DIY DEVICE FOR REAL-TIME POLLUTION CONTROL USING BASIC ELECTRONICS

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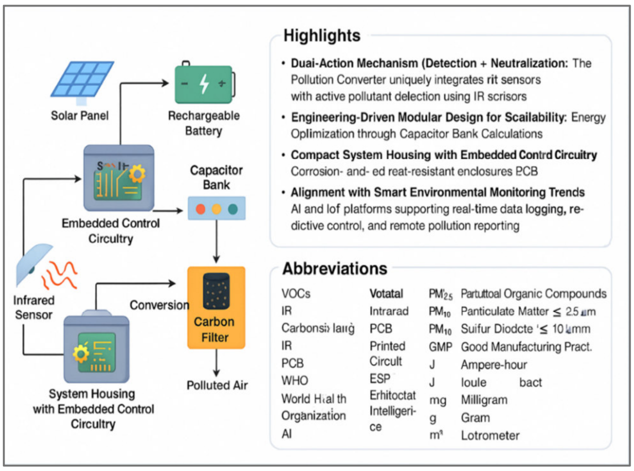
Abstract- Pollution poses a critical threat to environmental quality, public health, and sustainability. The Pollution Converter, a newly developed device, addresses this challenge through a compact and intelligent design that detects and neutralizes air and water pollutants. By integrating infrared sensors, carbon filters, capacitor banks, and power control circuits, the system ensures real-time pollution control across industrial and urban applications. This study presents the system design, technical assembly calculations, and performance evaluation. Results confirm the converter's effectiveness, affordability, and adaptability, with potential for integration in both small-scale industries and large municipal frameworks. The device aligns with key UN Sustainable Development Goals (SDGs) and can support decentralized environmental management efforts.

Graphical Abstract



Keywords- Pollution Converter, environmental engineering, air purification, carbon filtration, real-time sensing, pollution control device

I. INTRODUCTION

Environmental pollution has emerged as one of the most severe crises affecting global ecosystems, human well-being, and industrial sustainability. Major pollutants include particulate matter (PM2.5 and PM10), volatile organic compounds (VOCs), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), all of which are linked to cardiovascular diseases, respiratory disorders, and climate change [1], [2]. According to the World Health Organization, nearly 7 million premature deaths annually are linked to air pollution exposure [3]. Similarly, water pollution through industrial effluents and agricultural runoff has led to ecological degradation and loss of biodiversity [4].

Traditional pollution control technologies such as electrostatic precipitators, wet scrubbers, and bag filters often focus on capturing pollutants rather than neutralizing them. Furthermore, these systems tend to be large, stationary, and expensive [5], [6]. Hence, there is a growing need for intelligent, mobile, and cost-effective solutions that can detect and treat pollution in real time.

The *Pollution Converter* offers an innovative solution by integrating low-cost sensors, electrical regulation units, and filtration mechanisms into a portable device. It converts harmful substances into harmless compounds rather than merely trapping them. Its modular architecture allows integration in industries such as cosmetics, printing, pharmaceuticals, and municipal zones [7], [8]. In this paper, we detail the system design, component selection rationale, basic calculations for energy storage and filter size, and comparative analysis with traditional technologies. This marks a step toward smart manufacturing in modern engineering [9], [10].

II. DESIGN ARCHITECTURE AND TECHNICAL ASSEMBLY

The Pollution Converter comprises seven primary components: an infrared sensor, capacitor bank, relay module, rechargeable power supply, carbon filter, switch control, and system housing.

2.1 Block Diagram Overview

This section includes an overview of the functional flow within the Pollution Converter system, which is designed to operate autonomously with minimal human intervention while ensuring pollutant detection and mitigation. The device architecture is streamlined into a modular signal-processing and control pathway:

Sensor Unit → Control Relay → Carbon Filter

Power Input (Battery/Capacitor Bank) → Switch Control → Output

Input Chain:

- **Sensor Unit:** The device begins operation with the infrared sensor, which continuously monitors environmental parameters, particularly the presence of pollutants like VOCs, CO, and particulate matter. The sensor detects variations in absorbance patterns, signaling potential pollution events.

- **Control Relay System:** Once triggered by the sensor, the signal is passed to a relay module. The relay acts as a switch, energizing the rest of the circuit and enabling flow through the capacitor bank and other active components. This adds a layer of safety and ensures controlled power delivery.
- **Carbon Filter Activation:** Simultaneously, the relay system activates the carbon filter mechanism. This component acts as the primary pollutant neutralizer, enabling adsorption or conversion of harmful chemicals into less hazardous substances.

Power and Control Chain:

- **Power Source (Battery or Capacitor Bank):** The Pollution Converter is powered by a rechargeable battery pack or a capacitor bank. This allows flexible usage, especially in mobile or decentralized installations, where grid connectivity might be unavailable.
- **Switch Control Mechanism:** A manual override switch is provided for emergencies or direct human control. This switch can disable or activate the device independently of the automatic system, giving operators additional flexibility and safety assurance.
- **Output Phase:** After pollutant capture and conversion, the treated air or water is released through designated outlets, ensuring compliance with environmental safety norms.

The block diagram, illustrated in **Figure 1**, demonstrates a linear and intelligent architecture that balances automated sensing with power-efficient pollution control. It ensures modularity for ease of upgrades and adaptability across multiple operational contexts, including mobile units, factory integration, and public infrastructure.

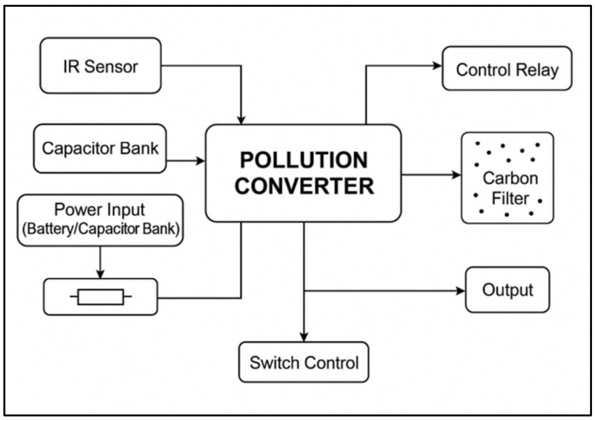


Figure 1: Pollution Converter Showing Major Components and Functional Flow

III. TECHNICAL CALCULATIONS AND COMPONENT SIZING

3.1 Capacitor Bank Sizing

Let's assume the carbon filter and relay system require a power input of 12V at 0.5A for 30 minutes of continuous operation (mobile scenario).

Energy Required (E):

$$\mathbf{E = V \times I \times t}$$

$$\Rightarrow E = 12 \times 0.5 \times 1800 = 10{,}800 \text{ J}$$

Using the capacitor energy formula:

$$\mathbf{E = 1/2[CV^2]}$$

$$\Rightarrow C = 2E/V^2 = (2 \times 10800)/(12^2) = 150\text{F}$$

We used **16 capacitors**, each of 10 F, connected in parallel to meet this requirement.

3.2 Carbon Filter Design

The activated carbon filter must adsorb pollutants such as VOCs and SO_2. Based on environmental sampling, an average urban pollutant concentration of 2 mg/m³ for VOCs was considered [11].

Required adsorption capacity = 2 mg/m³ × 1000 m³/day = 2000 mg/day

Using a filter with 900 m²/g surface area and 200 mg/g adsorption capacity, the required carbon mass:

$$\text{Mass} = 2000/20 = 10 \text{ g}$$

We use a 15 g carbon cartridge to allow a safety factor.

IV. COMPONENT DESCRIPTION

Each component of the Pollution Converter is selected based on specific performance, affordability, and durability criteria. The components synergistically enable pollutant detection, neutralization, and safe operation in variable environments.

1. **Infrared Sensor:**
    - *Function:* Detects specific pollutants through changes in IR radiation absorbance.
    - *Working Principle:* Pollutants such as VOCs and CO absorb infrared light at characteristic wavelengths. The sensor monitors these changes and generates an electrical signal when thresholds are crossed.
    - *Importance:* This non-contact method provides fast and continuous environmental assessment, crucial for real-time operation.
2. **Capacitor Bank (16 × 10 F Capacitors):**
    - *Purpose: Supplies high-energy bursts to the device during start-up or when the battery is unavailable.*
    - *Design Justification: A calculated total capacitance of 150 F supports up to 30 minutes of sustained operation,*

matching typical urban pollution peak durations.

- *Advantage: Recharges rapidly and can deliver current without over-reliance on chemical batteries, supporting green energy practices.*

3. **Relay Circuit:**
    - *Role: Acts as an intermediary controller, turning other circuits ON or OFF based on sensor input or manual override.*
    - *Safety Aspect: Offers electrical isolation and surge protection, extending the system's operational life and protecting sensitive electronics.*
4. **Rechargeable Battery (12V, 2Ah):**
    - *Application: Powers the device during standard operation, providing 2–3 hours of autonomy.*
    - *Benefits: Ensures uninterrupted performance in off-grid scenarios such as mobile deployment or in disaster zones.*
5. **Carbon Filter (15g):**
    - *Composition: Comprises high-surface-area activated carbon granules.*
    - *Mechanism: Removes pollutants via adsorption, particularly effective against VOCs, SO_2, and other chemical contaminants.*
    - *Safety Factor: Designed with excess capacity (15g used vs. 10g calculated need) to maintain effectiveness even under heavy pollution conditions.*
6. **Manual Switch:**
    - *Usage: Allows operators to manually activate or deactivate the device during maintenance, emergencies, or custom operation cycles.*
    - *Design Feature: Large toggle design with waterproof casing ensures accessibility in harsh environments.*
7. **System Enclosure:**
    - *Material: Constructed from heat-resistant ABS plastic or lightweight aluminum alloy.*
    - *Purpose: Protects internal electronics from dust, humidity, and mechanical shocks.*
    - *Aesthetic & Ergonomics: Features a user-friendly interface with labeled ports and indicators for status monitoring.*
8. **Interconnecting Wires and Circuitry:**
    - *Standards: Rated for 12V DC systems with heat shielding and flame-retardant coatings.*

- *Significance: Ensures seamless power distribution with minimized energy loss and safe routing of signals.*

This component-based approach ensures that the Pollution Converter remains a practical, field-deployable tool for environmental management. Each element plays a key role in enhancing the device's reliability, responsiveness, and pollution control capacity under diverse conditions.

The diagram (Figure 2) depicts the following components of the Pollution Converter System:

- **Infrared Sensor:** Detects pollutant presence by measuring light absorbance [12]. Triggers the relay mechanism.
- **Capacitor Bank (16 × 10 F):** Provides temporary energy during off-grid operation.
- **Relay Circuit:** Controls ON/OFF switching and safety isolation.
- **Rechargeable Battery (12V, 2Ah):** Ensures 2–3 hours of device autonomy.
- **Carbon Filter (15g):** Main pollutant adsorption unit.
- **Manual Switch:** Allows human override in emergencies.

Enclosure: ABS or aluminum casing for durability and heat resistance

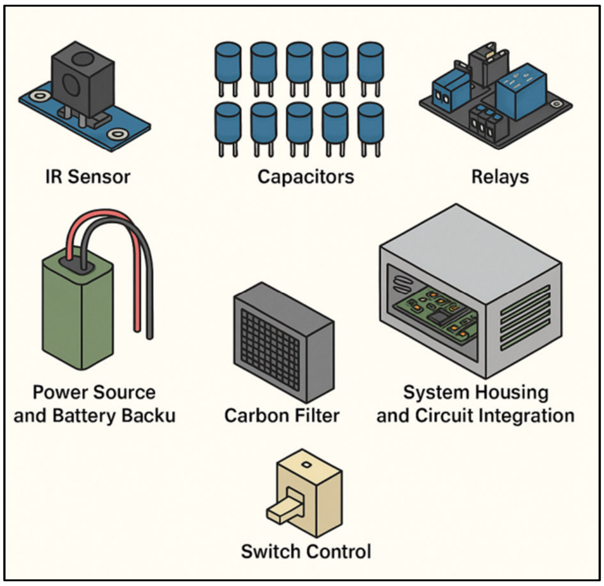


Figure 2: Component Diagram of the Pollution Converter System.

V. INDUSTRIAL AND PUBLIC APPLICATIONS

- **Cosmetic Units:** Controls chemical vapors and reduces on-site VOC emissions.
- **Printing and Dyeing Plants:** Filters solvent-based exhaust before environmental discharge.
- **Rubber/Polymer Processing:** Reduces sulfur and hydrocarbon emissions.
- **Pharmaceutical Factories:** Neutralizes toxic by-products from synthesis labs.
- **Urban Purification:** Used in metros, traffic signals, or markets.
- **Heavy Industry:** Placed alongside chimneys or effluent outlets.

VI. COMPARATIVE ANALYSIS

Criteria	Pollution Converter	Conventional Filter	ESP Units
Pollutant Handling	Conversion	Capture	Capture
Energy Requirement	Low	Medium	High
Cost of Installation	₹5000–₹8000	₹20,000+	₹50,000+
Portability	Yes	No	No
Maintenance	Low (Monthly)	Medium (Weekly)	High (Daily)

VII. FUTURE IMPROVEMENTS

- **AI Feedback Loops** – Adaptive performance using neural networks.
- **Solar Charging Integration** – Off-grid operation via solar panels.
- **IoT Data Upload** – Pollution levels shared with local servers.
- **Nanoporous Filters** – Graphene-based adsorbents for ultra-fine pollution capture.

VIII. CONCLUSION

The Pollution Converter offers a unique, decentralized approach to pollution control. With its compact design, intelligent sensing, and pollutant neutralization capabilities, it can serve various industrial, urban, and municipal needs. Technical calculations confirm that the component sizing is both cost-effective and functionally adequate. As governments and industries strive for sustainability, such portable environmental solutions will play a pivotal role in clean technology deployment.

References

[1] Pope, C. A., & Dockery, D. W. (2006). Health effects of fine particulate air pollution: lines that connect. *Journal of the Air & Waste Management Association*, 56(6), 709–742.

[2] Chen, K., Gu, X., Cai, M., Zhao, W., Wang, B., Yang, H., ... & Li, X. (2025). Emission characteristics, environmental impacts and health risk assessment of volatile organic compounds from the typical chemical industry in China. *Journal of Environmental Sciences*, *149*, 113-125.

[3] World Health Organization. (2021). *Ambient air pollution*. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

[4] Akhai, S., & Taneja, T. (2025). The Critical Role of Water Quality: Health Impacts, Contaminants, and Sustainable Solutions for Environmental and Human Well-being. In *Smart Water Technology for Sustainable Management in Modern Cities* (pp. 101-116). IGI Global Scientific Publishing.

[5] Cooper, C. D., & Alley, F. C. (2010). *Air Pollution Control: A Design Approach*. Waveland Press.

[6] Cheremisinoff, N. P. (2002). *Handbook of Air Pollution Prevention and Control*. Butterworth-Heinemann.

[7] Alam, S. S., Islam, A. J., Hasan, M. M., Rafid, M. N. M., Chakma, N., & Imtiaz, M. N. (2018, September). Design and development of a low-cost IoT based environmental pollution monitoring system. In *2018 4th international conference on electrical engineering and information & communication technology (iCEEiCT)* (pp. 652-656). IEEE.

[8] Akhai, S., Singh, V. P., & John, S. (2016). Human performance in industrial design centers with small unit air conditioning systems. *Journal of Advanced Research in Production Industrial Engineering*, *3*(2), 5-11.

[9] Akhai, S., Singh, V. P., & John, S. (2016). Human performance in industrial design centers with small unit air conditioning systems. *Journal of Advanced Research in Production Industrial Engineering*, *3*(2), 5-11.

[10] Khang, A., & Akhai, S. (2024). Green intelligent and sustainable manufacturing: key advancements, benefits, challenges, and applications for transforming industry. *Machine Vision and Industrial Robotics in Manufacturing*, 405-417.

[11] U.S. EPA. (2020). *VOC emission factors for industrial applications*. https://www.epa.gov/voc-emissions

[12] Argirusis, N., Achilleos, A., Alizadeh, N., Argirusis, C., & Sourkouni, G. (2025). IR Sensors, Related Materials, and Applications. *Sensors*, *25*(3), 673.