# DESIGN AND DEVELOPMENT OF POLLUTION CONTROL DEVICE USING ST MICROCONTROLLER NUCLEO FOR SUSTAINABLE INK PRODUCTION FROM AIR POLLUTANTS

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**Keywords:**

Pollution Control Device, Air Quality Monitoring, STM32 H563ZI, ESP32, Gas Sensors, PM2.5, HEPA Filter, Activated Carbon Filter, Zinc Oxide, IoT, Cloud Monitoring, Real-time Data, Embedded Systems, Sustainable Technology


**Introduction:**

This project is about designing and building a smart pollution control device that uses the STM32 H563ZI microcontroller to help manage the environment in a way that is good for the long term. Using several sensors, the system keeps an eye on important air quality factors like $CO_2$, CO, PM2.5, temperature, and humidity in real time. The device uses a multi-stage filtration system with HEPA and activated carbon filters and a ZnO-based solution to make the air cleaner. It does this based on the levels of pollution it detects. An ESP32 module enables IoT-based cloud connectivity, allowing remote monitoring and data visualization. The system also incorporates an airflow mechanism and energy-efficient operation, making it suitable for urban and industrial applications. Additionally, the collected particulate matter is utilized for sustainable ink production, promoting eco-friendly practices and contributing to pollution mitigation and circular economy principles.

**Objectives:**

1. To design and develop a pollution control device capable of capturing airborne pollutants using high-efficiency sensors and filtration mechanisms.
2. To implement pollutant capture through a filtration and purification system controlled by the ST Microcontroller Nucleo.
3. To enable real-time monitoring and automation through IoT integration and cloud-based visualization.
4. To construct a durable and lightweight enclosure using PVC for enhanced environmental resistance and portability.
5. To promote sustainable handling of collected particulate matter.

**Methodology:**

The project methodology focuses on designing an integrated embedded system for real-time air quality monitoring and pollution control. At the core of the system is the STM32 H563ZI microcontroller, which interfaces with multiple sensors including MQ-135, MQ-2, PM2.5, UV, and DHT11 to continuously monitor environmental parameters such as $CO_2$, CO, particulate matter, temperature, and humidity. The acquired sensor data is processed in real time to evaluate pollution levels and determine appropriate control actions.

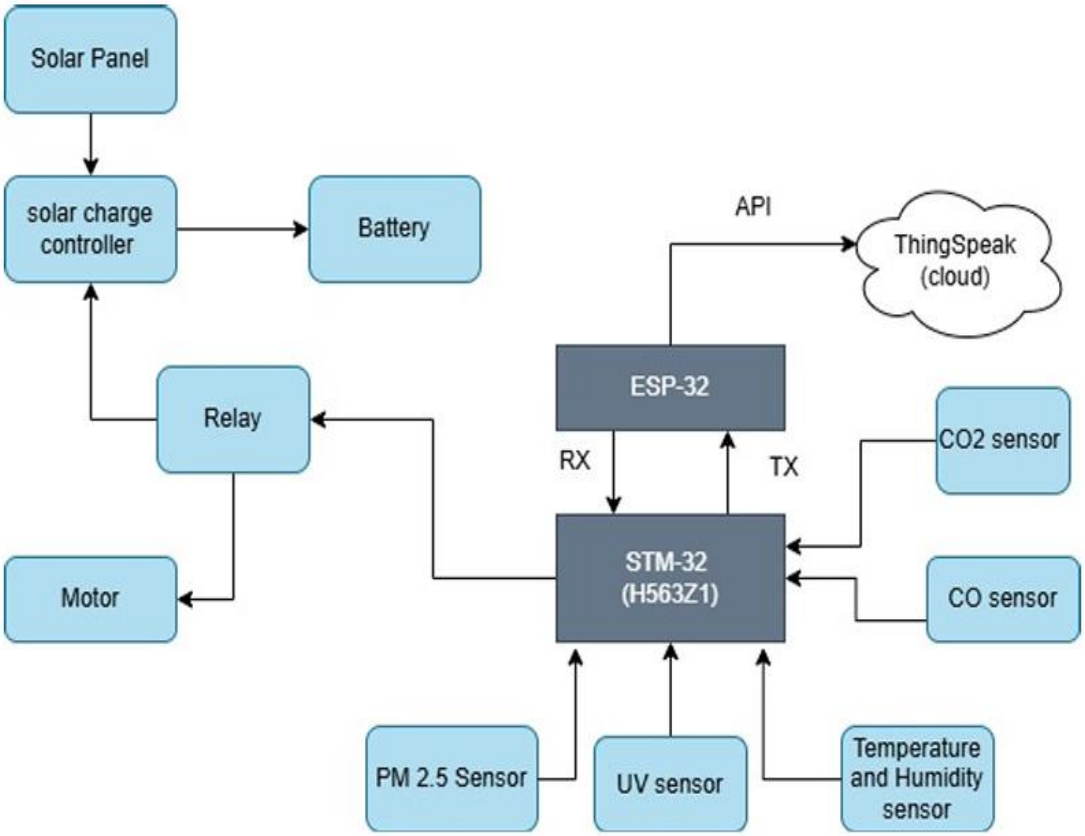


Figure 1: Model Design

An airflow system driven by a fan draws polluted air through a multi-stage filtration unit consisting of a HEPA filter, activated carbon filter, and a ZnO-based solution for effective removal of particulate and gaseous pollutants. Based on threshold conditions, the microcontroller controls a relay to activate or deactivate the purification process.

The ESP32 module is integrated with the STM32 via UART communication to enable IoT-based cloud connectivity. Processed data is transmitted to the ThingSpeak platform for remote monitoring and visualization. Additionally, a solar-powered energy system ensures efficient and sustainable operation. This tightly integrated system ensures synchronized sensing, processing, actuation, and monitoring for effective pollution mitigation.

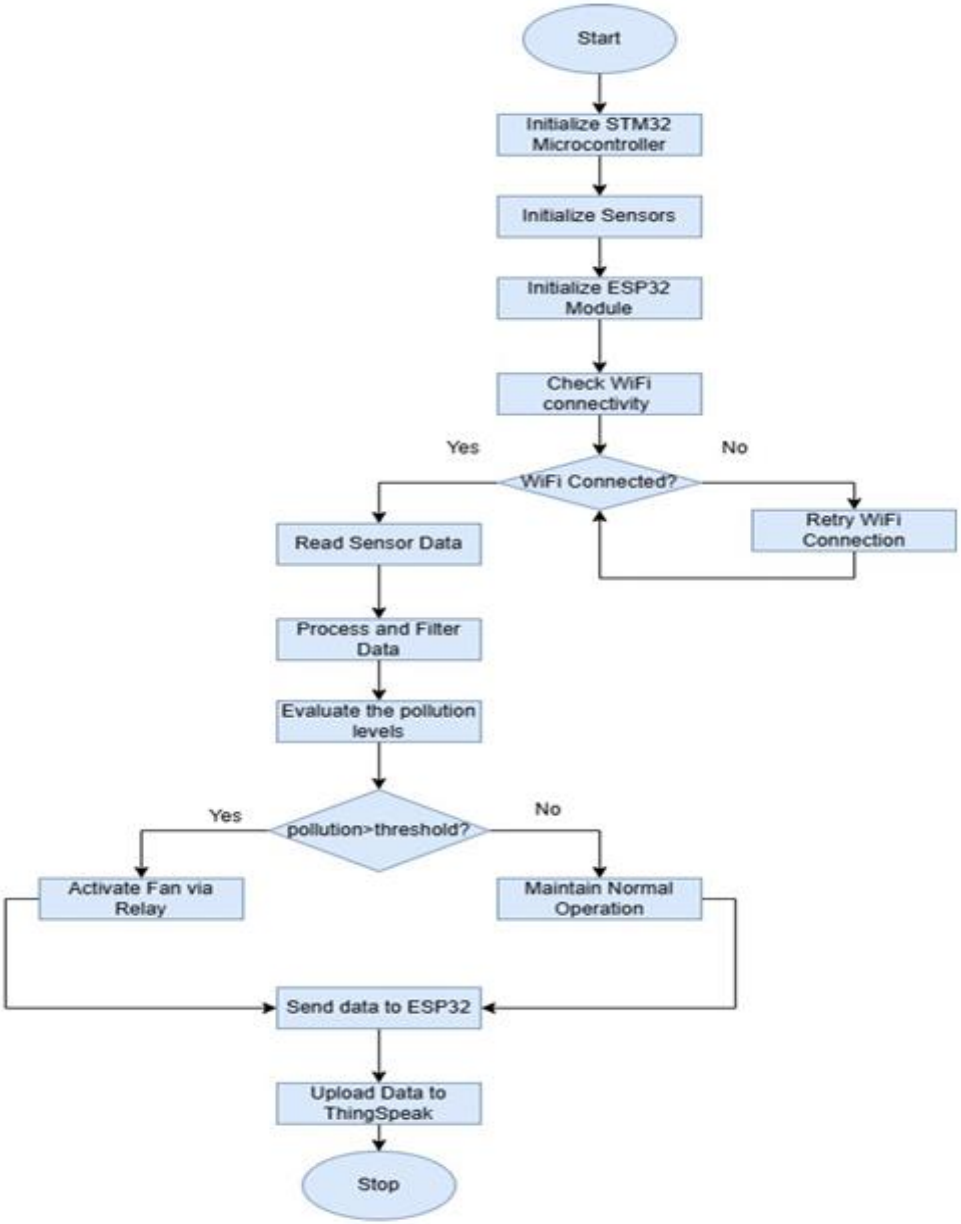


Figure 2: System functioning

**Result and Conclusion:**

In conclusion, the developed pollution control device successfully demonstrates efficient real-time air quality monitoring and purification using an integrated embedded system. The sensor readings for $CO_2$, CO, PM2.5, temperature, and humidity were accurately captured and processed, enabling effective evaluation of pollution levels. Based on these readings, the system automatically activated the multi-stage filtration unit, resulting in noticeable reduction of particulate matter and gaseous pollutants. The collection of soot confirmed the device's capability to capture harmful particles for further sustainable applications such as ink production. Additionally, IoT integration through the ESP32 allowed seamless cloud-based monitoring and visualization of environmental data. The system operated reliably with coordinated interaction between sensing, processing, and actuation modules. Overall, the project validates a cost-effective, scalable, and eco-friendly solution for pollution mitigation, contributing to improved air quality and sustainable environmental management.

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**Future Scope:**

The future scope of this project includes:

1. Integration of additional high-precision sensors to improve accuracy and enable monitoring of a wider range of pollutants.
2. Expansion of the system for large-scale deployment in smart cities and industrial environments with improved scalability.
3. Development of enhanced methods to convert collected pollutants into commercially viable products like ink and other sustainable materials.