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Distributed IOT Enabled Smart Integrated Water Quality & RO Membrane Performance Monitoring System on Measurement of TDS and Failure Symptoms of RO Membrane

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Abstract

Water is essential source of human life towards health livings with numerous nutrients and energy for chemical and biological process in the human body. Nowadays water is high vulnerable due to pollutions, natural calamities and climate changes. Especially increased population has increased urbanization by cutting the trees which leads to reduction in the ground water level and rain fall. Further increased population contaminates the water on basis of pollutants such as chemicals, bacteria's and parasites. In order to eliminate the toxicity in the freshwater , filtration becomes vital process to remove the impurities in the water. Hence reverse osmosis(RO) has been employed in large number as solution to filter the impurities in water by reducing the Total Dissolved Solids(TDS) in the range of 30mg/liter to 50mg/liter which is highly dangerous to human health and it leads to several challenges on removing vital nutrients in water creating malfunctioning of cells and muscles in the human body. In order to manage those challenges, a new distributed IOT enabled smart integrated water quality monitoring system is proposed in this paper . It is designed to keep the TDS in the desired operating levels on monitoring the RO membrane periodically against its performance. It is considered as hybrid multi layered monitoring model to mitigate the challenges of the RO plant and failures of RO membranes. Initially, Water Monitoring system is constructed with water parameter monitoring sensorto measure the nutrients in the water after removing contaminants in water using reverse osmosis. Water parameters measures pH, residual chlorine, carbon, potassium, zinc, magnesium, copper and sodium. Monitored data is transmitted to control unit and data is processed and computed to determine optimal level of water parameter to human health on desired range. On identification in variation of the optimal level of water in RO unit, IOT enabled module generates the warning message and notifies the consumer and service vendor with message through GSM module. Further IoT module enables locking of the RO unit against usage. Experimental analysis of the proposed modules is evaluated on its effectiveness and efficiency in monitoring the failure of RO plant due to RO membrane performance and production of water quality behind the desired level. Proposed model improves the resistance of RO model operating below and beyond the desired level and it is proved to be high effective and accurate compared to conventional models.

Keywords: Water Quality Monitoring system, Internet of Things, Reverse Osmosis , Total Dissolved Solids , Water parameters

1. Introduction

Water is highly significant to living things as it provides energy and several nutrients for biological and chemical reaction in cells and muscles on bodies of human, plant and animals. Nowadays water is high vulnerable due to pollutions, natural calamities and climate changes. Especially increased population has increased urbanization by cutting the trees which leads to reduction in the ground water level and rain fall. Hence it is mandatory to prevent the quality of water in all aspect of life on basis of research and development of new approach to control it.

Contamination of water deteriorates the health, environment and economy as it is growing concern among the various countries.. Further increased population and industrialization contaminates the water on basis of pollutants such as chemicals, bacteria's and parasites. In order to eliminate the toxicity in the freshwater , filtration becomes vital process to remove the impurities in the water. However, reverse osmosis is employed to domestic needs to provide the quality water on removing the impurities by reducing the Total Dissolved Solids(TDS) in the range of 30mg/liter to 50mg/liter.

Total Dissolved Solids(TDS) in the range of 30mg/liter to 50mg/liter in purified water is highly dangerous to human health and it leads to several challenges like malfunctioning of cells and muscles. In order to manage those challenges, a new distributed IOT enabled smart integrated water quality monitoring system is proposed in this paper due to progress of IOT in various areas . It is designed to keep the TDS in the desired operating levels on monitoring the RO membrane periodically against its performance. It is considered as hybrid multi layered monitoring model to mitigate the challenges of the RO plant and failures of RO membranes.

Water Monitoring system is preferred to monitor the water parameter using monitoring sensor to measure the nutrients in the water after removing contaminants in water using reverse osmosis. Water parameters measures pH, residual chlorine, carbon, potassium, zinc, magnesium, copper and sodium. Monitored data is transmitted to control unit and data is processed and computed to determine optimal level of water parameter to human health on desired range. On identification in variation of the optimal level of water in RO unit, IOT enabled module generates the warning message and notifies the consumer and service vendor with message through GSM module.

Further IoT module enables locking of the RO unit against usage. Experimental analysis of the proposed modules is evaluated on its effectiveness and efficiency in monitoring the failure of RO plant due to RO membrane performance and production of water quality behind the desired level. Proposed model improves the resistance of RO model operating below and beyond the desired level and it is proved to be high effective and accurate compared to conventional models.

Remaining paper is organized into following sections; section 2 describes the related work to remove impurities in water by employing reverse osmosis plants. In section 3, proposed model has been designed and implemented as water quality monitoring systems to RO plant in order keep water at desired level and to identify the performance of RO membrane in the plant on inclusion of water sensors and IoT module. Section 4 discusses the experimental results of the proposed architecture against numerous performance measures. Finally section 5 concludes the research work with future suggestion.

2. Related work

In this part, numerous related literatures for measuring the water quality on application of water filtration process has been described. Further those literatures has been analyzed with respect to performance of the sensor in measuring the quality and controlling the water filtering operation to preventive human health. Those architecture is represented in detail as follows

2.1. WaterNet: A Network for Monitoring and Assessing Water Quality for Drinking

In this literature, threshold levels of various parameters present in water samples is acquired. The Water Quality Index (WQI) is analyzed which expresses the level of these parameters to determine the overall water quality. It is analyzed as it is considered as benchmark solution against pre-set standards and adhere to various guidelines of world health organization. It evaluate the quality of water but it is not capable of controlling and preventing the filtering system dynamically against operating[6].

2.2. Fault Diagnosis of Water Quality Monitoring Devices

In this literatures, faults of water sensors and filtering unit is measured on the operation of the water quality monitoring. Predictive model is designed to measure the value of the devices, variation of the sensor data monitored triggers the alert system to notify the fault in the operation of the sensor and filtering unit. Model is highly robust and generalized to fault but it is not capable of measuring the quality of the water[7].

3. Proposed model

In this section, proposed design and its implementation of the water quality monitoring and sensor fault monitoring is established as hybrid multi layered monitoring model to mitigate the challenges of the RO plant and failures of RO membranes in the water quality monitoring operations. It identifies the failure and water quality to prevent from usage. Further proposed model attains high accuracy and efficiency using wireless water quality sensors. Proposed architecture of the hybrid multilayered monitoring system is illustrated in the figure 1 with various functional blocks. Each block is represented in detail on basis of its internal architecture and working model in following subsections[8].

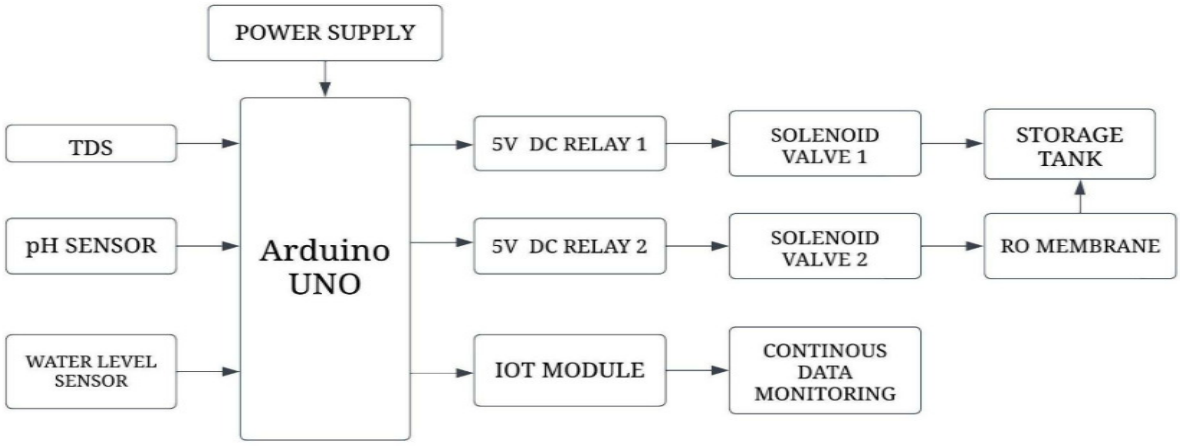

Figure 1: Block Diagram of the Proposed Architecture

3.1.1. Basic Module

Basic module of the proposed architecture composed of the processing component, memory components, transmission component, display component and display component. Each component is described on basis of the working module and its configuration in the application to achieve the monitoring and controlling[8].

3.1.1. Power Supply

Power Supply is electric device which is employed to power the hardware unit of the application such as controller and other electrical entities. It is powered with 5v. It is employed to regulate the power by converting the input voltage of 230V to 5V. Figure 3.2 represents the regulated power supply board[9].

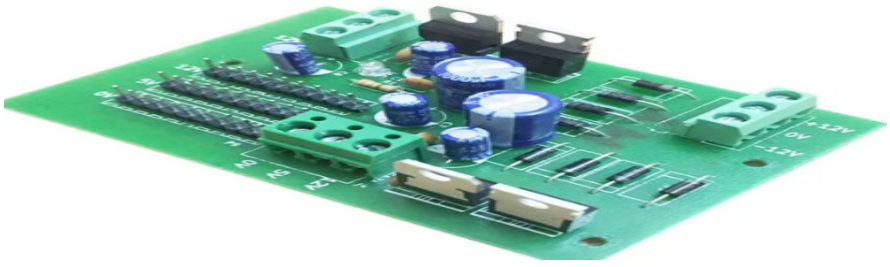

Figure 3.2 Regulated Power Supply Board

3.1.2. Microcontroller –Arduino

Arduino microcontroller is employed in this work as it is capable of achieving the separate buses and separate memory to handle the data instruction of the program code and program data[10]. It is based on the Harvard

architecture. Further it is composed of multiple addressing modes to interconnected hardware units. It performs multiple task in parallel on handling the multiple operation simultaneously. Figure 3.3 represents the Arduino UNO

Figure 3.3: Arduino UNO

3.1.3. Node MCU

Node MCU is the employed as IoT platform which includes firmware built-in component such as wifi microchip, wifi protocol and Web server to collects the data from the arduino micro controller. It records the data from the microcontroller regarding the sensor data. Further web server is modeled with decision making system to identify the quality of water and RO membrane in RO plant . Figure 3.4 represent Node MCU.

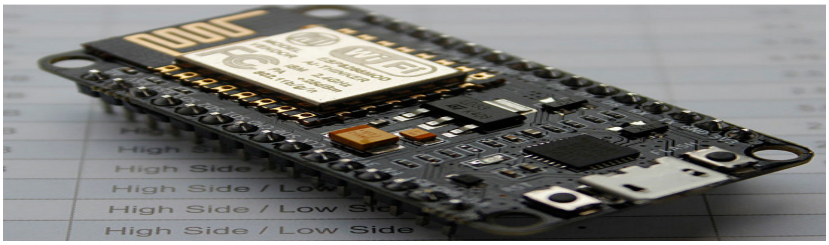

Figure 3.4: Node MCU

3.1.4. LCD Display

LCD display internal architecture composed of the materials which combines of properties of liquid and crystal along the polarizer. It is a flat panel display which is made of millions pixels. LCD is considered as active or passive matrix grid display. It is capable of display digits, images and words. In this application, it is to display the water quality details and fault details of RO membranes. Figure 3.5 represents the LCD display.

Figure 3.5: LCD display

3.2. Water Quality Monitoring system

Water Quality Monitoring system is considered to measure the water parameters measure the nutrients in the water after removing contaminants in water using reverse osmosis such as pH, residual chlorine, carbon, potassium, zinc, magnesium, copper and sodium andtotal dissolved solids(TDS) in the water. In this work, water parameter is

obtained by water sensor. Sensed information is processed by the controller and it is recorded in the memory in the web server.

3.2.1. TDS Sensor

Total Dissolved Solid sensor measure the presence of the TDS in the water after Reverse osmosis. It contains the presence of organic and sub-organic components. It is composed as probe measuring the electric charge and discharge Sensor measures the TDS value in terms of mg per liter. Sensor is interfaced with arduino to transmit the TDS value after water reverse osmosis. Figure 3.6 represents the TDS sensor[10]

Figure 3.6: TDS Sensor

3.2.2. Water level Sensor

Water level sensor is to measure the pH, residual chlorine, carbon, potassium, zinc, magnesium, copper and sodium parameter of water. It measure liquid level in water to the controller on basis of varying the resistance level on exposure to the water . Figure 3.7 represent the water level sensor.

Figure 3.7: Water level Sensor

3.2.3. Water Solenoid Value

Water Solenoid value consist of coil, plunger, sleeve. It is used to control the flow of water. It operate while water quality is in desired level and it resist the water during quality above specified range. It works on producing the electromagnetic field around the moveable core by opening and closing values. Figure 3.8 represent the water solenoid value

Figure 3.8: Water Solenoid Value

3.3. Working of the module

Distributed IOT enabled smart integrated water quality monitoring system keeps the TDS in the desired operating levels on monitoring and controls the performance of the RO membrane periodically against its performance. Water Monitoring system measure the nutrients such as pH, residual chlorine, carbon, potassium, zinc, magnesium, copper and sodium in the water after removing contaminants in water using reverse osmosis.

Monitored data is transmitted to control unit and data is processed and computed to determine optimal level of water parameter to human health on desired range. On identification in variation of the optimal level of water in RO unit, IOT enabled module generates the warning message and notifies the consumer and service vendor with message through GSM module. Further IoT module enables locking of the RO unit against It is considered as hybrid multi layered monitoring model.

Algorithm 1: Water Monitoring and controlling System

Input: Water Quality { pH,Magnesium , Zinc, Potassium etc, TDS)Desired Quality level
Output: Allow or Prevent the Water Flow using Solenoid Value
Process
Monitoring operation ()
Gathering the Water Quality Parameters and RO membrane performance data stored in webserver
Evaluate ()
If (Water Quality Parameter value = = Desired Range&&RO membrane value = Desired Range)
Open Solenoid Value to Discharge Water for Consumption in RO plant
Else
Close the Solenoid value in the RO plant against discharging water
Transmit the quality level to consumer and RO membrane fault to service vendor

4. Experimental Analysis

In this part, proposed architecture for water quality monitoring has been experimented in ArduinoMicrocontroller and Node MCU for controlling the operations. Experimental analysis is carried out of the working of the module towards measuring the quality of the water on exploiting the water parameters and RO membrane performance using various sensor elements. Experimental configuration of the module is tabulated in table 1

Table 1: Experimental Configuration

Parameter	**Specification**
Development Device	Window 7
Target Device	Arduino UNO
Simulation tool	Proteus
IDE	MPLAB

Decision making module in the server detects the variation in performance of RO membrane and water quality level on basis of its parameters. Furthermore performance of the proposed module is evaluated against conventional module on accuracy and efficiency[10]. Proposed module outperforms the conventional approaches on both effectiveness and efficiency. Figure 3.9 represent the hardware output of the module.

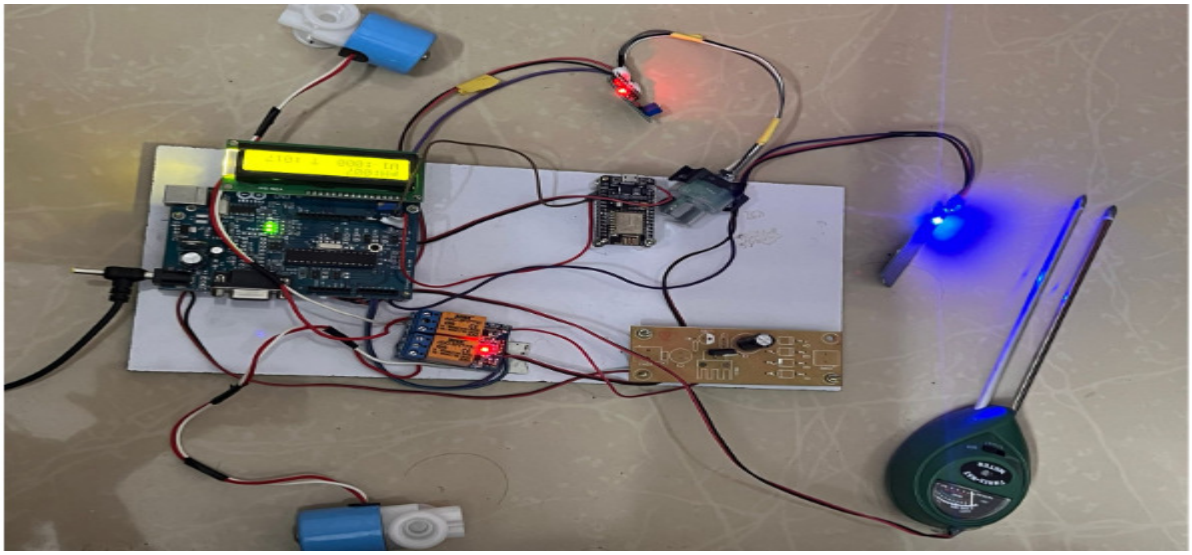

Figure 3.9: Hardware Output of the proposed module

Finally proposed system achieves the high accuracy and efficiency in measuring the water level of the RO plant to obtain desired water quality to the consumers and identify the fault of the components in device towards health living and well being on consumption of water.

Conclusion

Distributed IOT enabled smart integrated water quality monitoring is designed and implemented in this work to monitoring and controls the performance of the RO membrane and to provide desired water quality to human beings. It achieves better monitoring performance on measuring the water nutrients such as pH, residual chlorine, carbon, potassium, zinc, magnesium, copper and sodium in the water after removing contaminants in water using reverse osmosis. Monitored data is transmitted to control unit and data is processed and computed to determine optimal level of water parameter to human health on desired range. On identification in variation of the optimal level of water in RO unit, IOT enabled module generates the warning message and notifies the consumer and service vendor with message. Further IoT module enables locking of the RO unit against water discharge using water solenoid value. Proposed model proves to be efficient than conventional model on experimental analysis.

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