

WA 5: Fostering the uptake of novel technologies in the water sector

LCA/LCC of bioassays: case study at Waternet (NL)

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- Bioassays = new effect-based approach for monitoring of water quality
- What is the „**unique selling point**“ of bioassays?
 - Complementary monitoring technology for water quality
 - Used in addition of „single-substance“ chemical analysis
 - Regulatory framework not yet developed
 - ...?
- Evaluation of „bioassays“ technology in the **life-cycle**:
 - Life Cycle Assessment → environmental impacts of bioassays?
 - Life Cycle Costing → costs (= price) for operators for water quality monitoring

- Environmental impacts of using bioassays or chemical analysis?
- Quantitative input data required for CALUX and LC-MS :
 - **Direct effects:** direct emissions?? Not expected
 - **Indirect effects:** Energy, chemical demand, waste, and infrastructure

1) Cultivation and maintenance of ER CALUX® cells

Available in LCA database
ecoinvent v3

n.q. – not quantified

3.2 Chemicals

- 3.2.1 CO₂ cylinder with reduction-valve n.q.
- 3.2.2 Demineralised water n.q.
- 3.2.3 DF medium with phenol red as pH-indicator (Gibco, 31331-028)
- 3.2.4 EDTA (Acros, 147855000)
- 3.2.5 Ethyl Alcohol 70% n.q.
- 3.2.6 FCS (preferably from Australian origin; a first small quantity is provided by BDS).
- 3.2.7 Liquid nitrogen n.q.
- 3.2.8 MEM (100x) Non-essential amino acids (Gibco, 11140-035)
- 3.2.9 Penicillin-streptomycin (Gibco, cat nr. 15070-063; 5000 penicillin units per ml / 5000 µg streptomycin per ml)
- 3.2.10 Phosphate buffered saline pH 7.2 (PBS, Gibco, 20012-019)
- 3.2.11 Trypsin (Gibco, 27250-042) or equivalent

3.3 Apparatus

- 3.3.1 Autoclave (PBI-international, AUTO-KOCH) or equivalent → Electricity? Time n.q.
- 3.3.2 CO₂ incubator (Heraeus, Heracell) or equivalent → Electricity? Time n.q.
- 3.3.3 Pipette controller (Brand, accu jet) or equivalent
- 3.3.4 Refrigerator/freezer combination → Electricity? Time n.q.
- 3.3.5 Relief phase contrast microscope with 4x times objective and 10x times objective (Olympus, CK30) or equivalent → Electricity? Time n.q.
- 3.3.6 Safety-cabinet (Heraeus, HS-18) or equivalent
- 3.3.7 Water bath (37 °C; GFL 1083) or equivalent → Electricity? Time n.q.

→ not included in quantitative LCA due to data limitations

- Inventory data is difficult to obtain:
 - Quantification of lab chemicals and electricity demand?
 - Many substances not in LCA database
 - → No quantitative LCA in DEMEAU
- Qualitative assessment of environmental impacts:
 - In general, monitoring technology is expected to have low environmental impacts compared to water treatment processes
 - Energy use may be dominated by storage of cells? (→ freezer)
 - If chemicals used for analysis are environmentally hazardous, they will be disposed without harmful effects to the environment
 - Differences between CALUX and LC-MS could be discussed with experts for analytical chemistry and lab practitioners (“hands-on experience”)

- Here: LCC will be done from operators perspective (= “price”) and not in full life-cycle costs (= “costs”)
- Case study at drinking water production at Waternet (NL):
 - **Status quo:** regular monitoring of water quality with chemical analysis (LC-MS)
 - **Bioassays:** regular monitoring of water quality with bioassays plus additional chemical analysis if bioassays give positive signal

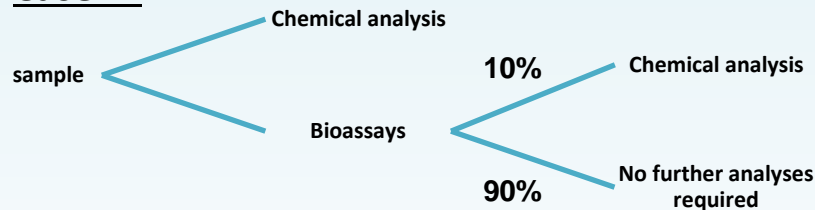
- Monitoring programme of Waternet

Samples	HWL broad screening #/year	
Waternet source 1	13	<i>Monthly</i>
Waternet source 2	52	<i>Weekly</i>
Waternet drinking water 1	4	<i>Quarterly</i>
Waternet drinking water 2	4	<i>Quarterly</i>
Total	73	

- How many samples would be analysed with LC-MS due to positive result in bioassays?
 - Estimation by Waternet: 10-25% of samples have to be analysed chemically

- Prices:
 - Chemical analysis (LC-MS): 640 € per sample
 - Bioassays (ER-CALUX): 100 € for extraction + 80 € for bioassay
- Sampling frequency: 73 regular samplings at Waternet per year
- Annual costs of chemical analysis: $640 * 73 = 46720€$

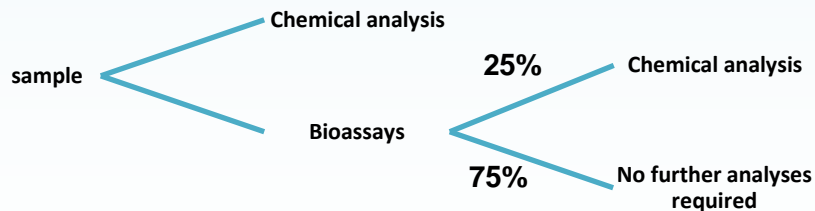
Case A:



$$C_A = 73 * (100 + 80) + 0,1 * 73 * 640 = 17.140 €$$

**-29.580 €
(- 63%)**

Case B:



$$C_B = 73 * (100 + 80) + 0,25 * 73 * 640 = 24.820 €$$

**-21.900 €
(- 47%)**

- **Environmental impacts of bioassays:**
 - Quantitative assessment (LCA) requires inventory data from lab protocols and handling
 - Qualitative assessment: monitoring of water quality not expected to have a significant contribution to overall environmental impact of water treatment
- **Economic assessment of bioassays:**
 - Comparison with regular chemical analysis (LC-MS)
 - Perspective of water utility (prices, not costs)
 - Bioassays can save monitoring costs for emerging contaminants (cheaper than chemical analysis) if they are used as screening indicator

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Thank you for your attention!