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Preliminary Laboratory Studies to Quantify the Effect of Plant Branches on Longitudinal Dispersion

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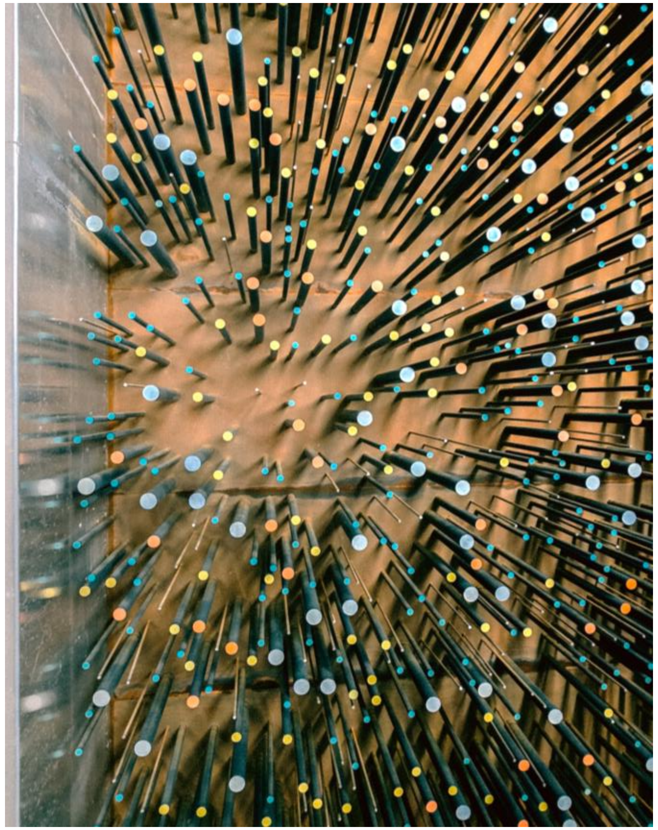
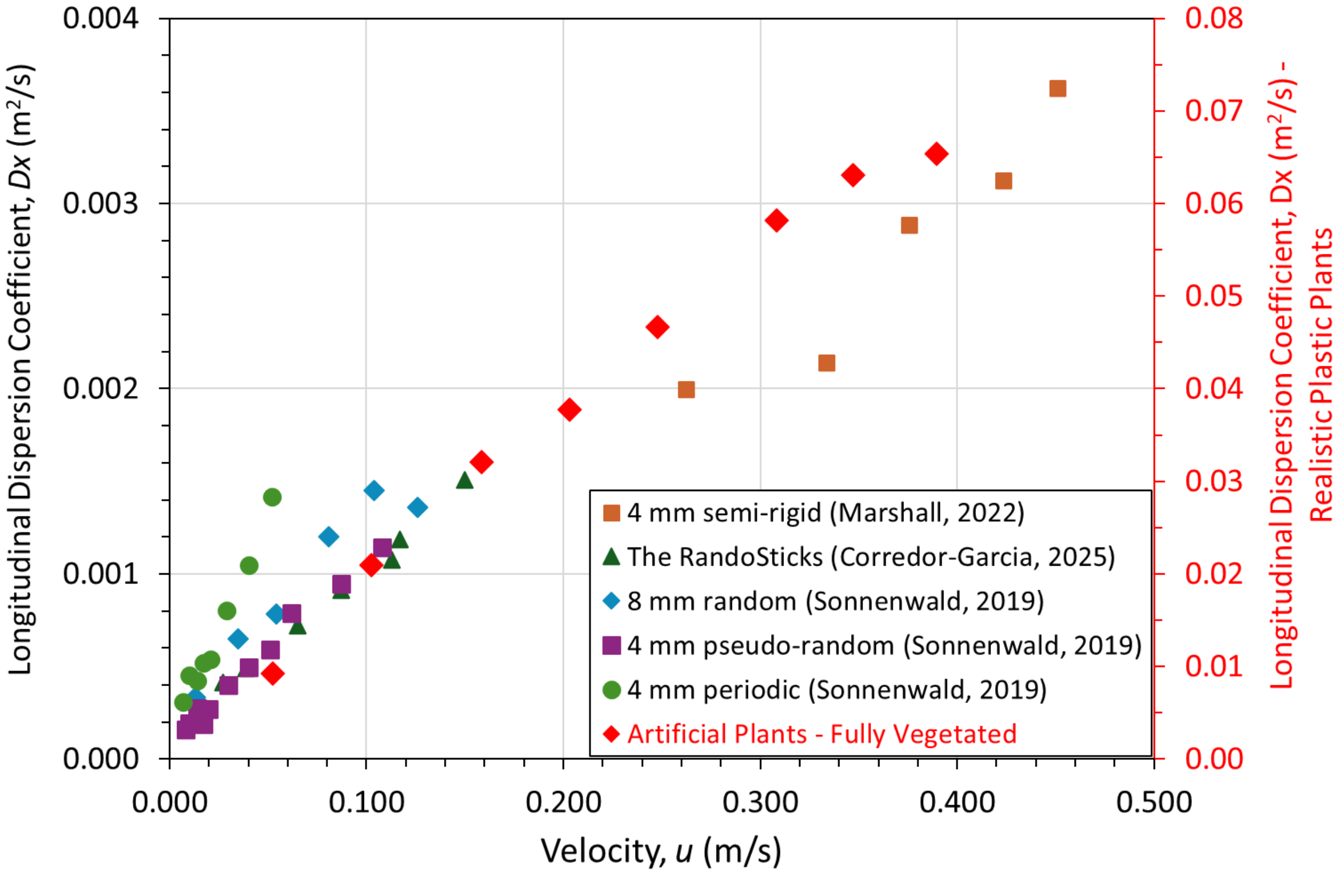
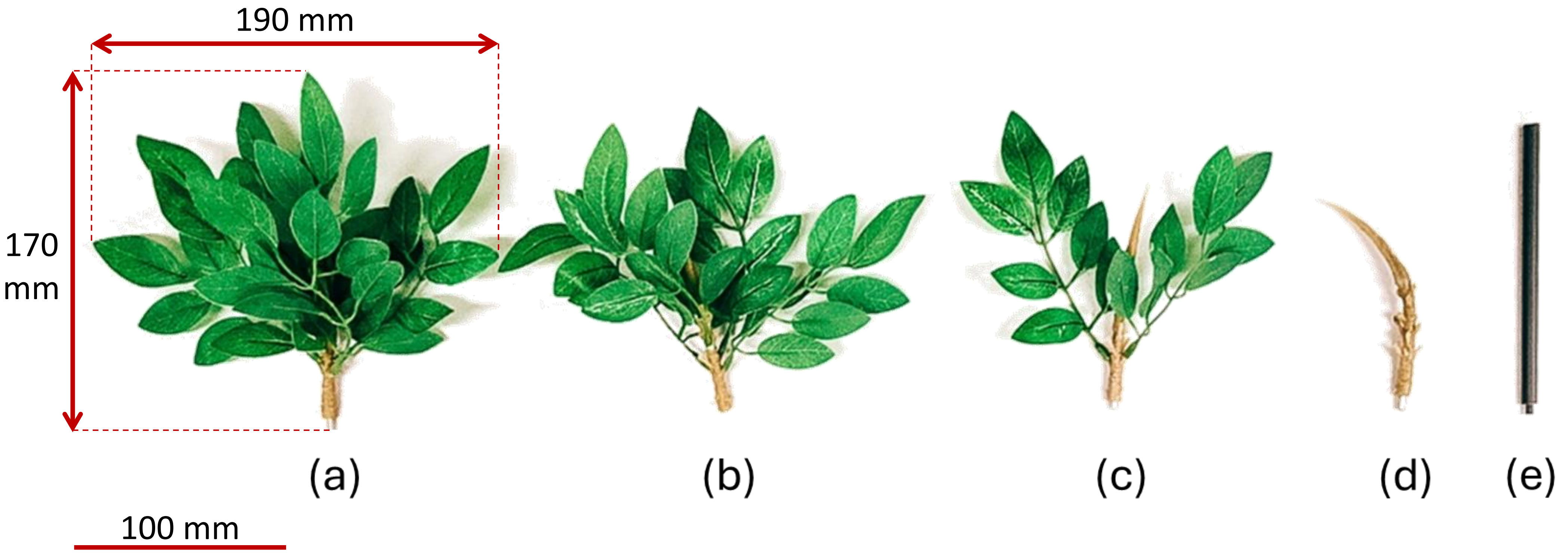
Background





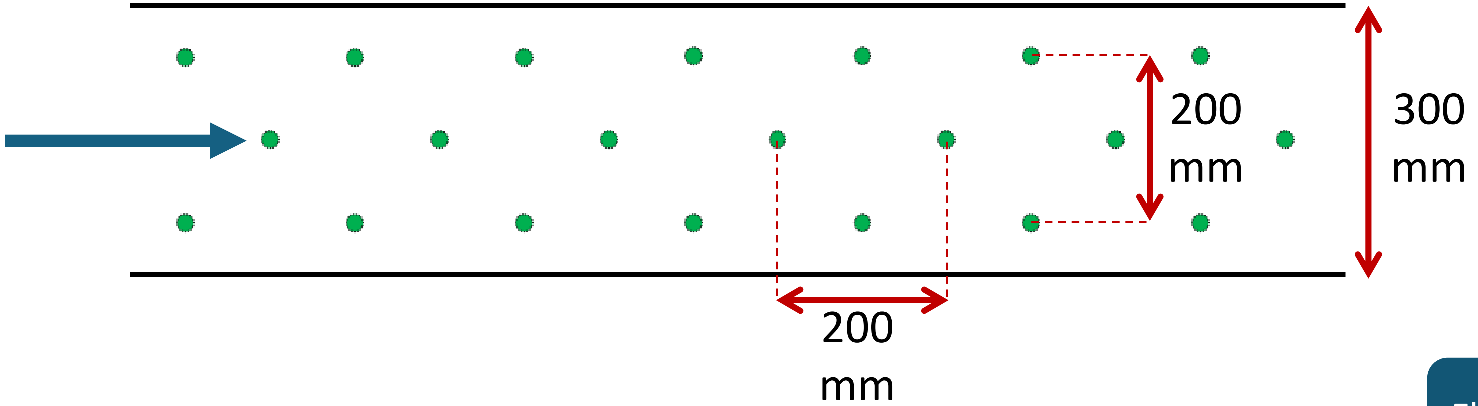
Previous studies on solute transport in vegetated channels often use simplified cylinder arrays, which fail to capture the complex hydrodynamics caused by realistic plant structures.

Realistic Artificial Vegetation



Switching from rigid cylinder arrays to realistic plant forms: (a) 6 branches, (b) 4 branches, (c) 2 branches, (d) single stem, and (e) 8 mm cylinder.

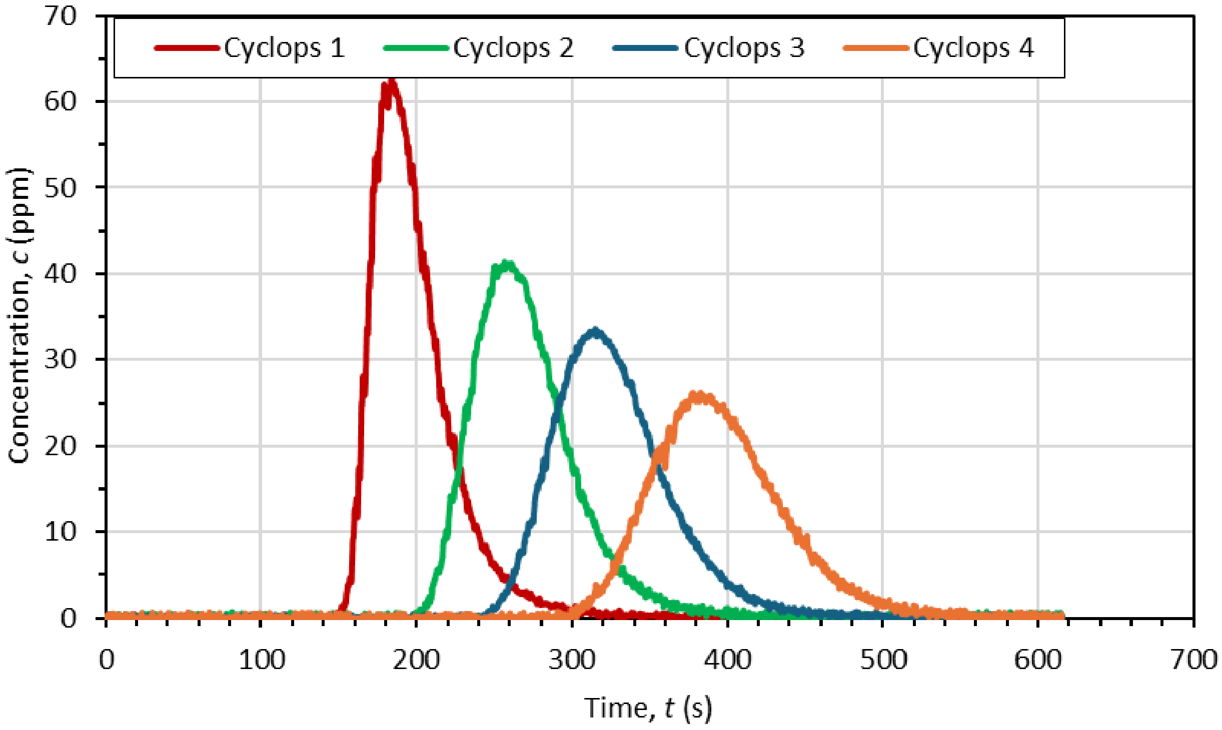
Laboratory Setup



Flume Setup	300 mm wide, 12.5 m long recirculating flume.
Dye	Rhodamine WT used as the tracer.
Sensors	4 Cyclops sensors installed at 3 m intervals along the flume.
Flow Rates	Tested at multiple flow rates ranging from 1.5 to 12 *l/s*.
Flow Conditions	Steady and uniform flow maintained at 105 mm water depth.
Bed Slope	Flume tilt adjusted to vary slope and ensure uniformity; used to estimate Manning's n.

Methodology

Tracer measurements using Cyclops sensors



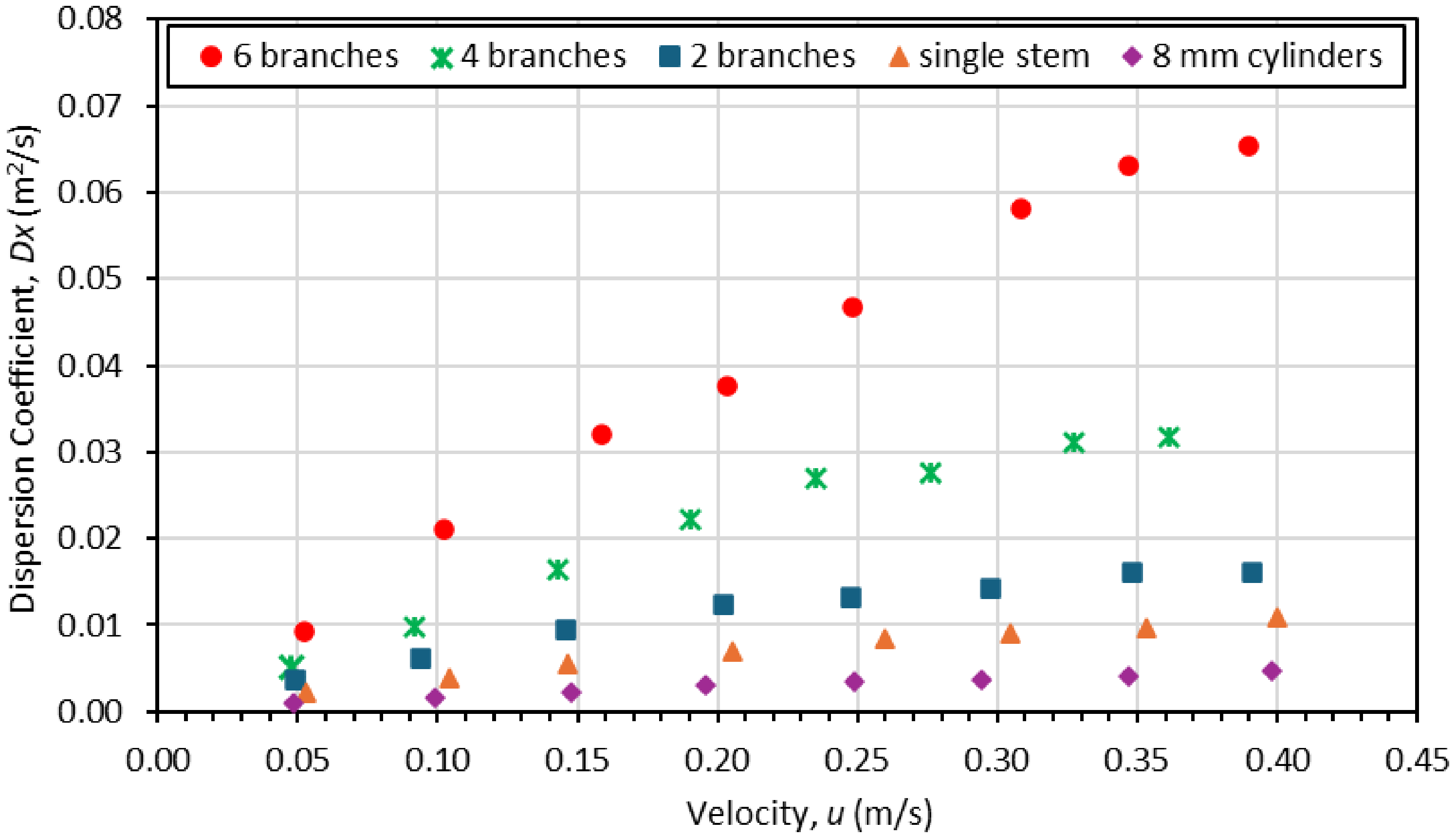
1D Advection-Dispersion Equation (ADE)

$$C(x_2, t) = \int_{\tau=-\infty}^{\infty} \frac{C(x_1, t)\,U}{\sqrt{4\pi D_x \bar{t}}} \exp\left(-\frac{U^2(\bar{t} - t + \tau)^2}{4D_x \bar{t}}\right) \mathrm{d}\tau$$

Optimized Dx and U through curve fitting.

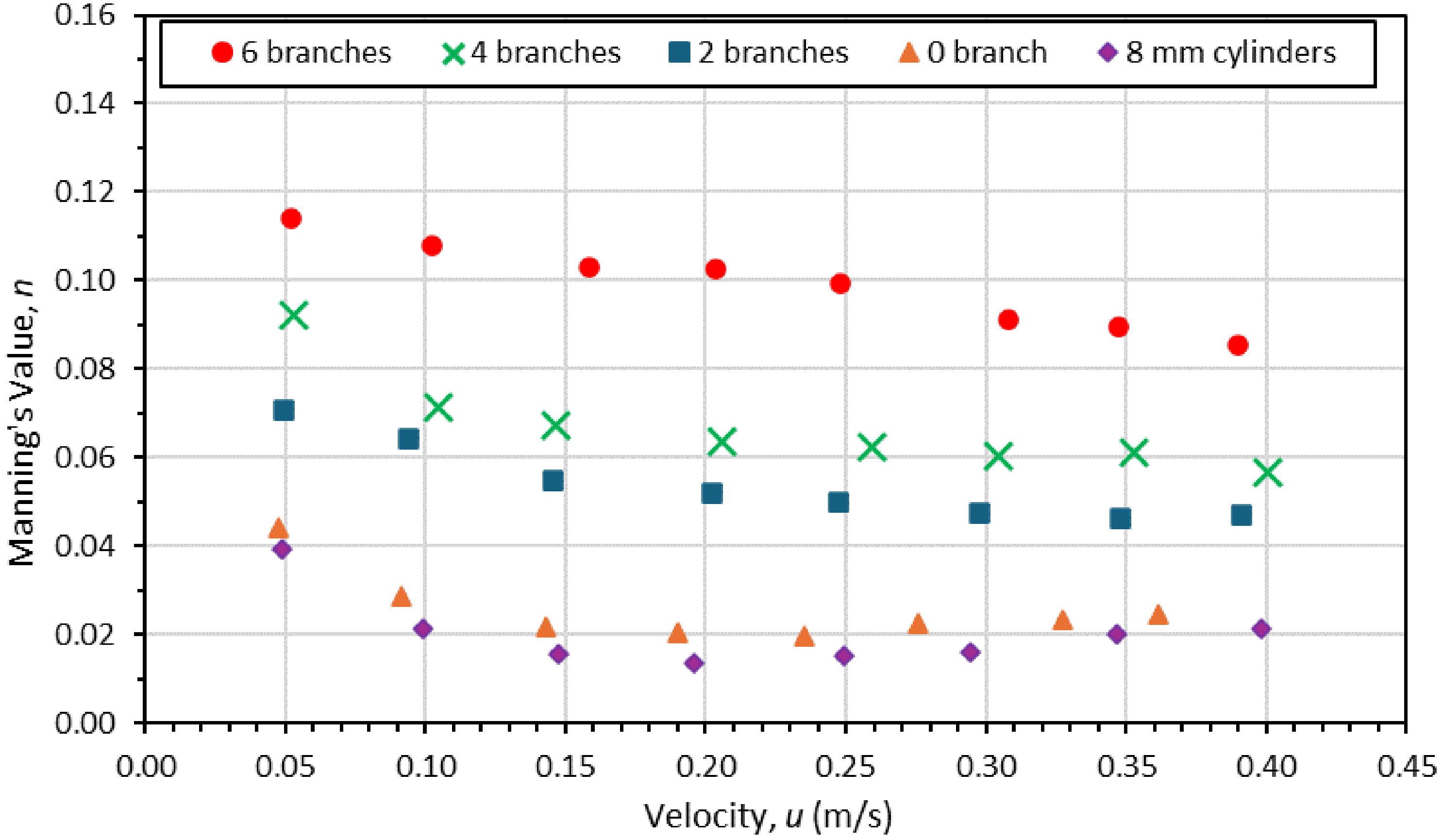
Validation: checked mass balance to assess recovery and mixing.

Results



Dx increases with velocity and vegetation density; denser setups show stronger dispersion, while sparse or cylinder setups show lower *Dx*.

Results



Manning’s n decreases with velocity; denser vegetation has consistently higher n values.

Conclusions

- Vegetation density significantly affects longitudinal dispersion, with higher branch density enhancing Dx and channel mixing.
- Dispersion increases with flow velocity, strongest in dense vegetation; cylindrical and zero-branch setups show minimal impact.
- Manning's n decreases with velocity but stays consistently higher in denser setups.
- Findings highlight vegetation's role in solute transport and provide a foundation for future modelling.

Thank You!

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