Affordable Portable Air Purification System for Wildfire-Affected Communities

A. Executive Summary

Wildfires across the United States are becoming more frequent and severe, exposing millions of people to dangerous smoke long after the flames are extinguished. In many affected communities, families are forced to breathe polluted indoor air because existing air purifiers are too expensive or inaccessible. Wildfire smoke contains harmful particles and toxic gases that can trigger asthma, worsen heart and lung disease, and create long-term health risks, especially for children, elderly individuals, and vulnerable populations.

This proposal introduces a low-cost, portable air purification device that uses biochar-based filtration to remove harmful smoke pollutants from indoor air during wildfire emergencies. Unlike many commercial systems that cost hundreds of dollars and require expensive filter replacements, this device is designed to be affordable, portable, and practical for communities with limited resources.

By combining sustainability, accessibility, and humanitarian impact, this project aims to provide a realistic solution to a growing public health crisis. Funding this proposal would support the development of a life-saving technology to help communities recover more safely and quickly after wildfires.

B. Introduction & Problem Context

Wildfires have become one of the most destructive and rapidly growing natural disasters in the United States. States such as California and Oregon continue to experience severe wildfire seasons that affect millions of residents each year. While public attention often focuses on the destruction caused by flames, the danger does not end when the fire is over. Wildfire smoke can remain in homes, schools, hospitals, and shelters for days or even weeks after a disaster.

According to research on wildfire smoke and indoor air quality, wildfire smoke contains fine particulate matter and toxic chemicals that can seriously damage respiratory and cardiovascular health. Studies also show that activated carbon and carbon-based filters can effectively reduce harmful airborne pollutants during wildfire events.

One major problem is that existing air purification systems are often too expensive for many families. Commercial air purifiers commonly range from $150 to over $600, and many require costly HEPA filter replacements. During emergencies, low-income households and vulnerable communities may not have access to reliable indoor air protection.

As wildfire seasons continue to intensify because of climate-related conditions, there is an urgent need for affordable and accessible air purification systems designed specifically for emergencies.

C. Audience & Impact

This project is designed to support:

- Families living in wildfire-prone communities
- Children and elderly individuals
- Schools, shelters, and hospitals
- Low-income households
- Emergency response centers

The primary funding audience includes alumni donors from The City College of New York, environmental organizations, and public health-focused supporters interested in practical disaster relief solutions.

This audience should care because the project:

- Protects public health during disasters
- Supports disaster recovery efforts
- Expands access to affordable technology
- Encourages sustainable engineering solutions
- Addresses climate-related challenges affecting vulnerable populations

The humanitarian impact of this project is significant. Clean air should not become a luxury during emergencies. This device is intended to help people breathe safely in their homes and shelters when they need protection most.

D. Proposed Solution

The proposed solution is a portable air purification device that uses biochar-based filters to remove harmful smoke pollutants from indoor air.

What It Is

The device is a compact, lightweight, and easy-to-use portable air purifier designed specifically for wildfire emergencies. The system is intended to be small enough for indoor household use and portable enough to be moved between rooms or emergency shelters.

Estimated prototype dimensions:

- Height: approximately 12–15 inches
- Width: approximately 8–10 inches
- Weight: approximately 5–8 pounds

These dimensions would allow the device to remain portable while still providing effective air filtration.

How It Works

The purifier operates through a simple three-step process:

1. A small fan pulls smoky indoor air into the device
2. Air passes through a biochar-based filter that traps smoke particles and toxic gases
3. Cleaner air is released back into the room

The system is designed to operate using a standard wall outlet or a portable battery source during emergencies.

Why Biochar?

Biochar is a carbon-rich material created from waste biomass such as wood waste or agricultural byproducts. Research on activated carbon and carbon-based sorbents has shown that these porous materials are highly effective at capturing airborne pollutants and volatile organic compounds.

Biochar offers several important advantages:

- Low-cost and widely available
- Highly porous and effective at trapping pollutants
- Sustainable and environmentally friendly
- Replaceable without expensive proprietary parts

Using biochar also supports sustainable engineering practices by turning waste materials into valuable filtration products.

E. What Makes This Different

Many portable air purifiers already exist, but most are not designed for wildfire emergency accessibility.

Limitations of Existing Systems

Most commercial systems:

- Costs between $150 and $600 or more
- Require expensive HEPA filter replacements
- Focus on general indoor use rather than disaster response
- Remain inaccessible to many low-income households

Advantages of the Proposed Device

Feature	Existing Devices	Proposed Device
Cost	High ($150–$600+)	Low ($40–$80 estimated)
Filter Type	HEPA + carbon	Biochar (low-cost, replaceable)
Accessibility	Limited	Designed for all income levels
Purpose	General use	Wildfire emergency-focused
Sustainability	Moderate	High (uses waste materials)

Unlike many commercial systems, this proposal focuses on affordability, portability, and emergency readiness rather than luxury consumer features.

F. Feasibility & Implementation

Research already demonstrates that carbon-based filtration systems can effectively reduce wildfire smoke pollutants indoors. Portable air purification technology also already exists, making this project realistic and achievable within an undergraduate research setting.

Materials Needed

- Small electric fan
- Biochar filtration material
- Lightweight plastic or recycled housing
- Power source (battery or wall outlet)
- Airflow and testing equipment

Implementation Plan

Phase 1: Research & Design (1–2 Months)

- Research wildfire smoke pollutants
- Design prototype structure
- Identify appropriate biochar materials

Phase 2: Prototype Development (2–3 Months)

- Build a prototype device
- Assemble the filtration system
- Begin airflow testing

Phase 3: Testing & Improvement (1–2 Months)

- Measure smoke filtration effectiveness
- Evaluate airflow efficiency
- Test filter replacement process
- Identify defects or performance weaknesses
- Improve durability, portability, and filtration performance

Testing would focus on whether the device successfully reduces visible smoke particles and improves indoor air quality compared to untreated conditions.

G. Budget Overview

Category	Estimated Cost
Materials (fan, casing, filters)	$60
Biochar production/testing	$40
Prototype development	$100
Testing & improvements	$75
Miscellaneous costs	$50
Total Estimated Cost	**$325**

This relatively low budget demonstrates that the project is realistic, scalable, and appropriate for undergraduate research funding.

H. Qualifications & Credibility

This proposal is supported by existing research on activated carbon adsorption, wildfire smoke filtration, and portable purification systems.

As a Chemical Engineering student at The City College of New York, I have developed a strong foundation in materials science, filtration systems, mass transfer, and environmental engineering concepts that directly support this project. With guidance and mentorship from a faculty member in the department, I will refine, test, and improve this design using both academic knowledge and expert support.

This combination of engineering training, faculty mentorship, and existing scientific research makes the project both credible and achievable.

I. Conclusion

Wildfires are no longer temporary environmental events; they have become a growing public health crisis that continues to threaten families long after the flames are gone. Across the United States, millions of people are exposed to dangerous smoke that enters homes, schools, hospitals, and shelters, placing vulnerable communities at

serious risk. Yet access to clean and safe air during these emergencies remains too expensive for many families.

This proposal presents a practical and affordable solution: a portable biochar-based air purification system designed specifically for wildfire emergencies. By combining low-cost materials, sustainable engineering, and accessible design, this project aims to provide communities with a realistic tool that can protect health, improve recovery, and reduce the long-term impact of wildfire smoke exposure.

With funding and support, this project has the potential to become more than an undergraduate research idea. It can become a life-saving innovation that helps families breathe safely, strengthens disaster preparedness, and demonstrates how engineering can create meaningful solutions for real human challenges.

Works Cited

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