Evaluation Of Best Available Techniques For Toxicity Monitoring Of Refinery Effluents

Megan Griffiths[1], Chris Hughes[1], Markus Hjort[2], Eleni Vaiopoulou[2]
1: Ricardo Energy & Environment, Harwell, UK | 2: Concawe, Brussels, BE.
Email contact: megan.griffiths@ricardo.com

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INTRODUCTION

- The **Industrial Emissions Directive** (2010/75/EU) prescribes that industry emissions should be treated using the **Best Available Technology (BAT)**.
- The parameters that refineries are obliged to monitor are laid down in a Commission Implementing Decision **BAT Conclusions (BATC)** document for the mineral oil refining sector, which are published alongside the BAT Reference document (BREF) – the **REF BREF**.
- The REF BREF specifies the requirements for wastewater, but contains no BAT for toxicity monitoring requirements.
- **Effect-based methods (EBMs)** have emerged as useful bioanalytical monitoring tools that can complement chemical analysis measurements of water or whole effluent quality [1][2].
- EBMs are being utilised by authorities more frequently, recently incorporated into the whole effluent assessment of discharges from offshore installations [3].
- EBMs use the responses elicited in **bioassays** to identify and quantify the toxic effects of chemical families in the sample.
- To capture the (eco)toxicological endpoints and modes of action of chemical constituents relevant to the sample, a **battery of bioassays** may be deployed.

AIM: To identify and evaluate toxicity test methods, in order to suggest which tests could be appropriate in a test battery for toxicity monitoring of refinery effluents such as may be required in future European Union legislation.

METHODOLOGY

Literature review
Identify potential *in vivo* and *in vitro* test methods for monitoring toxicity of refinery effluents.

Laboratory survey
Gain insights about the availability, cost, frequency of use, applicability and technical limitations of the tests in commercial laboratories.

Bioassay evaluation
Evaluate tests according to the same set criteria, including validation maturity, performance, use, conduct of test, result interpretation and possible application limitations.

Other considerations
Discuss the use of whole effluent samples vs passive sample extracts, and complementary techniques e.g. biomimetic solid phase microextraction and PETROTOX [4].

RESULTS & DISCUSSION

- A total of **13 *in vivo*** methods and **18 *in vitro*** methods were evaluated according to:

Description
basic principle, organism/cell line used, mode of action and endpoint measured

Validation maturity
validation maturity, commercial availability, standardisation to an ISO/CEN guideline, validation to water samples, and application in a regulatory context

Performance
sensitivity, potency of effects, predictability, specificity, repeatability, reproducibility, and high-throughput potential

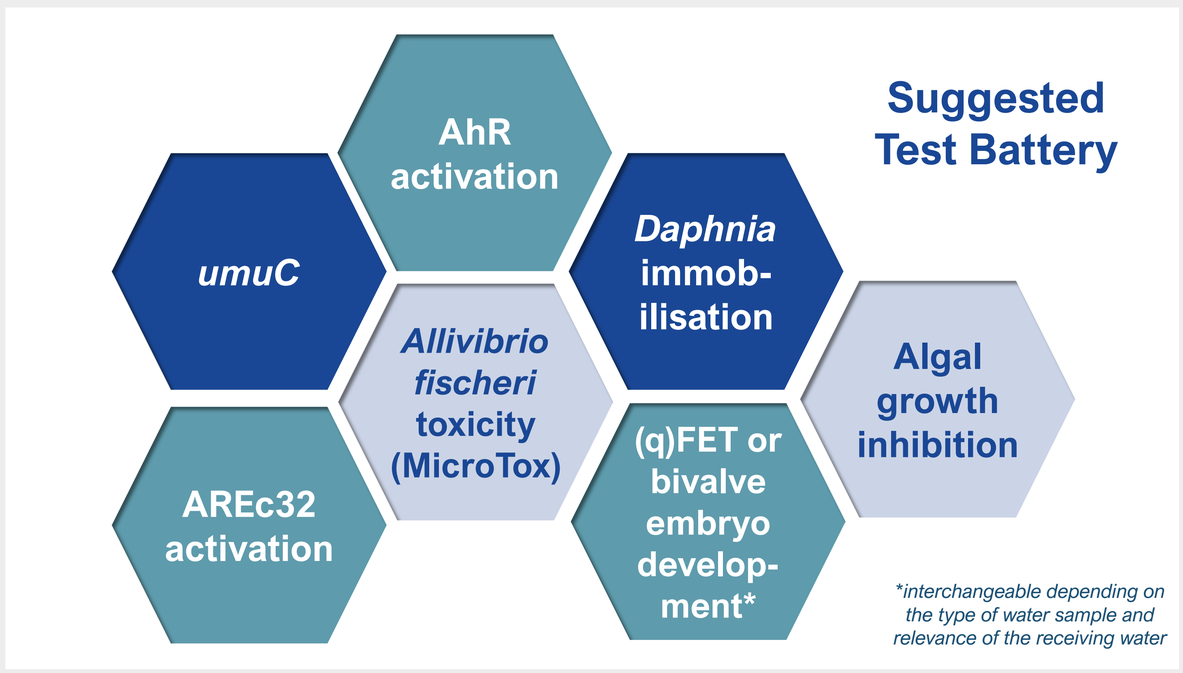
Use
frequency of use in environmental samples, use with refinery effluent constituents and/or whole samples of refinery effluents/produced water

Conduct of test
applicability to passive sample extracts, sample processing, and time and cost

Result interpretation
confounding factors, environmental relevance, trigger values, bioassay category [5], and whether the test results provide details that could replace chemical analysis

Possible application limitations
any practical or technical limitations, e.g. timing constraints, intensive labour, specialist equipment, commercial licensing, sample handling etc.

- The *Daphnia* reproduction and algal growth inhibition assays were the most performed *in vivo* tests, while the micronucleus and Ames assays were the most common *in vitro* of the 14 laboratories surveyed.
- The assays below are considered suitable for toxicity monitoring of refinery effluents:



- The battery covers *in vitro* modes of action (genotoxicity, metabolism and oxidative stress) and apical *in vivo* endpoints (cytotoxicity, developmental toxicity, immobilisation and growth inhibition).
- All tests are **commercially available**, **commonly used** for assessing environmental water, sufficiently **validated**, **standardised** to an ISO guideline (or one is in preparation) and are expected to be **responsive to refinery effluents** and their constituents.
- Not all tests necessarily need to be deployed as one fixed array; the choice of tests should depend on the **assessment objective**, **protection goal** of the monitoring campaign, **type of receiving water**, and **activity undertaken** (e.g. routine monitoring, full site risk assessment etc.).

CONCLUSIONS

- We present a battery of toxicity tests most suitable for toxicity monitoring of refinery effluents. The applied test array **can consist of one or more of the tests** depending on **the nature and objective** of the testing.
- No universally applicable test battery has been identified; test selection should be **sample-specific.**
- Further work may include a comparison of **test response sensitivities** to known contaminant concentrations in refinery effluents.
- **Trial testing** at a selection of sites to identify any potential implementation challenges may also be conducted.

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REFERENCES
[1] Wernersson AS, et al. 2015. Technical report on aquatic effect-based monitoring tools. [2] Carere M, et al. 2021. Technical proposal for effect-based monitoring and assessment under the Water Framework Directive. [3] OSPAR. 2013. Risk-based approach to the management of produced water discharges from offshore installations. [4] Redman AD, et al. 2012. PETROTOX: an aquatic toxicity model for petroleum substances. [5] Escher B, et al. 2018. Effect-based trigger values for *in vitro* and *in vivo* bioassays performed on surface water extracts supporting the environmental quality standards (EQS) of the European Water Framework Directive.