KING EDWARD VI CAMP HILL SCHOOL FOR GIRLS

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Green Armor Against the Heat: Bioengineered Algae Spray to Reduce Heat Stroke Risk

Introduction

Climate change is driving more frequent and intense heat waves, pushing global temperatures closer to or beyond the human body's ability to regulate heat. As a result, conditions like heat exhaustion and heatstroke are becoming more common and severe, especially in vulnerable populations, contributing to rising morbidity and mortality worldwide.

Proposed idea

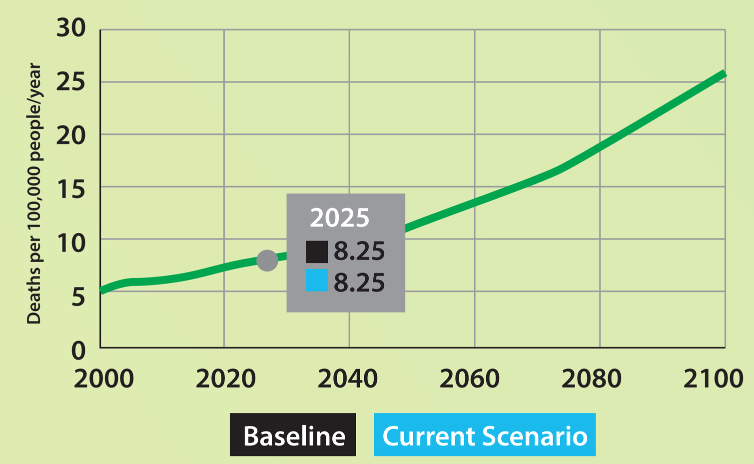
Our proposed solution to combat urban overheating is creating an algae spray, using Arthrospira platensis which can be applied to surfaces such as concrete, asphalt and rooftops to reduce urban heat and lower the risk of heatstroke.

We chose this specific photosynthetic bacterium due to its resilience, biocompatibility, and tolerance to high temperatures. It cools surfaces through multiple mechanisms. Firstly, the algae increase albedo, reflecting near-infrared radiation that would otherwise contribute to radiative heating—lowering surface temperatures compared to untreated areas. As the algae grow, they form a biofilm that increases surface roughness and blocks direct sunlight, enhancing light scattering and reducing heat absorption. Additionally, algae are water-rich organisms (80–90% water by weight), and as water evaporates from the biofilm, it absorbs latent heat, producing a prolonged evaporative cooling effect. Due to water's high specific heat capacity, the biofilm also helps buffer temperature changes and reduce thermal fluctuations in the surrounding environment.

Unlike passive solutions such as white paint or reflective foils, our biodegradable and self-generating algae provide dynamic cooling through both their moisture-retaining biofilms and metabolic activity, offering a more active and sustained reduction in surface temperature.

How Climate Change is affecting heatstroke

Climate change is raising both temperatures and humidity, which disrupts the body's natural cooling mechanisms—convection, radiation, and evaporation. As humidity increases, sweat can no longer evaporate efficiently due to the reduced water vapor gradient between skin and air, making it difficult for the body to release heat, sharply increasing the risk of heatstroke. Urban heat islands—dense areas with little greenery—intensify extreme temperatures, particularly in South Asia and the Middle East, where temperatures are nearing fatal thresholds.



Graph showing exponential increase in deaths from extreme heat per 100,000 people/year as time progresses

Heatstroke is a life-threatening condition that causes systemic cardiovascular overload and reduced blood flow to vital organs (brain, heart, kidneys, liver) as a result of the body's attempt to manage the extreme heat, leading to ischemia (O2 deprivation) and potential long-term organ damage. The increased vasodilation significantly decreases the blood pressure (hypotension), causing the heart to pump faster and eventually the heart becomes unable to meet the increased demand for blood flow.

Prolonged sweating depletes the body of fluids and electrolytes, further reducing blood volume and impairing circulation, worsening hypotension, making it harder for the heart to maintain sufficient blood flow to tissues.

Methodology

To test the ability of A.platensis to reduce surface heating, we created an algae-based spray and applied it to a Leslie cube surface:

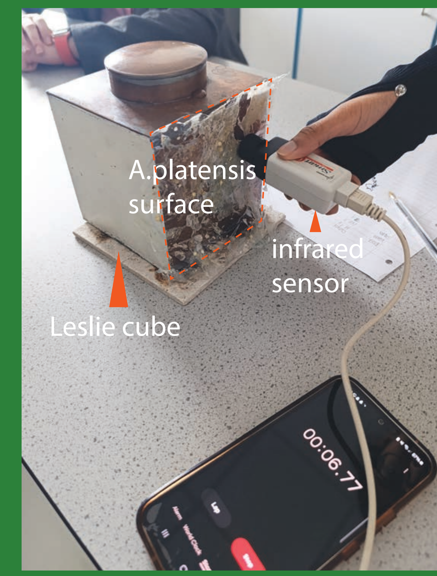
Spray Preparation:

We mixed live A. platensis culture with sodium alginate to enhance adhesion, added water to improve sprayability and incorporated slow-release fertiliser to support growth.

The mixture was sprayed onto a transparent plastic film, allowing the algae to grow for a few days before testing. This setup was used instead of spraying directly onto the Leslie cube to allow easy removal and handling

Experimental Setup:

To form the control, a Leslie cube with three different surfaces was filled with boiling water. The surfaces tested were copper, matt white and matt black. An infrared sensor was used to measure the heat intensity of the surface in W/m² and the distance between the infrared sensor and the cube is kept controlled. The sensor was placed on the algae-covered surface for ten minutes before recording, to allow the plastic film and algae to reach thermal equilibrium with the Leslie cube. A thermometer was kept in the water inside the Leslie cube to ensure the internal temperature was constant, and only the surface temperature was changing.



Results

Surface Tested	Intensity of Heat (W/m²) without algae	Intensity of Heat (W/m²) with algae
Copper	93.1	48.5
Matt White	168.7	92.8
Matt Black	187.8	98.4

When we placed the layer of algae over the Leslie cube surface, the heat detected by the infrared sensor had greatly decreased, even though only a thin layer of algae had been used. Algae was effective in reducing heat loss and therefore surface temperature on all three surfaces tested, with the most significant difference being on the matt black surface, likely to be because it had the highest initial temperature. The surface temperature was almost halved for all surfaces showing just how significant the algae was.

Conclusion: These findings show the algae spray's strong potential to reduce surface temperatures, supporting its use as a low-cost, scalable solution in heat-prone regions where heat stroke risk is rising.

Improvements: Future experiments could explore the effect of varying algae thickness or surface coverage on cooling performance. Additionally, testing how long the algae remains viable under different environmental conditions would help determine optimal reapplication intervals for long-term use.

Applications

Our algae-based spray offers a low-cost, scalable, easy-to-maintain solution to reduce urban heat and lower the risk of heatstroke, especially in densely populated and low-resource regions where indoor cooling is limited. Applied to rooftops, pavements, and building walls, it actively cools surfaces through light reflection, moisture retention, and evaporative cooling—unlike static solutions like white paint. It also improves air quality by absorbing CO_2 via photosynthesis.

The spray is especially useful in water-scarce regions like Sub-Saharan Africa, where desertification and heat pose serious health risks. Its low-maintenance design suits areas with limited access to air conditioning or water. A.platensis forms moisture-retaining biofilms that recycle water, enabling surface cooling through evaporation with minimal reapplication, unlike conventional cooling methods such as misting systems or irrigation-dependent green roofs which require regular water supply.

In wildfire-prone regions like the Amazon Basin and Western U.S., the spray could be applied to tree surfaces to lower surface temperatures and reduce wildfire risk. In contrast, high-altitude flood-prone zones like the Himalayas may be less suitable due to excess moisture concerns.

The spray could be deployed via jet-wash systems to coat urban surfaces efficiently. A bottom-up approach, involving local communities in production and application, would ensure cultural sustainability and long-term adoption. For example, countries in the Sahel like Chad can use locally available A.platensis from Lake Chad, reducing both cost and supply chain barriers.

Innovative design

To enhance the water retention, heat tolerance, and reflectivity of our algae spray for commercial and long-term use, we propose a multi-layered genetic and structural strategy:

1. Enhanced Biofilm Retention: By upregulating genes responsible for extracellular polymeric substance (EPS) production, we can produce thicker, gel-like biofilms that retain more moisture and slow water loss. This increases evaporative cooling and prolongs surface hydration in hot environments.
2. Improved Water Uptake: Introducing aquaporin genes from drought-tolerant plants can help the algae absorb and retain water more efficiently, reducing the risk of desiccation under high temperatures.
3. Heat Tolerance Engineering: Using CRISPR, we aim to upregulate heat shock proteins (e.g. HSP70, HSP90), which stabilise proteins and membranes under thermal stress, ensuring the algae continues to function even in extreme heat.
4. Boosting Reflectivity: Genetically modifying pigment pathways to produce lighter or more reflective tones (while maintaining photosynthetic function) can help reflect more solar radiation. Additionally, nanostructuring the biofilm's extracellular matrix to mimic natural reflective surfaces—such as silvery fish scales or diatom shells—can further scatter sunlight. This could be achieved by genetically altering EPS composition to form layered or crystalline textures or by embedding light-scattering biominerals (e.g. silica or calcium carbonate).

Contributions

Sahana - Led the algae spray experiment, managing setup, methodology, and data collection.

Bhumika - Supported practical setup and measurements; researched algae biofilms and proposed genetic modifications for heat resilience.

Manahil - Researched the biological mechanisms behind how the algae spray functions.

Emily - Researched region-specific climate impacts and proposed targeted applications of the spray.

Birle - Researched heatstroke physiology and developed global, low-cost deployment strategies.

Millie - Designed the experiment and supported practical measurements. Designed and formatted the scientific poster and researched heat stroke physiology.

References