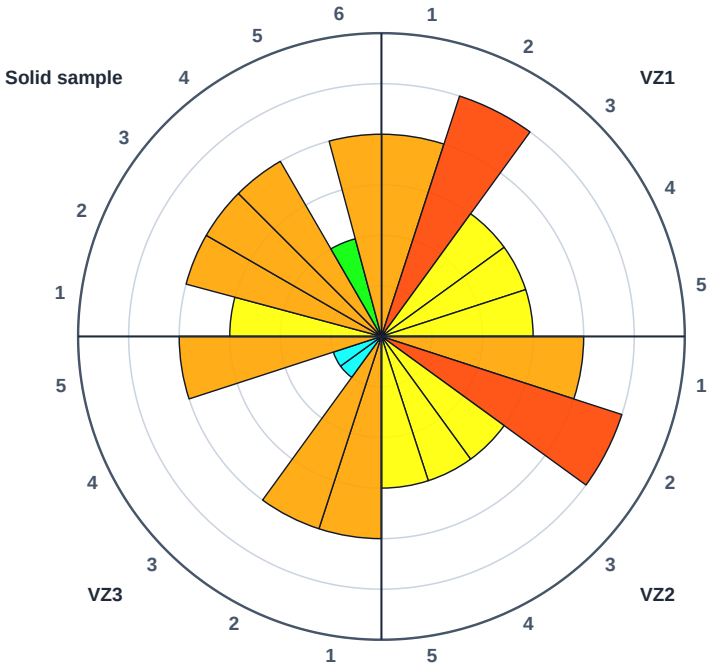
# Ecotoxicology Analysis

Before Remediation

| | |
|---|---|
| **Locality:** | Ferrara, Italy, ER-site |
| **Bioremediation method:** | Before Bioremediation |
| **Sample type:** | water, soil |
| **Collection date:** | 2023-04-04 – 2023-07-07 |




## ORGANISMS

1. *Algae*
2. *Daphnids*
3. *A. fischeri 15*
4. *A. fischeri 30*
5. *Lettuce aquatic*
6. *Lettuce terestric*

## CATEGORIES

- **A** Non-toxic
- **B** Low toxicity
- **C** Medium toxicity
- **D** High toxicity
- **E** Very high toxicity
- **F** Extreme toxicity

## Category Distribution (% of organism readings)

**A: 10%** **B: 5%** **C: 33%** **D: 43%** **E: 9%**

**Resulting category:** **E** Very high toxicity

## Test Organisms by Type

**Consumers:** *Daphnids*

**Producers:** *Algae*, *Lettuce aquatic*, *Lettuce terestric*

**Destruent:** *A. fischeri 15*, *A. fischeri 30*

**Most sensitive organism:** Daphnids

### Critical ecotoxicological response recommended

Samples fall into category E. At 10% sample concentration inhibition is 51–100%, or EC50 is 1–10%. A severe toxic effect is present.

- It is recommended to implement immediate measures and conduct intensive monitoring.

## Ecotoxicity Assessment Criteria

| CATEGORY | DESCRIPTION | CRITERIA (ACTIVE RULES) |
|---|---|---|
| A | Non-toxic | Undiluted sample: inhibition / stimulation -19.99% – 19.99% |
| B | Low toxicity | Undiluted sample: stimulation 20% – 50%, or<br>Undiluted sample: inhibition 20% – 50% |
| C | Medium toxicity | Undiluted sample: stimulation 51% – 90%, or<br>Undiluted sample: inhibition 51% – 90% |
| D | High toxicity | At 10% sample concentration: inhibition / stimulation -50.99% – 50.99%, or<br>EC50 10% – 50% |
| E | Very high toxicity | At 10% sample concentration: inhibition 51% – 100%, or<br>EC50 1% – 10% |
| F | Extreme toxicity | At 1% sample concentration: inhibition 10.01% – 100%, or<br>EC50 0% – 0.99% |

**Notes:** A sample's category is the worst (most toxic) grade reached by any single test organism. Determination of EC50 takes precedence over the inhibition value. In a luminescence bacterial test, an undiluted sample corresponds to a sample concentration of 500 mL/L.

# Chemical Risk Assessment

Before Remediation

| | |
|---|---|
| **Locality:** | Ferrara, Italy, ER-site |
| **Bioremediation method:** | Before Bioremediation |
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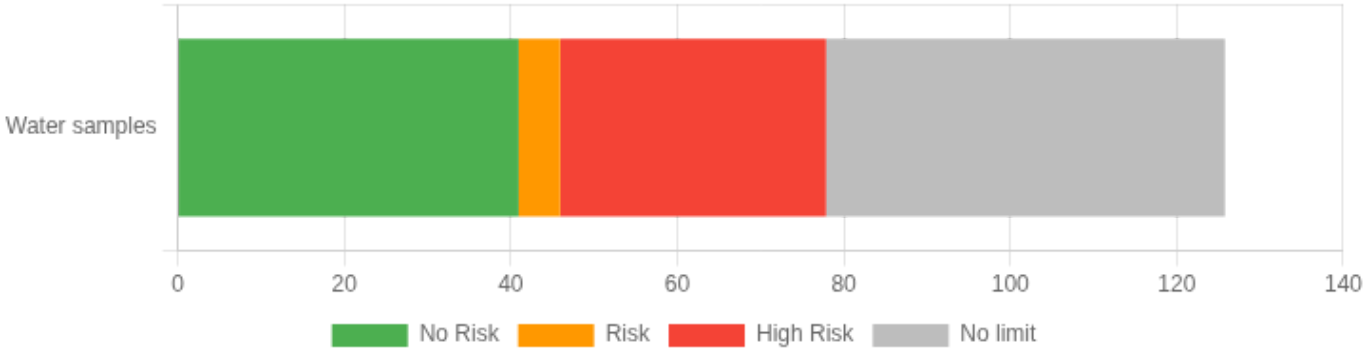
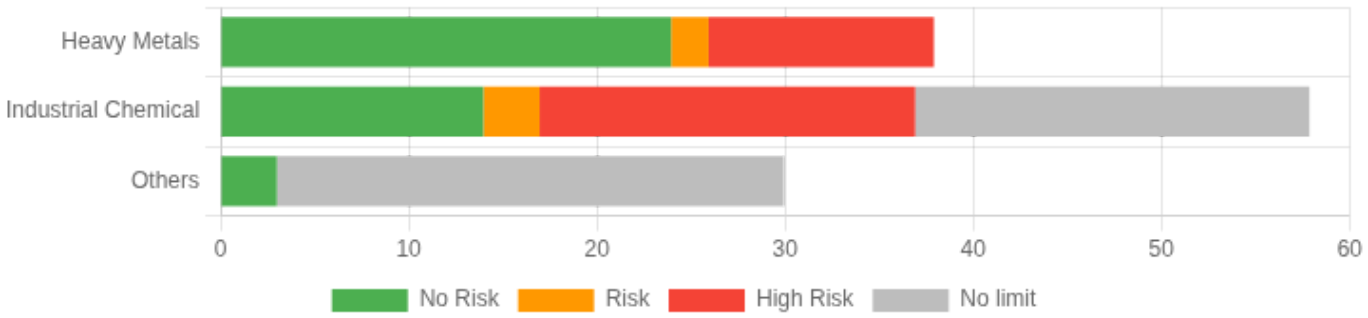
No Risk — at/below limit  Risk — over limit (up to 50%)  High Risk — more than 50% over limit

No limit — not defined

## Risk distribution by sample type



## Water samples




No risk 33% | Risk 4% | High risk 25% | No limit 38%

| CLASS | NUMBER | OVER LIMIT | SUM CONCENTRATION |
|---|---|---|---|
| Heavy Metals | 38 | 14 | 81954.171 µg/L |
| Industrial Chemical | 58 | 23 | 398618.3667 µg/L |
| Others | 30 | 0 | 1448.22 mg/L |

| SAMPLE | COMPOUND / ELEMENT | CLASS | MEASURED | UNIT |
|---|---|---|---|---|
| VZ2 | **arsenic** | Heavy Metals | **31.7** | µg/L |
| VZ2 | **iron** | Heavy Metals | **24800** | µg/L |
| VZ2 | **manganese** | Heavy Metals | **1720** | µg/L |
| VZ2 | **1,1,2-trichloroethane** | Industrial Chemical | **5** | µg/L |
| VZ2 | **1,1-dichloroethylene** | Industrial Chemical | **71** | µg/L |
| VZ2 | **benzene** | Industrial Chemical | **3000** | µg/L |
| VZ2 | **ethylbenzene** | Industrial Chemical | **1000** | µg/L |
| VZ2 | **toluene** | Industrial Chemical | **3780** | µg/L |
| VZ2 | **vinyl chloride** | Industrial Chemical | **20200** | µg/L |
| VZ3 | **arsenic** | Heavy Metals | **19** | µg/L |
| VZ3 | **arsenic** | Heavy Metals | **19** | µg/L |
| VZ3 | **cobalt** | Heavy Metals | **156** | µg/L |
| VZ3 | **cobalt** | Heavy Metals | **156** | µg/L |
| VZ3 | **iron** | Heavy Metals | **25400** | µg/L |
| VZ3 | **iron** | Heavy Metals | **25400** | µg/L |
| VZ3 | **manganese** | Heavy Metals | **1710** | µg/L |
| VZ3 | **manganese** | Heavy Metals | **1710** | µg/L |
| VZ3 | **1,1,2-trichloroethane** | Industrial Chemical | **19.3** | µg/L |
| VZ3 | **1,1,2-trichloroethane** | Industrial Chemical | **19.3** | µg/L |
| VZ3 | **1,1-dichloroethylene** | Industrial Chemical | **311** | µg/L |
| VZ3 | **1,1-dichloroethylene** | Industrial Chemical | **311** | µg/L |
| VZ3 | **benzene** | Industrial Chemical | **3380** | µg/L |

| SAMPLE | COMPOUND / ELEMENT | CLASS | MEASURED | UNIT |
|---|---|---|---|---|
| VZ3 | **benzene** | Industrial Chemical | **3380** | µg/L |
| VZ3 | **ethylbenzene** | Industrial Chemical | **1750** | µg/L |
| VZ3 | **ethylbenzene** | Industrial Chemical | **1750** | µg/L |
| VZ3 | **toluene** | Industrial Chemical | **4950** | µg/L |
| VZ3 | **toluene** | Industrial Chemical | **4950** | µg/L |
| VZ3 | **vinyl chloride** | Industrial Chemical | **50800** | µg/L |
| VZ3 | **vinyl chloride** | Industrial Chemical | **50800** | µg/L |
| water sample | **manganese** | Heavy Metals | **388** | µg/L |
| water sample | **benzene** | Industrial Chemical | **29** | µg/L |
| water sample | **toluene** | Industrial Chemical | **37** | µg/L |
| VZ2 | **cobalt** | Heavy Metals | **66** | µg/L |
| VZ3 | **1,2-dichloroethylene** | Industrial Chemical | **73** | µg/L |
| VZ3 | **1,2-dichloroethylene** | Industrial Chemical | **73** | µg/L |
| water sample | **iron** | Heavy Metals | **205** | µg/L |
| water sample | **n-Hexane** | Industrial Chemical | **388** | µg/L |
| VZ2 | **Aluminium** | Heavy Metals | **21.7** | µg/L |
| VZ2 | **Chromium (total)** | Heavy Metals | **1.15** | µg/L |
| VZ2 | **chromium VI** | Heavy Metals | **1.06** | µg/L |
| VZ2 | **copper** | Heavy Metals | **0.921** | µg/L |
| VZ2 | **nickel** | Heavy Metals | **17.5** | µg/L |
| VZ2 | **1,1-dichloroethane** | Industrial Chemical | **9.11** | µg/L |
| VZ2 | **1,2-dichloroethylene** | Industrial Chemical | **27.8** | µg/L |
| VZ2 | **1,2-Dichloroethylene** | Industrial Chemical | **18.4** | µg/L |
| VZ2 | **1,2-Dichloroethylene** | Industrial Chemical | **9.39** | µg/L |
| VZ2 | **Nitrites** | Others | **0.13** | mg/L |
| VZ3 | **Aluminium** | Heavy Metals | **15.9** | µg/L |
| VZ3 | **Aluminium** | Heavy Metals | **15.9** | µg/L |
| VZ3 | **Chromium (total)** | Heavy Metals | **1.18** | µg/L |
| VZ3 | **Chromium (total)** | Heavy Metals | **1.18** | µg/L |
| VZ3 | **chromium VI** | Heavy Metals | **0.732** | µg/L |
| VZ3 | **chromium VI** | Heavy Metals | **0.732** | µg/L |
| VZ3 | **copper** | Heavy Metals | **0.44** | µg/L |
| VZ3 | **copper** | Heavy Metals | **0.44** | µg/L |
| VZ3 | **mercury** | Heavy Metals | **0.05** | µg/L |
| VZ3 | **mercury** | Heavy Metals | **0.05** | µg/L |

| SAMPLE | COMPOUND / ELEMENT | CLASS | MEASURED | UNIT |
|---|---|---|---|---|
| VZ3 | **nickel** | Heavy Metals | **15.3** | µg/L |
| VZ3 | **nickel** | Heavy Metals | **15.3** | µg/L |
| VZ3 | **1,1-dichloroethane** | Industrial Chemical | **4.72** | µg/L |
| VZ3 | **1,1-dichloroethane** | Industrial Chemical | **4.72** | µg/L |
| VZ3 | **1,2-Dichloroethylene** | Industrial Chemical | **52** | µg/L |
| VZ3 | **1,2-Dichloroethylene** | Industrial Chemical | **21.3** | µg/L |
| VZ3 | **1,2-Dichloroethylene** | Industrial Chemical | **52** | µg/L |
| VZ3 | **1,2-Dichloroethylene** | Industrial Chemical | **21.3** | µg/L |
| VZ3 | **Nitrites** | Others | **0.08** | mg/L |
| VZ3 | **Nitrites** | Others | **0.08** | mg/L |
| water sample | **Aluminium** | Heavy Metals | **30.4** | µg/L |
| water sample | **arsenic** | Heavy Metals | **2.83** | µg/L |
| water sample | **Chromium (total)** | Heavy Metals | **3.04** | µg/L |
| water sample | **chromium VI** | Heavy Metals | **0.576** | µg/L |
| water sample | **cobalt** | Heavy Metals | **12.6** | µg/L |
| water sample | **copper** | Heavy Metals | **3.79** | µg/L |
| water sample | **nickel** | Heavy Metals | **10.7** | µg/L |
| water sample | **1,2-dichloroethane** | Industrial Chemical | **0.122** | µg/L |
| water sample | **ethylbenzene** | Industrial Chemical | **32** | µg/L |
| water sample | **pyrene** | Industrial Chemical | **0.0207** | µg/L |
| water sample | **vinyl chloride** | Industrial Chemical | **0.121** | µg/L |
| VZ2 | **naphthalene** | Industrial Chemical | **425** | µg/L |
| VZ2 | **sum organohalogen** | Industrial Chemical | **20300** | µg/L |
| VZ2 | **Tetrachloroethylene** | Industrial Chemical | **2.97** | µg/L |
| VZ2 | **total hydrocarbons as hexane** | Industrial Chemical | **34300** | µg/L |
| VZ2 | **Trichloroethylene** | Industrial Chemical | **2.55** | µg/L |
| VZ2 | **Xylene** | Industrial Chemical | **3180** | µg/L |
| VZ2 | **ammonia nitrogen** | Others | **23.9** | mg/L |
| VZ2 | **chlorides** | Others | **448** | mg/L |
| VZ2 | **organic nitrogen** | Others | **9.1** | mg/L |
| VZ2 | **potassium** | Others | **2.23** | mg/L |
| VZ2 | **sulphates** | Others | **23.3** | mg/L |
| VZ2 | **TOC** | Others | **154** | mg/L |
| VZ2 | **total inorganic nitrogen** | Others | **18.6** | mg/L |
| VZ3 | **naphthalene** | Industrial Chemical | **327** | µg/L |

| SAMPLE | COMPOUND / ELEMENT | CLASS | MEASURED | UNIT |
|---|---|---|---|---|
| VZ3 | **naphthalene** | Industrial Chemical | **327** | µg/L |
| VZ3 | **sum organohalogen** | Industrial Chemical | **51100** | µg/L |
| VZ3 | **sum organohalogen** | Industrial Chemical | **51100** | µg/L |
| VZ3 | **Tetrachloroethylene** | Industrial Chemical | **1.66** | µg/L |
| VZ3 | **Tetrachloroethylene** | Industrial Chemical | **1.66** | µg/L |
| VZ3 | **total hydrocarbons as hexane** | Industrial Chemical | **39200** | µg/L |
| VZ3 | **total hydrocarbons as hexane** | Industrial Chemical | **39200** | µg/L |
| VZ3 | **Trichloroethylene** | Industrial Chemical | **2.99** | µg/L |
| VZ3 | **Trichloroethylene** | Industrial Chemical | **2.99** | µg/L |
| VZ3 | **Xylene** | Industrial Chemical | **3880** | µg/L |
| VZ3 | **Xylene** | Industrial Chemical | **3880** | µg/L |
| VZ3 | **ammonia nitrogen** | Others | **16.7** | mg/L |
| VZ3 | **ammonia nitrogen** | Others | **16.7** | mg/L |
| VZ3 | **chlorides** | Others | **200** | mg/L |
| VZ3 | **chlorides** | Others | **200** | mg/L |
| VZ3 | **organic nitrogen** | Others | **3.46** | mg/L |
| VZ3 | **organic nitrogen** | Others | **3.46** | mg/L |
| VZ3 | **potassium** | Others | **1.55** | mg/L |
| VZ3 | **potassium** | Others | **1.55** | mg/L |
| VZ3 | **sulphates** | Others | **0.9** | mg/L |
| VZ3 | **sulphates** | Others | **0.9** | mg/L |
| VZ3 | **TOC** | Others | **119** | mg/L |
| VZ3 | **TOC** | Others | **119** | mg/L |
| VZ3 | **total inorganic nitrogen** | Others | **13** | mg/L |
| VZ3 | **total inorganic nitrogen** | Others | **13** | mg/L |
| water sample | **naphthalene** | Industrial Chemical | **3.7** | µg/L |
| water sample | **sum organohalogen** | Industrial Chemical | **0.243** | µg/L |
| water sample | **Xylene** | Industrial Chemical | **51** | µg/L |
| water sample | **ammonia nitrogen** | Others | **0.89** | mg/L |
| water sample | **chlorides** | Others | **20** | mg/L |
| water sample | **potassium** | Others | **2.3** | mg/L |
| water sample | **sulphates** | Others | **27** | mg/L |
| water sample | **TOC** | Others | **8.7** | mg/L |
| water sample | **total inorganic nitrogen** | Others | **0.69** | mg/L |

## Chemical Assessment Criteria

**Chemical data exceed the limit values**

Exceedances of limit values indicate the presence of chemical risk. The remediation is insufficient or ineffective for the substances concerned. It is recommended to identify the source of contamination, reassess the remediation strategy, and propose additional measures. Exceedances are considered relevant above 0.5 µg/L for water samples and 0.5 mg/kg for soil samples.

# Supportive Methods

Before Remediation

**Locality:** Ferrara, Italy, ER-site

**Bioremediation method:** Before Bioremediation

## Per-sample evaluation

| Sample | Type | Diversity — Shannon (H') | Diversity — Simpson (1−D) | Nitrification | Respiration | Conformity |
|---|---|---|---|---|---|---|
| **VZ1** | Water | — expected: Low | — expected: Low | 8.3% **Within ±20%** Conforming | | Conforming |
| **VZ2** | Water | — expected: Low | — expected: Low | 58.1% **Exceeds ±20% — significant effect on the nitrifying community** Nonconforming | | Nonconforming |
| **VZ3** | Water | — expected: Low | — expected: Low | 56.4% **Exceeds ±20% — significant effect on the nitrifying community** Nonconforming | | Nonconforming |

**Diversity (Shannon / Simpson):** read as a trend across the before / during / after phases (rising = recovery), compared with the expected level per phase. **Respiration:** QR ≤ 0.5 acceptable; above that the AHB count is checked (≥ 1000 CFU/g = not suitable, below = not suitable without microbial augmentation). **Nitrification:** inhibition / stimulation within ±20%.