# An Exploratory Approach to Monitor the Quality of Supply-Water Through IoT Technology

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***Abstract*— An IoT based design for monitoring the quality of supply-water is represented in this paper. The sensor-based circuitry is completely powered up with solar energy which is a sustainable approach as well. Through this designed system using Arduino Mega 2560, different qualitative parameters of water namely, the pH level, turbidity, salinity, arsenic level etc. can be measured by simple modification but for implementation purpose only the pH level and turbidity of water have been measured using sensors. However, the information gathered from the sensors are sent to the cloud server by means of a WiFi module. The collected data is further analyzed, is shown in visual format in LCD and graphical comprehension is demonstrated via 'ThingSpeak', a cloud server. The circuit is also modified to control the water pump for decreasing the wastage of water and hence electricity usage. The designed system can be utilized not only to the rooftop tank but also to overhead water tanks for monitoring the quality of water easily and from anywhere in the world through internet.**

**Keywords—** ***water quality monitoring system, wireless monitoring, ThingSpeak, IoT for water quality, sustainable water monitoring***

## I. Introduction

With the familiarization of lots of innovations, and developments as well as globalization it is said that life has become easier than before. However, in this 21st century messy or tainted water is yet being used for drinking purposes with no sort of separating or filtering in many developing nations. People are getting affected by various diseases like cholera, typhoid, guinea worm disease and typhoid. In addition, it is seen that lots of water is being wasted by people for that there is a shortage of water in many developing areas. The lack of user-friendly water quality monitoring system and automatic water saving system is creating these serious problems [1][2]. Keeping these thoughts in mind, a system can be developed and implemented which can monitor the quality of water and can control the flow of water automatically by analyzing some of the important and critical factors of water as well as the level of water in the container. The different parameters of water can be measured by means of different sensors. The level can be estimated with the help of sonar sensors [2].

To make this system user friendly, the real time data acquisition, transmission and processing system was needed which can be made by the development of Wireless Sensor Network (WSN) a user can get the continuous information of the water quality and level from far away.

Keeping these in mind a system was set up, with several nodes and a base station (Fig.1). Each node contains a gathering of sensors which were distributed throughout different water bodies. Data was collected through those sensors and then sent to the cloud server through wireless sensor network. In this case Thingspeak.com was used as cloud server. To monitor the water quality and control the flow in a continuous application, a base station and relating distinctive sensor nodes were utilized to cover the diverse water tanks. As this work was done in a remote zone with restricted access, motion from the sensors were gathered and transmitted remotely on cloud server from where the framework was observed [2].

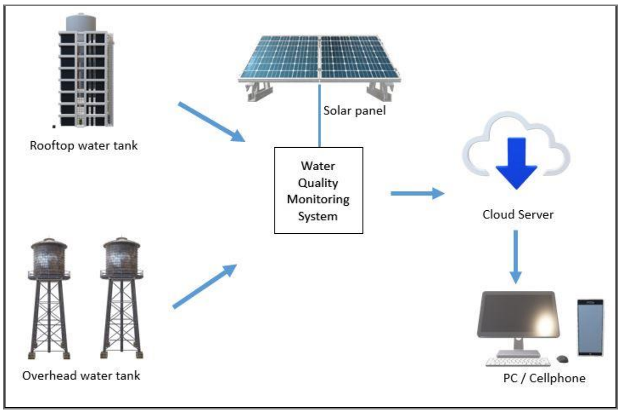


Fig. 1. Wireless water quality monitoring system

The LCD display was used to monitor normal drinking water, but for the monitoring of rooftop water tank and overhead tanks, the results were shown in "ThingSpeak" (an IoT analytics platform service) through PC or cellphones. A Wi-Fi module was used to connect the nodes and cloud server. Water pump was used to control the flow of water for the rooftop water tank. Solar cells can power-up the microcontroller and different types of sensors those are used for collecting data and control the pump. This use of different sensors organized for a water quality and flow estimating comprises of various sensor nodes. The sensors used in the article are pH, turbidity and ultrasonic.

## II. Related Study

### A. Earlier Researches

*1) Researches on Water Quality Monitoring:* In the course of recent decades, water quality observing technology has quickly advanced to address the issues of the inhabitants. Firstly, the work started with survival, scan for predators look for source of movements under water or beside the watering hole. The understanding of health and science regarding this issue has ascended due to the need of clean water. This action was started in mainly Egypt through the Hippocratic sleeve system which. was a basic filtering system[1]. The scope of water pollution changed drastically in the late 1945. Lots of industries exploded during the war, chemicals and byproducts entered the wasted streams during this period. So, the focus back then was to support the water issues [1][2].

In 1948, the first advanced water monitoring system was tested. That was mainly done to check whether the water was contaminated or not though no sensor were not used. In 1956, the system became a little more advanced for the usage of different chemicals with turbidity sensors, but it was not permanent. After that, in 1970, after the production of first portable pH sensors, people started measuring the pH levels of water. After a short period of time, the oxygen sensors were introduced in the monitoring system. It was mounted to monitor the proportion of oxygen in water [2][3][4].

Water quality data collection moved from written notes to digital displays through sophisticated digital electronics with the real time data. Examining limit has progressed from a couple of hand estimations every day, one parameter at any given moment, to steady surges of information transmitted by multi parameter instruments sent for couple months on end. The accuracy has developed a lot in between the development of this technology [5][6]. The recent researches about this system is shown in the following table.

TABLE I. PREVIOUS RESEARCHES ON WATER QUALITY MONITORING

| *Year* | *Author(s)* | *Study Objective* | *Features* | *Limitations* |
|---|---|---|---|---|
| 2012 | Zulhani Rasin, Mohd Rizal Abdullah | Monitoring the water quality [7]. | ZigBee | System does not run by solar energy. |
| 2013 | Unyoung Kim, Sarah Ghanbari, Anusha Ravikumar, John Seubert, Silvia Figueira | Monitoring the quality of water by detecting the bacterial pathogens, e.g. E. Coli. [8]. | Use of DNA hybridization into a readily detectable electric signal by means of a conformational change of DNA stem-loop structure. | System does not include checking other germs or factors. |
| 2014 | R. K. Kumar, M. C. Mohan, S. Vengateshapandiyan, M. M. Kumar, R. Eswaran | Solar based monitoring of water [9]. | ZigBee and GUI (Graphical User Interface) | Live data |
| 2016 | N. A. Cloete, R. Malekian, L. Nair | Designing of various sensors to check the condition of water [10]. | ZigBee used for transmission and checking of chlorine concentration in a pool. | Turbidity sensor was not included. |
| 2018 | F. Yuan, Y. Huang, X. Chen, E. Cheng | Monitoring the quality of water [11]. | System combined with the computer image processing technology | Result was not highly accurate since the sensors were not used. |
| 2018 | A. Abubaker, K CR, T. Thomas, N. Joseph, S. Begum | Checking the different factors and monitoring the water condition at different places [12]. | Using of MQTT algorithm | Buzz and delaying of data transmission |
| 2018 | Hao Yang, Shahbaz Gul Hassan,Liang Wang, Daoliang Li | Water quality monitoring device fault diagnosis [13]. | Use of multiclass support vector machines (MSVM) in combination with rule-based decision trees (RBDT) | Result is not 100% accurate. |

*2) Researces on Automatic Water Pumping System:* Water service establishes a noteworthy issue in nations including Indonesia, Mexico, Guatemala, and El Salvador. The water organization restricts the measure of water it distributes to networks in these nations which makes it exceptionally troublesome for the occupants to know when and how much water they use later on. For instance, in El Salvador, the water organization gives water to a few networks to 4 hours out of every day or once every four days. Indonesia, Mexico, and Guatemala, have a comparative water supply issue. As a result, individuals used to store water in underground reservoirs and private housetop water tanks. In any case, the funnels used to transport water from the city water experts frequently don't have enough water strain to supply water to the housetop water tanks. Then again if there is no water and the pump runs, the pipe leaks and air gets into it, compelling the user to fix it. Without a legitimately working water pump, the underground water supply restrains the measure of water that can amass. While the vast majority of people physically take care of the necessities of their water framework manually, numerous individuals, for example, the deep-rooted people face physical difficulties to effectively keep up the usefulness of their water siphon framework. That’s why an automatic water pump controlling system is considered as the main solution [14][15].

### *B. Relavant Tools*

*1) Solar Energy Harvestor:* A solar photovoltaic cell is a particular semiconductor diode which alters visible light into direct current (DC). The most commonly used cells were made with silicon. Solar photovoltaics directly converts solar energy into electricity. Solar panel absorbs sunlight and transfers the light energy into electricity. A method that causes voltage or electric current in a photovoltaic cell when it is exposed to sunlight is known as the photovoltaic effect [25]. Working on the principle of this effect, when a little amount of silicon are exposed to light, the photovoltaic absorbs photon and release free electrons. This phenomenon is known as the photoelectric effect. The sunlight is converted into direct current (DC) electricity based on the principle of photovoltaic effect [16].

*2) Microcontroller (Arduino Mega 2560):* A microcontroller essentially is a little PC on a solitary integratedcircuit thathas a processor core, memoryandalsoit hasprogrammable input/output peripherals. In this article, an Arduino Mega 2560 is utilized as microcontroller. It has 54 digital I/o pins, 16 analog pins, 256 KB streak/flash memory, 8 KB SRAM, 4 KB EEPROM, a 16 MHz crystalline oscillator, a USB association, a power jack and a reset button[17].

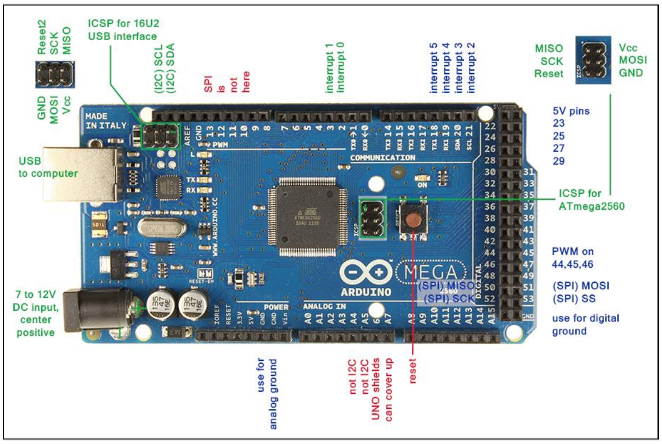


Fig. 2. Arduino Mega 2560 with pin configuration.

*3) pH Sensor:* The pH sensor is a scientific instrument that estimates the hydrogen particle movement in water based arrangements, demonstrating its corrosiveness or alkalinity. An acidic arrangement has much more positively charged hydrogen particles in it than a basic one, so it can possibly create an electric flow in a specific circumstance, it's somewhat similar to a battery that can deliver a more noteworthy voltage. A pH meter exploits this and works as a voltmeter. [23] It evaluates the voltage created by the arrangement whose acidity is being estimated, contrasts it and the voltage of a known arrangement and utilizes the distinction in voltage between those two to discover the difference in pH. Same strategy is pursued to quantify the basic [18].

TABLE II. pH LEVEL AND VOLTAGE RELATIONSHIP

| *pH State of Water* | *pH Level of Water* | *Voltage at Arduino (mV)* |
|---|---|---|
| Acidic | 0.00 | 414.12 |
| | 1.00 | 354.96 |
| | 2.00 | 295.80 |
| | 3.00 | 236.64 |
| | 4.00 | 177.48 |
| | 5.00 | 118.32 |
| | 6.00 | 59.16 |
| Neutral | 7.00 | 0.00 |
| Alkaline | 8.00 | -59.16 |
| | 9.00 | -118.32 |
| | 10.00 | -177.48 |
| | 11.00 | -236.64 |
| | 12.00 | -295.80 |
| | 13.00 | -354.96 |
| | 14.00 | -414.12 |

*4) Turbidity Sensor:* Turbidity mainly is the ambiguity or nebulosity of a fluid which is caused by large numbers of seperate particles that are generally hidden to the naked eye, like smoke in air. In this research, the SKU: SEN0189 was used as a turbidity sensor. Suspended particles in water is detected by measuring the light transmittance and the scattering rate using light, that changes with the amount of total suspended solids (TSS) in the solution (water). The TTS increases with the increase of liquid turbidity.

The sensor demonstrates an analog value when it is dipped into water. The Sensor Value (SV) ranges from 0 to 1023. The sensor value is then converted to voltage using the formula in (1) [19]. After that, the voltage is converted to equivalent NTU (Nephelometric Turbidity Unit) using formula mentioned in (2) [19]. The table IV represents the relationship between the turbidity and the equivalent float voltages for different conditions.

$$\text{Float voltage, } x = (SV * 5) / 1024 \qquad (1)$$

$$\text{Turbidity, } Y = 1120.4x^2 + (5742.3)\,x - (4352.9) \qquad (2)$$

TABLE IV. TURBIDITY AND EQUIVALENT FLOAT VOLTAGE

| **Float Voltage (mV)** | **Turbidity of Water (NTU)** |
|---|---|
| 4.2 | 0 |
| 4.1 | 355.50 |
| 3.9 | 999.36 |
| 3.7 | 1554.434 |
| 3.5 | 2019.35 |
| 3.3 | 2394.634 |
| 3.1 | 2680.286 |
| 2.9 | 2876.306 |
| 2.7 | 2982.694 |
| 2.5 | 2999.45 |

The turbidity sensor can also be used to check the quality of water in different ponds, lakes or rivers. It can also be used for controlling instrumentation for settling ponds, sediment transport, research and laboratory measurements. [19]

*5) Ultrasonic Sensor:* Ultrasonic sensor module includes a transmitter and a receiver. The transmitter sends a wave of 40KHz. If any obstacle comes ahead of the ultrasonic sensor, the sound wave gets reflected in the form of echo and produces an electric pulse [20]. The distance (height) is calculated by multiplying the time difference between the sent wave and the echo and speed of the ultrasonic wave through the air.

(a) pH sensor (b) Turbidity sensor (c) Ultrasonic Sensor

Fig. 3 Sensors used for measuring water quality.

*6) WiFi module (ESP8266ESP-01):* The ESP8266ESP-01 is a Wi-Fi module which permits microcontrollers access to a Wi-Fi arrange. It offers a total and independent Wi-Fi organizing arrangement, enabling it to either have the application or to offload all Wi-Fi organizing capacities from another application processor[21].

*7) Cloud Server (ThinkSpeak):* 'ThingSpeak' is an internet of things [IoT] based investigation stage benefit that permits to total, imagine and examine live information streams in the cloud. It gives moment perceptions of information posted by the associated gadgets. With the capacity to execute MATLAB code in ThingSpeak it is susceptible perform online examination and handling of the information as it comes in [22].

## III. Design and Implementation

Photovoltaic panel was used to power up the microcontroller. The input of battery charger was connected to the solar cell. The output of the battery charger was connected to the lithium battery. To convert the voltage from 3.7V to 5V, a step-up voltage booster was connected to the battery. The interfacing of solar to power up the microcontroller can be described using the following figure (Fig.).

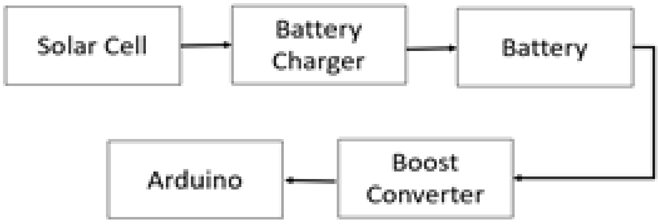


Fig. 4. Power supply to Arduino using solar panel

This system is comprised of three sensors, which were pH sensor, turbidity sensor and the ultrasonic sensor. The pH sensor was used to check the pH of water, turbidity sensor checks the haziness while the ultrasonic sensor detects the level of the water. The output of the system was demonstrated on the LCD and the data was sent to cloud server and can be monitored continuously. A water pump was used to control the supply of water and a relay was used to control the water pump. The supply of water depends on the volume of water in the container.

At the beginning, the microcontroller takes reading from the sensors and sends the data to display and cloud server. The volume of water regulates the water supply. The water pump will start automatically if the volume of water gets less than 20% of the container. When the water volume increases to 90%, the pump will turn off.

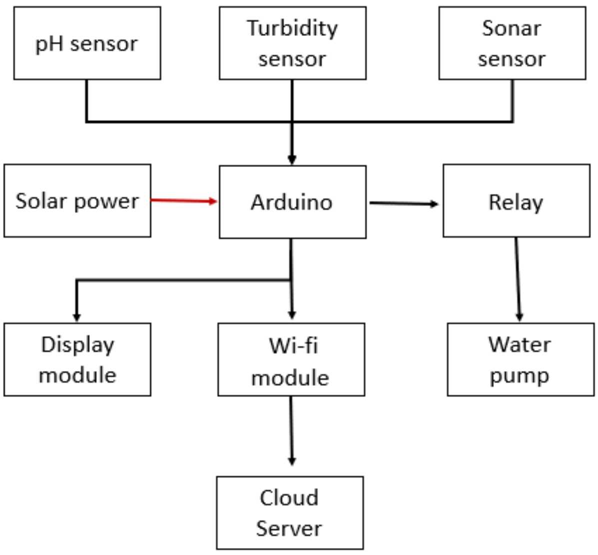


Fig. 5. Block diagram of the system

The microcontroller was programmed in Arduino IDE. The RS (reset), EN (enable), the input $D_4$, $D_5$, $D_6$, $D_7$ and R/W (read or write) pins of LCD were connected to digital pin 12, 11, 5, 4, 3, 2 and ground respectively of Arduino Mega 2560. The biasing voltage pins $V_{CC}$ and $V_{SS}$ were connected to 5V and ground respectively. The pH sensor was connected to analog pin $A_0$ and turbidity sensor was connected to analog pin $A_1$. The ESP8266 WiFi module was connected to $TX_0$ and $RX_0$. The ultrasonic sensor was connected via trigger and echo pins to digital pins 22 and 23.

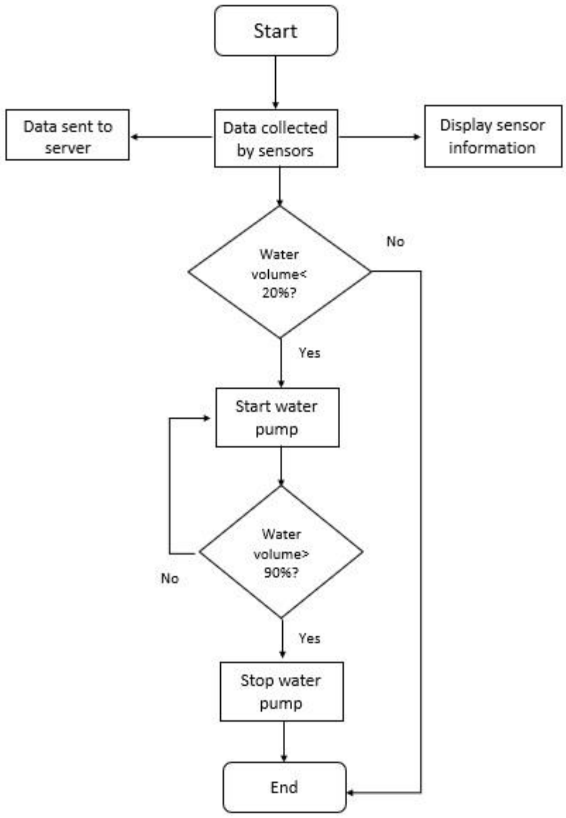


Fig. 6. Flow chart of the system

In this research, www.thingspeak.com was used to store data in server, visualize and analysis the data. 'ThingSpeak' is a platform that is based on IoT (internet of things) and this service allows to analyze and visualize live data stream that are displayed on the cloud server.

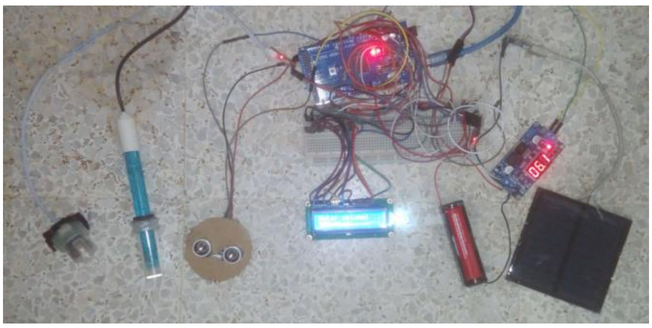

Fig. 8. Implementation of the system

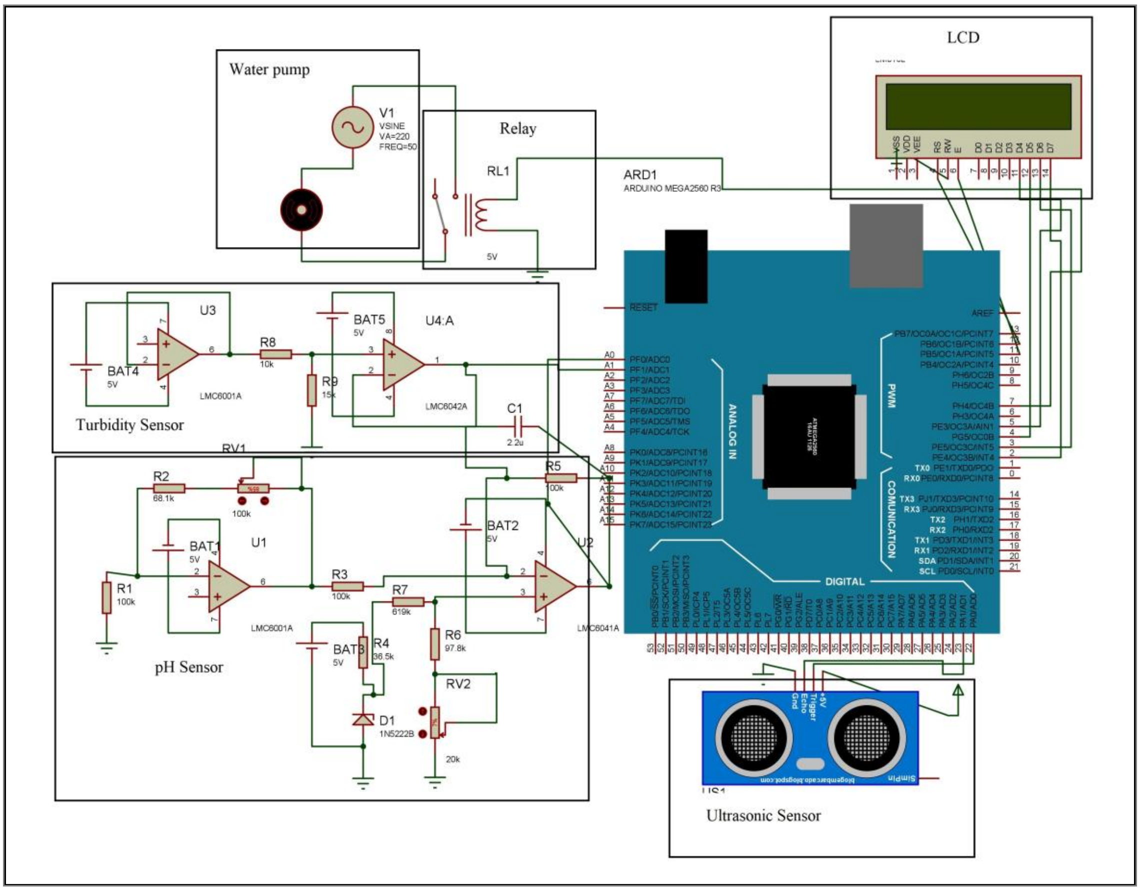


Fig. 7. Complete design of water supply and quality monitoring system

## IV. Output Analysis

### A. *Case I (Water quality of rooftop water tank)*

The water in rooftop tanks can get dirty or contaminated for various reasons. Sometimes the amount of water in the container increases and water water starts to get wasted. Its not easy for people to continuously go to the rooftop and check the quality and control the supply of water. With this system, the continuous monitoring and supply of water can be done sitting at home.These were some of the important issues behind this case.

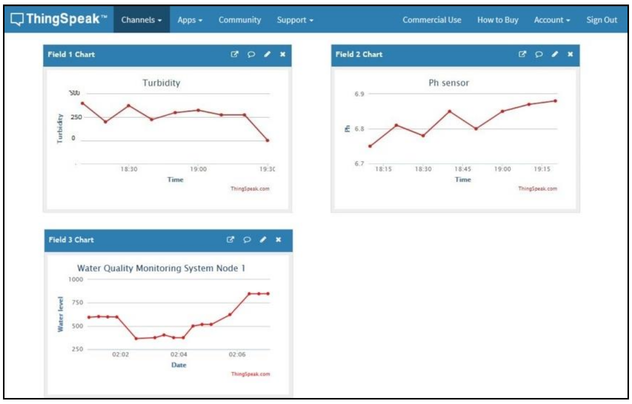


Fig. 10. Output through "ThinkSpeak"

In this work, the factors of water have been shown through the cloud server (ThingSpeak). According to the graphs in fig. 12, it is shown that the turbidity decreased to zero and pH level is varying with the change with time. The volume of water is also displayed.

Fig .11. When tank is full (100%), water pump is off (light OFF)

Fig. 12. When tank is less than 20%, water pump (light) turns ON

For the supply of water, a bulb was used as the water pump. According to the logics of the system the bulb glows when the water volume is under or equal to 20% of the container. Which means that the water pump will start. The bulb will glow until the water volume reaches 90% of the container, i.e the pump will run till the water volume gets to 90% of the tank. The visual representation was done in Fig 11 and 12.

### B. *Case II (Water quality of multiple overhead tanks)*

This case was taken under consideration since it is hard to check the quality of water endlessly there. People had to go up and monitor the water over there. It is tough and dangerous. Taking this issue into account the work for this case was done. The monitoring can be done easily from the ground station with the help of a common server.

For this case, the information was taken for two tanks. The information has been shown in “ThingSpeak” which was used as the common server and checked in two different tabs since two water tanks were used and easily monitored.

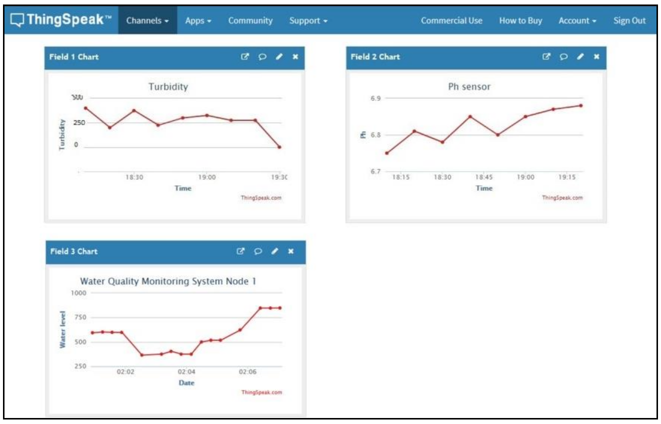


Fig. 13. Water quality information of tank 1

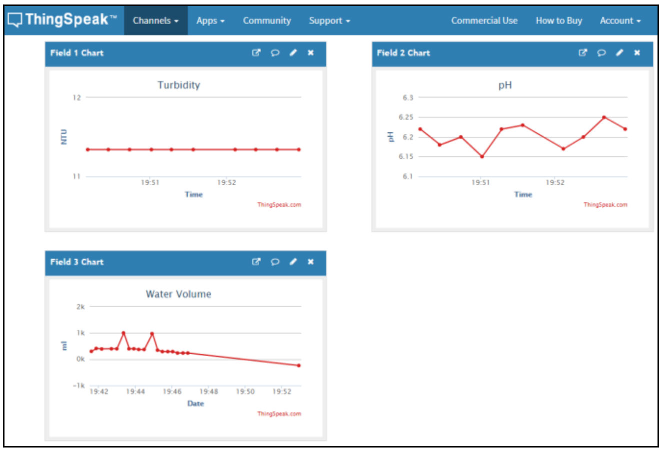


Fig. 14. Water quality information of tank 2

## V. CONCLUSION

This system offers continuous transmission of results and works comparatively at a faster rate, so the monitoring gets easier. Transferring the irregular water quality information to base stations by quicker communication network and providing multiple graphical references for the decision-making department to understand the status of the damage to establish the prevention and curing policy.

The future scopes of this system include monitoring the quality of soil. Establishing a system with more improvising sensor nodes and base stations in order to monitor quality in multiple sites. Purification and filtering of dirty or contaminated water and adding arsenic sensor.

## REFERENCES

[1] A. Joshi, "Water Quality Monitoring System Using Zig-Bee and Solar Power Supply", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol.4, no.10, 2015

[2] "Water Quality Legislative History," [Online]. Available: www.des.nh.gov/organization/divisions/ water/ wmb/wqs/history.htm

[3] Jiang Peng, Huang Qingbo, Wang Jianzhong Research on Wireless Sensor Networks Routing Protocol for Water Environment Monitoring 07695-2616-0/06 2006 IEEE.

[4] R. Yue and T. Ying, "A water quality monitoring system based on wireless sensor network & solar power supply," in the proceedings of 2011 IEEE International Conference on Cyber Technology in Automation, Control, and Intelligent Systems, Kunming, China, 2011.

[5] R. Kumar, M. Mohan, S. Vengateshapandiyan, M. Kumar and R. Eswaran, "Solar based advanced water quality monitoring system, "International Journal of Science, Engineering and Technology Research (IJSETR), vol.3, no.3,2014.

[6] F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, “Wireless sensor networks: a survey,” Computer Networks, Volume 38, Issue 4, pp 393-422, 2002.

[7] Rasin, Z. and Abdullah, M. (2012). Water Quality Monitoring System Using Zigbee Based Wireless Sensor Network. p.6

[8] Unyoung Kim, Ghanbari, S., Ravikumar, A., Seubert, J. and Figueira, S. (2013). Rapid, Affordable, and Point-of-Care Water Monitoring Via a Microfluidic DNA Sensor and a Mobile Interface for Global Health. IEEE Journal of Translational Engineering in Health and Medicine, 1, pp.3700207-3700207

[9] Kumar, R., Mohan, M., Vengateshapandiyan, S., Kumar, M. and Eswaran, R. (2014). Solar based advanced water quality monitoring system using wireless sensor network. p.5.

[10] Cloete, N., Malekian, R. and Nair, L. (2016). Design of Smart Sensors for Real-Time Water Quality Monitoring. IEEE Access, 4, pp.3975-3990.

[11] Yuan, F., Huang, Y., Chen, X. and Cheng, E. (2018). A Biological Sensor System Using Computer Vision for Water Quality Monitoring. IEEE Access, 6, pp.61535-61546.

[12] Abubaker, A., CR, K., Thomas, T., Joseph, N. and Begum, S. (2019). A Study on IOT Approach for Monitoring Water Quality Using MQTT Algorithm. p.3.

[13] Yang, H., Hassan, S., Wang, L. and Li, D. (2017). Fault diagnosis method for water quality monitoring and control equipment in aquaculture based on multiple SVM combined with D-S evidence theory. Computers and Electronics in Agriculture, 141, pp.96-108.

[14] Hadipuro, 'Indonesia’s Water Supply Regulatory Framework: Between Commercialisation and Public Service?', Water-alternatives.org, 2010. [Online]. Available: http://www.water-alternatives.org/index.php/allabs/111-a3-3-1/file. [Accessed: 17-Oct2015]

[15] Weifeng Huang, Tao Zeng, Liping Ye and Zhen Li, 'A self-acting water pump control system for residential buildings based on resonance water level sensor', 2011 International Conference on Electric Information and Control Engineering, pp. 265-357, 2011.

[16] Energy.gov. (2019). Solar Photovoltaic Cell Basics. [online] Available at: https://www.energy.gov/eere/solar/articles/solar-photovoltaic-cell-basics [Accessed 15 Jan. 2019].

[17] Arduino.cc. (2019). Arduino - ArduinoMega2560. [online] Available at: https://www.arduino.cc/en/Guide/ArduinoMega2560 [Accessed 2 Jan. 2019].

[18] "pH meter," [Online]. Available: www.dfrobot.com /wiki /index.php/ PH_meter (SKU:_SEN0161)

[19] Engineersgarage.com. (2019). How Turbidity Sensor Works | Working Principle of Turbidity Sensor.[online] Available at: https://www.engineersgarage.com/insight/how-turbidity-sensor-works

[20] Service, U., Science, D., Team, T., Science, D., BSC Associates, L., USA, O., Systems, W., Council, S., Ltd., E., Ira Leifer, B. and National University of Ireland, G. (2019). Ultrasonic distance measurement sensor applications. [online] Senix.com. Available at: https://senix.com/distance-ranging/ [Accessed 14 Jan. 2019].

[21] "ESP8266 Overview | Espressif Systems," [Online]. Available: www.espressif.com/en/products/ hardware/esp8266ex/ overview.

[22] "ThingSpeak", 2018. [Online]. Available: https://thingspeak.com/

[23] S. Rafid, F. Redwan, A. H. Abrar, S. N. U. Ahmed, and B. B. Pathik, “Water Quality Monitoring System: A Sustainable Design”, 6th International Conference on Signal Processing and Integrated Networks, Delhi, India, Mar. 7 – 8, 2019.

[24] Cosgrove, W. J., and D. P. Loucks (2015), Water management: Current and future challenges and research directions, Water Resource. Res., 51, 4823–4839, doi: 10.1002/2014WR016869.

[25] M. M. Billah, S. K. Das, M. T. Islam, M. A. Haque, and B. B. Pathik, “Design, Simulation and Implementation of a Grid Tied Solar Power Controller Integrated with Instant Power Supply Technology”, 2015 IEEE International Conference of Innovative Smart Grid Technologies - Asia (ISGT Asia), Bangkok, Thailand, Nov. 4-6, 2015. ISBN: 978-1-5090-1237-4.