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Wireless Sensor Networks for Green Cities: A Comprehensive Review of Environmental Pollution Monitoring

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Abstract*:* *This research paper investigates the design and implementation of a Wireless Sensor Network (WSN)-Based Data Acquisition System tailored for collecting environmental pollution factors with a specific focus on contributing to the realization of a Green City. Leveraging various literature surveys on WSN and its applications with different techniques, a comprehensive analysis of the existing body of knowledge in the field. The paper explores the deployment of WSN technology as a cost-effective and scalable solution for real-time monitoring of pollution-related parameters, including air and water quality, noise levels, and other relevant environmental factors.By synthesizing insights from diverse literature sources, propose an intelligent and adaptable WSN framework capable of capturing, analyzing, and transmitting real-time environmental data. The research highlights the importance of integrating advanced sensor technologies within the WSN infrastructure to ensure a holistic monitoring of pollution factors. This analysis also delves into various data acquisition methodologies and explores the potential for advanced data analytics and visualization techniques to derive meaningful insights.*

Keywords: WSN, IoT, Data Acquisition, Environmental Pollution, Green City.

I. INTRODUCTION

This research paper presents a comprehensive study on developing and implementing a Wireless Sensor Network (WSN)--based Data Acquisition System designed to collect environmental pollution factors, explicitly focusing on fostering the creation of a Green City. As urbanization and industrialization expand, effective environmental monitoring becomes paramount to mitigate the adverse impacts on urban ecosystems. This project addresses this imperative by leveraging WSN technology, which offers a cost-effective and scalable solution for real-time data acquisition in diverse environmental contexts.The primary objective of the research is to establish an intelligent and efficient system that monitors and gathers crucial pollution-related parameters contributing to the vision of a Green City. By deploying wireless sensor nodes strategically placed across the urban landscape,the aim is to capture data on various environmental factors, including air quality, water quality, noise levels, and other relevant pollutants. The collected data will be a foundation for informed decision-making processes and proactive interventions to enhance urban spaces' sustainability and livability.

Specifically, delve into using WSN technology for its inherent advantages, such as flexibility, adaptability, and minimal infrastructure requirements. The Wireless Sensor Network facilitates seamless communication among sensor nodes, creating a dynamic and responsive data acquisition system. The focus extends beyond data collection to developing an integrated and intelligent framework that can analyze, process, and transmit information in realtime.Throughout the research paper, meticulously examine the application of WSN technology in conjunction with advanced data acquisition methodologies. Incorporating sensor nodes with diverse environmental sensors ensures a holistic approach to monitoring pollution factors. Also, explore the integration of data analytics and visualization techniques to derive meaningful insights from the collected data, fostering a deeper understanding of the environmental dynamics within the urban landscape.

Thepaper emphasizes the significance of the WSN-based Data Acquisition System in the broader context of urban sustainability and the Green City concept. By providing a robust and adaptable framework for monitoring environmental pollution factors, the research contributes to the ongoing efforts to create urban environments that are not only technologically advanced but also environmentally conscious and ecologically sustainable; this research paper represents a comprehensive exploration of a WSN-based Data Acquisition System tailored for collecting environmental pollution factors to support the realization of a Green City. Through integrating advanced sensor technologies and intelligent data processing, the project aims to advance the understanding of urban environmental dynamics and contribute to developing strategies for sustainable urban development.

II. REVIEW OF THE WSN (WIRELESS SENSOR NETWORK) BASED ON THE DIFFERENT SYSTEMS

According to several research, air pollution and monitoring systems are essential topics to remember. This article overviews the various approaches researchers take to determine airborne particle and gas concentrations. This research delves into the various networks the pollution monitoring system utilizes and their efficacy.[1]

A new technology called a wireless sensor network (WSN) can gather, process, and transmit data about the environment or human health through a network of interconnected nodes called sensors. This network has potential medical, military, and other uses. Data security should be the priority while developing a protocol to transmit data over a wireless network. While presenting safe data transmission, several traditional routing techniques ignored energy consumption. Energy efficiency is a significant challenge when developing a wireless sensor network routing architecture (WSN). In a WSN setting, extending the network's life while retaining high scalability is difficult.[2]

Sensors that detect changes in the surrounding environment are the building blocks of wireless sensor networks or WSNs. Human health is jeopardized by air pollution. Periodic monitoring of polluting gases is essential for controlling air pollution. The use of sensor networks to monitor air pollution has been the focus of several published effortsAt design, implementation, and evaluation. Three distinct kinds of air pollution monitoring systems are identified in this study: static, dynamic, and approaches for analyzing pollution data. This work compares the literature on these categories. The critical criteria to compare these pollution monitoring systems are evaluation qualities, tested location, methodology, microcontrollers, communication devices, sensor contaminants, and overall system quality. [3]

Wireless sensor networks (WSNs) consist of interconnected sensors that collect data wirelessly from various locations and relay it to a central hub or base station in the case of an occurrence. This research looks at the latest WSN applications, focusing on EMSs in particular. WSNs are becoming more popular because they make it possible to do manyessential things that would be very difficult, if not impossible, for humans to do on their own. Performance and resilience have been improved with the usage of WSNs. They also provide remarkably effective monitoring systems. Last but not least, EMSs are going to be an integral part of people's futures. Compared to more traditional approaches that depend on human labor to monitor environmental conditions, EMSs are a clear winner. Privacy and security are just two areas where these systems need improvement.[4]

This work provides better environmental monitoring methods using WSN, UAV, and crowdsensing technologies. This is a much-needed improvement. This evaluation looks at the present status of air, land, and marine applications and ranks them based on their pros and cons. The study emphasized the need for advanced signal processing for tasks such as determining the best location for sensors and accurately recreating environmental events. Developing a three-layer architecture that integrates WSN/crowdsensing with UAV capabilities enables the scalability and affordability of large-scale monitoring. Signal processing is utilized by this design. In the report's final section, the authors call for new research directions involving collaboration across disciplines.[5]

This study has covered how WSN technology can be used for environmental monitoring. With an emphasis on a subset of the WSN protocol stack, this article examined critical protocols employed by WSNs for EMAs. Some suggested challenges for environmental monitoring applications (EMAs) using WSNs, which took security in these applications seriously, were covered in this review. Researchers mustconsider the applications and their quirks while designing protocols at the physical, data connection, and network layers. Research protocols for monitoring animal populations, water quality, and forest health are also included in the article.[6]

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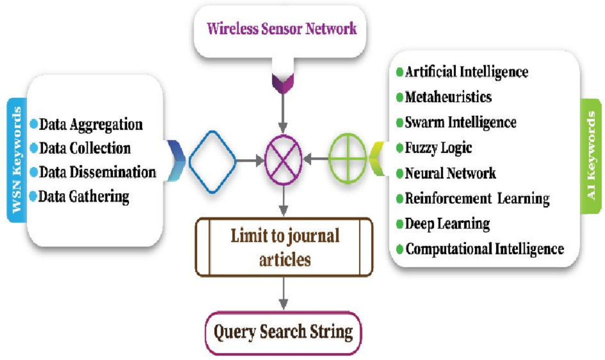

Figure: WSN Based Techniques

More recent uses involve large-scale, geographically dispersed WSNs incorporating numerous sensor nodes and UAVs, going beyond proof-of-concept systems. Due to their complexity and the multitude of functions that need to be managed, such as acquisition, processing, cooperation, and communication, these systems are systems of systems. Cloud computing, edge computing, and fog computing are newer terms used in data processing. The convergence of the entities in (UAV-WSN-IoT) is becoming more critical due to the artificial intelligence of the fundamental components (SNs and UAVs). More and more, UAVs and WSNs are seen as complementary components of a more extensive multi-agent system that works harmoniously together. Finally, the nodes that make up a WSN are getting more intelligent and capable, bringing them closer to the Internet of Things paradigm. As a result, it is reasonable to assume that WSN, UAV, and IoT integration technologies will be trendy in the business world very soon.[7]

2.1 WSN(Wireless Sensor Network)

Prioritizing reduced power usage and optimized data transfer, this study focuses on energy-efficient WSNs for environmental monitoring. The infrastructure is implemented using the TelosB mote and TinyOS, and an algorithm is utilized to save energy and increase the network's lifetime. Instead of using cryptographic procedures, lightweight cypher text addition is used, which improves network longevity and reduces aggregator strain. Data aggregation using MAX, Average, and Sum reduces communication overhead, increases WSN longevity, and decreases redundancy. Although impossible, the paper proposes a probability-based method for deactivating sensors to save energy. It considers adding camera modules to the system to detect infrared movements and capture low-power images.[8]

Such systems may conduct continuous pollution measurements in (near) real-time, even in inaccessible and hostile locations, thanks to a data collecting and dissemination infrastructure based on Wireless Sensor Networks (WSNs). This can significantly affect the ability to promptly identify and anticipate pollution hotspots and sources. However, the fundamental technological limitations mean these solutions must be used more often. This article provides an overview of the current technological initiatives aimed at low-cost, continuous water and air quality monitoring in near real-time. It primarily focuses on techniques and algorithms for data collecting and dissemination, as well as on processing and transmission. While confronted with numerous obstacles, it examines the necessity of new technologies in this field, the structure of their hardware and communication, and their ability to supplant the current technologies. In addition, it suggests academic, technical, and future lines of inquiry for enhancing the real systems.[9]

This study presents a fresh approach to incorporating WSNs into innovative city applications for remote sensing and monitoring. Suggest utilizing UAVs as a data mule to move the data collected from the sensor nodes to a remotecontrolcenter, where it may be securely analyzed and used for decision-making. The article also delves into the difficulties of implementing the proposed framework. The article also gives an experimental assessment of the suggested design in natural settings, including several typical outdoor field obstacles. The performance measurements claimed in the hardware data sheets did not match up with the results of the laboratory examination.The advertised coverage distance and signal strength were far off compared to the actual results. Therefore, before developing and launching the WSN into a real-world field setting, network engineers and designers must conduct field tests and assessments of device performance.[10]

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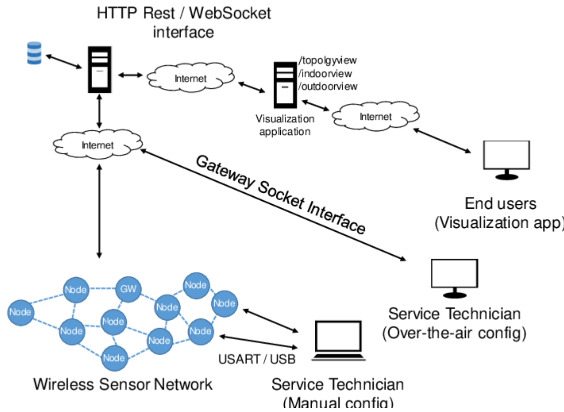

Figure: Structure of WSN

Using numerous unmanned aerial vehicles, a conceptual design for wireless sensor networks in this article (UAVs). With limited resources and electricity, they focused on reducing deployment and operations expenses to a minimum. To achieve this goal, begin by maximizing the coverage of all sensors by carefully planning the placement and quantity of cluster heads (CHs). To minimize the flying time required for data collecting. Categorize two trajectory methods based on the location of the visited CH: 1) where the UAV hovers directly above the CH and 2) where the UAV hovers within a range of the CH. Data collecting design guidelines are one outcome of this. Next, talk about the features of the K-means clustering of the sensor nodes. Trajectory planning heuristics and effective solutions are then demonstrated. With just a 3.5% degradation rate, the genetic algorithm is demonstrated to be almost optimum. Researchers examine how environment, UAV height, and trajectory approach affect the results. Finally, it discussed how UAV trajectories are fair.[11]

Embedded in this design is the flexibility needed for deployment and upgrades without arranging complex infrastructures; it may be adapted to many different applications. The approach relies on a cloud architecture that stores data and sends it to distant customers and tiny wireless receivers linked to the Internet and autonomous wireless sensor nodes. Thanks to this approach, on-site supervisors may use their smartphones to stay updated on the present situation, and they can also keep an eye on remote sites through the Internet. All measurements are kept redundantly at different concentration levels to ensure quality, even during a network outage or failure. This allows for a secure back-trace. Sensing nodes are small and inexpensive enough to be used set-and-forget for intervals longer than a year; their dimensions can be less than 2.5 cm $\times1.5$ cm when all they need to measure is temperature and relative humidity.[12]

This chapter uses big data, the Internet of Things, and wireless sensor networks to outline environmental monitoring systems (IoTs). In this chapter, we look at how wild animals are being impacted by climate change and how innovations are being made to address this issue. Electric fences are a typical tool in game reserves, private games, and farms to keep animals in their designated areas and out of the way of humans and other potential dangers. To reduce the number of conflicts between humans and animals in Africa, this system presents a wireless sensor network-based approach for intrusion detection and monitoring. Due to the great distances that these massive creatures travel, monitoring elephants is a difficult task. The current wireless anti-poaching system's main drawback is its spotty or nonexistent coverage. Consequently, poaching becomes the only option for unprotected animals. This chapter proposes an anti-poaching system that makes use of WSN.[13]

Various forms of the application of existing sensor networks in the agriculture sector are described in this study, along with specific technological considerations. Therefore, to remedy the energy efficiency issues with current WSNs, the suggested model incorporates high-performance data that lays the groundwork for WSNs to enhance agricultural production. This research shows how the suggested method outperforms competing water-saving process monitoring and energy conservation approaches in wireless sensor networks.[14]

A periodic hybrid routing technique that is threshold-sensitive in this chapter for gathering environmental data. The suggested method uses cluster approaches based on regions to effectively cover the entire agricultural area to deploy sensor nodes.A clustering method that considers residual energy and the distance between neighboring nodes is also offered, which can help achieve optimal Cluster-head and improve energy efficiency in the WSN. Regarding energy consumption, network longevity, and packet delivery, the simulation results show that the proposed routing method outperforms popular methods.[15]

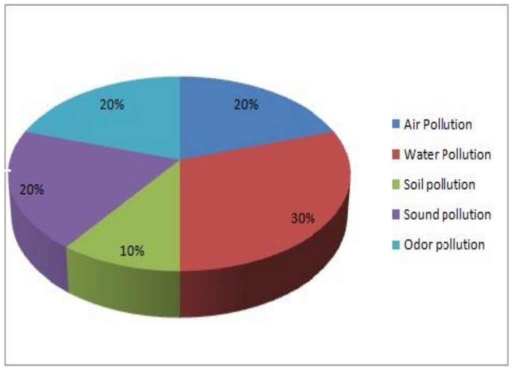

Figure: Different pollution % in the city

A practical, scalable, and cost-effective real-time factory monitoring system can be created by combining Wireless Sensor Networks (WSN) with Embedded Systems. To keep tabs on the state of machines, the production line, and the overall factory environment, this article details the development of a WSN-based Distributed Data Acquisition System (DDAS). Notifications are sent to authorities during severe events about the factory. The system collects data in realtime from several sensor nodes installed throughout the factory and transmits it to a central hub. Experimental results from DDAS's test platform demonstrate the sensor nodes' accuracy, scalability, and low power consumption. [16]

Urban regions are particularly vulnerable to air pollution. According to studies, Exhaust emissions from road and non-road vehicles account for around 78% of urban air pollution. Several studies have attempted to track and manage vehicle emissions of pollutants. However, these studies still need to address critical issues, such as the practicality and ease of implementation of the suggested solutions. This article offers a wireless sensor network system to track the pollution of cars' exhaust systems. Furthermore, simulation is used to assess the practicability of the suggested method regarding energy usage and network longevity. These findings show that utilizing widely-used MAC layer protocols is a realistic option for implementing the suggested system. [17]

Using a sensor node that can switch between two modes of operation, this study proposes a UAV-assisted data-gathering strategy. A mixed-integer nonlinear programming problem to minimize the weighted sum of the energy consumption from the WSN and UAV. The BCD method was employed to resolve it. The MAR algorithm was suggested to determine the best threshold for working modes, while the purpose of developing the PSCA algorithm was to identify appropriate cluster heads. The numerical results show that the proposed technique successfully protects the sensor nodes with little remaining power.[18]

"Wireless Sensor Networks for Environmental Monitoring" is a unique journal issue comprising articles summarising its contents. Explore this Special Issue's state-of-the-art obstacles, breakthroughs, and enhancements in environmental data collection, monitoring, analysis, risk assessment, and management. Wireless sensor networks (WSNs) enable the creation of appealing and creative solutions and the global monitoring of the environment through features. These networks, which consist of several distributed devices with sensing, processing, and wireless communication capabilities, have greatly improved risk assessment and management, monitoring various physical systems, and remote environmental sensing. [19]

To implement WSNs for EMAs efficiently, it is necessary to use the various strategies described in this study carefully. To keep the wireless sensor network's lifetime and quality of service in mind, it is essential to consider the type of parameters, the number of sensors, and the network architecture while developing WSNs for EMAs. The hardware architecture of EMAs opens the door to addressable communication between sensor nodes. Stakeholders can watch data collected from EMA-deployed sensor nodes in real-time through a web portal hosted on a web server or the cloud. Typically, the online interface will have a dashboard that shows parameter-derived sensor readings. Wireless sensor node topologies help EMAs save power, reuse hardware, manage resources, and perform in real-time. Improvements in WSNs enabled by AI and the IoT were also covered in this study (IoT).[20]

Using a Wireless Sensor Network to keep tabs on the surroundings is the subject of this article. A smaller antenna for a sensor node was also detailed, along with its design, implementation, and experimental characterization. An RF switch controls the six-section BS antenna. The two antennas are combined with Lopy4 transceivers to form a WSN to monitor the environment. In addition to studying the proposed architecture's coverage and maximum range, experimental findings in the field demonstrate the 360◦ FOV and good behavior of the BS antenna's RF switching mechanism. The given network and the WSN-EM project's abided requirements were satisfactorily met with a maximum range of 3.85 km between the SN and BS, which was constrained by the location of the measurement site. [21]

This study aims to collect data from various sensors so that weather variables can be used. The user can check the agriculture or reforestation climate conditions on a specially made website. Various devices linked to a central unit have been created to transmit cultivation measurements for the farmer to analyze later. This study proposes a WSN that can acquire microclimatic data. With this data, a farmer may decide when to water the crops, how much fertilizer to use, how long to let the crops grow and mature, and how to harvest at the best possible time.[22]

Examining the present scholarly discourse on agricultural wireless sensor network (WSN) applications is the primary goal of this study. The software VOSviewer created the keyword co-occurrence network and divided the relevant literature. The results demonstrate the exponential rise of WSN studies during the last several years. The most referenced countries, influential research, and publications were also located. Results from the summary and in-depth analyses of term co-occurrence clustering show that WSN is an essential tool for precision farming. Smart irrigation and soil management are only two examples of the many agricultural tasks that WSN studies concerning the potential contributions of other technologies like the cloud, AI, the Internet of Things, and unmanned aerial vehicles. Findings from this study shed light on the perspectives of academics and industry professionals on the state of the art and point to avenues for further investigation.[23]

This research presents a model to maximize sensor nodes' energy use in precision agriculture production. The suggested model offers a thorough examination of precision agriculture. This model enhances the usage of WSN in precision agriculture by concentrating on its features. Furthermore, this study presents several technical prospects that might serve as a solid reference for enhancing the overall precision of agricultural growth and making it more effective. The current sensor networks utilized in agricultural production technology are examined in this research, along with their limits and potential applications. The ZigBee and Lora wireless protocols are employed to achieve optimal power consumption and communication over short and long distances. To help WSN have a more meaningful impact on agricultural output, the suggested model addresses current WSN's energy efficiency problems and offers solutions.[24]

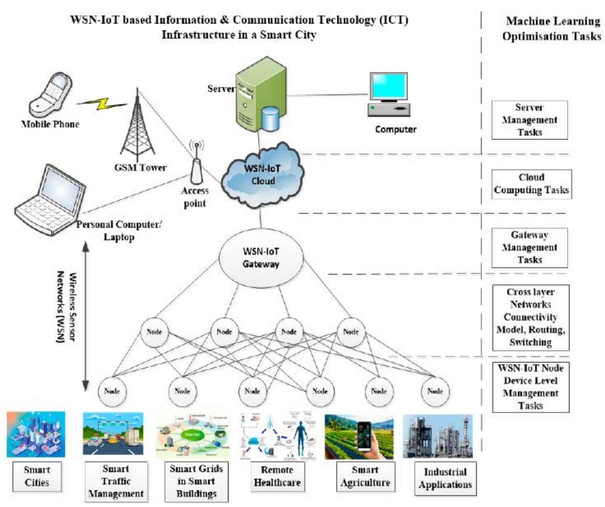

Figure: WSN- IoT Infrastructure

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2.2 Internet of Things (IoT)

This work introduces three separate wireless sensors that are part of the Internet of Things (IoT) and can be used to monitor the environment. By collecting data in remote places and making it accessible from any Internet-connected device, these technologies enable monitoring of enormous geographical regions. The details of their development and the main similarities and contrasts between these systems are included. The three systems built were suitable for Internet of Things (IoT)-based solutions for creating monitoring applications due to their autonomy in energy, ease of use, solution complexity, and Internet connectivity. [25]

Wireless sensor networks (WSNs) enhance the wireless interconnection of electronic devices and sensors, which can significantly contribute to resolving environmental issues. Problems with environmental monitoring and solutions can be greatly aided by integrating WSN and the Internet of Things. When compared to other ways, it is more cost-effective. The state-of-the-art has been reached for several reasons, one of which is the tremendously evolving nature of technology. Still, many researchers have been looking for effective ways to resolve environmental challenges. Specifically, this research investigates WSNs and how they can be integrated with the Internet of Things. The COVID-19 pandemic has affected every corner of the globe. Suggested framework for COVID-19 security uses WSN and the Internet of Things.[26]

Efficient data-gathering for WSN/IoT applications with little Age of Information is the main topic of this article. UAVs assist in this endeavor (IoT). The optimization of IoT is highly dependent on the UAV's trajectory, which is one of the critical components along with energy consumption and UAV flight. Energy consumption is minimized by reducing the flight distance. Topics covered include scheduling, quality of service measurements, energy usage, and the time UAVs spend flying. Optimization methods, energy harvesting, UAV trajectories, and backscatter communication are some of the significant contributions. The work proposes avenues for further investigation by highlighting difficulties in AI minimization and the significance of optimization algorithms. Protocols for routing, covert communication, and security are areas requiring further investigation. [27]

The importance of IoT and WSN is underscored by the fast-paced development of technology within the framework of Industry 4.0. The risks linked to these networks are investigated in a comprehensive literature study, highlighting their susceptibility as entry points for obtaining valuable patterns from user and system data. Coverage areas, network incursions, security assaults, main concerns, limitations, and contributions of WSN and IoT in Industry 4.0 are all covered in this article, which tackles seven research questions. Security must be considered at every stage of the process, from planning to execution, and this highlights the importance of increased research to meet the changing demands of the fourth industrial revolution. Finding workable answers to problems in areas with limited coverage using wireless sensor networks is the goal for the future. Weak and inefficient data transmission to distant places is critical to Industry 4.0's use of WSN and the Internet of Things. [28]

This work presents a novel approach to environmental monitoring by developing a system based on five hitherto unseen parameters: temperature, humidity, barometric pressure, light intensity, and gas concentration. The simultaneous use of AES encryption for data security, RSSI-based network efficiency calculation, and the PAN ID-secured Zigbee network is unprecedented in environmental monitoring systems. [29]

The results show a limit to how far mobile sensor networks connected to the Internet of Things may be extended to maintain optimal energy utilization. These assertions are supported by mathematical and simulational evidence and a suggested method for choosing coverage and connection with neighboring nodes. Calculating optimal transmit power and updating the routing table with the status of surrounding nodes is embodied by adding new entries to the list to enable energy sharing among nearby nodes. Consequently, the network connection is guaranteed to follow a binomial distribution. This paper's research takes free-space propagation into account. Taking this a step further means thinking about how multi-path fading and interference from nearby nodes affect the strength of the received signal. More transmit power could be needed to get the signal-to-interference noise ratio where it needs to be. Consideration of battery life is another way of looking at it. Future applications of artificial intelligence methods, such as convolutional neural networks (CNNs), may include determining a vehicle's energy requirements about its speed.[30]

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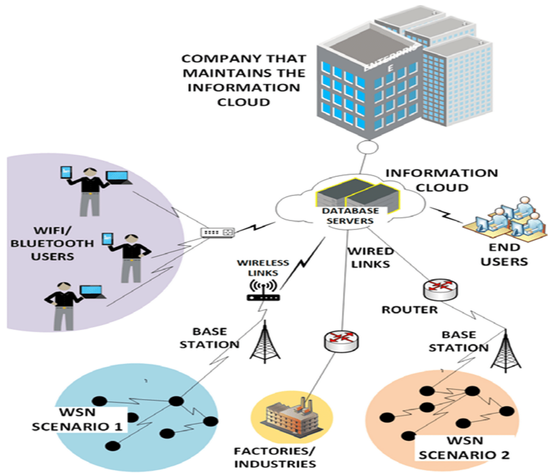

Figure: WSN enabled with IoT.

2.3 WSN with different Techniques

Due to the often long-chain topology of (WSNs), the energy consumption of sensor nodes varies in these networks when used to monitor pavement information. Improving energy balance at the nodes, lowering data transmission in WSNs, and utilizing WSN technology for pavement monitoring are all critical. A technique for data collection for WSN pavement-monitoring systems using hybrid compressed sensing is proposed in this work, along with an estimate of the system's energy usage (HCS). After that, we need to evaluate the proposed data-gathering procedure compared to the industry norms. According to the experimental results, a pavement-monitoring system that uses HCS can extend the life of its WSN sensors, reduce overall network energy consumption, and distribute power usage more evenly among the nodes.[31]

The clustering-based localization algorithms for WSN and WMSN are in this paper. Distributed computing and parallel processing are possible in wireless multimedia sensor networks, which arrange sensor nodes into smaller, independent groups. The traditional localization process can be made more efficient using clustering technologies. By breaking the network into smaller, more independent nodes, clustering can lower communication expenses. Clustering facilitates distributed computation, which in turn enhances the network's throughput. It also draws attention to issues that may arise in the future, which can help guide the work of aspiring wireless sensor network researchers. [32]

The center of this research is a secure routing technique for WSNs based on evolutionary algorithms. The article overviews wireless sensor networks' features, protocols, and performance metrics. The paper then delves into attack techniques and security needs. It employs a symmetric encryption algorithm, a hash function, a single-key digital signature, and a preshared critical model for crucial generation to encrypt and authenticate routing communications. Synthetic encryption relies on the public key to encrypt the processed object. The key is generated using a 128-bit random number, which remains relatively short even when the algorithm's efficiency is low. There are benefits, such as nonrepudiation of node authentication and easy key management. However, key encryption and decryption techniques will have little to no effect on the network's algorithm performance. The results show that the protocol is superior regarding security, energy consumption balance, latency, and packet delivery rate. [33]

When thinking about wireless sensor networks, energy efficiency is vital. The proposed model seeks to improve the existing WSN's information platform to contribute to agricultural output by fixing energy efficiency problems. An essential factor propelling WSN is the agricultural sector, which plays a pivotal role in the global economy. Depending on the strategy, this irrigation system could reduce water use by 19%. Wireless sensor networks not only save expenses associated with wireless protocol systems but can also improve the accuracy and efficiency of agricultural goals. Management and output in agriculture can both be improved with the help of an automated system.[34]

The data real-time visualization system is constructed to analyze the outcomes to facilitate the real-time visualization technology. Researchers have achieved their objective of studying virtualization technology. Along with developing the system, one also learns the process theoretically. By establishing a serial port connection to a computer, collecting and storing data from a sensor network, facilitating data searches, and modeling real-world distributions, the visualization system has the potential to achieve the primary design objective of this project. This study discusses and assesses various methods for visualizing data in realtime. The objective is to continuously gather and analyze pollution data to implement focused and efficient strategies for lowering pollutant emissions, provide a healthy benchmark for travel, and utilize the data for rebranding. [35]

Focusing on the effects of the LEACH algorithm on energy consumption and network lifetime in a WSN context, Although LEACH decreases energy consumption by nodes, the fact that it is not evenly distributed causes network overload. We solve this by combining LEACH with a tweaked version of the K-means clustering technique, which increases the network's lifetime and efficiency. Results demonstrate enhanced performance and extended network lifetime when comparing continuing energy consumption in different pollution circumstances utilizing K-LEACH in static and dynamic settings. Future research will investigate edge computing architectures and software-defined networking to maximize data routing and clustering in environmental contexts.[36]

This research comprehensively analyzed wireless sensor networks, including their architecture, operational procedure, environment, applications, and security issues. After that, the ML algorithms employed and analyzed the most recent research that attempted to strengthen WSN security by utilizing ML techniques. The benefits and drawbacks of each study were also presented. Because machine learning has so much potential in WSN security, this article continued by outlining future solutions that might use its methods. Statistics show that error and intrusion detection are the two most common uses of ML algorithms in WSN security. SDN technology is an essential and optimal choice to expand the use of ML algorithms to additional security areas. Its use can improve WSN node efficiency and total usage cost. [37]

III. CONCLUSION

This research study builds a robust Data Acquisition System for gathering pollution factors in a Green City setting by integrating results from a comprehensive literature assessment on WSN applications in environmental monitoring. An intelligent and efficient WSN framework that can tackle the complex issues of urban pollution has been designed using a combination of findings from several studies. The suggested system provides an all-inclusive real-time monitoring and analysis solution by combining several sensor nodes and using sophisticated data processing techniques. By highlighting its scalability, cost-effectiveness, and versatility, the literature study highlights the importance of WSN technology in environmental sustainability. In addition to adding to what is already known about WSN applications, the proposed system has real-world implications for city planners, lawmakers, and researchers trying to build more environmentally friendly and sustainable cities. The study also points to potential future directions for improvement and growth, such as using AI to improve data analytics and incorporating new sensor technologies. The WSN-Based Data Acquisition System described in this study could be a game-changer for environmental monitoring and the global development of Green Cities if it keeps improving and adjusting to new technologies.

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