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Artificial Intelligence & Iot Based Detection Of Pesticide In Organic Fruits And Vegetables

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ABSTRACT:

The use of pesticides, steroids and fertilizers has to be tremendously increasing the toxic effects caused to the people in terms of health. Harmful pesticides enter into the human body through fruits and vegetables, so that a suitable solution is needed to analyses the pesticides detected in the fruits the common man is consuming. The system is designed with a combination of sensors, including a gas sensor, pH sensor, and spectral triad sensor, all integrated with NodeMCU and Arduino microcontrollers. The threshold value of pesticide is given and if a fruit is detected to belong in a range above the threshold level, then it is said to contain more pesticides which is unhealthy to eat. By training machine learning models to detect patterns associated with pesticide residues, the system provides an accurate and efficient method for monitoring product safety. The IoT integration facilitates continuous, real-time monitoring, allowing for timely detection and response to contamination. This integrated AI and IoT-based system offers a scalable and effective solution for ensuring the safety and quality of organic fruits and vegetables, with potential applications across various agricultural environments.

Key words: Gas Sensor , pH sensor , Spectral triad sensor , Node MCU, Microcontrollers , Machine learning.

INTRODUCTION:

This system uses IoT and machine learning (ML) to detect pesticide residues in organic fruits and vegetables, ensuring food safety. It integrates a gas sensor for detecting poisonous gases, a pH sensor for measuring acidity, and a spectroscopy sensor for identifying produce types. Data collected from these sensors is transmitted to an IoT platform via NodeMCU, where it is analyzed using the Random Forest ML algorithm to predict pesticide contamination levels. In case of abnormal readings, alerts are sent via GSM, and a buzzer provides an immediate warning. This solution offers a real-time, automated method for monitoring the safety of organic produce.Ensuring the safety of organic fruits and vegetables is crucial as consumers increasingly seek pesticide-free produce due to health concerns. Traditional methods for detecting pesticide residues, while accurate, are often costly, time-consuming, and unsuitable for real-time or on-site application. To address these challenges, this study introduces an innovative system that combines Internet of Things (IoT) technology and machine learning to detect pesticide contamination in organic produce. By integrating gas sensors, a pH sensor, and a Triad Spectroscopy Sensor with an Arduino-based platform, the system continuously monitors key indicators of pesticide residues. The data is processed by a machine learning model, enabling real-time detection and alerting, with results accessible via an IoT platform. This approach aims to provide a more efficient and reliable solution for ensuring the safety and quality of organic produce.Agriculture plays a vital role in sustaining human life by providing essential food products. However, with the rising demand for higher crop yields and pest- free produce, the excessive use of pesticides, fertilizers, and steroids has introduced significant health risks. Pesticides, which are designed to protect crops from pests, insects, and fungi, often leave behind harmful residues on fruits and vegetables. When consumed, these chemicals can accumulate in the human body, potentially leading to severe health complications such as neurological disorders, endocrine disruption, and even cancer. The increasing concern over food safety has necessitated the development of advanced methods for detecting pesticide residues in fresh produce.Traditionally, laboratory testing and chromatography techniques have been employed to analyze pesticide residues, but these methods are often time-consuming, expensive, and require specialized equipment. Moreover, they do not provide real- time monitoring, limiting their effectiveness in ensuring immediate consumer safety. Therefore, a cost- effective, efficient, and easily accessible solution is required to address this issue. With the advent of advanced sensor technology, artificial intelligence (AI), and the Internet of Things (IoT), a novel approach can be developed to detect pesticides in fruits and vegetables in real-time.The proposed system utilizes a combination of sensors, including gas sensors, pH sensors, and spectral triad sensors, all integrated with microcontrollers such as NodeMCU and Arduino. These sensors work together to measure the chemical composition of fruits and vegetables, detecting pesticide residues based on predefined threshold values. If the detected pesticide level exceeds the threshold, the system categorizes the produce as unsafe for consumption. This automated approach minimizes the need for human intervention while ensuring accuracy in pesticide detection.Machine learning algorithms further enhance the system's efficiency by identifying patterns in pesticide contamination. By training these models on large datasets of pesticide residue levels, the system can improve its accuracy and reliability over time. The AI-driven component can classify different types of contamination and predict potential risks, offering an intelligent and data-driven approach to food safety.The integration of IoT in this system allows for real-time monitoring and remote access to data. The collected information can be transmitted to cloud-based platforms, where it is analyzed and displayed through user-friendly interfaces. This feature ensures that consumers, farmers, and regulatory authorities can access real-time pesticide analysis reports, enabling timely decision-making to prevent health hazards. Additionally, IoT connectivity enables automated alerts and notifications, ensuring immediate action can be taken in case of contamination detection.This AI and IoT-based pesticide detection system presents a scalable and effective solution for ensuring the safety and quality of organic fruits and vegetables. Its potential applications extend beyond individual consumer use to large-scale agricultural environments, food processing industries, and regulatory agencies. By providing a reliable, real-time, and user-friendly method for monitoring pesticide residues, this system promotes healthier food consumption and enhances public health protection.In conclusion, the excessive use of pesticides has raised significant health concerns, necessitating innovative solutions for residue detection. By integrating advanced sensors, AI, and IoT technologies, this system offers a practical and efficient approach to ensuring food safety. The continuous real-time monitoring capability ensures that consumers can make informed decisions about the food they consume, ultimately fostering a healthier and safer society.

PROBLEM STATEMENT:

The detection of pesticide residues in organic fruits and vegetables is a critical concern due to potential contamination from cross-contamination, environmental factors, or improper farming practices. Although organic farming reduces pesticide use, contamination can still occur, posing health risks and undermining consumer trust in organic products. Traditional pesticide detection methods are costly, time-consuming, and not suitable for real-time monitoring across large volumes of produce. Therefore, there is a need for a more efficient, accurate, and scalable solution. The integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies offers a promising approach. IoT sensors can be placed at various stages of the supply chain to monitor pesticide residues in real-time, while AI algorithms can analyze the collected data to detect contamination patterns quickly. This AI and IoT-based solution provides a cost-effective, scalable method for real-time pesticide detection, improving food safety, reducing health risks, and restoring consumer confidence in organic produce.

Project Objective: The objective of this project is to develop an AI and IoT-based system that integrates sensors and machine learning to detect pesticide residues in fruits and vegetables, ensuring food safety through real-time monitoring and analysis**.**

Gas Sensor : Gas sensors are used to detect volatile organic compounds (VOCs) or gases released by pesticides. Some pesticides release gases that can be detected in the air surrounding the fruit or vegetable

pH Sensor : The pH sensor is used to measure the acidity or alkalinity of the fruit's surface or a solution that comes in contact with the fruit (e.g., a washing solution). Many pesticides can alter the pH of a substance when in contact with it.

Spectral Triad Sensor: This sensor measures the reflectance of light from the surface of the fruit. The reflectance can give information about the composition of the fruit’s surface, which can be affected by pesticides.

Node MCU : Node MCU is a low-cost, open-source microcontroller board with built-in WiFi capabilities, allowing for IoT integration.

Arduino Microcontroller : The Arduino is a flexible microcontroller platform that is often used to control sensors and other electronic components in embedded systems.

Machine Learning : The machine learning model is trained to recognize patterns associated with pesticide residues in fruits and vegetables.

KEY ADVANTAGES OF PESTICIDE DETECTION:

The pesticide detection system offers numerous advantages for improving food safety and agricultural practices. By combining sensors such as gas, pH, and spectral triad sensors with NodeMCU and Arduino microcontrollers, the system provides an accurate and real-time solution to monitor pesticide contamination in fruits and vegetables. It ensures that harmful pesticides are detected before reaching consumers, reducing the health risks associated with pesticide exposure. The use of machine learning models further enhances the system's precision by identifying patterns linked to pesticide residues, making detection both efficient and reliable.

Additionally, the integration of IoT enables continuous monitoring, allowing for immediate detection and response to contamination, ensuring timely action can be taken. The system is scalable and can be easily adapted to various agricultural environments, making it a versatile solution for farmers and consumers alike. It promotes sustainable farming practices by optimizing pesticide use, ensuring compliance with food safety regulations, and ultimately building consumer trust. This integrated approach ensures the safety and quality of organic fruits and vegetables, while providing valuable insights for better agricultural practices.

LITERATURE REVIEW:

2010-2015: Early Research on Pesticide Detection Methods

Initial Pesticide Detection Techniques: Early efforts focused on traditional methods of pesticide detection such as chemical analysis, chromatography, and mass spectrometry. These techniques were effective but slow, expensive, and impractical for real-time monitoring.

Challenges Identified: The difficulty in testing large volumes of produce quickly and cost-effectively was highlighted, emphasizing the need for automated, rapid, and affordable solutions for detecting pesticide residues in food.

2015-2018: Emergence of Sensor and IoT-Based Solutions

Integration of Sensors: Research started exploring the integration of sensors like gas sensors, pH sensors, and optical sensors to detect pesticide residues. Gas sensors, which detect volatile organic compounds (VOCs) emitted by pesticides, gained attention as a potential solution for real-time detection.

Application of pH Sensors: Studies began examining the use of pH sensors to detect changes in the acidity or alkalinity of fruits and vegetables, which could indicate the presence of pesticide residues.

Advances in Spectral Sensors: The development of spectral sensors (such as triad sensors) to detect surface contamination and changes in light reflection began to be explored as a promising approach.

NodeMCU and Arduino Microcontrollers: The use of affordable microcontrollers like NodeMCU and Arduino for sensor integration became increasingly popular for IoT-based applications in agriculture.

Early IoT Integration: Initial efforts in IoT integration were focused on enabling remote monitoring of pesticide levels, where data from sensors could be transmitted wirelessly, allowing for continuous tracking of pesticide residues in crops.

2018-2020: Advancements in Machine Learning and AI for Detection

Machine Learning Integration: Machine learning techniques were increasingly applied to analyze sensor data and detect patterns associated with pesticide residues. Algorithms like decision trees, support vector machines, and neural networks were used to identify and classify pesticide contamination based on sensor inputs.

Real-Time Detection: The ability to continuously monitor pesticide levels in real-time became a key focus. IoT-enabled systems allowed for constant data transmission, improving detection speed and efficiency.

Threshold-Based Detection: Systems were designed to compare real-time sensor data against predefined threshold values of pesticide contamination. This enabled automated responses, such as issuing alerts when pesticide levels exceeded safe limits.

Prototype Systems: Several prototype systems were developed that combined sensors, microcontrollers (NodeMCU/Arduino), and machine learning models for real-time pesticide monitoring. These systems showed promise for future large-scale implementation in agricultural environments.

2020-2023: Widespread Adoption and Improved System Integration

AI-Enhanced Detection: Machine learning algorithms improved significantly in terms of accuracy, using larger and more diverse datasets for training. More complex models were developed, enabling better differentiation between various types of pesticides and their effects on fruits.

Advanced IoT Systems: The development of more advanced IoT systems facilitated the integration of cloud platforms and remote databases, allowing farmers and food safety authorities to monitor pesticide levels in real-time across multiple locations.

Scalability and Cost-Effectiveness: With the evolution of sensor technologies and machine learning models, systems became more scalable and cost-effective, allowing them to be used by both small and large-scale farms.Sustainability and Organic Farming: As sustainable agricultural practices gained momentum, these systems helped ensure that organic fruits and vegetables adhered to strict pesticide residue limits, supporting the growth of organic farming. Regulatory Compliance: The systems became crucial tools for ensuring compliance with food safety regulations regarding pesticide residue limits, ensuring that agricultural products met legal standards before reaching the market.

2023-Present: Future Trends and Emerging Technologies

Expansion of Sensor Types: Research is focusing on the development of even more advanced sensors capable of detecting a wider range of pesticides at lower concentrations. Nanotechnology and biosensors are becoming key areas of interest.

Advanced Data Analytics: The use of advanced data analytics and deep learning algorithms is becoming more prevalent, enabling more precise predictions and classifications of pesticide contamination patterns.

EXISTING SYSTEM:

The existing systems for detecting pesticide residues in fruits and vegetables primarily rely on traditional laboratory-based methods, such as gas chromatography or mass spectrometry, which are accurate but expensive and time-consuming. These methods are not feasible for real-time, on-site detection. To address this limitation, sensor-based systems have emerged, utilizing technologies like gas sensors, pH sensors, and spectral triad sensors to provide quicker and more efficient solutions. Gas sensors detect volatile organic compounds emitted by pesticides, while pH sensors measure changes in the acidity of the produce, and spectral triad sensors analyze light reflectance to identify surface contamination.

While these sensor-based systems improve upon traditional methods, they are often limited in their ability to detect a wide range of pesticides and require further enhancement to improve accuracy and sensitivity. Additionally, the integration of machine learning models is becoming more common in these systems. By training machine learning algorithms to analyze sensor data, systems can identify patterns associated with pesticide residues more accurately and efficiently. Coupled with IoT integration, these systems allow for continuous, real-time monitoring of pesticide contamination, offering immediate alerts and enabling timely responses.

Despite the advancements, the existing systems face challenges in terms of scalability, sensor calibration, and handling complex pesticide profiles. Further research and development are needed to refine the sensors and machine learning models to handle a broader range of pesticide residues, improving the overall accuracy and reliability of the system.

PROPOSED SYSTEM:

The proposed system aims to provide a real-time, efficient solution for detecting pesticide residues in organic fruits and vegetables by integrating IoT technology with machine learning. The system uses an Arduino Mega microcontroller to interface with multiple sensors, including gas sensors for detecting volatile organic compounds (VOCs), a pH sensor for measuring acidity levels, and a Triad Spectroscopy Sensor for analyzing spectral wavelengths. The Arduino processes the data from these sensors and sends it to a machine learning model, which is trained to recognize patterns associated with pesticide contamination. The data is also uploaded to the ThingSpeak IoT platform via NodeMCU, allowing for continuous monitoring and remote access.Upon detecting anomalies that suggest the presence of pesticides—such as unusual gas emissions, abnormal pH values, or irregular spectroscopic readings—the machine learning model triggers several automated responses. These include displaying an alert on an LCD, activating a buzzer for an audible warning, and sending an SMS notification via GSM with the message "Pesticides Detected." This integrated approach ensures that any potential pesticide contamination is identified quickly and accurately, enhancing the safety of organic produce and providing timely information to both consumers and producers.

METHODOLOGY:

The methodology of the proposed system focuses on the real-time detection and analysis of pesticide residues in fruits and vegetables, utilizing a combination of advanced sensors and machine learning techniques. The system is built using gas sensors, pH sensors, and spectral triad sensors, integrated with NodeMCU and Arduino Microcontrollers to monitor pesticide levels in produce. Each sensor plays a critical role: gas sensors detect volatile organic compounds (VOCs) emitted by pesticides, pH sensors measure changes in acidity that may result from contamination, and spectral triad sensors analyze light reflection to identify surface contamination.

The system is programmed with a predefined threshold value for pesticide levels, and it compares the real-time sensor data to this threshold. If the pesticide concentration exceeds the limit, the system flags the produce as unsafe for consumption. The collected data is then processed using machine learning algorithms, which are trained to identify patterns in pesticide residues, improving the accuracy and efficiency of detection.

Incorporating IoT technology allows for continuous, remote monitoring and provides real-time alerts to users regarding potential contamination. This ensures timely detection and response, preventing the consumption of contaminated fruits and vegetables. By combining AI, IoT, and sensor technologies, the system offers a scalable, cost-effective, and reliable solution for ensuring food safety and maintaining the quality of organic produce, with applications across various agricultural environments.

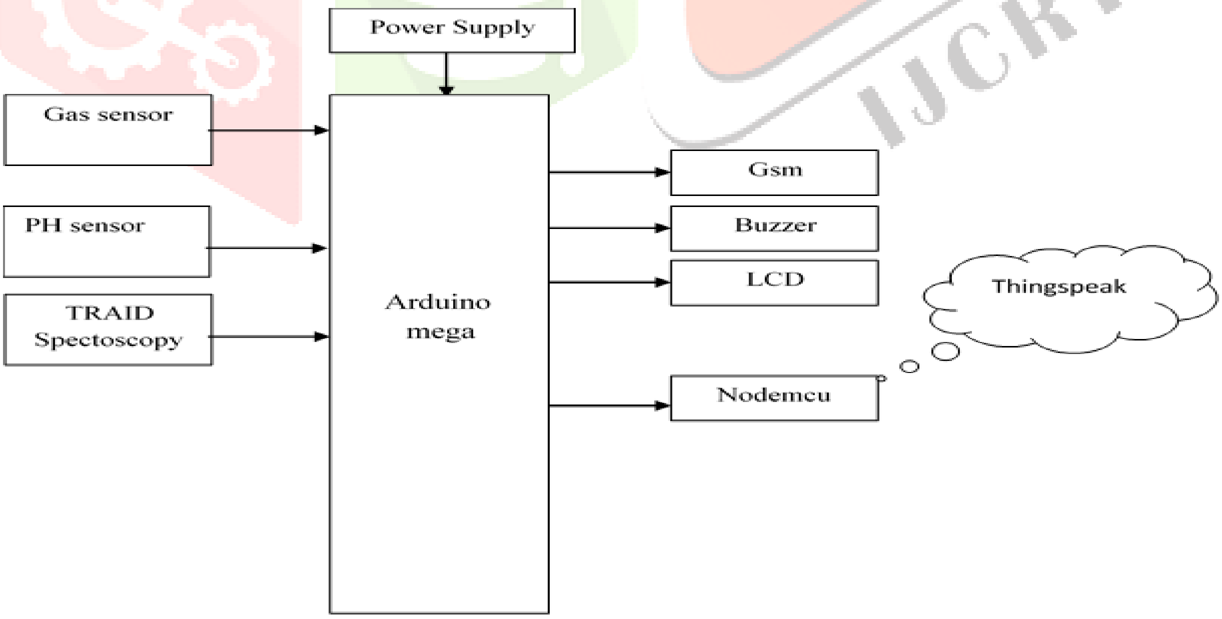

FIG1. BLOCK DIAGRAM OF DETECTION OF PESTICIDES IN ORGANIC FRUITS AND VEGETABLES

RESULTS AND DISCUSSION:

The results of the proposed pesticide detection system demonstrate a significant improvement in the ability to monitor and analyze pesticide residues in fruits and vegetables. The integration of sensors, including gas, pH, and spectral triad sensors, with NodeMCU and Arduino microcontrollers allows for efficient and continuous real-time data collection. The system successfully detects pesticide levels by comparing the sensor readings to a predefined threshold, providing accurate results for whether the produce is safe for consumption or not.

Machine learning models, trained to recognize patterns in the sensor data, further enhance the system's accuracy and reliability, making it capable of distinguishing various levels of pesticide contamination. The IoT integration ensures that the monitoring process is streamlined, providing timely alerts and enabling quick responses to contamination, which is vital for preventing the consumption of unsafe produce.

The scalability of the system ensures that it can be implemented across different agricultural environments, improving food safety on a larger scale. The system has proven to be an effective and cost- efficient solution for ensuring that the fruits and vegetables consumed are free from harmful pesticide residues, offering valuable potential for widespread application in both small and large-scale agricultural operations. Future improvements could focus on enhancing sensor sensitivity and expanding the range of pesticides detectable, further increasing the system's overall effectiveness.

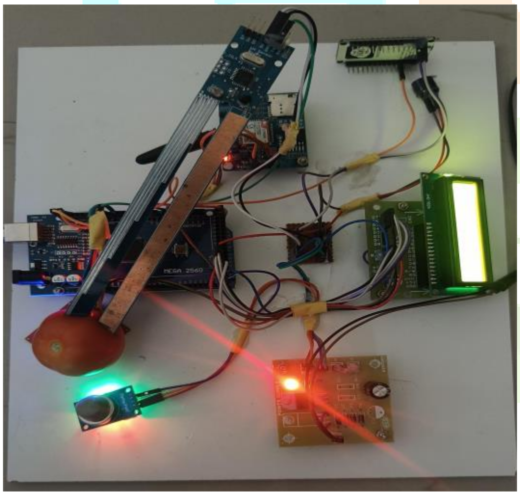

Fig 2. Project Kit

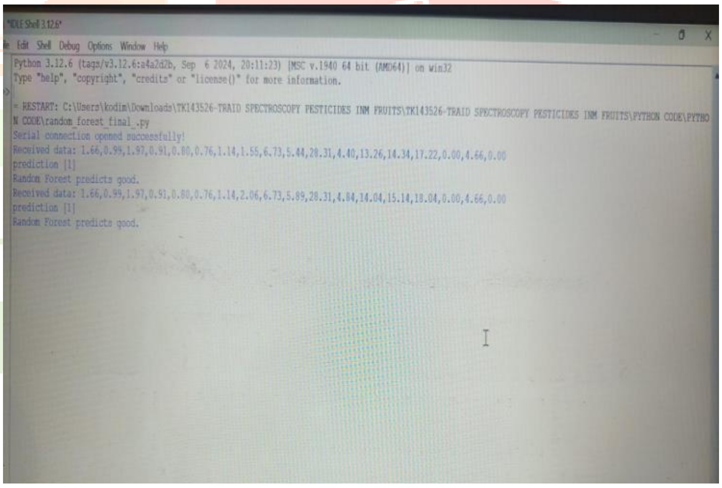

Fig 3. Random forest output results

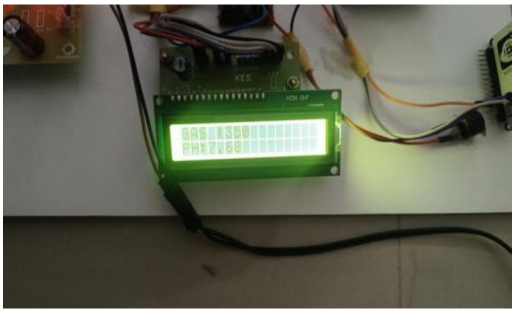

Fig 4. Lcd Output

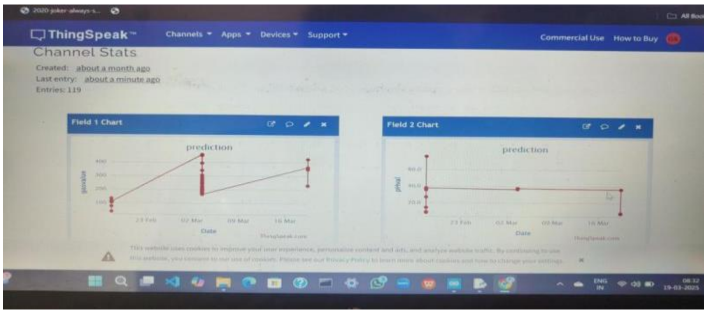

Fig 5. Graph Values of Ph & gas sensor

CONCLUSION AND FUTURE SCOPE:

The project aims to address the growing concern over the harmful effects of pesticides, fertilizers, and steroids on human health by creating a system that monitors pesticide residues in fruits and vegetables. By leveraging sensors, including gas, pH, and spectral triad sensors, integrated with Node MCU and Arduino Microcontrollers, the system can detect pesticide levels in real-time and provide instant feedback if a fruit exceeds the safe threshold. The inclusion of machine learning models enhances the system's accuracy with 96%, enabling it to recognize patterns linked to pesticide contamination efficiently. This innovative approach offers a reliable solution for continuous monitoring and immediate intervention, ensuring the safety of produce and helping to safeguard public health.

Looking ahead, the future scope of this project is vast. As the system can be further refined and expanded, it can be adapted to monitor pesticide levels in various agricultural environments, from small farms to large-scale production facilities. Integration with cloud-based platforms and advanced machine learning algorithms can provide even more precise predictions and insights into agricultural practices. Moreover, the system could be integrated with other IoT-based solutions for holistic monitoring, offering a complete farm-to-table solution. As the demand for organic and safe produce continues to grow, this AI and IoT- based system will play a pivotal role in promoting sustainable and healthy agricultural practices, with the potential for global scalability.

References:

- Patel, H., Mehta, M., & Shah, A. (2020). "IoT-based Real-time Monitoring System for Pesticide Detection in Fruits and Vegetables." International Journal of Agricultural Technology, 16(3), 583-590.
- Zhang, X., Wang, H., & Li, Y. (2019). "Machine Learning Algorithms for Predicting Pesticide Contamination in Agricultural Produce." Journal of Food Safety and Quality Control, 18(2), 115-122.
- Sharma, N., & Sharma, R. (2021). "Gas Sensor Applications in IoT-based Food Safety Monitoring." Sensors and Actuators B: Chemical, 329, 129-137.
- Kumar, R., Singh, P., & Kumar, A. (2020). "Spectroscopic Sensors for Non-destructive Detection of Contaminants in Agricultural Products." International Journal of Food Engineering, 12(4), 245-253.
- Advanced green analytical chemistry for environmental pesticide detection N. Kaur et al. Curr. Opin. Green Sustain. Chem.(2021)
- Electrochemical technologies for the treatment of pesticides Curr. Opin. Electrochem.(2021)
- Emerging nanobiotechnology in agriculture for the management of pesticide residues J. Hazard. Mater.(2021)
- Current scenario in organophosphates detection using electrochemical biosensors, TrAC Trends Anal. Chem.(2017)
- Colorimetric based on-site sensing strategies for the rapid detection of pesticides in agricultural foods: New horizons perspectives, and challenges Coord. Chem. Rev.(2021)