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Durability and performance of Geotech Enclosure Box for air pollution detection

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ABSTRACT –

The Geotech Enclosure Box for air pollution detection project involves the design and manufacture of robust, weather-proof enclosures that protect sensitive monitoring equipment from harsh environmental conditions such as snow, rain, and strong winds. Built with durable materials, these enclosures ensure the long-term reliability and performance of the internal components. They are specifically engineered to maintain stable internal conditions, minimizing the impact of temperature fluctuations and humidity, which could otherwise compromise the accuracy of pollution-monitoring sensors. These enclosures house various air quality sensors, including those for particulate matter (PM2.5, PM10), nitrogen dioxide (NO_2), and carbon monoxide (CO), enabling continuous data collection for real-time environmental monitoring. Key features include high corrosion resistance, high ingress protection ratings (IP65/IP66), and adaptable mounting systems suitable for urban, industrial, or remote environments. They also offer convenient maintenance access for calibration and data retrieval, along with integrated communication interfaces such as cellular, Wi-Fi, and LoRaWAN for seamless data transmission to centralized or cloud-based systems. Addressing critical challenges like energy efficiency, maintenance accessibility, and operational stability in diverse settings, the Geotech Enclosure Box offers a practical and sustainable solution for industries and government agencies involved in pollution monitoring and environmental protection.

Keywords- Geotech Enclosure Box

INTRODUCTION

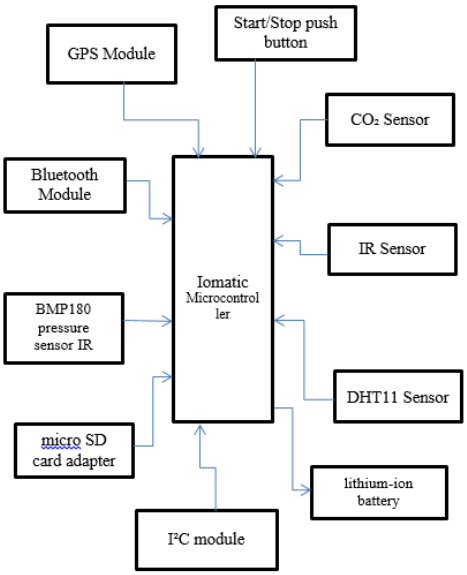
The project focuses on developing the Geotech Enclosure Box, a protective housing for pollution monitoring equipment designed to ensure durability, reliability, and accurate data collection in harsh environmental conditions. These enclosures safeguard sensors measuring air pollution from extreme weather, temperature fluctuations, and humidity, which could otherwise impact performance**.**Made from weatherproof and corrosion-resistant materials, the enclosures offer high ingress protection and feature easy installation and maintenance options suitable for various environments, including urban, industrial, and remote areas. They also support multiple communication interfaces like cellular, Wi-Fi or LoRaWAN for seamless data transmission to centralized systems.In terms of physical characteristics, the enclosure measures 8 cm in height and 15 cm in breadth, making it compact and portable. Despite its small size, the enclosure is engineered to optimize internal space and airflow. Ventilation holes are strategically integrated into the design to promote natural air exchange, prevent the buildup of heat from electronic components, and allow external air to reach the sensors without introducing contaminants like dust or rain. This ensures accurate sensor readings and thermal regulation, which are both critical for reliable long-term data collection.By ensuring uninterrupted and precise environmental monitoring,

METHOLOGY

Detailed overview of the design, development, and implementation process for the Geotech enclosure box used in air pollution monitoring.

- Initial research and analysis of existing enclouser box for air pollution detection and monitoring.
- Identifying and selecting the most suitable electronic components for reliable, real-time air pollution monitoring. Sensors and modules were chosen based on accuracy, power efficiency and precision. The enclosure's physical structure was carefully designed using Tinkercad, a user-friendly tool for rapid prototyping. It was chosen for Its ability to simulate component fitting,
- In the Geotech enclosure box design, strategically placed ventilation holes are included to enable controlled airflow while safeguarding internal sensors and electronics from dust, water, and pests.
- Making it well-suited for creating compact sensor-integrated enclosures.Material selection for the Geotech enclosure box was crucial to ensure protection of internal components in harsh environments.
- Once the enclosure was fabricated, Sensor integration and assembly phase commenced.
- After assembly, the system undergoes to testing and calibration process.Both are crucial step to ensure the reliability and accuracy of the Geotech enclosure box.

- In the Geotech enclosure box, environmental data collected from sensors is first stored locally on a micro SD card and the system uses Bluetooth and Wi-Fi modules to wirelessly transmit data to external devices. The transmitted data is displayed through a connected web application or mobile application.



1.1 Block diagram of Geotech Enclouser Box

Table 1- List of Component

Sr .No	Components	Function
1	Microcontroller (Arduino UNO)	It is a widely used open-source microcontroller board based on the ATmega328P chip.. It features 14 digital input/output pins, 6 analog inputs..
2	Neo-6M GPS Module	The Neo-6M is a high-performance GPS module designed for real-time geographic positioning. It operates at 3.3V or 5V .
3	MQ-6 Gas Sensor	The MQ-6 is a semiconductor-type gas sensor specifically designed to detect gases such as LPG, butane, propane, and methane. It operates on a 5V supply and outputs an analog signal proportional to the gas concentration.
4	IR Sensor	Used to detect the presence of airborne particulates and certain gaseous pollutants using infrared light absorption.
5	DHT11 Sensor	The DHT11 is a cost-effective sensor offering reasonable accuracy for general environmental monitoring purposes. .
6	Bluetooth Module	Used for short-range wireless transmission of data to smartphones or nearby computers, allowing real-time monitoring and system configuration.
7	BMP180 pressure sensor IR Sensor	This sensor is used in the Geotech enclosure to measure atmospheric pressure accurately. It works on the principle of piezoresistive sensing
8	I²C module	The I²C module facilitates communication between the microcontroller and multiple I²C-compatible devices using only two wires.
9	micro SD card adapter	This module is used to store environmental data collected by the sensors. It communicates with the microcontroller via SPI protocol
10	lithium-ion battery	The lithium-ion battery is used as the primary power source for the Geotech enclosure, offering high energy density in a compact form.

11	**start/stop push button**	**The start/stop push button provides manual user control over the data logging process. It is a simple momentary switch that connects to a digital input pin on the microcontroller.**

Description of component

The following components which are used in Geotech Enclouser Box :

1. Microcontroller (Arduino UNO): The Arduino Uno is a widely used open-source microcontroller board based on the ATmega328P chip. It features 14 digital input/output pins, 6 analog inputs, a USB connection for programming, and a power jack. The board runs at 16 MHz and operates at 5V, making it suitable for interfacing with a variety of sensors and modules. It includes built-in flash memory, SRAM, and EEPROM, which allow it to store code and data effectively.
2. Neo-6M GPS Module: The Neo-6M is a high-performance GPS module designed for real-time geographic positioning. It operates at 3.3V or 5V and communicates via UART, making it compatible with microcontrollers like the Arduino Uno. The module can track multiple satellites simultaneously and offers a location accuracy of approximately 2.5 meters under open sky conditions.
3. MQ-6 Gas Sensor: The MQ-6 is a semiconductor-type gas sensor specifically designed to detect gases such as LPG, butane, propane, and methane. It operates on a 5V supply and outputs an analog signal proportional to the gas concentration. The sensor has a sensitive element made of SnO_2 (tin dioxide), whose conductivity changes with the concentration of gases in the surrounding air, providing real-time gas detection capabilities.
4. The IR Sensor: This sensor is employed to detect particulate matter and gaseous pollutants using infrared light absorption or scattering techniques. These sensors are effective in identifying suspended particles like PM2.5 and PM10.Their integration allows the Geotech box to operate efficiently in real-time, providing critical information about air pollution levels. This data can be used to alert individuals in high-risk zones or initiate actions such as ventilation control or emission reduction in industrial setup..
5. DHT11 Sensor (Temperature and Humidity):
   The DHT11 sensor combines both temperature and humidity measurement capabilities in a single module, offering a compact and economical solution for environmental monitoring. While less accurate than high-end sensors, it provides sufficient precision for general air quality applications. Humidity levels are crucial in determining the behavior and presence of airborne particles, as moisture can cause certain pollutants to become more harmful or settle differently in the environment.
6. Bluetooth Module: The Bluetooth module provides wireless connectivity between the Geotech enclosure and nearby devices such as smartphones, tablets, or laptops. It uses UART serial communication to send sensor data and receive control commands wirelessly. Operating at 3.3V–5V with a range of up to 10 meters. It allows users to retrieve data or interact with the system without opening the enclosure or physically connecting cables.
7. The BMP180 pressure sensor: The BMP180 pressure sensor is used in the Geotech enclosure to measure atmospheric pressure accurately. It works on the principle of piezoresistive sensing, where the sensor's internal diaphragm deforms slightly under pressure changes, causing a corresponding change in electrical resistance. This is converted into a digital signal via its onboard analog-to-digital converter and transmitted over the I2C communication line.
8. I^2C module: The I^2C module facilitates communication between the microcontroller and multiple I^2C-compatible devices using only two wires: SDA (data) and SCL (clock). This bus system reduces wiring complexity and allows efficient integration of sensors like the BMP180. The I^2C bus typically supports data transfer speeds of 100 kHz to 400 kHz.
9. Micro SD card adapter module :The micro SD card adapter module is used to store environmental data collected by the sensors. It communicates with the microcontroller via SPI protocol and can write to FAT-formatted SD cards with capacities up to 32GB. Operating at 3.3V–5V, the module allows for long-term data logging even in offline conditions.
10. Lithium-ion battery : This battery can power the system for extended periods depending on load. A battery management system (BMS) is often included to protect against overcharging and deep discharge. Its inclusion ensures that the enclosure operates independently of external power sources.
11. start/stop push button : The start/stop push button provides manual user control over the data logging process. It is a simple momentary switch that connects to a digital input pin on the microcontroller. When pressed, it triggers software routines to start or stop data recording. This button operates at standard logic levels (3.3V–5V) and is integrated to enhance usability, giving field operators an easy way to manage system operation without needing a computer interface.

CONCLUSION

This project presents a smart, eco-friendly, and modular air pollution monitoring system housed in a PLA-based enclosure designed using Tinkercad. It integrates multiple sensors (CO_2, IR, DHT11, GPS), a microcontroller, Bluetooth, and an SD card for data logging. The enclosure is optimized for airflow and protection, ensuring accurate sensor performance. Real-world testing confirmed the system's reliability, accuracy, and stable communication. Key achievements include its low cost, portability, real-time data capabilities, and environmental sustainability. The system is scalable for broader applications and has future potential for upgrades like solar power, advanced sensors, cloud analytics, and enhanced weatherproofing. It demonstrates how accessible tech and thoughtful design can support environmental monitoring and research. This project stands as a testament to the power of accessible technology and innovative design in tackling critical environmental challenges. It delivers not just a functional prototype, but a promising platform that can inspire and empower further research, education, and actionable change in the realm of environmental monitoring.

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REFERENCE

1. Jacopo Corona, Stefano Tondini, Duccio Gallichi Nottiani ,Wilmer Pasut, Francesco Babich , Roberto Lollini , Riccardo Scilla , Andrea Gambaro 28 March 2024, Environmental Quality bOX (EQ-OX): A Portable Device Embedding Low-Cost Sensors Tailored for Comprehensive Indoor Environmental Quality Monitoring.
2. Montaser N.A. Ramadan, Mohammad Alherbawi,Mohammed A.H.Ali , Shin Yee Khoo, Mohammad Alkhedher 2024,Real-time IoT-powered AI system for monitoring and forecasting of air pollution in industrial environment.
3. Gäbel, P. Koller, C. Herting ,Development of Air Quality Boxes Based on Low-Cost Sensor Technology for Ambient Air Quality Monitoring. Sensors.
4. Daniel Burge and Andrew Lerwill; Image Permanence Institute, Rochester Institute of Technology, Rochester, NY,Mitigation of Pollution-induced Deterioration of Digital Prints through the Use of Enclosures.
5. Michelle A. North ,David W. Kinniburgh &Judit E. G. Smits 24 Nov 2017,Enclosure design for flock-level, chronic exposure of birds to air contaminant mixtures.
6. P Gäbel, C Koller, E Herting 2022, Development of Air Quality Boxes Based on Low-Cost Sensor Technology for Ambient Air Quality Monitoring.
7. Y Lv, X Wang, D Liu - Urban Climate 2025. Predicting environmental pollutants in the apartment public space: Evaluating the impact of spatial enclosure and monitoring locations.
8. F Lenartz, M Dury, B Bergmans, V Hutsemékers 2021,Antilope, A Portable Low-Cost Sensor System for the Assessment of Indoor and Outdoor Air Pollution Exposure.
9. RB Ramakrishna Subramanya ,Rakshith Bharadwaj 2021,Cabin air-Quality pollution detection and prevention.
10. U Schilt, B Barahona, R Buck, P Meyer, P Kappani 2023 , Low-Cost Sensor Node for Air Quality Monitoring: Field Tests and Validation of Particulate Matter Measurement.