

References & Extras

Influence of Road Salt on the Mobilization of Bioreactive Elements in Regenerative Stormwater Conveyance (RSC) Systems

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Introduction

- Road salts can induce accelerated ion exchange, which has the potential to mobilize contaminants to drinking water supplies
- RSCs may be successful at primarily mitigating stormflow, but little is known how road salts affect water quality in their step pools.
- **How do road salts affect restoration?**
- Compare the influence of different salt ions on mobilizing other base cations
- RSC sediments should have a greater mobilization potential compared to other urban streams due to greater contaminant loading as a result of longer water residence times in the step pools
- Laboratory experiments can reveal responses of bioreactive elements to road salts in sediments

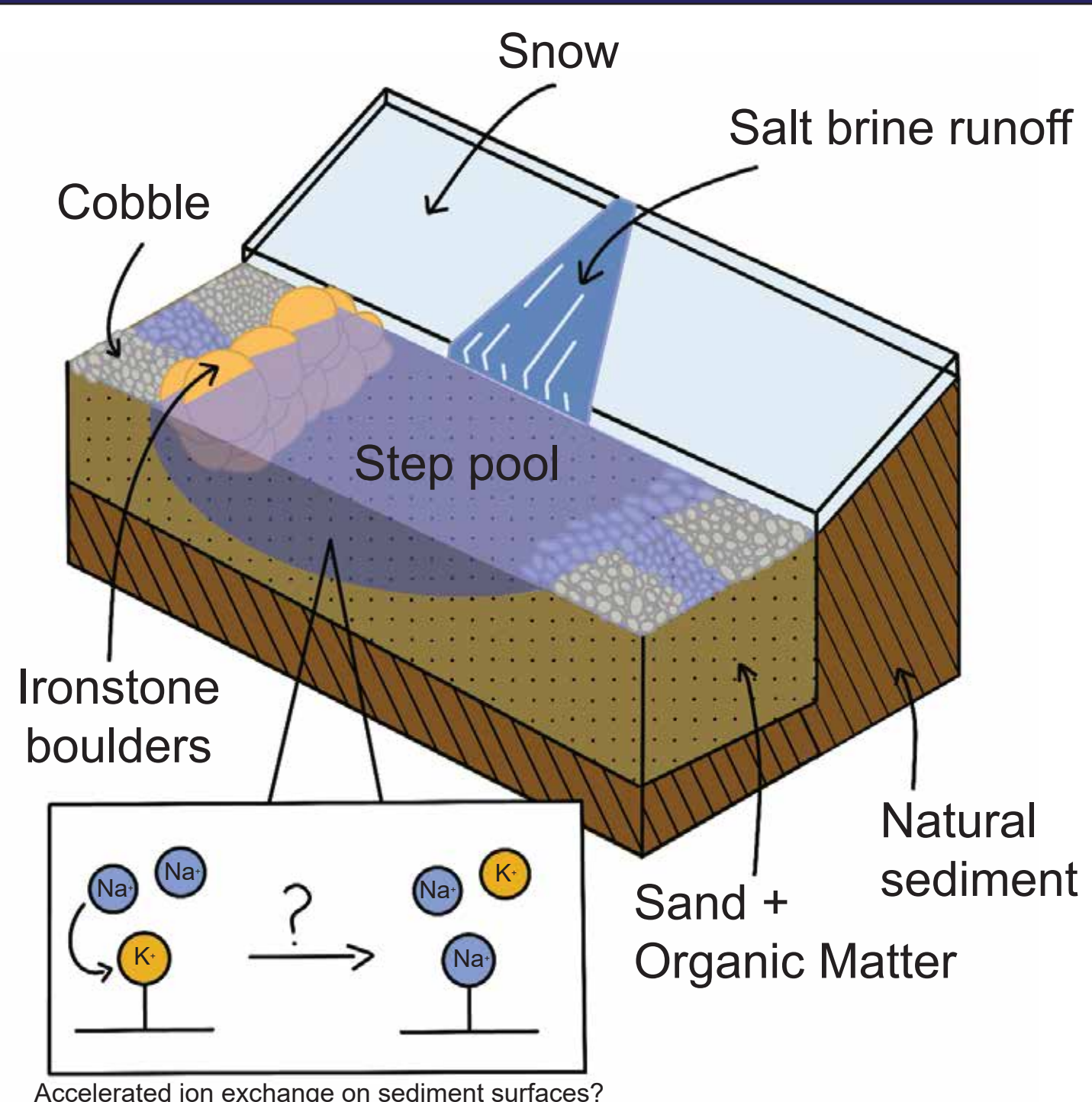


Fig. 1: Typical structure of an RSC step pool and possible mechanism for ion exchange during a deicing event.

Study Site & Methodology

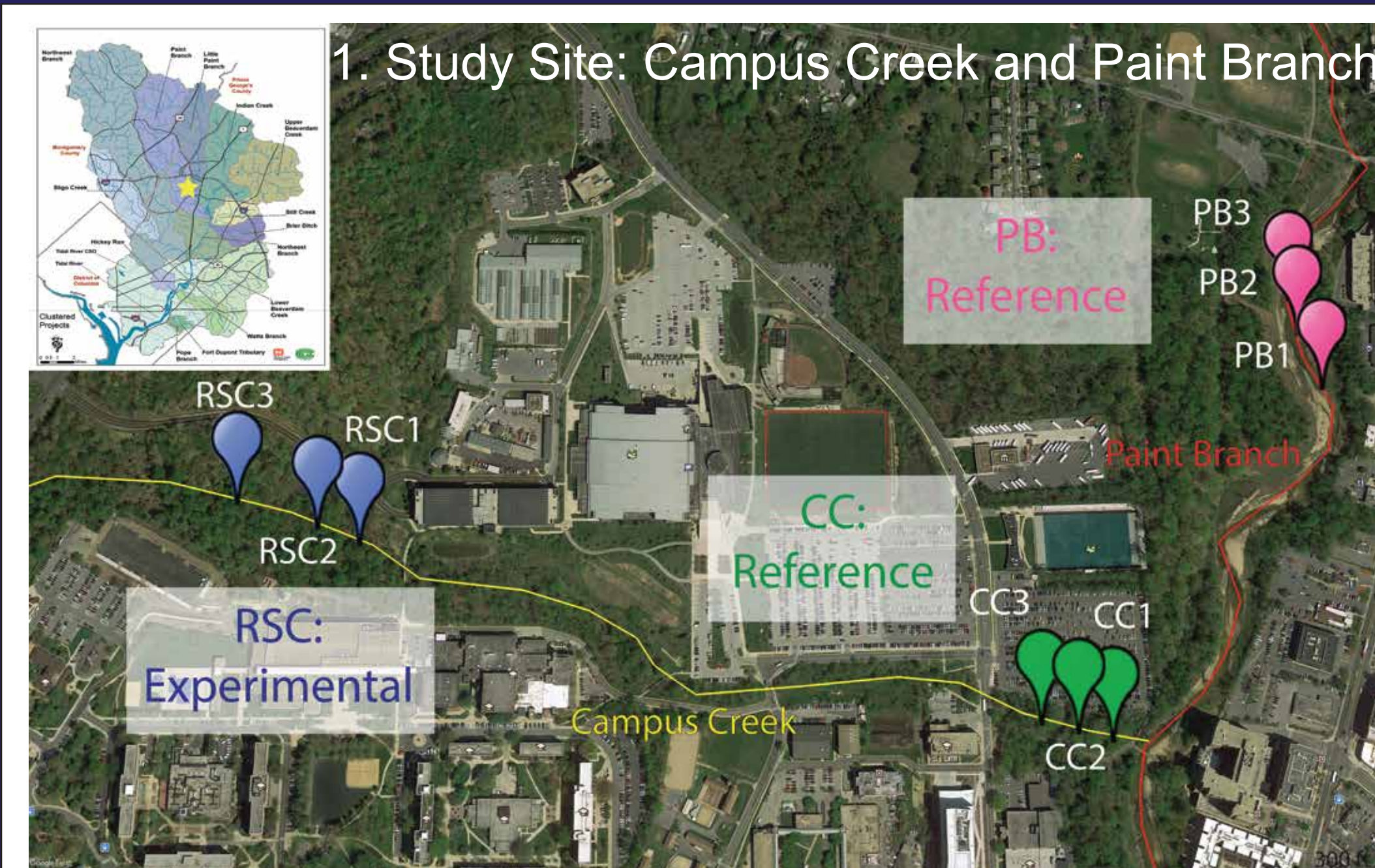
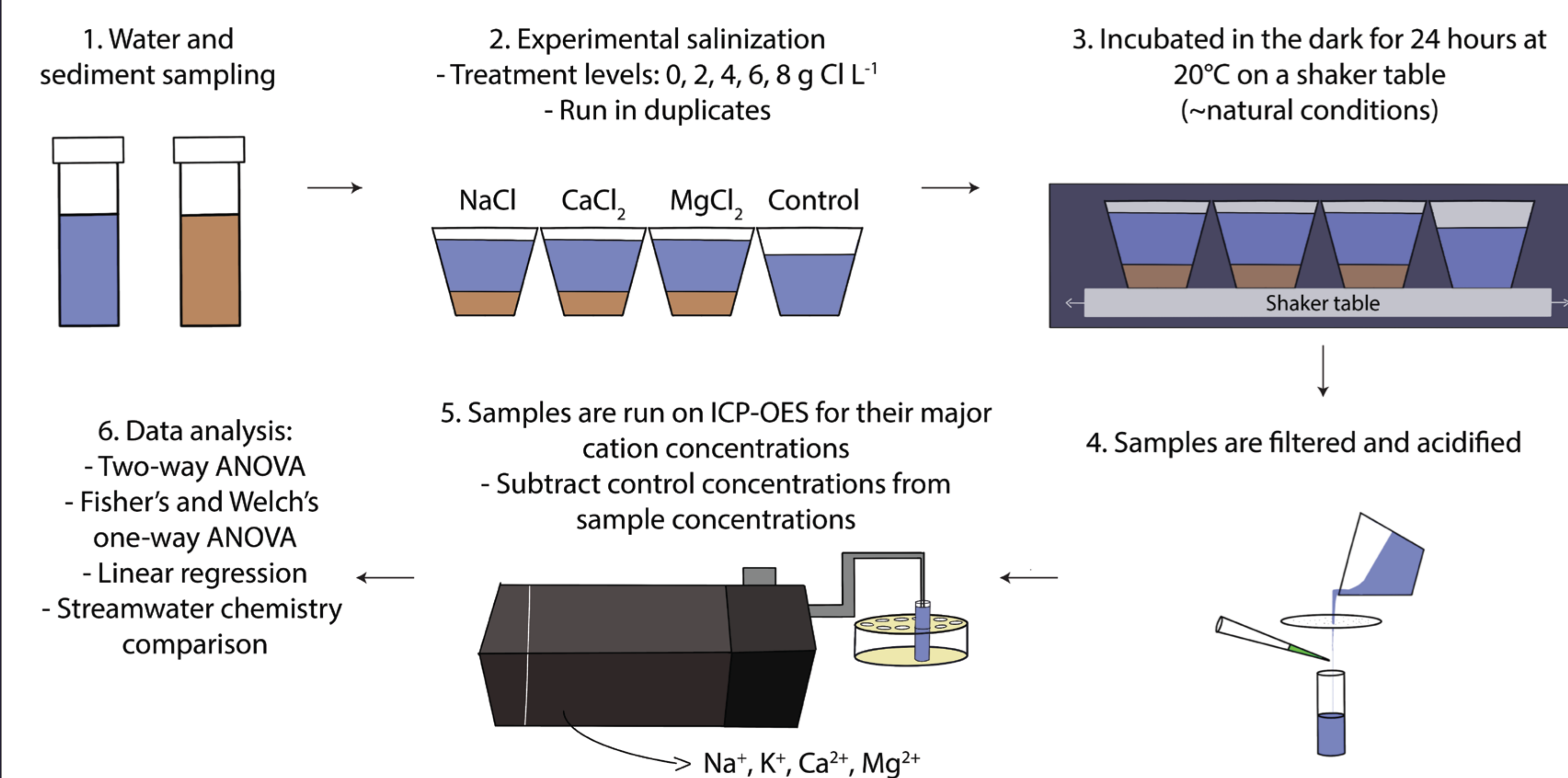


Fig. 2: Map of study watershed. Study locations are located along the Northeast Branch of the Anacostia watershed. One reference site is located along Paint Branch (PB) near the University of Maryland, College Park campus. The other reference site is located along Campus Creek (CC) near the confluence with PB. The experimental RSC site is located around 200m upstream of CC.

2. Overarching questions:

- How do different road salt ions affect mean base cation mobilization potentials from restored streams?
- What is the relationship between salt ion concentrations and mobilization potential?

3. Methodology:



1. Experimental salinization with NaCl shows evidence for retention of Na⁺ and mobilization of other major base cations

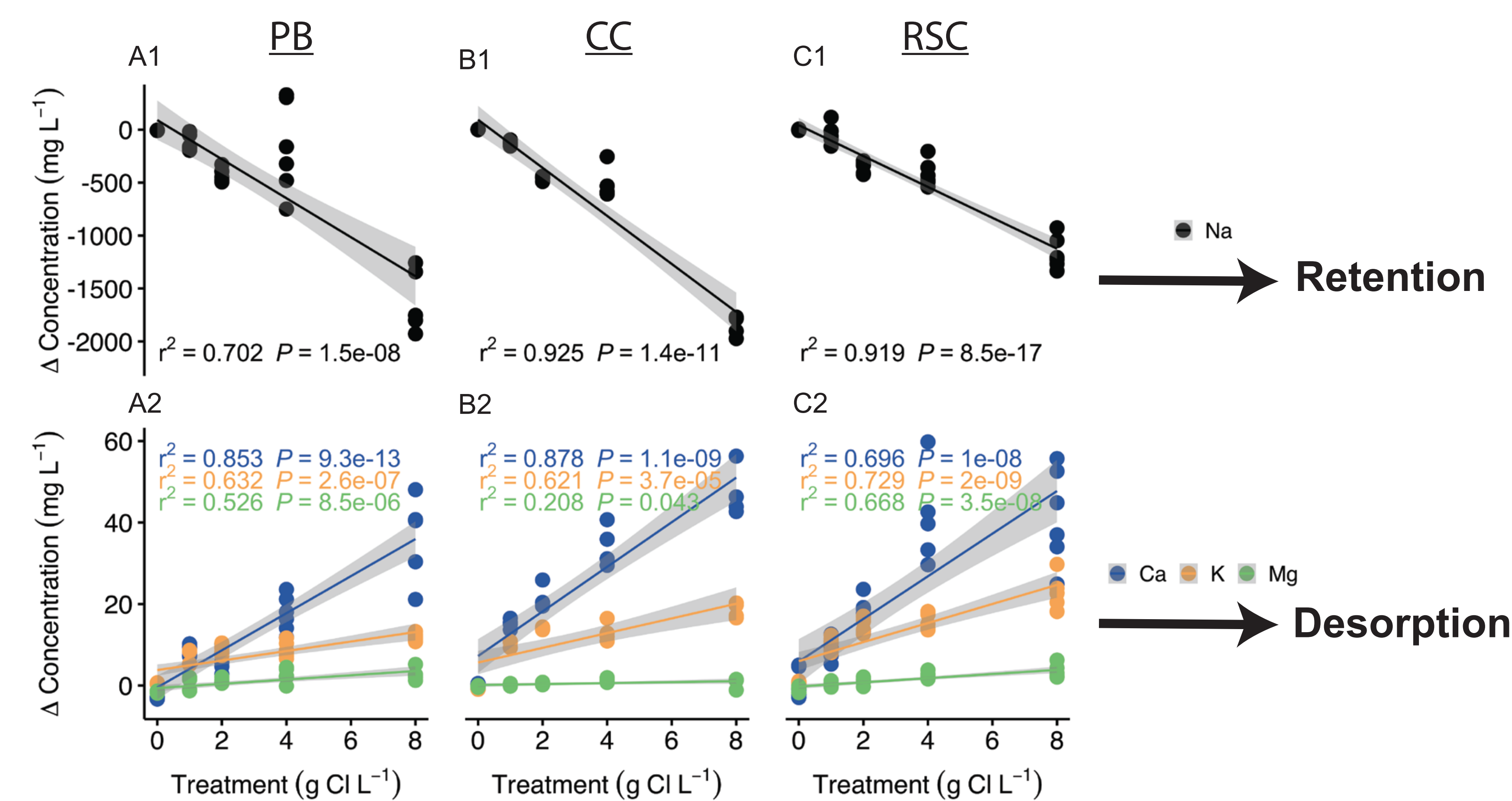


Fig. 3: Base cation concentration responses to experimental NaCl input (relative to an untreated control incubation) along PB (A1-2), CC(B1-2), and RSC (C1-2). Linear models were fitted for each cation concentration response. Solid lines represent interpolated linear regression slope and grey regions define confidence bounds (95%).

Results

2. Distribution of cation concentration responses vary among sites. These differences are statistically insignificant (Na⁺ and Mg²⁺) or insubstantial (K⁺ and Ca²⁺)

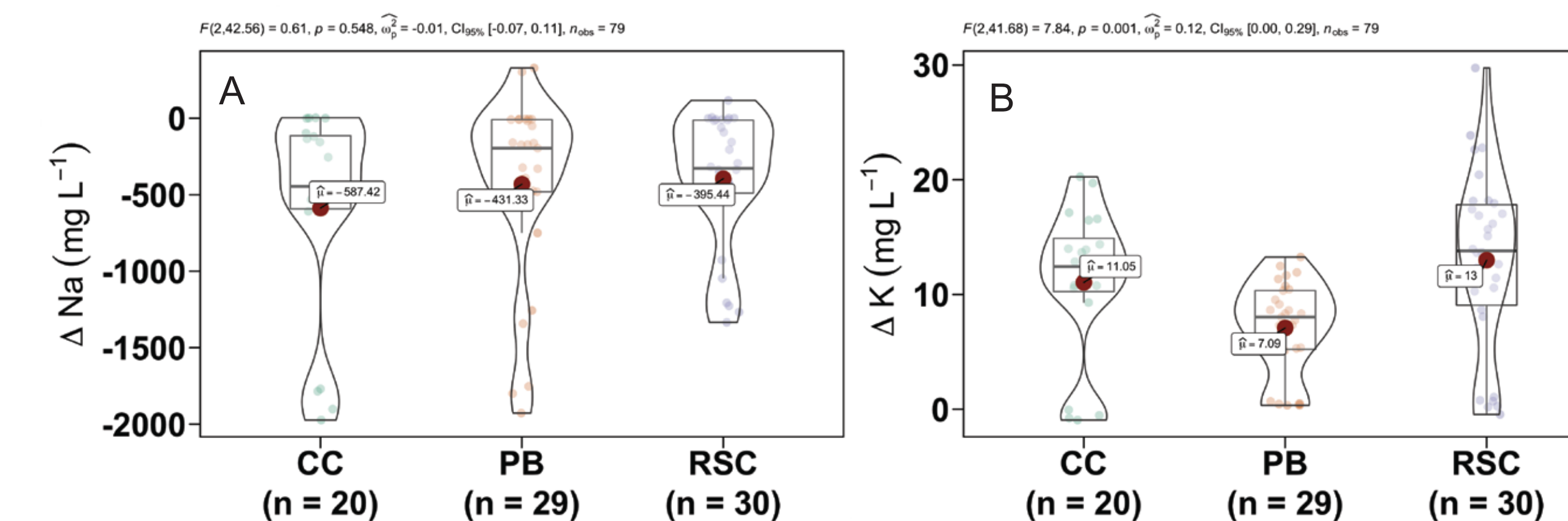


Fig. 4: Violin plots showing results of Fisher's and Welch's one-way ANOVA tests among the different cations for all sites in response to NaCl treatment where A) is Na⁺ concentration and B) K⁺ concentration.

3. Transect variance is not important, but the type of deicer salt used creates distinctions in base cation concentration response. Not all ions are equal in their mobilization potential.

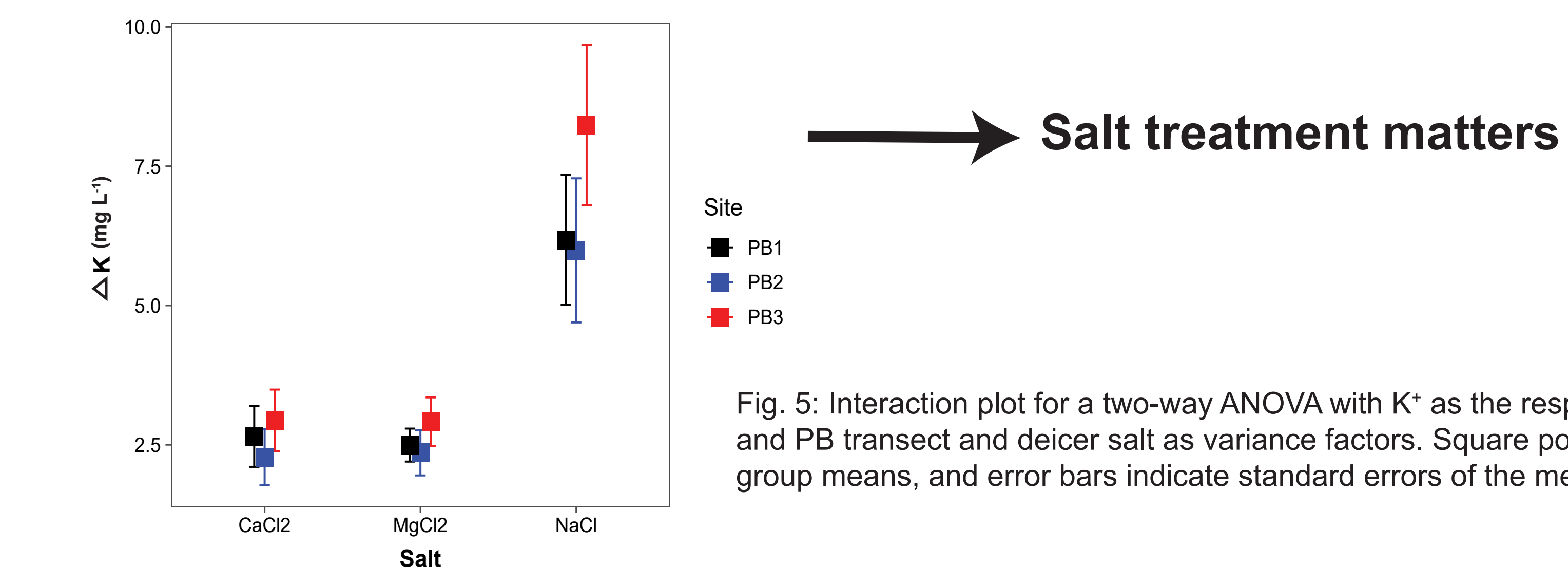


Fig. 5: Interaction plot for a two-way ANOVA with K⁺ as the response factor and PB transect and deicer salt as variance factors. Square points represent group means, and error bars indicate standard errors of the mean.

Discussion

- **Fig. 3:** Decrease in change of Na⁺ concentration is almost two magnitudes higher than increase of the other major base cations (see y-scales)
- There is evidence of preferential ion exchange (retention and desorption), but also an indication that sediment surfaces are not fully saturated and Na⁺ can bind readily without exchanging

- **Fig. 4:** RSC sediments are not relatively more prone to contaminant loading in the context of major base cations

- **Fig. 6:** Discrete streamwater samples reveal that while base cation concentrations did not vary much over the construction period (June-September 2019), there is a significant increase in all base cation concentrations after that time period along CC (black)
- PB (red) cation concentrations varied after the construction period, with only strong increases in Mg²⁺
- Increase in base cations may be due to lack of rainfall (dilution effect)
- Peak streamwater concentrations after construction are relatively similar to the average change in concentration in laboratory experiments at 8 g Cl L⁻¹

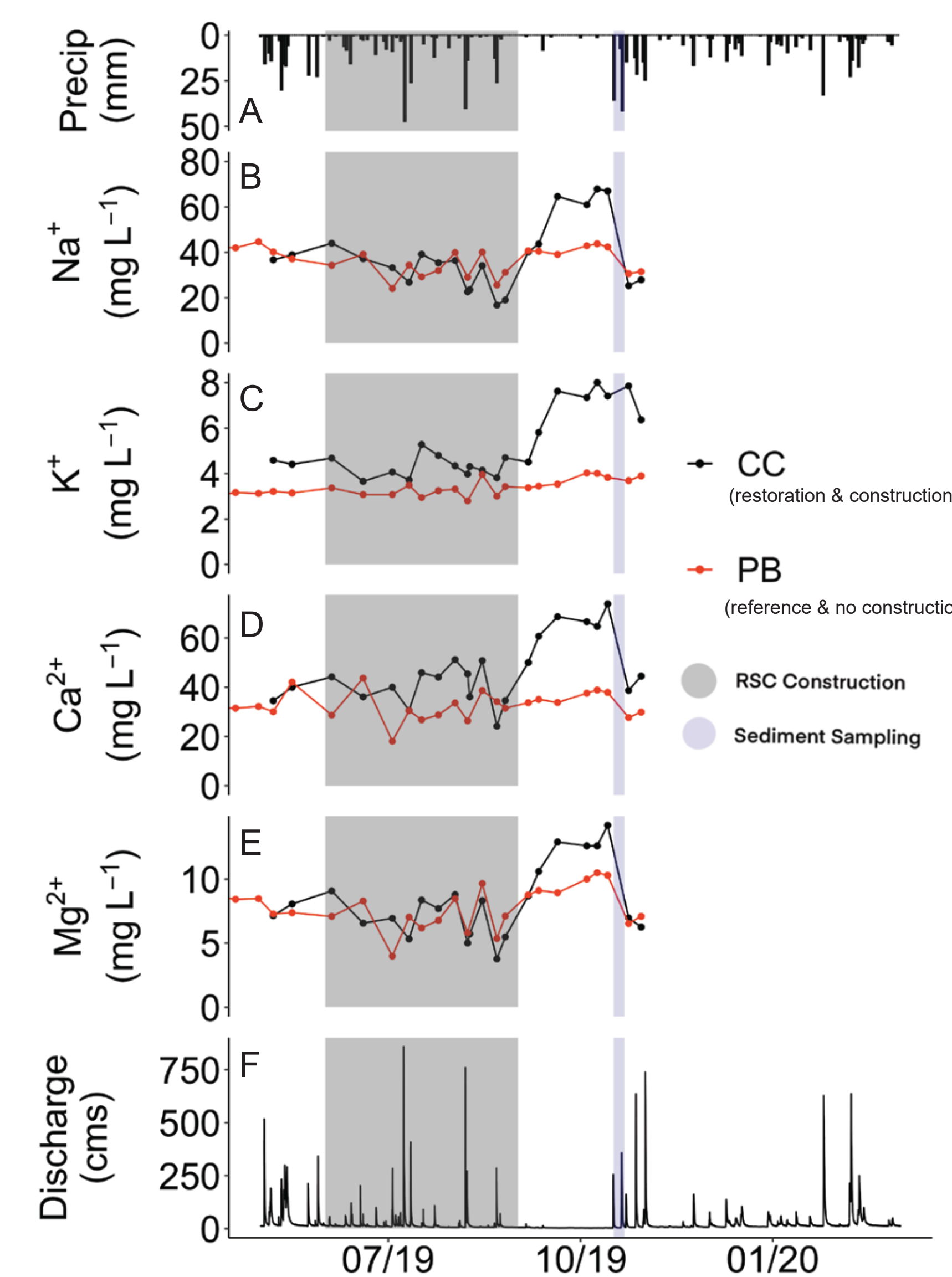


Fig. 6: Ladder plot displaying hydrological and chemical concentration trends for Campus Creek and Paint Branch: A) hyetograph, B) dissolved Na⁺, C) dissolved K⁺, D) dissolved Ca²⁺, E) dissolved Mg²⁺, and F) hydrograph (interpolated). Only hydrograph data was available for Campus Creek.

Conclusions

- Similar to this study, previous work has shown that Na⁺ can mobilize other base cations. However, this work showed that Na⁺ and other salt ions can be retained on exchange sites while mobilizing other ions. This finding suggests that **cation exchange capacity of sediments may be an important predictor of ion mobilization** in some streams.
- There were no or weak significant differences in cation mobilization across sites, but different salt ions showed significantly different mobilization potentials for other ions (e.g. Na⁺ and K⁺). This finding suggests that **different road salt ions may have different potentials to mobilize contaminants**, and information like this can be used to select deicers which may have less water quality impacts in the future.
- The concentration of base cations desorbed from sediments may be **as high** as the concentration found in ambient streamwater during deicing events

Future Research:

- How do other salts and deicers (i.e. beet juice) interact with sediments?
- What do we observe in other major and minor elements and compounds in response to experimental salinization?

Acknowledgments

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