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The role of coastland wetlands as environmental buffers: comparison of phosphorus retention capacity between hydro-sedimentary environments

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Introduction

Since the middle of the twentieth century, human societies have fourfold the environmental flow of phosphorus –P, dramatically impairing freshwater and coastal marine ecosystems (Lane and Autrey, 2017).

Coastal wetlands are ecosystem services providers performing as environmental buffers retaining nutrients and pollutants delivered from upstream parts of river systems. This buffering effect avoids the conveyance of these pollutants and excess of nutrients to the marine environment preventing eutrophication of coastal marine ecosystems.

Aims

To assess total, organic and inorganic P concentrations within s'Albufera wetland, Mallorca, Spain

To quantificate sediment accretion rates by the use of ^{137}Cs measurements within s'Albufera wetland

Study area

S'Albufera, with an extension of 1,708 ha, is the main wetland of Mallorca (Spain) and is protected by the Ramsar list of wetlands of international importance.

Since the middle of the nineteenth century, it is an artificial system, in which waters are forced to take the shortest route to the sea (Lopez et al., 1996). In addition to anthropic effects resulting from the construction of artificial channels, since the 1960s, s'Albufera wetland has been suffering a very high urban pressure around it due to increasing tourism.

Nowadays, s'Albufera receives an excess of nutrients upcoming from the large amount of fertilizers used by the intensive agriculture present in the surroundings of the wetland. Likewise, pollutants and wastewater are also dumped to s'Albufera.

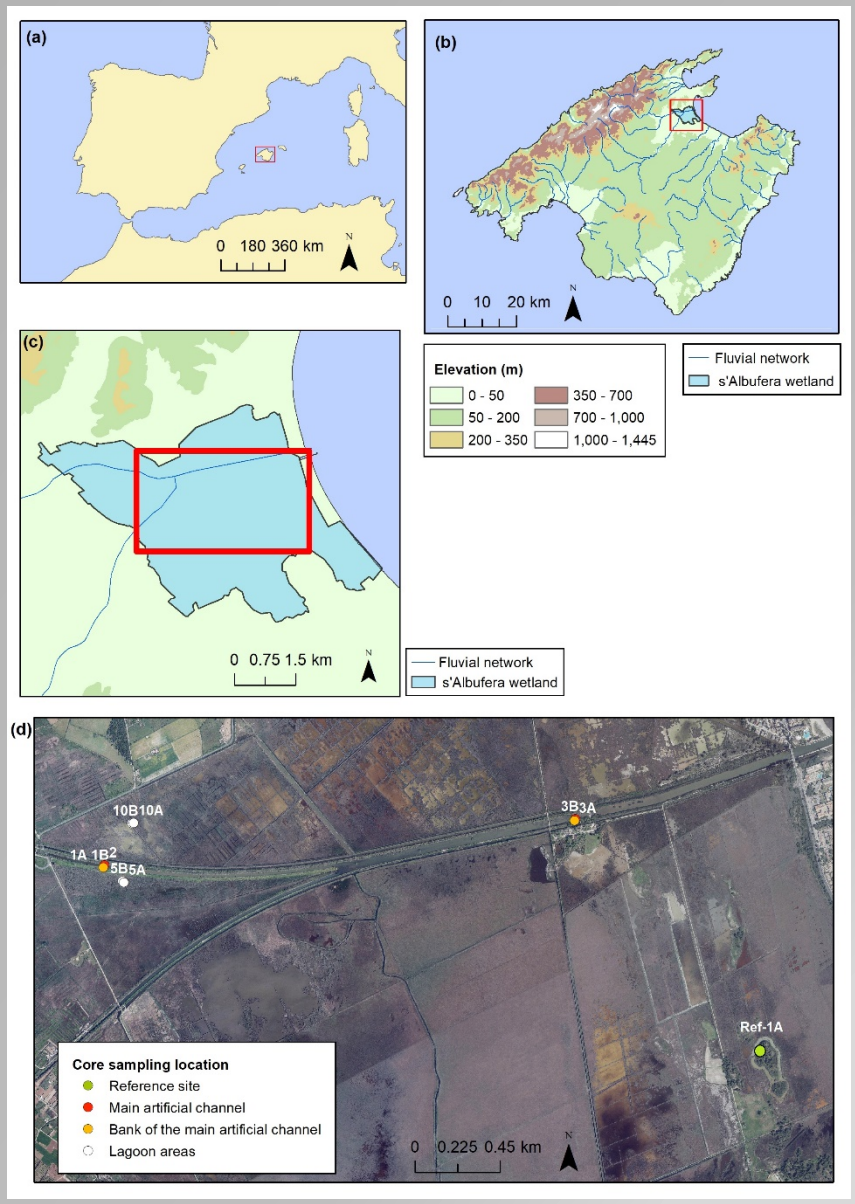

Figure 1. (a) Location of the Mallorca Island within the Mediterranean Sea. **(b)** Map of the Mallorca Island, showing the location of s'Albufera wetland. **(c)** Map of the s'Albufera wetland, showing the area where the sediment cores were sampled. **(d)** Orthophoto of s'Albufera wetland where the cores sampling were collected in contrasting hydro-sedimentary environments.

Methods – Sediment cores sampling

Two cores at the middle of the main artificial channel

One core at the bank of the main channel and two cores within the lagoon areas

Extracted using a PVC-tube (internal diameter 5.5 cm) with a mechanical percussion driver

Stored at -20°C before pre-treatment

Methods – Sediment cores pre-treatment

Slides of sediment cores were regularly sectioned at 5-cm intervals

A small sediment sub-sample (i.e. 5 g) was separated with a sterile centrifuge tube for each interval and stored at -20°C to estimate P concentration

Sediment 5-cm slides were dried at 70°C, manually disaggregated and sieved through a 2-mm mesh and finally integrated with the replicate samples.

Methods – ^{137}Cs measurements

^{137}Cs activity was measured by gamma spectrometry using a high-purity coaxial intrinsic germanium detector.

Methods – P concentration analysis

Sediment samples were dried at 60°C and manually disaggregated. For every 5-cm interval 6 replicates of 0.3-0.5 g were weighted. Half of the replicates were used to assess total P and the other half to assess inorganic P. The method described in Aspila et al. (1976) for P extraction from sediment samples was followed.

P concentration determination was made by spectrophotometric analysis by the method of Murphy and Riley (1962) with a calibration curve with 6 known P concentrations.

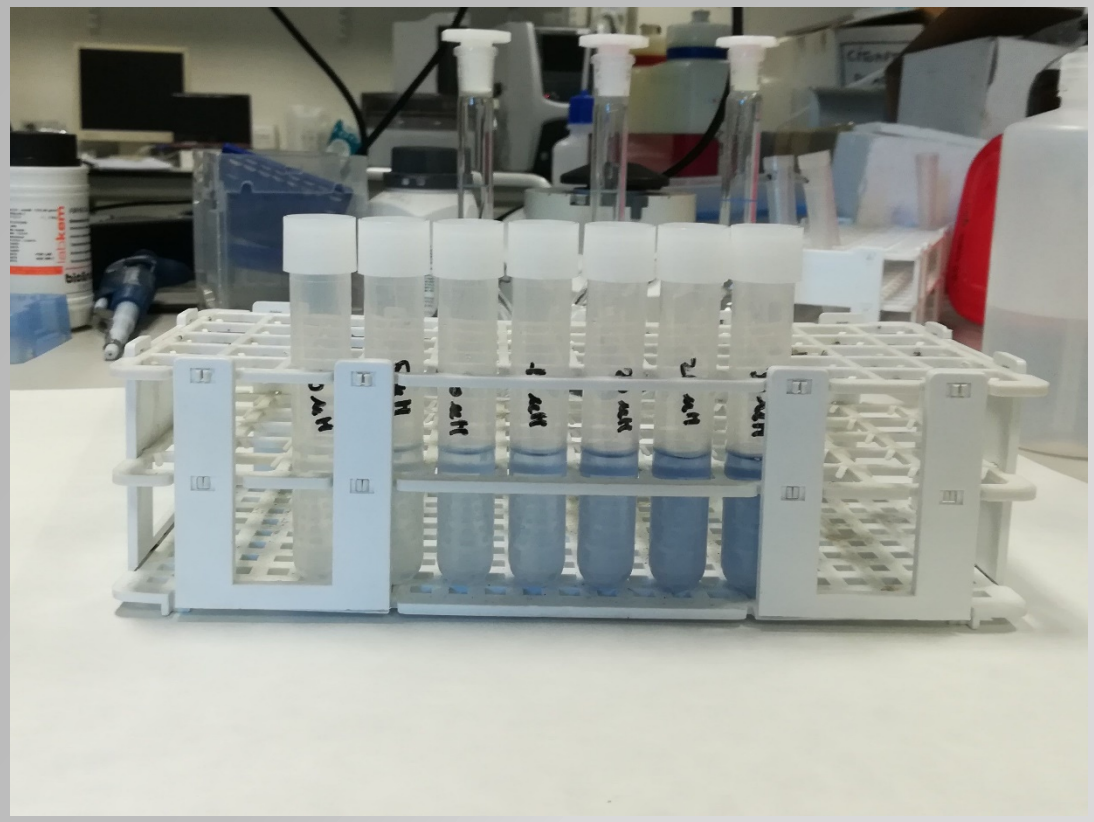

Figure 2. Dilutions with 6 different known P concentrations to carry out the calibration curve prior to sample analysis.

Results - ^{137}Cs inventories

For sediment core 1, sampled at the bank of the main artificial channel, no ^{137}Cs activity was detected.

For sediment cores 2 and 3, sampled at the main artificial channel, 69.81 Bq m^{-2} and no ^{137}Cs activity were measured, respectively.

For sediment cores 5 and 10, sampled at lagoon areas, 3915.84 Bq m^{-2} and 2104.7 Bq m^{-2} ^{137}Cs inventories were measured, respectively.

For sediment core Ref-1, sampled at the reference site, 885.51 Bq m^{-2} ^{137}Cs inventory was measured.

Table 1. Sediment cores ^{137}Cs inventories.

Location	Sediment core	^{137}Cs inventory (Bq m^{-2})
Bank of the main artificial channel	1	Undetectable
Main artificial channel	2	69.81
	3	Undetectable
Lagoon areas	5	3915.84
	10	2104.7
Reference site	Ref-1	885.51

Results – Bank of the main artificial channel

Mean total P concentration was 0.037 mg P g^{-1} sediment. However, statistically significant differences between replicates were found in total P concentrations (Wilcoxon signed-rank test, p-value < 0.05).

Mean inorganic P concentration was 0.018 mg P g^{-1} sediment.

Mean organic P concentration was 0.019 mg P g^{-1} sediment.

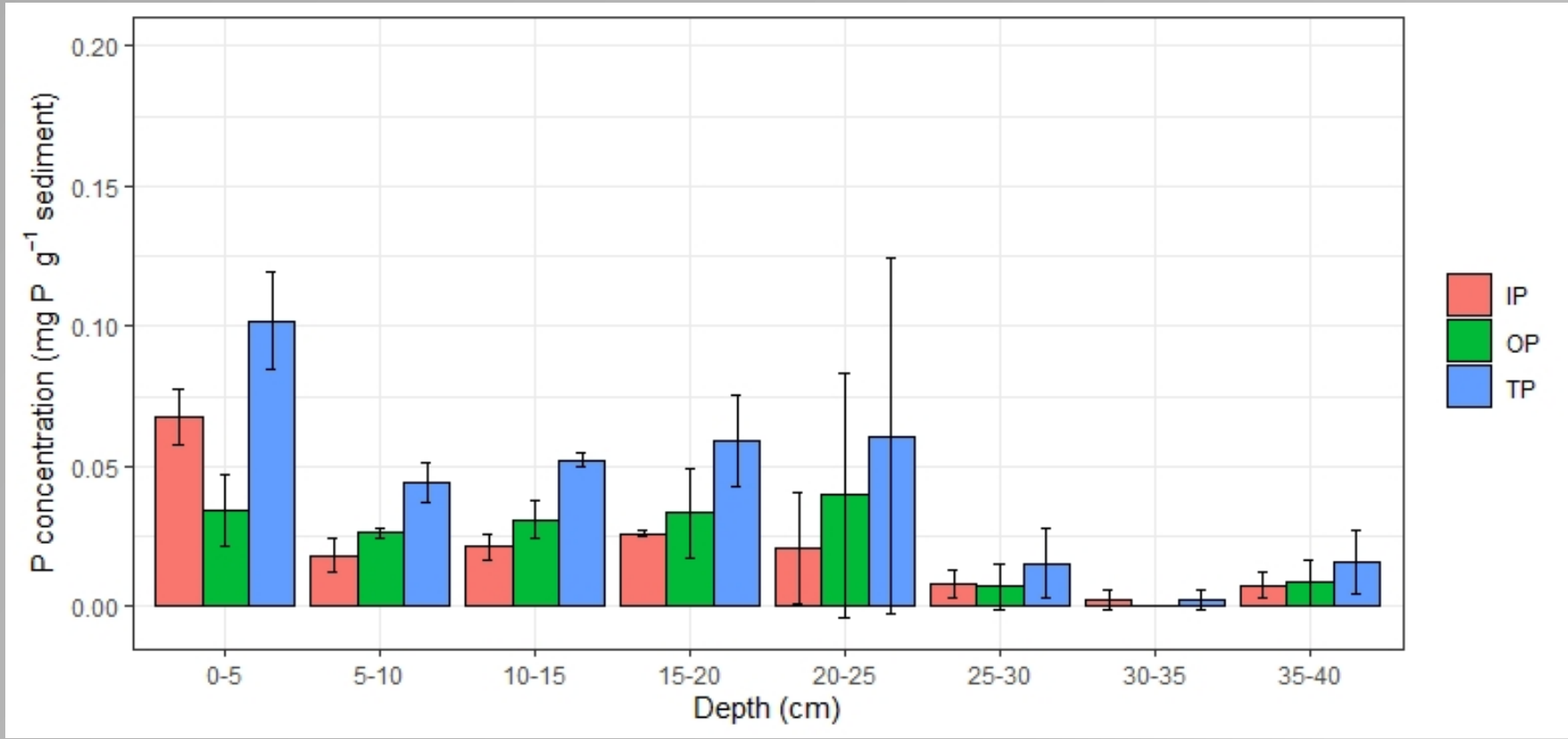

Figure 3. Mean total P, inorganic P and organic P concentrations with their respective standard deviations for each 5-cm interval of sediment cores 1 and 3A, located at the bank of the main artificial channel.

Results – Main artificial channel

Mean total P concentration was 0.03 mg P g^{-1} sediment.

Mean inorganic P concentration was 0.014 mg P g^{-1} sediment.

Mean organic P concentration was 0.016 mg P g^{-1} sediment.

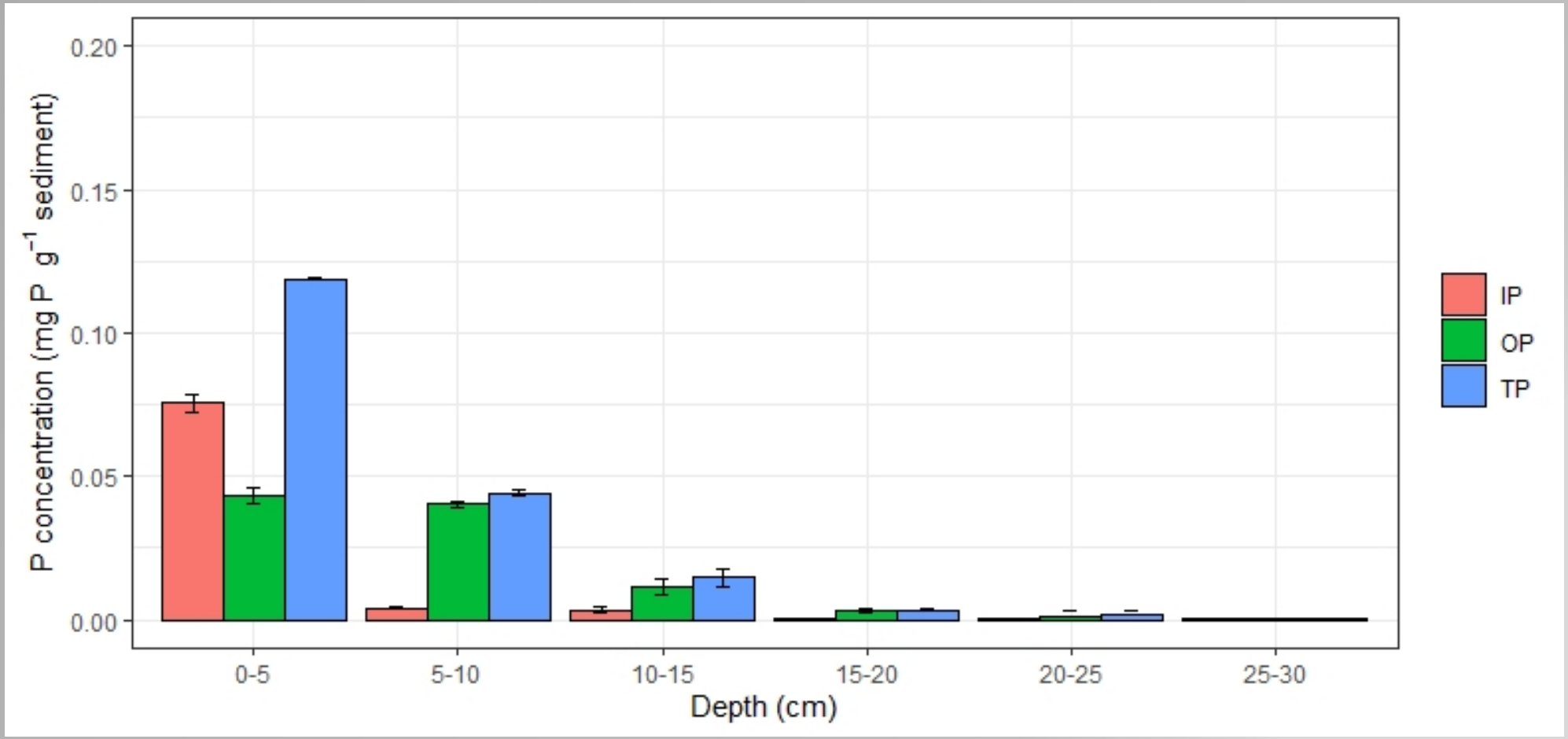

Figure 4. Mean total P, inorganic P and organic P concentrations with their respective standard deviations for each 5-cm interval of sediment cores 2 and 3B, located at the main artificial channel.

Results – Lagoon areas

Mean total P concentration was 0.082 mg P g^{-1} sediment. No statistically significant differences were found in total P concentration between replicates (Wilcoxon signed-rank test, p-value > 0.05).

Mean inorganic P concentration was 0.043 mg P g^{-1} sediment.

Mean organic P concentration was 0.039 mg P g^{-1} sediment.

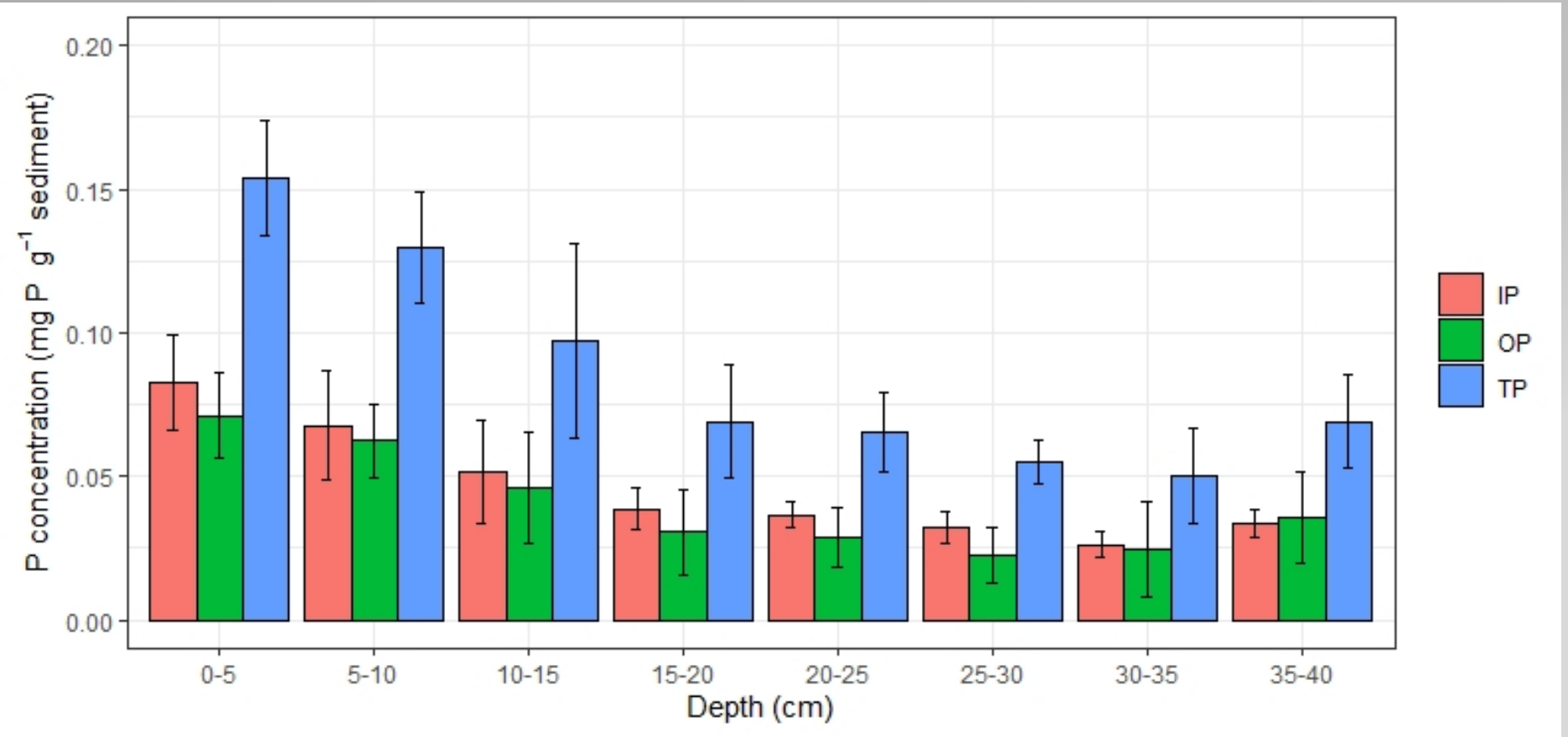

Figure 5. Mean total P, inorganic P and organic P concentrations with their respective standard deviations for each 5-cm interval of sediment cores 5 and 10, located at lagoon areas.

Results – Total P concentration

Total P concentrations are higher in lagoon areas than in the main artificial channel and the bank of the main artificial channel.

Statistically significant differences existed between total P concentrations in lagoon areas and the main artificial channel (one-way ANOVA, p-value < 0.05) and the bank of the main artificial channel (one-way ANOVA, p-value < 0.05).

On the other hand, no statistically significant differences were found between total P concentrations in the main artificial channel and the bank of the main artificial channel (one-way ANOVA, p-value < 0.05).

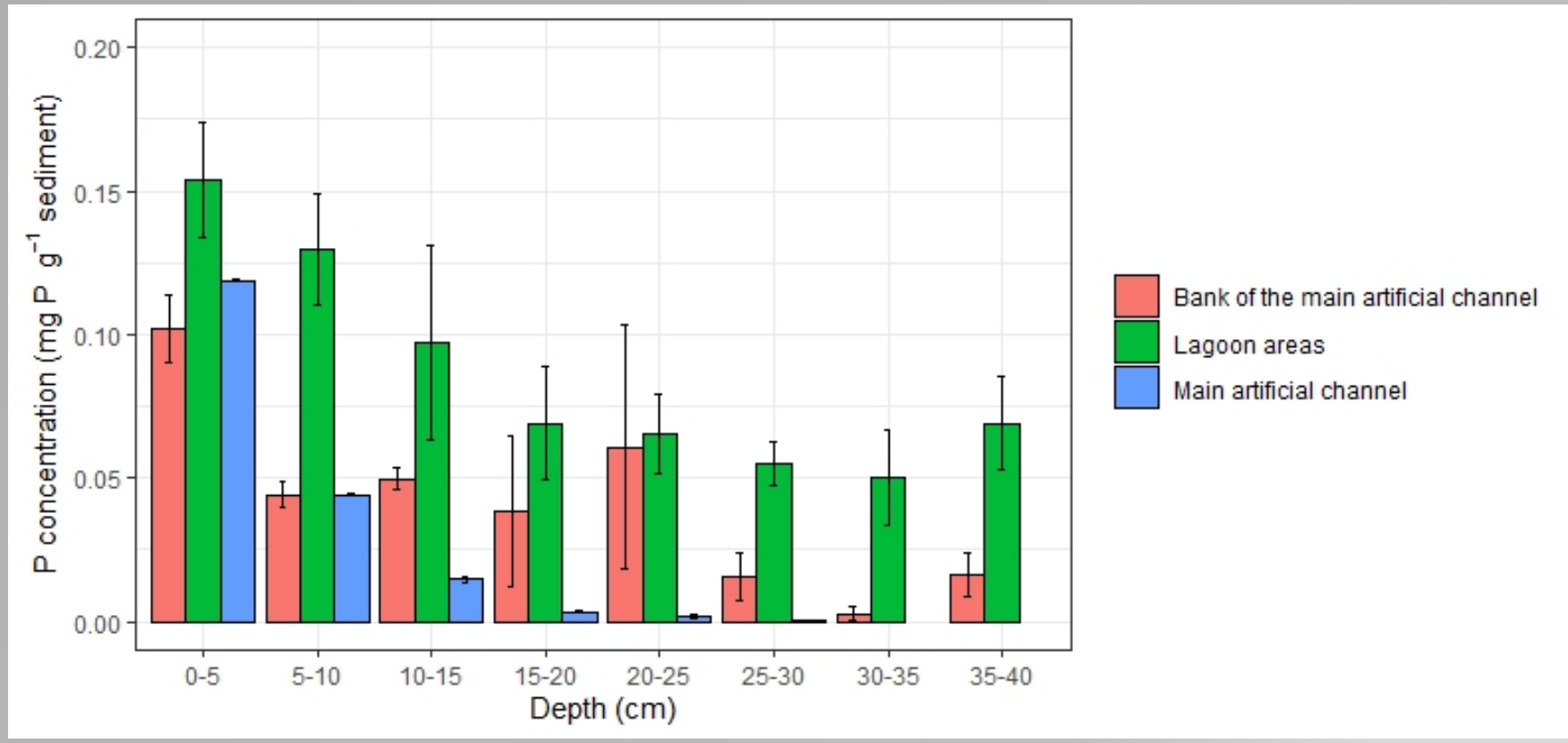

Figure 6. Mean total P concentrations with their respective standard deviations for each 5-cm interval of sediment cores 5 and 10, located at lagoon areas.

Table 2. p-values for each one-way ANOVA test performed between mean total P concentrations for sediment cores sampled at the different locations.

Location	Location	p-value
Lagoon areas	Main artificial channel	<0.05*
Lagoon areas	Bank of the main artificial channel	<0.05*
Bank of the main artificial channel	Main artificial channel	0.9955

Conclusions

The main artificial channel and the bank of the main artificial channel are locations suffering of erosional processes as no ^{137}Cs activity or minimal inventories were detected. Lagoon areas can be considered as depositional sites as their ^{137}Cs inventories were higher than reference site ones.

P retention capacity and, in consequence, P concentration is higher in lagoon areas than in the main artificial channel and the bank of the main artificial channel. This is correlated with the ^{137}Cs inventories results, showing higher P retention capacity at depositional sites and lower P retention capacity at erodible sites.

These results elucidate that the maintenance of s'Albufera coastal wetland is crucial to ensure its optimal functioning as environmental buffer and avoid eutrophication in Alcudia Bay coastal waters.

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DIRECCIÓ GENERAL POLÍTICA UNIVERSITÀRIA I RECERCA

Acció especial de recerca i desenvolupament AAEE100/2017 "Determinació del balanç de nutrients al sistema fluvio-costaner del torrent de Sant Miquel i s'Albufera de Mallorca"

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formació i ocupació

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