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VISIÓN ELECTRÓNICA

# Monitoring of environmental variables based on the Internet of Things (IoT) and supported by the ThingSpeak platform in the Las Siras stream, in the municipality of Duitama, Colombia.

*Monitoring of environmental variables based on the Internet of Things (IoT) and supported by the ThingSpeak platform in the Siras stream, in the municipality of Duitama, Colombia.*

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## Abstract

Understanding and protecting natural environments is essential for the survival of living beings, being water one of the vital elements for humans, therefore water resources and other elements must be monitored to understand and protect their environment, this leads to apply the Internet of Things (IoT) technology for monitoring environmental variables, in the stream La Siras, in the municipality of Duitama, department of Boyacá in Colombia.

The IoT technology integrated with the ThingSpeak platform that allows collecting and analyzing data in real time, having a follow-up by reading each of the data captured by temperature, humidity and turbidity sensors, fundamental variables to evaluate the water quality and

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environmental conditions in the stream, the integration of the sensors through an Arduino board, which through a Wifi module sends the recorded data to the cloud on the ThingSpeak platform.

The environmental monitoring system becomes a tool that facilitates real-time decision making by helping decision makers to act and manage processes and implement environmental protection measures based on accurate and current data.

**Keywords:** Arduino, IoT, monitoring, Sensors ,ThingSpeak, variable.

**Resumen**

Comprender y proteger los entornos naturales es esencial para la supervivencia de los seres vivos, siendo el agua uno de los elementos vitales para los humanos, por lo anterior los recursos hídricos y otros elementos deben ser supervisados para comprender y proteger su entorno, esto lleva a aplicar la tecnología Internet de las Cosas (IoT) para el monitoreo de variables ambientales, en la quebrada La Siras, en el municipio de Duitama, departamento de Boyacá en Colombia.

La tecnología IoT integrada con la plataforma ThingSpeak que permite recopilar y analizar datos en tiempo real, teniendo un seguimiento por la lectura de cada uno de los datos capturado por sensores de temperatura, humedad y turbidez, variables fundamentales para la evaluar la calidad del agua y las condiciones ambientales en la quebrada, la integración de los sensores mediante una placa de Arduino, que a través de un módulo Wifi envía los datos registrados a la nube en la plataforma ThingSpeak.

El sistema de monitoreo ambiental se convierte en una herramienta que facilita en tiempo real la toma de decisiones ayudando a los responsables actuar y gestionar procesos e implementar medidas de protección ambiental basadas en datos precisos y actuales

**Palabras Clave:** Arduino, IoT, monitorización, sensores, thingSpeak, variable.

## 1. Introduction

In an increasingly interconnected world, environmental monitoring has become a priority to understand and protect nature's physical environment. This paper explores how IoT integrates with the ThingSpeak platform, which acts as a centralized command center, providing data analysis and visualization capabilities. From the detection of harmful substances to the management of natural resources, this combination offers a powerful solution to address environmental challenges and contribute to the sustainability of the planet.

The IoT has revolutionized the way we interact with the physical world. This technological paradigm enables the connection and communication between devices and sensors, providing unprecedented opportunities to monitor environmental variables efficiently [1]. The La Siras stream, with its rich biodiversity and ecological relevance, becomes an ideal scenario to implement an IoT-based monitoring system.

La Siras Creek is a vital tributary in the municipality of Duitama, located in the CundinamarcaBoyacá highlands of Colombia. Its meandering course flows through mountainous landscapes, native forests, and agricultural areas. In addition to its natural beauty, it plays a crucial role in the local ecological balance, providing habitats for diverse species of flora and fauna. However, it also faces environmental challenges. Water pollution, deforestation and climate change affect its health and sustainability, causing it to overflow. To address the latter problem, a system for monitoring variables such as temperature, humidity and turbidity using IoT technology and supported by the ThingSpeak platform and in real time is developed to assess environmental conditions and take preventive measures [2].

This study contributes to the knowledge on IoT-based environmental monitoring and will provide valuable information for resource management decision making. It will also serve as a model for other similar projects in vulnerable areas.

## 2. Methodology

### 2.1. Sensor Selection

The selection of the appropriate sensors is an essential component in the configuration of the monitoring system. Taking into account three key parameters: temperature, humidity and turbidity (Figure 3, 4 and 5). For the measurement of temperature and humidity, the DHT11/DHT22 (AM2302) sensor is selected, which offer high accuracy and stability in various environmental conditions. For turbidity, the SEN0189 sensor can provide accurate measurements of the amount of light scattered by particles suspended in the water.

Integrating these sensors with an Arduino module is the next step in the process. Arduino, being an open source hardware platform, offers great flexibility and ease of use. The sensors are connected to the Arduino board using the analog or digital input pins. Through programming in the Arduino development environment, we can configure the system to read and process sensor data efficiently [3].

Finally, to facilitate data transmission to ThingSpeak, an ESP8266 Wifi module is incorporated into the system. This module, once connected to the Arduino board, supports wireless data transmission. We can program the Arduino to send the data collected by the sensors to ThingSpeak at regular intervals using the ThingSpeak API. This monitors the Siras Creek conditions in real time, and allows us to store and analyze the data over time, which could be invaluable for understanding trends and patterns in the creek conditions.

In the IoT world, ThingSpeak has established itself as a leading analytics platform that supports real-time data aggregation, visualization, and analysis in the cloud [4]. For the environmental monitoring project in the creek, ThingSpeak is an ideal choice due to its ability to handle large volumes of real-time sensor data, its ease of use, and its wide range of functionalities [5]. In addition, ThingSpeak offers a robust and easy-to-use API that facilitates integration with a variety of devices and hardware platforms, including Arduino [6].

By setting up an account on ThingSpeak, a cloud platform that facilitates real-time data collection and visualization, you enable real-time data collection and visualization by creating the necessary channels for sending data and its subsequent analysis.

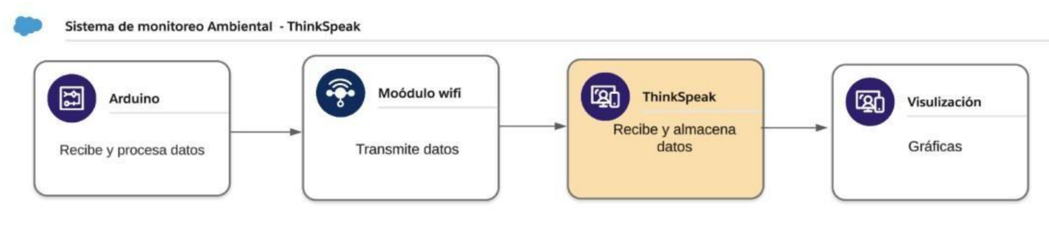
Given the hardware configuration, a connection is established between the Arduino and the DTH11 and SEN0189 sensors which, being connected to the ESP8266 Wifi module, establish the Internet connection and thus be able to transmit data to ThingSpeak.

Subsequently, it is necessary to create a channel, where your data will be stored, configuring the necessary fields for the data to be collected, there is required to obtain an API Key, which is necessary for the device to send data to the ThingSpeak channel securely, once this process is done, the necessary code is written and loaded into the microcontroller to collect data from the sensors and send them to ThingSpeak and display the data by accessing the channel in ThingSpeak to view the data collected in the form of graphs and tables updated in real time.

Therefore, sensors are installed in a strategic area of the Siras Creek to measure key parameters such as temperature, humidity and turbidity. These sensors are connected to an Arduino module, which acts as the brain of the monitoring system. The Arduino is programmed to read data from the sensors and send it to ThingSpeak via a Wifi module. Once the data reaches ThingSpeak, it is stored in a pre-configured channel.

ThingSpeak plays a crucial role in this project by providing us with a platform to store, visualize and analyze data. But it goes beyond being a data repository. With ThingSpeak, we can perform pattern analysis on the data, which helps us understand how environmental conditions in the creek change over time. This is vital for monitoring and protecting the environment in Duitama, Colombia. In addition, ThingSpeak's ability to integrate with other platforms and services allows us to create a complete and robust environmental monitoring system [7][8].

**Figure 1. Monitoring system**




Source: Own elaboration

### 2.2. Sensor Deployment

Within the framework of this project, one of the fundamental steps is the Implementation of Sensors. This process involves the strategic placement of sensors near one of the populated areas since, if the stream is near populated areas, it could be useful to place sensors near these areas to provide early warnings of possible flooding [9].

Once located, these sensors are programmed to continuously transmit data to ThingSpeak. This transmission will be done through wireless connections, making it possible to receive and analyze the data in real time. This approach is conducive to closely monitoring stream conditions and making informed decisions based on the data collected. To ensure the accuracy and reliability of the data collected, regular tests were conducted from January and April 2024 and necessary adjustments were made to the sensors. This included verification of the physical integrity of the sensors, calibration to ensure accuracy of readings, and testing of wireless connections to ensure uninterrupted data transmission to ThingSpeak.

**Figure 2.** Sensor location area

Source: Own elaboration

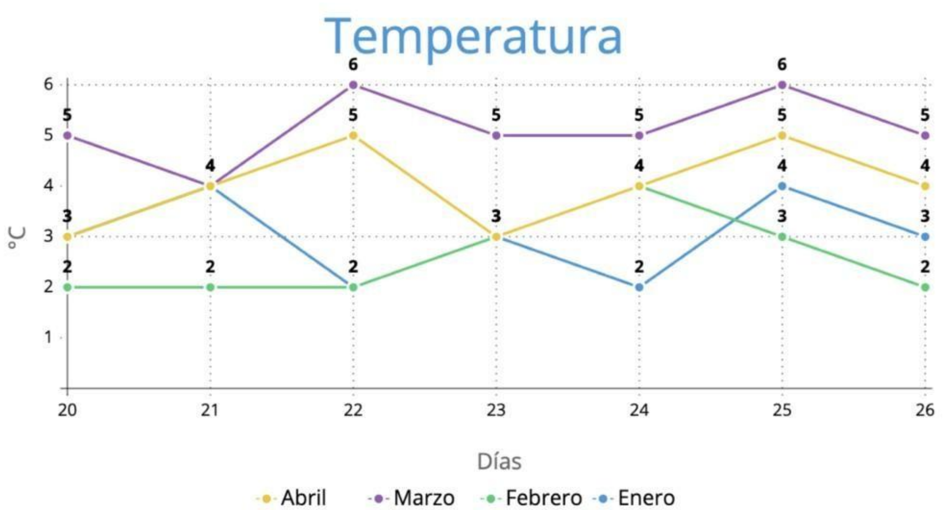
**2.3. Data Analysis**:

The initial phase of data analysis focuses on data collection and preparation. Sensors strategically placed along the stream collect temperature, humidity and turbidity data (Figure 3, 4 and 5). These are transmitted to ThingSpeak via wireless connections. Once in ThingSpeak, the data undergoes a cleaning and preprocessing process.

With the data prepared, we proceed to Exploratory Data Analysis. This is an important step in understanding the structure and relationships inherent in the data.

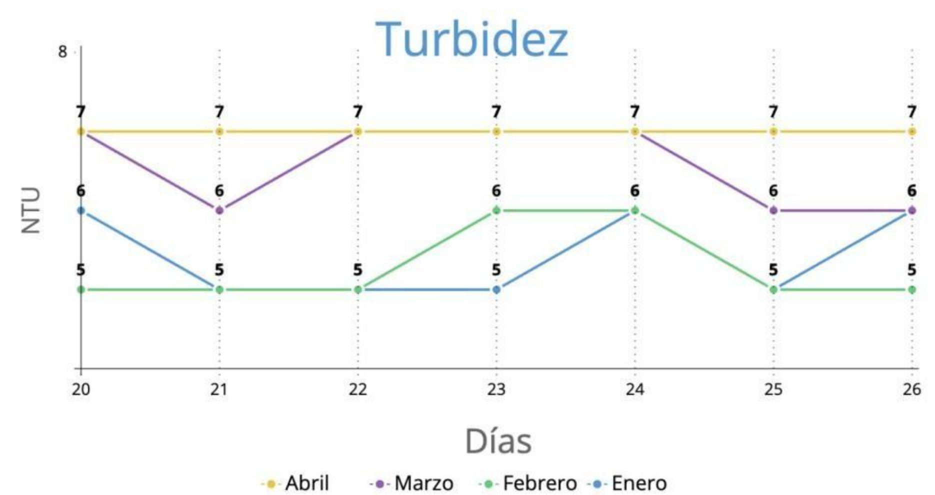
The last phase of data analysis is the interpretation and communication of the results. Here, the technical results of the models are translated into understandable and actionable information. An interactive dashboard is also implemented in ThingSpeak (Figure 6) that gives users access to explore the data, providing clear and useful information that can be used to make informed decisions about the management and protection of the stream.

**Figure 3.** Broken temperature behavior results



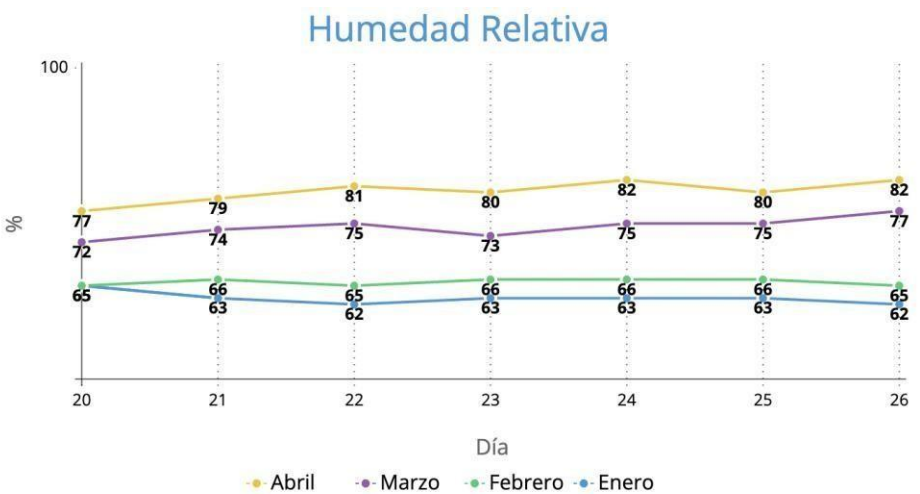

Source: ThingSpeak

**Figure 4.** Results of broken turbidity behavior



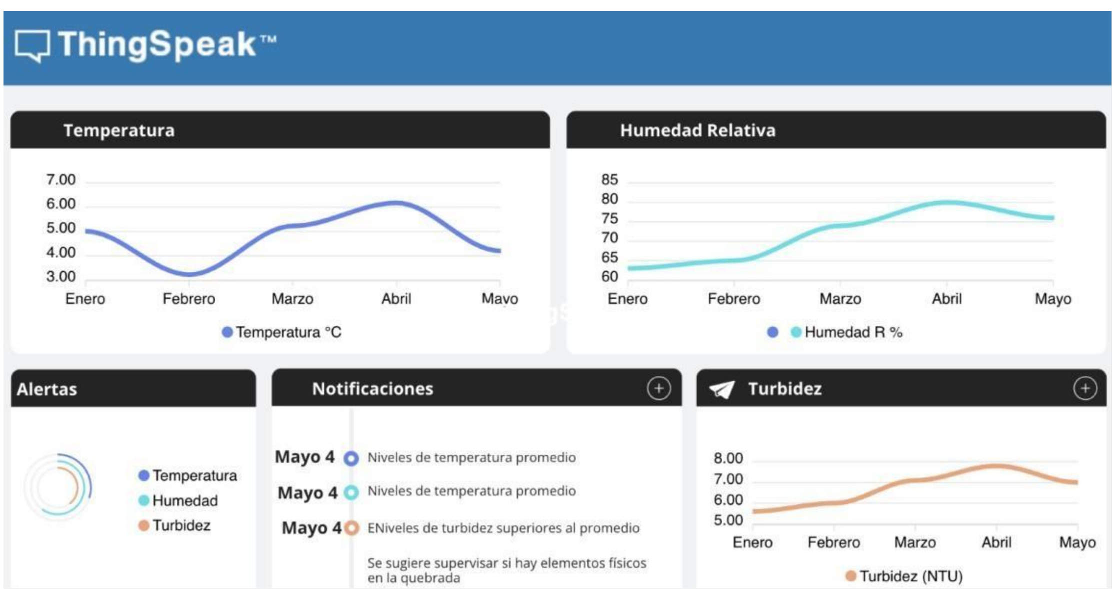

Source: ThingSpeak

**Figure 5.** Results of broken turbidity behavior




Source: ThingSpeak

**Figure 6. Dashboard**




Source: ThingSpeak

### 2.4 Alerts and Notifications

An essential part of the system is the configuration of alerts and notifications. These are designed to inform us when the data collected by the sensors exceeds certain predefined thresholds. For example, if the temperature or turbidity in Siras Creek exceeds a certain level, the system can send an alert to inform us of this situation.

Real-time notifications are a key feature of the system. Thanks to wireless connectivity and the ThingSpeak platform, it is possible to receive real-time notifications on the devices whenever an alert is triggered [10]. This is conducive to responding quickly to any changes in environmental conditions. [11]

Alerts and notifications are crucial to the success of the project as they allow us to monitor conditions in the creek efficiently and effectively. By receiving real-time alerts, we can take immediate action to protect the environment if potentially harmful conditions are detected.

In addition to simply receiving alerts, we also perform an analysis of the alerts received. This helps to better understand conditions in the stream and to identify any patterns or trends in the data. For example, if we receive regular high turbidity alerts after heavy rains, this could indicate that soil erosion is a problem in the area.

Once we receive an alert, the next step is to determine the appropriate action. Depending on the nature of the alert, this could involve further testing, modification of sensor parameters, or even physical intervention in the stream. For example, if we receive a high turbidity alert, we might need further testing to determine the cause and take necessary action to mitigate the water level at that point [12].  Thus, alerts and notifications inform us about current conditions and guide us in actions to prevent future overflows [13] [14].

## 3. Results

The data show that the temperature measured in degrees Celsius (°C) remains constant throughout the months, ranging between 20 and 26 degrees Celsius. There is no clear trend of increasing or decreasing temperature over time.

Turbidity measured in Nephelometric Turbidity Units (NTU) appears to increase slightly from January to April. In January, values range from 5.7 to 6 NTU, while, in April, values range from 7.2 to 7.8 NTU. This could indicate an increase in the amount of suspended particles in the water over time.

Relative humidity measured in percent (%) also seems to increase from January to April. In January, values range from 62% to 65%, while in April, values range from 77% to 82%. This could indicate an increase in the amount of humidity in the air over time.

A significant correlation is identified between the simultaneous increase in turbidity, temperature and relative humidity indices with the increase in stream levels. This suggests that these environmental parameters can be reliable indicators of hydrological changes in small water bodies. Understanding these dynamics is crucial for action to prevent possible flooding, highlighting the importance of continuous and accurate monitoring of these variables.

The sensors installed in the target area are designed to collect data on temperature, humidity and turbidity and transmit it in real time to ThingSpeak, providing a continuous, real-time view of the environmental conditions in the creek. This data collection is critical to the project, as it provides the information we need to understand and protect the environment in the creek.

The system also includes a real-time alert and notification system. If data collected by the sensors indicate that conditions in the creek are changing in a way that could be detrimental to the environment, the system sends an alert to project managers. This allows them to respond quickly to any changes in environmental conditions, and to take action to protect the environment if necessary.

Through data collection and analysis, the project provides us with the information we need to improve environmental management in the stream. For example, if the data indicate that the water quality in the stream is increasing, we can protect the stream environment by checking for significant amounts of solid waste or if the constant rains have raised the water level.

Finally, we hope that the project will help increase awareness and education about the importance of environmental protection. By sharing the data and findings with the local community and the general public, we hope to inspire others to take action to protect the environment. In addition, by providing a real-time view of conditions in the creek.

## 4. Conclusions

IoT-based monitoring of environmental variables is a useful tool for understanding and preserving the environment by alerting about future overflows.

The implementation of IoT sensors in the creek study area has enabled the successful collection of real-time environmental data. The sensors have proven to be reliable and accurate, providing valuable data on temperature, humidity and turbidity in the creek. The results of the project have proven to be a crucial source of information for environmental management decisions.

The observed correlation between increased turbidity and heavy rainfall underscores the importance of implementing proactive erosion control measures to preserve the ecological integrity of Siras Creek.

The data collected has been analyzed using the ThingSpeak platform. It has been possible to identify significant patterns and trends in the data, which has provided a deeper understanding of the environmental conditions in the creek.

The alert and notification system has proven to be extremely useful for real-time monitoring of conditions in the creek. The alerts have allowed us to respond quickly to any significant changes in environmental conditions.

The data and analysis provided by the project have guided the implementation of measures to prevent future overflows.

The use of IoT in environmental monitoring offers significant advantages, such as automation, real-time collection and scalability. However, it also faces challenges, such as data security, interoperability between devices, and power management.

The effectiveness of the current monitoring system suggests a favorable opportunity for expansion. Replication of this system in other areas of the creek, and potentially other creeks in the region, could provide a broader and more detailed view of local environmental health. Areas identified for improvement, such as sensor accuracy or sampling frequency, should be considered in future iterations of the system.

A technical review of the monitoring system is recommended to identify opportunities for improvement in the technology and methodology used. The adoption of emerging technologies could increase the efficiency and accuracy of monitoring.

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