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DEVELOPMENT AND EXPERIMENTAL ASSESSMENT OF A PASSIVE MICROCLIMATE-CONTROLLED CART FOR SUSTAINABLE POST-HARVEST FLOWER PRESERVATION

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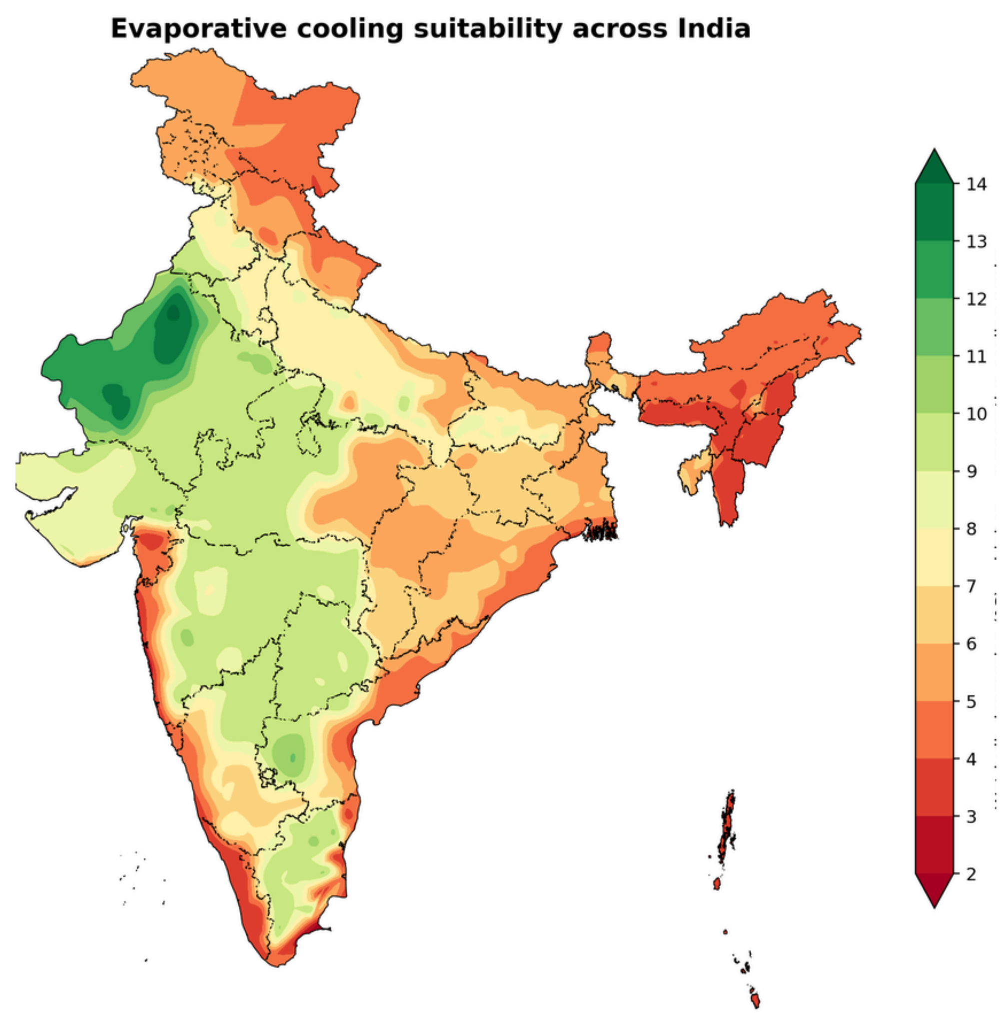
INTRODUCTION & AIM

- Post-harvest losses of cut flowers are 30–40% worldwide due to poor temperature and humidity control during transport and display.
- High respiration and transpiration rates lead to moisture loss, wilting, and reduced quality.
- Conventional refrigeration systems can maintain freshness but are costly and energy-intensive.
- This study introduces a passive evaporative cooling flower cart that uses adiabatic cooling to create an optimal storage environment.
- The system maintains 20–25 °C and 85–92% humidity, extending freshness while reducing energy use and environmental impact.
- The redesigned pad enhances airflow and contact area for improved cooling effectiveness.



METHOD

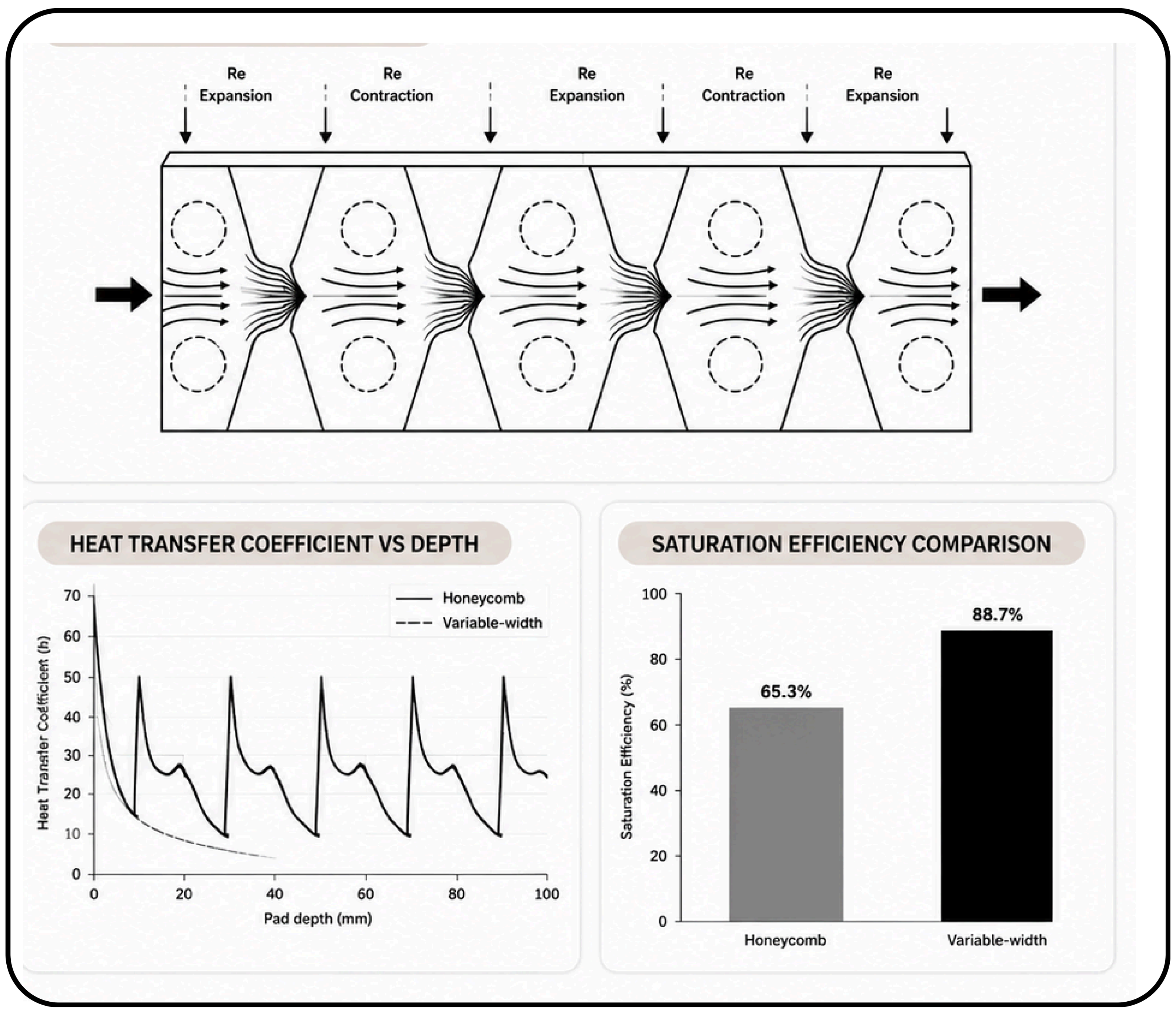
- Evaporative cooling is more effective in hot, dry conditions and less so in humid air.
- A fully passive flower cart uses PCM thermal storage with Direct Evaporative Cooling (DEC).
- PCM modules lower water temperature before it enters the cooling system.
- Redesigned pad geometry enhances heat and mass transfer rates.
- Pre-cooled water improves heat extraction and humidity generation.
- PCM buffering and better evaporation maintain a stable environment for preserving cut flowers.

RESULTS & DISCUSSION

- Conventional evaporative cooling is limited by ambient **wet-bulb temperature**, resulting in reduced cooling performance under high humidity conditions.
- **PCM-integrated** water pre-cooling lowered the inlet water temperature below ambient conditions, introducing an additional sensible heat sink and enabling cooling beyond the conventional adiabatic evaporative limit.
- The **variable-width** expansion evaporative pad continuously disrupts thermal and concentration boundary layer growth, maintaining higher local heat and mass transfer coefficients throughout the pad depth.

VARIABLE-WIDTH EXPANSION EVAPORATIVE PAD

- Periodic **expansion** and **contraction** of airflow channels disrupt boundary layer growth, maintaining higher heat and mass transfer rates throughout the pad depth.
- Enhanced **airflow** redistribution increases active wetted surface utilization, reducing flow channeling and improving **evaporative efficiency** across the entire media volume.
- The optimized variable-width geometry is expected to improve cooling effectiveness by approximately **10–20%** compared to conventional straight-channel pads, enabling greater temperature reduction and more uniform **cooling performance.**



PHASE CHANGE MATERIAL

- PCM modules such as **capric–lauric eutectic acid** ,are integrated within the water reservoir to store cooling energy through latent heat absorption and maintain the circulating water at a lower temperature.
- The PCM absorbs excess **thermal energy** during daytime operation, delaying water temperature rise and providing a continuous supply of pre-cooled water to the evaporative pad.
- The PCM is recharged naturally during nighttime, when ambient temperatures drop below its melting point, allowing it to solidify and regain its **cooling capacity** without additional **energy input.**

CONCLUSIONS

By integrating **PCM**-based thermal storage, a boundary-layer-engineered **variable-width evaporative pad**, and passive airflow management, the proposed system delivers a fully passive, portable, energy-efficient, and cost-effective solution for last-mile **flower preservation**, eliminating the need for conventional refrigeration while significantly extending freshness and reducing post-harvest losses.

FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

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