International Journal of Electrical Engineering and Technology.
ISSN 2249-3085 Volume 11, Number 1 (2021), pp. 1-12

http://www.ripublication.com

An Internet of Things Tap Water Usage Monitoring System Device

Ahmed Hussain Sain[1], Sajid M. Sheikh[2], Benjamin C. Molefhi[3]

[1,2,3]Department of Electrical Engineering, Faculty of Engineering and Technology, University of Botswana, Private Bag UB0061, Gaborone, Botswana.

Abstract

Some countries like Botswana and South Africa have faced major water shortages in the past. Water charges have also increased over the years. Usually in homes and business premises, there are some taps, that have high water usage such as garden taps. For such taps, to control and monitor the water usage can help control high bills as well as water wastage. In this work, an Internet of Things (IoT) based device is developed that is connected to the tap to monitor water usage. The device needed to be easy to install onto a tap, compact, have the key components protected from the weather and have an internet connection through a Wi-Fi network to be able to send data to the server so the user can access it through a phone. The user should also be able to access for water usage for previous days or weeks. The developed device uses the NodeMCU ESP8266 board, having Wi-Fi capabilities and a flow rate sensor is used which attaches to the tap mouth. The power source of the device is a battery. The IoT platform used was Thingspeak, which is an online platform where data is send to or from the device through the internet. The way the device functions is that after it is installed onto a tap the sensor is then able to access the data through their phone. During the testing stages of this project, the device functioned as expected and the users were able to view the summaries of water they were using, and they could start saving where possible.

Keywords: Flowrate sensor, IoT, NodeMCU ESP8266 Microcontroller, Thingspeak, Water Usage Monitoring

I. INTRODUCTION

Water is one of the most essential substances on earth and water wastage is a problem in some households and businesses, which leads to excessive bills. High usage of water through some taps can be mainly due to watering the garden or washing cars. Technology can play a huge part in saving water where possible through water usage notifications.

This paper presents a system where an Internet of Things (IoT) enabled device is built to be able to monitor water usage of a tap. Data from the tap is sent over the internet to a server. The user can then connect through this server and few summarised data on a mobile smart phone.

II. LITERATURE REVIEW

Similar projects have been completed in the past by individuals around the world. Agustinus N, Denny K and Resmana L [1] created a water volume detection system using an Arduino Uno, Wi-Fi module and a water flow sensor. They designed a device which can monitor the water being used from a storage tank. The device can communicate with the user on a mobile phone through the internet. Communication was done with the use of Ubidots, an online server which receives data from the Arduino and sends it to the users' phone. A system used to monitor the quality and quantity of water was designed by Gowthamy J, Chinta R, Pijush M, Saransh S and Guddu K [2]. The system uses an Arduino uno, Wi-Fi module and couple of sensors for different parameters like ph, TDS, turbidity, and water flow to measure the quantity and quality of water supplied. In their project they mention the use of a cloud server to store data from the sensor, they do not mention which platform the used. Lalbihari Barik [3] created a system to monitor temperature and humidity of particular surroundings using an Arduino and a Raspberry Pi. His project uses sensors to measure the parameters, and the data is uploaded to a cloud server. The online cloud server platform they used is Thinkspeak. The user can access the data through the Thinkspeak cloud server. He also included an LCD display panel for local monitoring. Dr.N.Suma, Sandra R S, Saranya S, Shanmugapriya G and Subhashri R[4] created agriculture monitoring system where various sensors where deployed the field to measure parameters such as ph level, temperature and soil moisture. Their system notifies the user of the parameters measured through SMSs. This is done with the help of a GSM module connected to the microcontroller. Another temperature and humidity monitoring system was developed by Wong G S, Mariam M, Hafiza H and A.Z. Annua [5]. Their system contained sensors and a NodeMCU ESP8266 microcontroller. The platform they choose monitoring the parameters online is Thinkspeak. A project by Sorash A [6] is a water monitoring system using an Arduino and a flow sensor. In his project he does not make use of remote viewing through the internet, he uses an LCD display panel to output the measurement A smart water quality monitoring system created by Sathish Pasika and Sai Teja Gandla[7] measured four key water parameters. Water's pH value, turbidity of the water, water level present in the tank and temperature and humidity of the surrounding atmosphere which were measured by different sensors. The online there choose to use was ThingSpeak and the controller was an Arduino Mega and NodeMCU. Another very similar project was done by Aldrin C. Tasong and Roland P. Abao[8]. Their project was about water consumption monitoring for household and commercialized building applications. In their project each faucet was fitted with a Hall effect sensor (water flow sensor), a NodeMCU, and an LCD display which showed the water consumption in real time. The water consumption data for all the faucets were uploaded to the Heroku cloud database which the use could access in a web browser. Vaishnavi V. Daigavane and Dr. M.A Gaikwad[9] had a similar project to Sathish Pasika and Sai Teja Gandla[7]. The same four parameters were measured using the same sensors and the controller used was similar. The difference between the two projects was the online platform, Vaishnavi V. Daigavane and Dr. M.A Gaikwad used Blynk. A comparison of these projects are presented in table 1.

Table 1: Comparison of IoT based water monitoring systems

Paper	**Application**	**Controller**	**Monitoring**	**Online Platform**	**Sensors**
[1]	Monitoring water volume exiting a tank	Arduino Uno with Wi-Fi module	Online monitoring	Ubidots	Water flow sensor
[2]	Monitoring quality and quantity of water	Arduino Uno with Wi-Fi module	Online monitoring	Not shown	Water flow, pH, TDS, and Turbidity sensors
[3]	Monitoring temperature and humidity of surroundings	Arduino Uno and Raspberry Pi	Online and local monitoring	Thinkspeak	Temperature and humidity sensor
[4]	Monitoring agricultural parameters	PIC16F877A	Remote monitoring (SMS)	N/A	Temperature, soil moisture and PIR sensors
[5]	Monitoring temperature and humidity of surroundings	NodeMCU ESP8266	Online monitoring	Thinkspeak	Temperature and humidity sensor
[6]	Monitoring water flow	Arduino Uno	Local monitoring (LCD display)	N/A	Waterflow sensor
[7]	Monitoring water quality	Arduino Mega and NodeMCU	Online monitoring	Thinkspeak	pH sensor, turbidity sensor, ultrasonic sensor, temperature sensor, and humidity sensor
[8]	Monitoring water consumption	NodeMCU	Online monitoring	Heroku	Water flow sensor
[9]	Monitoring water quality	Arduino Uno and NodeMCU	Online monitoring	Blynk	pH sensor, turbidity sensor, ultrasonic sensor, temperature sensor, and humidity sensor

For this work, the ESP8266 NodeMCU microcontroller was chosen because it was cheap as compared to the others and it has Wi-Fi functionality built-in. NodeMCU is an open-source development board specially intended for IoT based applications. It contains firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems [10]. 3.3v is the running voltage of the board, the maximum is 3.6v and the minimum is 2.58v. It can be powered by batteries through the VIN pin or with a USB connection[11]. This is possible because the NodeMCU contains 3.3v voltage regulator which accepts a maximum input voltage of 15v. The board as mentioned has Wi-Fi capabilities. It can be used to connect devices to the internet to send and receive data[12]. Another good board available on the market is Arduino as shown in Table 1. It also makes a good choice for this project, but it becomes a bit pricey because a separate Wi-Fi shield will have to be bought unlike the NodeMCU which has it inbuilt and is quiet small in size.

To measure water flow, a water flow sensor was sed. A water flow sensor is a device of a plastic body which contains a water rotor and a hall-effect sensor. When water flows through the rotor, its speed changes with different flow rate and the hall-effect sensor detects the speed and outputs the corresponding pulse signal [15]. It has an operating voltage range of 5~18v. The water flow sensor has three wires, ground, power, and pulse.

For the online analysis and monitoring, Thingspeak was used. Thingspeak is an IoT analytics online service that allows users to analyse and visualize live data in the cloud. Data can be send to Thingspeak from a device connected to the internet and the live data can be visualized [17].The Thingspeak platform is run by MathWorks so, in order to sign up for Thingspeak, a new Mathworks account will need to be created or an existing one can be used[18]. To link a device to a Thingspeak account an API key from the account is copied on to the device C++ code. Another online platform available to choose is Ubidots as shown in table 1. However, Thingspeak was used.

III. METHODOLOGY

Figure 1 shows a schematic of how the NodeMCU ESP8266 was connected to a flow rate sensor and the battery. A 9v battery block was connected to the Vin and ground pin. Since the ESP8226 has a 3.3v voltage regulator on board the 9v from the batteries was dropped to the required 3.3v. Power was delivered to the flow rate sensor through the GND and 3.3V pin. The pulse signal wire from the sensor was connected to the GPIO 2. The ESP8266 board and the battery were stored in a electrical junction box and the flow rate sensor was installed on the lip of a water tap. The sensor was connected to the ESP8266 through extended jumper wires.

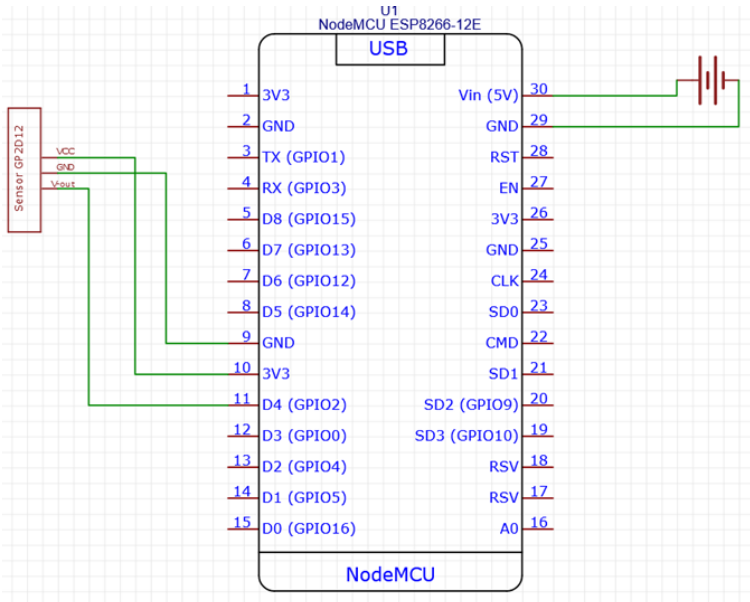


Figure 1: Schematic diagram of the system.

The block diagram of the complete system is presented in figure 2. To read data from the Thingspeak server, a widget app was downloaded from the Play store (Android). The widget app was the IoT Thingspeak monitor Widget. For the widget app to receive data from the server the unique API key was entered into the app. After the widget app was set up and the device was installed onto a tap, flow rate data was then able to be read on the phone.

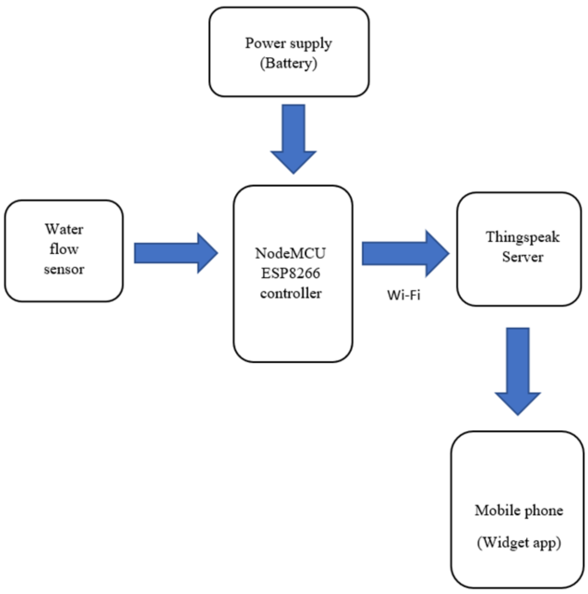


Figure 2: Block diagram of the system.

The flowchart in figure 3 shows how the system functions. Once water starts to flow, the sensor starts measuring the flow rate. The ESP8266 board then takes the measured water data and uploaded it the Thingspeak server via a Wi-Fi network. The widget app on the mobile has a function where a user can set a limit of the water usage and it will notify the user if the water exceeds the set limit. If the set limit of water is exceeded, the app on the phone notifies the owner. The user is then able to view the data on the mobile phone through the app. The app on the mobile phone developed has the option to show water used to show daily, weekly, and or monthly water usages.

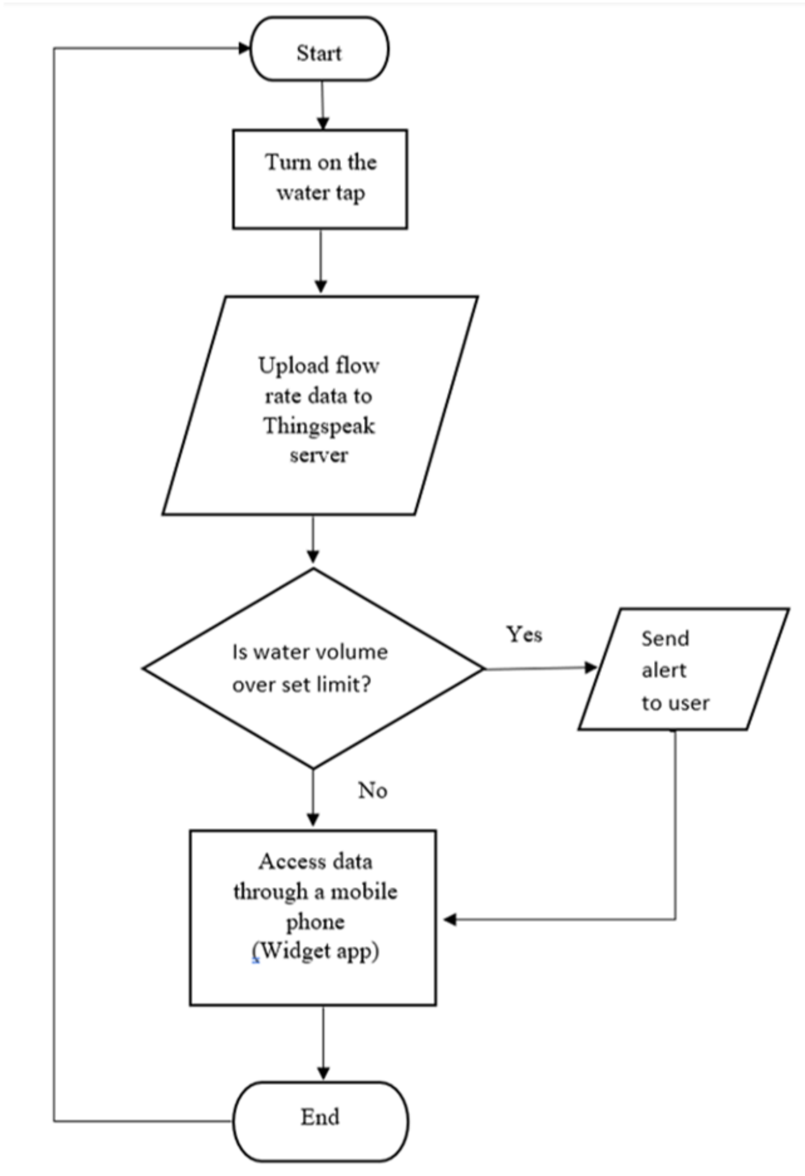


Figure 3: Flowchart showing how the system functions.

IV. RESULTS

The device built is shown in figures 4 and 5 connected to a tap. The ESP8266 board was contained in the electrical junction box and the flow rate sensor had a cable from the box connected to it.

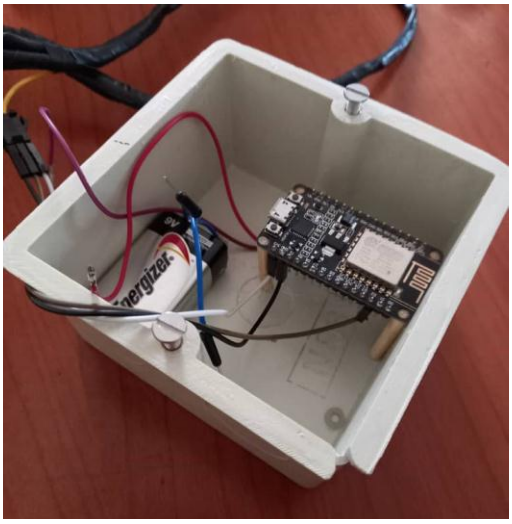


Figure 4: Device components enclosed in a weather guard box.

Figure 5: System connected to a tap for testing.

Figure 6: Live water data on mobile phone (widget app).

Figure 6 shows a mobile phone screen which showed the live water flow and water volume data on the widget app. The live data was captured during the testing stage.

Figure 7 shows a notification indicating that the water usage exceeded the set limit in the app. A low limit was set on the app to be able to test the notification system.

Figure 7: Notification alert for water usage.

Figure 8 shows the water usage chart at different times on a mobile phone on the widget app.

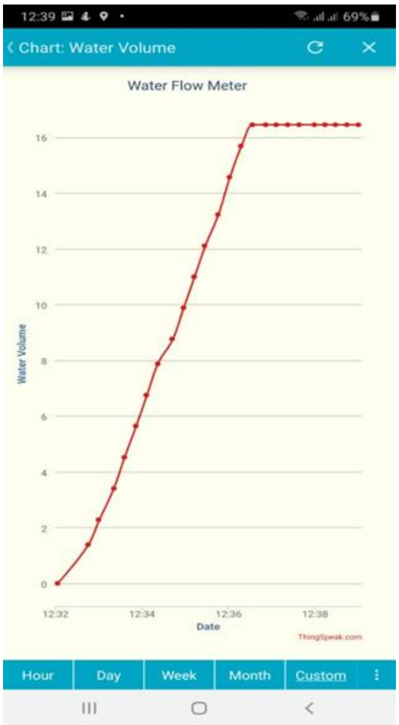
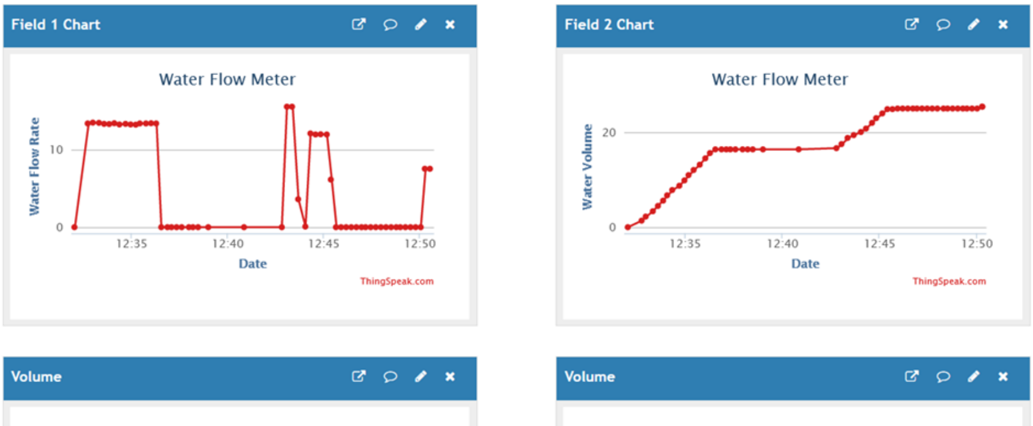


Figure 8: Water volume chart on mobile phone.



(a) **(b)**

Figure 9: Water data charts on Thingspeak.

Figure 9 shows the water data charts on Thingspeak website. Both water flow rate and water volume charts were available to view on the site.

The ESP8266 NodeMCU in the junction box was able to connect to the internet and send live data to Thingspeak as expected. The requirement is that the Wi-Fi signal must be in the range of the tap. The live data can be seen on a mobile screen through the widget app. The widget app got the data from the Thingspeak server as anticipated. The widget app also gave notification alerts when a limit was set. For testing a 10 litre alert was set. When water volume exceeded 10 litres an alert popped up and the widget showing the water volume turned the numbers red. In figure 9a, a chart of the water volume on the app is shown, this was taken during the testing stages. The tap was turned on and left running for about four minutes into a bucket. As shown on the chart at 12:32 the water volume was 0 L and it gradually climbed as the tap was on. Then at around 12:36 the tap was turned off and as seen the water volume stopped changing and remained constant at around 16.4 L. Figure 9b also shows water data charts, but on the Thingspeak website. At around 12:33 the flowrate was 0 L/s, and the water volume was also 0 L. When the tap was turned one the flowrate immediately climbed until it was constant at around 13L/s and dropped to 0 L/s at around 12:36 when the tap was turned off. In the second chart the water volume gradually increased until 12:36 where it stayed constant, and the tap was turned off. When the tap was turned on at 12:43 the flowrate immediately jumped to 15L/s and the water volume gradually till 20L. Then around 12:44 the tap was turned off for a couple of seconds and as seen the flowrate went to 0 and the water volume remained constant for a few seconds at 20 L. Immediately after the tap was turned off it was turned on, the flowrate jumped again to around 11L/s and the water volume went to 25L. The tap was then turned off at around 12:45 which dropped the flow rate and the water volume stayed at 25L. The reason the flowrate kept on going back to 0 L/s when the tap was turned off is because water was not flowing through the sensor when the tap was turned off. The water volume remained constant when the tap was turned off is because it was the water used till that time.

There could be one possible error with the water data of this project. The flow rate sensor is not accurate to the millimetre. And calibrating the sensor plays a huge part with the accuracy. The calibrating factor must be the correct one for the sensor to be calibrated correctly.

V. CONCLUSION

A low cost IoT based tap water usage monitoring system was developed in this work. As seen in the results, the device was built, and it operated as expected. The results also show that all the objectives were meet. The device was easily installed on the tap to measure its water flow rate and water volume. The device was small and the electronics were enclosed in an electrical junction box to protect it from the weather elements. The device was able to connect to a Wi-Fi network and send data to the Thingspeak server. The user could access the water data through a widget app on her/his phone. The system was also able to notify the owner when water usage exceeded a set amount. The user also had water usage record on her/his mobile phone through the app and on the Thingspeak website.

Since the batteries need to be healthy for the system to work successfully, the system can be improved through the use of solar power usage to power the system. This will ensure less battery use as well as less maintenance of the system.

REFERENCES

[1] A. Noertjahyana, D. Kuriando, and R. Lim, "Water Volume Detection System in Galon using Arduino."

[2] J. Gowthamy, C. R. Reddy, P. Meher, S. Shrivastava, and G. Kumar, "Smart Water Monitoring System using IoT," *Int. Res. J. Eng. Technol.*, p. 1170, 2008.

[3] L. Barik, "IoT based temperature and humidity controlling using Arduino and Raspberry Pi," *Int. J. Adv. Comput. Sci. Appl.*, vol. 10, no. 9, pp. 494–502, 2019.

[4] N. Suma, S. R. Samson, S. Saranya, G. Shanmugapriya, and R. Subhashri, "International Journal on Recent and Innovation Trends in Computing and Communication IOT Based Smart Agriculture Monitoring System," 2017.

[5] W. G. Shun, W. M. W. Muda, W. H. W. Hassan, and A. Z. Annuar, "Wireless Sensor Network for Temperature and Humidity Monitoring Systems Based on NodeMCU ESP8266," in *Communications in Computer and Information Science*, 2020, vol. 1132 CCIS, pp. 262–273.

[6] "Water flow rate and volume measurement using Arduino in 2020 - Arduino Project Hub." [Online]. Available: https://create.arduino.cc/projecthub SAROSH_AHMAD/water-flow-rate-and-volume-measurement-using-arduino-in-2020-5377df. [Accessed: 14-Oct-2020].

[7] S. Pasika and S. T. Gandla, "Smart water quality monitoring system with cost-effective using IoT," *Heliyon*, vol. 6, no. 7, p. e04096, Jul. 2020.

[8] A. C. Tasong and R. P. Abao, "Design and Development of an IoT Application with Visual Analytics for Water Consumption Monitoring," *Procedia Comput. Sci.*, vol. 157, pp. 205–213, Jan. 2019.

[9] V. V Daigavane and M. A. Gaikwad, "Water Quality Monitoring System Based on IOT," vol. 10, no. 5, pp. 1107–1116, 2017.

[10] "NodeMCU ESP8266 Pinout, Specifications, Features & Datasheet." [Online]. Available: https://components101.com/development-boards/nodemcu-esp8266-pinout-features-and-datasheet. [Accessed: 25-Oct-2020].

[11] "The best battery for ESP8266 microcontrollers - DIYI0T." [Online]. Available: https://diyi0t.com/best-battery-for-esp8266/. [Accessed: 25-Oct-2020].

[12] "Getting Started with the NodeMCU (ESP8266 Based Development Board) - Electronics-Lab.com." [Online]. Available: https://www.electronics-lab.com/project/getting-started-with-the-nodemcu-esp8266-based-development-board/. [Accessed: 15-Apr-2021].

[13] "NodeMCU Lua V3 ESP8266 WIFI with CH340C." [Online]. Available: https://www.cytron.io/p-nodemcu-lua-v3-esp8266-wifi-with-ch340c. [Accessed: 01-May-2021].

[14] "NodeMCU ESP8266 Pinout, Specifications, Features & Datasheet." [Online]. Available: https://components101.com/development-boards/nodemcu-esp8266-

pinout-features-and-datasheet. [Accessed: 01-May-2021].

[15] “Water Flow Sensor - Seeed Wiki.” [Online]. Available: https://wiki.seeedstudio.com/Water-Flow-Sensor/. [Accessed: 25-Oct-2020].

[16] “How to Use Water Flow Sensor - Arduino Tutorial : 5 Steps (with Pictures) - Instructables.” [Online]. Available: https://www.instructables.com/How-to-Use-Water-Flow-Sensor-Arduino-Tutorial/. [Accessed: 01-May-2021].

[17] “IoT Analytics - ThingSpeak Internet of Things.” [Online]. Available: https://thingspeak.com/. [Accessed: 15-Apr-2021].

[18] “ThingSpeak.” [Online]. Available: https://www.halvorsen.blog/documents/technology/iot/thingspeak/thingspeak.php. [Accessed: 15-Apr-2021].