Bio-Algae Sticker: A Sustainable Concept for Reducing Vehicular Pollution

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***Abstract*—Vehicular emissions are one of the primary sources of urban air pollution and a major contributor to global climate change. The increasing number of two-wheelers, especially in developing nations, releases large volumes of carbon dioxide (CO_2), carbon monoxide (CO), and unburnt hydrocarbons. This paper proposes a conceptual innovation - a bio-algae sticker designed to reduce vehicular pollution in an eco-friendly and affordable manner. The sticker contains live Chlorella vulgaris algae encapsulated in a hydrogel medium that absorbs CO_2 and releases oxygen through photosynthesis. It functions as a mini carbon sink, converting harmful exhaust gases into less harmful by-products naturally. Constructed using heat-resistant, moisture-retaining, and UV-protective layers, the bio-algae sticker can be easily attached to vehicle silencers. This literature-based conceptual model integrates biotechnology, materials science, and environmental engineering to promote sustainable and green mobility. The paper also discusses its feasibility, advantages, challenges, and future research directions.**

***Index Terms*—Microalgae, Chlorella vulgaris, CO_2 reduction, Vehicular emissions, Biofilter sticker, Hydrogel, Sustainable innovation.**

I. INTRODUCTION

Air pollution from vehicles remains one of the most persistent environmental challenges of the 21st century. Two-wheelers, which form the largest share of urban transport in many developing countries, emit harmful gases such as CO_2, CO, nitrogen oxides (NOx), and hydrocarbons. These pollutants contribute to smog formation, respiratory illnesses, and the greenhouse effect.

Traditional technologies such as catalytic converters and exhaust filters can reduce certain pollutants but are limited in addressing CO_2 emissions. Therefore, alternative and sustainable biological methods are being explored for carbon capture and air purification. Microalgae nature's own oxygen producers can serve as a powerful biological tool for pollution control.

This paper introduces an innovative concept: a bio-algae sticker that can be attached to vehicle silencers to absorb CO_2 and release oxygen. Unlike conventional devices, this sticker relies on a living biological process to convert harmful gases into beneficial oxygen, offering a green solution to vehicular emissions.

II. BACKGROUND AND LITERATURE REVIEW

Several studies have demonstrated the remarkable ability of microalgae to fix atmospheric carbon dioxide. Chlorella vulgaris, in particular, is widely studied for its high CO_2 uptake rate, rapid growth, and resilience under varying light and temperature conditions. Research by Singh and Sharma (2022) highlighted that Chlorella vulgaris can capture up to 50% of emitted CO_2 in controlled systems.

Hydrogel-based algae cultivation systems have also been developed to maintain moisture and provide structural stability for microalgae. Li et al. (2021) demonstrated that algae embedded in polymer-based hydrogels could photosynthesize efficiently for extended periods. Moreover, the hydrogel medium allows the algae to remain active without continuous water flow a key feature for mobile applications like vehicle-mounted systems.

Existing biofilters and algae bioreactors used in industries are effective but bulky and expensive. No compact, portable biological solution currently exists for small-scale or vehicular applications. Hence, this study proposes the bio-algae sticker as a novel, scalable, and low-cost concept that can be easily adapted to individual vehicles.

III. CONCEPT AND DESIGN

The bio-algae sticker is envisioned as a thin, flexible, and multi-layered sheet that can be attached to or near the exhaust outlet of two-wheeler vehicles. The basic working principle is the absorption of CO_2 from exhaust gases and the release of oxygen through photosynthesis by living algae cells.

Structural Components:

1. Heat Shield (Mica or Ceramic): Protects the algae from direct exhaust heat, allowing only filtered warm air to pass.
2. Support Frame: Provides shape and stability to the sticker structure.
3. Moisture Sponge: Retains humidity necessary for algae survival.
4. Algae Hydrogel Layer: Contains live Chlorella vulgaris culture in a nutrient-rich gel.
5. Protective Mesh: Prevents physical damage while allowing airflow and light penetration.
6. Transparent UV Film: Permits sunlight for photosynthesis while shielding the algae from harmful UV rays.

Working Principle:

The bio-algae sticker functions using natural photosynthesis. When the vehicle runs, CO_2 from exhaust gases diffuses into the algae hydrogel. The hydrated algae absorb this CO_2 and convert it into oxygen and biomass through the photosynthetic process.

The UV film allows sunlight to reach the algae, while the heat shield prevents thermal damage. The moisture sponge keeps the microbes active, ensuring continuous CO_2 capture. Although each sticker captures a small amount individually, large-scale adoption could significantly reduce localized CO_2 levels. The used algal biomass can be repurposed as organic fertilizer.

Expected Benefits

1. Environmental Impact: Helps in direct CO_2 absorption from vehicle emissions and improves air quality.
2. Health Benefits: Reduces harmful gases that cause respiratory and cardiovascular disorder.
3. Sustainability: Uses renewable biological materials and promotes green technology.
4. Cost-Effectiveness: Low production and maintenance cost compared to mechanical filters.
5. Scalability: Can be applied to various vehicle types or adapted to urban installations like traffic lights or tunnels.
6. Educational Value: Encourages public awareness of environmental responsibility and green innovation.

Limitations and Scope for Future Work

1. Survival of microalgae under high-temperature exhaust conditions requires testing.
2. CO_2 absorption efficiency varies with sunlight availability.
3. Long-term durability and maintenance methods need experimental validation.
4. Future designs can incorporate smart sensors, automated hydration systems, or nutrient microcapsules.

IV. CONCLUSION

The bio-algae sticker represents a novel and sustainable approach to mitigating vehicular pollution through natural biological processes. By harnessing the carbon-fixing ability of Chlorella vulgaris, this concept transforms vehicle exhaust into an opportunity for carbon capture. Its simplicity, affordability, and eco-friendliness make it an attractive solution for future green transportation systems.

Although theoretical, this innovation highlights the potential of bioengineering in addressing pressing environmental issues. With further research, prototype testing, and optimization, the algae sticker could become a practical and impactful step toward achieving cleaner air and sustainable urban mobility.

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