Fachhochschule Nordwestschweiz
Hochschule für Life Sciences

How well do you know your wastewater?

Application of degradation tests and bioassays for the characterization of Swiss industrial wastewater

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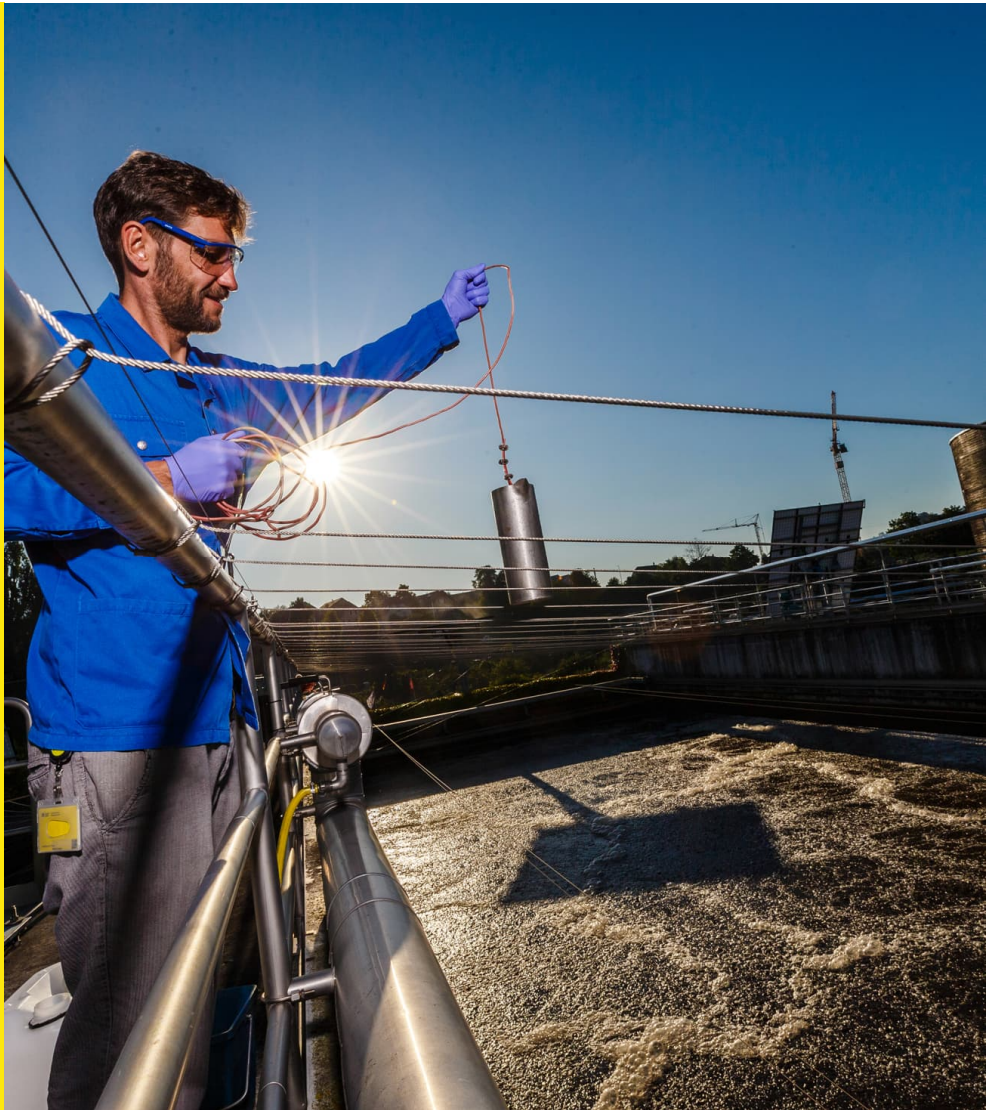
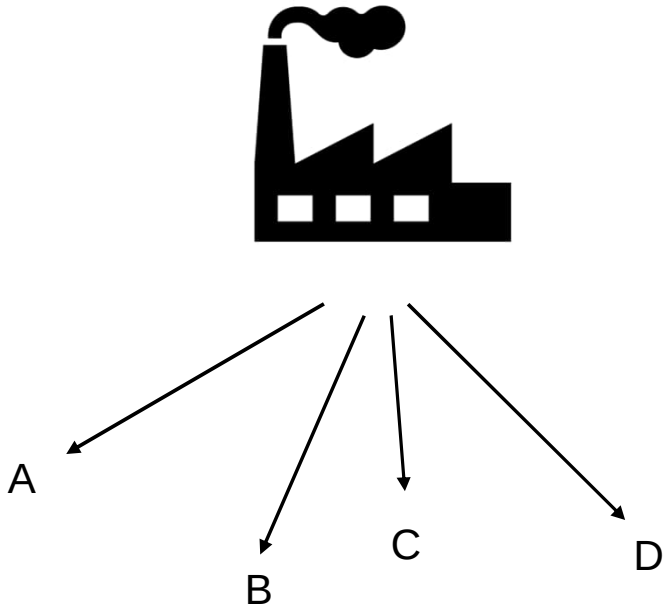
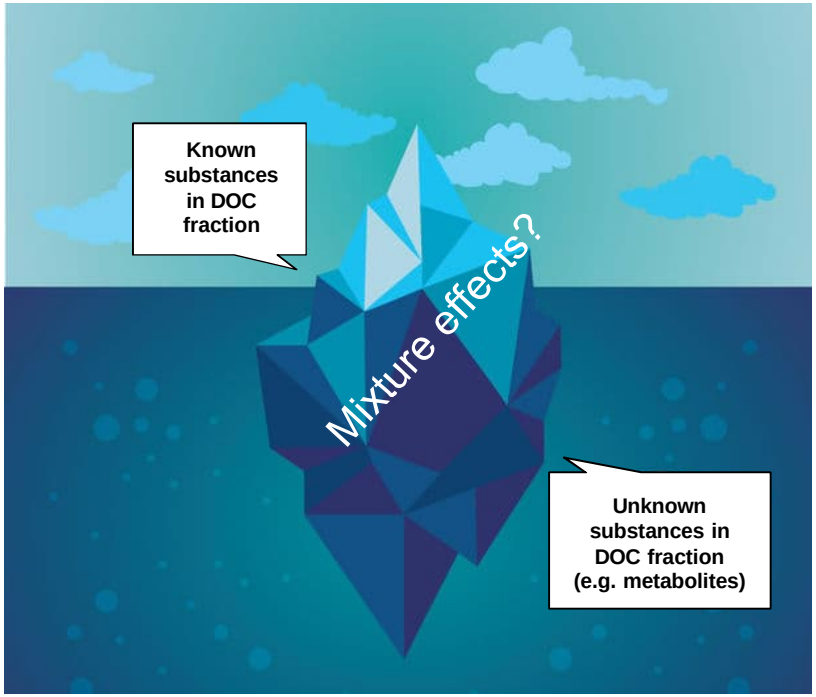
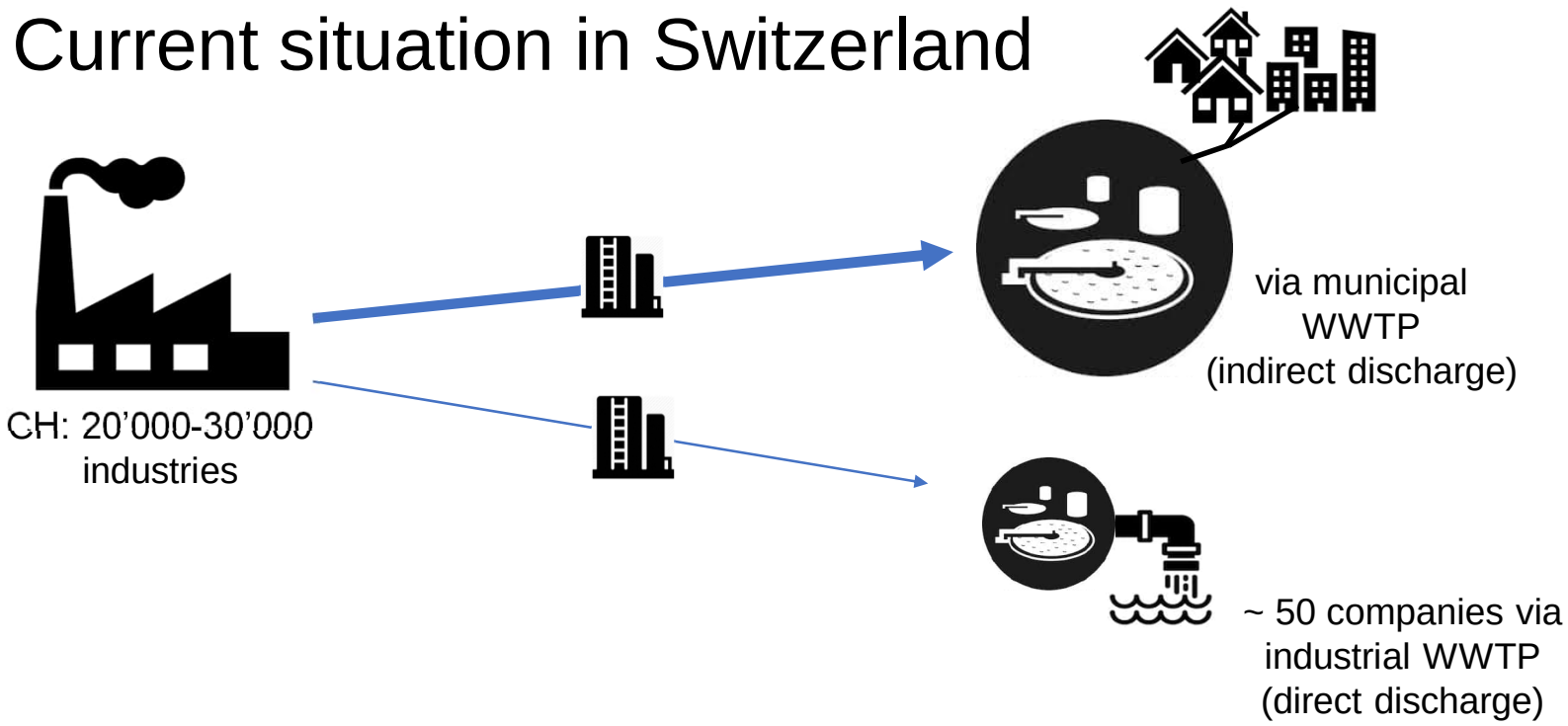


Challenges of industrial wastewater discharges





Current situation in Switzerland



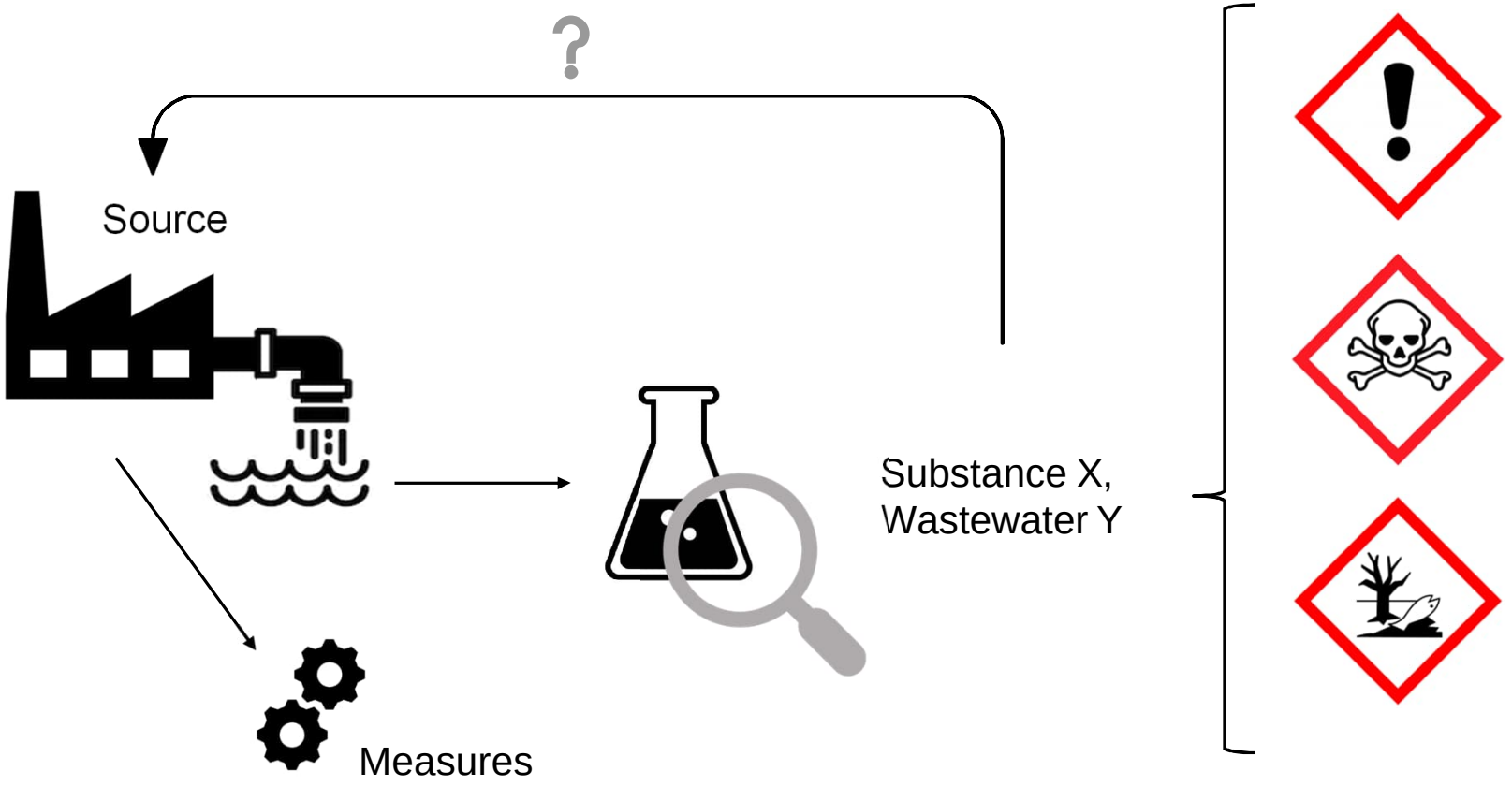
Legal requirements for wastewater (GSchV)

- Function of the WWTP must not be disturbed by industrial inputs
- **10 mg/L DOC** in the effluent (WWTP > 2,000 PE)
- **DOC purification effect** > 85% (WWTP > 2,000 PE)

Open questions:

- Is the wastewater biodegradable?
- Does the industrial wastewater have the potential to disrupt the function of the WWTP?
- Does the treated wastewater show problematic potential for the environment?

Key to solutions: source identification



Ecotoxicology and bioassays

- **Ecotoxicology** investigates the **effects of pollutants on the living environment**.
- **Ecotoxicological bioassays** use cells or whole organisms to **measure their response to a specific exposure**.
- Bioassays can be applied for single substances or for the **analysis of wastewater samples**.

➔ Identification of wastewater samples with high toxicity

➔ Mapping of effects of unknown substances and substance residues as well as combinations (mixture toxicity)

Degradation and bioassays in industrial wastewater

(Aqua & Gas N°10, 2020)

Abwasser	TU-Wert (Verdünnungsfaktor)					
	Leuchtbakterien		Algen		Daphnien	
	Before degradation	After degradation	Before degradation	After degradation	Before degradation	After degradation
Waste disposal	< 34,2	< 8	< 9,17	< 5	< 9,8	< 4
Waste disposal	< 44,1	< 22,4	< 22,6	13,2	< 22,5	11
Waste disposal	< 2	1,7	7,3	2,3	15	130
Chemical industry	385	< 17,2	>1000	< 10,7	3448	17
Chemical industry	< 18	< 10,1	< 50,8	6,2	67,6	6,7
Chemical industry	< 2	< 2	< 2	< 1,25	< 2	< 1
Pharmaproduction	17	< 3,8	< 18,8	< 1,9	17	< 1,9
Metal/Galvanic industry	< 2	< 2	< 2	< 1,25	1,7	< 1
Metal/Galvanic industry	42	< 4	22	< 4	3333	21
Metal/Galvanic industry	9,8	< 2	14,8	< 1,25	< 2	1,0
Metal/Galvanic industry	< 2	< 2	< 2	< 1,25	28	1,0
Laundry Service	16	< 2	12	< 1,25	31,6	< 1
Laundry Service	37	< 2	127	< 1,25	333	< 1
Textile company	9,2	< 2	< 100	< 1,25	7,1	< 1
Textile company	7,8	< 2	16	< 1,25	4,5	< 1

Otto et al. 2020, Aqua & Gas N°10

- Toxicity (in Toxic Units, TU) decreased in most samples after biological treatment, in a few sample it increased

- **Combination of degradation test and bioassays promising for the analysis of industrial wastewater**

➔ Simulation of degradation processes in WWTP

➔ Covers the fact that most companies in CH discharge into municipal WWTP (indirect dischargers)

➔ Visualization of non-biodegradable and toxic substances

Why an alternative degradation test?

Disadvantages of the commonly used degradation tests

- Long test duration
- Space and resource-intensive
- Interpretation of the data

Requirements for "new degradation tests":

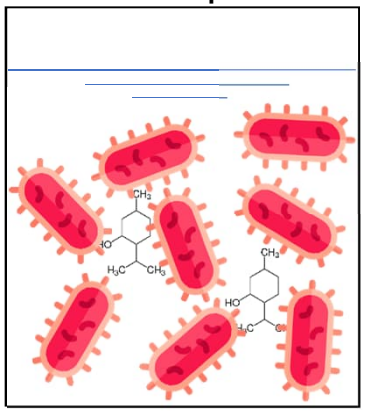
- Time- and resource-efficient testing
- Robustness
- multiparametric information

Degradation test: Zahn Wellens-Test OECD 302b

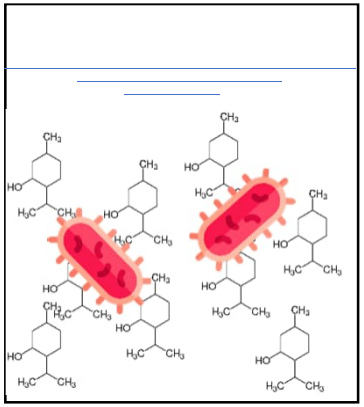
- determining inherent biodegradability of chemical single substances
- Test duration **28 days**
  - Activated sludge 0.2-1.0 gTSS/L and test substance/ wastewater sample 50-400 mg DOC/L
  - Monitoring of the DOC concentration (Dissolved Organic Carbon) for 28 days

→ Substrate to biomass ratio for wwtp not comparable (difficult for behaviour at the wwtp)

wwtp



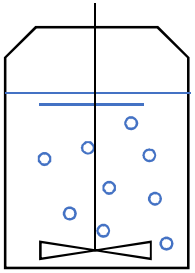
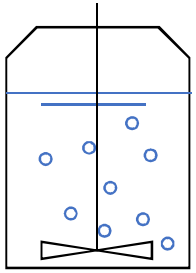
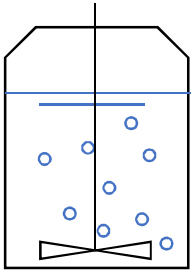
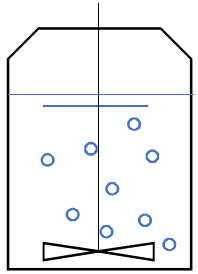
OECD 302b



- Advantage
  → Growth of biomass required → Adaptation
  → less adsorption

- Disadvantage
  → long test duration

AIA-Test

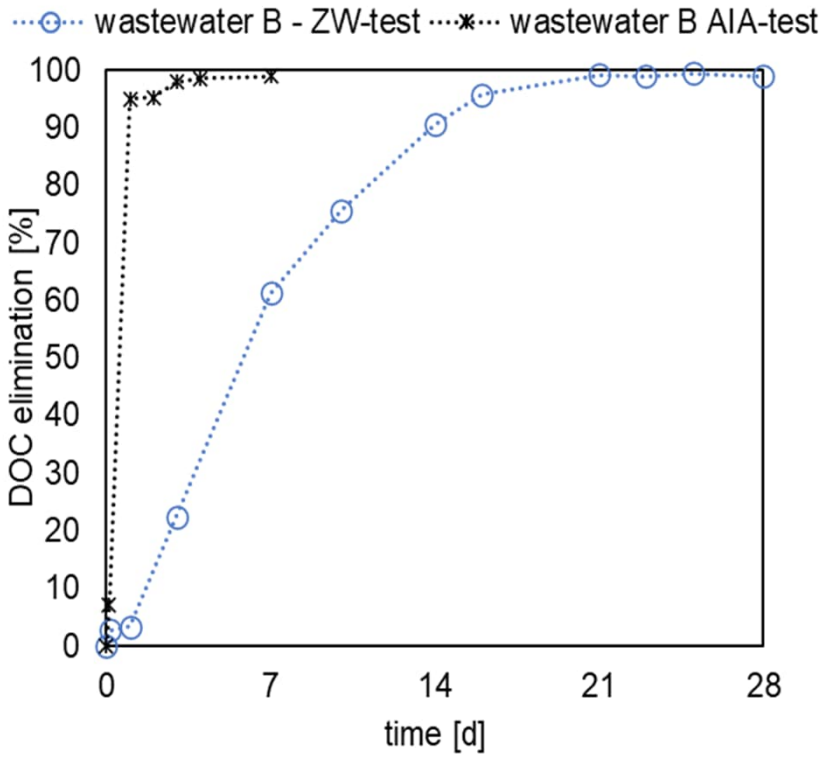
		Blind	Control	Test-batch	Test-batch diluted
Activated sludge	gTSS/L	5	5	5	5
Wastewater sample	mgDOC/L	-		400	50
Control	mgDOC/L		400		
NH_4Cl		-	20 mg N/L	20 mg N/L	

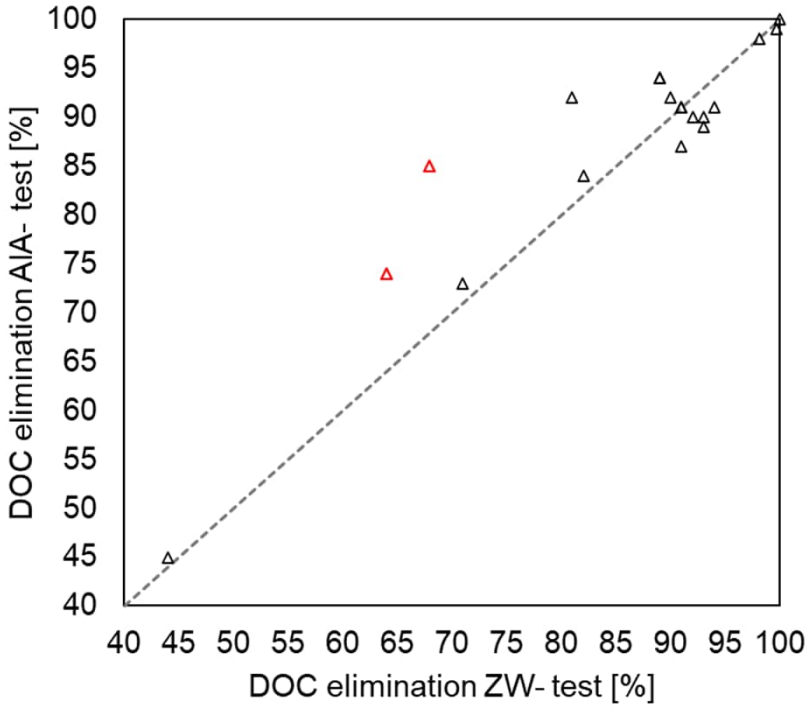
- Activated sludge from the plant where the wastewater is or will be treated
- Vessels containing the batches are aerated and stirred
- Daily measuring of the DOC concentration
- **Process of adsorption and biological degradation are simultaneous**

adsorption can be evaluated by comparing the DOC concentration in diluted solution without sludge and test batch time 0

→ **result DOC elimination**

AIA-test - Results DOC elimination





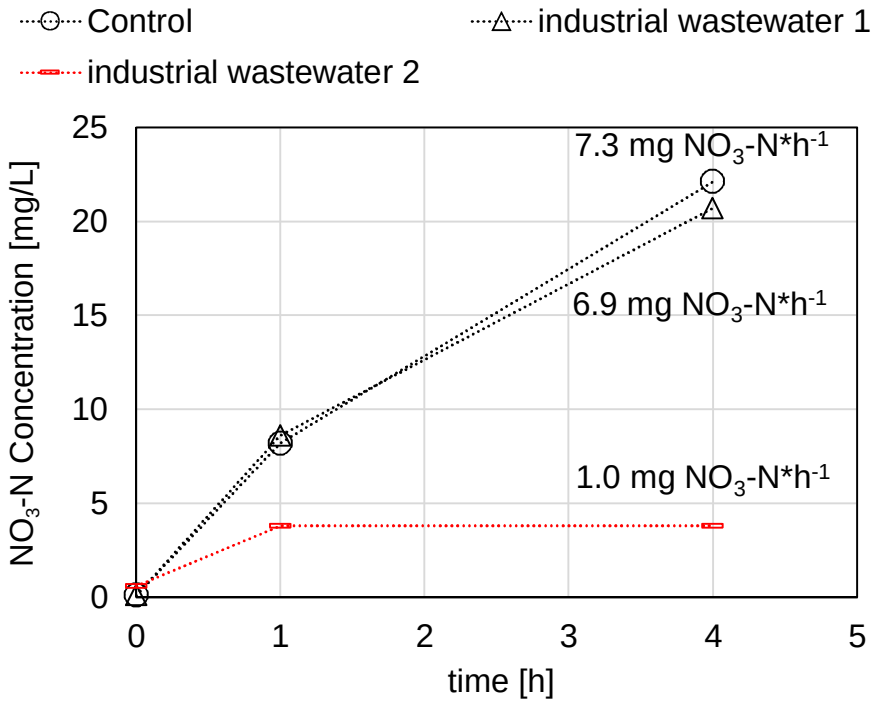
AIA-test - Inhibition of nitrification

Does the industrial wastewater have a negative impact on the nitrification process?

–Nitrifiers are generally **more sensitive** to toxic wastewater compared to heterotrophic biomass

- Addition of NH_4 to the control batch and test batch
- Analysis of ammonia and nitrate after 1h and 4h
- Determination of the nitrification rate based on the nitrate concentration

→ statement whether wastewater is **inhibiting** or **non-inhibiting**, no information about the EC_{50}



Limitations of the AIA-test

Limitations of the AIA-test

- Effect of adaption

  → AIA-test over longer time or ZW-test

- Not suitable for low concentrated wastewater samples (wastewater sample DOC < 30 mg/L)

  → ZW-Test

Reference wastewater treatment plant

- Dilution ratios
- Physical / chemical processes
- Batch vs. continuous system

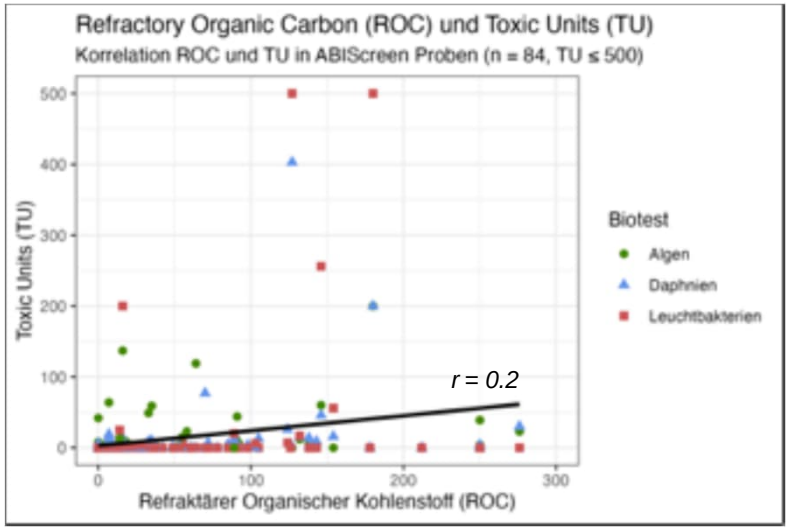
Limitations sum parameter (DOC)

- Biological degradation test gives no information about the content of the refractory carbon

→ **Bioassays (ABIScreen)**

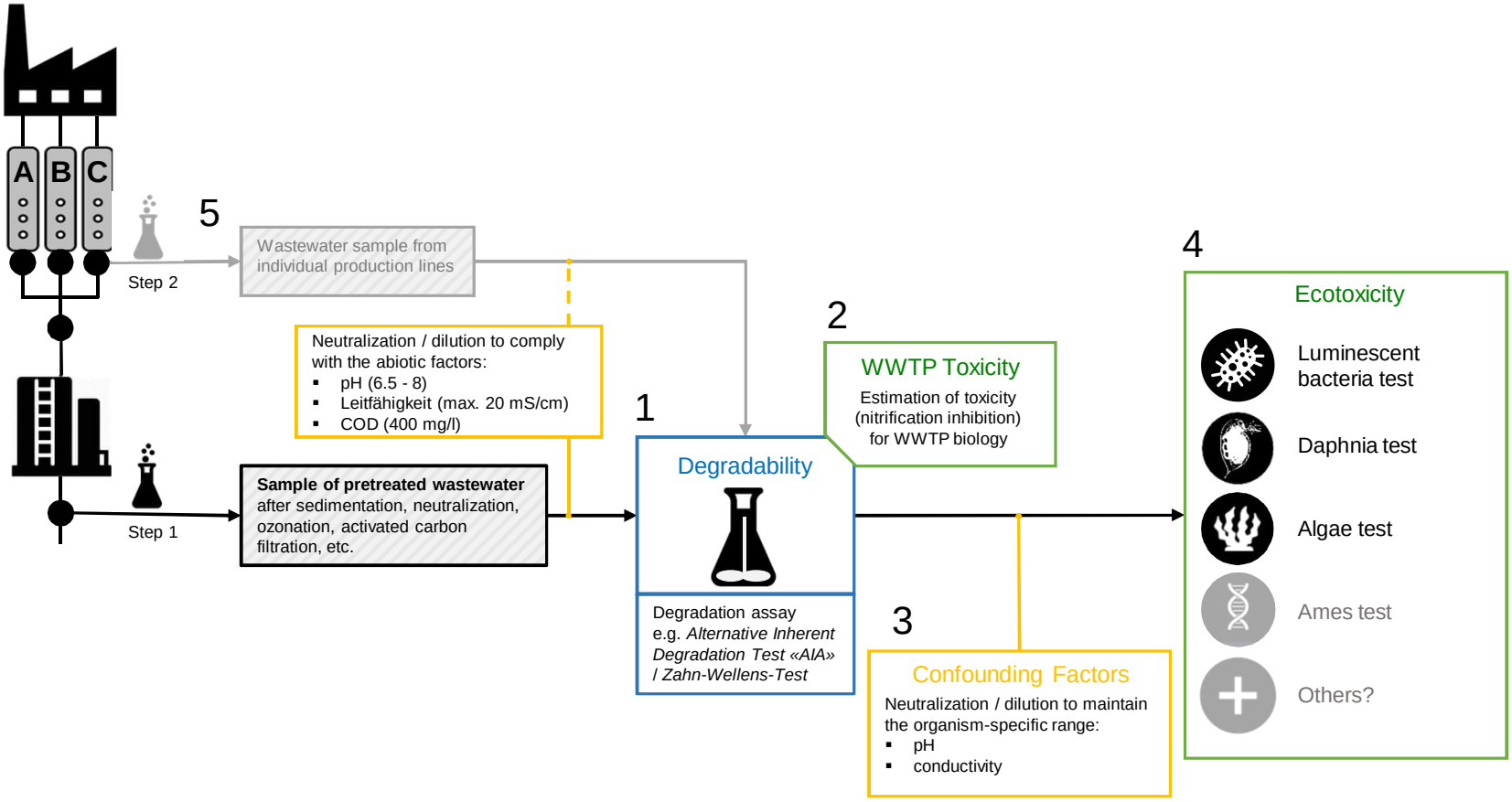
Legal requirements regarding the discharge of industrial wastewater

- The discharge of wastewater from Swiss companies is regulated by requirements in the **Water Protection Ordinance** (GSchV).
- The GSchV currently requires the **sum parameter DOC** as a **limit value for organic substances**.
- But: there is usually **no correlation** between the occurrence of organic substances (i.e. high DOC or ROC values) and toxicity.

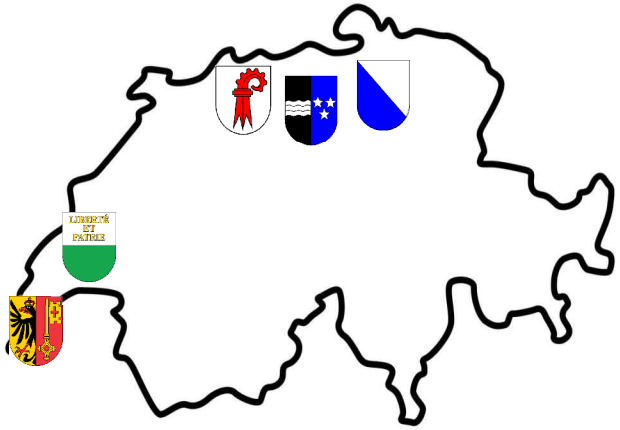


➔ **The possibilities with regard to the requirements for the input of organic micropollutants have not yet been fully exploited!**

ABIScreen (**A**bbautest **B**iotest **I**ndustrieabwasser **Screen**ing)



Biotest & Industry 3.0 (2023 – 2026)

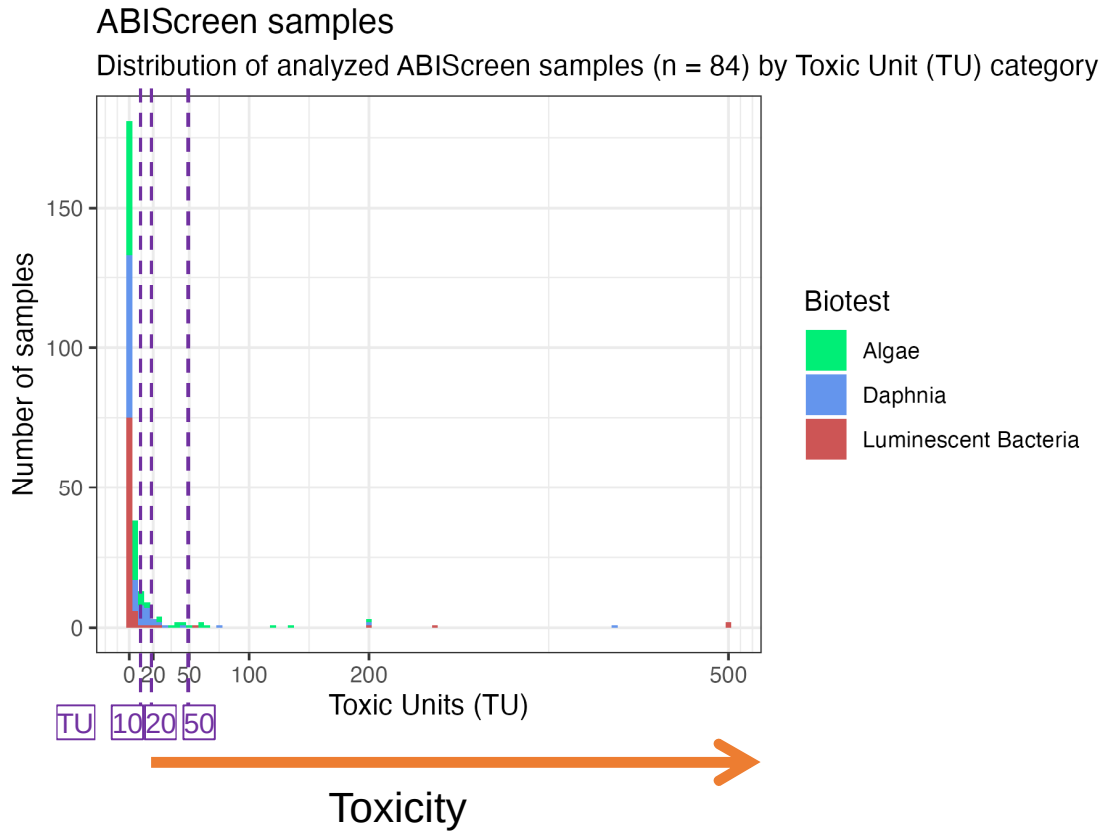


- Switzerland-wide monitoring of industrial wastewater with ABIScreen
- Project start March 2023
- Funded by FOEN, 5 Swiss cantons (AG, BL, GE, VD and ZH) and the FHNW
- Supervision by VSA Platform Process Micropoll

Objectives

- Overview of the state of the art of wastewater treatment in various companies and sectors with degradation and bioassays
- Broad data basis and collection in a database
- Derivation of toxicity threshold values
- Creation of a toxicity register for a complex industrial site

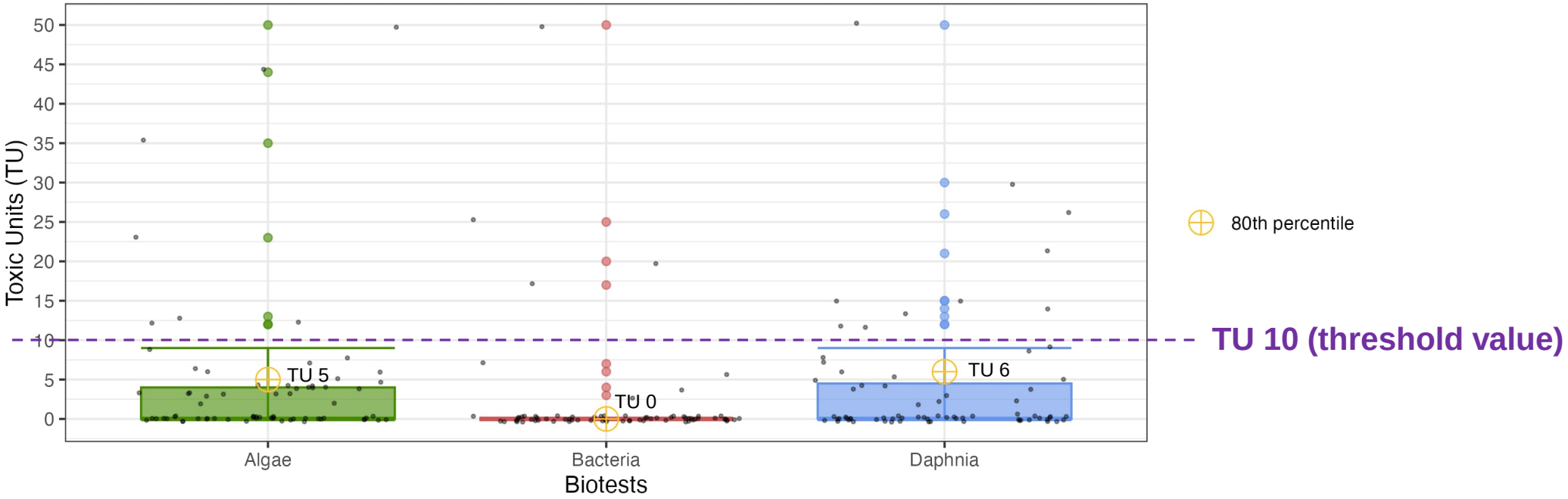
Preliminary Results I



Preliminary Results II (representing the current state of the art)

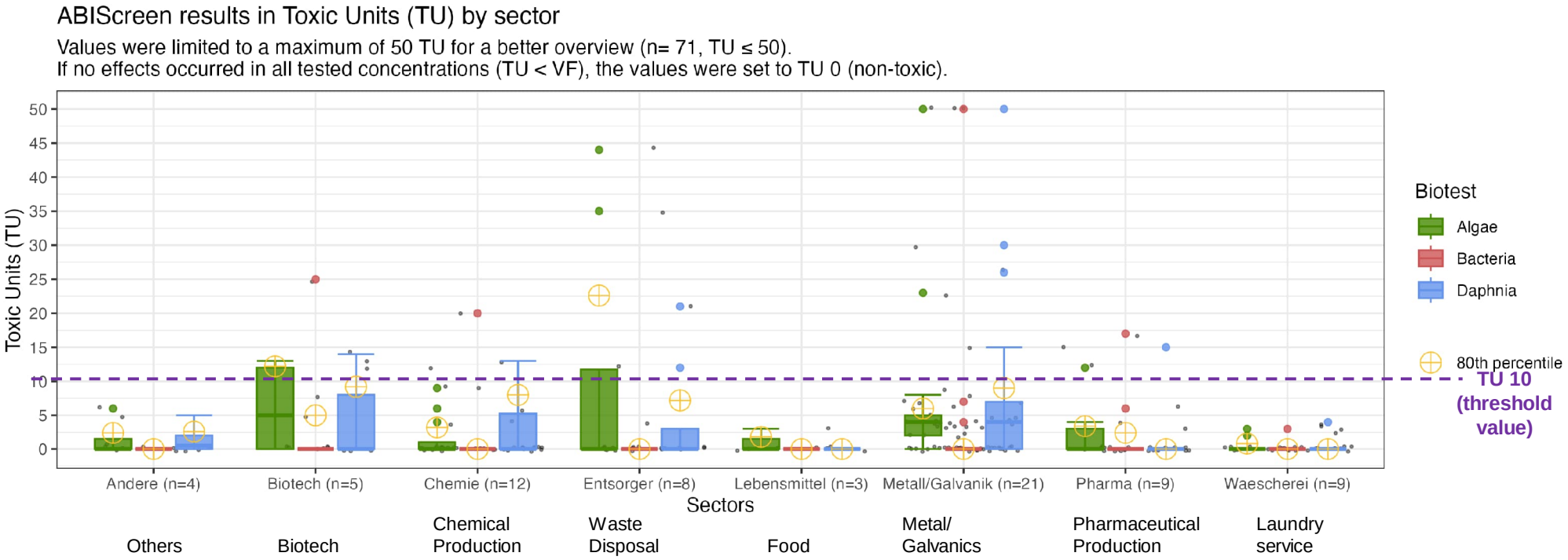
ABIScreen results in Toxic Units (TU) across all sectors*

Values have been limited to a maximum of 50 TU for a better overview (n= 71, TU ≤ 50).
If no effects occurred in all tested concentrations (TU < VF), the values were set to TU 0 (non-toxic).



*industries examined so far: biotech, chemical production, waste disposal, paint/lacquer, food, logistics, metal/galvanics, pharmaceutical production, laundry services

Preliminary Results III (current state of the art by sector)



ABIScreen threshold value

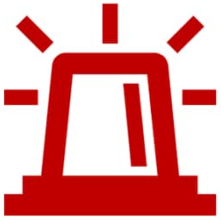
- Based on current data, **TU 10** has been defined as the threshold value for ABIScreen results.

The ABIScreen threshold value

- is influenced by the **current** (constantly improving) **technical state of the art** of wastewater treatment
- is to be understood as a **orientation value and not as a discharge limit value** (no “filling up to this value”-principle)
- indicates to companies and authorities whether the wastewater management needs to be reviewed (quality check, guidance, alarm signal)
- can be reviewed regularly and adapted to the progressing state of the art

Conclusions

- Characterization tools facilitate the identification of problematic wastewater of industrial origin
- In Switzerland municipal WWTPs often treat industrial wastewater
- The AIA degradation test is able to simulate WWTPs with regard to DOC elimination
- The combination of degradation and bioassay in ABIScreen characterize the hazard potential of non-biodegradable substances in industrial wastewater streams
- Results show that the majority of samples are non-toxic, but there are exceptions ➔ Focus of ABIScreen
- Technical current state of the art in Switzerland as a basis for deriving an ABIScreen threshold value (TU 10)



- ABIScreen is not a regulatory instrument and does not replace water monitoring
- The ABIScreen threshold value is intended as an alarm signal for problematic wastewater and not as a discharge limit value

Thank you for your attention!

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Abbau- und Biotests in Industrieabwässern

Entwicklung effizienter Abbautest

Untersuchungskonzept von Biotests für Industrieabwasserproben

ABIScreen: Kombination Abbau- und Biotest

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