Chemical Heat Sponge: A Conceptual Model for Localized Coral Reef Cooling Using Reusable KCl Thermal Units

Abstract

Rising ocean temperatures threaten many parts of our ecosystem, and coral reefs are among the most affected. Increasing temperatures lead to coral bleaching and death, causing widespread ecosystem loss. Corals are not only individual organisms but also vital habitats and food sources for marine life. Current intervention strategies such as mechanical fans and artificial shading are costly and often impractical.

This paper proposes a conceptual system for localized reef cooling using reusable potassium chloride (KCl) thermal cylinders, which utilize endothermic reactions as "chemical heat sponges." The cylinders are metallic containers designed with holes or abstract shapes to minimize hydrodynamic resistance, filled with KCl solution that absorbs heat from surrounding water. This provides short-term—and potentially long-term, depending on size and number—cooling to targeted coral patches.

An estimated total volume of 1 m³ (two units, each 0.5 m³) containing 1000 L of KCl solution (20 g/L)

can lower the surrounding water temperature by approximately **1.15°C** for around **15–30 minutes** (up to one hour in calmer waters). For extended cooling, adding 10–20% of a gelling agent such as agar may slightly reduce the cooling effect (to around 0.9–1°C) but increase the duration to several hours. The units are reusable, as leaving them underwater overnight allows them to “reset” and absorb heat again during the day, requiring minimal maintenance.

1. Introduction

When potassium chloride dissolves in water, it forms an endothermic reaction that absorbs heat, giving it a cooling effect. KCl is also safe for humans and marine organisms. Only high concentrations or large leaks could stress corals, but since the solution is sealed inside metal containers, this risk is minimal.

Metal containers are ideal for this project because of their thermal conductivity and durability. Shaping the containers similarly to coral reefs helps reduce hydrodynamic resistance and minimizes ecological disturbance.

2. Environmental and Safety Considerations

Effect on oxygen levels, ion conductivity, pH, and viscosity: None. Both KCl solution and KCl–agar solution are sealed within the containers.
Leak risk:

- *KCl solution only:* At 2% concentration, even a large leak would not be harmful. Ocean currents would quickly dilute the solution to safe levels.
- *KCl–agar solution:* Because the gel is denser, it allows higher KCl concentrations but remains easy to filter out in case of leakage.

Overall, the system presents negligible risk to coral reef ecosystems when properly sealed and deployed.
3. Deployment and Operation

Containers can be easily attached to the ocean bed or placed around coral clusters in smaller sizes. In large-scale applications, multiple units can be installed around reef areas to ensure adequate coverage while avoiding drift. Installation and removal can be handled by winch, capstan, or divers for smaller versions.
The units absorb heat during the day and naturally reset at night as temperatures cool, making them

sustainable and reusable without additional energy or chemicals.

4. Implementation Plan

Before large-scale use, the system should undergo controlled testing in the following stages:

- **Tank trials:** Test KCl solution behavior and stability in seawater tanks, monitoring temperature change and containment performance.
- **Reef simulation:** Test on tanks containing live coral to observe effects on coral color, temperature response, water acidity, and viscosity.
- **Field testing:** Apply the system to small reef patches and evaluate temperature stability, ecological effects, and maintenance needs.

5. Discussion

This method still requires experimental validation and optimization. Factors such as unit size, surface area, material efficiency, and long-term maintenance must be examined. Cost-effectiveness should also be evaluated for deployment at different reef scales.

The proposed KCl "chemical heat sponge" offers a novel and practical solution for short-term coral reef cooling. By leveraging the endothermic dissolution of potassium chloride in reusable metallic units, the system provides localized temperature regulation without external power input. Its safety, reusability, and adaptability make it a potential complement or alternative to existing coral protection strategies such as artificial shading or mechanical cooling.

6. Conclusion

Although conceptual, this idea demonstrates a viable path toward sustainable, low-maintenance reef protection technology. With laboratory experiments and scaled testing, the KCl thermal unit system could become a valuable tool in mitigating coral bleaching and supporting marine biodiversity under increasing ocean temperatures.