A Smart Water Management System for Rural Area Water Tanks

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ABSTRACT

Now a day's pure drinking water is a valuable resource for all human beings, so the supply of pure drinking water for rural areas is a challenging task for concerned authorities. In this report, we have primarily centered on two major issues in maintaining the water tanks. Primarily, calculating the level of water tanks using the low-cost Ultra-sonic sensor, which can be used for intimate whether the tank is full or not. Secondly, knowing the pH value of a water using the pH-sensor, which can be used for examining the quality of water. This information can be broadcast to the mobile for decision-making purpose.

KEY WORDS: Smart, Management, Rural.

1. INTRODUCTION

In the 21st century era, there were lots of innovations taken place, but depending on the time different populations are global warming and water population, so on are also being increased, because of this, there is no safe drinking water for the world's population (Karthik Kumar, 2014). The drinking water is more precious and valuable for all the human beings, so the quality of water should be monitored in real time. Nowadays water quality monitoring (Jayti Bhatt, 2016) in real time faces challenges because of global warming, limited water resources, growing population, etc. According to WHO (World Health Organization) 1.2 billion people or almost one-fifth of the world's population, live in areas scarcity of water and by 2025 water scarcity is expected to increase up to 1.8 billion. The availability pure drinking water is also less in India. The Government of India is providing drinking water by water tanks in cities and villages.

With the advancement of IoT (Internet of Things) the levels of water tank can be measured with the help of an ultra-sonic sensor. This sensor can gather data for analytics, so the management of the water tank and distribution of water is possible. In earlier works, Kudva (2014). Proposed real-time water management system for a campus and used the off-the-shelf ultra-sonic sensor for a campus. This can measure up to 4m level of the water tank. Which cannot measure the large distributed water tanks. The other proposed work, Pipenet (Ivan Stoiano, 2007) uses the Bluetooth-based network sensors. It collects the data in the form of clusters from different sensors in the network which forms a pipe. The clusters will communicate with the server via GSM in this data analyzed to pipe bursts or signal leaks.

The water comes from different sources like rivers, canals, ponds, spring, etc..., and water environment can be categorized into ground water and surface water. There are several models presenting to measure the quality of water they are primarily using artificial sampling, which detects the quality of water and subsequent lab analysis. It has fixed sampling frequencies ranging depending on days and months. Secondly, by using automatic monitoring systems, which continuously monitoring the water environment parameters and data can be sent remotely to other stations. This system is more costly.

2. PROPOSED SYSTEM

The proposed system consists of mainly two sensors connected to the Raspberry pi chipset. In this one sensor is an ultra-sonic sensor, which will find the level of the water tank. It has two major cases, if the tank is full or empty, then the red LED bulb will glow else the green LED bulb will glow. The red LED bulb will glow when tank is full there may be a chance water over flow or empty (tank water is very low). If the level of the tank is between full and empty then the green LED bulb will glow. The ultra-sonic sensor will take 5V power as an input from the raspberry pi chipset. The level of water tank can be stored in local database as well as data in the cloud environment, which can be used for future data analytics.

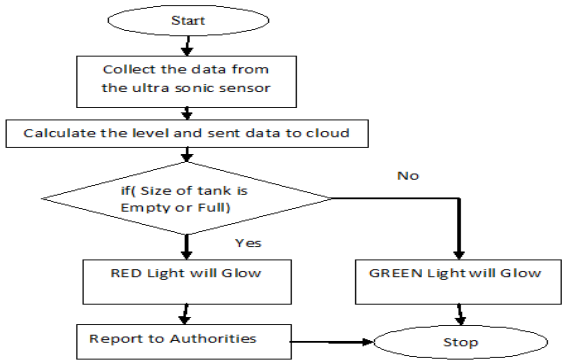

Figure.1. Flowchart for measuring the levels of the water tank

The other sensor used in the system is pH sensor, which is used for measuring the quality of water. The full form of pH is "Potential of Hydrogen", which will measure the amount of hydrogen in water. The circuit is designed with three basic components they are firstly sensor element, which can be tested electrode, secondly a threshold electrode and finally temperature sensor electrode is connected .The material that is used in the sensor is insulator, which performs the process of absorption. It takes the water as an input and releases water depending on the temperature and sample of the material. The pH Sensor the pH values range from 0 to 14. The Over acidity can cause all types of diseases like obesity. A solution which is having a pH value less than 7 considered as acidic. A solution which is having a pH value greater than 7 is considered as basic. The water quality has to be adjusted to 7 to get the purified water.

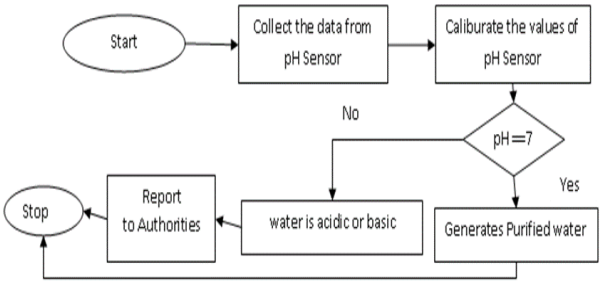

Figure.2. Flowchart for measuring the purity of quality water

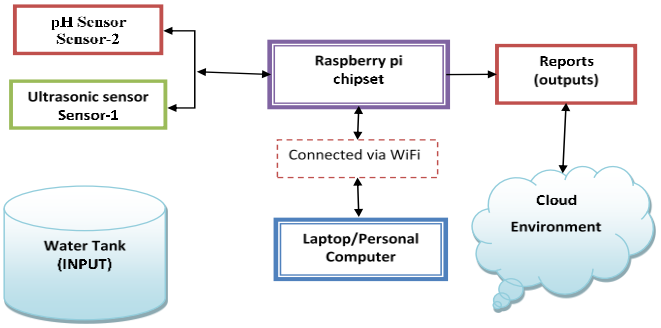

Figure.3. The Block Diagram of Smart water management system for Rural area water tanks

The block diagram of the smart water management system for the water tanks is as shown in figure 3.The input is taken from the water tank by using the two sensors mainly one is ultra-sonic sensor which measures the level's in the water tank. This data can be stored in the local system and also send to the cloud Environment for future data analytics. Depending on the ultra-sonic sensor data the green or red led light will glow, which can be used for maintenance of the tank.

The second sensor used in this system is pH Sensor, which is used to find the purity of water in the tank. pH is one of the important factors for determining the level of corrosion. The pH of a solution can be calculated with the following formula.

$$pH = -\log(H+) \qquad (1)$$

By using pH parameter value water can be measured by the acid-base equilibrium. The natural water is coming from the rivers, lakes and ponds. Which water is controlled by the carbon dioxide bicarbonate, carbonate equilibrium systems? The functionality of pH sensor is explained in figure 2. The water can be present in many forms like solid, vapor and liquid state. When the water is streaming it can be too acidic or basic. The H+ or OH- activity of ions can be disturbed, which affects the quality of water. The purity of water can be maintained by controlling the activities of the H+ and OH- ions in the solution. If H+ activity is more than the OH- in the solution, then it is considered as acidic water. If the OH- ion activity is more than the H+ activity, then solution is considered as basic or alkaline and if H+ activity is equivalent to OH- then the solution is pure water.

Table.1. pH ranging values

pH value Range	Property
0-6	Acidic Water
7	Neutral of pure water
8-14	Alkaline Water

By using this two sensor data can be sent to a laptop via WIFI or Bluetooth can be used, so it can be stored in the local databases like mysql (my structure query language) or to a cloud environment like to think speak. These reports can be used for higher authorities who are maintaining the tank. The chipset will throw the signal via internal WIFI signal or for larger distance we have to use the GSM sensor which is integrated into the raspberry pi chipset. The reports generated in the chipset is alpha numeric values which can be converted to the graphs.

Limitations of proposed system:

- The ultra-sonic sensor can measure up to 400 cms with much accuracy more than that the accuracy varies.
- By using the WIFI signal of raspberry pi chipset, it is possible to communicate only less amount of distance. To communicate with more amount of distance it is required to add sensors.
- To run this system we are using the battery connected to chipset, which has to be charged every day.

3. EXPERIMENTAL SETUP AND RESULT ANALYSIS

The smart water management for rural area water tanks is a product which is developed by using IoT technology. The system can be developed based multiple sensors connected to the raspberry pi chipset. So far by using Micro Controllers this was developed to measure the level of a tank but by using System on a Chip (SOC) the device size is reduced and Cost is less and new additional features can be added easily.

Hard Ware Components: SOC Chipset: Raspberry Pi3 Model B Chipset which consists of 1GB RAM, Wi -fi, and Bluetooth enabled 64-bit Quad- Core ARM Cortex 53 CPU.

Accessories: Jumper cables for connectivity, Glass for storing water samples, chemical solutions for calibration of pH sensor.

Sensors used: Ultra-Sonic sensor, pH Sensor, temperature sensor.

Software Components: Programming language: Phython

Operating system: Customized unix based operating system

Database: MYSQL

Cloud Environment: thinkspeak.com

The Raspberry pi 3 is a SOC (System on a Chip) which consists of an operating system and My sql database in it. It is connected a set of sensors like ultrasonic sensor, pH sensor and Temperature Sensor. The python is an open source programming language, which is having syntax inheritance from the programming languages like C and Java programming languages. Mysql is database engine, which can store the values permanently in it. Think speak is an open source web site, which can be used for the IoT Analytics. This environment will perform the three basic operations like collect the data from the sensors, Analyze the data using MATLAB and Act depending on the data.

The testing experiment panel consisting of four glass test tubes which has infected water samples in it. The first test tube consists of distilled water or pure water, which can be used for the batteries in houses. The second test tube consists of regular water, which can be used for drinking water for the people. The third test glass consists of hard water, which has a salt in it. The fourth test glass consists of impure water or acidic water, which it contains impurities in it. The Sensing circuit is designed using the two types of conducting electrodes in this the electrodes are dipped in each and every test glass sample. In the water the electrode from a cathode-anode pair, which generates the certain amount of current. The 1 ohm resistance is connected to the circuit which will oppose the flow of current and finding the potential difference occurs between the electrodes is found.

Generally the water coming into the water tank is from different resources like ponds and lakes in rural areas. The water is mainly depending on the environment. The floating stream water can be effected with the photosynthesis. The below is the chemical equation, how pH is depending on the photosynthesis.

$$12\ H_2O + 6\ CO_2 \Rightarrow C_6H_{12}O_6 + 6\ H_2O + 6\ O_2 \quad (2)$$

$$CO_2 + H_2O \Rightarrow H_2CO_3 \quad (3)$$

During the process of photosynthesis plenty of CO_2 is changed to the $C_6H_{12}O_6$. In equation 3 when water (H_2O) is combined with the carbon dioxide (CO_2) H_2CO_3 is liberated. So considering H_2CO_3 is an important factor, which lowers the H_2CO_3 content in the water can be considered as acidic water. If the content of H_2CO_3 in the water is higher than then water can be considered as alkaline water. So, H_2CO_3 must be balanced. The artificial sampling is a normal technique, where the samples are tested at chemical laboratories. By comparing the pH Sensor values with artificial sampling values as follows in table 2. The artificial sampling values collected from lab for every 2 hours and compared with pH sensor values.

Table.2. Response of Artificial sampling and pH Sensor values for Regular Water

Sampling Time	9AM	11AM	1PM	3PM	5PM	7PM
Artificial Sampling	7.79	7.74	7.86	7.96	8.04	8.17
pH Generated Sampling	7.82	7.78	7.82	7.98	8.09	8.19

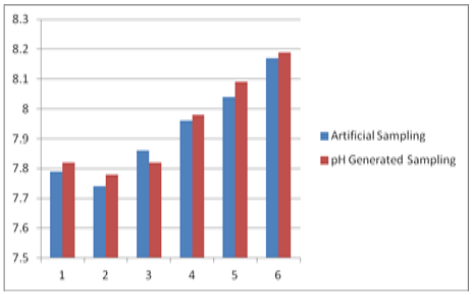

Figure.5. Comparing the Artificial sampling and pH Sensor values

Considering the four water samples like acidic water, hard water, regular water and pure water in the four different test tube glasses then dipping the pH sensor in each sample. The voltage response of the water under the test glasses is recorded. Then the results observed by using pH Sensor are given below.

Table.3. Output Response of different sample water

Water Sample	Binary Reading on Display
Acidic content in Water	151
Hardness in Water	428
Regular Water	947
Pure Water	998

The testing sample having higher the value to display on record, the better is the quality of the water and lowers is the poor quality of water. The graph shows the quality of water samples. Depending on these statistics with low time the higher authorities can make the decisions. The pH Sensor will generate the analog values, this value are converted into digital values by using the python programming.

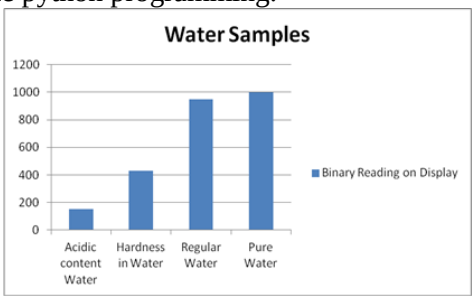

Figure.4. Comparing the different water sample

The distilled water is tested at different level of temperature and conductivity of water is observed. The increase in the temperature of water sample increases the output voltage response. The conductivity of water is increased at boiling point, but didn't reach the threshold level of hard water. The hard water is tested at different level of temperature and pH value of water is mentioned.

Table.4. Output response generated from distilled water combined with salt

Water Samples (100 ml)	pH Value at the room temperature	pH value of the temperature (100^0 C)
Distilled water + One gram salt	6.1	6.0
Distilled water + Two gram salt	6.6	6.4
Distilled water + Three gram salt	7.2	7.0
Distilled water + Three gram salt	7.2	7.1

In the distilled water when different gram of salt is added the pH value of the room temperature is all most equal to the pH value of the temperature at boiling point. But the pH value of boiling point does not exceed the pH value of the room temperature.

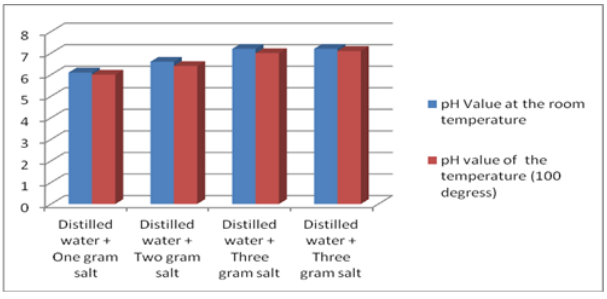

Figure.5. Comparing the distilled water with different gram salt

The based on the ultra-sonic sensor. Which calculates the level of the water tank with date and time. This data can be sent to the cloud. The ultra-sonic sensor can be fixed at the top of the water tank which is connected to

the raspberry pi chipset. This sensor can measure up to 10 meters more than that the accuracy varies. Depending on these values RED or GREEN lights will glow. The ultra-sonic sensor consists of four pins like GND(ground) connected to pin2 GPIO GND, Vcc(5V Power) connected to pin6 GPIO 5V, ECHO which is an input pin connected to pin18 GPIO 24 and TRIG which is output pin connected to pin 16 GPIO 23 to the raspberry pi chipset. The distance can be calculated by using the general formula.

$$speed = \frac{distance}{time} \qquad (4)$$

The ultra-sonic sensor will send pulse signal which is listened by the input pin ECHO. The sensor sets the value of ECHO pin too high for the amount of time it goes and come back. So it is required to measure the amount of time the ECHO pin is high. The value we will get in decimal values. This value can be rounded off by using a function round (distance, 2) , which is round off to two decimal places. The time and date also calculated by using the predefine function present in date and time package.

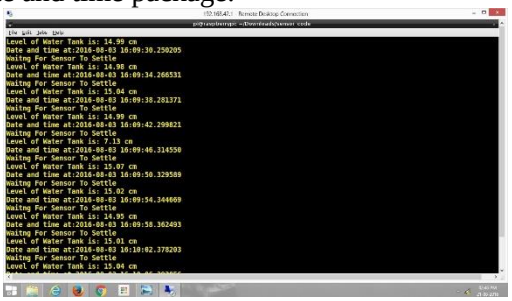

Figure.6. The level of Water tank in calculating in cm's

Think speak is an open source cloud environment website which accepts the data from the IOT devices. The level of water tank data generated from the ultra-sonic sensor is sent to thinkspeak.com for visualization of data. By using this data we can develop the dashboard which can be viewed around the world.

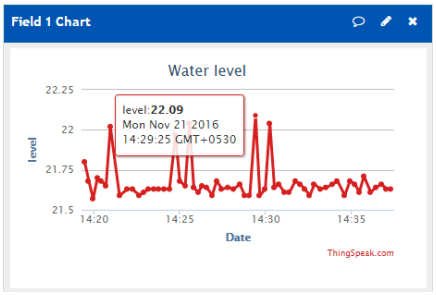

Figure.7. Data upload to a cloud environment by using ultra-sonic sensor

4. CONCLUSION

This proposed system is more suitable for monitoring the level of the tank and to know the purity of drinking water with the help of pH Value. To improve the quality of drinking water, the pH value and level of water can be stored in databases and sent to the cloud data online for visualization and using big data analytics. To achieve the scalability for existing chip we can add more sensors like GSM Sensor, turbidity sensor, etc..,. The mobile app can be developed for monitoring the tank. In the remote areas power is a major problem so, solar plate can be attached to the system. Which charges at day time and discharges at night time. The multiple sensors can be installed on multiple tanks and they can be communicated with each other by using the protocols.

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