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Design and Implementation of the Marsh Climate Monitoring System Using the Internet of Things

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Abstract
The Internet of Things (IoT) has become a major enabler for sustainable development and has begun to have an impact on society as a whole. Marshes are significant ecosystems for the environment that are essential to biodiversity support and ecological equilibrium. However, environmental changes and human activity are posing an increasing threat to these fragile ecosystems. An Internet of Things (IoT)-based marsh monitoring system was created and put into operation to gather data in real-time on a variety of environmental factors, such as wind speed, CO2 and hydrogen levels, temperature, humidity, voltage, and current. The system makes use of a network of sensors spread out throughout the marsh, which may promote sustainable development. send data to a central node for processing before sending it to a platform hosted in the cloud. After that, an interactive online application is used to visualize the data, giving stakeholders important information about the condition and health of the marsh. Because the suggested system makes it possible to monitor and manage marsh ecosystems effectively, it may promote sustainable development.

Keywords
Cloud Computing, Environments, IoT, Marshes, Monitoring Stations, Sensor, WSN, Sustainable Development.

I. Introduction

Environmental conservation and sustainable digital transformation are thought to be made possible by the Internet of Things (IoT). Supply chain management, smart cities, smart industries, environmental monitoring, health, and water and energy management are just a few of the application areas where IoT is starting to show its true potential [1]. The Iraqi marshes are one of the tourist areas in the country. This region in southern Iraq has an aquatic ecosystem that is home to a variety of animals [2]. The researcher (Abu Jerry) and his colleagues confirmed that the marshes are an archaeological area with (250) archaeological mounds. This prompted those interested in heritage and archeology to add these marshes to the World Heritage List and their global campaign to determine the water levels sufficient for their survival as a protected environment [3]. With regard to plants, there are approximately 260 species of phytoplankton and parasitic algae, 89 species of zooplankton, and 92 species of invertebrates. More than 41 species of marine fish live in the marshes [4]. Researcher Thomas confirmed that the severe water shortage has led to the depletion of more than 9,000 square kilometers of swamps and lakes. Adding an impact on its picturesque nature, as well as the number of residents and tourists. Fig. 1 Indicates the nature and importance of this environment. Given the importance of swamps and the changes that occur in the swamp environment and the preservation of existing organisms and plants, it was necessary to build a remote monitoring system using Internet of Things technology [5]. In [6] the researcher explains that by the year 2020 50 billion devices will be connected together due to the rapid and impressive progress in this technology.

In [7] asserted, it would be the same for the rest of the world, which would turn into a ”growing nervous system” capable of absorbing and managing new tools and objects. In [8] asserts that an automated connection known as M2M (machine to machine) is provided to a router by a service provider, who then sends it to a cloud server environment where it is collected and evaluated. IoT technology is based on the electronic cloud that he defined. In [9] says that the electronic cloud is a storage unit in the field of technology with that newly developed phrase that has been used as an effective tool for the simpler exchange of electronic information resources. In [10] indicated that this cloud includes tools for data processing, archiving, storage, and retrieval as needed. In [11] Both CSPs and ISPs provide services, and the cloud adds an abstraction layer and is available even when computer capabilities are limited. In [12] defined cloud computing as a collaborative mode of supercomputing that combines large-scale and scalable data storage, applications, and other resources of distributed computing under the term cloud collaboration. In this research the microcontroller board called Arduino Mega 2560 is based on the ATmega2560 family. 16 MHz crystal oscillator, USB interface, 14 PWM outputs, 16 analog inputs, 4 UART serial ports, and 54 digital I/O. DHT22 temperature and humidity sensor. These are low-cost sensors that measure humidity and temperature. These sensors contain a chip that converts analog data into digital data, resulting in a digital signal that includes temperature and humidity. These signals can be easily read by any microcontroller (MCU). Through the YL-83 Rain Sensor, the airport sensor can sense raindrops when they collect on the surface of the sensor and send them as a digital signal sent to the Arduino. Then the MQ8 hydrogen gas sensor The MQ8 is sensitive to smoke and other flammable gases, and is increasingly used against chlorine, fluoride, carbon, butane, propane, methane, alcohol and hydrogen gases. The atmosphere of that environment. The MQ8 sensor includes in its structure a variable resistor that acts as a voltage divider that allows adjusting the sample of the sensor's digital output (DO), where the value of this sample determines the output value corresponding to the state (HIGH), and in other cases the words determine the value of the minimum at which the sensor operates. We conclude from this that there is a relationship between pressure and the concentration of gases in the atmosphere, according to the following:

- As the gas concentration increases, the voltage value at the sensor output increases
- As the gas concentration decreases, the voltage value at the sensor output decreases. In addition to the MQ-7 carbon dioxide gas sensor module:

Through this sensor, the percentage of carbon dioxide in the surrounding environment can be known, as its concentration can be measured from 10 to 10,000 parts per million. The sensor uses less than 150 mA at 5 volts, and it can operate in temperatures ranging from -10 to 50°C. Analog and digital outputs are provided by this device. Using the on-board preset, the digital output threshold level can be easily changed. Microcontrollers such as Arduino can simply be connected to the MQ-7 sensor module. As for the wind speed sensor, One piece of equipment frequently used at weather stations to measure wind speed is an anemometer. This elegant anemometer is designed to be in contact with the outside air to easily measure speed. with a voltage of 7–24 volts and direct current. The voltage will range from 0.4 volts at zero wind speed to 2.0 volts at thirty meters per second. It sends an analog signal to the Arduino. After that, a GPS sensor was added to determine the location of each node. In addition, each node is equipped with a voltage and current sensor to measure the energy consumption there. These sensors work with wireless sensing technology (WSN). Battery power powers all the smart sensor nodes, and that data is collected, analyzed, stored in the cloud, and transmitted via nRF (“Northern Semiconductor Radio Frequency”) to the ESP32, which is a programmable integrated circuit. The actual ESP32 comes in a variety of designs. It also supports Wi-Fi and TCP/IP. It comes preinstalled with TCP/IP. It also contains RAM, which is used to store the data. And through the third node, which in turn carries out the process of receiving and sending data, the third node receives information from the first and second nodes through the Esp32 processor and via the Wi-Fi network linked to the NRF, through which all the information obtained from the deployed sensors is received. in the environment. which is responsible for providing data to that environment, and via the transmission medium (nRF), transmission is done from the first and second nodes in which the Arduino type (2560) was used, and then the data is sent to the third node, which contains the ESP32, and via the Internet as a transmission medium, the data is sent to a database. Cloud (In the event that the Internet is not available or the signal is weak, the information is stored in the processor's memory until the Internet connection is secured between the third node and Firebase, and then the interactive interface via the MIT APP application.

II. Related Work

In [13] the researchers were able to monitor air quality. This study used RFID, M2M, and sensor networks. In order to reduce air pollution, cloud-based decision making enables intelligence to be integrated into traditional electrical equipment to allow it to operate autonomously and reliably. Through big data analysis, the intelligent air quality monitoring system is flexible, reliable and efficient. Microcontrollers, wireless

Fig. 1. Shows the nature of the marshes.

sensor networks (WSN), cloud computing, GPS, Service and Android are major contributors to air quality regulation. In the same context, and based on the implementation strategy. In [14] Enables the design of an EMS using an Arduino Cloud service hardware components DHT11 and ESP8266 where connected DHT11. And thing speak to each other using arduino IDE and android App. in [15] the efforts of the researchers using LabVIEW technology, multiple sensors were linked to analog sensor data that was measured and displayed on a screen in LabVIEW using a graphical user interface (GUI) in Smart Cities and direct ambient air quality monitoring in real time using that technology, and LabVIEW. A real-time air quality monitoring system was introduced that included carbon monoxide and nitrogen measurements, as well as carbon dioxide and methane measurements. Through that system, the system combats pollution in public places and paves the way for reducing pollution. In [16] Monitoring weather and ecosystem as an advanced weather monitoring solution through the Internet of Things (IoT). It is an advanced and useful way to connect Internet things and people to the entire network of connected things through environmental monitoring and management. Data is displayed graphically and updated information from the port system can be accessed online from anywhere in the world. In [17] (proposes a smart agricultural strategy based on the Internet of Things. This study introduced a soil moisture and temperature monitoring system for agriculture. After inserting the sensors, it will work automatically. Things speak cloud stores soil temperature and humidity for testing. And with Wi-Fi based on UDP and HTTP, and one with Bluetooth Smart. All systems provided can remotely capture and display data on any device connected to the Internet. In [18] were also able to monitor the soil moisture and temperature of agricultural land and control that process using the Internet of Things software system on a cloud platform server and a cloud platform client. Uploading data into the cloud server through TCP and transmitting data of vital fungi affecting vital agricultural crops. In [19] the researchers confirmed that the Internet of Things is a technological tool that will greatly assist in research and Understanding the dynamics of wetlands, especially the wetlands of the high andes, and their relationship to climate change, which at least from the literature, has not been sufficiently explored. As for [20] and where the environmental conditions were monitored through the IoT KAA platform and temperature control, Humidity, carbon dioxide and real-time data transmission from sensors to web applications. To enhance the capabilities of IOT, the researchers confirmed in [21] that they was able to harness it in electronic games. Given the flexibility of the Internet of Things technology, this flexibility was exploited by the researchers in [22] smart homes to monitor gas leaks, electricity meters, and others. This and many applications that work with this technology. A comparison was presented in previous studies with the study in this paper, as this paper differs from what was mentioned in the Table I. It contains three nodes instead of one and contains a number of sensors for the marsh environment, determining the location of each node, a measure of the voltage and current consumed, as well as the structure of the database on the fire applica-

TABLE I. COMPARISON BETWEEN PREVIOUS STUDIES.

References number	The technology used	Cloud type	Environment type
[12]	IOT technology	Satellites	To monitor natural disasters
[13]	IOT technology (Lab view)	Cloud computing platform	Air pollution monitoring (one node)
[14]	IOT technology	Thing speak cloud	Environmental monitoring system
[15]	It uses the Zig bee communication system directly on the computer screen	Without a cloud	Air quality monitoring
[16]	Use Kalman filter	The absorption method is known as Ensemble	Flood forecasting
[17]	IOT technology	Thing speak cloud	To sense the proportion of gases in nature
[18]	IOT technology	Thing speak cloud	To monitor the climate of agricultural fields
[20]	IOTKAA	KAA cloud servers	Environmental monitoring
[22]	IOT technology	Cloud computing	Monitor and control smart cities

tion. Pace as a work environment that connects between the sensors and the interactive interface designed with the MIT APP system that can be work as an application on the smart phones.

III. STAGES OF BUILDING A MONITORING SYSTEM

In this paper, we discuss the working mechanism of the monitoring system for the marsh environment, which consists of a weather monitoring system that includes temperature and humidity monitoring. The wind speeds up the percentage of carbon dioxide, the percentage of hydrogen, and the percentage of rain, as well as determining the location of the knot. In addition, knowing the current each node consumes and the amount of voltage and the use of Internet of Things technology. Fig. 2 shows the phases of the monitoring system, where the life cycle of the system consists of five successive phases.

A. *Building of the System*

The stage of building the system is the first stage, which consists of three nodes, an electronic cloud, and a user interface, Fig. 3. shows the structure of the system.

the system consists of the following components:

- **Arduino mega**

It is the microcontroller board called Arduino Mega 2560, which is considered the main processor for the first and second

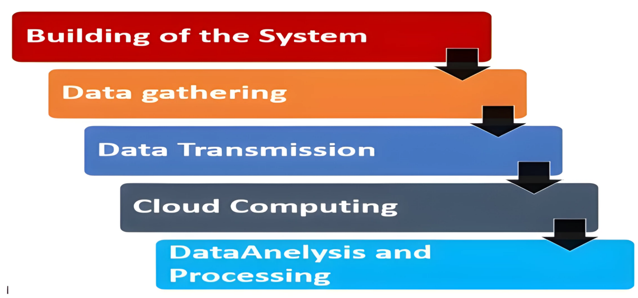


Fig. 2. Describes the stages of system lifecycle.

node. The temperature and humidity sensor, which has an analogue signal, is connected to it. The wind speed sensor, which has an analogue signal, is also connected to it. After that, the rain sensor, the carbon dioxide gas, the hydrogen gas, the voltage and current sensor, as well as the rain rate sensor, which is in the form of a digital signal, and the GPC, which is responsible for determining the location of each installed node. In the marshland environment in Fig. 3, each node contains nRF24L01, which is responsible for communicating between nodes through radio waves.

- **ESP32**

It is an integrated circuit capable of programming. using LED boards that feature Atmel processors and connectivity. These

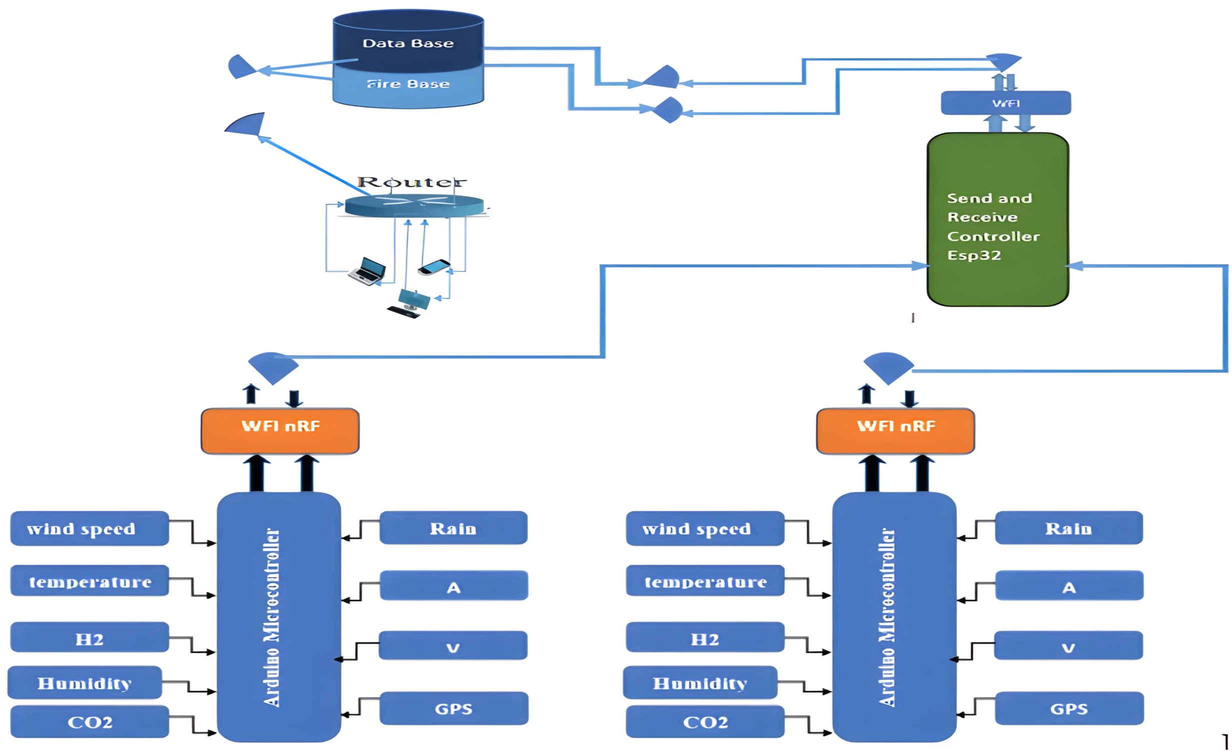


Fig. 3. Shows the structure of the system.

CPUs have as much RAM and storage capabilities as a PC. For permanent data storage, it has a Micro SD and ARM card with more RAM. Microcontroller clusters support a large number of devices in the available communication protocols. such as SPI, I2C, UART, etc. As a result, it is currently using a small wireless network. The actual ESP32 is similar to the microprocessor described previously; it also supports Wi-Fi and TCP/IP. It comes pre-installed with TCP/IP.

- **Batteries**

This system contains 12-volt DC batteries on the number of nodes (3 batteries), where each battery supplies the nodes with the required power source, and there is an electronic circuit that converts 12 volts to 5 volts DC, where there are different voltages in each node according to different sensors.

B. Data Gathering

The data is collected through wired sensors to the processor (Arduino Omega), where the sensors take samples as a signal, either digital or analog, and deliver it to the processor as shown in Fig. 4a, which represents the first node, and Figure 4b, which represents the second node.

- **Sensors attached to the nodes**

wind speed sensor, rain sensor, air temperature sensor, humidity sensor in the air, sensor of carbon dioxide in the air, hydrogen sensor in the air, location sensor node, voltage sensor, consumed current sensor.

C. Data Transmission

Fig. 5 represents the third node, which in turn performs the process of receiving and transmitting data, as the third node receives information from the first and second nodes via the Esp32 processor and via Wi-Fi associated with nRF, through which all nodes receive information obtained from other devices. Sensors scattered in the environment. Send it over the Internet to a cloud database. In the event that the Internet is not available or the signal is weak, the information is stored in the memory of the processor until the Internet connection is secured in the third node with the data hall or the radio waves used between the third node, the first node, and the second node. Then it is received from the site stations, then to the receiving station, and sent to the cloud via the Internet periodically, and through sensors it sends its data, such as wind speed, which can be determined through the existing sensor, as well as knowing the percentage of rain, air temperature, and humidity in the air surrounding that environment. There are two sensors to know the percentage of carbon and hydrogen, as well as the location of the node, which can be

(a) The first node. (b) The second node.

Fig. 4. Comparison of the first and second nodes.

determined through the GPS, and there is a sensor to measure the voltage consumed and the current required to operate the station. All these sensors are responsible for giving the required information, each according to its specialization, and then communicating through the processor. (Arduino 2560) and then the nRF responsible for sending data to the ESP32 located in the three nodes.

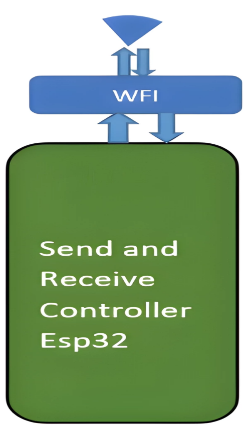


Fig. 5. The routing node.

D. Cloud Computing

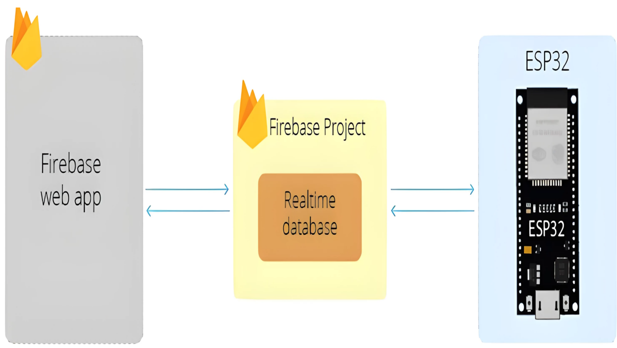
After the data reaches the third node, the processor (ESP32) connects to the database via the wife network and through the Internet as a carrier, where that data arrives in the Firebase to be processed and then sent to the user's interactive interface. Fig. 6a illustrates this. We took advantage of Google's free privacy policy and created a database for these sensors using Firebase and the HTTP communication protocol to secure communication to and from the database as in Fig. 6b.

E. Data Analysis and Processing

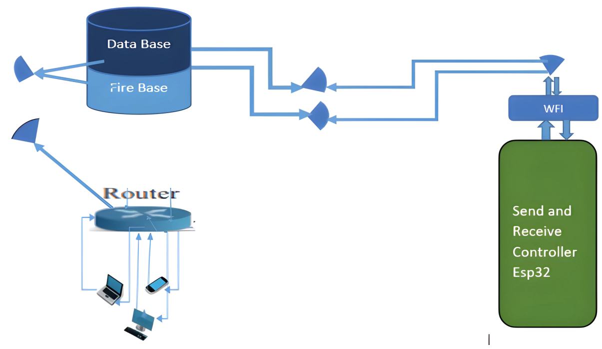
Fig. 7a the interactive interface of the system and it is also possible to add other interfaces for each added node, whereby the client allows those interactive interfaces to deal with the internal data that has been processed and programmed in the cloud after the process of receiving information from the site node through the three nodes, which It, in turn, is linked to the online cloud, where the cloud contains Firebase. Which in turn converts the data into information ready for transmission and links it to the interactive interface using communication protocols. The interactive interface on the mobile phone is designed according to the MIT APP system for Android, and through the interactive interface, the user can browse and navigate between pages so that each node has its own page; i.e, there is freedom of movement. The ability to access Google Earth through an existing button that links the user there. Through Fig. 7b of the project flowchart, where the data is collected in Node 3, and in the event that the transmission is not possible for some reason or not, the process is restarted again when the sending environment is available and then to the cloud via the Internet, and the cloud also considers data access for processing when it is provided; otherwise, it will look and repeat the process again until the data is completed, converted into information, and sent to the user through the interactive interface.

IV. Samples of the Climate of the Stagnant Marsh Waters

Climatic samples of the marshes: at this stage, samples were taken from three areas of that environment through the two nodes. The results were obtained and presented in the form of tables. Through the tables, the interactive interfaces were obtained as shown in Fig. 8, and displayed as an interactive interface on the mobile phone, where the climate of the stagnant aquatic environment of the marshes was sampled.



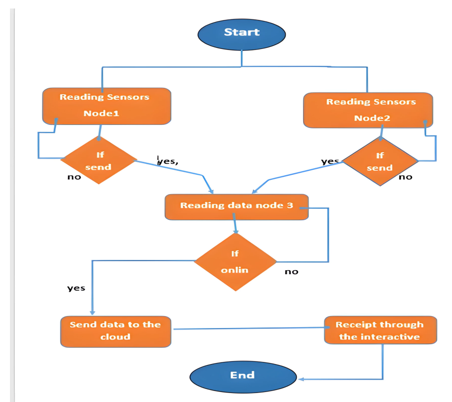
(a) Fire Base.



(b) Cloud Computing.

Fig. 6. Fire base and cloud computing.

(a) The user mobile app interface.



(b) The project flowchart.

Fig. 7

Fig. 8. Interactive interface models used to build table.

The following readings were obtained and recorded in Table II. Fig. 9, shows a graph of those table values appears.

As for the climate of the environment of one of the marsh feeding rivers (Euphrates River), it was read in the Table II below, and the Fig. 10 shows the values of the table.

The sampling time was at different times: 9 a.m., 5 p.m., and then 9 p.m. that the current was stable in the nodes at all times and in different places where the current was not interrupted. Table I for the marsh climate environment well as the Euphrates River climate environment, where the current was fairly stable; it ranged between 0.11A and 0.24A, and as for the voltage, it ranged between 6 and 12 volts, as in the above tables. Where it is possible to benefit from the stability of the voltage and current in the sense that there is no specific defect in the sensors, but if any change occurs in it, such as a current rise or a voltage drop, then we conclude that there is a malfunction in one of the sensors or a malfunction in the battery charge. Through Tables II and III for those

TABLE II. SHOWS THE SAMPLE VALUES FOR THE CLIMATE OF THE MARSHES AT 9 AM, 5 PM, AND 9 PM. NODE1, NODE2.

Sensor type	Time 9:00 am		Time 5:00 pm		Time 9:00 pm	
	Node 1	Node 2	Node 1	Node 2	Node 1	Node 2
Temperature	41.3	40.9	45.7	45.0	41.3	40.9
Humidity	20 %	15.7 %	17.4 %	12.7 %	20 %	15.7 %
Voltage	12	12	12	12	12	12
Current	0.24	0.16	0.11	0.15	0.18	0.24
LAT	30.92527	30.92526	30.92527	30.92525	30.92527	30.92526
LOG	46.50834	46.50825	46.50834	46.50825	46.50834	46.50825
Wind speed	1.70	1.73	1.64	2.23	1.70	1.73
Rain	0 %	0 %	0 %	0 %	0 %	0 %
CO2	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%

TABLE III. SHOWS THE SAMPLE VALUES FOR THE CLIMATE ENVIRONMENT OF THE EUPHRATES RIVER AT 9 AM, 5 PM, AND 9 PM. NODE1, NODE2.

Sensor type	Time 9:00 am		Time 5:00 pm		Time 9:00 pm	
	Node 1	Node 2	Node 1	Node 2	Node 1	Node 2
Temperature	53.90	55	38.70	38.3	31.3	33.9
Humidity	14.7 %	18.5 %	23.7 %	24.4 %	21.9 %	20.7 %
Voltage	11	11	11	11	11	11
Current	0.22	0.19	0.13	0.16	0.14	0.21
LAT	30.92564	30.92564	30.92564	30.92564	30.92564	30.92564
LOG	46.50884	46.50890	46.50886	46.50890	46.50884	46.50885
Hydrogen	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Wind speed	1.79	1.73	1.50	2.11	2.10	0.53
Rain	0 %	0 %	0 %	0 %	0 %	0 %
CO2	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%

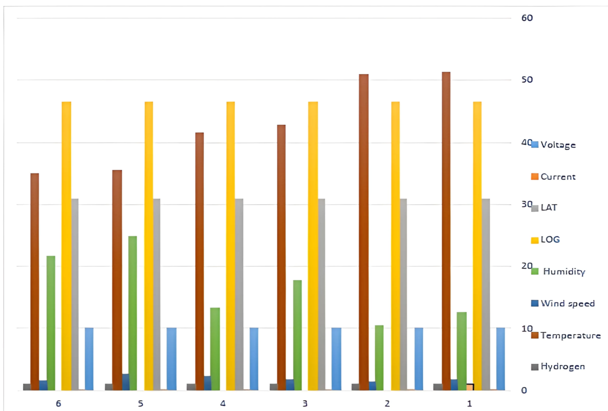


Fig. 9. A graph of the climate values of the marshes that were obtained at 9 am, at 5 pm, and at 9 pm. Node1, Node2.

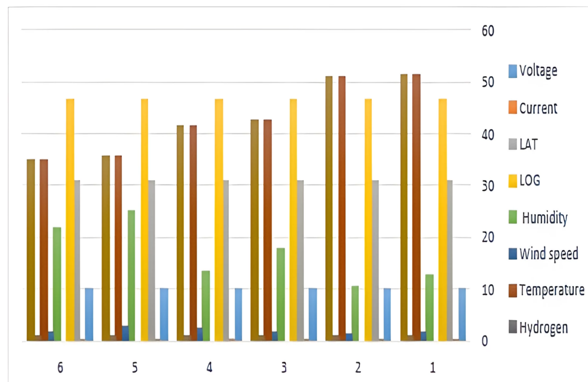


Fig. 10. Graph of the climatic values of the Euphrates River obtained at 9 am, 5 pm, and 9 pm. Node1, Node2.

environments, we note that the percentage of rain is non-existent (0.0%) due to the summer season, as there is no rain in that environment.

- Through the values established in Tables I and II , the percentage of hydrogen and the percentage of carbon at all times and in different environments did not exceed 1.00%. This means that the percentage is very low, and therefore it can be said that the percentage of air purity there is very high because those The environment is open; there are no pollutants or emissions in it, and the frequent exchange of light is constant due to the abundance of plants in that environment. As well as determining the location through the global positioning system (GPS) of the contract, which gives the longitude and latitude fixed in the following tables, Table II gives the values of latitude and longitude for the climate of the stagnant marsh environment and the climate table of the Euphrates River (2), through which the location of the contract can be determined. accurately and can also be used as guideposts in the marshland environment and the Euphrates River environment, as it is difficult to track this environment and contact due to the density of reeds grasses, and plants with a high and dense height. We notice this through the readings fixed in Tables II and III. These readings are in the marsh climate environment, where the wind speed was in the marsh climate environment; as shown in Table II, its maximum speed was 2.96 m/s, while its lowest speed was at 9 pm, when it reached a low level of 1.0 3 m/s. As in Table I, as for the wind speed in the Euphrates River climate environment, which reached the highest speed (2.53 m/s) as in Table III at 9 pm, the lowest speed in that environment was at 5 pm, when the speed reached 1.4 m/s. It has been observed through the values shown in the tables that the wind speed fluctuates and its speed varies according to the nature of the climate there, where the summer is moderate and the wind is moderate. • Weather temperature and humidity have changed over time. It was in the marshes and at 9 am the temperature ranged between (41-47) degrees Celsius, and the humidity ranged between (15-21%) as in Table. II from 9 am until five in the afternoon we notice the temperature between (45-45 41) degrees Celsius, and the humidity ranges between (9.9 - 16.9%), as shown in Table II Where we notice in the evening a decrease in temperature due to the absence of sunlight, and the humidity also ranges between (10.5-22%). As for the climate of the Euphrates River at 9 am, the temperature ranged between (53.9-51.9) degrees Celsius, and the humidity ranged between (18.9-13.7%) as shown in Table III and at five o'clock in the evening, the temperature ranged between (36-41.7) and the humidity ranged between (22-24%) at 9 o'clock in the evening in the absence of sunlight. Note that the temperature ranged between (34-31). Humidity ranged between (22.6-19.7), as shown in Table III There is a variation in temperatures from one decade to another and from environment to environment due to the high summer temperatures in that environment. This negatively affects the moderation of the climate there and the occurrence of biological changes due to the low water level.

V. Conclusions

Through IoT technology and periodically planting sensors in the marsh environment, that environment can be monitored accurately, as the climatic conditions of the marsh environment can be monitored, such as temperature, humidity, wind speed, carbon dioxide, hydrogen, and rainfall, in addition to determining the location through GPS technology. The climate changes that the marshes are experiencing are monitored smoothly and regularly through an interactive method with the user. Which is in the form of an interactive interface, after the marsh environment was difficult to monitor and access to that environment and the difficulty of taking samples for that area, the most important problem of which is the inability of the research team to stay there for a long period. Thus, this system succeeded in monitoring the marsh environment, and the results we obtained in terms of the degree The temperature, humidity, and locations of the nodes distributed in that environment, and determining the wind speed and the percentage of hydrogen and carbon, and thus this system succeeded in monitoring that environment remotely by exploiting the IoT technology to achieve the sustainability development and keep the marshes nature, saved researchers time, efforts and safety from risks with save of the green life.

Conflict of Interest

The authors have declared no conflict of interest.

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