A sensitive integrated approach to assess sediment quality: application to a low contamination case study (Minho River)

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Introduction

• Sediment quality is crucial for the aquatic ecosystem functioning

• How to assess sediment quality?
  • Chemical parameters
  • Responses of organisms to contaminants
  • Use of ecotoxicological assays

• This approach has been mainly used in contaminated sediments

Do ecotoxicological assays respond to low contaminated systems? Are ecotoxicological assays more sensitive than chemical parameters to assess sediment quality?
Twenty two surface sediment samples collected along the Minho River estuary
Analytical methods: Trace elements

**Samples**
- Sediment samples were dried
- Grounded in agata mortar
- Digested with different acids

**Chemical analysis**
- Determination by ICP-MS:
  - Al, As, Cd, Co, Cr, Cu, Ni, Pb and Zn
- Determination by thermal decomposition AAS:
  - Hg
Analytical methods: ecotoxicological assays

Microtox assay with bacteria - *Vibrio fischeri* (decomposer)

- 15 minutes exposure to evaluate bioluminescence inhibition

Mortality and growth endpoints with ostracods - *Heterocypris incongruens* (primary consumer)

- 72 hours exposure to evaluate mortality and growth inhibition
Analytical methods: ecotoxicological assays

Growth inhibition with green microalgae – *Pseudokirchneriella subcapitata* (primary producer)

- 72 hours exposure to evaluate growth inhibition

Embryonic development with fish – *Danio rerio* (secondary producer)

- 96 hours exposure to evaluate embryonic development (heart beats/10 s) and mortality
Sediment Quality is influenced by

- Grainsize
- Lithology
- Anthropogenic pressures
Results: Grain-size composition

Variability of grain-size distribution along 4 Water Bodies (WBs) of Minho Estuary (Al used as proxy)

Sediment composition normalized to Al (minimize grain-size variation)
Results: Metal/Al ratios – lithology or pressures?

Median Cd/Al ratios higher in WB3 and WB4

Similar Pb/Al ratios along the estuary

No evidence of Anthropogenic pressures

Anthropogenic pressures
Results: Metal/Al ratios – lithology or pressures?

Enhanced Hg/Al ratios in WB4

KW-H(3,16) = 8.0, p = 0.047

Anthropogenic pressures

Higher median As/Al ratios in WB2, 3 and 4

KW-H(3,22) = 5.3, p = 0.15

Lithology
Results: Comparison of metal concentrations with SQGs

Comparison of 90th percentile

<table>
<thead>
<tr>
<th>Benchmarks (90th percentile)</th>
<th>As</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Hg</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
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<tbody>
<tr>
<td></td>
<td>(µg g⁻¹)</td>
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<td>(ng g⁻¹)</td>
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<td>ERL</td>
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<td>1.2</td>
<td>81</td>
<td>34</td>
<td>0.15</td>
<td>21</td>
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<td>270</td>
<td>0.71</td>
<td>52</td>
<td>218</td>
<td>410</td>
<td>0.18</td>
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</tbody>
</table>

ERL - Effects Range-Low; ERM - Effects Range-Median

Above the guideline values: As (all WBs), Ni (WB4)
Results: bioluminescence inhibition (*Vibrio fischeri*)

- No significant effects were observed for the bioluminescence production of the bacteria *Vibrio fischeri* after exposure to sediments.
Results: Growth inhibition and mortality (*Heterocypris incongruens*)

Mortality higher
Higher growth inhibition and mortality in the WB4
TMS4 - 70%
TMS8 - 37%

Are organisms responding to enhancement of metal availability?
e.g., Cd and Hg
Results: Growth rate *Pseudokirchneriella subcapitata*

Comparison to control: lower growth rates in samples from WB3 and WB4

Is growth rate affected by metal(s) present in the sediment?
Results: Embryonic development *Danio rerio* (heart beat, mortality)

Comparation to control: Lower heart beat was observed in all WBs

Mortality was observed in all WBs
Results: Embryonic development *Danio rerio*

High effects on embryonic development and mortality in all WBs

Are organisms responding to metal(s) present in the sediment?

KW-H(3,22) = 5.5, p = 0.13
Final remarks

- Low metal concentrations in sediments (except As)
- No responses were observed for the bioluminescence production of the bacteria
- High growth inhibition and mortality found for the ostracods in WB4
- Lower growth rates in WB3 and WB4 in green microalgae
- Effects on heart beat and mortality of fish (larvae) in all WBs

Minho estuary

Vibrio fischeri

Heterocypris incongruens

Pseudokirchneriella subcapitata

Danio rerio

Low impacted system

Presumably, organisms respond to the presence of contaminants

Natural system
Synergetic relations
Other contaminants

Important to use ecotoxicological indicators as a complement of chemical indicators to assess sediment quality
Thank you