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ARM based Low Cost Sensor Network for Real Time Contamination Detection in Drinking Water Distribution System

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***Abstract*— In order to prevent health issue one should drink contamination free water. As we know that human body contains about 80% of water. We can't even imagine life without water. International research missions such as mission Mars by NASA is searching for water traces on Mars. This is enough to highlight the importance of water in living things. Such quality of water should be available to everyone in abundant quantity. For availability of such quality water we have developed a strict regulatory mechanism to monitor water quality. Our system will make sure that the water supply to the city is as per the quality marks opted by the government. Our system will monitor pH, turbidity, conductivity, and temperature on real time basis. Hence immediate action can be taken before creating any issue relating to public health. Contaminated monitoring will help to stop supply of water to city thereby reducing the water wastage. This is current need of our society. This system consists of in-pipe electrochemical and optical sensors and is very reliable & can work for a long time. It also helps us to reduce the manpower which in turn reduces the expenditure on workers salary.**

Keywords*— *ARM Microcontroller, Zigbee, pH, turbidity, conductivity, Programming, arduino due,WTP…

INTRODUCTION

Drinking water is defined as water intended primarily for human consumption but which has other domestic uses also. It may be consumed directly from the tap, indirectly in beverages or foods prepared with water or for bathing and showering. In short, just about anything we do or touch involves water directly or indirectly. Drinking water should be safe to use and aesthetically pleasing. Ideally it should be clear, colorless and well aerated with no unpalatable taste or odor and it should contain no suspended matter, harmful chemical substances or pathogenic microorganisms. From public health perspective physical and chemical factors determine whether our water is safe to drink.

Access to good water supply and sanitation generally improve people's health and quality of life. Good quality water is also critical to ecosystem and economics.

21st century continuously goes with use of Robotics and automation. This give very high performance and high operation speed within minimum cost and time, having minimum error. We are managing various things for our convenience and comfort. Today, time is an important parameter. Everyone is expecting that particular thing should be done at appropriate time.

Metro cities like Mumbai, Bangalore Delhi having rich municipal Corporations can spend large amounts on water treatment and monitoring process. But this is not the case everywhere in India. A low cost and reliable mechanism is proposed in this paper. Multi barrier approach providing safe drinking water is based on ensuring that several barriers are put in place to prevent contaminants getting entering into drinking water. These include physical barrier such as source protection and treatment processes. Another important barrier is the regular monitoring and testing of water. Without monitoring and testing, there is no other way of knowing whether or not the system is giving quality water that meets the guidelines for safe drinking water. Traditional system includes collecting samples from various spots and analysis is done in test labs. So disadvantages of these systems are that there is no continuous and remote monitoring, more manpower requirements, less reliability, no on field monitoring etc. Hence there is a need to have low cost reliable and real time system which monitor water quality from remote location. System proposed in this paper will overcome all these drawbacks.

II. LITERATURE SURVEY

Sensor networks in their initial phase of development were designed and deployed on the ground for operations. Now a day's In-pipe, compact, reliable and wireless sensor networks are attracting increasing interest from the researchers. Various advanced and sophisticated sensors were deployed to measure and monitor the contamination in drinking water. In general, drinking water tone measures are determined by the system and ensure that the detected parameters were found within the range specified by World Health Organization for drinking water.

At present, very few number of online and chemical reagent free water monitoring systems are available those can be use for commercial purpose. For example Hach HST, Guardian [1], J-MAR, Biosentry [2]. These are some of the techniques found useful for water contamination monitoring. But these techniques are too much expensive and can't be afforded by small scale institutions for their laboratory experimentation. Along with high cost, sensors in these systems are so bulky and enclosed in close cabinets. So these systems are prone to haziness as time goes. Because of encapsulation they can't be frequently opened and cleaned at regular intervals. Moreover

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set up of these systems are very large so system can take reading from limited number of spots. Contrary to these large scale systems, multi-parametric solid state sensors using semi-conductor ruthenium oxide nano structure were also developed for water quality monitoring. Similarly various chemical composition based sensors were also developed using thick film technology [3].
In addition to all above systems, large number of other water monitoring technologies have been developed using wireless sensor networks (WSN) [4, 5]. For example a WSN and an energy efficient solar panel module for monitoring proportion of chlorine, ammonia, nitrates in rivers and lakes. A technology with very less cost has been developed which consist of sensors such as Endetec KAPTA 3000-AC4 for detection of residual chlorine and conductivity of water. One more promising but not fully developed technology is Lab On Chip (LOC). Lab on Chip technology makes use of micro fluids and sensing capabilities and produces results of contamination on the go (OTG). This technology expands the range of remote location parameter analysis capabilities in near future time and eliminates certain analysis done in laboratories.
Along with the R&D in the field of sensor technologies another aspect is also getting popular. This includes use of software and algorithm for detection of water quality anomalies. For example Hach event monitor [6], Blue box algorithm [7] etc. However these are very costly due to their initial phase of development. Most popular and widely used software is CANARY. This software is free ware and so free of cost. CANARY produces results on mathematical and statistical modeling.
Traditional and promising water quality monitoring technology is given in next section of this paper with particular emphasis on low cost and innovative sensor technologies.

III. SYSTEM MODELLING

The proposed system in this paper monitors water samples on real time from remote location using WSN (Wireless Sensor Network). Continuous monitoring is done on a computer placed in laboratory. The proposed system for Water quality monitoring is divided into two parts.
3.1 Remote monitoring station:
Remote monitoring station equipped with computer terminal along with ZigBee module. ZigBee module receives data continuously from controller placed at remote site. Received data is then displayed on computer. Figure 3.1 shows block diagram of Remote Monitoring system.

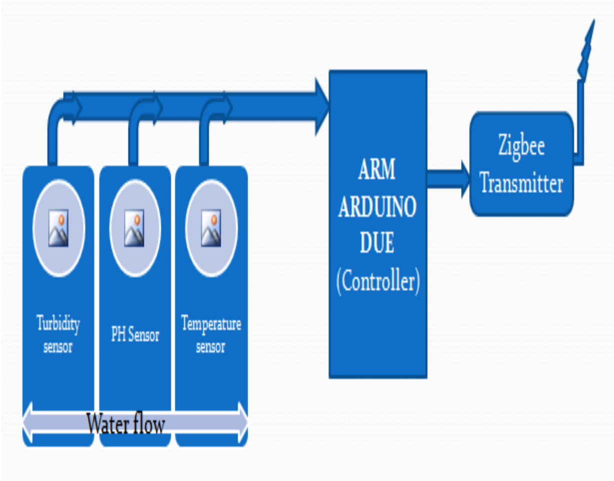

Figure 3.1: Block Diagram of the Transmitter Section

3.2 Transmitting station
This station equipped with ARM controller and four sensors. These sensors interfaced in such a way that they immediately feed the sensed data to controller without any delay. This ensures the real-time working of the system. ARM controllers manipulate this sensed data with high speed and transmit it to remote monitoring station. For regular check up transmitting station is also equipped with LCD screen so that water parameters can be checked easily during regular maintenance. Hence no need to go to monitoring station each time when system is under maintenance. Figure 3.2 shows Transmitter Station block diagram

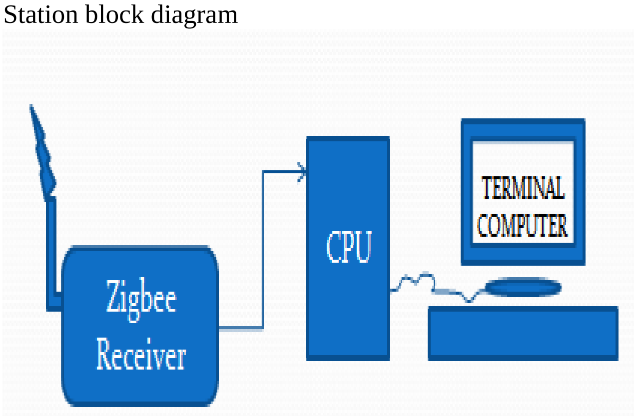

Figure 3.2: Block Diagram of the Receiver Section

This is the overall scenario of the system. Working of system and results analysis is done in next section.
ARM controller monitors pH, turbidity, conductivity and temperature values. Four parameters are monitored simultaneously and continuously on real time basis. In this approach ARM arduino due Cortex M3 controller acts as Central Controlling Node (CCN). ARM receives the data from multi array sensors and provides wireless gateway to send data to remote location.
Turbidity sensor: In this system optoelectronic turbidity sensor is used shown below.

Figure 3.3: Turbidity sensor

Although many turbidity sensors are available in market we choose optoelectronic based sensor. This sensor is low cost compatible with ARM controller and also easy to calibrate. Basic principle behind working of this sensor is explained below.

An infrared narrow beam LED emitting a ray of light through a gap of water and two IR photodiodes placed 1 cm apart receives this 90 °scattered and 0° transmitted light. Based on this difference, sensor generates certain voltage. This voltage is the actual output from the sensor. This can be given to input of controller. Next to this is to calibrate this sensor. Calibration is done in very simple fashion. To calibrate sensors multiple numbers of samples were prepared with different turbidity values. Each sample is then measured both by the turbidity sensor and with the pre existing turbidity meter. From the relationship between outputs of these two systems, sensor is calibrated. The output generated by the turbidity sensor is directly proportional to turbidity of water samples.

pH sensor: This is the electrochemical sensor used for monitoring alkalinity of water. Internal schematic of pH sensor used in this technique is shown below.

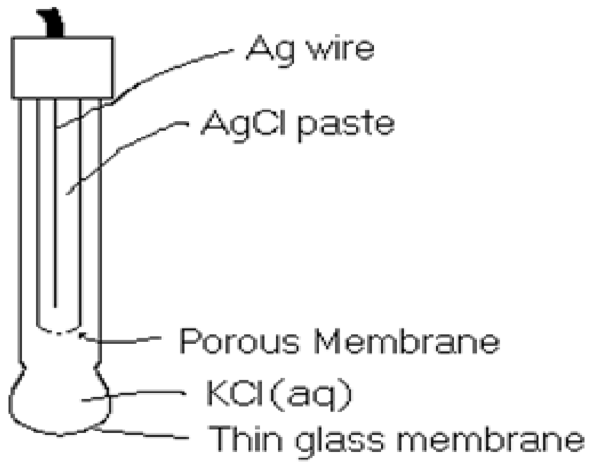

Figure 3.4: pH sensor

The basic principle behind operation of pH sensor can be understood from its internal structure. It consists of two glass tubes inner tube and outer tube respectively. Inner tube consists of silver wire surrounded by silver chloride membrane. Outer tube consists of aqueous solution of KCl.

When pH sensor is dipped in water sample outer tube gets in touch with water. So hydrogen atoms contained in water get aligned to walls of outer tube of pH meter. This in turn develops potential difference across two boundaries of tubes. This potential difference is proportional to the pH values of water. Calibration of pH sensor is done in similar way as that of turbidity meter. i.e. dual method comparison and then compensating the difference using mapping in programming in ARM controller.

Temperature sensor: In this approach temperature of surrounding is measured because it plays vital role in chemical process involved in water filtration process.

LM35 is used as temperature sensor for temperature measurement. Fig shows the LM35.

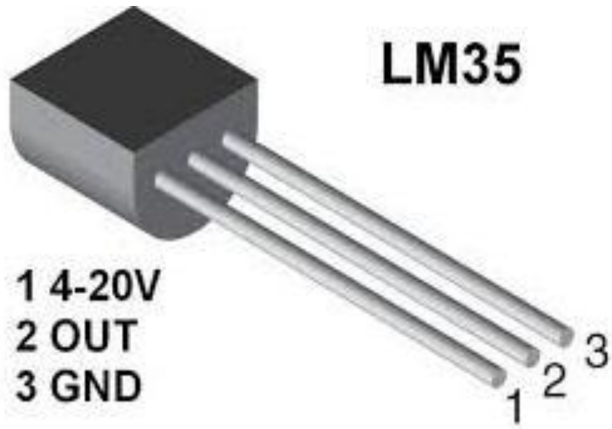

Figure 3.5: Temperature sensor

Here in this sensor there are three pins one for the voltage (Vin), ground (GND), other for Output. LM35 gives output in analog form in specific voltage range. This voltage can be mapped into actual values of temperature using arduino controller.

Conductivity sensor: Conductivity of drinking water ensures the range of standards to which water filtration process carried out. Figure 3.6 shows working principle of conductivity cell.

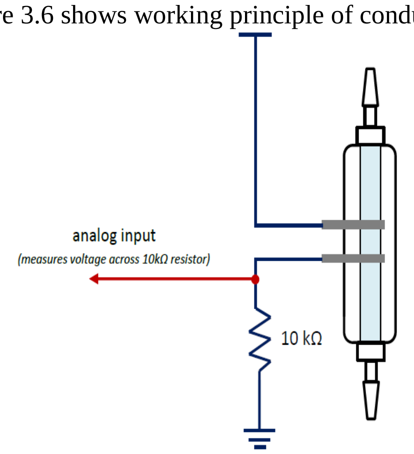

Figure 3.6: Conductivity circuit.

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If water is not treated to the mark then chemical composition of water is less. So conductivity of such water sample is less (Below 150 Siemens) because of low concentration of ions and thus lesser conductivity of water. Multiple readings are taken by making different samples with different conductivity. These samples are checked through both the system. Differences in readings were noted down and then system is calibrated.

By using this array of sensors we can monitor these four parameters on real time basis. Since all these sensors are analog we have to use analog pins of ARM controller. After calibrating all the sensors they are mounted on actual platform. While mounting sensors on platform special care has been taken so that their orientation inside pipe should be specific so that it will not block flow of water in the pipe. Water should freely flow through it. Final output is taken after fixing the sensors on platform and compares the output with standard system.

The pictorial view of developed system is shown below.

Figure 3.7: Developed System

As seen from the figure water enters the pipe from top side leaves from bottom. Four sensors from top to bottom are conductivity,temperature,turbidity and pH respectively.

IV. PERFORMANCE ANALYSIS

After mounting sensors on fixed platform,system performance is checked. The output of system is checked and compared with pre exixsting lab sensors. Following table I shows the standard values for water quality.

Table I: Parameters and their standard values

PARAMETER	STANDARD VALUE	UNIT
Turbidity	0-900	NTU
Conductivity	160-250	Siemens/cm
pH	0-14	pH
Temperature	5-40	°C

Calibration: It is the key aspect of this proposed method.ARM controller gives output in 10 bit resolution. So we are getting output values in the range of ‘0 to 1024’.By analyzing the response of each sensor to different samples, a scale was developed & then the system is calibrated accordingly.

Developed system gives output in two stages. In first stage, system showing output before calibration. Readings before calibration shown by system are given in table II.

Table II: System performance before calibration

Sr.No	Turbidity (In NTU)		Conductivity (IN Siemens/cm)		pH -	
	Standard	Approximated	Standard	Approximated	Standard	Approximated
1	1	3	178	245	8.41	8.30
2	1	3	188	253	7.83	7.53
3	2	6	186	249	7.90	7.58
4	1	2	189	255	7.88	7.55
5	1	3	188	254	6.99	7.31

At this stage, system performance giving erroneous output. This output is corrected after re calibrating the system. Final results are obtained and are shown in table III.

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Table III: System performance after calibration

Sr.No	Turbidity (In NTU)		Conductivity (IN Siemens/cm)		pH -	
	Standard	Approximated	Standard	Approximated	Standard	Approximated
1	1	1	178	180	8.41	8.35
2	1	2	188	190	7.83	7.79
3	2	2	170	168	7.90	7.85
4	1	2	189	187	7.88	7.80
5	1	3	188	189	6.99	7.09

As seen from table III, after successful calibration system gave proper values of water samples which are same as that of standard system.

V. CONCLUSION

In this project we have developed a system which detects contamination in drinking water such as Turbidity, pH value of water. By making use of advanced sensors the output we are getting from system is sure enough and accurate. As calibration is very important issue, proposed method makes calibration task very easy. We made this system wireless with the help of Zigbee module, so that we can remotely determine the instantaneous values of water samples. Performance of the system is crosschecked in municipal corporation lab and output is found same as that of the standard value.

VI. ACKNOWLEDGMENT

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