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# Harnessing Machine Learning With Iot For Intelligent Environment Monitoring And Sustainable Ecosystem Management

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**Abstract:** *Machine learning, a prevailing application of Artificial Intelligence (AI) is an effective weapon in the fight against environmental degradation that can model climate change and develop more sustainable production techniques. Meanwhile, the Internet of Things (IoT) can transmit data across networks without the need for human intervention. It is essential to identify dangerous materials in the environment in order to safeguard ecosystems and human health. Artificial intelligence (AI), as technology develops, has become a promising technique for developing sensors that can efficiently identify and evaluate these dangerous materials. The use of information technology for environmental pollution detection is becoming more popular as a result of its rapid improvements. The Internet of Things (IoT), machine learning (ML), and sensor systems can be effectively employed for environmental monitoring, including the detection of soil toxins, water pollutants, and air pollutants. This paper describes the development of an Internet of Things (IoT)-based system that uses sensor networks to detect CO, CO2, and alcohol in a real-time environment. To gather real-time data on air pollution, such systems have been erected at different locations across the city. In order to identify the sustainable environment, the collected data was processed using an ML model on the central server. Additionally, results can be posted on the website for public distribution.*

***Keywords:*** *Machine Learning, Internet of Things, Air Quality Index.*

## INTRODUCTION:

Environmental hazards are pollutants that endanger the ecosystem, plant and animal life, or human health. Heavy metals, pesticides, herbicides, and persistent organic pollutants (POPs) are among the compounds that have been released into the environment through a variety of methods [1]. Hazardous materials in soil can come from a variety of sources, including natural processes like weathering and erosion, industrial operations, agricultural practices, and inappropriate disposal of hazardous waste. These compounds have the potential to negatively affect soil quality, plant growth, and human health, and they can linger in the environment for extended years [1]. Depending on the kind, concentration, and length of exposure, hazardous substances can have different effects on the environment. While certain dangerous drugs can result in persistent health issues including cancer, reproductive diseases, and developmental abnormalities, others can produce acute health impacts like respiratory issues, skin irritation, poisoning, nausea, and vomiting [1].

Air
pollution is the biggest environmental and public health challenge in the world today. Air pollution causes adverse effects on human health, climate and ecosystems [2]. One of the main causes of global warming is the emission of carbon dioxide into the atmosphere [3]. Currently, the decline in air quality in several cities in Indonesia is increasing continuously due to industrial growth.

The largest threat to the environment and public health in the modern world is air pollution. The climate, ecosystems, and human health are all negatively impacted by air pollution [2]. Carbon dioxide emissions into the atmosphere are one of the primary causes of global warming [2]. Due to the expansion of industry, the quality of the air is currently steadily declining in a number of Indian cities. Technology that can deliver real-time information and warnings regarding air quality levels and be directly monitored online is essential for determining if the air quality is good or terrible. The Internet of Things (IoT), whose fundamental idea is the capacity to transmit data over a network, is one of the technologies that can be employed.

A Raspberry Pi is an inexpensive, credit card-sized computer that may be used for a number of things, such as robotics, home automation, industrial automation, Internet of Things devices, and hobby projects. The flagship Raspberry Pi series—often just called "Raspberry Pi"—offers a full Linux operating system, a number of standard ports, and high-performance hardware in a small package. A Raspberry Pi can interact with a variety of gas sensors for uses such as leak detection and environmental monitoring. Catalytic gas sensors, electrochemical sensors, and MQ series sensors (such as MQ-2, MQ-3, and MQ-5) are common varieties; each has a unique set of sensing capabilities. For instance, the MQ-2 can identify alcohol, smoke, butane, methane, propane, and LPG. MQ-3 is specifically capable of detecting alcohol vapours. MQ-4 is capable of detecting CNG and methane. MQ-5 is capable of detecting LPG and natural gas. MQ-6 is capable of detecting butane and LPG. Carbon monoxide and hydrogen gas can be detected by MQ-7 and MQ-8, respectively. The MQ-9 can identify flammable gases including carbon monoxide. In the current investigation, the most promising MQ-135 has been employed to detect air quality (CO, ammonia, benzene, alcohol, and smoke). Numerous temperature and humidity sensors with varying features and degrees of accuracy are frequently used with Raspberry Pi. The DHT11 and DHT22 are well-liked options for simple temperature and humidity detection. DHT22 is more accurate and potent for the current research.

Data has been processed on the central server after being gathered from multiple points throughout Anand city. Regression tasks, which entail predicting continuous numerical values, are handled by Support Vector Regression (SVR), a machine learning algorithm that builds upon Support Vector Machines (SVMs). This model is used on the gathered data to identify and forecast environmental hazards. Predicted data has been made available for distribution on a web portal.

## LITERATURE SURVEY

Numerous techniques that can successfully identify and preserve a sustainable ecosystem have been researched. As seen in Figure 1 [1], one widely used approach divides AI solutions into three stages or phases: inputs (data), models (AI algorithms), and outputs (monitoring or decision support). The foundation of any AI solution is data. High data points are ideal for these models, particularly those originating from surroundings that are continuously observed and awaiting solutions for likely behaviours. Numerous sensors, including distant and in-contact sensors that produce vast amounts of data, as well as imaging and non-imaging types, can serve as data sources. Massive volumes of sensor readings, historical data, and other crucial information from monitoring systems can be analysed by AI algorithms [1]. By employing machine learning and data mining techniques to find patterns, trends, and anomalies in data, artificial intelligence (AI) can discover hazardous substance levels and contamination occurrences. Using satellite or drone shots, image analysis can identify spills of dangerous materials. Algorithms using computer vision can identify pollutants, chemicals, and changes in vegetation. Using historical data, AI algorithms can be trained to forecast the release of dangerous materials and pollution of the environment. Therefore, autonomous pollution monitoring systems, decision support systems, and early warning systems for the release of dangerous materials are examples of AI solutions for environmental monitoring. Organisations and authorities can use these models to better plan for and handle emergencies [1].

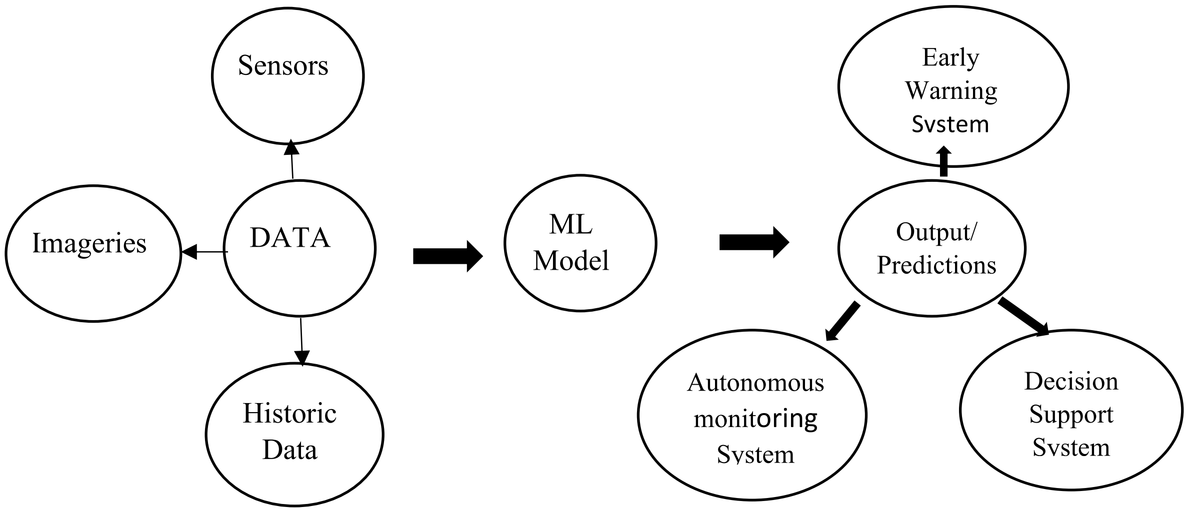


Figure 1: Data and AI algorithms for hazardous substance monitoring and containment [1]

Another well-known method suggests an air quality monitor that uses DHT11 and MQ135 sensors, an Arduino Uno, and a Raspberry Pie to detect CO, CO2 gases, and alcohol in real time. It can also display web-based data to show the temperature and air humidity [2]. The suggested approach can effectively display every air quality parameter on the website and offer recommendations regarding the general level of air quality. According to Figure 2, the system will begin collecting data as soon as the DHT11 sensor begins measuring the temperature and humidity of the air. The MQ135 sensor, which is connected to the Raspberry Pi and the internet, will then begin to identify air contamination. After that, the recorded data will be uploaded to the database and made available online. When residents visit the web, they can view the outcomes of air quality monitoring [2].

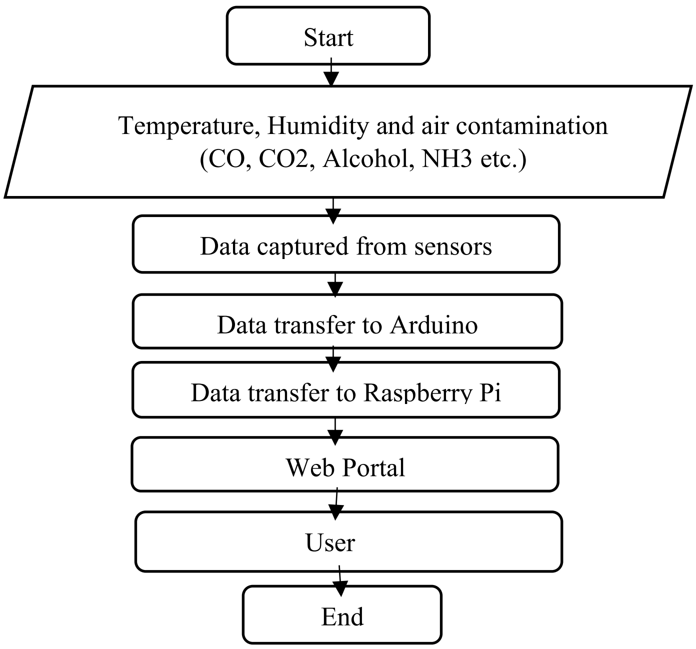


Figure 2: Flowchart for Air Quality Monitoring System [2]

**PROPOSED METHOD**

The suggested method not only gathers data on air pollution but also uses machine learning (ML) to interpret this data and determine whether or not the ecosystem is sustainable. In order to gather data on temperature, humidity, CO, CO2, and alcohol compounds, the Raspberry Pi module has been equipped with MQ135 and DHT22 sensors, as shown in Figure 3. A Wi-Fi module connects the Raspberry Pi to the internet directly, allowing it to continuously upload the data it has collected to the central web page. SVR is a machine learning model that was trained using data that had already been gathered. The model was then evaluated using data that had just been received to determine whether or not the current environmental circumstances were sustainable. On the portal, the resulting data has been shown.

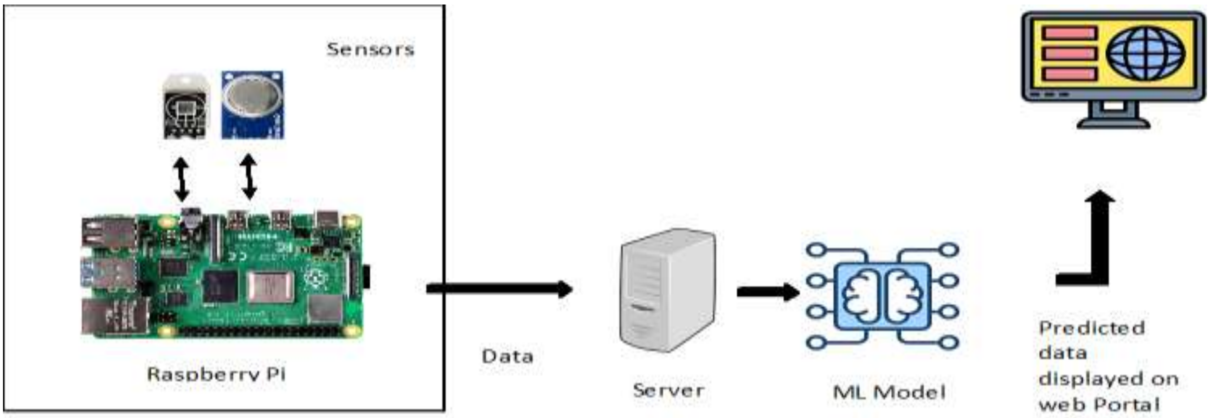


Figure 3: Proposed architecture for Environment Monitoring and Sustainable Ecosystem Management

The following rating categories will be used by the DHT22 sensor to determine humidity and temperature in Celsius: The gateway instantly notifies it if the air temperature rises to 35 to 40 degrees Celsius, indicating that it is still within normal limits. The site instantly alerts users with a red light if the ambient temperature rises above 40 degrees Celsius. The National Ambient Air Quality Standards (NAAQS) evaluation criteria are still followed by the MQ135 sensor when detecting air pollution. Figure 4 displays the system flow diagram.

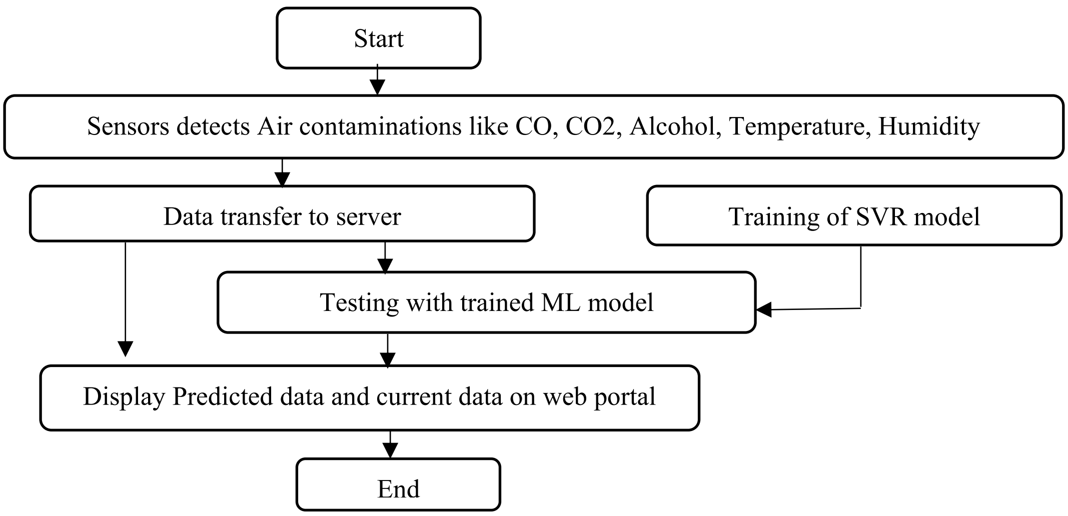


Figure 4: Flow chart for the proposed system

## RESULTS AND DISCUSSION

Since the Raspberry Pi can only read digital data, an Arduino Uno has been linked to it in order to record the analogue data that the sensors have read. A serial connection on the Raspberry Pi is used to transfer data between the Arduino Uno and the Pi. Following that, the sensor's successfully collected data is synchronised with the prepared database. Table I displays the prepared dataset.

Table I: Data captured from Sensors

| Serial No. | Time Stamp | CO | CO2 | Alcohol | Humidity | Temperature |
|---|---|---|---|---|---|---|
| XiX001 | 12 January 2025 10:20 | 12 PPM | 25 PPM | 5 PPM | 47 % | 16$^o$C |
| XiX002 | 12 January 2025 10:20 | 15 PPM | 38 PPM | 2 PPM | 43 % | 18$^o$C |
| XiX003 | 12 January 2025 10:20 | 18 PPM | 30 PPM | 8 PPM | 40 % | 15$^o$C |
| : | : | : | : | : | : | : |
| XiX500 | 12 January 2025 10:21 | 11 PPM | 20 PPM | 7 PPM | 41 % | 16$^o$C |

Data has been gathered from Anand City's multiple places. Data from the ADIT campus in New Vidyanagar, Anand, is shown in Table I. According to Table I, the DHT11 sensor registers an ambient temperature of 16 °C; the sensor chart displays a red value since this number is beyond the typical temperature range. Additionally, the DHT22 sensor detects 47% of the ambient humidity. The MQ135 sensor, meanwhile, can identify 25 ppm CO2, 5 ppm alcohol, and 12 ppm CO air contamination. The average of the three contaminants found is used to calculate the air quality rating; in this test, the average value of air pollution is 14 ppm, placing the air quality category in the Good category, which is shown by the green. Ten successive locations throughout the city were used to collect the same data, which was then prepared and sent to a server using a Wi-Fi module.

Regression tasks are handled by support vector regression (SVR), a subset of support vector machines (SVM). When an input value is given, it looks for a function that can best predict the continuous output value. Both linear and non-linear kernels are compatible with SVR. A non-linear kernel is a more complicated function that can identify more complex patterns in the data, whereas a linear kernel is just the dot product of two input vectors. Kernel selection is based on the complexity of the task and the properties of the data. The trained model was tested using current data after SVM was trained using historical data. Radial Basis Function, or RBF, has been utilised to train the model. In Table-II, the obtained model accuracy is shown.

Table-II: Accuracy achieved through SVR

| ML Model | Type of Dataset | Size of Dataset | Accuracy |
|---|---|---|---|
| SVR | Prepared dataset from system | 10000 rows | 92.25 % |
| SVR | Existing Dataset from Kaggle | 15000 rows | 96.5 % |

It is shown in Table II that greater accuracy has been attained with larger data sets. The highest accuracy of 96.5% was attained. The accuracy of the model is also impacted by the dataset's size and kind. Predicted output and data retrieved from IoT devices have been shown on the web site for user distribution.

**CONCLUSION:**

Detecting and responding to environmental risks could be completely transformed by the development of AI and ML-driven sensors for environmental monitoring of dangerous compounds. Our capacity to safeguard the environment and public health can be significantly enhanced by these sensors' capacity to evaluate vast volumes of data in real-time and spot trends and abnormalities that might point to the presence of dangerous materials. The accuracy and dependability of these sensors as well as the most effective methods for incorporating them into current monitoring systems are only two of the numerous issues that still need to be resolved. Notwithstanding these difficulties, AI-driven sensors provide promise for further study and advancement in the realm of environmental monitoring due to their prospective advantages. Several machine learning models, including SVR, Random Forest, Logistic Regression, and many more, can attain the highest accuracy. Future developments in AI-powered hazardous drug monitoring could include further automation, the development of more complex models, and the integration of AI with cutting-edge technologies like the Internet of Things.

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