Water Quality Monitoring for Smart Irrigation

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Abstract : IoT technology is showcasing its benefits is many areas of societal requirements. Water is always a precious resource that has to be efficiently used and properly utilized based on the purpose and requirement. Agriculture is one of the areas where enormous quantity of water is required for irrigation and some crops are sensitive to the type of nutrients in water. Hence IoT technology can be used in farms for agricultural resources utilization and management. This paper proposes a design and discusses the implementation of a low-cost water quality monitoring system for the benefit of high yielding crops. The designed system consists of various sensors for monitoring temperature, pH value, turbidity, conductivity and dissolved oxygen of the water sample. Using the data collected through this measure, water flow to the farm can be controlled.

***IndexTerms* - Component,formatting,style,styling,insert.**

I. INTRODUCTION

An efficient water supply system is required for utilizing water in irrigation without any wastage and maintaining the water quality. Irrigation is a science of water management through proper planning, designing, deployment of water resource usage system for agricultural purpose. Rainfall is the most essential source of water for agriculture. Plants especially the food crops require adequate amount of water throughout its growth period. But rain water may not be adequate to satisfy the complete water requirement of crops from seeding to harvesting. So it is necessary to learn the factors that necessitate the importance of irrigation even further. They are insufficient rainfall, uneven distribution of rainfall, improvement of perennial crops and development of agriculture in desert area (N N Basak, 1999). Proper planning and utilization of irrigation systems help in good crop yield during the low rainfall and drought periods and to improve cash crops. This in turn helps to prevent famine in our country and leads the farmers to earn better. Excessive water usage through irrigation should be avoided which will otherwise leads to the downside of water utilization. During the supply of water, leakage or overuse may constantly settle the water near plant roots and spoil the crop or induce more soil alkalinity. When this also forms marshy lands, it may become the source of mosquito breeds and becomes the reason for various diseases.

Water application in agriculture varies based on the type of crop, season, time in a day, duration, climate, ground slope variability and method of ploughing. Water requirement for crops may be collectively viewed as for consumptive use, unavoidable water losses and water for special requirements (D. Lenka, 1991). Consumptive use of water is the sum of the quantities used by the plant for its vegetative growth in transpiration from germination to ripening, water evaporation from soil and metabolic activities for tissue building in plants. Unavoidable water losses may be due to water seepage, deep percolation and evaporation of water at its storage area. Water requirement for agriculture is met from rainfall, irrigation, ground water and dew. If rainfall is untrustable, ground water level is very low and the quantity of dew is ignorable, then agriculture has to mainly depend on irrigation.

Pure water is mostly distributed for drinking and cooking purpose in residential areas. So feasibility of pure water supply for irrigation purpose is totally rare. At the same time quality of water also directly or indirectly affects the crop yield in various ways. Fine silt sedimentation improves the soil fertility. But the other sediment types decreases the fertility of the soil. These other sediments can be due to various reasons and particles. Due to acid rain various types of gases and suspended particulate matters of the air can mix with water drops before it reaches the earth (T. C. Jermin Jeaunita, Sarasvathi V, Saritha, 2019). And before this water reaches the canals, rivers or water tanks, many kinds of organic or inorganic matters may add up with it. Many kinds of salts like calcium, magnesium, sodium and potassium are also found dissolved in it. If these salts crosses the permissible limits, that may affect the growth of crops. The chemical or biological impurities are found more during rainy seasons compared to other seasons. The discharges from chemical factories, production industries and mines in the vicinity also influences the water stored for irrigation. Electrical conductivity of saline water from 250 to 750 micro mho/cm is found to be very injurious for crops. Concentration of boron above 0.3 ppm may be harmful to plants. Bacterial contaminated water, irrigated for food crops may be very dangerous for human beings.

It is essential to mind water is the nutrient carrier into the plant body. The water quality is determined by the pH level, hardness, turbidity, specific gravity and conductance. For irrigation, tolerance limits of pH value is 6.5 to 8.5, total dissolved solids (TDS) in mg/l is 2100, chlorides is 600 mg/l, sulphate is 1000mg/l, sodium absorption ratio is 26mg/l, boron is 2mg/l and sodium is 69% maximum. Poor water quality leads to deterioration of land. The different periods of plant growth like germination, vegetation, reproduction also requires varied tolerance levels of water quality. If the salinity of the soil is affected by the water used for irrigation, this leads to poor or delayed germination. Some crops are tolerant to alkali, but more sensitive to salts and some acts vice versa.

When agriculture is concentrated in large scale of around 5000km^2 area, the level of irrigation required goes complex(T.C.Jermin Jeaunita and Sarasvathi V, 2019). To reduce the irrigation cost sewage irrigation is a better choice(T. C. Jermin Jeaunita, et. al., 2018). Domestic sewage may contain relatively harmless bacterias but few being pathogenic or disease inducing. Even more harmful is the industrial waste that depends whole on the manufacturing process. Issues that may occur with sewage irrigation for some crops are delayed harvest, low quality product and lower disease resistance capacity.

Internet of Things(IoT) technology is used for connecting the agro based sensors and actuators to coordinate with each other and send and receive data through Internet. The data collected can be used for analysis and decision making activities. In case of decision making applications, the sensing side of the network is made smart to control the environment. This automation can be optimized for reducing manual investigations in the farm, water, air and soil quality monitoring, better crop yield (T. C. Jermin Jeaunita et al, 2018), agricultural resources saving, live stock monitoring and logistics tracking. Through water quality monitoring, the crop stages and the required water quality can be mapped for decision making on irrigation control. This helps in the protection of soil from deterioration and crops from damages and diseases. Inclusion of such a system in farm land automation system should be highly cost efficient through the sensor and actuator components used and the communication technology that lies behind.

Section II gives a discussion of other related works in the field of water quality assessment. Section III explains the proposed system design and implementation. Section IV discusses the outcome of the work and section V concludes the paper.

II. Literature Review

The literature has demonstrated the benefits of IoT and its use in agricultural monitoring purposes. Based on the application requirement and on the nature of the components used, various surveillance or monitoring systems has improved the way farming has been concentrated. Water quality assessment can be done for irrigation purposes, to check the quality of water for drinking and cooking or for domestic household usages or livestock feeding. The quality test can be done using laboratory methods and can be linked with an application, and through network connectivity the data can be stored in the cloud. Due to the advent of MEMS and nano technology, and the anytime and anywhere networking technologies, sensor based water quality assessments make the system of surveillance processes faster and low-cost.

The authors of (Dung Nguyen and Phu H. Phung, 2017) have proposed a system to identify the changes in the quality of pond water and notify it to the users through SMS. Using temperature and pH sensors it was shown to transfer the sensed data without loss, but to save energy at nodes. M. Parameswari and M. Balasingh Moses (2017) have proposed a water quality assessment system to assess the pond water quality using temperature sensor, pH sensor, dissolved oxygen sensor and turbidity sensor connected to the Arduino Genuino 101 and using HTTP protocols the data is sent to the application waiting for this data. As ground water is an important source of water for irrigation, an assessment of the quality of ground water was performed by (A. Jafar Ahamed, et. al, 2013) . Through this research the authors have found that some stations show high salinity hazards. They have suggested to take proper measure to avoid crop spoilage due to water salinity. The water quality monitoring system developed by (S.Geetha and S. Gauthami 2017) aims at monitoring electrical conductivity, turbidity, water level and pH. TI CC3300 microcontroller with an inbuilt WiFi is used for controlling the sensors. The sensor values read, are stored in the cloud and at the same time displayed in the LCD. Even though various sensors and microcontroller are used, a low cost system will be more beneficial for building a scalable system.

III. System Design And Implementation

The challenge in developing a water quality monitoring system lies in the selection of hardware and software components that gives the real efficient solution in an affordable cost at the development side. This will eventually motivate and encourage lot more such researches and deployments for the usage of IoT in the field of agriculture. Identification of the physical and chemical properties of water helps in the identification of the quality of water. With this intention is this work on water quality monitoring was designed and developed. Such systems will also help in the development of automated systems without or with less intervention of man power. This together gives assurance of the faster and economical water quality monitoring systems.

3.1 Components Used

The system consists of Arduino and Rasperry Pi boards, pH sensor, temperature sensor and turbidity sensor. For testing the water quality, its different forms like soap water and muddy water, and from different sources like lake, sea, tank and tap water are used.

The amount of suspended particles or foreign bodies like sand or fungus, is assessed using the turbidity sensor. Figure 1 shows the turbidity sensor SEN0189. Turbidity generally refers to the cloudiness of the water, which is the dirt or solid particles in water. Turbidity is measured using optical devices as the measurement is done based on the amount of light received or scattered. The pH sensor used is shown in the Figure 2. pH sensor SKU:SEN0161 is a sensor which detects pH of water. The term “pH” refers to the power of hydrogen termed from Latin. It measures the hydrogen ions in water that helps us to identify the acidity and alkalinity in the solution. The pH sensor is connected to the Arduino to capture the values and then connected to Rasperry Pi. This step helps in the conversion of analog values to digital values. pH value between 6-8 is the measure accepted for plants and trees. As the temperature and pH are dependent, measuring the temperature of the water is considered appropriate. Also the ionization process in water increases with increasing temperature. Hence these three parameters are considered in our work for water quality monitoring. The temperature sensor (DS18B20) used is shown in Figure 3.

3.2 Steps Involved

The diagrammatic representation of the overall architecture is shown in the
Figure 4.

The following steps are followed for measuring the required data.

1. All sensors except the pH sensor are connected directly to the Rasperry Pi.
2. The sensors are immersed in to different water sources and the values are sensed continuously.
3. Threshold limits are preset and if the values go below or above the limit, the same has to be informed to the user.
4. For the messaging service Twilio application is used. The message sent to the user helps the user to protect his crops from any harmful contaminants.

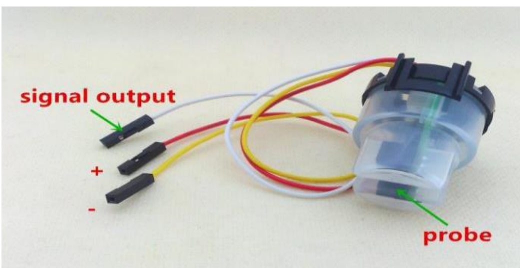

Figure 1 Turbidity Sensor

Figure 2 pH Sensor

Figure 1 Temperature Sensor

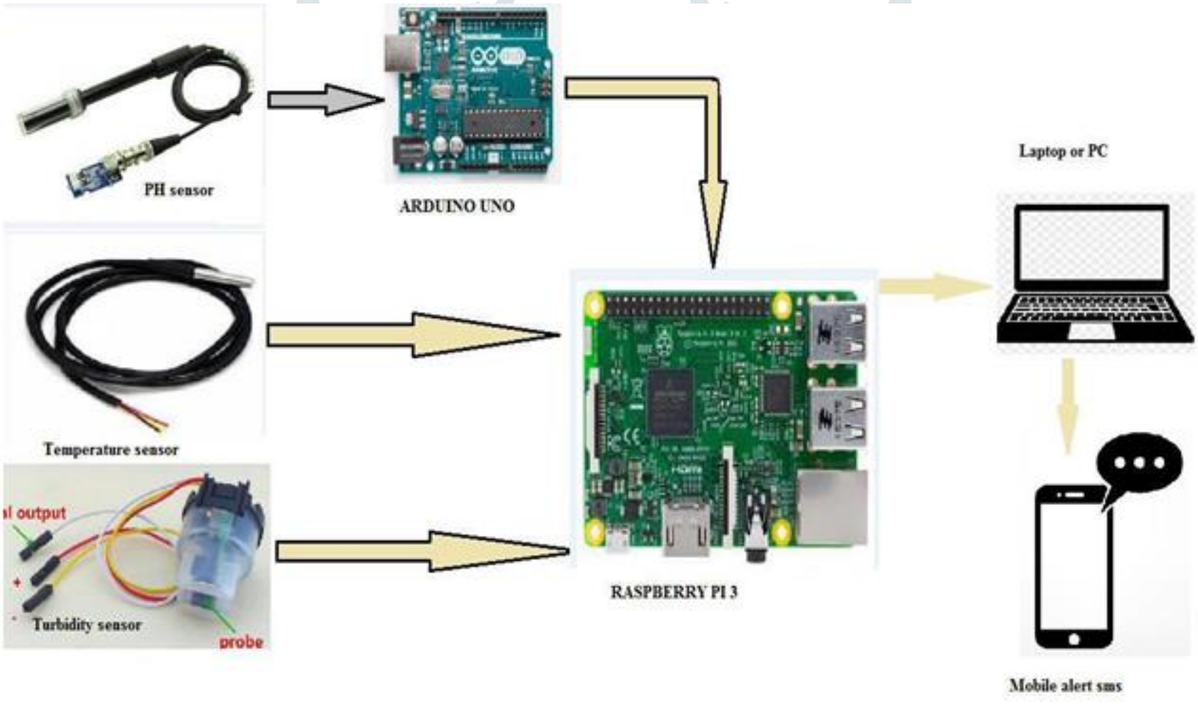

Figure 4 System Architecture

Table 1. Change in pH due to change in temperature

pH Range	Temperature		
	0°C	25°C	60°C
Acid	pH 0.99	pH 1.00	pH 1.01
Neutral	pH 7.47	pH 7.00	pH 6.51
Base	pH 14.94	pH 14.00	pH 13.02

Table 2. pH value of different solutions

Liquid	pH value
Lemon	2.2
Tomato juice	4.13
Tap water	6.85
Distilled water	7
Soap water	11.8

Figure 2 Water with varied turbidity

IV. Results and Discussion

The system is tested with water collected from different sources such as lake, river, muddy water, soapy water, water tank, ground water, etc. The microcontroller device is first connected with the required sensors and the sensing is started. The temperature measure is a factor that even varies the pH of water. Table 1 helps us to learn the variation in the pH value of different types of solutions, as the temperature varies. Acidic solutions seem to show a very minute variation in the pH value with various temperature levels. But a drastic change is noted in other solutions.

The turbidity of varied levels are measured by adding dirt particles in to water of different quantity. The sensor gives a qualitative analysis of turbidity by measuring the voltage levels. It was found that if turbidity is increased, the voltage levels decreased.

Finally, the pH value measurement involves analysis with various types of water solutions- acidic, neutral and base. Table 2 shows the pH of different liquids. Fig 5 shows the measurement of turbidity with various levels of dirt particles.

V. Conclusion

There are various sensors available in the market for the measurement of water quality deciding parameters. Efficient sensors with low cost are chosen for monitoring pH, turbidity and temperature of water. It was shown that as the temperature increases, this shows variation in the pH value too. Thresholds are set for the parameters and an unexpected range of sensing notifies the user immediately through the messaging service. This data can be stored in cloud for visualization and analysis. The system is also scalable for measuring various other parameters in future. This requires very less improvement in the implementation.

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