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Solar Energy - Driven Water Monitoring and Purification System using IOT

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ABSTRACT :

Currently, water scarcity is one of the major problems that the world facing in this rapidly increasing population. It is due to the releasing of Industrial waste into the free environment which are polluting surface and ground water. Thus, encountering numerous water- related issues. To provide clean drinking water in the impacted locations where pure water is difficult to obtain, so thought to develop an IOT based system for monitoring and purifying water quality using solar power. The implemented system utilises various sensors to measure water parameters such as conductivity, turbidity and pH value and then the data is sent to controllers, where it compares the data with drinking water parameters and purifies the water which is suitable for drinking. The system is powered through the abundantly available solar energy to monitor and purify the water quality.

Keywords: Arduino Nano, NodeMCU, Turbidity sensor, Conductivity sensor, pH sensor.

1. Introduction :

Water scarcity is a pressing global challenge exacerbated by industrial pollution, threatening the availability of clean drinking water in many regions worldwide. To address this issue, an innovative solution leveraging IoT technology and solar power has been proposed. This system integrates sensors to monitor key water parameters such as conductivity, turbidity, and pH levels, transmitting data to controllers for real-time analysis. By comparing this data with established drinking water standards, the system autonomously initiates purification processes to ensure the water meets safety requirements. Powered by solar energy, this sustainable approach offers a promising avenue for efficiently monitoring and purifying water quality in areas facing acute scarcity, thereby mitigating the detrimental effects of industrial contamination on freshwater resources.

2. Literature Survey:

Water quality monitoring research aims to safeguard human health by ensuring safe drinking water. Researchers are actively pursuing innovative approaches for real-time monitoring systems to achieve this goal. Key areas of focus include sensor technology, data analysis techniques, and system integration. Here's a concise overview of existing proposals in this field:

Sabari introduced a project titled "Water Quality Monitoring System Based on IOT" in 2020. This system utilizes Arduino Atmega 328 as the core controller, ESP8266 Wi-Fi module for data transmission, and various sensors including pH, turbidity, temperature, and flow sensors. Analog-to-Digital converter (ADC) and LCD are employed for signal conversion and data display, respectively. The measured data is stored in the cloud for further analysis. The output includes continuous real-time monitoring of water quality parameters like pH and turbidity, with applications in pollution control and agriculture [1].

Elamathi proposed an article titled "IOT Based River Water Quality Monitoring System Using Node MCU" in 2023. The system integrates IOT devices, notably Node MCU, and various sensors such as pH, turbidity, and temperature sensors, for continuous water quality monitoring. Real-time water quality data is made accessible through a web user interface, with SMS alerts triggered in case of poor water quality. This paper provides a valuable contribution to the field of water quality monitoring, particularly in the context of river water monitoring [2].

Rajendra Prasad proposed an IOT-based Smart Water Quality Monitoring and Flow Control System. The system aims to address the critical issue of water pollution and the need for real-time monitoring of water quality. It measures various physical and chemical parameters of water, including temperature, pH, turbidity, and water flow. These sensor readings are processed using an Arduino UNO controller, and the data is transmitted using a Wi-Fi module. All collected data is sent to the cloud via the Wi-Fi module, enabling remote access and real-time monitoring from any location [3].

3. Working Model:

The operational system for water monitoring has been implemented, with a primary focus on incorporating Turbidity, pH, and Conductivity sensors. Each sensor is linked to an Arduino Nano, which, in turn, connects to a Node MCU. Initially, each sensor involves three key connections: a data or signal wire transmitting sensor output to the Arduino Nano's analog input pins. To overcome the Node MCU's limitation of only one analog pin, an Arduino Nano has been integrated to handle multiple sensor inputs. A solar panel is utilized to efficiently charge the battery and power the system. The sensors continuously assess water quality parameters, while the microcontroller processes the sensor data. It then compares the readings to predefined thresholds for clean water. Upon detecting contamination, the system triggers an alert and switches to purification mode through relay activation.

Water Quality Monitoring Sensors: The water quality monitoring system utilizes three essential sensors to assess crucial water parameters in real-time, all powered by solar energy:

pH Sensor:

- Works: Determines the acidity or alkalinity of water within a range of 0-14, where 7 represents neutrality.
- Standard Drinking Water Parameter: Ideal pH levels for drinking water generally range between 6.5 and 8.5. Deviations from this range may lead to a metallic taste, pipe erosion, and potential health issues.
- Sensor Calibration: The pH sensor's accuracy can be confirmed using a standard buffer solution with a known pH value, ensuring alignment with the expected measurement.

Turbidity Sensor:

- Works: Measures water clarity by detecting suspended particles, with higher turbidity indicating increased particle presence, potentially harboring bacteria and contaminants.
- Standard Drinking Water Parameter: Optimal turbidity levels for drinking water generally remain below 5 NTU (Nephelometric Turbidity Unit). Elevated turbidity may not pose immediate health risks but can affect water taste and aesthetics.
- Sensor Calibration: The turbidity sensor's performance can be assessed through calibration with a reference solution of known turbidity, ensuring measurement consistency.

Conductivity Sensor:

- Works: Assesses water's electrical conductivity, influenced by dissolved particles and minerals, with higher conductivity suggesting elevated total dissolved solids (TDS).
- Standard Drinking Water Parameter: While no universal standard exists for drinking water conductivity due to natural mineral variations, - excessively high conductivity levels may indicate potential health hazards or affect water taste.
- Sensor Calibration: Calibration with a known conductivity reference solution allows for confirming the accuracy of the conductivity sensor, ensuring reliable measurements.

By utilizing these sensors, the system facilitates continuous monitoring of key water quality parameters, enabling prompt detection of deviations from acceptable levels and facilitating timely interventions to ensure water safety and quality.

4. Specification

Table 1: Components and its specifications

Component	Model	Range
Micro controller	Arduino Nano	6.5MHz
Relay	JQC3F-5VDC-C	3.3-5VDC
WiFiModule	ESP8266	2.412GHz-2.484GHz
PH	HW-828	0-14
Conductivity	HW-103	1-30ml/min
Turbidity	MJKD7	0%~3.5 %(0-1000NTU)

Table 2: Sensors and Arduino Interface details

Name of the sensor	Sensor pin	ArduinoNano pin
pH sensor	PO	A0

	GND	GND
	VCC	5V
Turbidity sensor	A0	A1
	GND	GND
	VCC	5V
Conductivity sensor	GND	GND
	A0	A2
	VDD	5V

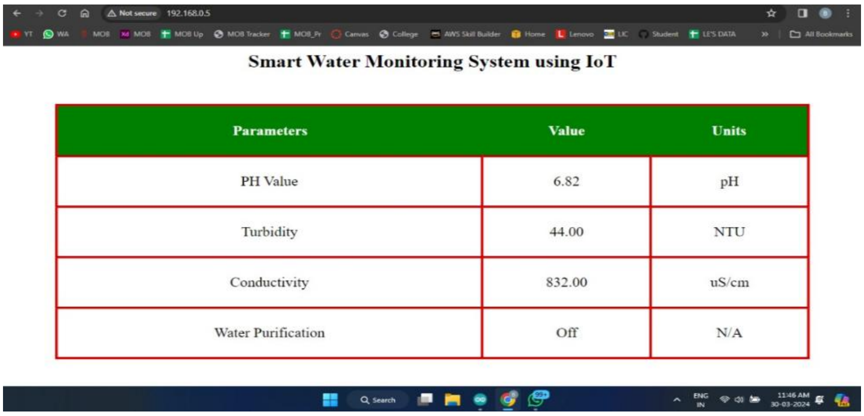
Table 3: Water Quality Parameters measured for various

Variables	Quality range
pH	6.5-8.5
Turbidity	<50
Conductivity	200-900

5. Results

Solar-driven water quality monitoring and purification system transmitted sensor data of pH, turbidity, conductivity from the Arduino Nano to a web server interface through the NodeMCU's IP address. This allows for real-time monitoring of water quality from any device with a web browser, such as a phone or any system. The web server interface effectively visualizes the real-time water quality data collected by the system, that enabling users to monitor water quality remotely and make informed decisions about water purification. The interface displays the measured values for pH, turbidity, and conductivity.

Data Displayed on the Web Server Interface:



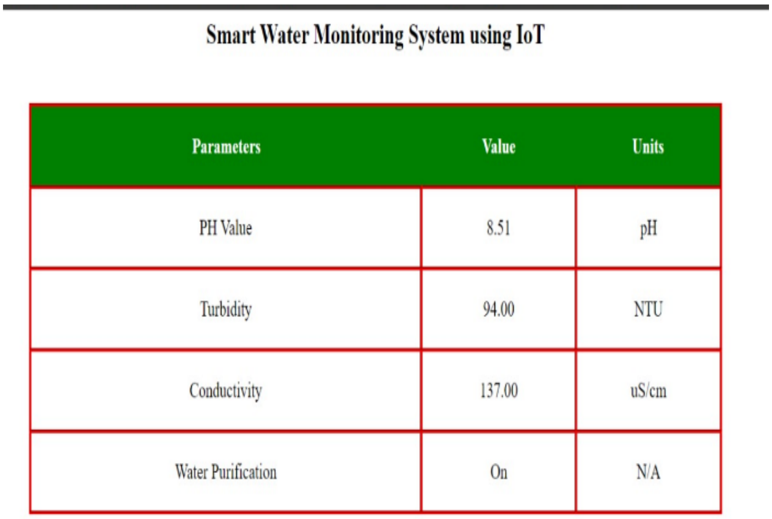
Smart Water Monitoring System using IoT

Parameters	Value	Units
PH Value	6.82	pH
Turbidity	44.00	NTU
Conductivity	832.00	uS/cm
Water Purification	Off	N/A

Figure: 1 Purification Inactive

The interface displayed the following values: pH: 6.82, Turbidity: 44.00 Nephelometric Turbidity Unit, Conductivity: 832.00 microSiemens per centimetre.

The interface also indicates the water purification status. In this instance,"Water Purification is currently "Off,"suggesting that the sensor readings are within acceptable limits.The system continues to monitor water quality in real-time, ready to activate purification if readings exceed predefined thresholds.



Smart Water Monitoring System using IoT

Parameters	Value	Units
PH Value	8.51	pH
Turbidity	94.00	NTU
Conductivity	137.00	uS/cm
Water Purification	On	N/A

Figure: 2 Purification active

The interface displayed the following values: pH: 8.51, Turbidity: 94.00 Nephelometric Turbidity Unit, Conductivity: 137.00 microSiemens per centimetre. The interface indicated the water purification status. In this case,"Water Purification is currently "On,"suggesting that the sensor readings exceed predefined thresholds for clean water, triggering the purification system to activate.

SYSTEM DESIGN:

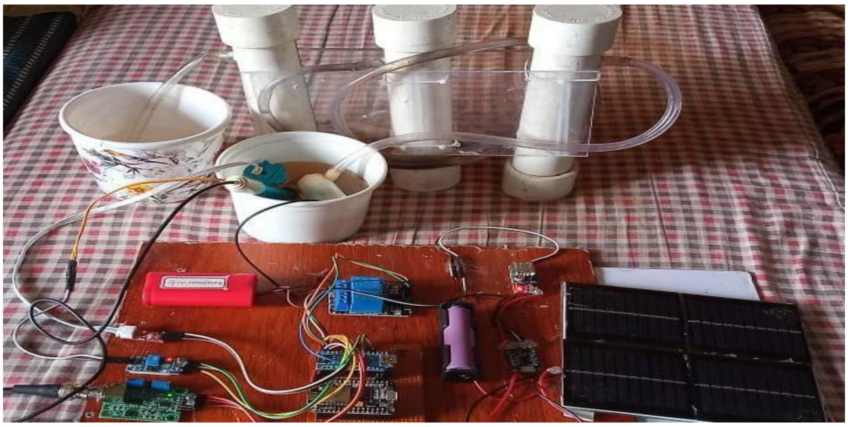


Figure 3 Represents System view

Figure 4.TP40556 1A Li-ion Lithium Battery Charging module Glows when the solar panel placed in sunlight. Red light indicates that the battery is charging and Blue light indicates battery is completely charged.

Figure 5 Sensor frame work has been turned on

6. Conclusion

The solar-driven water quality monitoring and purification system presented in this project offer a sustainable solution to the pressing issue of water pollution. By integrating sensor technology, microcontrollers, and renewable energy sources, the system effectively addresses the challenge of ensuring clean water access, particularly in areas with limited infrastructure or unreliable electricity. The deployment of conductivity, turbidity, and pH sensors enables real-time monitoring of key water quality parameters, providing valuable data for analysis. The Arduino Nano and NodeMCU microcontrollers manage data acquisition, processing, and transmission, ensuring efficient operation of the system. Through a user-friendly interface accessible via a web browser, stakeholders can easily access real-time updates on water quality status and purification processes. Crucially, the system's reliance on solar energy and lithium batteries ensures continuous, sustainable power, reducing reliance on traditional electricity sources and minimizing environmental impact. The automated purification process, triggered by sensor readings exceeding predefined thresholds, guarantees the delivery of clean water by removing contaminants effectively. Overall, this integrated approach offers a reliable, scalable, and environmentally friendly solution for maintaining clean water supplies and safeguarding public health.

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