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Energy Efficient Water Quality Monitoring using Wireless Sensor Networks

Manish Purohit[*1], Anand A Bhaskar[2], Seema Oza[3]

Research Scholar, Sir Padampat Singhania University, Udaipur, Rajasthan, India[1]

Sir Padampat Singhania University, Udaipur, Rajasthan, India[2]

Saurashtra University, Rajkot, Gujarat, India[3]

Abstract: Wireless sensor Network (WSN): A sensor network is a wireless network that consists of thousands of very small nodes called sensors. WSN sensors are equipped with sensing, limited computation, and wireless communication capabilities many times called as mote, shown in Figure-1. Water Quality Monitoring (WQM) is one of the application areas of WSN.

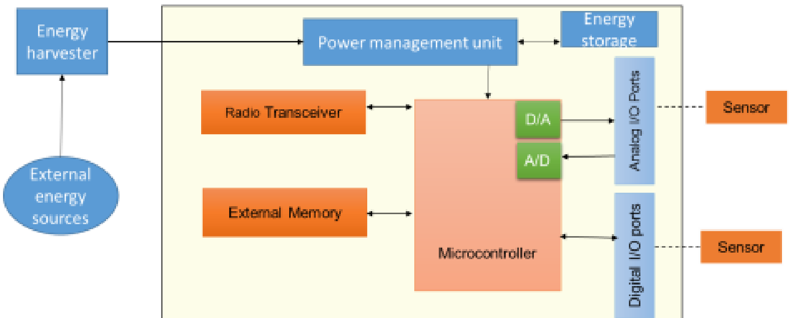

Figure-1: Hardware components of sensor node in WSN.

Water is an important natural resource; regular quality monitoring is required for its safe use. Generally, the water quality identification was done manually in Labs. Manual methods fail to deliver real-time collection of data. In the presented work aquatic area water quality monitoring (WQM) system based on WSN to help in continuous and remote monitoring of the water quality data in India is executed. The WSN node designed for monitoring three of the main parameters that affect the quality of water, i.e. pH, dissolved oxygen (DO) and temperature of water. The presented WSN node design mainly comprises of a microcontroller and radio module with sensors for WQM. In the presented work the energy efficient water quality monitoring system is interfaced with the energy harvester along with storing element in the WSN node. The sensed parameter values will be wirelessly transmitted in real time to the base station using radio module after processing. The system provides an energy efficient and low cost sensor unit for WQM through the use of inexpensive, low power devices for the hardware design.

Water pollution is one of the biggest fears for the green globalization. In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time. In this paper we present a design and development of a low cost system for real time monitoring of the water quality in IOT(internet of things).The system consist of several sensors is used to measuring physical and chemical parameters of the water. The parameters such as temperature, PH, turbidity, dissolved oxygen sensor. The measured values from the sensors can be processed by nodemcu controller. This controller board comes with an inbuilt WiFi module; this makes it possible to connect the remote water monitoring system to the cloud for further reference. Here we can use a solar panel as a secondary source of power but the system is mainly powered through USB port on nodemcu.

Keywords: Water Quality Monitoring; Wireless Sensor Network; Energy Efficiency; Sensor Node, Energy Harvesting

I. INTRODUCTION

Nowadays, water is considered as one of the scarcest natural resources on our planet. It is important to humankind, animals, and plants. Depending on the quality of water, it may either be a source of life and good health or a source of diseases and deaths. The growing environmental degradation in recent years brought about by development, population increase and climate change increases the need for researchers to look into its negative impact in the environment, especially in water sources and its implication. The Wireless Sensor Network (WSN) is suitable for monitoring physical and chemical water characteristics in remote areas at lower cost and reduce manpower requirement. It can be utilized for water quality monitoring which presents many advantages like its portability and near real-time data acquisition and data logging capability. It has gained popularity among the research community ranging from environmentalist to embedded systems community.

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II. BLOCK DIAGRAM

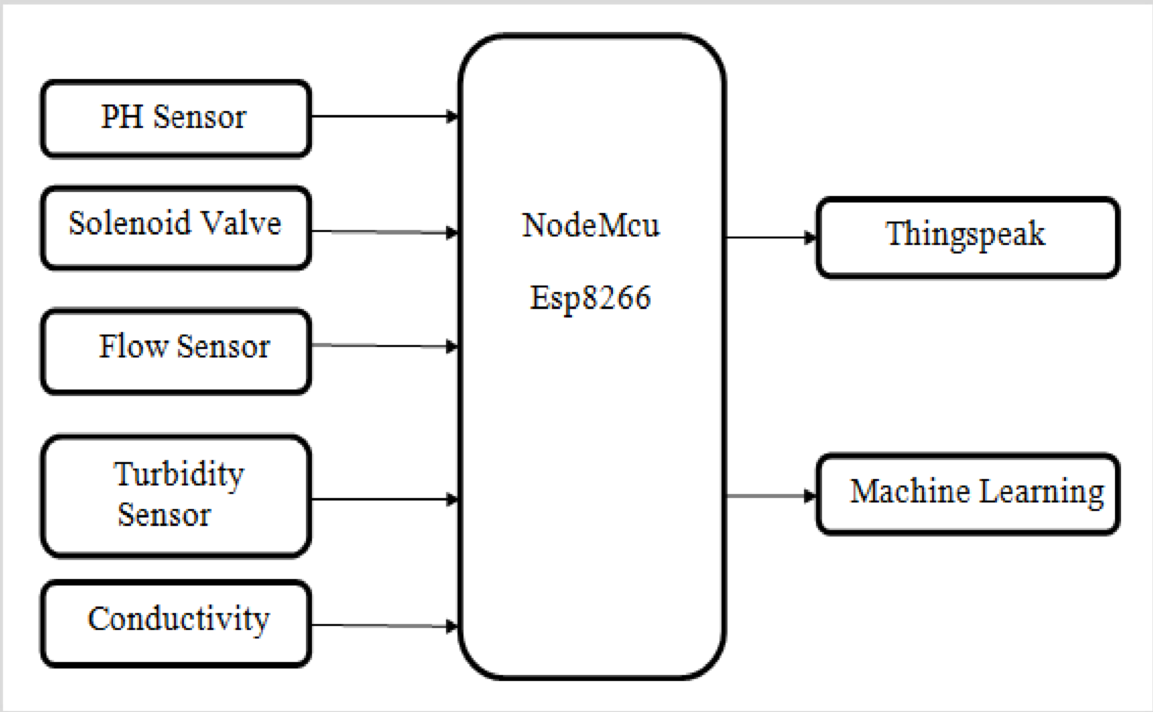

Figure-2: Proposed Model

III. HARDWARE

1. Nodemcu
2. LM35-Temperature sensor
3. PH sensor
4. Conductivity sensor
5. Turbidity sensor
6. Dissolved oxygen sensor

IV. SOFTWARE

1. Arduino IDE

A. Design/methodology/approach- Selection of Sensors & Development of microcontroller interface circuitry:
Temperature, pH, and DO sensors (electrodes) are connected to the microcontroller using their respective interface circuits.

B. The NodeMCU (Node MicroController Unit) is an open source software and hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266:
The development of energy and cost efficient IoT nodes is very important for the successful deployment of IoT solutions across various application domains, which will enable the estimation of battery life, for both time-based and event-based low-cost IoT monitoring nodes.

C. Findings- Data acquisition and control:
Data acquisition (DAQ) is the process of measuring real-world conditions and converting these measurements into digital readings at fixed-time intervals (the data sample rate). Sensors are the input components that measure physical variables and convert them to electrical signals (voltages). Sensors includes temperature, humidity, pressure, smoke, gas, light, sound, vibration, air-flow, water-flow, speed, acceleration, proximity, GPS position, altitude, or force, and the list goes on. Actuators are commonly deployed within industrial IoT applications.

D. Data processing and storage:

IoT devices require data processing and storage capabilities to perform basic handling, transformation, and analysis of the data that they capture. IoT devices can process data directly, or they can transmit this data to other devices, gateway devices, or cloud services or apps for aggregation and analysis. The processing power and storage that is used by an IoT application will depend on how much processing occurs on the device itself as opposed to how much processing is performed by the services or apps that consume the data.

E. Practical implications- Connectivity:

Network connectivity is one of the defining characteristics of any IoT device. Devices communicate with other devices locally, and publish data to services and apps in the cloud. Some devices communicate wirelessly, by using 802.11(wifi), Bluetooth, RFID, cellular networks, or Low Power wide area network (LPWAN) technologies like LoRa, SigFox or NB-IoT.

F. Originality/value:

The nodes are based on the low-cost ESP8266 (ESP) modules which integrate both transceiver and microcontroller on a single small-size chip and only cost about $2. The active/sleep energy saving approach was used in the design of the IoT monitoring nodes because the power consumption of ESP modules is relatively high and often impacts negatively on the cost of operating the nodes. A low energy application layer protocol, that is, Message Queue Telemetry Transport (MQTT) was also employed for energy efficient wireless data transport. The finite automata theory was used to model the various states and behavior of the ESP modules used in IoT monitoring applications.. The battery life of batteries rated in mAh can therefore be easily calculated from the current consumption.

A comparison of Arduino, Raspberry Pi and ESP8266 Node MCU

	Arduino	**Raspberry Pi**	**ESP8266 Node MCU**
Developer	Arduino	Raspberry Pi Foundation	ESP8266 open source community
Type	Single board Microcontroller	Mini computer	Single board microcontroller
Operating System	None	Linux	XTOS
CPU	Atmel, ARM, Intel	ARM Cortex	LXT106
Clock Speed	16 MHz	1.2GHz	26 MHz – 52 MHz
Memory	32KB	1-4GB	Upto 128MB
Storage	1KB	MicroSDHC Slot	4MB
Power	USB, Battery, Power Supply	USB, Power Supply	USB
Operating Voltage	5V	5V	3.3V
I/O Connectivity	SPI I2C UART GPIO	SPI DSI UART SDIOCSI GPIO	UART, GPIO

Table 1: A comparison of development boards

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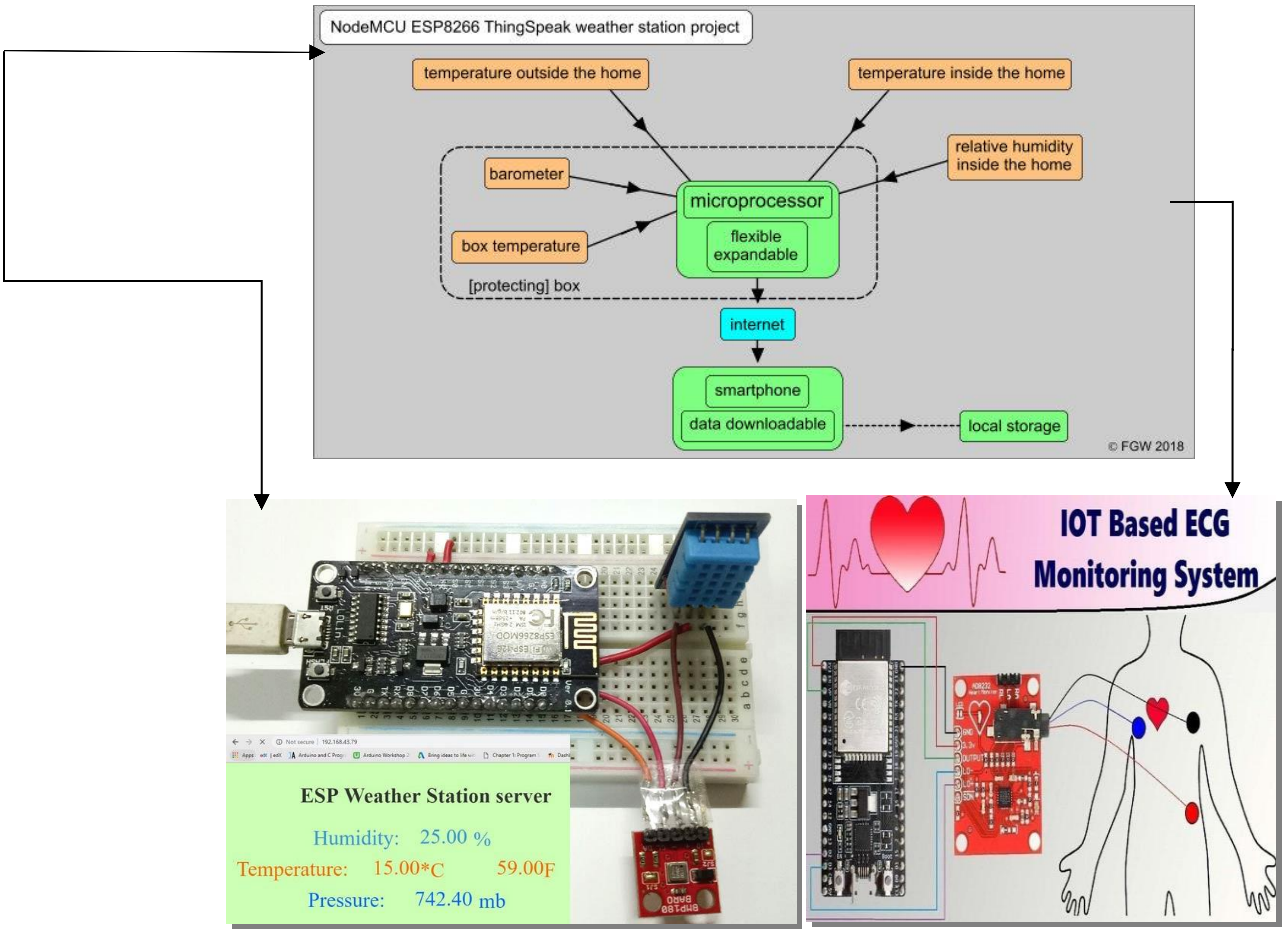
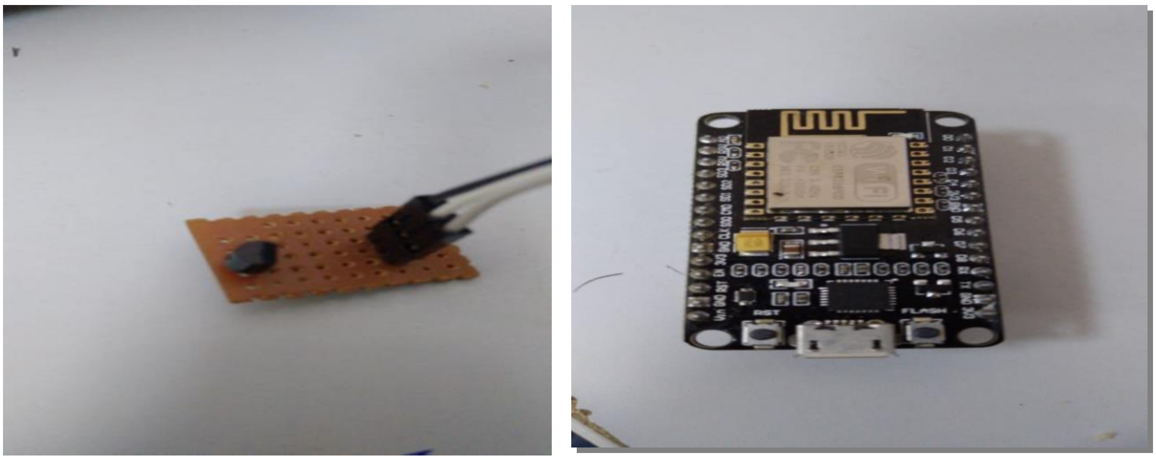


Figure-3: Wireless Sensor Networks in medical field

V. NODE MCU ESP8266 IOT BASED FOR TEMPERATURE VALUE IN WATER QUALITY MONITORING

Arduino and Raspberry Pi do not have built-in support for wireless networks. Developers will have to add a wifi or cellular module to the board and write code to access the wireless module. So open source IoT development board called NodeMCU is used and allows you to code your device using Lua scripts. One of its most unique features is that it has built-in support for wifi connectivity. It is a very inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains all crucial elements of the modern computer: CPU, RAM, networking (wifi), and even a modern operating system and SDK. This makes NodeMCU a smart choice to play with the IoT.



(a)Temp sensor (b) Node MCU

Figure-4 (a)-Temp sensor, (b)-Node MCU

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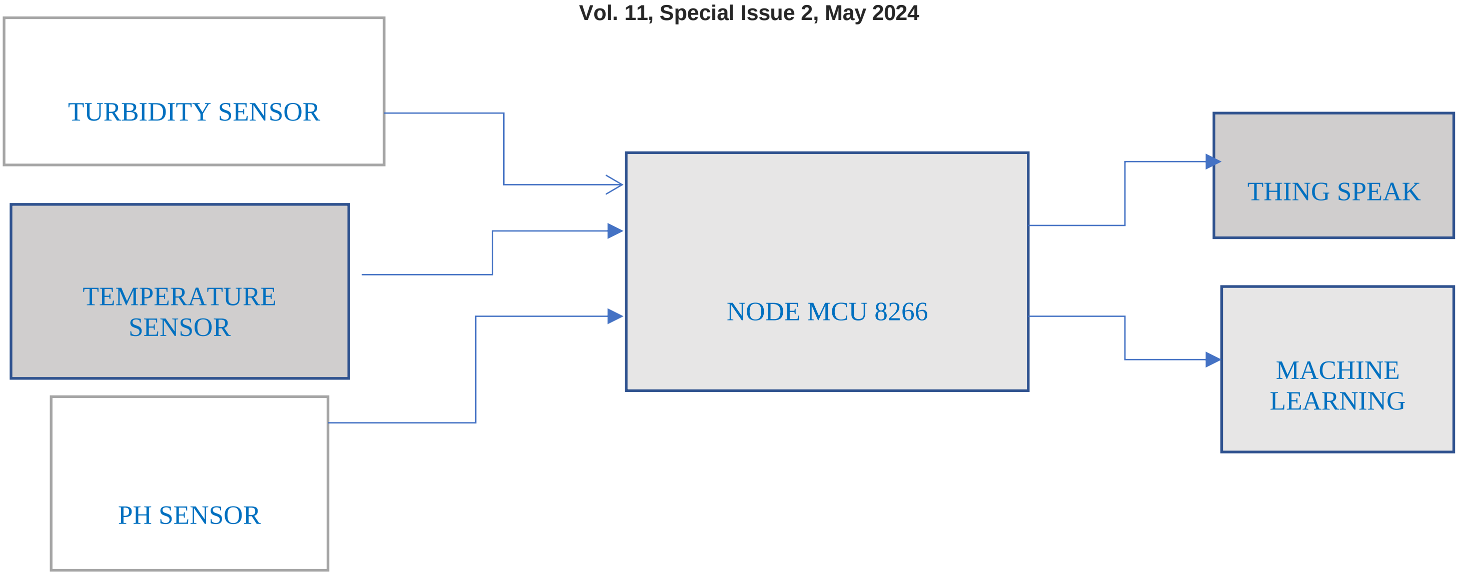

Figure-5: Block diagram

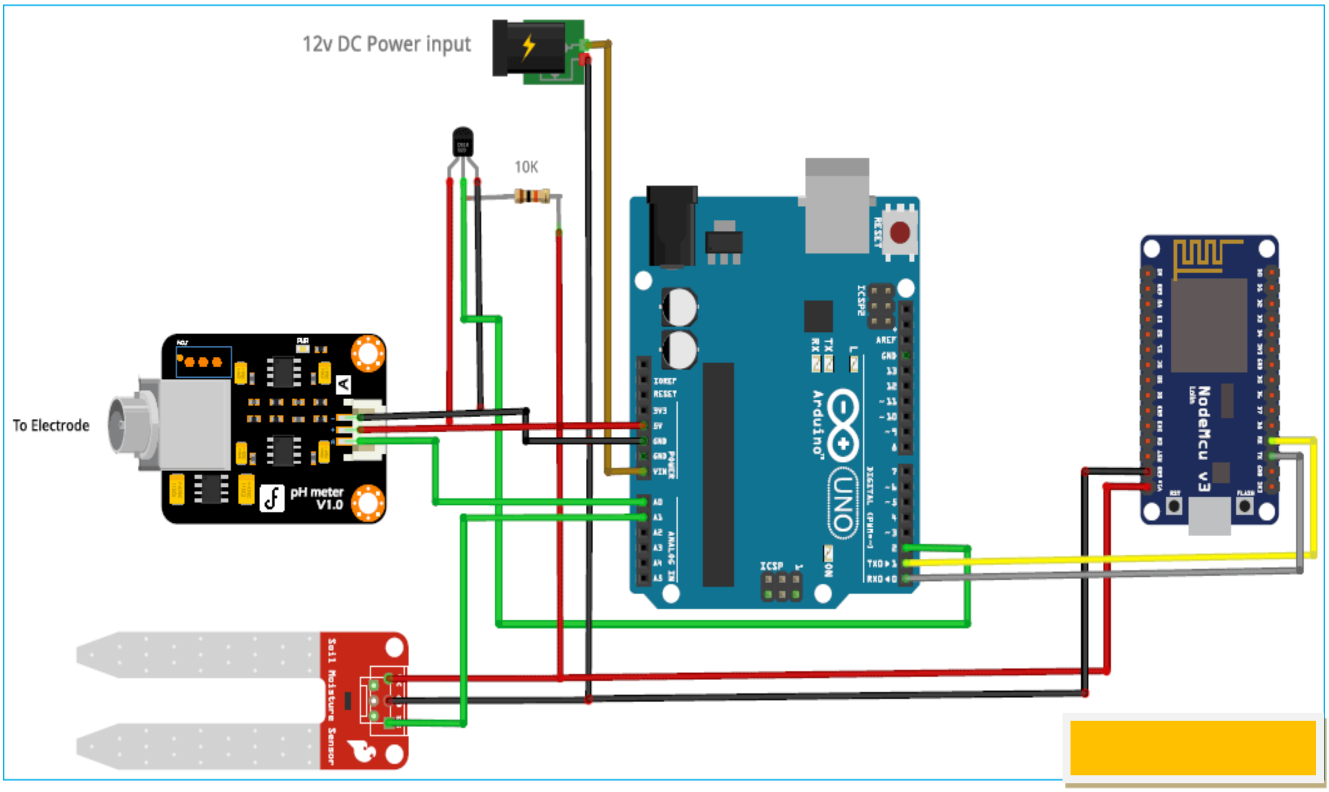

Figure-6:- Block diagram implementation-schematic diagram

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G. Work done for parameters monitoring

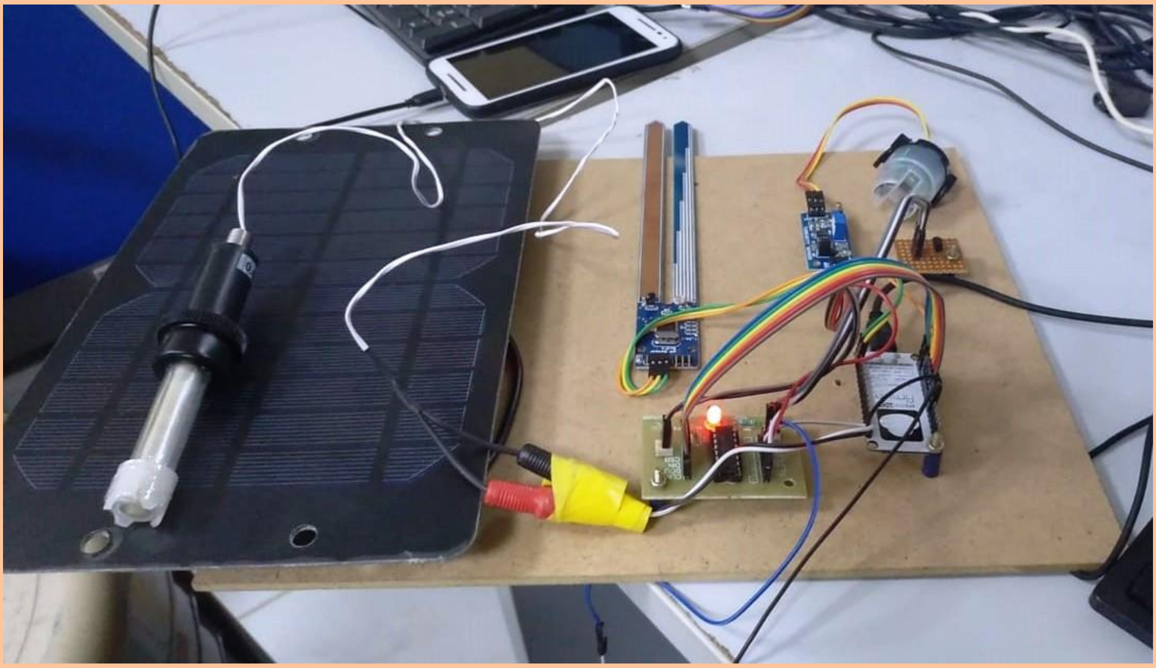

Figure-7: Practical Implementation

SOFTWARE MODULE DEVELOPMENT

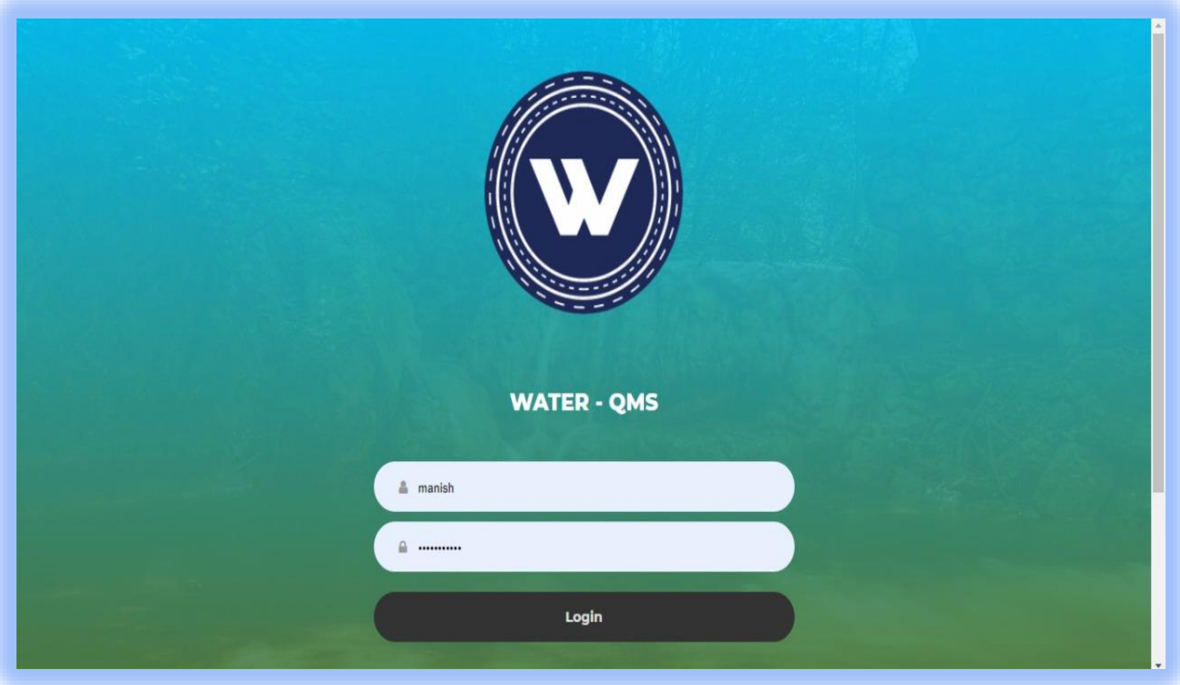

Figure-8:-Software Development Module

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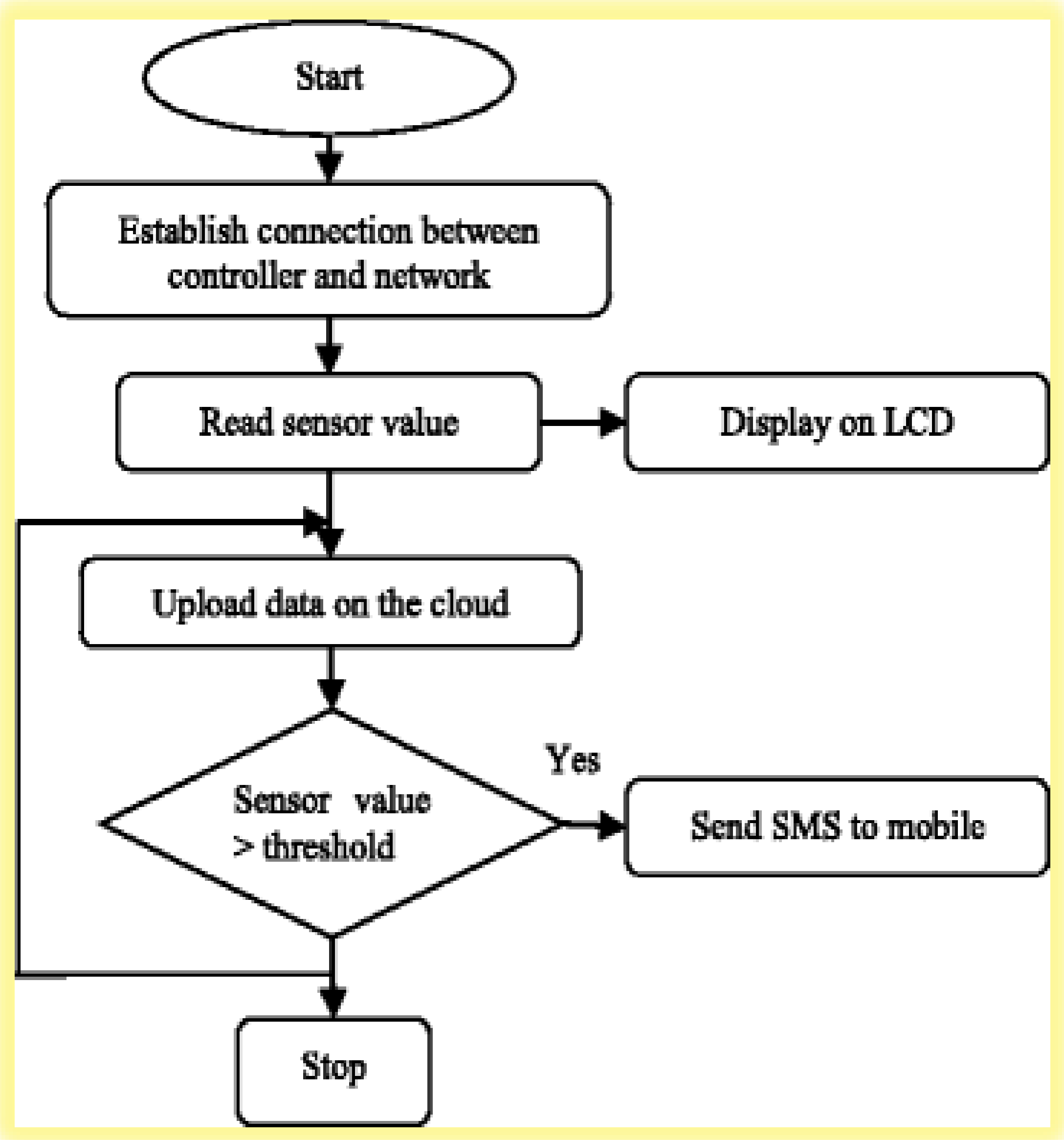

Figure-9-Flow chart used at server end

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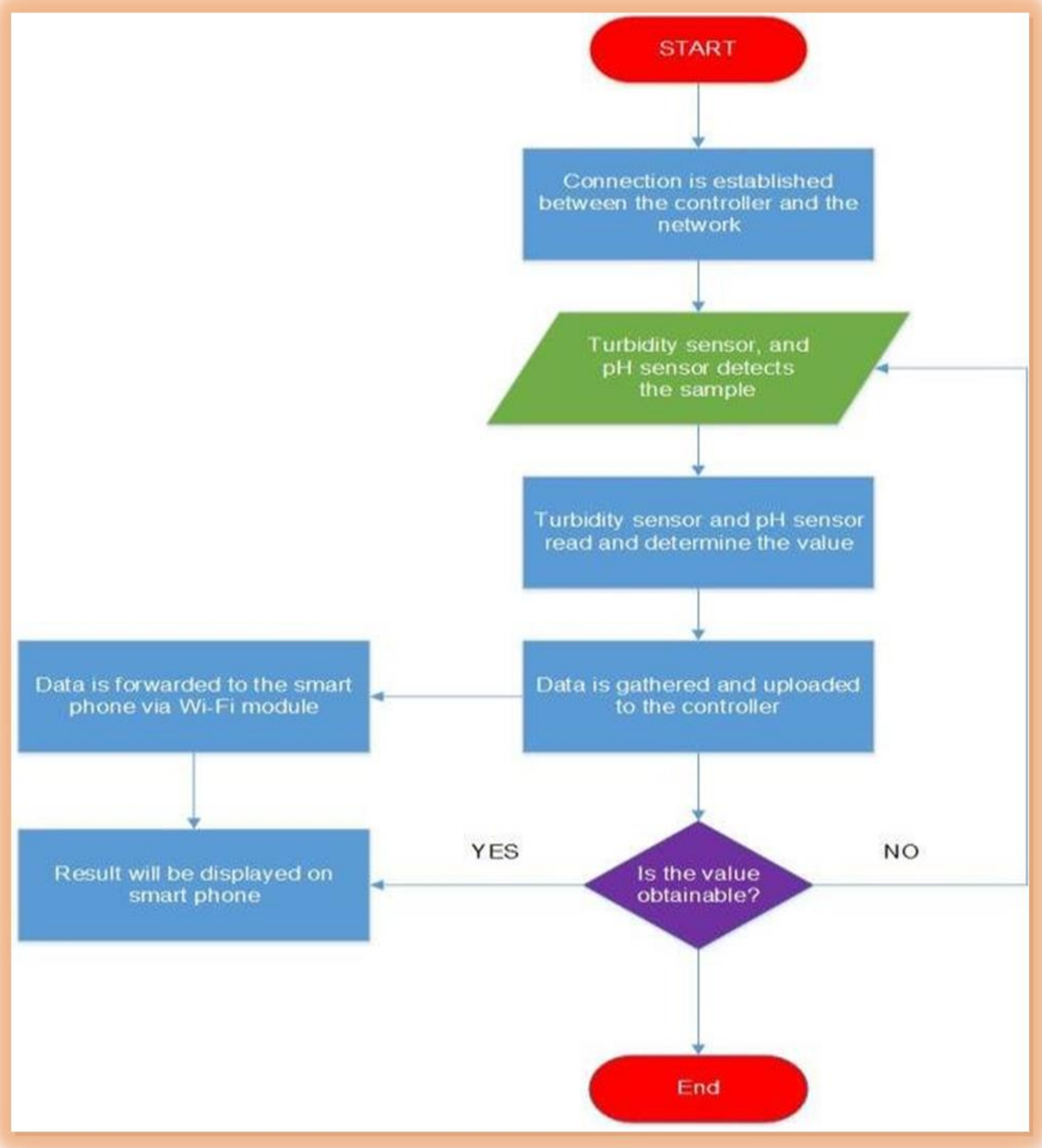

Figure-10-Flow chart used at Browser end

S. No.	Parameters	Standard Value	Permisible values
1	pH	6.5 – 8.5	No relaxation
2	Turbidity (NTU)	1	5
3	Total Dissolved Solids (mg/L)	500	2000
4	Total Hardness (as $CaCO_3$, mg/L)	200	600
5	Sulphates (mg/L)	200	400
6	Magnisium (mg/L)	30	No relaxation
7	Nitrate (mg/L)	45	No relaxation
8	Chloride (mg/L)	250	1000
9	Residual Free Chlorine, (mg/L)	0.2	1
10	Calcium (mg/L)	75	200
11	Total Alkalinity (as $CaCO_3$, mg/L)	200	600

Figure-11-Comparison Chart

VI. RESULTS/DISCUSSIONS/FINDINGS

Water samples from different water sources were tested to build a reference on the parameters for each type of sample. The chosen sample of water belongs to tap water, surface water, pool water, etc.

The nine water samples were tested all together at indoor ambient temperature. Readings were taken simultaneously. For security reasons the systems were not installed in the specific areas of interest, instead water samples were collected and tested in a safe controlled environment.

VII. CONCLUSION

The main purpose of this work is to observe the quality of water samples by designing an intelligent water quality monitoring setup implemented in IoT platform that can detect water's physical and chemical parameters. The interfacing is done between the system and the sensor network on a single chip solution wirelessly. For the monitoring process, the system is achieved with reliability and feasibility by verifying the four parameters of water. The time interval of monitoring might be changed depending upon the necessity of water resources .The time is reduced, and the cost is low in this environmental management. The water samples were collected from nearby areas in Jodhpur filter plant , during the peak season of water supply. A general study over these parameters was done once we compared our sensor values with the standard values defined by WHO for Indian outskirts.

Further advancements could be done in areas of using the history of these hosted values to form a chart in order to apply data science algorithms to deal with the varying trends in near future as per the previous records. The various parametric measurements were being verified with the standard parametric values stated by WHO, as follows:

VIII. OBSERVATION

Monitoring of Turbidity, PH & Temperature of Water makes use of water detection sensor with unique advantage and existing GSM network. The system can monitor water quality automatically, and it is low in cost and does not require people on duty. So the water quality testing is likely to be more economical, convenient and fast. The system has good flexibility. Only by replacing the corresponding sensors and changing the relevant software programs, this system can be used to monitor other water quality parameters. The operation is simple. The system can be expanded to monitor hydrologic, air pollution, industrial and agricultural production and so on. It has widespread application and extension value.

By keeping the embedded devices in the environment for monitoring enables self protection (i.e., smart environment) to the environment. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi.

Future Scope:

- In future we use IOT concept in this project
- Detecting the more parameters for most secure purpose
- Increase the parameters by addition of multiple sensors
- By interfacing relay we controls the supply of water

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