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CLOUD-BASED MAIN PIPELINE PRESSURE AND FLOW MEASUREMENTS FOR MOSUL PURE WATER NETWORK

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Abstract- in the (water treatment plant left side new) which is located in Iraq/Mosul city, the system created and put into place for measuring and monitoring the flowing and pressure values of the water in real-time. It is consisting of flowmeter, pressure sensor, current to voltage converter, DC 12v source power, solar cell, and Thingspeak website. The proposed system is split to monitoring and measurement sections. The measuring component measures the flowing and pressure values from the sensors using an Arduino platform. The GSM Sim900 then transmits the data to the second component. The Thingspeak website for PCs or smartphones is the second component (the monitoring component), and it keeps track of the whole system's performance. We can develop the website thanks to the Thingspeak website. This technology's primary benefit is its ability to reliably and affordably monitor the water remotely. The detected water losses in the pipe were about (10%).

Keywords: IoT, Internet of Things, Water Management, Thingspeak.

1. INTRODUCTION

Water management is the control of water resources within specific plans. Because misuse and droughts, water is becoming a more precious commodity. A part of water cycle management is the management of water resources. The regulation of water resources within predetermined parameters is known as water management. Water, once a bountiful natural resource, is now becoming more valuable due to abuse and droughts. Water resource management includes all aspects of planning, developing, allocating, and monitoring the optimal utilize of water in the water resources. Water resources management is a component of water cycle management [1].

The network was abused and exposed to illogical connecting activities since there was no law, which led to line-jumping and illegal connection because the terrorist group was allowed to occupy Mosul [2]. Through intricate pipe networks, drinking water distribution systems (WDS) provide water to industrial, commercial, and residential customers from reservoirs and water tanks. For many everyday chores to be completed, a sufficient water supply is essential. Disrupting the water supply due to planned maintenance or leakage repairs might result in serious issues. Increased urbanization increases the strain on the water supply system. Furthermore, to the rising expenses of repairing and replacing the existing system, utilities must create new pipes to service the expanding population. Water utilities are forced to develop techniques to find, locate, and correct leaks to minimize water loss due to increases in pumping, treatment, and operational expenses. If they go unnoticed for a long time, they can result in severe water loss within a distribution network. The United States has to repair 7,000 km of pipe annually, which costs about $2.7 billion, as water evaporates, which are anticipated to cost around $4.3 billion annually, are in the 20-30% range in places like England, France, and Italy. An estimated 237,600 pipe breaks occur annually in the United States. Corrosion buildup, which results in structural problems in old pipes, especially at joints, is a common source of leaks. Rapid detection and localization of pipe bursts and leaks are crucial for water utility operators since they may happen in pressurized water transmission mains and distribution pipes and may be expensive to repair as well as cause damage to nearby property and infrastructure. These failures may also have significant social and environmental repercussions, including service outages, traffic jams, and energy and water waste [3].

Whether wired or wireless networks, network technologies have become a significant component of our environment. Networks are employed in many areas, including our daily lives, business, and education. Wireless networks offer flexible wireless communication through wireless channels that use RF waves in free space. In recent years, it has seen tremendous change. Based on many wireless technologies, including Bluetooth, ZigBee, Wi-Fi, and GSM, they transfer electrical messages via radio waves [4].

A network of interconnected smart objects or devices that can collect and exchange data online is known as the Internet of Things (IoT) [5]. The IOT links all things has a discernible economic worth, and interacts with other objects. IoT has received a IoT of attention from IT scientists and engineers during the past 10 years. Such a revolution in the IOT or in intelligence has advanced quickly. It is now moving toward a completely linked and intelligent planet. Several issues have been resolved using wireless networks and resolving issues with wired networks. Wireless networks provide several benefits, including transporting data to distant locations without needing expensive connections, lacking infrastructure requirements, cheap cost, and excellent power efficiency. Numerous industries employ wireless networks because they can assist in overcoming the limitations of wired networks and provide additional advantages like mobility and design freedom [6].

1.1. Related Researches

Andrew, et al. (2010) proposed a wireless sensor network that allows the monitor of a Singapore (WDS) in real time. It is a low-priced wireless sensor network that may monitor hydraulic parameters in a sizable metropolitan water distribution system online at high data rates. It enables remote leak detection and pipe rupture event prediction [7]. Using an Arduino microcontroller equipped with pH and temperature sensors, Nahla, et al. (2019) developed and put into use a system for measuring and monitoring pH and temperature values of water in real-time. The data is subsequently transmitted through Bluetooth to a smartphone app that keeps track of the overall system's health. The primary benefit of this technology is its capability to reliably and affordably monitor fish farms at a distance [8].

Lim, et al. (2019) created a system with a sensor node that gathers data on water use and sends it to a sink node. As an alarm mechanism for the user in the event of water waste, an ultrasonic sensor, LED, and buzzer are linked to the sensor. The sink node wirelessly accepts information from sensor node, timestamps it using a Real Time Clock, and stores to a database. With helping of an SD card module, the database is connected to the sink node. Additionally, the water-using data is presented graphically for ease of user interpretation via a Graphical User Interface. The technology is appropriate for use in homes and other compact spaces. To test the system's data recording capabilities and check the water flow meter's accuracy, 400, 500, 600, and 700 milliliters of water were utilized. According to the results, the water flow meter can gather data with an estimated value of 30 ml. The results do not differ by more than 40 ml [9].

George, et al. (2020) developed a system that takes advantage of soil moisture, humidity, and temperature sensors and has a low power need. The input is stored and is used for predictions by the system. Solar panels power automated motor controls. The information is kept in tabular format. The internet provides access to all info. Regardless of the weather, this technique may assist the user in obtaining essential information about the fields [10]. Physical, network, processing, and application layers make up a prototype of an online intelligent water monitoring system for the University of Technology Malaysia that was created by Nur, et al. (2021) using the combination of Internet of things and Geographical Information System. The results demonstrate that the water pressure drops as the water flow rises. The lowest rate is 52 Psi, and maximum rate is 60.916 Psi when there is no water flow. The most recent technology utilizing IoT-GIS for intelligent water monitoring has demonstrated a very successful method of supplying real-time water parameter information [11].

Siti, et al. (2022) created a system that uses the (IoT) to monitor water consumption behavior remotely. The system may be deployed in a pipeline, where a water flow sensor detects real-time water characteristics. By using the Blynk application, which creates a clear data visualization, the homeowner can see the accuracy and availability of their water system thanks to the data that has been transmitted to the cloud. In contrast to traditional manual monitoring, this initiative aims to provide households with a wireless, portable, cost-effective, and systematic way to self-monitor their water usage [12].

A low-priced and intelligent industrial remote monitoring and control system was created by Maryam, et al. (2022) using NodeMCU with Blynk server. It is used to monitor and operate the manufacturing environment and industrial machinery from a distance. The system consists of two components: actuation and sensing. Three subsystems make up the sensor part, which measures water flow, flame, temperature, and humidity. The water pump, light, and fan make up the actuation part. The suggested method operates the water pump by independently detecting water flow. In the event of a fire, a protective mechanism is in place to turn off the electricity from the load. A number of testing scenarios were conducted to evaluate the system's reaction, and the outcome demonstrates that the suggestion for handling various situations has been successfully implemented [13].

2. METHODS

The proposed system designed and implemented consists of: Arduino, GSM Sim900, flowmeter, pressure sensor, current to voltage converter, DC 12v source power, solar cell, and Thingspeak website. The system contains sensors, Arduino and ThingSpeak website for monitoring flowing and pressure of the water in the pipe.

The hardware has been designed to measure the flow and pressure of the water in the pipe. The Arduino utilizes sensors for reading the flow/pressure. After reading the data, it sends results to the end user by internet using GSM Sim900.

2.1. Hardware Parts

2.1.1. Arduino

The microcontroller is open-source and easily programmable; it may be rapidly wiped and reprogrammed at any time. In 2005, the Arduino platform (Figure 1) made its debut. It was developed to provide experts, students, and laypeople with an easy and economical way to design devices that interact with their environment through the use of sensors and actuators. The system code contains a portion of code Figure 2. These microcontrollers are easily programmable using the Arduino IDE and the C or C++ languages [14].

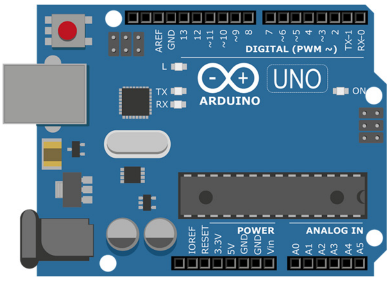
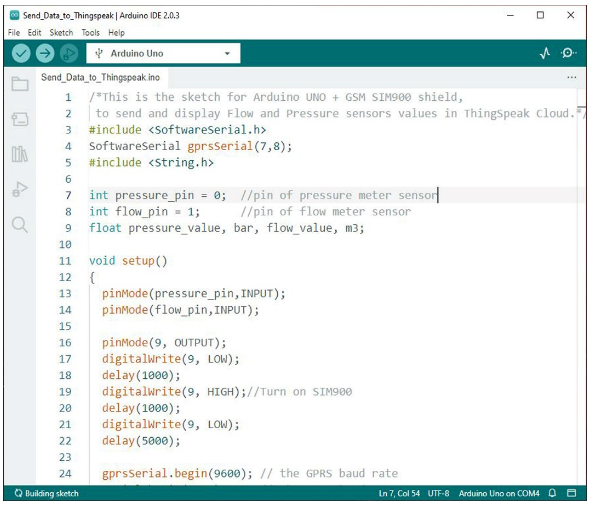


Figure 1. shows Arduino Uno [14]



```
/*This is the sketch for Arduino UNO + GSM SIM900 shield,
 to send and display Flow and Pressure sensors values in ThingSpeak Cloud.*/
#include <SoftwareSerial.h>
SoftwareSerial gprsSerial(7,8);
#include <String.h>

int pressure_pin = 0;  //pin of pressure meter sensor
int flow_pin = 1;      //pin of flow meter sensor
float pressure_value, bar, flow_value, m3;

void setup()
{
  pinMode(pressure_pin,INPUT);
  pinMode(flow_pin,INPUT);

  pinMode(9, OUTPUT);
  digitalWrite(9, LOW);
  delay(1000);
  digitalWrite(9, HIGH);//Turn on SIM900
  delay(1000);
  digitalWrite(9, LOW);
  delay(5000);

  gprsSerial.begin(9600); // the GPRS baud rate
```

Figure 2. part of the code

2.1.2. Current to Voltage Converter

It is integrated with a 4-20 mA transmitter using a 4-20 mA signal converter. When electrical interference is an issue, analog signals can be sent over great distances using the 4-20 mA technique. This module's power supply ranges from 5 to 10 volts. This module uses an industrial-grade sensor with a 4-20 mA current source signal. The anti-reverse protection circuit is present to ensure that the signal polarity is not reversed. The output voltages are 3.3V and 5V. Potentiometers are utilized to modify the output voltage and 4-20 input signal, as shown in Figure 3 [15].

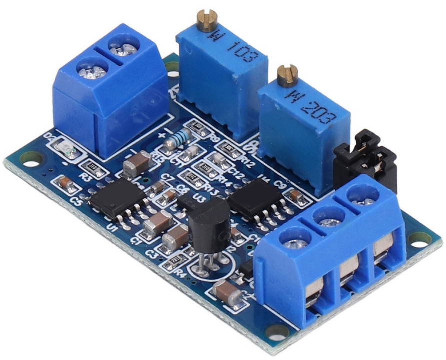


Figure 3. current to voltage converter overview [15]

2.1.3. Proline Prosonic Flow 91W

It is a flow rate measurement used in typical drinking and processed water applications. It is appropriate for pipes with diameters between 0.5" and 80". Without having to stop the operation, the Prosonic Flow ultrasonic device enables precise and affordable flow monitoring outside the pipe. There is no pressure loss during the two-way flow measurement. The transit time difference theory underlies the operation of the measurement system. Ultrasonic impulses are sent between two sensors in this measuring technique. The signals have been transmitted both ways. Therefore, the sensor in issue serves as a sound transmitter and receiver. There is a difference in transit time because waves move more slowly when they go against the flow than when they move faster along it. The flow velocity is precisely proportional to this transit time difference [16]. The transit time difference is measured by Equation (1):

$$Q = v \times A \tag{1}$$

where,

Q: Volume flow

v: Flow velocity

Δt: Transit time difference ($\Delta t = t_a - t_b$)

a and b: sensors

A: Pipe cross-sectional

Figure 4 shows the sensor overview.

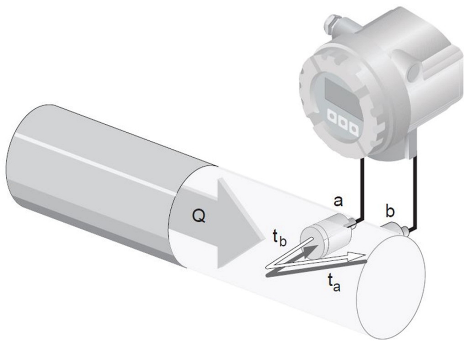


Figure 4. principle work of Proline Prosonic Flow [16]

2.1.4. Pressure Sensor (Cerabar PMP11)

For measurement pressure in gases, the Cerabar is a pressure transducer. Due to several clearances and process links, the Cerabar may be utilized abroad. Sensor for measuring ranges up to 400 mbar, reference accuracy up to 0.3%, as shown in Figure 5 [17].

Figure 5. Pressure sensor overview [17]

2.1.5. GSM SIM 900

A GSM modem known as the SIM900 GSM/GPRS shield may be incorporated into a large variety of AIoT applications, and this SIM900 GSM/GPRS module can be used to send data to the server. This one can make and receive phone calls, send and receive messages, and connect to the internet over a GPRS network. The GSM SIM900 pinout diagram is shown in Figure 6 [18].

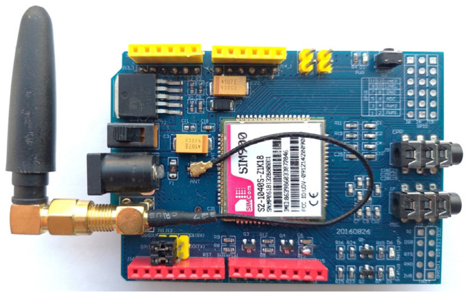


Figure 6. GSM SIM900 pinouts [18]

2.1.6. Battery DC 12 Volt

2.1.7. Inverter and Solar Cell

2.2. Software Part

2.2.1. ThingSpeak

It is a platform for creating IoT applications. Real-time data collection can work with various application programming interfaces and web services Figure 7 [18].

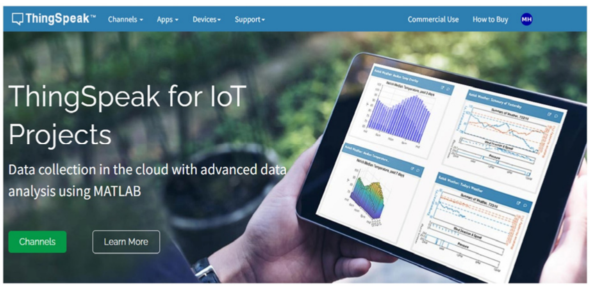


Figure 7. Thingspeak website [19]

2.2.2. Software Serial Library

Over short distances, it is feasible to send and receive more than 50 characters reliably. The SoftwareSerial library was created to add a serial port to the Arduino board to connect more serial devices. Unlike the hardware UART already on the board and ready for serial connection, this serial port is software-based. This makes it feasible to connect many serial devices to an Arduino board simultaneously [20].

2.2.3. String Library

It can utilize and modify text more easily and intricately than character arrays. It is a component of the Arduino core libraries. Even though using the String library is more accessible than character arrays, it uses more RAM [21].

2.3. Darcy-Weisbach Equation

It can hypothetically be used to determine water losses in the pipeline [22]:

$$h_f = f \times L \times \frac{V^2}{2 \times g \times D} \tag{2}$$

where,
h_f: Friction head loss (units of length)
f: Darcy friction factor, a dimensionless quantity that accounts for the roughness of the pipe and the fluid properties
L: Length of the pipe (units of length)
V: Mean fluid velocity in the pipe (units of velocity)
g: Acceleration due to gravity (units of acceleration)
D: Inside diameter of the pipe (units of length)

The pipeline, the subject of the study, passes through nine districts in the city of Mosul. This research aims to monitor the amount of water pumping and ensure that the required amount reaches the last point using the Internet of Things technology. The amount of water sent from the beginning of the line "the new left water filtration project" is 4500 to 5000 cubic meters per hour.

3. RESULTS AND DISCUSSION

Our project applied in (the water treatment plant left side new) in Iraq republic, Mosul city, which takes the water from Tigris River, that shown in Figure 8 which displays the three points on the pure water pipe, the length of the pipe is 14.6 Km with a diameter of 120 Cm, this pipe serves about (275000) people. These people suffer from a shortage of safe drinking water. The distance between the first and second points is 9.5 Km, and from the second to third points is 5.1 Km.

Water flowing and pressure measured in the 3 points with blue color Figure 8, the first point in the central plant Figure 9a and the second point in the AL-Arabi region Figure 9b, and the third point in the Kafaat region Figure 9c.

Figure 8. Water treatment plant left side new pipe

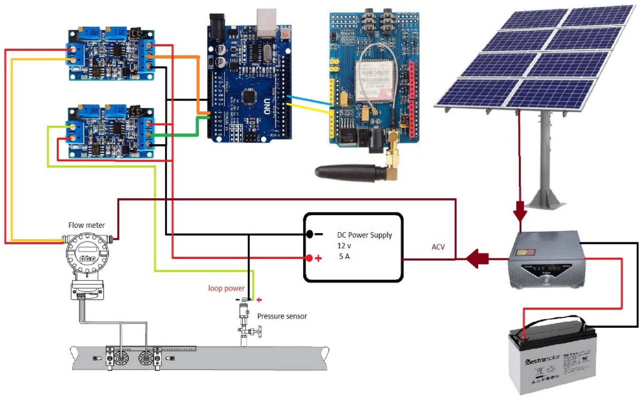
The circuit diagram and board connection are cleared in Figure 10, Arduino pins (7, 8) connected to GSM Sim900, and Arduino analogue pins (0, 1) connect to signal pins in the converters. VCC and GND of the converters connected to the DC power supply. Flow meter supplied by AC power directly then connected to converter through input pins (+ –). VCC of the pressure meter connected to (+) of the input of the converter and (–) of the pressure meter connected to (–) of the DC power supply. It is supplied by power from Inverter, battery, and solar cell. The board connection is easy to use and low cost. The proposed system doesn't need an electricity source because of using inverter and solar cell where it can work at least 5 days in the rainy and cloudy circumstances depending on the battery connected.

(a)

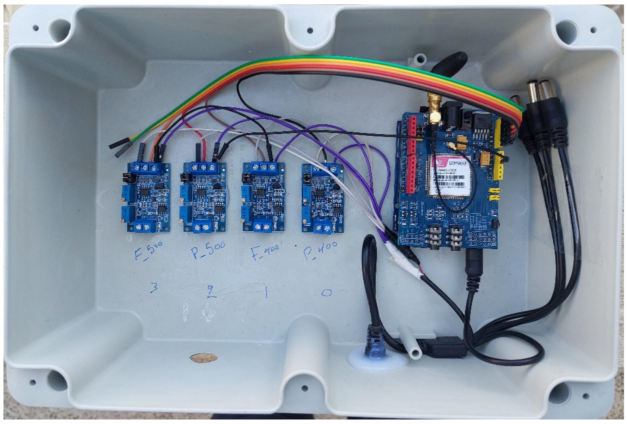
(b)

(c)

Figure 9. the three points our system applied on



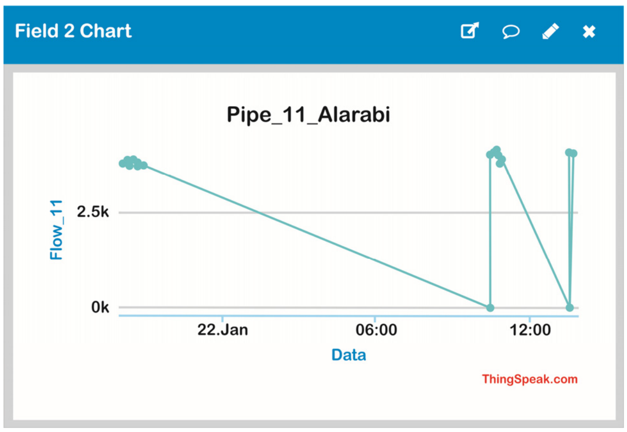
(a)

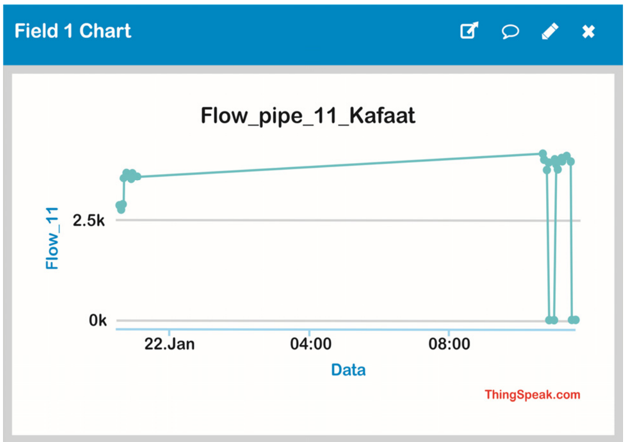


(b)

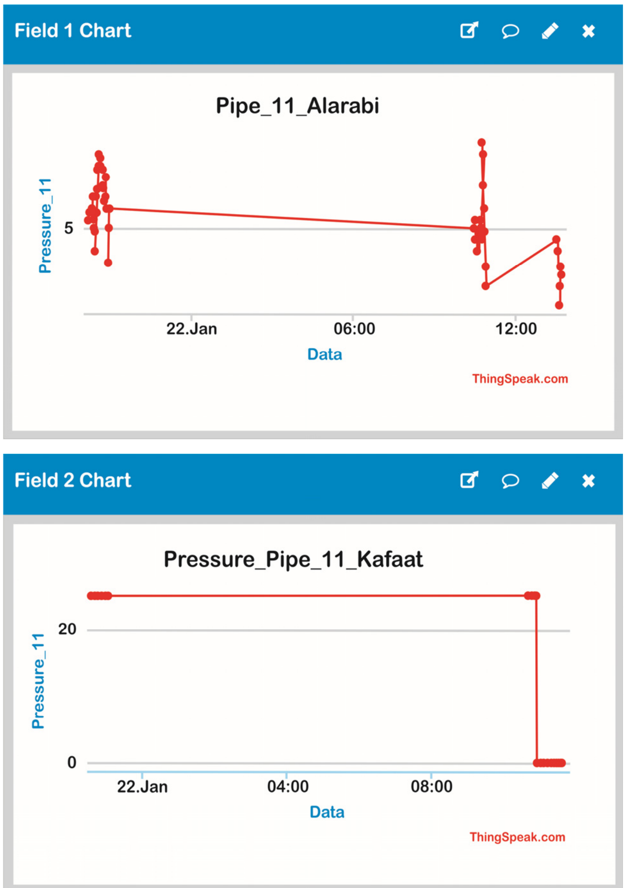
Figure 10. System connection

The monitoring part (ThingSpeak) was signed-in and programmed. Then the system powered, started, and connected to the internet. Thingspeak takes the data from GSM Sim900 and shows it on the website. Figure 11a shows water flowing, where *x*-axis represents water flowing and y-axis represents the time at different periods in AL-Arabi region and the Kafaat region. Same for figure 11b that shows water pressure, where *x*-axis represents water flowing and y-axis represents the time at different periods in AL-Arabi region and the Kafaat region.





(a)

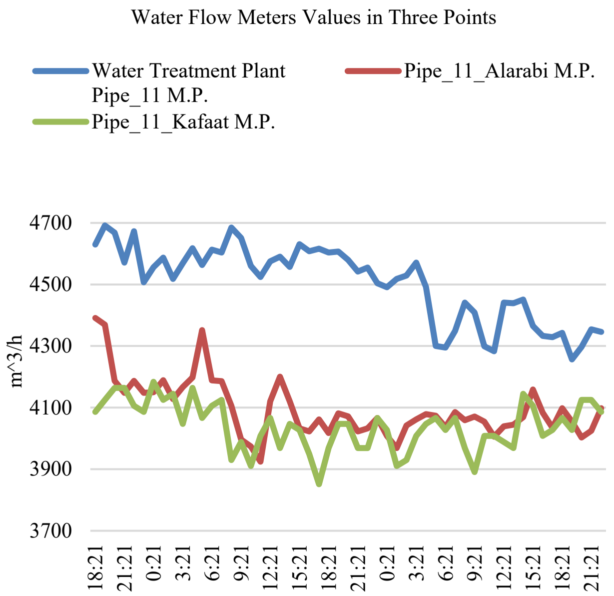


(b)

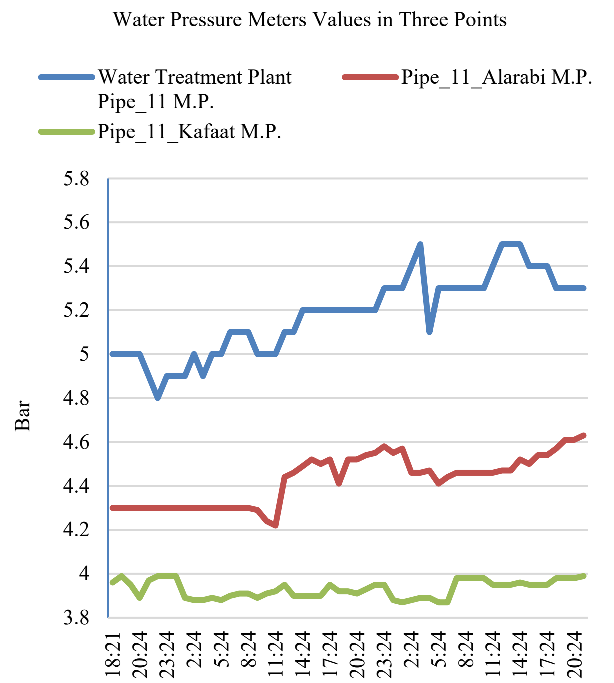
Figure 11. ThingSpeak readings

The results in Figure 12a show that the readings of the flowing water of the first point (Blue line) are changed from 4625 to 4250 m^3/h, while the second point (Red line) is changed from 4400 to 3900 m^3/h, the last point (Green point) is changed from 4180 to 3850 m^3/h. The results in Figure 12b show that the readings of the water pressure of the first point (Blue line) are changed from 5.5 to 4.8 bar, while the second point (Red line) is changed from 4.2 to 4.63 m^3/h, the last point (Green point) is changed from 3.87 to 4 bar.

By monitoring the flow and water pressure on this pipe and when we take a vertical line at first point, we notice that the difference between the blue and green points on that line is in range of 400-600 m3/h losses (about 10%) and 1-1.3 bar (about 20%). These are big losses in the fresh water supplied to this part of the city. The friction of the water in the pipe, the overtaking on the line, Bypassing the line and illegal linking due to the exposure of the city of Mosul to the occupation of the terrorist organization (ISIS), the network was subjected to abuses and unscientific linking operations as a result of the absence of the law.



(a)



(b)

Figure 12. Represents (a) Flow, (b) Pressure in the three points

4. CONCLUSION

Climate change, rising population, and increased industrial activity severely threaten water resources' availability. One of the effects on the environment that is growing is the lack of fresh water. Thus, one of the critical objectives of academics in recent years has been to monitor water consumption and effectively manage this finite resource. By minimizing waste and regulating supply, effective water management will optimize the use of this resource. It has created a clever technology that can automatically regulate the water usage. Compared to earlier studies, this project is more efficient and has a lower cost. This project automates controlling and keeping track of the water flow. This real-time initiative offers a simple, automatic water management method that reduces water waste. It has been noted that the system works effectively and produces a precise real-time data of the water supply pressure and flowing on the ThingSpeak web site. The government of Mosul city must take steps to decrease these water losses by prevent these illegals linking to give enough water to those (275000) people because those people doesn't have enough water now.

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