |
| | | Good | $0.1 \leq QR < 1$ | |
| | | Medium | $1 \leq QR < 2$ | SQC exceeded |
| | | Poor | $2 \leq QR < 10$ | |
| | | Bad | $QR \geq 10$ | |



Results: ecotoxicological quality

| | Less impacted sites | | | | Sites under agricultural pressure | | | | | Sites under agricultural and urban pressure | | | |
|------------------------|---------------------|--------|--------|-------|-----------------------------------|--------|--------|--------|--------|---------------------------------------------|--------|--------|--------|
| Bioassay | GB | HB | LOG | MB | BAI | CHS | EB | NC | RG | BOI | FB | LAG | URT |
| Ecotoxicological class | Yellow | Yellow | Yellow | Green | Orange | Orange | Yellow | Yellow | Orange | Orange | Orange | Yellow | Yellow |

- The sediments at all sites except one (less impacted catchment) were toxic to at least one endpoint (ostracod growth), but three AGR sites and two AGR+URB sites are of poor ecotoxicological quality (moderate effects for two species or one with severe effects)

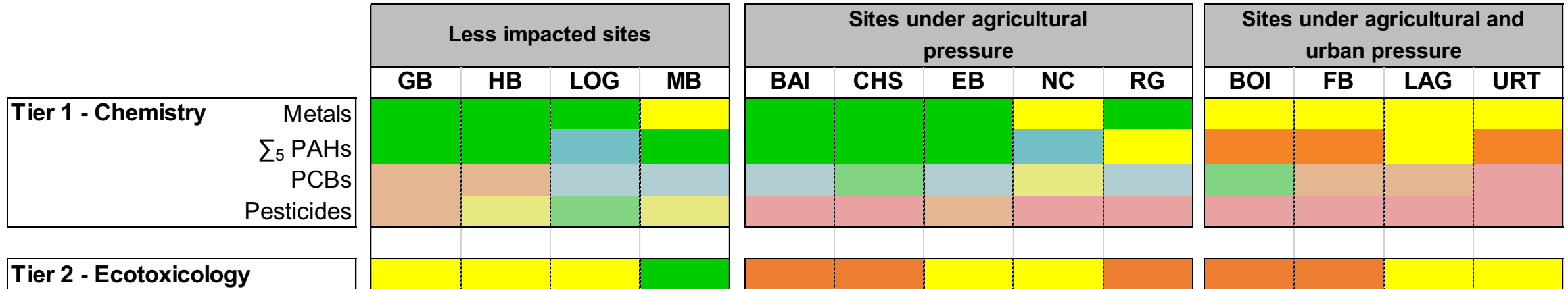
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| Bioassav | GB | HB | LOG | MB | BAI | CHS | EB | NC | RG | BOI | FB | LAG | URT |

- Nematode test: statistical significant inhibition of growth/reproduction compared to controls, but toxicity threshold not exceeded.
- Ostracod test: two sites per type with lethal effects but only severe at AGR and AGR+URB. Growth inhibition exceeding the toxicity threshold at 12 out of 13 sites.
- Chironomid test: moderate effects in one AGR and one AGR+URB sites.

Results: comparison of chemistry and ecotoxicology



- Less impacted sites: sediments less toxic and less contaminated sediments although some metals and organics above SQC ($RQ > 1$). Difference in bioavailability (MB), confounding factors or unmeasured contaminants with toxic effect on ostracods (LOG)?
 - AGR+URB: mixture of traditional sediment contaminants and pesticides leading to potential toxic effects in benthic invertebrates.
 - AGR: pesticides ($RQ \gg 1$) potentially causing toxic effects, no or low risk from traditional sediment contaminants (metals, PAHs, PCBs).
- **Bioassays can provide complementary information to risk assessment based on chemical analyses and SQC.**

«Take home messages»



- **Bioassays allow assessing contaminant mixtures** in environmental samples, because all substances accumulated in sediments cannot be measured.



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- **Chemical analysis** and risk assessment allow making conclusions on potential causes of observed effects.



«Take home messages»

- **Bioassays allow assessing contaminant mixtures** in environmental samples, because all substances accumulated in sediments cannot be measured.
- **Chemical analysis** and risk assessment allow making conclusions on potential causes of observed effects.
- **Risk assessment** based on bioassay results can also provide complementary information to risk assessment based on chemical analyses.



«Take home messages»

- Complementarity of the implemented tests, **confirming the recommendation of using a battery** with different taxonomic groups, with different exposure routes and complexity level for an in-depth analysis.



«Take home messages»

- Complementarity of the implemented tests, **confirming the recommendation of using a battery** with different taxonomic groups, with different exposure routes and complexity level for an in-depth analysis.
- The implementation of the **ostracod bioassay as screening tool at Tier 1 could help prioritise** sites with highest ecotoxicological potential for in-depth assessments, either through chemical analyses of substances not routinely monitored (e.g. pesticides) or through additional biological tools (bioassays and/or bioindication).



«Take home messages»

■ Further developments:

- Nematode test: further studies should address the natural variability of the endpoints for refining the toxicity thresholds and minimise potential false negatives.
- Ostracod test: significant mortalities indicate an important risk according to chemical assessment. However, high incidence of exceedance of toxicity threshold for growth endpoint should be confirmed to minimise potential false positives.

More information (in FR and DE)



Das Oekotoxzentrum hat die Wasser- und Sedimentqualität von 15 Fließgewässern in acht Kantonen mit verschiedenen biologischen effektbasierten Methoden untersucht. So wurden drei komplementäre Projekte durchgeführt mit dem Ziel, für die umfassende Beurteilung der Wasser- und Sedimentqualität eine aussagekräftige Batterie an Biotests auszuwählen und zu validieren und Biomarkermethoden weiterzuentwickeln. Dieser Artikel gibt einen Überblick über die gewählten Methoden und Standorte und die wichtigsten Ergebnisse. Die detaillierten Ergebnisse der einzelnen Projekte werden in weiteren Artikeln dieser Aqua & Gas-Ausgabe präsentiert.

Cornelia Kienle*, Rébecca Beauvais, Carmen Casado-Martínez, Anne-Sophie Voisin, Inge Werner, Etienne Vermeirssen, Benoît Ferrari, Oekotoxzentrum



Zur Entwicklung eines Verfahrens zur Beurteilung der Wasserqualität von Oberflächengewässern mit einer Biotestbatterie wurden insgesamt 15 Proben von Standorten mit unterschiedlicher Landnutzung mit einer umfangreichen Palette von *In-vitro*- und *In-vivo*-Biotests untersucht. Ziel des Projektes war es, eine aussagekräftige und kosteneffiziente Teststrategie für zukünftige Monitoringprojekte zu ermitteln.

Cornelia Kienle*, Nadine Bramaz, Andrea Schifferli, Daniel Olbrich, Inge Werner, Etienne Vermeirssen, Oekotoxzentrum



PROJET PILOTE D'APPLICATION D'UNE BATTERIE DE BIOESSAIS À L'ÉCHELLE NATIONALE

Une batterie de bioessais est utilisée pour évaluer la qualité des sédiments de treize cours d'eau. L'objectif est d'évaluer la faisabilité et la pertinence du recours à des tests écotoxicologiques dans la surveillance de la qualité des sédiments. Les avantages et la complémentarité de ces outils aux approches chimiques, ainsi que la sensibilité relative des bioessais sont discutés dans le but de recommander une batterie de tests pertinente pour de futurs projets.

Carmen Casado-Martínez*, Rébecca Beauvais, Benoît J.D. Ferrari, Centre Ecotox
Sergio Cirelli, Emmanuel J. Schaad, Aurea C. Chiala-Hernandez, Deschger Centre for Climate Change Research, Université de Berne
Sebastian Höss, Ecossa, Jean-Luc Lozeau, Département F-A, Forel Université de Genève



APPLICATION POUR LA SURVEILLANCE DE LA QUALITÉ DE L'EAU AVEC LA TRUITE DE RIVIÈRE

Mesurer l'expression des gènes est une méthode prometteuse permettant de détecter les effets précoces de stress environnementaux, dont l'exposition aux pesticides. Un outil permettant de mesurer une centaine de biomarqueurs moléculaires a été développé et utilisé chez des jeunes truites de rivières provenant de dix cours d'eau en Suisse.

Anne-Sophie Voisin*, Melanie Fasel, Rébecca Beauvais, Centre Ecotox
Cornelia Kienle, Centre Ecotox
Benoît Ferrari, Inge Werner, Centre Ecotox

Acknowledgements



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- Jean-Luc Loizeau, Dept. F.-A. Forel (UniGE) for sediment physico-chemical analysis.
- FOEN and VSA for useful discussions.