Ecotoxicological assessment of the environmental impact of anti-corrosion coatings

Anna Maria Bell[1], Simon Brand[2], Thomas Ternes[2], Georg Reifferscheid[1], Sebastian Buchinger[1]

[1] Federal Institute of Hydrology, Department G3 – Biochemistry/Ecotoxicology, Am Mainzer Tor 1, Koblenz, Germany
[2] Federal Institute of Hydrology, Department G2 – Aquatic Chemistry, Am Mainzer Tor 1, Koblenz, Germany
Corresponding author: Anna Maria Bell; E-Mail: Bell@bafg.de

Background

In order to prevent corrosion damage, steel structures must be protected. Passive methods mechanically isolate the steel from its environment by the application of metallic or organic coatings (see Fig. 1). Common binding agents are epoxide and polyurethane resins which harden by polymerization reactions. In contact with water, various organic substances could be leached and released into the environment. The investigation of possible adverse effects of anti-corrosion coatings on the environment is one aim of a Network of Experts funded by the German Ministry of Transport and Digital Infrastructure (BMVI).

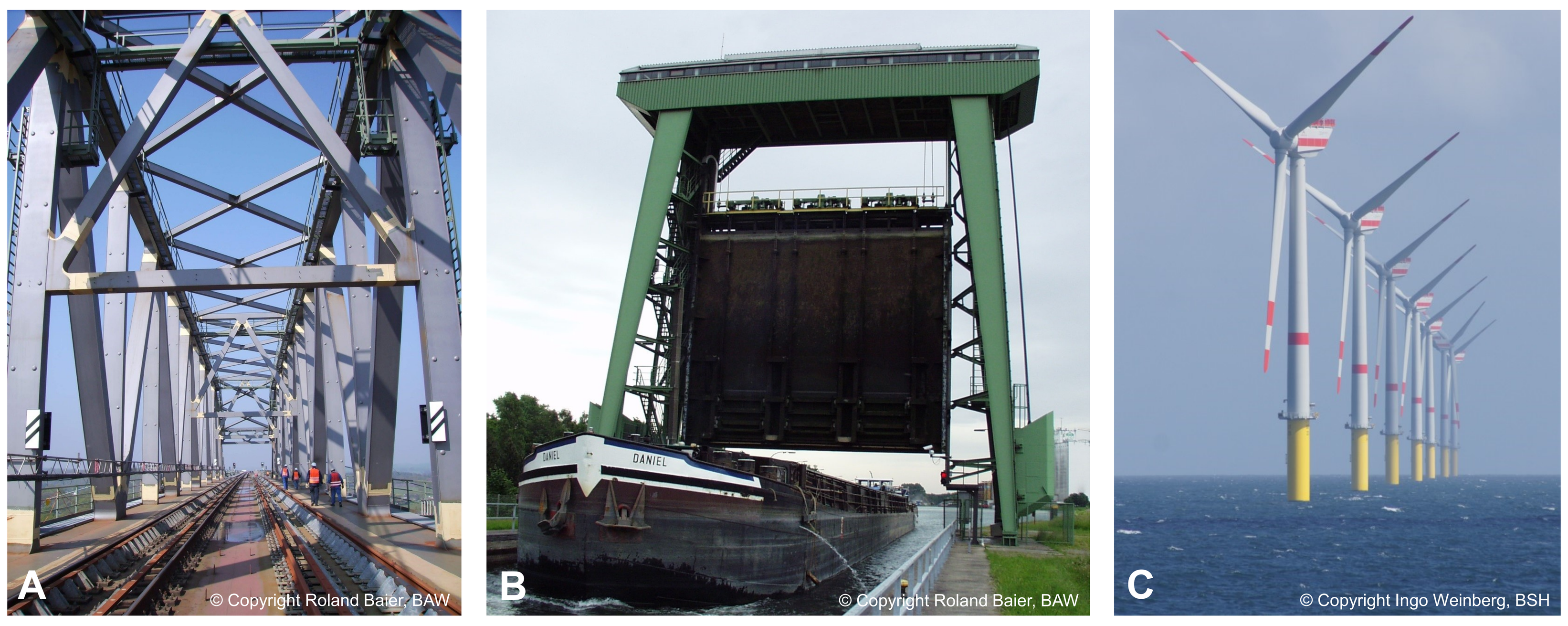

Figure 1: Application examples for anti-corrosion coatings: railway bridge (A), ship lock (B), offshore wind turbines (C)

Material and methods

- Leaching of entirely coated steel plates (see Fig. 2 and 3)
  - Two coating materials for hydraulic engineering
  - Plates with and without UV aging (65 h UV-A)
  - Elution for 4 weeks in 3 L deionized water
- Acute toxicity testing
  - *Daphnia magna* acute immobilization test
  - Freshwater algal growth inhibition test
  - Luminescent bacteria test (cuvette and HPTLC-coupled)
- Investigation of specific toxic effects
  - Ames fluctuation test for mutagenicity
  - Yeast Estrogen Screen for estrogenicity

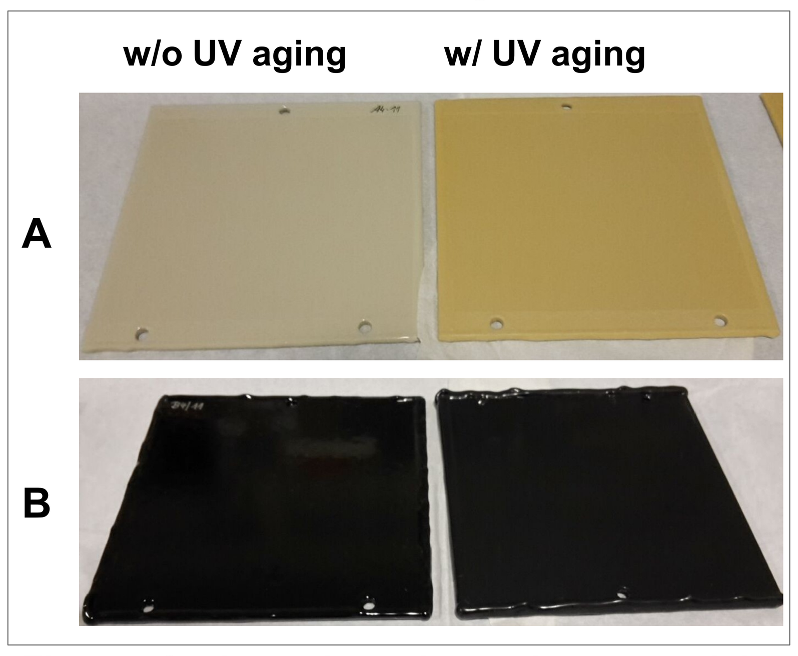

Figure 2: Investigated coating materials used for hydraulic engineering

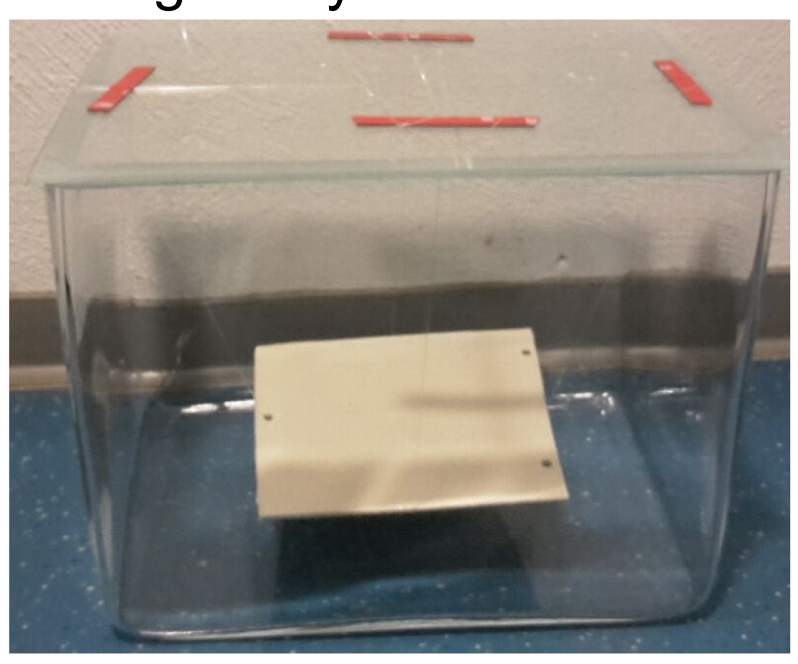

Figure 3: Experimental setup for leaching of coated steel plates

Toxicity of anti-corrosion coatings and its relevance

sample	bacterial toxicity	algae toxicity	daphnia toxicity	estrogenicity	mutagenicity
Blank	2	1,25	1	< LOQ	< LOQ
A	4425	2	4	176	< LOQ
A-UV	2766	1.25	2	165	< LOQ
B	678	1.25	1	77	< LOQ
B-UV	564	1.25	1	51	< LOQ

■ failed assessment criteria/estrogenic effects detected
■ passed assessment criteria/no estrogenic effects detected

Figure 4: Evaluation of anti-corrosion coating systems with and without UV aging according to DIBt. Additionally mean LID of acute toxicity tests and EEQ in ng/L aqueous sample are shown.

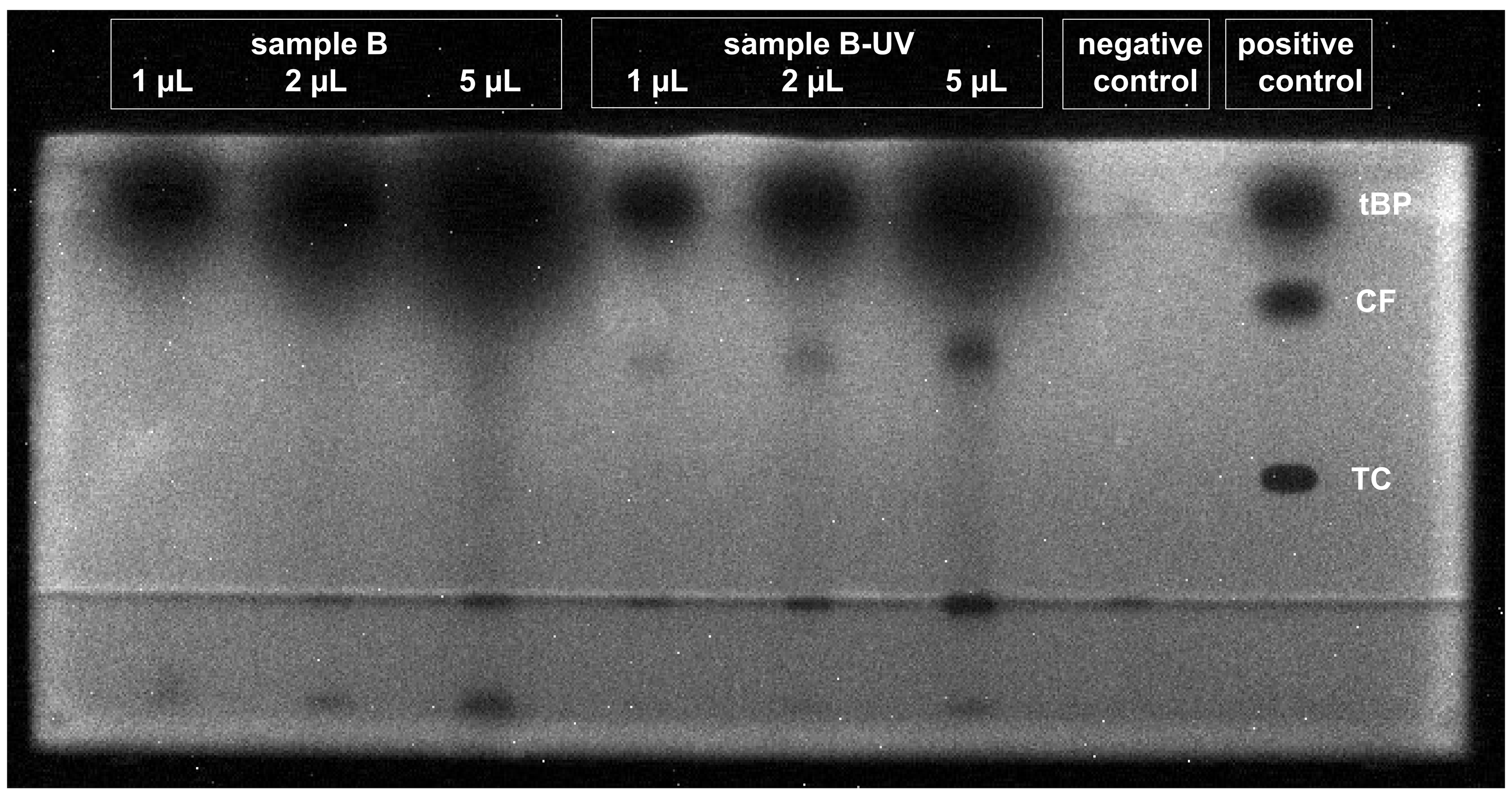

Figure 5: Luminescence inhibition of a coating system with and without UV aging after chromatographic development of 1000x extracts. Triclocarban (TC), carbofuran (CF) and 4-tert-butylphenol (tBP) served as positive controls.

- No sample would pass the assessment criteria for construction products of the German Institute for Building Technology (DIBt) (see Fig. 4): $LID_{bacteria} \leq 8$, $LID_{algae} \leq 4$, $LID_{daphnia} \leq 4$, no mutagenicity
- Occurrence of high bacterial toxicity and estrogenic effects

- Decreased ecotoxicological effects and appearance of a second inhibition spot after UV aging (see Fig. 5)
- 4-tert-butylphenol was identified as main contributor to acute and specific toxic effects by GC-MS and biolumi-nescence inhibition assay

Conclusion and outlook

- Applied methods allowed a reproducible characterization of aquatic emissions from steel coatings
- For the assessment of anti-corrosion coating systems the additional investigation of estrogenicity is recommended and evaluation criteria have to be defined for surface water
- To clarify which substances contributed to toxicity a strategy for effect directed analysis is developed

Acknowledgements

The authors would like to thank the BMVI Network of Experts for its financial support of this research project.