Efficacy of recent remediation measures in a protected coastal lagoon (Paramos, Portugal): toxicity of surface versus subsurface sediments

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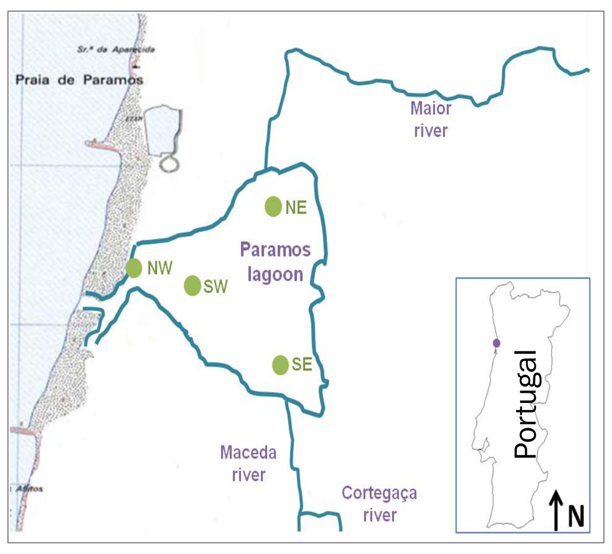
Introduction & Objective

Wetlands are considered among the richest ecosystems concerning biodiversity and primary productivity, being responsible for many processes such as production of biomass, water replacement, retention of nutrients and sediment, and control of floods. As a result, they help to maintain water quality and provide various ecosystem services. However, wetlands (namely coastal lagoons) are vulnerable ecosystems facing various threats. This is related with the fact that coastal areas are among the most developed regions supporting large urban and industrial areas, leading to the deterioration of these ecosystems that may last for many years. To mitigate the adverse effects caused by such contamination, several remediation projects have been implemented in these ecosystems. However, in many cases, knowledge on the efficacy of remediation measures is scarce or even inexistent

OBJECTIVE: to assess the efficacy of the remediation measures already implemented in the Paramos lagoon (coastal lagoon), by comparing the toxicity of surface versus subsurface sediments, as depth profiles in sediments provide information about the temporal contaminant inputs.

Material & Methods

Study site



Paramos lagoon:

❖ Long-term contamination: domestic sewage; effluents from agricultural and industrial activities (latter, leader, wood, textile, painting, metallurgic).

❖ Remediation actions: management of a connection channel between the lagoon and the sea; implementation of a treatment centre for domestic wastes.

❖ Four sampling sites were selected within the wet area of the lagoon: NW, NE, SW and SE.

Environmental samples

Water samples

• Surface water samples: 5 cm depth

• Filtered through 0.20µm for chemical analysis

Sediment samples

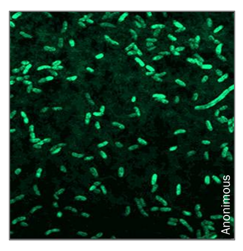
• Composite sediment cores:
- Surface sediment-**S**: 5 cm
- Subsurface sediment-**ID**: 15 cm

• Sediment physical determinations

Solid-phase toxicity assays

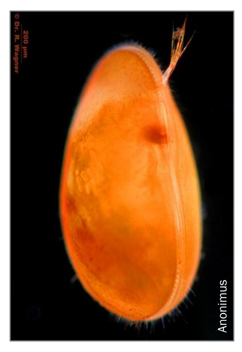
Laboratory solid-phase ecotoxicity assays

❖ Solid-phase toxicity assays were carried out with a battery of species, representative of different taxonomic groups, trophic levels and key ecosystem functions:



Vibrio fischeri **(Bacteria; decomposer)**
30-min solid-phase luminescence inhibition assay (Azur, 1998)
Exposure to 100% of S and ID sediments.

Pseudokirchneriella subcapitata **(Algae; primary producer)**
72-h growth inhibition assay (OECD, 2006)
Exposure to 100% of S and ID sediment and 100% water sample (filtered).



Heterocypris incongruens **(Crustacean; epibenthic omnivorous)**
6-d growth inhibition assay (Creasel, 2001)
Exposure to 100% of S and ID sediment

Chironomus riparius **(Insecta; benthic deposit feeder)**
10-d growth inhibition assay (OECD, 2004; EC, 1997)
2-d feeding inhibition assay
Exposure to 100% of S and ID sediment and 100% water sample.

Results

Physico-chemical parameters

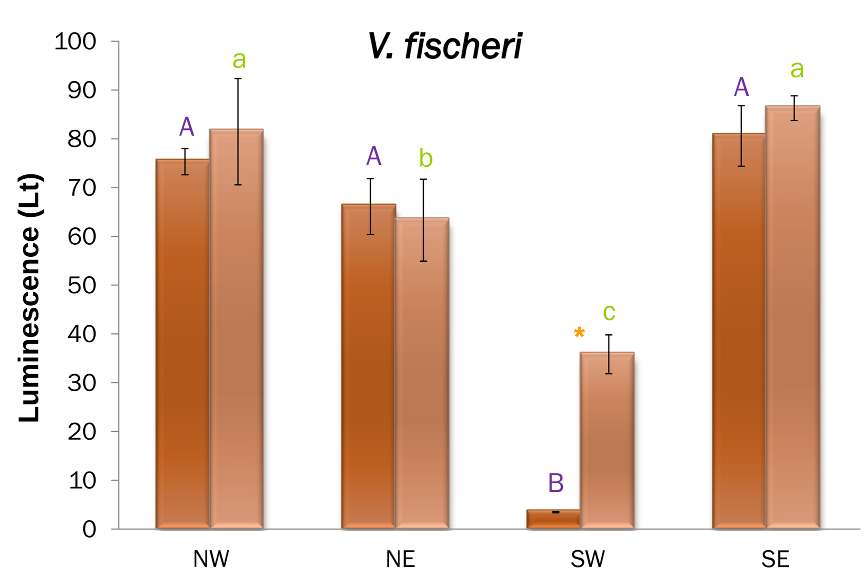
WATER SAMPLES	NW	NE	SW	SE
pH	7.40	7.20	7.49	7.34
Salinity	0.5	0.1	0.5	0.0
Conductivity (µS/cm)	**1460**	686	**1431**	334
Dissolved oxygen (mg/L)	5.2	**1.8**	7.2	8.7
Hardness (mg CaCO3/L)	142	145	182	**104**
NO^{2-} (mg/L)	< 0.1	< 0.1	< 0.1	**0.44**
NO^{3-} (mg/L)	0.08	0.07	2.00	**7.32**
NH_4^+ (mg/L)	< 0.05	< 0.05	< 0.05	**1.30**
PO_4^{3-} (mg/L)	0.037	0.043	< 0.03	**0.63**

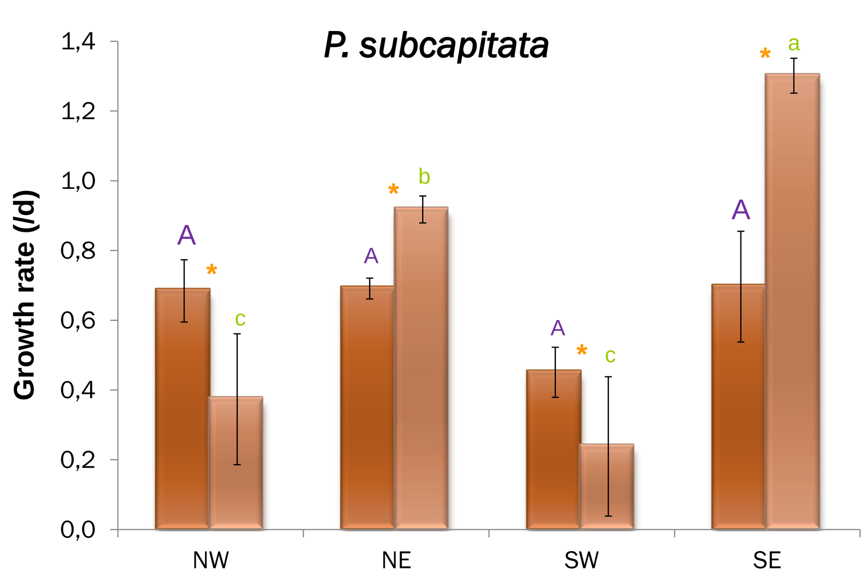
SEDIMENT SAMPLES	NW		NE		SW		SE	
	S	ID	S	ID	S	ID	S	ID
Organic matter	0.25	0.53	**12.3**	1.16	7.74	0.67	8.11	0.55
Particle size (µm)								
> 2000	0.14	0.00	**9.22**	**23.3**	0.00	0.12	11.3	7.11
1000 – 2000	0.08	0.19	**33.4**	**34.0**	0.13	0.42	12.7	11.5
500 – 1000	8.19	16.7	39.7	27.8	13.2	15.4	27.3	27.3
250 – 500	84.1	74.4	16.5	12.9	73.2	75.1	46.1	50.2
125 – 250	7.12	7.39	0.70	1.28	8.30	5.45	2.05	3.53
63 – 125	0.21	0.79	0.24	0.29	1.91	1.14	0.23	0.15
< 63	0.20	0.50	0.21	0.42	3.18	2.37	0.34	0.17

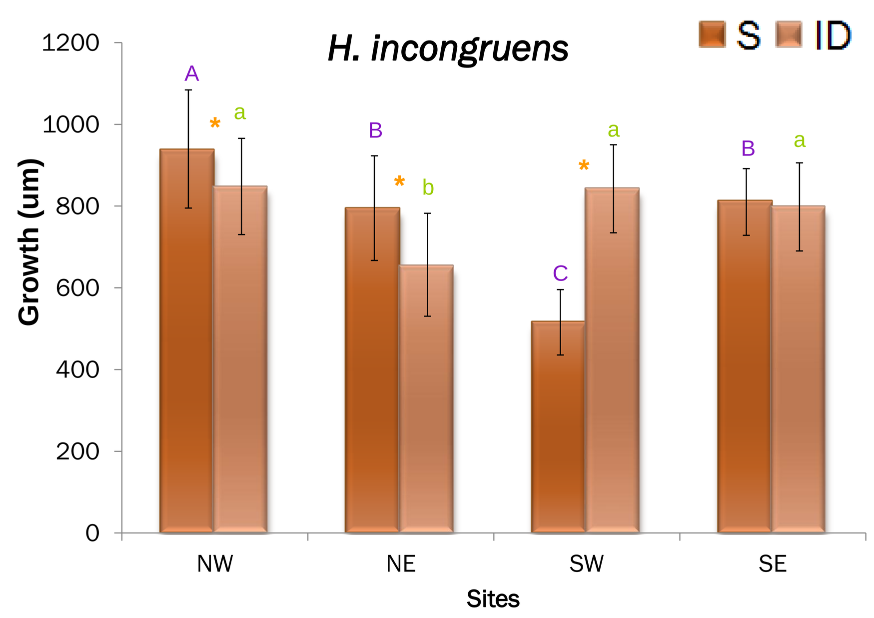
❖ pH, salinity and hardness of water samples were similar among the four sites.
❖ NW and SW exhibited the highest conductivity levels, NE the lowest dissolved oxygen values (< 2mg/L), and SE the highest nutrients values.

❖ Organic matter was the highest in S sediments of NE.
❖ At NW, SW, and SE >50% of S and ID sediment was composed of medium sand and >75% of medium coarse and sand.
❖ NE had the highest value of very coarse sand (>30%) and gravel (>9%).

Remediation efficacy – toxicity assays



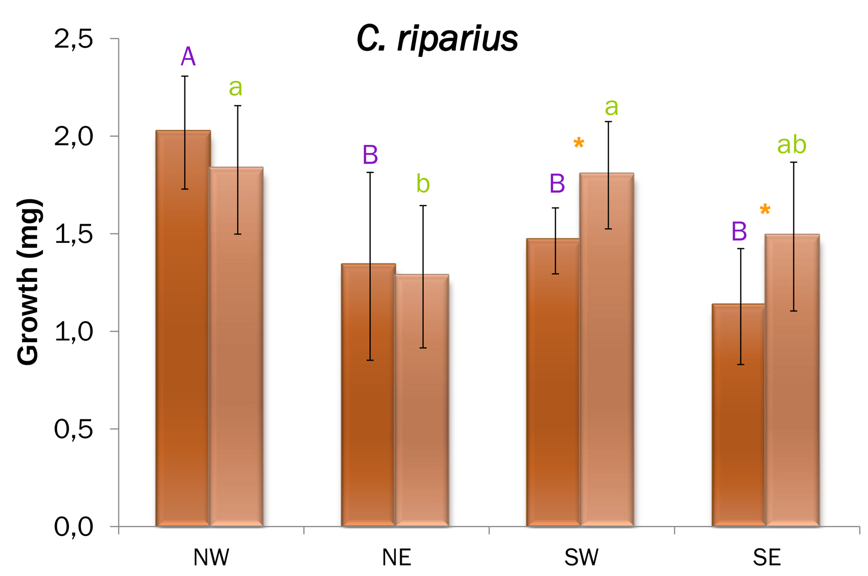


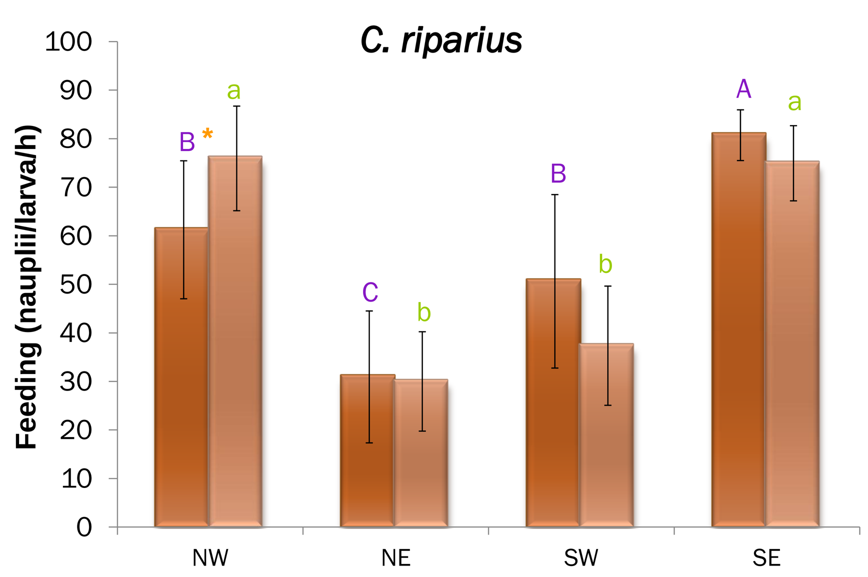


A - capital letters mean significant differences within S sediments
a - small letters for significant differences between ID sediments
* - asterisks denote significant differences between S and ID sediments within each site

❖ **Bacteria luminescence** significantly decreased at SW site, being lower in S than in ID sediments (P<0.001)

❖ **Algal growth** was lower at NW and SW than at NE ID sediments. At sites NW and SW algae grew less in ID than in S sediments. (P<0.001)





❖ In *H. incongruens* exposed to SW -S sediments 74% of mortality was registered.
❖ *H. incongruens* growth was higher at NW for S sediments, and at NW, SW, SE for ID sediments. Growth was higher at S than at ID sediment in NW and NE. (P<0.001)

❖ *C. riparius* growth was higher at NW for S sediments, and at NW, SW, NE for ID sediments. Growth was higher at ID than at S for SW and SE. (P<0.05)
❖ *C. riparius* postexposure feeding was lower at NE for S sediments, and NE and SW for ID sediments. Postexposure feeding was lower at S than at ID in NW. (P<0.001)

Conclusion

✓ Results obtained suggest that further interventions should take place at the Paramos lagoon in order to remediate this ecosystem: though though in general organisms performed better in surface sediments (except the bacteria and ostracod at SW) significant adverse effects in the biota were observed across sites, mainly at NE and SW.

✓ Differences in sensitivity to chemical contamination was observed among the tested species, thus, revealing that a battery of assays is an important approach for impacted environments where industrial and domestic contamination is observed providing information with ecological realism.

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