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Water Quality: IoT-Based pH Level Monitoring Device

Abstract

Water pollution is a global problem. Because of the water scarcity and water impurity many human has been falling ill and catching different diseases. In this project, the causes and effects of water are explained, and IoT-based pH level monitoring is discussed. The pH level of pure water is pH 7. This initiative involved low-cost real-time water quality monitoring. The pH sensor 4502C is primarily concerned with producing an analog output that represents the pH value of a solution. The external Microcontroller present on the Arduino handles data processing, calibration, and data use. This project's components are very inexpensive and simple to use. Water is a necessity for humans so that's why using this project, we can test the pH of the water and determine whether or not it is drinkable.

Introduction

In 21st Century, our world faces a number of environment difficulties such as global warming and pollution, which is leading to a scarcity of safe drinking water world wide. And unsafe water quality has caused millions of deaths of people around the world. Some of the rural areas there are scarcity of safe drinking water, they drink water from the well or from rivers which are not often healthy for their health and can lead to various diseases. By the result of population increased, limited resources, climate change, a real time water quality monitoring face challenges. And because of this there's a vital need for an advanced need for monitoring crucial parameters which will help in real time. Where these parameters include, ph level which is extremely critical for measuring water acidity and alkalinity. The range of ph level is 0-14. 7 pH value is considered pure water, and water which has less than 7pH value has acidity in it, more than 7pH has alkaline. The World Health Organization (WHO) recommends ph level for drinking water from 6.5 to 8.5, imbalance of ph level in water can be dangerous for someone's health. Turbidity is a measurement where we can measure suspended particles which are invisible in ware and which can affect the risk of cholera, diarrhoea. Whereas lower turbidity in water is indicating that water is clean. And Temperature sensor will show the water condition if it's hot or cold, and flow sensors help in measuring the flow of water through flow sensor. All these sensors help developing a more complete understanding in water quality. Manual testing was used in traditional water quality monitoring before, however now modern solutions are necessary. A real time IoT water quality pH level monitoring device is excessively crucial, which focuses on monitoring the ph level of water. Key components of pH level monitoring device are Arduino Uno, LCD 16x2, pH sensor 4502c.

Data Acquisition

Sensors play a crucial role in converting physical parameters like pressure, light intensity, temperature, or voltage into electrical signals, acting as a vital link between the physical and electronic domains. In this project, the pH sensor takes on the essential task of translating these physical parameters into measurable data. pH, which measures hydrogen ion concentration in a fluid, follows a logarithmic scale ranging from 0 to 14. A pH of 7 signifies neutrality, values above 7 indicate alkalinity, and those below 7 represent acidity. The standard pH range is typically between 6 to 8.5. This sensor system seamlessly integrates with Arduino and operates with a 5V power supply. The pH detector (4502C) boasts a technical glass body with a glass membrane acclimatized for comity with different process liquids. Its operation involves generating an electrical voltage proportionate to the hydrogen ion attention in the fluid. The detector's body encompasses three electrodes a dimension electrode, a temperature electrode, and a reference electrode. The reference electrode, a vital element of the reference system containing electrolyte, is designed to maintain impartiality at a pH of 7. When the pH sensor come in contact with the liquid, the pH glass forms a sensitive gel subcaste around it, the result which is being measured and the internal reference electrode they must be coupled electrically, these are all possible by the liquid junction. ["IoT based smart water quality monitoring system," 2021] ["HOW DOES A PH SENSOR WORK?," 2023]

pH sensor [4502C] pinout ["Arduino pH-meter using PH-4502C," 2020]: -

TO – Temperature output

DO – 3.3V pH limit trigger

PO – PH analog output

Gnd – Gnd for PH probe

Gnd – Gnd for board

VCC – 5V DC

POT 1 – Analog reading offset (Nearest to BNC connector)

POT 2 – pH limit setting

Data Transmission

Communication between Arduino and pH sensor is primarily involves the transmission of data through analog signals. pH sensor sends the data that have been tested to the Arduino Uno, and this information that has been transferred then it is transmitted to the other components that are connected to the Arduino Uno. Acidity sensor is not enough to show the value of pH value so that it requires the another device to translate the data into readable form for the Arduino. That is where the analog output device pH 4502C comes in. The pH 4502C which is also known for its analog output, it continually measures the pH value of the solution and it translates the information it got from the solution into an analog voltage signal. The measured pH value of a solution, and it corresponds to the amplitude which is characterized by the analog signals. Physically connecting the pH sensor to the Arduino involves three wires: VCC(power), GND(ground), and OUT (analog output). Arduino's power supply is connected to the VCC and GND pins, while the OUT pin links to one of the Arduino's analog input pins, that is A0.

When after powering up the Arduino, it supplies electrical power to the pH sensor through the VCC and GND connections. ["IoT based smart water quality monitoring system," 2021]
The important part of the data transmission is when during the analog- to- digital conversation process in the Arduino. While it is equipped with the analog- to- digital converters (ADC), the Arduino occupy the function called 'analogRead ()' which read the the analog voltage signal from the pH sensor continuously.

Data Processing and Management

As mentioned above the pH sensor 4502C is an analog sensor. It does not need any complex data processing within the sensor itself, instead processing unit or the microcontroller [ATmega328] which are connected to the sensor. It handles the data processing which are related to the pH measurement and calibration externally. So the data processing and management with Arduino and pH sensors are mainly handled the microcontroller chip which is on the Arduino board. ATmega328 microcontroller is a 8- bit microcontroller and it also has the built in memory and peripherals and they are found in Arduino Uno and can read analog signals from the pH sensor, which also use its built in ADC. The ADC Standard is stored in ATmega328. It also converts analog signals into digital values, which are range from 0 to 1023. The chip is also responsible for executing the code which has been uploaded to the board. The microcontroller executes a program, typically written in C/C++ using the Arduino IDE, which defines how the Arduino interacts with the pH sensor and processes the acquired data. ["What is Arduino, how it works and what you can do with arduino - Circuit Schools," 2023]

Data Analysis and Visualization

After Arduino Uno reads the pH sensor data, the next step includes analysing the data. This process inclused statical measures, like calculating the mean or the standard deviation of the pH readings. Indentifying the trend over time, helps users to recognizw the patters or any change in pH levels, and it also could be indicative of the environment.
The pH sensor takes the measures of the pH level solutions continuously and send it to Arduino in analog form. The Arduino Uno then reads the analog output which the pH sensor provided and it converts it to the digital pH value.
The LCD screen is connected to the Arduino Uno using specific pins. These connections can be facilitated using the library like LiquidCrystal for Arduino. In the code for Arduino, the LiquidCrystal library is initialized in the code to set up the communication between Arduino and LCD. After applying the codes to the Arduino Uno with the help of Aduino IDE, the Arduino Uno alnalise the data and exute them to LCD 16x2, the obtained digital value in LCD represents the pH level. The LCD screen updates continuously to reflect the real-time changes in the pH level. As the user measures more pH values with the pH sensor, the Arduino also processes new data and the data keeps updating in LCD accordingly. Users can also set up the delay time in code in which the LCD screen shows the result of the pH measurement. Because this is a simple project so it does not keep the track of previously recorded measures in the data and this project also doesn't include any users input or controls, is just an simple project for easy understanding of pH level in water, however in future we can upgrade the project and make it more advance. While the current project is showing the real time data we can keeping the track of water's acidity and alkalinity. As in Arduino/ Rbi there are this type of pH measures of different liquids. Sometimes the value of the pH measures might not be accurate.

pH Meter Measurement Results v0.3 tlfong01 2019apr26hkt0928					
Sample	Output (V)	Googled pH	pH per V (1/V)	Measured pH	Error (%)
Water	2.50	7.00	n/a	n/a	n/a
Drain Pipe Cleaner	1.33	14.00	-5.98	13.44	-4
Bleach	1.89	13.00	-9.84	10.36	-25
Green Tea	2.58	7.20	2.50	6.56	-10
Milk	2.62	6.60	-3.33	6.34	-4
Body Wash pH 5.5	2.77	5.50	-5.56	5.51	0
Soy Sauce	2.91	5.00	-4.88	4.74	-5
Chinese Madarin	2.96	3.00	-8.70	4.47	33
Coffee	2.90	5.00	-5.00	4.80	-4
Vinegar	3.07	2.00	-8.77	3.86	48
Min	1.33	2.00	-9.84	3.86	-25
Max	3.07	14.00	2.50	13.44	48
Average	2.56	6.81	-5.51	6.68	3

Fig.1 Source: tlfong 01. Blog

The content of the both data is different from eachother, where the above data is provided with the rasberrypi and whereas the below data is provided with the help of the Arduino.

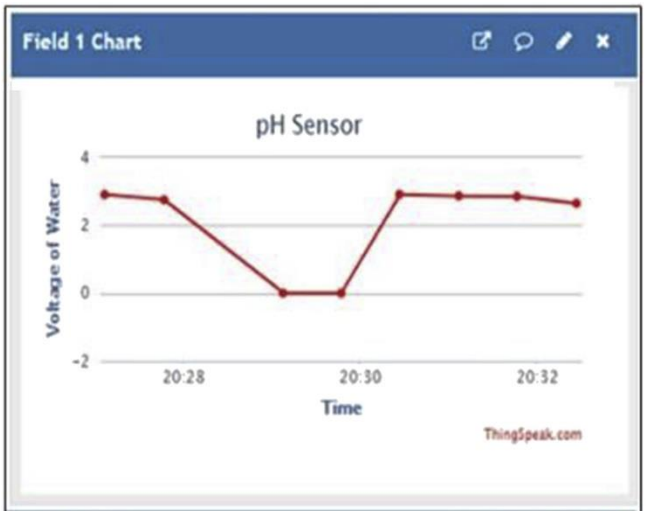

Fig. 2 Source: ScienceDirect

Fig. 3 Source: ScienceDirect

Here the data has been stored in the Thing speak server. And in that server the two fields are updated with their corresponding values. And every 20 seconds the server is being updated. From the sensor, the voltage of the water is being calculated in the first field. And in the second field the pH level of the water is being updated. The Nernst equation, the voltage of the water is directly proportional to the pH water. ["Smart water quality monitoring system with cost-effective using IoT," 2020]

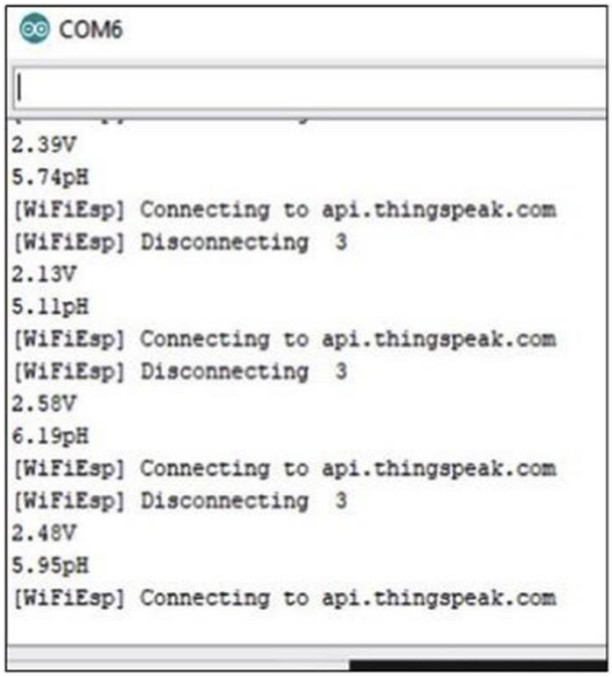

Fig. 4 Source: ScienceDirect

This is the output of the pH sensor which is being observed in serial monitor of the Arduino IDE. ["Smart water quality monitoring system with cost-effective using IoT," 2020]

Conclusion

Water pollution is a world wide threat. In this project causes and effect of the water presented and also the pH level monitoring of the water or any liquid, IoT based pH level monitoring has been discussed. This project was inexpensive real time water quality monitoring. The pH sensor 4502C mainly focuses on creating the analog output that represents the pH value of a solution. Data processing, calibration and utilization of the pH data are all done by the external Microcontroller which is found on the Arduino. This projects components and all cost effective and really easy to use. And with this project we can test the pH of the water and can determine if the water is drinkable or not. In future we can also upgrade the project and use many more sensors like Turbidity sensor, tempreture sensor and water flow sensor to test the liquid's purity. And it will help a lot of people who are suffering from poorly water supply.

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