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Solar Powered Water Quality Monitoring Using Wireless Sensor Network

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ABSTRACT: Nowadays, the water pollution is a serious world issue. Observing the quality of water in recent days is more essential as a result of environmental factors which causes pollution and health problem in human life like dysentery, cholera, diarrhoea, etc and also a great concern to the aquatic organisms. Testing the water in chemical laboratory manually is very tedious and consumes more time. In order to reduce the time consumption and remote monitoring the Arduino based water quality monitoring system that monitors the water quality in real time. This paper presented a vision of low cost wireless water quality monitoring and collection of data from the water body. Water quality parameters like temperature, turbidity and PH values are monitored and data are collected from the different water bodies. The acquired data have been shown on the graphical display.

KEYWORDS: Water quality monitoring, Data collection and monitoring, Arduino c

I. INTRODUCTION

Water pollution is a booming problem in India. A result obtained from a recent survey conducted over 180 countries across the world have placed India 145th position in concern with water quality and sanitation. According to Central Pollution And Control Board almost half of India's interstate rivers are polluted day by day.The study found that almost one-fourth of the river locations had BOD values exceeding the normal limit.

Water quality monitoring plays an important role in environmental monitoring, and its protection and maintenance of water environmental health. In order to overcome the above water quality issues, we described a solar based water quality monitoring system using WSN technique. The present monitoring method is a regular manual analysis process to gather the data. The proposed system is used to monitor the data autonomously at regular intervals using Arduino. It is programmed with C and C++ language.

On the other hand, power supply to the system could be replaced with solar energy when the main energy sources are unavailable. Solar energy is a renewable energy source, thus it compliments the aim of the proposed model.
This paper will mainly cover large water body monitoring, concentrating on pH, temperature and turbidity as water quality factors using WSN technique. The information on quality of different water bodies are collected as data and sent to the graphical display for the purpose of analysis. This data can be regularly monitored from a remote location and decreases the need for manpower. This monitoring system can be monitored throughout the day and improve the efficiency of the water quality monitoring.

II. DESIGN OF SYSTEM

The system consists of three unit systems: control unit, sensor unit and display unit.The basic block diagram of this system is shown in Figure 1.

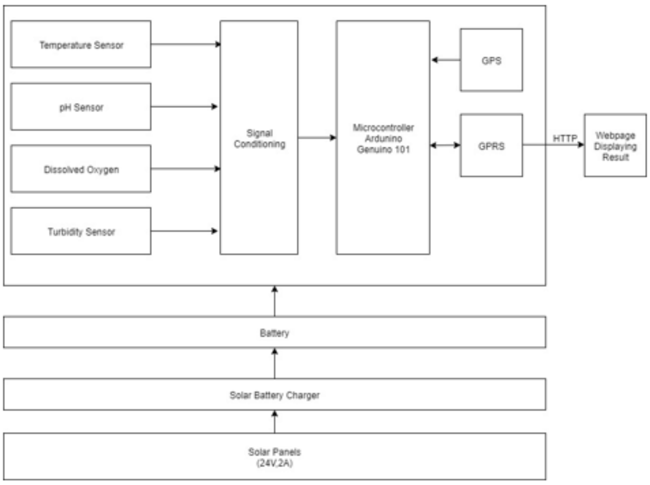

Figure. 1 Basic block diagram of water quality monitoring system.

Choice of platform

By relating the performance of several versions of Arduino IDE software and comparing the precision ratio, this system plans to use Arduino 1.8.11 as a application platform. The Arduino software (IDE) is a open source which makes simpler to code and upload it to the board with the aid of third party cores. The software has built in functions and the data obtained from the system can be displayed graphically.

It enables the user to store the code in the cloud and can be backed up from any device. The data collected from water bodies is stored and sent through the arduino to the excel. This data can be expressed in graphical form.

Energy System

i)Battery:

The important problem in the consideration of energy source for water quality monitoring system is the location of the sensor system in the water body. The optimal performance of the system can be ensured with the implementation of battery source to power up the system. This battery has better long-term performance and self-discharge rates. During interruption or in the event of battery dry-out condition solar power can be used as the backup energy system.

ii) *Solar powered system*:

For a successful working of a water quality monitoring system additional source for power supply is provided as solar power. This solar panel can be connected in series or parallel based on the system requirements. The charge controller are used to control the power fed to the battery to provide supply to the sensor block and the microcontroller unit.

C. Materials Used

i) *pH sensor*

A pH sensor is an instrument that measures the acidity and alkalinity or base level of the given solution. It is usually expressed with a numeric scale which ranges from 0-14. The value 7 implies neutrality. If the value of pH increases then the given solution implies alkalinity. If the value of pH decreases then the given solution implies acidity. The pH value is also equal to the negative logarithm of the hydrogen ion concentration.

Basically, there are three types of pH sensor. They are combinational, differential and laboratory. In this system, combinational pH sensor is used. Combination pH sensor is a electrochemical sensor that has a measuring electrode and reference electrode. The measuring electrode identify changes in the value of pH while reference electrode gives a stable signal.

The pH values for some solutions are listed below:

Name of the solution	*pH value*
Battery	*0.5*
Stomach acid	*2*
Coca cola	*2.53*
Lemon	*2.93*
Coffee	*5*
Pure Water	*7*
Household Bleach	*12.7*

Table1. pH values for different solutions

ii) Temperature sensor:

The temperature sensor is a thermocouple device that gives temperature measurement through an electrical signal. Temperature sensor mesasures the amount of heat energy or coldness generated by a system in the water according to the atmospheric conditions. There are different types of temperature sensor and all have various characteristics depending upon their application. The sensor used in this system is thermistor which is the combination of thermal and resistor.

The temperature sensor LM35 is a linearly proportional to the centigrade temperature. It does not require any external calibration or trimmer to provide exact accuracy.

iii) Turbidity sensor

Turbidity sensor measures the quantity of scattered particles that is suspended through the light. It checks the purity of water against microparticles. It is also used to analyze the formation of precipitation or algae and yeast formation. Turbidity is measured in NTU: Nephelometric turbidity unit. The instrument used for measuring is called nephelometric or turbidimetric.

iv) Ultrasonic sensor

The ultrasonic ranging module HC-SR04 is used in this monitoring system. This module includes an ultrasonic transmitter and receiver and also a separate unit for control circuit. The module transmits eight separate wave of 40khz and detects whether the signal is received back. If the returning time of the signal is long then the distance is proportionally longer. It's measuring range is from a minimum value of 2cm to the maximum value of 4m. This range is calculated through the time interval between the trigger signal and the received echo signal.

D. Sensor node

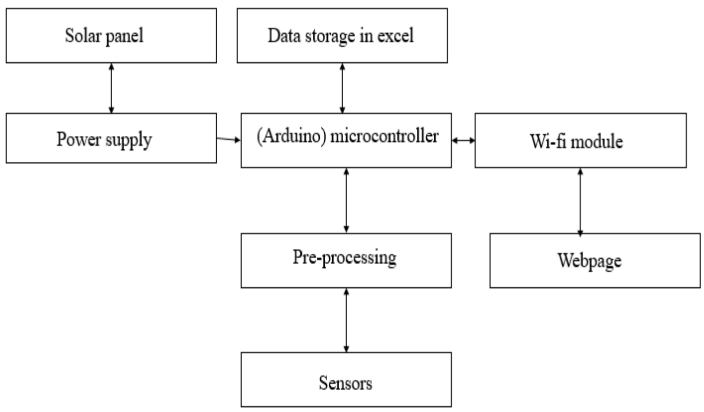

Figure2. Sensor node

This sensor node consists of seven blocks. For the water quality monitoring system prototype the sink node is constructing the main building block by using sensor node by collecting and pre-processing data from electrodes and

transferring it to the sink node. This prototype includes four sensors for measuring the turbidity level, temperature, ultrasonic (which detects the level of water) and ph. A excel sheet is used as a backup storage for all gathered data. For power supply it uses battery for powering sensors. During interruption or in the event of battery dry-out condition solar power can be used as the backup energy system.
Sink node is generally a sensor node with the ability to send data within the portable distance using wi-fi module as shown in Figure3.
The availability, affordability and compatibility with Arduino- based architecture was the main reason for the selection of water quality monitoring system using wireless sensor network.

D. Wireless Communication

The sensed data from the nodes of the sensors are received directly from the water body or the test sample whose physical parameters to be monitored. The data are collected through the electrodes submerged into the sample body by the help of Arduino uno board. The sensors are calibrated primarily to acknowledge accurate operation resulting in correct water quality parameter data using standard calibration methods.

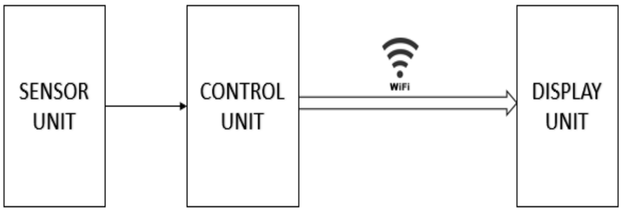

Figure3. Wireless communication

E. Analysis Of Arduino Output

Figure4. Arduino output

The value of pH ranges 0 to 14. At room temperature, if the value is approximately 7 then the quality of water is neither acidic nor basic. The analysis conducted on highly acidicwater is shown in figure4. This test sample consists of less amount of light scattered particles, thus showing the turbidity value of approximately 6NTU. This value indicates that the turbidity level of the test sample is clean.The efficiency of the sensors such as ph, temperatare and turbidity are evaluated by comparing the observed data values, with the standard value.
The monitoring of pH values and temperature of the water sample at different intervals is shown in Figure5.

Identify applicable funding agency here. If none, delete this text box.

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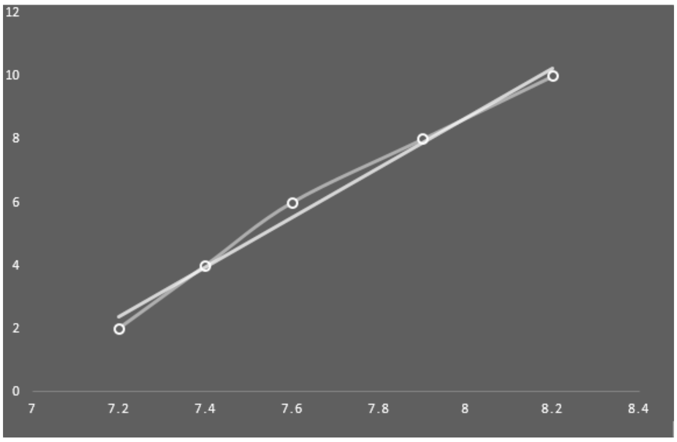

Figure5.1. pH versus time interval

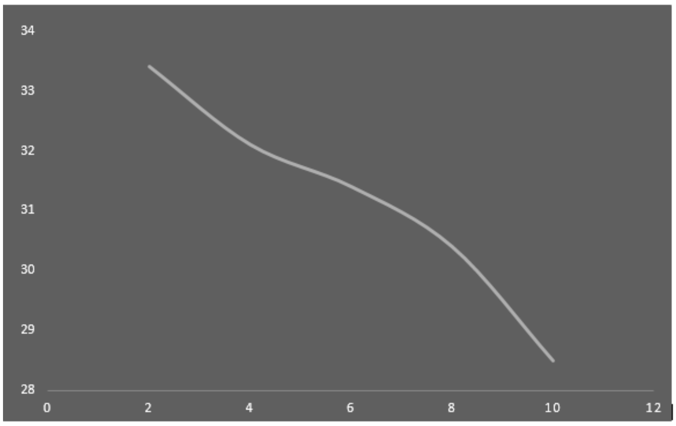

Figure5.2

F. Function Of The Data Analysis

According to the results of the analysis of user demand, the system has realized the following information testing methods: quality check, field check, bidirectional check between Graph and status check.

1) The quality check appears through the dialog box. Users can input the value condition that needs to be queried, and the system will provide a data records that corresponds to status of the water quality as a table.

2) Field check runs on information check according to some field values determined by the system. Related Information can be obtained after the user has selected the target needs to interrogate the field that sets the system.

3)Two methods of investigation can be realized for Bidirectional check between graph and status check. The first check feature is graph information and related information. As long as the status information is displayed in the form of a list, the user selects any layer object. Another is inquiring status information, and spatial object by relating the spatial object is displayed until the user is exposed. Information required to query for input information.

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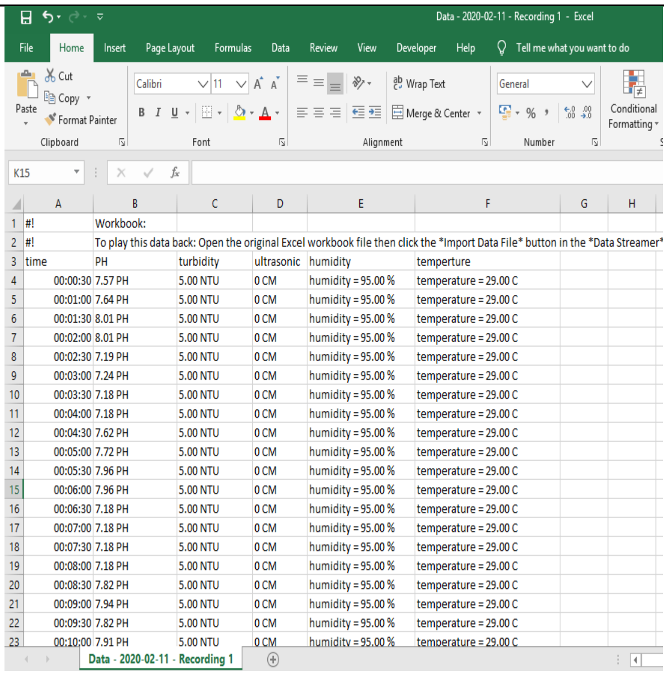

	A	B	C	D	E	F
1	#!	Workbook:				
2	#!	To play this data back: Open the original Excel workbook file then click the "Import Data File" button in the "Data Streamer"				
3	time	PH	turbidity	ultrasonic	humidity	temperture
4	00:00:30	7.57 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
5	00:01:00	7.64 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
6	00:01:30	8.01 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
7	00:02:00	8.01 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
8	00:02:30	7.19 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
9	00:03:00	7.24 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
10	00:03:30	7.18 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
11	00:04:00	7.18 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
12	00:04:30	7.62 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
13	00:05:00	7.72 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
14	00:05:30	7.96 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
15	00:06:00	7.96 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
16	00:06:30	7.18 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
17	00:07:00	7.18 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
18	00:07:30	7.18 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
19	00:08:00	7.18 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
20	00:08:30	7.82 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
21	00:09:00	7.94 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
22	00:09:30	7.82 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C
23	00:10:00	7.91 PH	5.00 NTU	0 CM	humidity = 95.00 %	temperature = 29.00 C

Figure6. Analysis of data in excel

F. Data storage and visualization

The system was designed to store and fetch data in two possible ways: a) in a system PC which can be used for temporary storage; b) in a excel spreadsheet which can be used for long time storage and can be analysed with different data. In case of failure or interruption in a transmission of data through excel, data can be retrieved from the onboard microcontroller (Arduino). Date and time are added to the values of the water quality parameters like pH, temperature, and turbidity for simple analysis and display in the web.

G. Challenges and Recommendations

Some developed countries are using real-time water quality monitoring systems to monitor their water resources such as the United States Geological Survey and the European Innovation Partnership on Water. For developing countries like India, this real-time monitoring is only in the experimental phase. Some of the following challenges are on the recommendation for real implementation and potential future studies of real-time water quality monitoring systems: reliability and stability of the sensor and its ability to support the entire system, power system and for the long term. For implementation, cost and affordability.

Constant changes in weather conditions like temperature and water intrusion can affect some the functions of the electronic component, thus, it is very important to consider this in the design phase of entire system. A well-designed system that houses all Electronics component may be considered as one solution.

Also, the use of antenna-less transceivers may also be a factor to consider to avoid the risk of intrusion of water and strong wind loading. Energy source issues can be addressed through design of energy management and high efficiency utilization battery. Lithium-ion battery capacity can increase four times the capacity of Lead acid battery. Solar energy harvesting system has been proved to be an effective energy harvesting system and its fast charging capability would be a good fit. Lithium ion battery which has durable characteristics and capacity for high charging rate.

Cost and affordability are one of the main problems for this comprehensive implementation of automated water quality monitoring system in developing countries. The cost of such unfamiliar technology is confusing, especially in places where water quality monitoring is rarely conducted or not at all necessary. Perception has to be changed and correction must be done through the Government institutions, related private institutions and research community monitoring that water quality should be done regularly and efficiently. Standard sampling frequency / interval and water quality monitoring methods will reveal the high cost of manual monitoring (cost of laboratory equipment, wages of highly skilled personnel, and transportation costs) against much less expensive automation and could change the perception about costs and benefits of working on automatic monitoring. In addition, the following could further reduce the cost of automated water quality monitoring system: usage of local materials (material for floating system), tapping local researchers to collect their own automated water quality monitoring system and using the latest technology such as lithium-ion batteries and more efficient types of solar panels.

III. CONCLUSION

In the water quality monitoring and analysis system we preliminarily accomplish the match between the standard water quality and the different water sample bodies. For large area coverage, a low cost water quality monitoring system has been proposed in this study. It attributes to long duration operation, flexibility, sensitivity, stability and reliability. Arduino based embedded platform is designed for data acquisition and data transfer.

The water quality parameters are acquired through the Arduino board and sent over the wireless network to the server node. Arduino is adopted for water quality objective management as well as dynamic display and simulation for pollution data. Practice shows that it is an inevitable trend to apply Arduino wi-fi in water quality management.

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