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# INTERNET OF THINGS IN A GREENHOUSE USING ARDUINO

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**Abstract.** ***Monitoring parameters such as humidity, temperature, pressure and light are essential for the good development of plants in a greenhouse. This article represents incipient research for emphasizing the importance of data monitoring, data acquisition and data interpretation in order to obtain best results in greenhouse plant production. The monitoring system is composed of Arduino microprocessor-based system and Arduino shield with sensors. The presented greenhouse is heated with wood burning boiler which uses heated water that circulates through pipes and radiators inside the greenhouse. By continuously monitoring the greenhouse's temperature, the operator will be able to control the wood resupply considerably more effectively.***

Keywords: internet of things, monitoring system, Arduino, greenhouse, data acquisition

## 1. INTRODUCTION

Like it is mentioned in literature, a greenhouse is a structure designed to create a controlled environment for growing plants [1-2].

**Figure 1. Plants in a greenhouse.**

Greenhouses are commonly used for various purposes, including growing vegetables, fruits, flowers, and other plants year-round, regardless of external weather conditions. They can be found in commercial agriculture, research facilities, and home gardening. Also, greenhouses are typically made of transparent materials, such as glass or plastic, which allow sunlight to enter while trapping heat inside [1-2].

Greenhouses play a vital role in modern agriculture and environmental control. Also, greenhouses play a crucial role in enhancing food production efficiency while minimizing environmental impact.

Using Internet of things in a greenhouse can greatly enhance your ability to monitor and control the environment for optimal plant growth. This controlled environment helps regulate temperature, humidity, and light levels, promoting optimal growth conditions for plants [3-4].

**Figure 2. Internet of things in greenhouse**

Parameter monitoring in a greenhouse is crucial for optimizing plant health, growth, and yield. One of the most important parameters to monitor is temperature. Maintaining the optimal range for plant growth usually between 18-27°C is essential for a well-developed plant.

Another important parameter to monitor is humidity. Like it is mentioned in literature, ideal humidity levels vary, but generally range from 40% to 70% depending on

different plants. Also, an important aspect is that high humidity can lead to mold and diseases [1-2].

Also, monitoring light levels usually in micromoles of photons per meter squared per second is important for photosynthesis. Another aspect to mention is that supplemental lighting may be required in low-light conditions [1-2].

Other sensors such as soil moisture sensors, pH level sensors, carbon dioxide sensors, electrical conductivity sensors are also very important when implementing a microprocessor-based systems project in a warehouse. Using moisture sensors can help track the moisture levels in the soil to ensure proper watering without over or under-watering [1-2].

For soil or hydroponic systems, maintaining the right pH, which is typically around 6.0-7.0 for most plants, is essential for nutrient uptake. Electrical Conductivity sensors measure the concentration of nutrients in the water; an ideal range ensures plants are receiving appropriate nutrients [1-2].

Carbon Dioxide level sensors are used for monitoring CO2 levels, which has to be around 400-1000 ppm, which can enhance growth, especially in enclosed greenhouses. Also, an important factor is the proper airflow needed to avoid stagnant air, which can lead to temperature spikes and humidity issues. Also, regular testing of nutrient solutions or soil can help maintain the right nutrient balance [1-2].

For effective monitoring, consider using automated systems equipped with sensors to continuously track these parameters and provide data for analysis. Additionally, integrating a data logging system will allow for historical tracking and help identify trends or areas for improvement [5-6].

## 2. PROCESS DESCRIPTION

The aim of this part of the paper is to highlight the essentiality of the parameter monitorization of essential parameters for proper development of greenhouse plants which is very important for economic and health reasons in many fields of industry.

Heating a greenhouse is crucial for maintaining optimal growing conditions, especially in colder climates. For this case study, the greenhouse is heated with Wood Burning Boiler. This system heats water using a wood boiler, which then circulates hot water through pipes and radiators inside the greenhouse [3-4].

The necessity for remote temperature monitoring is to effectively manage the consumption of wood needed to heat the greenhouse. The operators monitor the temperature in the greenhouse in real time, so they will manage the resupply with wood much more efficiently. Also, proper insulation may help retain heat. Using double-layer polycarbonate panels or bubble wrap on the greenhouse walls and roof represents also a good choice for maintaining warm [3-4].

**Figure 3. Inside of a greenhouse**

Wood heating represents an efficient and eco-friendly method to warm a greenhouse, especially in rural areas where wood is readily available. Using hot water pipes, where the boiler heats water that circulates through pipes, it radiates heat into the greenhouse assuring the proper temperature for the plants [3-4].

## 3. APPLICABILITY OF ARDUINO SYSTEM IN GREENHOUSE

The aim of this part of the paper is to highlight the essentiality of the parameter monitorization of essential parameters for proper development of warehouse plants which is very important for economic and health reasons in many fields of industry. In this paper, the monitoring system is composed of:

- Arduino MKR WiFi 1010
- Arduino MKR ENV Shield with temperature humidity atmospheric pressure and light intensity sensors
- laptop
- wireless router
- smartphone

Like it is mentioned in literature, microprocessor systems are used on Internet of Things process of parameter monitoring. In order to remotely monitor the plants from a greenhouse, this article employed the

Arduino MKR WiFi 1010 board in conjunction with a shield equipped with temperature, humidity, pressure, and light sensors. Because of its high accuracy, all of these sensors can be used in a variety of intriguing experimental configurations [7-9].

Monitoring is accomplished by utilizing a laptop or smartphone with internet access to view a web page after the software program has been installed and compiled onto the Arduino board. In the figures below are presented images of the Arduino board and shield:

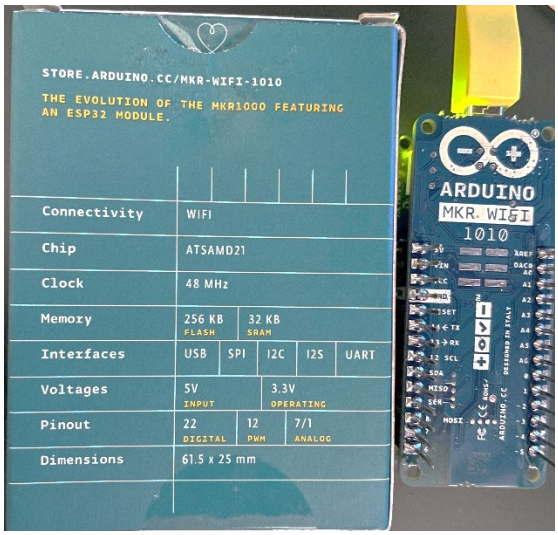


**Figure 4. Arduino MKR WiFi 1010.**

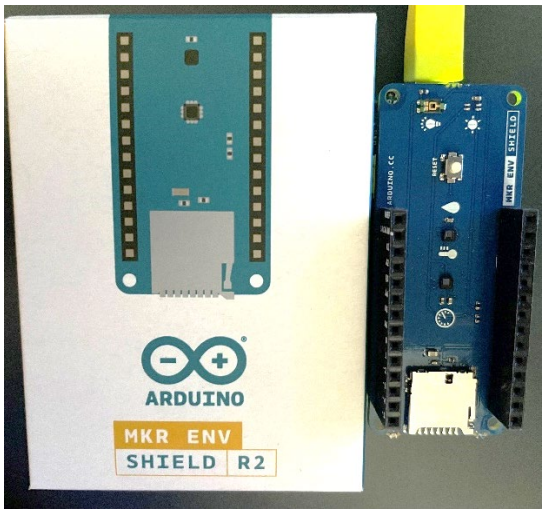


**Figure 5. Arduino MKR ENV Shield that contains temperature humidity atmospheric pressure and light intensity sensors.**

As has been noted in literature, microprocessor systems are used in the Internet of Things process of parameter monitoring. Using an Arduino in a greenhouse can greatly enhance the ability to monitor and control the environment for optimal plant growth [10-11].

Measured data is collected, processed and prepared for analysis after it has been gathered. Remote temperature monitoring is essential for efficiently controlling the amount of wood used to heat the greenhouse. In the following figure is presented a screenshot with user interface.

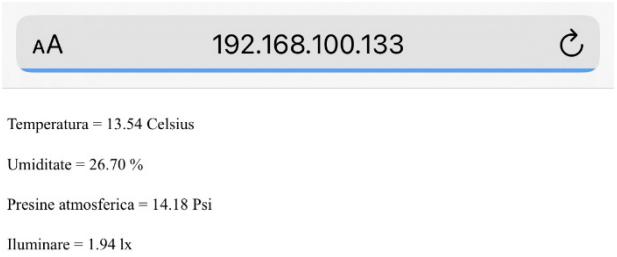


**Figure 6. User interface.**

In the following figure is presented the Arduino Integrated Development Environment and the Arduino circuit.

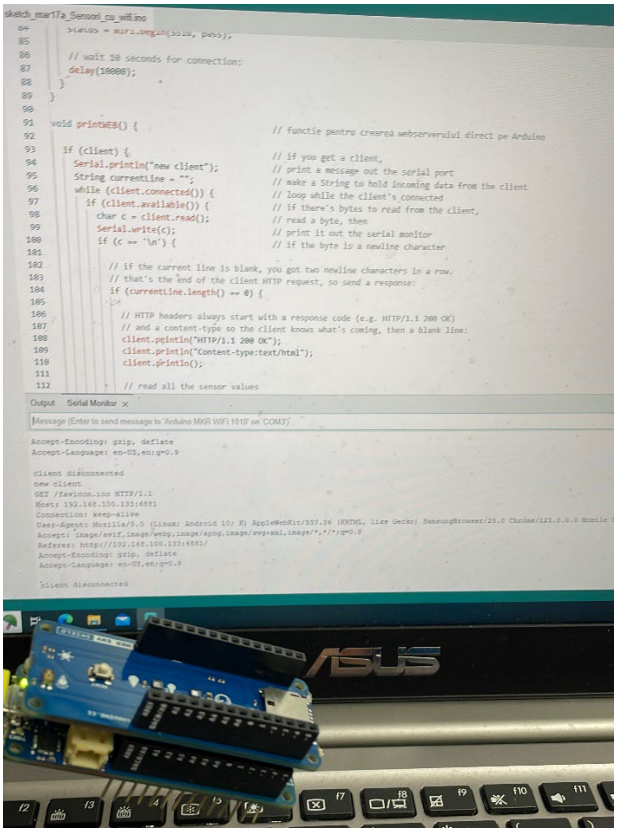


**Figure 7. Arduino IDE and circuit.**

An important aspect to mention is that the circuit is composed of MKR ENV shield which is attached with Arduino MKR WIFI 1010 board. The Arduino IDE (Integrated Development Environment), which is a program that enables creating, editing, and uploading code to the Arduino board, was used to develop the software application for temperature, humidity, pressure, and light intensity monitoring. The "sketch" code was created with the C/C++ programming language [7-9].

By continuously monitoring the greenhouse's temperature, the operator will be able to control the wood resupply considerably more effectively. Also, monitoring is accomplished by visiting a webpage that shows these parameters in real time, allowing one to examine the state of the plants from the greenhouse.

## 4. DATA PROCESSING AND ANALYSIS

The aim of this case study emphasizes the necessity of temperature monitorization in order to maintain proper temperature in greenhouse. Daytime and nighttime temperature analysis is part of the data processing research derived from parameter monitoring.

Remote temperature monitoring is essential for efficiently controlling the amount of wood used to heat the greenhouse. In order to handle the resupply with wood considerably more effectively, the operators keep a close eye on the greenhouse's temperature in real time.

Temperature monitoring occurs during a cold period, from 1st November until 13th December. Based on the outside temperature, the greenhouse is heated with a predetermined amount of wood. By monitoring the temperature in the greenhouse both during the day and at night, the operator streamlines wood consumption, thus achieving heating savings.

Using Microsoft Excel application, the collected data is transformed into a graph for improved presentation.

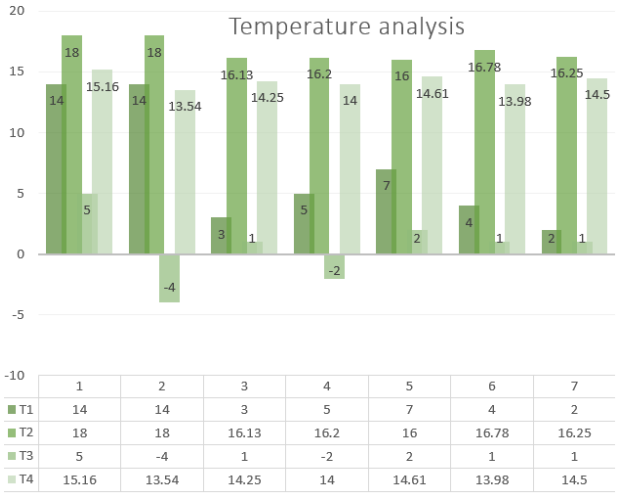


**Figure 8. Temperature values from 1st November until 13th December 2024**

Where:

- T1 – represents the outdoor temperature during the day
- T2 – represents the greenhouse temperature during the day
- T3 – represents the outdoor temperature during the night
- T4 – represents the greenhouse temperature during the night

Outdoor temperatures for November and December 2024 are collected and confirmed with accuweather.com website [12].

The collected data is presented in tabular form for improved presentation.

**Table 1. Temperatures from 1st November until 13th December 2024**

| no | date | outdoor temp | greenhouse temp | outdoor temp night | greenhouse temp night |
|---|---|---|---|---|---|
| 1 | 01.11.24 | 14 | 18 | 5 | 15.16 |
| 2 | 08.11.24 | 14 | 18 | -4 | 13.54 |
| 3 | 15.11.24 | 3 | 16.5 | 1 | 14.25 |
| 4 | 22.11.24 | 5 | 16.2 | -2 | 14 |
| 5 | 29.11.24 | 7 | 16 | 2 | 14.61 |
| 6 | 6.12.24 | 4 | 16.7 | 1 | 13.98 |
| 7 | 13.12.24 | 2 | 16.25 | 1 | 14.5 |

Remote temperature monitoring is essential for efficiently controlling the amount of wood used to heat the greenhouse. In order to handle the resupply with wood considerably more effectively, the operators keep a close eye on the greenhouse's temperature in real time.

## 5. CONCLUSIONS

The purpose of the paper is to highlight the importance of temperature control in a greenhouse in order to maintain the proper temperature for healthy plants in winter.

This article represents an incipient case study of temperature monitoring for greenhouse plants. The monitoring system is composed of Arduino microprocessor-based system and Arduino shield with sensors.

The greenhouse is heated with wood burning boiler which uses heated water that circulates through pipes and radiators inside the greenhouse. Boilers are quite efficient and provide consistent heat. By monitoring the temperature in the greenhouse both during the day and at night, the optimal temperature is ensured, avoiding excessive wood consumption.

For plants to grow well in a greenhouse, it is crucial to monitor variables including humidity, temperature, pressure, and light.

This article is an example of early research that highlights how crucial data collection, monitoring, and interpretation are to achieving the greatest outcomes in greenhouse plant production.

The Arduino shield with sensors and the Arduino microprocessor-based system make up the monitoring system. Utilizing a wood-burning boiler, hot water runs via pipes and radiators within the greenhouse to provide heat. The operator will have far better control over the wood resupply if the temperature in the greenhouse is regularly monitored.

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