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IoT BASED WATER QUALITY MONITORING & ALERT SYSTEM FOR RO PURIFIERS

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Abstract

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 monitored in real time. Therefore design and development of a low cost system for real time monitoring of the water quality in RO purifiers in proposed in this work. The system consists of several sensors that is used to measure the physical and chemical parameters of the water such as temperature, pH, and TDS to assess the quality of water. The sensor values are interfaced with the wifi microcontroller and any non compliance with the standards will be indicated to the user through a visual indicator. Mean while the same will be communicated to the service vendor through email/sms. In addition, for periodic cleaning of the filters, a scheduled reminder is issued. The proposed system will avoid drinking non quality water and will pave way immediate redressal mechanism.

Keywords: pH, IoT, TDS, Wifi.

1. Introduction

1.1 PREAMBLE

Water covers 71% of earth's surface. However, only 2.5% of it is fresh water and 0.3% of it is in rivers, lake or atmosphere. Freshwater is then a limited resource that impacts biological life development in rivers or lakes as well as the quality of the food we eat. Monitoring the quality of the water has become imperative nowadays. Water in lakes or rivers can be easily contaminated by human actions such as industrial or waste pollution. This can cause illness or death of animals that live or drink that water, it will impact the growth of vegetation around that particular location and it can also cause illnesses in people that use that water to bath. Water quality has to obey to strict regulations and be constantly monitored. The Internet of Things (IoT) brings new possibilities for water quality control. Inexpensive connected devices can be deployed in key points such as lakes, next to industry complexes or close to the beach. These can constantly monitor water parameters and communicate to a system that would alert authorities as soon as a problem is detected. IoT allows for new smart systems that are capable of real time water quality monitoring and are smart enough to interpret that data. This is a cheap and reliable way to allow environmental management and minimise human health issues.

Although potable water is an essential resource for humankind, the real-time management of portable water utilities is faced with several challenges as a result of the depletion of water sources, outdated infrastructure, and population increase. Therefore, there is an urgent need to develop new systems for water quality control. Water quality evaluation in conventional strategies consists of an analysis of water samples in the laboratory collected by hand at several sites. Although these strategies are effort-intensive, time-consuming, expensive, and do not provide real-time information concerning water quality that could be essential in making decisions of safeguarding public health, they are informative about the chemical, biological, and physical water properties There is a need to develop new approaches taking advantage of Internet-based tools to control water quality due to the decline of efficiency of current strategies. There has been a substantial development of Internet based technologies to manage and control water utilities. However, the number of monitoring sensors to be installed and calibrated across a wide area is large, therefore, such technologies are quite expensive. Also, the employment algorithm for these technologies has to be suitable for a specific area. Based on the above problems, the present work has proposed an IoT-based system that is cost-effective for managing potable water quality in real-time. For this reason, a main controller used in this system along with a specialized IoT module to ensure the sensor information from the key controller can be accessed or visualized on mobile phones through Wi-Fi or via cloud computing.

1.2 Internet of Things

The Internet of things (IoT) is a system of interrelated computing devices, mechanical and digital machines are provided with identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The definition of the Internet of things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building Automation) and others all contribute to enabling the Internet of things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smart phones and smart speakers. Developments in computing and consumer electronics technologies have recently triggered the paradigm of the Internet of Things (IoT). The Internet of Things is described as an enabler that connects seamless objects the environment and Developments in computing and consumer electronics technologies have recently triggered the paradigm of the Internet of Things (IoT). The Internet of Things is described as an enabler that connects seamless objects the environment and executes some kind of exchange of messages between them. The Internet of Things (IoT) is a collection of objects that work together in a federated manner to serve consumer tasks It binds computational power to deliver environmental data These devices can be microchips in the form of tailor made sensors, devices, embedded systems, and data analysis One of IoT's rapid influences is environmental monitoring, particularly on disaster management, early warning systems, and environmental data analytics. Water monitoring and sustainability are one of the major issues in an environmental monitoring. Water monitoring and conservation from a consumer perspective is an important utility service that often faces many challenges. A real-time scenario with an IoT-based water monitoring system is proposed in this thesis. The solution proposed is low cost, with an integrated sensory system that enables internal water quality monitoring. The factors that affect the water quality are toxic metals, dissolved oxygen, sedimentation, erosion etc. Alerts and relevant data are transmitted to a cloud server over the Internet and can be received by a consumer-owned user terminal. The water measurement results are displayed in a remote dashboard based on the web. Homeowners can use this system as efficiently as industrial users and other water utilities. The system can provide a pervasive early warning system through the Internet of Things for portable water quality.

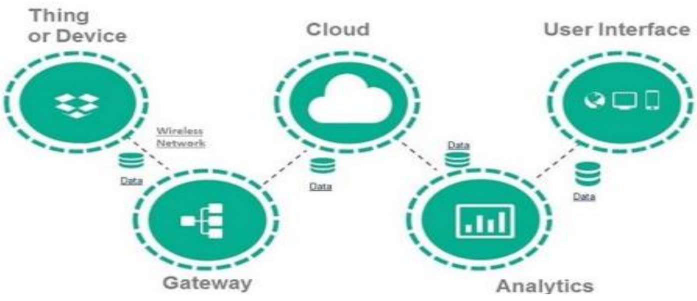


Figure. 1. Components of IoT

1.3 Objectives

Our framework utilizes RFID tags which allow school/college to monitor the student attendance in and out of the class, upload the data on Google Spreadsheet and also temperature of the student.

The main objectives of this dissertation are

i. To monitor the water quality of the RO purifiers using TDS and PH sensor continuously.

ii. To assess the membrane efficiency by comparing the quality of the output water with the predefined standards.

iii. To alert the user through an indication LED, when the TDS or the PH values reaches the predefined threshold value.

iv. Report the deteriorating quality of the water to the service vendors through IoT before it becomes unsafe for drinking.

v. Alert the user through buzzer on the scheduled periodic maintenance of the pre filter membranes

2. Existing System

In recent years, IoT has secured well-deserved attention in information technology (IT) as it seeks to create intelligent systems for social relevant applications to make lives more comfortable. Thus, a lot of research has been put in to place for proper monitoring of the water quality throughout the world. Most of them were focusing on manual monitoring of water quality. Recently, people start using technology for monitoring water quality in an efficient way.

2.1 Literature Review

[1] The recent research has been done to develop a water surface platform for the Internet-based river water monitoring system in which several-sensors based setup is placed on the water surface area to collect the data such as temperature, humidity, carbon monoxide and pH level of water. All the recorded data from each sensor are saved into the data logger. The collected data can be viewed real time on mobile phone. The concept addresses water quality monitoring system using emerging technologies such as IoT and NodeMCU.

[2] Sujay and others uses ARM 7 micro controller and GPRS module to develop smart system for real time monitoring of water parameter including temperature, turbidity, pH, conductivity.

[3] The presented work develops water temperature alarming system using DS18B20 temperature sensor, raspberry pi and internet.

[4] The research shows development of IoT based water quality monitoring system using sensors, FPGA board, Zigbee wireless communication module.

[5] Vijayakumar and others connected several sensors to core controller raspberry pi for development of the real- time monitoring of the water quality. Most of the existing system use costly hardware whereas Zigbee wireless module has smaller range of communication, there IoT with cheaper hardware is possible solution for water quality monitoring.

[6] Manju.M, Hariharan.S, Karthick.V, Sreekar.B proposed a system which continuously recycles the water, the quality of water must be constantly monitored at regular intervals. Manually doing this task can be very tiring. Hence, Internet of Things (IoT) can be used as an effective application for this purpose. These techniques are highly useful in traditional farming. The system is continuously monitoring the water quality and the plant's environment by using different sensors. The Lumisense IoT Board is made use of for providing the IoT application for the aquaponic system.

The proposed aquaponics system would require only very minimal manual intervention and yield great results with the help of technology. Electrical conductivity is another parameter which can be helpful to determine the condition of an aquaponic system. The ideal range of Electrical Conductivity in the aquaponic system is between 0.2 to 2.0.If it is lower, and then it indicates that the system is unbalanced. Lumisense IoT board featured with SIM900 GPRS modem to activate internet connection also equipped with a controller to process all input UART data to GPRS based online data.

[7] M. Carminati, V. Stefanelli, G. Ferrari, M. Sampietro, A. Turolla, M.M.A. Rossi, S. Malavasi, M. Antonelli, V. Pifferi, L. Falciola proposed a prototype of the smart Pipe, a compact and intelligent wireless node hosting miniaturized sensors, embedded in a flange, for distributed and real-time monitoring of water contamination. A single-chip impedance analyzer and low-parasitic analog multiplexer (ADG604) are used to sequentially connect the four probes to the conductivity measuring circuit. Due to its ease of use for rapid prototyping and flexibility, the Arduino UNO board was chosen to control the system. Demonstrating self powering of the unit by means of an energy harvesting control valve, regulating the flow in the water distribution network where an efficient installation of the sensors. a single illimetric microelectronic CMOS chip to be installed in every kitchen water tap, bringing disruptive innovation in pervasive water monitoring and life quality.

[8] Vincenzo Di Lecce, Domenico Petruzzelli, Domenico Soldo, Alessandro Quarto proposed framework of the Adaptive Water Management policies enforced by the current EU legislation. It introduces a new device, namely VPeN (vapour phase e-nose), VPeN is a real time water quality system for speditive water monitoring and control. The main idea is based on the potential use of cheap gas sensors inserted into confined gas expansion chamber to detect the presence of volatile pollutants in the vapour/gasphase (atmosphere) overlooking the aqueous-phase. MOS gas sensor and a specific calibration procedure was introduced to minimize the off calibration errors. Several commercial analyzers are now available for monitoring turbidity, suspended solids, nutrients, ammonia, organic parameters such as BOD5, COD and TOC as well as inorganic and physicochemical parameters. This method provides largescale, online, reliable and cost-effective data to be acquired, integrated and applied.

[9] Ni-Bin Chang, Sanaz Imen proposed a remote sensing-based early warning system for decision support is developed and applied to improve the treatment efficiencies in a drinking water treatment plant. With the help of developed decision support architecture, water treatment plant operators will be able to create and access a visual preview for the concentration of two key water quality parameters (i.e. TOC and TSS) throughout the Lake for specific dates using the historical or updated database. The Nevada Administrative Code

(NAC) for the Lake Mead suggested the water quality standard of less than 25 mg.L-1 for TSS beneficial use .DSS is able to provide the water treatment plant operator with timely information about the temporal variation of TOC/TSS concentrations at the specific location with forward-looking perspective and it enables the water treatment plant operators to tackle unexpected events before they occur.

[10] Yogesh K. Taru and Anil Karwankar proposed a system to develop, implement, monitor and control some parameter of water such as pH level, temperature, turbidity. The availability of potable water is an issue as it is contaminated, there are basic qualitative observations that quickly determine if water is not safe to consume hence detecting the pollutants is a important phase. The Arduino UNO use as Controller unit is used to read the analog values from the sensors and converted into the voltage form then calibrates. The Arduino board provide with ADC (Analog to Digital converter) with analog input slot. The remote control panel manager show the how many clients are connected to the server and also ability to disconnect specific client with help of the touch button. The use of the remote panel tool is very simple and powerful security because of there are three option Allow Viewing and controlling, allow Viewing, Deny Access. The use of system is more economical and reliable for water monitoring.

[11] Sona Pawara, Siddhi Nalam, Saurabh Mirajkar, Shruti Gujar, Vaishali Nagmoti proposed a system to automate the Monitoring process, water quality monitoring sensors, arduino IDE and RF module are placed in water sources. The sensors gather data like pH, temperature and turbidity which is forwarded to arduino IDE for binary to digital conversion. This data is transferred by radio frequency transmitter module to the lab. The sensors deployed in water send data to sink, which further sends it to arduino. Thus data is send over the physical layer in the form of bits. Once this data reaches arduino, it forwards it to RF module. RF module gives data in the form of bits at a specified port of the computer which reads data from it, manipulates it according to need and displays it to the user.

[12] Different surveys have done to find out the impact of parameters chosen in the water monitoring systems. Methods of Hyperion, water quality index, and hazard quotient as the criteria for concluding the water quality. The survey discussed the various Physio-chemical parameters like temperature, pressure, pH, electrical conductivity, biochemical oxygen demand (BOD), oxidation-reduction potential (ORP), etc., and the impact of them in disturbing the quality of water. Another survey was done by Tufekci et al. The survey was conducted based on the pollutants from textile industries The Water Quality Act of 1967, has mentioned the different areas where the water is been polluted. The chemical discharge from

industries is the primary source of pollution. The geographical information system helps in monitoring and source assessment. Surveys are based on the geographical specification of the area also. The area is divided into urban agriculture, grassland, forest, etc. The water is monitored in all these areas. Four parameters are set as the base for the monitoring. Suspended solids (SS), phosphorus content, nitrogen content, and BOD.

A survey was done on the impact of pollutants in the sea by Berry et al. ERS-1 Geodetic Mission is a waveform analysis used in monitoring the water surfaces. Echo shape analysis is used to monitor the effect of non-oceanic echo shapes returning to the water surface. Geographical information systems (GIS) will be used here to illuminate the water surfaces.The sensing part of the water monitoring system includes the water quality parameter sensors. The parameters for an IoT based work can be temperature, turbidity, pressure, and conductivity. The sensing will be achieved using multiple sensors like an ultrasonic sensor, pressure sensor, and temperature sensor. Site detectors are another medium available to detect the parameters related to water quality. It is based on google maps. Using a biosensor, the aquatic imbalance in water can be determined. This is used to find out the concentration of the organic compounds in the water like linear alkylbenzene sulfonates (LAS) .Continuous multichannel tubing is another method used in sensing the parameters related to groundwater. It uses a multi-channel flexible tubing. For irrigation applications, the parameters used are pH, water flow, water level, power supply, and water control valve. Based on the parameter value only the final valve operations will be controlled. Sensing can be done manually also. Diatom is one type of algae that grows immense in water bodies. People manually collect the samples and monitor the parameters. Image processing is another method used for data aggregation. The use of a high-resolution visible and infrared satellite images for doing the quality analysis. By using the high resolution satellite, it will be able to find out the environmental impact of pollution in the water. The concentration of salinity in water can be monitored using microwave techniques. An open-ended coaxial probe (OECP) sensor is used for monitoring .The data transmission layer of the monitoring system consists of a wireless communication device. The data transmission methods available are GPRS, Wi-Fi, Ethernet, etc. with security features. The work by Peng et al uses GPRS to send the aggregated data to the monitoring stations and to alert the user through the message using a sim card. The drawback of such systems is the additional cost for a sim card. The monitoring station monitors and processes the quality parameters. Alarms will be given based on the monitored data. Code Division Multiple Access (CDMA) is used as a medium of data transmission to the monitoring center. The detection and real-time time monitoring are implemented using

CDMA in the paper by Wang et al. The data transmission terminal, data transmission equipment, and the monitoring center is connected over the internet. The CDMA will transmit and receive data to achieve communication between the DTE and the monitoring center. The paper by Vijayakumar et al uses a Wi-Fi module for connecting the device to the database. The data processing will be done at the monitoring centers. This system will access the data storage and displays the data to the end-user. GIS technologies integrated with computer modeling are used as monitoring model. These techniques are cheaper and valuable tools that are used to detect the water quality parameter in coastal areas and freshwater bodies. Ubidots platform will create real-time dashboards to analyze data and to control the devices. Based on the data SMS, email alerts can be given.

3. Problem Formulation

3.1. **Introduction**

Water is always an important part of daily life. Water management and conservation is vital to human survival due to the global environmental situation. There have been huge needs of consumer-based humanitarian projects in recent times that could be rapidly developed using the technology of Internet of Things (IoT). Almost every houses and commercial buildings have RO purifiers in place. However, their filter membrane requires maintenance and replacement over the times. This replacement happens only after the membrane loses its property. Meanwhile the customer happens to drink non purified water that is harmful to health.

3.2. Problem Statement

The RO Water Purifiers requires periodic maintenance / replacement of filter membranes. The malfunctioning of the membranes is identified only when the taste of the water changes . The present system has no immediate alert on changing water quality. Also the membranes can be assessed only after the water taste changes. As a result there are delays in approaching vendors and carrying membrane replacement works. Studies also reveal that the first stage of the membrane requires periodic cleaning so as to improve the life time of the main membrane. This cleaning is often not taking place as the customers do not maintain any schedule and reminders. Therefore RO service dealers do not know their target consumers easily for their service orders.

3.3. Proposed Methodology

The TDS level of the final stage membrane is monitored continuously using a TDS sensor. The output of TDS sensor is interfaced with a Wifi Microcontroller which senses the TDS value and compares with the predefined threshold value. If the TDS value crosses above the threshold range it provides alert indication through the LED and buzzer. This indication will intimate the user about the un safeness of the water and as a result the user may stop drinking the unhealthy water. At the same time, this information is also sent to the service vendor. The service vendor may call the customer directly and can do the needful with the consent of the customer. This not only avoids delay in the service process, also it increases the business avenues of the RO purifier service vendors. To increase life time of the membrane, a weekly reminder is also provided to the user for cleaning the first stage of the filter through mobile alert and with an external indication LED / buzzer.

3.3.1 Schematic of the System

The schematic of the system is shown below.+5V Power supply (common ground to microcontroller relay and sensor --not shown) is provided through a SMPS.

+5 V power supply to PH Sensor, TDS Sensor , RTC and ESP8266

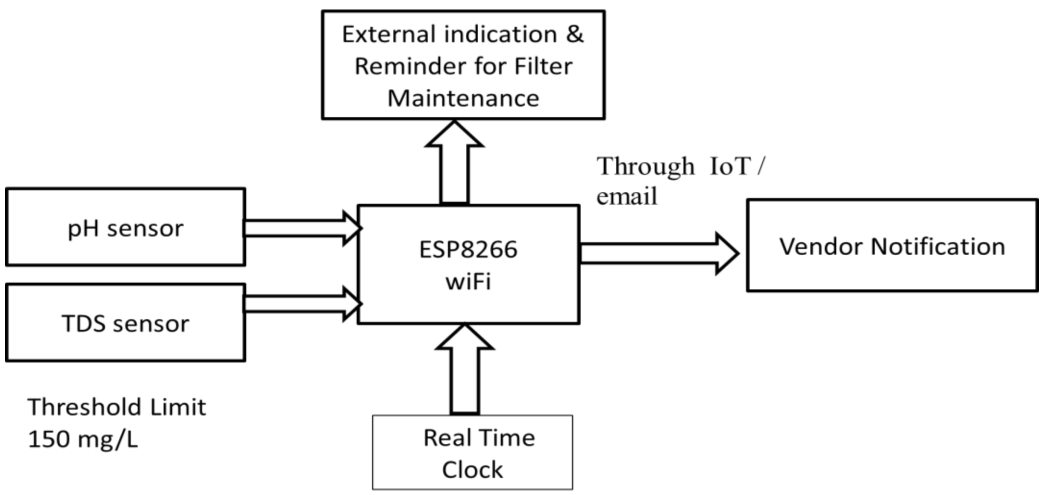


Figure. 2. Block Diagram of the Proposed System

3.3.2 Experimental Setup

The below figure depicts the experimental setup that has been developed to realize the proposed methodology. The tests were conducted using the below setup.

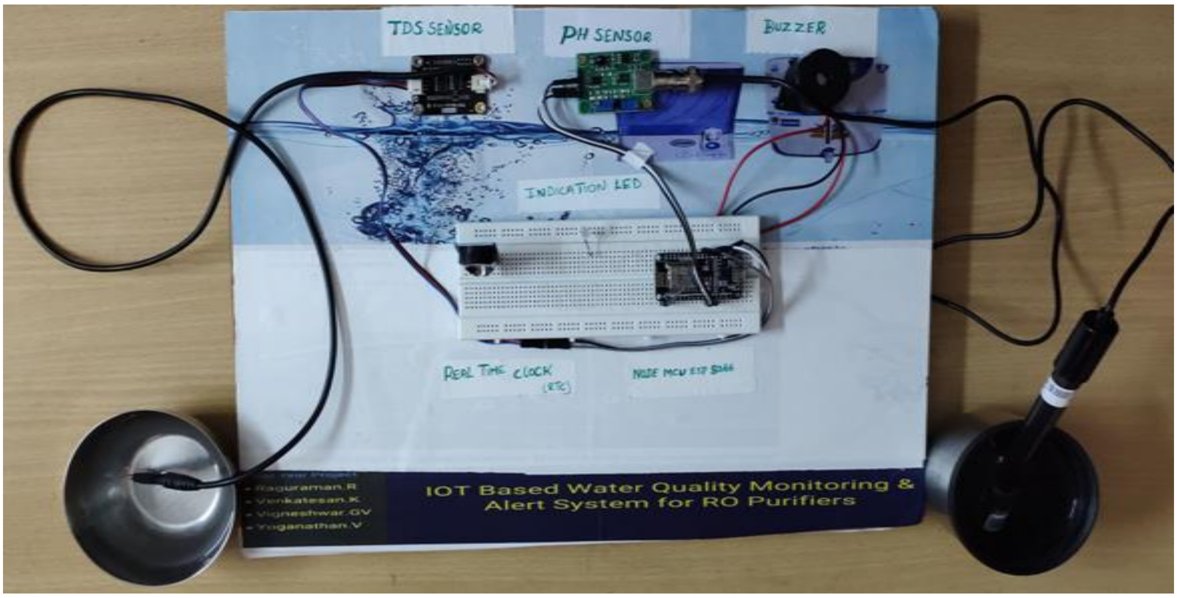


Figure.3. Experimental Setup

3.3.3 Working

The TDS Sensor is interfaced with the ESP8266. A Software code is embedded with a logic of issuing an alert through indication LED and email alert through IoT to the vendor on crossing the TDS of 150 mg/L. A PH sensor is also interfaced with microcontroller as a onetime activity to understand the PH value of the water. As generally there will not be much change in the PH concentration it is done as an onetime activity. However, in places where PH boosters are added, this PH testing can be done on as and when basis to estimate the PH level in the water. A RTC is also interfaced with the ESP8266, in order to issue a weekly alert. The RTC inputs are transferred to then ESP8266 which turns on the buzzer for 10 seconds with an interval of 1 minute for 10 times.

4. Results & Discussion

4.1 Validation & Calibration of The Sensor

The readings of the PH sensors are tested in the chemistry laboratory at the college premise. The sensor is calibrated against the standard solution. Then the sensor is tested with a NaoH base solution, a HCl acid solution and against a distilled water solution. The outputs are immediately compared with the standard PH meter available in the laboratory. The results are found to be same and thus the working of the PH sensor was validated successfully.

Figure.4. pH Sensor with NaoH & Hcl

Figure.5. pH Sensor Output Comparison with Standard Digital Meter

4.2 TDS Sensor Interfacing with Arduino

Initially, to understand the working of the TDS sensor, it was interfaced with an Arduino Nano and its output was seen in the serial Monitor. The TDS sensor probe is immersed in water and the sensor output is sent into Arduino Nano. The Arduino nano simply reads the value from the sensor and displays it into the serial monitor. The output is shown in the below figures.

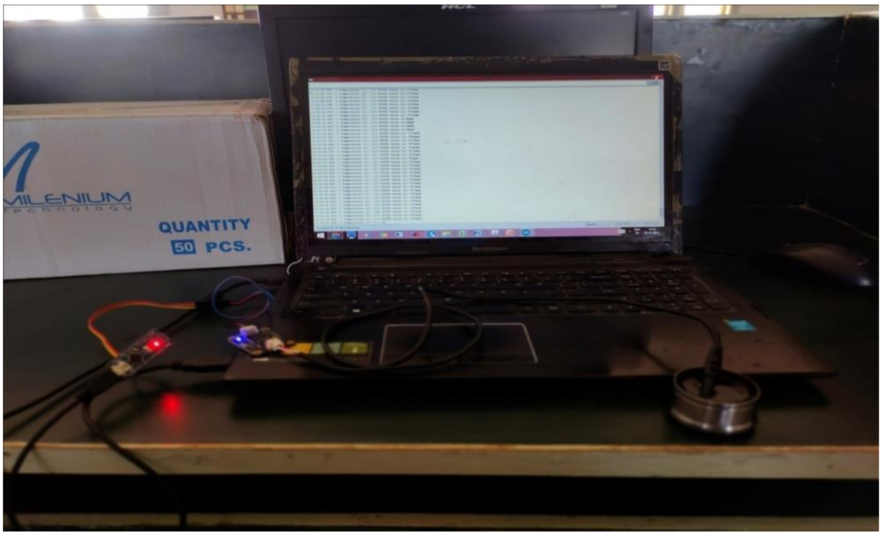
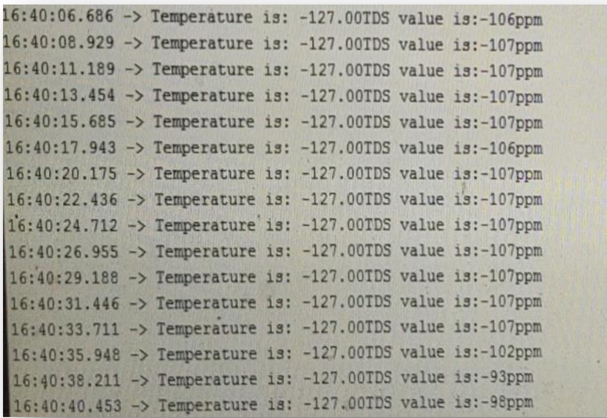


Figure.6. TDS Sensor Interfaced with Arduino Nano



```
16:40:06.686 -> Temperature is: -127.00TDS value is:-106ppm
16:40:08.929 -> Temperature is: -127.00TDS value is:-107ppm
16:40:11.189 -> Temperature is: -127.00TDS value is:-107ppm
16:40:13.454 -> Temperature is: -127.00TDS value is:-107ppm
16:40:15.685 -> Temperature is: -127.00TDS value is:-107ppm
16:40:17.943 -> Temperature is: -127.00TDS value is:-106ppm
16:40:20.175 -> Temperature is: -127.00TDS value is:-107ppm
16:40:22.436 -> Temperature is: -127.00TDS value is:-107ppm
16:40:24.712 -> Temperature is: -127.00TDS value is:-107ppm
16:40:26.955 -> Temperature is: -127.00TDS value is:-107ppm
16:40:29.188 -> Temperature is: -127.00TDS value is:-107ppm
16:40:31.446 -> Temperature is: -127.00TDS value is:-107ppm
16:40:33.711 -> Temperature is: -127.00TDS value is:-107ppm
16:40:35.948 -> Temperature is: -127.00TDS value is:-102ppm
16:40:38.211 -> Temperature is: -127.00TDS value is:-93ppm
16:40:40.453 -> Temperature is: -127.00TDS value is:-98ppm
```

Figure.7. TDS Output in the Serial Monitor

4.3 TDS Sensor Interfaced with ESP8266

The TDS Sensor is then interfaced with the ESP8266 wifi microcontroller. The TDS output is displayed in the serial monitor. In addition, the electrical conductivity output is also visualized in the serial monitor. The same output is then made available in the Blynk App with a gauge widget. The wifi microcontroller is provided with a fixed hotspot credentials. The microcontroller reads the sensor value and sends the value to the mapped api credentials of the user's mobile application. The probe is immersed in the bore water and the TDS value is measured. The probe is then immersed in the RO output water. It is found that the TDS of the RO output water is very less when compared against the output of the bore water.

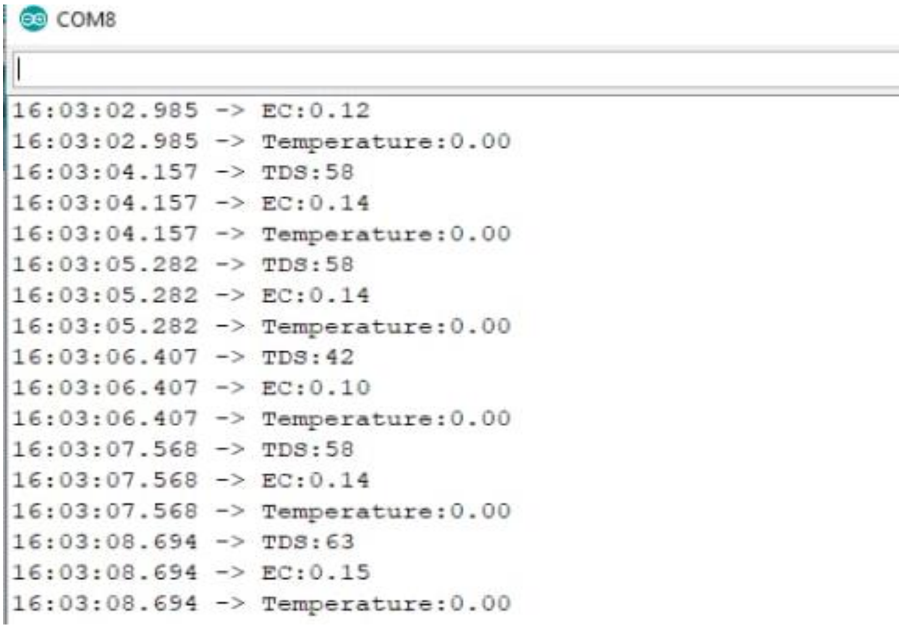


Figure.8. Serial Monitor Output of the ESP8266

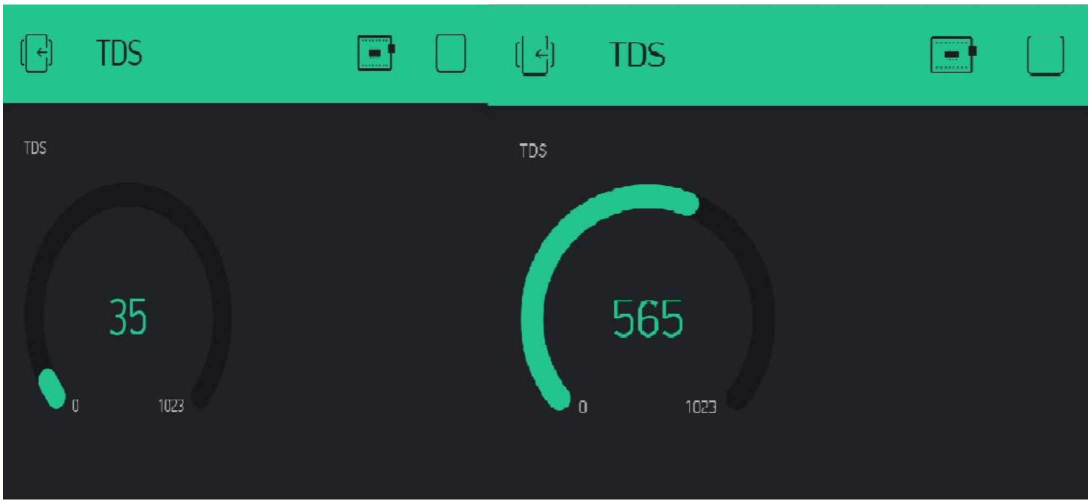


Figure.9. TDS Comparison of Bore Water and RO water in the Blynk Application

4.4 Complete Output

A Real Time Clock is interfaced along with the ESP8266. The microcontroller will turn on the buzzer every week for 10 seconds with an interval of 1 minute for 10 times until a push button is pressed. This push button serves as an acknowledgement from the user to the reminder for cleaning the pre filter. The buzzer stops immediately when the push button is pressed. The TDS output is continuously sensed and displayed to the user's mobile application. Whenever the TDS reaches the predefined threshold limit, it immediately turns on the red colour LED mounted on the RO machine. This indication LED will start to blink continuously when the TDS of the water increases. This avoids drinking unsafe water. This TDS value output is an assessment of the membrane efficiency. As the output increases, the membrane efficiency decreases and this information is sent to the service vendor through email. Now the RO service vendor exactly know their target customer and they may approach the customer for service. As a result the vendor business increases. Also there will be timely replacement of the membrane for the users. Thus the redressal mechanisms will be incorporated immediately from the user's perspective.

7. Conclusions & Future Scope

Thus a IoT based water quality monitoring and alert for RO purifier system was successfully built and tested. The results are very much satisfactory and it depicts that the project has every potential of turning into a product. The results also depicts that all the objectives of the project is attained. This project has potential applications in all domestic homes where purifiers are used. It also finds applications in institutions and other work place where RO machines with higher capacity in place. It also finds application in diary industries, beverage industries etc, where water treatment plants are installed. The project can be also extended to monitoring the water quality in rivers, ponds, panchayat over head tanks and in aquariums. The extended version of this project finds application in shrimp farms after carrying out a detailed study on the optimal conditions for growth of shrimps.

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