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Design for Water Quality Monitoring System

Dr. Amit Sexena[1], Dr. Akhilesh Shukla[2], Saumya Agarwal[3], Sandeep Kumar[4], Vimal Kumar[5]
[12]Associate Professor, Dept Of Electronics & Communication Engg. , Moradabad Institute Of Technology, India
[345]UG Student, Dept of Electronics & Communication Engg. , Moradabad Institute of Technology , India

Abstract

In this paper, a low cost, water quality monitoring system which can be applied in remote rivers, lakes, coastal areas and other water bodies is presented. The main hardware of the system consists of off-the-shelf electrochemical sensors and a microcontroller. It detects water temperature, dissolved oxygen, turbidity, conductivity and pH in a pre-programmed time interval. The developed prototype disseminates the gathered information in graphical and tabular formats through a customized web-based portal and preregistered mobile phones to better serve relevant end-users. To check the system effectivity, the buoy's stability in harsh environmental conditions, system energy consumption and data transmission efficiency were carefully evaluated. The experimental results prove that the system has great prospect and can be practically used for environmental monitoring by providing stakeholders with relevant and timely information for sound decision making.

Keywords: Dissolved oxygen, Turbidity, Conductivity, pH, Water quality monitoring.

INTRODUCTION

Water is an important resource required to sustain life and the quality of drinking water plays a very important role in the health of living beings. Water supply to taps at urban homes and water sources available in more rural areas, is however, not necessarily safe for consumption. It is thus necessary to monitor the quality of water for consumption. Traditional water quality monitoring methods involve samples and laboratory techniques. These techniques are however time consuming and not very cost effective. There is thus a need for more extensive and efficient monitoring methods. Water quality monitoring can be achieved through microbial measurements as well as physiochemical measurements. Physiochemical parameters include electrical conductivity, pH, oxidation reduction potential (ORP), turbidity, temperature, chlorine content and flow. These parameters can be analysed quickly and at less cost than the microbial parameters. Commercially available products capable of monitoring such parameters are usually bulky and quite expensive. In this paper the development of a low-cost, multi-sensor network for measuring the physicochemical water parameters enabling monitoring, is presented. The system implements flow, temperature, turbidity, conductivity and pH sensors from first principles. All the data from the sensors are processed and analysed. Algorithms are developed to detect possible contaminations. The notification node informs the user as to whether the water quality parameters are normal or abnormal. There is little indication of small scale and inexpensive projects that have a similar role in places like marine jetties, cities and industrial rivers to preserve aquaculture and public health. By applying a strategic, cheap and methodical technique this project hopes to achieve this in an effort to sanitize our stored water.

Materials and methods

To design the proposed water quality monitoring system for this study, the sensors used and the system design is discussed in this section.

1- Sensors

The availability, affordability, and compatibility with Arduino-based architecture was the main reason for the selection of these water quality sensors. Temperature, pH, turbidity and conductivity are connected to the microcontroller using their respective interface circuits.

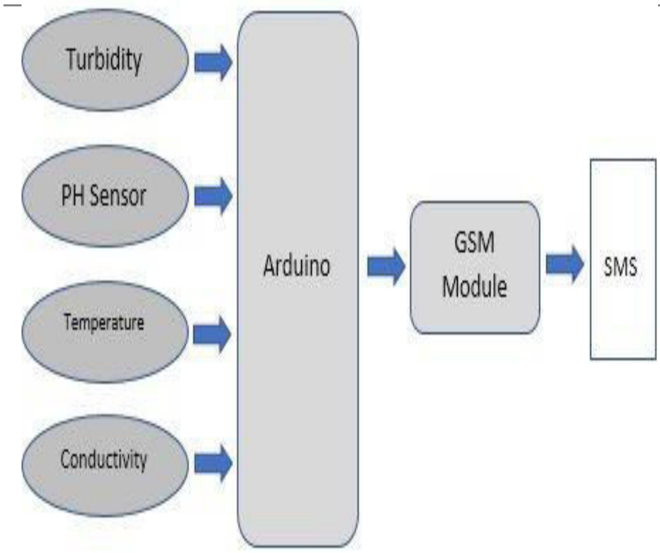

Fig: - Block Diagram

2- System design

The system is designed and implemented with its main goal of monitoring water quality with the consideration that the system: 1) is suitable in a large aquatic area, 2) can measure in a real-time scenario, and 3) has a SMS alert system for measured value. The most important function of the system is to ensure that the data collected from the sensor reflects the actual aquatic scenario and the data are delivered information as a short message service (SMS) sent to pre-identified key users. Therefore, the system was designed to provide the following: 1) data collection, 2) maintenance interface for administrators.

3- Software configuration

It will also ready the GSM module for data transmission. After a few seconds, the system will now start collecting data thru the on-board electrodes (pH and temperature). Data will be sent using GSM transceiver to the base station or the pre-identified cell phone number. After the transmission the system will automatically turn-off and wait for the 30 min time interval to conserve the energy. A separate timer circuit will awake the sensor if it reaches the required time interval of 30 min. The cycle will go on until the required tasked is achieve. This is a user-friendly interface, providing a real-time update of the sensed values for sensors, temperature, and pH level. It provides graphs for easy monitoring of abnormalities in the covered area. Real-time values for the 3 parameters will also be sent using SMS into a predefined cell phone number of some concerned persons.

WATER PARAMETERS

1- Temperature

It is important to record temperature. Relating to temperature-relation theories, pH, turbidity and conductivity have an undesirable effect with large temperature changes.

2- PH

The pH of a solution is the measure of the acidity or alkalinity of that solution. The pH scale is a logarithmic scale whose range is from 0-14 with a neutral point being 7. Values above 7 indicate a basic or alkaline solution and values below 7 would indicate an acidic solution. The majority of aquatic life prefers a pH level of 6.5 – 9.0. Anything outside of this optimum range is considered fatal to the marine ecosystem. Extreme pH values also increase solubility of elements and compounds making them toxic and therefore more likely to be absorbed by marine life. Furthermore, temperature has an inverse relationship with pH that is, as temperature increases pH levels decrease and vice versa.

3- Conductivity

Conductivity signifies the ionic strength of a solution. In other words, it is the ability of a solution to conduct electricity with the typical unit for measurement being micro-Siemens per centimetre (cm). As the dissolved ions increase in the water, conductivity increases. Therefore, the conductivity of tap water is perceptibly low at around 100 cm. On the other hand, expected values for sea water are 55000-60000 cm due to its high ionic content. Any further increase in the conductivity value may be indicative of polluted waters, such as sewer leaks or chemical wastes flooding into the water. Moreover, conductivity is directly related to salinity that is conductivity improves with high salinity. Conductivity values outside of the optimum levels indicate a possible negative scenario. Dead Sea is a prime example of lethal concentrations of salt. The temperature relation with conductivity is a proportional one. A general assumption of a temperature conductivity relation is taken to be linear in nature with a deviation of 2%/°C.

4- **Turbidity sensor**
The turbidity value is monitored based on the light transmittance and scattering rate of a liquid solution. The turbidity information is obtained by the AD (analog to digital) conversion interface in the dynamic monitoring environment. The working voltage and accuracy of turbidity sensor are 5 V and 0.75%, respectively. The response time is shorter than 500 ms.

CONCLUSION

The temperature sensor was completed using a thermistor-based design. The conductivity sensor design was based on a two-electrode method. The signal conditioning circuit yielded acceptable results. The conductivity cell/electrodes were however not verified. The pH sensor made use of a glass electrode and yielded acceptable results. A measurement node consisting of a microcontroller was implemented to process the raw sensor data into usable measurement values. The microcontroller then transmitted the measurements through GPS. A notification node consisting of a microcontroller, LCD and buzzer was implemented as a user interface to display the different water quality parameters. The buzzer was used as an audible alert when a specific parameter was at an unsafe level. The accuracies of the different sensors and other findings are as follows. Temperature sensor: 2.5◦C. Conductivity sensor: 14.71%. pH sensor: ±0.51. The raw sensor data was processed successfully. The water parameters were displayed clearly on the LCD and audible warnings were heard from the buzzer when parameter is at an unsafe level. Future work could include the design and implementation of a turbidity sensor, as this an also an important quality monitoring parameter. The current design is able to display the parameters in real-time; however, a history of the readings is not available, thus data logging of the sensor measurements could also be considered.

In this study, a low-cost water quality monitoring system has been developed which is applicable to a large area of coverage. Its applicability was attributed to its long duration operation, flexibility, and reproducibility. It utilized commercially available electrochemical sensors to monitor water quality parameters accurately. Expansion of the coverage area for this system using autonomous surface vehicle is ongoing to cover large areas like lakes and other bodies of water which need constant monitoring due to its importance both to humankind and nature.

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