

Does Adding Brown Algae (*Sargassum muticum*) Affect the Porosity in Concrete?

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Introduction

- In 2021, U.S. cement production facilities reported 69 million metric tons of carbon dioxide equivalents (CO₂). This represents nearly 5% of U.S. industrial sector total greenhouse gas emission (DOE 2023).
- Sargassum muticum* is a rapidly growing, invasive seaweed that can outcompete native species (Susano et al. 2022). As a perennial, it converts large amounts of CO₂ to biomass each year through photosynthesis.
- One potential way to reduce carbon emissions from concrete is to incorporate carbon-storing natural materials like *S. muticum* as an additive in cement mortar.
- In this study, we measured the effects of different percentages of *S. muticum* and a superplasticizer on the porosity of cement mortar.

Treatments

0%, 5%, 10%, 15%, and 20% algae, each tested with and without 2% polycarboxylate ether (PCE) superplasticizer (SP)

Hypotheses

- As algae percentage goes up, the porosity would increase in treatments,
- Cement mortar containing superplasticizer will have a higher porosity overall

Methods



Results

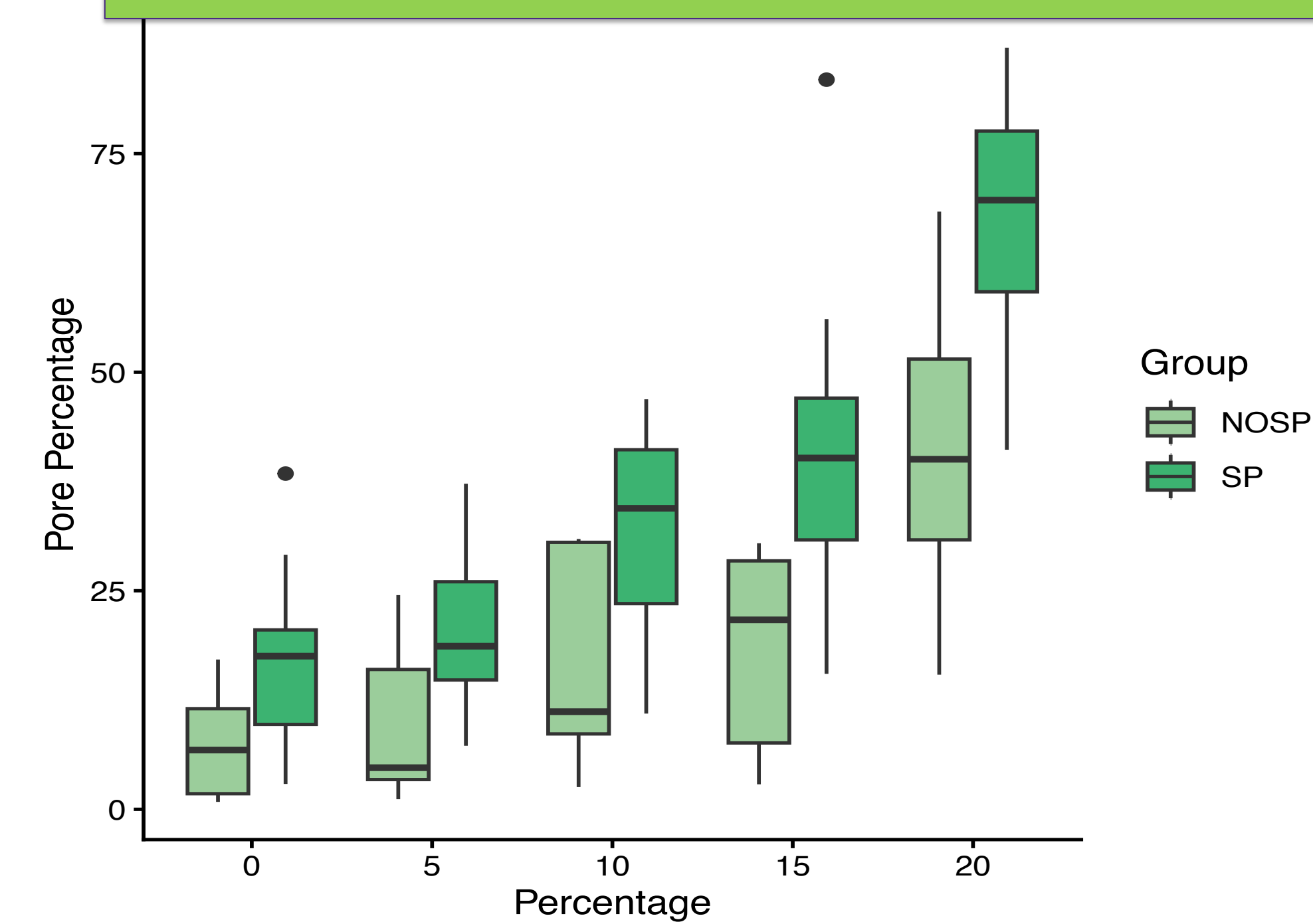


FIGURE 1: Distribution of pore percentage (%) at different *Sargassum muticum* contents (0–20%) for mixtures with superplasticizer (SP) and without superplasticizer (NOSP).

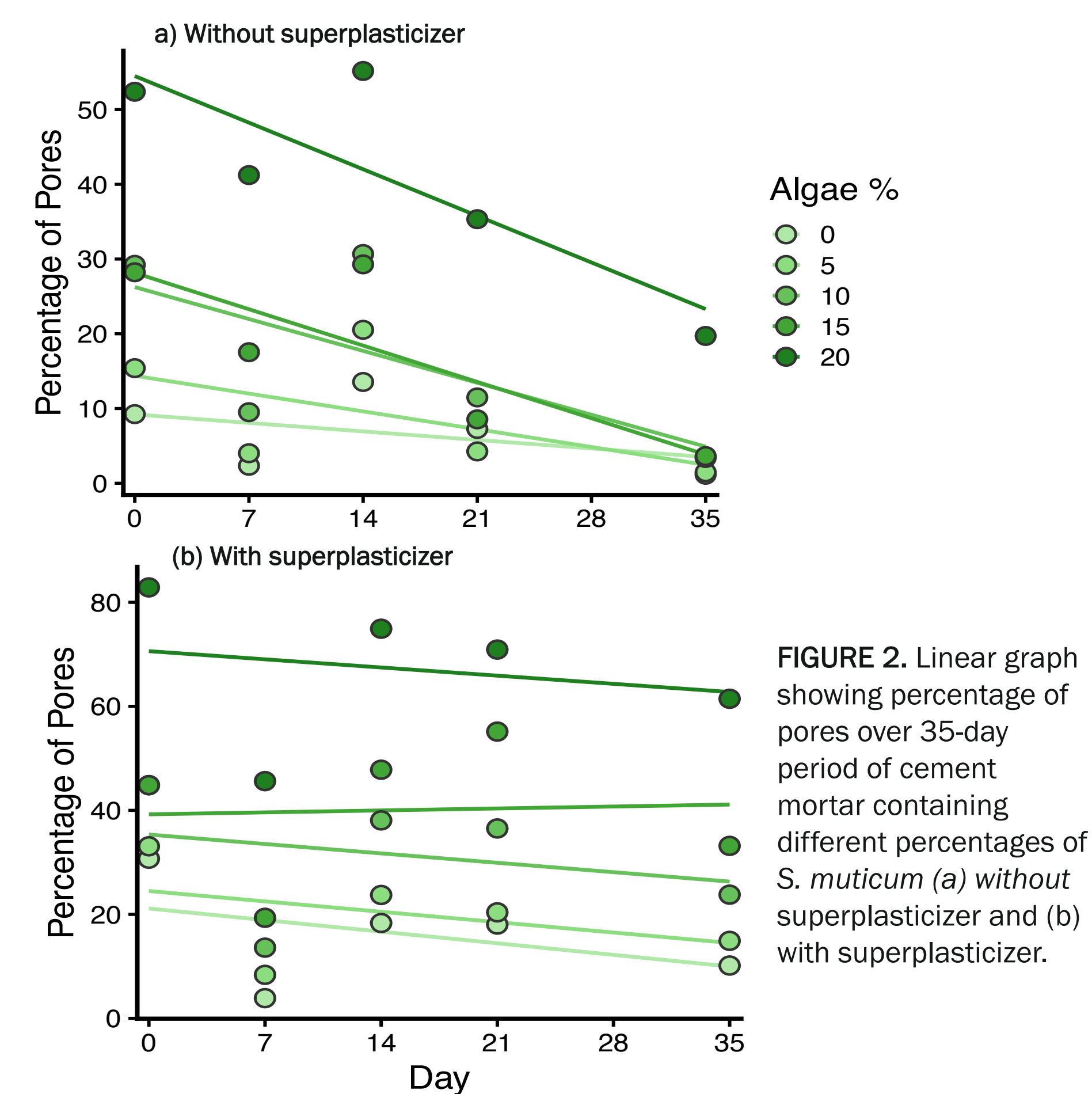


FIGURE 2: Linear graph showing percentage of pores over 35-day period of cement mortar containing different percentages of *S. muticum* (a) without superplasticizer and (b) with superplasticizer.

- Porosity decreased over time with curing
- Higher algae content resulted in higher porosity across all treatment groups.
- Day 35, mixtures containing up to 15% algae without superplasticizer had pore percentages similar to the control (0% algae)
- Mixtures without superplasticizer had lower porosity than mixtures with superplasticizer (ANOVA, $p < 0.001$)



FIGURE 3: 3D reconstruction of the mortar microstructure showing pore regions (brown), dense material (green), and matrix material (blue)

Discussion

- Our results were consistent with recent research demonstrating that algae absorbs water and makes voids in mortar (El Mendili et al. 2025).
- S. muticum* contains polysaccharides and other compounds that influence material behavior when added to mixtures (Susano et al. 2022).
- This may have implications for material strength, which should be explored further in future work.
- The performance of HPEG, a polycarboxylate ether (PCE) superplasticizer, depends on the water ratio, absorption, and interactions with other materials in mixture (Bhandari et al. 2023). An interaction effect between algae x superplasticizer was therefore expected. However, the higher porosity in the superplasticizer mixtures was unexpected.
- PCE superplasticizers improve workability by adsorbing onto cement particle surfaces and preventing flocculation (Bhandari et al. 2023).
- The higher porosity observed in the PCE-containing mixtures was unexpected and may indicate that the ASTM mixing procedure did not provide sufficient time for full particle dispersion.
- While further research is needed to understand the strength, porosity give insight into how *Sargassum* can be used in concrete Additional testing is needed to determine whether material strength decreases.

References



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	Cement (g)	Algae(g)	Sand(g)	Water (g)	SP (g)
0%	30.928	0.000	30.928	15.000	0.619
5%	29.381	1.546	30.928	15.000	0.619
10%	27.835	3.093	30.928	15.000	0.619
15%	26.289	4.639	30.928	15.000	0.619
20%	24.742	6.186	30.928	15.000	0.619

TABLE 1. Measurements used for cement mortar mixture with *S. muticum* and superplasticizer.

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TABLE 2. Measurements used for cement mortar mixture with *S. muticum*.