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# An Intelligent IoT based Wireless Sensor Network for Monitoring Water Quality by using RNN in Real-Time

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***Abstract:*** ***Water uses is increasing day by day. As development continues, the demand for water is increasing. Water is require for daily routine, for irrigation, for fish and wildlife and for industrial use, not only water but pure water is require. This is a helpful approach to make people or authorities aware and alert about water quality in real-time situation. In this paper, the proposed technology helps to monitor the water quality in real time situation or environment. The technology such as Internet of Things, Wireless Sensor Networkand Cloud Computingare used in this approach for water quality parameters (pH, minerals and Temperature) measuring in real-time environment. For water quality prediction and analysis, a training data set has been prepared and these training data sets use for categorize utility of water in different field. The sensor sensed the water parameters and send this sensed value to the cloud server for processing. These data compared with training data set. In this paper monitor data classify by using Naive Bayes and the utility of water can be predicted by Recurrent Neural Network. The resultant of this proposed approach are: it gives high accuracy and the response time of this approach is very less comparatively.***

***Keywords: WQM system, IoT, WSN, Cloud Computing***

## I. INTRODUCTION

One of the most essential source of life is water. The good quality water is needed for many purposes like drinking, agriculture, outdoor bathing, industrial cooling and many other purpose. Around 71% of Earth's surface is occupied with water. However, approximately 3% of total water is freshwater and the rest 97% water is saline water. Most of the 3% of freshwater exist in the form of glaciers and ground-water and almost its 0.3% fresh water is in rivers, lakes and ponds. The 0.3% water is used for many different purposes. It has become mandatory to check the water quality nowadays.

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The surface water like rivers, lakes, ponds can be easily contaminated by throwing human waste, industrial waste and waste pollution. Drinking such polluted water is the reason of illness and death of animals, it impacts on human health and causes diseases and deaths of humans, it can also impact the growth of vegetation where the waters are polluted. This project aims water quality has to be monitored regularly in real-time environment. Wireless Sensor Network, Internet of Things and Cloud Computing are the easiest and cheapest way for WQM [1]. Cheap and inexpensive wireless devices can be installed in particular area such as rivers, lakes, homes, ponds and next to industry.

It continuously monitors the water quality (pH, minerals and temperature) and keeps sending the monitored value to a centralized system or cloud that would alert the people and authority to take action if any problem arises. IoT and WSN makes an intelligent and smart monitoring system that are capable of monitoring water quality in real-time environment and alert the people or authority by sending the message like 'good quality water' or 'bad quality water' or storing data on cloud after monitoring the quality of water that can be access by people. By using IoT and WSN technologies we can create a cheap and effective way to monitor water quality [3]. and other environmental conditions.

## II. TECHNOLOGY USED IN PROPOSEDAPPROACH

### A. Internet of Thing

The abbreviation for Internet of Things is IoT, basically used for collecting and sensing the data from the physical and environmental conditions to across the world and share these data on the internet where it can be utilized and processed for different purpose [4]. In short IoT is a platform where many enclosed devices are connected to each other via internet for sharing data and information.

There is various kinds of IoT applications like wearable technologies, smart phones, personal computers, home applications, environmental monitoring systems, health centric devices etc which are very beneficial for human life. IoT applications help users to acquire high automation, analysis and integration within a system. For my project, IoT has become the cheapest object that include sensors, nodes, WiFi, Bluetooth, battery and memory. Sensors sense the water parameter like pH, temperature and mineral, the collected data is transmitted from source node to destination node by internet, it can also store data [7].

### B. Wireless Sensor Network

WSN is type of wireless distributed networks that is consisted with distributed autonomous devices. The sensors are basically used for monitoring the physical and environmental conditions. These automation devices or nodes combine with routers or Wi-Fi and the gateway to develop a WSN system. For collecting natural data such as parameters of water, temperature, pressure, noise etc., we use sensors and transmit it to the server for processing and utilization of these data [5]. The applications like environmental applications, military applications, home applications, health applications etc are basic applications of WSN. In case of my approach that is the monitoring of water quality, the data transmitted through wireless network ensures the security and integrity of data. Wireless network sends data to the centralize system or cloud server [6].

### C. Cloud Computing (CC)

CC is a computing model that provides services via internet. Cloud Computing is development of grid computing, parallel computing and distributed computing and it is the combination and evolution of Virtualization and Utility computing. Cloud computing provides services such as Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS). Cloud shows web server as a space where computing has been installed previously and it exist as services, data operating systems, storage, applications and processing power and these services are always ready to be shared. Cloud Computing provides services to the users as Pay-per-Use or On-Demand mode by which user can easily access and share IT resources via Internet, where IT resources are network, server, storage, applications, services etc.
In our approach CC gives services in distributed network to process and store data in virtual memory. Here the data is processed with help of previous stored data.

## III. EXISTING SYSTEM

Nowadays the quality of water is depleting day by day. This causes various diseases and deaths. The surface water like rivers, lakes, ponds can be easily contaminated by throwing human waste, industrial waste and waste pollution. WQM system needs fast and accurate system that gives high accuracy. The existing system is not sufficient to give high accuracy. The old process of monitoring water quality like manually collect the water and tests in labs are very costly and ineffective process [2]. The old process is not sufficient for WQM system. Nowadays the water quality is monitored by sensors and sensor transmit these data to the cloud, this process is not much sufficient because it creates large number of data which is not processed. It is also a time-consuming process.

## IV. PROPOSED SYSTEM

To aware the people or authority about water quality in real-time, proposed technique help to implement an environment for different use of water in different field. this technique monitors the water quality in real-time situation by using sensors. In this technique sensors helps to monitor the quality of water like pH, minerals and temperature in different situation or condition and send these data on the cloud. In this approach, sensors monitor the water parameter from real-time condition or situation. The sensed data is transmit to the cloud server, where data processing gets started. The processed data is classified by using Naive Bayes algorithm, into different class, the range predicted by using Recurrent Neural Network and make a tested water data set. The final result shows the use of water for different purpose.

## V. METHODOLOGY

In this approach, the sensors are used for sensing the water quality parameter like pH, TDS and temperature, on the basis of the sensed data it classifies the data and predicts the water quality range for what purpose water can be used. The NB and RNN algorithms are used in this technique for classification and categorization of use of water.

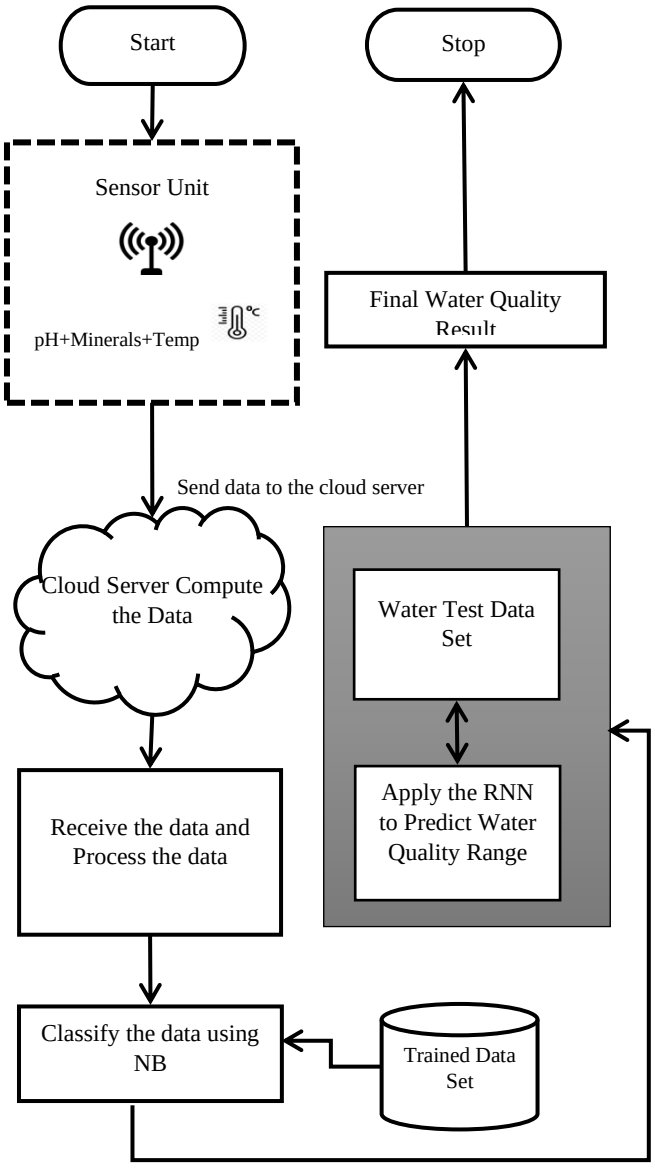


**Fig. 1 Model of Proposed Approach**

### A. Working of proposed approach are

**Start**

**Step 1.** Sensors sense the water quality parameters like pH, minerals and temperature.
**Step 2.** Sensed data is transmit to the cloud server.
**Step 3.** Cloud server receives the sensed data.
**Step 4.** After receiving the sensed data cloud server process or computes the received data.
**Step 5.** The processed data is classified by using Naive Bayes Algorithm and training data set.
**Step 6.** Classified data is converted into the tested data set and predicts the range of water quality by using Recurrent Neural Network.
**Step 7.** The final results aware the people or authority about the water quality by sending them alert messages.
**Stop**

### B. Hardware used

- Generic pH electrode sensor.
- DS18B20 water proof temperature sensor.
- TDS 407 ppm

## VI. ALGORITHMS

### A. Proposed Algorithm

The collecting data from sensor nodes and processing data into cloud the algorithm includes following steps to predict the water quality and categories the utility of water in different field.
**Step 1:** Install the Raspbian Stretch Operating system on Raspberry Pi 4.
**Step 2:** Connect the pH sensor, water temperature sensor and TDS sensor with Raspberry Pi 4.
**Step 3:** Since all sensor would detect all the values of water such as, pH value, current temperature and mineral values and send these values to the cloud.
**Step 4:** In next step we collect the data set of different pH values, water temperature and mineral sets and water result for training.
**Step 5:** After formation of all values, it is trained. Once the training is complete, it creates a. pickle file, is generated for matching feature to know the water quality. After the training, the system is prepared to decide good water quality and bad water quality.
**Step 6:** Water quality is decided by the Naive Bayes algorithm, and Recurrent Neural Network algorithm predicts the water utility for specific field.

### B. Naive Bayes Algorithm

Naive Bayes is a simple and easy technique used for constructing classifiers base on Bayes' Theorem. It labels the classes in the basis of some strong independence assumption that presence of a specific feature in a class is not related to the other feature of class. Naive Bayes model is a probability model that can be trained easily in supervised learning mode.
In this approach, Naive Bayes use for classify the data set according to the training data set. These data set includes water quality parameters like pH, minerals and temperature of water.

**Steps in Naive Bayes algorithms:**

**Step 1:** Convert data set according to pH, Minerals and Temperature.
**Step 2:** Create likelihood of water parameter for different probability.
**Step 3:** by using Naive Bayes algorithm, data sets can be classified.

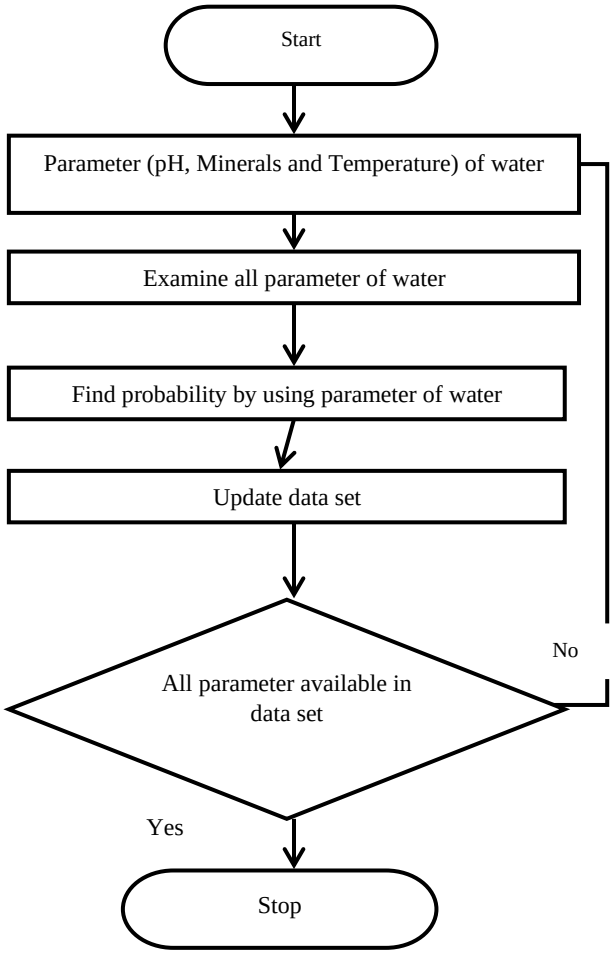


**Fig. 2 Model of Naive Bayes**

### C. Recurrent Neural Network Algorithm

RNN is a part of Neural Network that fed the previous output as input to the current state. In RNN, all inputs and outputs are independent but if system requires to predict something, it requires the previous output and for this it needs to remember previous output for that RNN have "memory" it remembers some information about 'what has been calculated so far?'.
In this approach, RNN is use to calculate the final output, RNN takes classified data set as current input and calculate the final output. Final output is compared with the provided data sets, if the current output is matched with the provided data set then the water is usable otherwise water is not usable.

**Steps in Recurrent Neural Network:**

**Step 1:** An input is provided to the network.
**Step 2:** Calculate current state by using current input and previous state output, hence current output fed as previous output to the next step.

**Step 3:** Step 2 will be repeated until the final current state is use to calculate the output.
**Step 4:** After calculating the output it compares the provided output.
**Step 5:** If the output is same as the provided output
Then final output is correct.
Else
Back-propagate to the Step 2 and update the input.

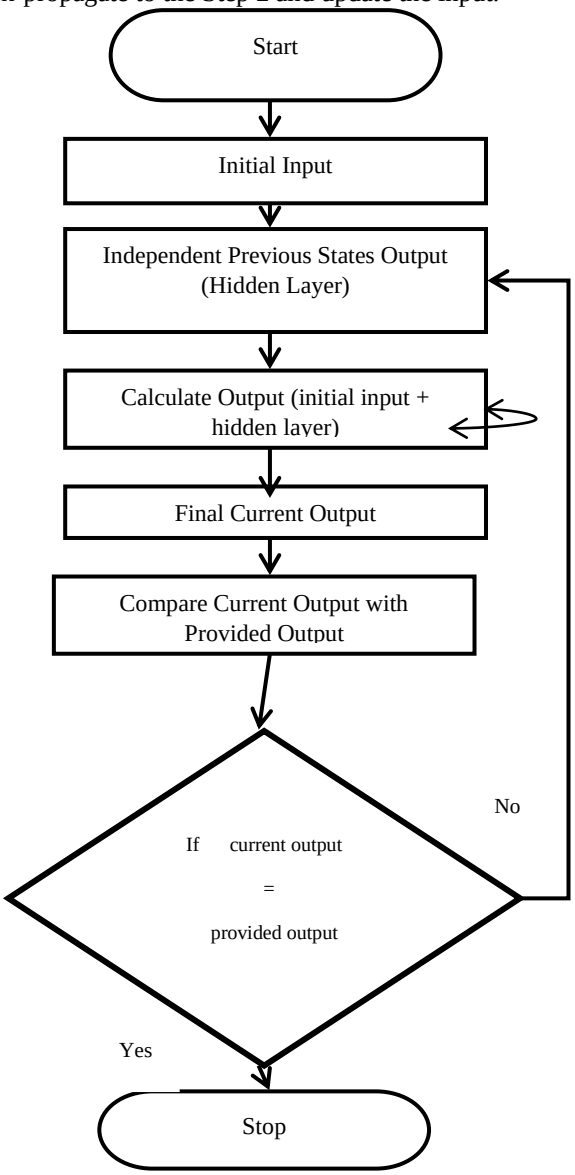


**Fig. 3 Model of Recurrent Neural Network**

## VII. RESULT AND ANALYSIS

The IoT and WSN creates a system which monitor water quality in real-time environment and by this approach, the collected sensed data, process on the cloud and aware the people by sending message or storing it on the cloud. This approach creates training data sets of minerals and pH values for prediction and analysis.

### A. Analysis of pH value

As the graph, which is a training graph of pH value, shows the taste of water on different point. The water with lower than 7 pH value is considered acidic and the water with greater than 7 pH value is considered basic. The pH value 7 is pure water.

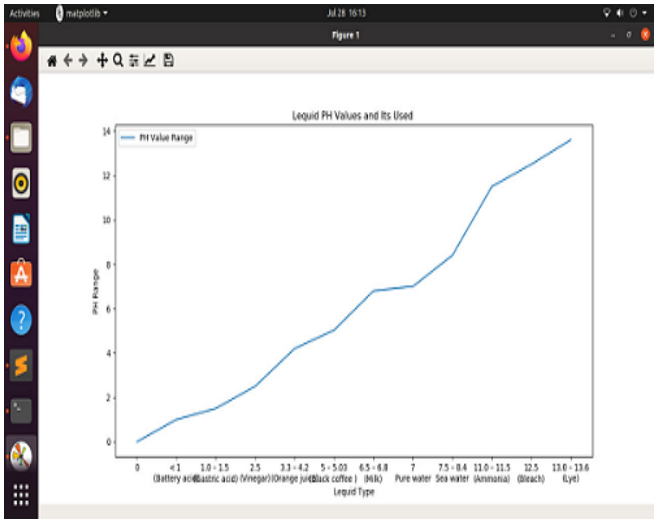


**Fig. 4 pH value range**

The pH value lies between 6.5 to 8.5 can be use for different purpose like drinking, out-door bathing, propagation of wildlife and fisheries and Irrigation, Controlled Waste disposal, Industrial Cooling etc. The analysis shows the different taste of water on different point. The above graph shows the different point of pH value and taste

**Table 1: Taste of water in different range of pH**

| pH | Taste |
|---|---|
| 6.5 to 6.8 | The pH value lies between 6.5 to 6.8 tastes like milk |
| 5.0 to 5.3 | The pH value lies between 5.0 to 5.03 tastes like black coffee |
| 3.3 to 4.2 | The pH value lies between 3.3 to 4.2 tastes like fruit juice (orange juice) |
| 2.5 | When the pH value is 2.5 then it tastes strongly acidic (vinegar) |
| 1.0 to 1.5 | The pH value lies between 1.0 to 1.5 is gastric acidic |
| 0 to 1.0 | If the pH value is less than 1.0 then it is very strongly acidic which is taste like battery acid |
| 7 | The pH value 7 is pure water. |
| 13.0 to 13.6 | If the pH value lies between 13.0 to 13.6 the it is taste like Lye |
| 12.5 | When the pH value is 12.5 then it is taste like bleach |
| 11.0 to 11.5 | The pH value lies between 11.0 to 11.5 it is taste like ammonia water |
| 7.5 to 8.4 | The pH value lies between 7.5 to 8.4 is basically sea water |

### B. Analysis of TDS value

The next training graph shows TDS value, it shows range of TDS by which it shows the use of water, that water is acceptable or not acceptable for different purpose.

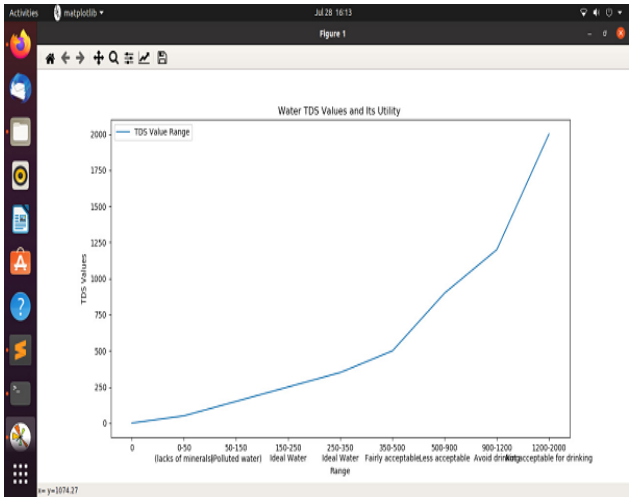


**Fig. 5 TDS value range**

TDS (total dissolve solid) is in water known as minerals, salt, metals etc., which is completely dissolved by water. The graph shows the range of TDS (range in ppm) in water, safe for drinking or not and also categories the different purpose. The TDS range lying between 0-50 is unacceptable for drinking because lack of minerals or polluted water. The TDS range lying between 50-150 is acceptable for drinking. The TDS range lying between 150-250 is ideal water and TDS range lying between 250-350 is also ideal water for drinking. The TDS range lying between 350-500 is fairly acceptable for drinking. The TDS range lying between 500-900 is less acceptable for drinking. If the TDS range lies between 900-1200 then avoid to drinking the water. If the TDS range lies between 1200-2000 or more than 2000 the water is unacceptable for drinking. Other uses of water, like irrigation, fisheries and outdoor bathing TDS range are : TDS range in water for irrigation should be lying between 0-500 is acceptable for all crops. The TDS range lying between 500-1500 is acceptable for highly tolerant crops and the TDS range is grater than 1500 is not acceptable for crops. The ideal TDS range of water for outdoor bathing is should lie between 200-400 and the maximum TDS range for swimming pools are 1500. The fresh water-fishes should have TDS range 400 or less than 400 and on the other side salt-water fishes need high level TDS range which is lies between 5000 to 50,000.

### C. Accuracy and Comparison of proposed algorithm

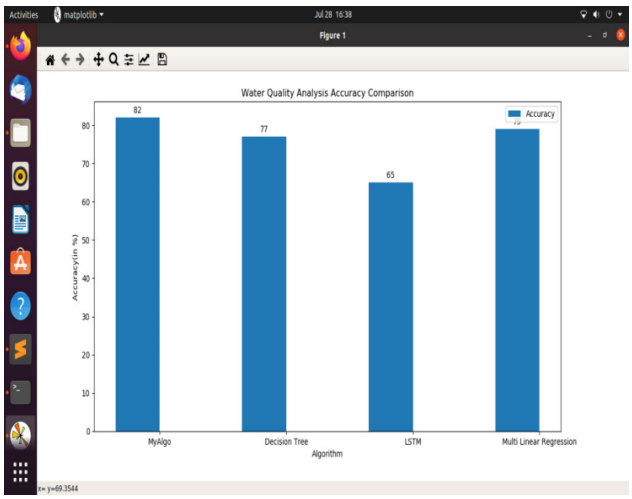


**Fig. 6 Accuracy and Comparison of algorithm**

The following graph is the accuracy comparison graph of WQM system. My approach of WQM system gives more accuracy by using proposed algorithm, than other algorithms. Proposed algorithm gives 82 % accuracy than other algorithms like LSTM which gives 65% accuracy, Decision tree gives 77% accuracy and Multi Linear Regression gives 79 % accuracy comparatively.

**THE PROPOSED ALGORITHM ACCURACY = 82 %**

### D. Response Time of my approach

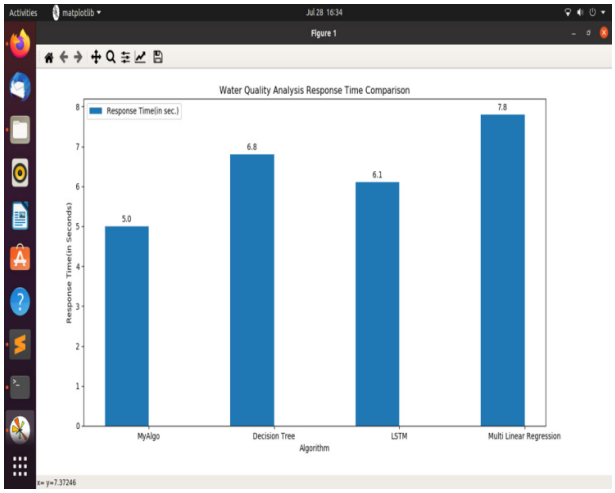


**Fig. 7 Response Time of my approach**

The above graph is response time comparison graph of proposedalgorithm. Response time of proposedalgorithm is less than the other algorithm. The response time means, the response of my algorithm is very fast than others like if there are any impurities in water, it gives faster response that water is good quality water or bad quality water. The response time of my approach is 5 second which is less than other approach, like Multi Linear Regression response time is 7.8 seconds, Decision Tree response time is 6.8 seconds and the LST Mresponse time is 6.1 seconds comparatively.

**PROPOSED APPROACH RESPONSE TIME = 5 SECONDS**

With the comparison of other algorithm MY ALGORITHM gives high accuracy and response time.

## VIII. CONCLUSION

This approach is helpful to alert the people or authority about water quality in real-time. This approach, helps people about current quality of water by processing the sensed data of the water. By this approach the pH value, TDS value and temperature is monitored by the sensors. Sensors sense real-time condition of water and send these data or value to the cloud for processing where data are classified and compare with the trained data and this system predicts the water utility for different use. The IoT and WSN helps to sense the data and send the data or value to the cloud. This approach is a cheap and effective approach for WQM system.

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