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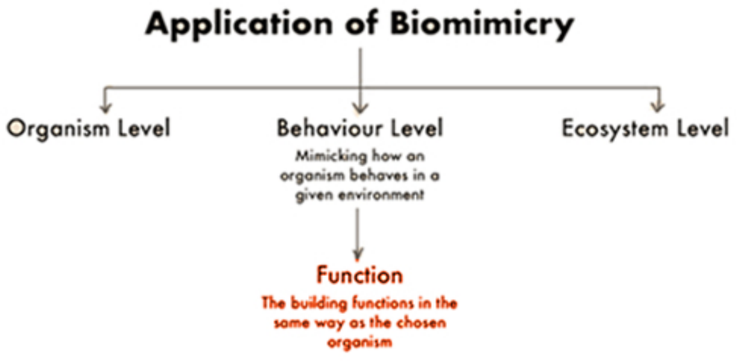
Biomimetic Distribution Systems: Investigating Building Water Supply Systems Through a Study of Xylem Network

Mannat Chopra, Mohammed Athar Mansury
School of Planning and Architecture, New Delhi 110002, India

INTRODUCTION & AIM

This research aims to promote a holistic approach to the management of water through the use of biomimetic principles. The aim is to check the application of nutrient distribution principles inspired by the xylem network (vascular system) observed in **Ficus Religiosa (Peepal Tree)** to enhance the efficiency of water distribution systems in residential buildings.

Is bio-imitation applicable in building services, and if so under what constraints?
Are buildings with increased correspondence to vascular networks more efficient?



Ficus group possesses large vessels which reduce resistance and show signs of higher hydraulic conductivity. They are also extremely adaptable and show strong resilliance. At the same time, the layout configuration in a plumbing system, influences water age, making it an integral choice.

METHOD

	Objective	Research Method	Outcome
	Study xylem network	Literature review, Interviews of medical professionals	Better understanding of the system and analytical framework
	Study plumbing system	Literature review, Interview of plumbing consultant	Better understanding of the system and analytical framework
	Compare base and secondary characteristics	Comparative analysis	Inferences, which system performs better where
	Analysis of key parameters, test of efficiency	Calculations, comparisons	Potential of incorporation of biomimicry in plumbing systems

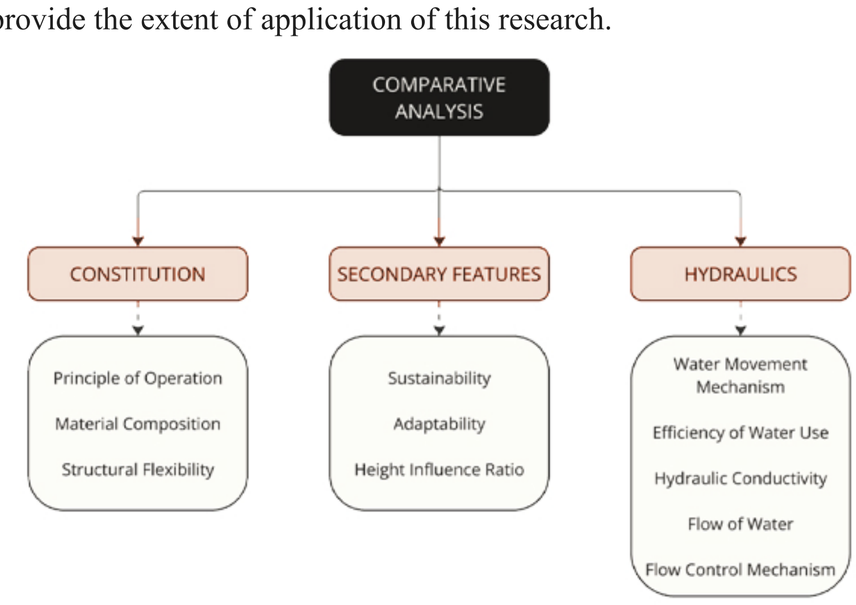
This method will establish an inter-connection between the prime fields of study. **The Hagen Poiseuille and pressure formula** help quantify the data.

$$Q = \frac{\pi d^4 \Delta p}{128 \mu L}$$

$$P = \rho g h$$

The idea is to study and implement key integral and unique characteristics found in the xylem network of plants to figure if these principles can be applied to our plumbing systems to make them more adaptable, sustainable and efficient. This research adopts both a quantitative as well as a qualitative approach, where quantitative ideas provide the basis and way forward, whereas the qualitative techniques provide the extent of application of this research.

The analytical framework for this comparison has been established carrying forward some case study parameters and literature review, focusing on the parameters most relevant to the merger of both topics.



RESULTS & DISCUSSION

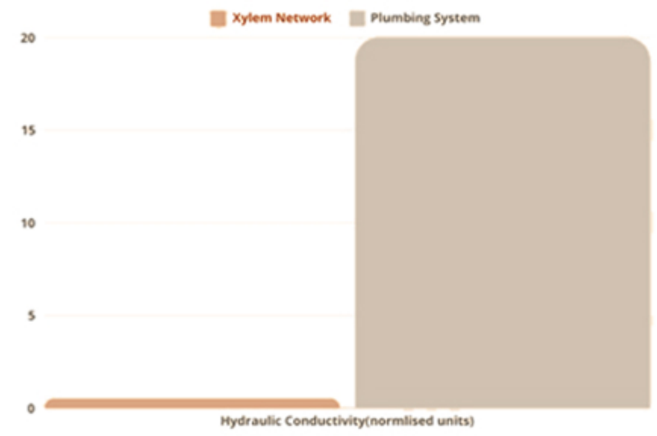
$$Q = \frac{\pi \, d^4 \Delta p}{8 \mu L}$$

Xylem Hydraulic Conductivity (k_{xylem}): $\frac{\pi R^4 g}{8 L \mu}$

where,
R= radius of the xylem vessel
g = acceleration due to gravity (approximately 9.8 m/s²)
L= length of the xylem vessel

Plumbing Hydraulic Conductivity (k_{pipe}): $\frac{\pi R^4 H}{8 L \mu}$

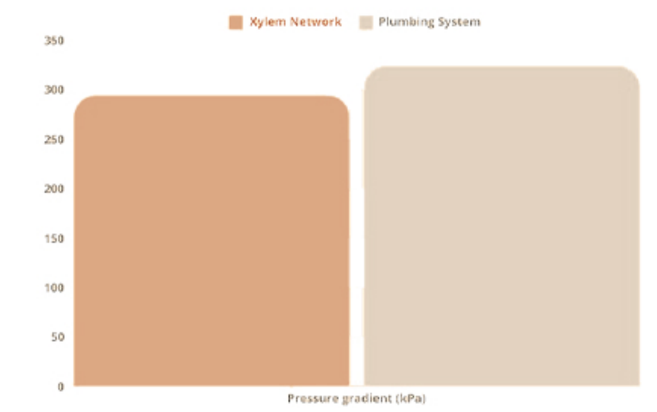
where,
R= radius of the pipe
H = height of water column in the pipe
μ= dynamic viscosity of water (approximately 0.001Pa·s)



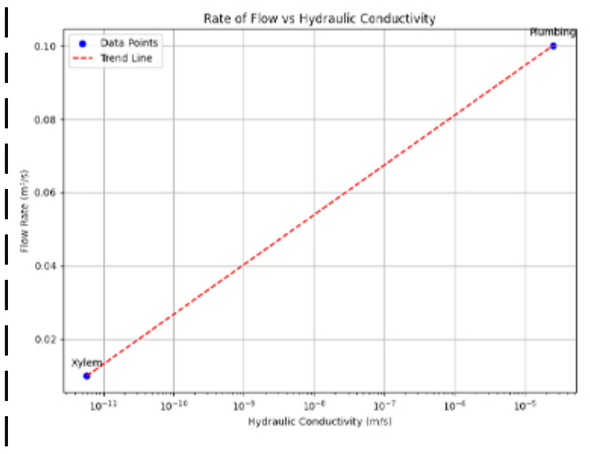
Using the hydrostatic pressure formula:

$$P = \rho g h$$

Assuming:
- Height of tree/plumbing pipe: H=30 m
- Density of Water: ρ=1000 kg m³
- Acceleration due to Gravity: g=9.81 ms²



Despite the apparent disparity in hydraulics, the xylem network trumps plumbing in other sectors. **Plumbing on average produces 60% wastage, compared to a mere 20% wastage produced by vascular networks.** Xylem is also a lot more adaptable in nature.



CONCLUSION

Relative to plumbing, xylem achieves **only about 10% of the volumetric flow rate.** However, just as the xylem structure experiences **tip-to-base widening in Ficus species**, this strategy can be explored and adopted. We could involve potentially using **more valves or variable flow control mechanisms**, or employ materials that suport this. Small pumps at different levels creating a **suction pull** to help the flow of water upwards at different occasional levels.

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