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In-Situ Water Monitoring Using Portable Sensor

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ABSTRACT

Pathogen screening is very important in water quality monitoring in water quality monitoring, because the presence of dangerous bacteria can seriously endanger human health. There are different methods for in-situ water monitoring. But this system has more advantages when compared to different methods. The advantages of this method are the time taken to find purity of the water is reduced when compared to other methods. Periodic checking is available in this method. The operations which is takes place in this system is completely automatic and thereby reduces manual work. This system consists of a thermoregulation board and impedance measure board. Both boards were connected with the incubation chamber which consist of sample under test which is directly in contact with stainless steel electrodes. The pH, turbidity and temperature of sample under test(SUT) is measured separately by using sensors. GPRS is used to collect data from impedance measure board, pH sensor, turbidity sensor and temperature sensor and sends the information to the user. The input from the waveform generator in the impedance measure board is given to the electrode which is directly contact with sample in the chamber. The resistive and capacitive components of electrode which is directly contact with the sample is calculated by controller and sent to the user by GPRS.

Keywords: Bacteria, Coli Forms, Impedance, Portable Sensor.

I. INTRODUCTION

A. Water borne disease and bacteria

Drinking water contaminated by human or animal faeces, which contain pathogenic microorganism. Water borne diseases are caused by digesting or coming into contact with and infected or contaminated water source The full picture water-associated diseases is complex for a number of reasons. Over the past decades, the picture of water-related human health issues has become increasingly comprehensive, with emergence of new related infectious diseases. Some water related diseases are almonellosis, cholera, shigellosis, malaria,S chistosomiasis, Anaemia, ,Ascariasis, Botulism, Campylob, Acteriosis, Cryptosporiodiosis, Cyanobact, Erial,T oxins, Dengue, Diarrhoea, Dracu, Flurosis, Giardiasis, Hepatits and Hookworm. Numerous bacteria, Viruses, Parasites and Toxins can potentially cause waterborne diseases. The bacteria which causing waterborne disease are Salmonella, Campylobacter, clostridium, Shiga toxin-produced Escher coli (STEC), Listeria, Vibrio, Yersina, etc. Virus which causing diseases are Norovirus, Rotavirus, Hepatitis. Some parasite causing waterborne diseases are Entamoeba histolytica, Cryptosporidium parvum, Cyclosporine, cayetanensis, Microsporidia, Cystoisosporabelli, Trichinellaspiralis, Taeniasolium, Taeniasaginata, Toxoplasma gondii, Giardia duedenalis.

B. Methods to determine Water bacterial content

There are different methods for monitoring coli forms in drinking water. Traditional method to determine coli forms in drinking water are multiple-tube fermentation (MTF) technique and the membrane filter (MF) technique using different specific media and incubation conditions. Limitations of those methods are given below

i. Duration of incubation is large.
ii. Antagonistic organism interference.

iii. Lack of specificity and poor detection of slow growing or viable but non-culturable (VBNC) microorganisms.

The membrane filter method is an inexpensive and simple method to determine coli forms in drinking water. The detection of coli forms based on specific enzymatic activity has improved the sensitivity of these methods. The enzymes b-D galactosidase and b-D glucuronidase are widely used for the detection and enumeration of total coli forms and Escherichia coli, respectively. Solid phase cytometry can be employed to decrease the time needed for the detection of bacterial enzymatic activities, with a low detection threshold. Molecular methods is used to detect coli forms with very specific and rapid detection without any cultivation step. There are different types of molecular methods. They are the immunological, polymerase chain reaction (PCR) and in-situ hybridization (ISH) techniques.

C. Role of impedance techniques for bacteria detection

In the field of microbiology to detect and quantify the bacterial content using impedance technique which has principle, transduction.

Impedance microbiology is one of the common impedance method for detection of bacterial growth. It is based on the measurement of changes in electrical impedance of a culture medium or a reaction solution resulting from the bacterial growth. By this method bacterial content can be detect within 24 hrs. Association of Official Analytical Chemists International (AOAC) approved impedance technique in 1992 as a first action method for screening Salmonella in food samples. The integration of impedance technique with biosensor technology has led to the recent development of impedance biosensors that is expanding rapidly for bacteria detection (Ruan et al., 2002; Yang et al., 2004b; Radke and Alocilja 2005).

The impedance biosensor methods have substantially reduced the assay time down to between 30 min and 2 h compared with growth-based impedance methods.(Liju Yang et al., Biotechnology Advances 26 (2008) 135–150). In this project we are going to design impedance biosensor to detect insitu water bacterial content. The sample water is also connected with pH, Turbidity, temperature sensor to identify the bacterial content. The detected values are collected by user through GPRS. The method can be applied in tanks, lakes, ponds etc which is used to store water for drinking. Here stainless steel electrodes are used which may not cause any disadvantage, Because stainless steel has no toxin material which effects the water. This sensor is portable setup ,it can be set in different places and information can be collected by single user.

Parameter	Accuracy	Range
Temperature	±0.5 °C	-10 °C to +85 °C
pH	±0.20	0 to 14
Dissolved Oxygen	±0.1 mg/L	0 mg/L to 20 mg/L
Conductivity	±5µS	1300 µS to 40000 µS
Oxidation-Reduction Potential (ORP)	±2 mV	-450 mV to +1100 mV

II. METHODS AND MATERIAL

1. Existing Work

Bacterial concentration detection is very important in water monitoring. Various methods were available to check bacterial concentration. These methods includes physical, biological and chemical processes. Physical processes such as filtration, sedimentation and distillation and the heterotrophic techniques were used.

The heterotrophic plate count, formerly known standard plate count technique. It is the procedure for estimating the number of bacteria in water environment. It is widely used to measure the micro organism population in drinking water. It is an analytical method. It is suitable for lower concentration of bacteria. Sample of products were blended in the appropriate solution and aliquots of the suspension, after dilution as necessary, were applied to the medium. The inoculated plate is incubated under required conditions and after the specified time. The number of visible colonies is counted. The result typically expresses colony forming units (C.F.U/g). The purpose of SPC is obtaining an estimate of the number of microorganisms in a feed product can be used to evaluate sanitary practices during processing and handling. It can also be used to determine potential sources of contamination by testing line samples taken at successive stages of receiving, storage, processing, transport, and feeding. Selective

testing for pathogens, were costly, time consuming and risky. SPC is generally a cheaper and quicker test.

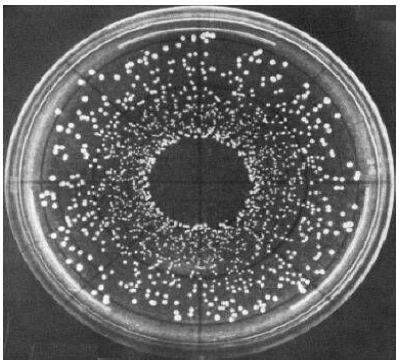


Figure 1.

A. Limitations**:**

SPC measures most microbiological growth, but does not differentiate between naturally occurring bacteria, yeast, molds, etc. and the pathogenic or spoilage organisms. While a high SPC may be used as an indicator of poor sanitation, inappropriate storage, or problems with process control, it does not determine the presence of pathogens (to humans or animals). A low SPC, likewise, does not guarantee samples were pathogen free. SPC does not measure the entire bacterial population, but rather the number of microbes that grow on the specific medium under particular growing conditions.

The type of bacteria that is present is not known - it might be good, it might be bad. The medium/agar may not support growth of certain pathogenic bacteria. It is difficult to distinguish between feed particles and bacteria. It cannot be used on fermented ingredients like cheese. Bacteria colonies may be too small to be seen. Conversely, the colonies can be overcrowded or clumped together, increasing error in reporting. Careful consideration must be given to the agar or medium being used, temperature and time of incubation, length of time and storage conditions of samples, potential contamination of samples, proper dilution of the sample to avoid over-crowding of colonies on plates.

2. Proposed Work

A. Module Description

In this paper there are three modules.

1. Thermoregulation board.
2. Impedance measure board.
3. Incubation chamber.

B. Hardware description

(a). LM135

It is precision temperature sensor which can be easily calibrated. They operate as a 2-terminal zener and the breakdown voltage proportional to the absolute temperature at $10mV/^0K$.The circuit has a dynamic impedance of less than 1Ω and operates within a range of current from 450µA to 5mA without alteration of its characteristics. Calibrated at $+25^0C$, LM135 have a typical error of less than 1^0C over a 100^0C temperature range. It has a linear output.

(b)Analog to digital converter (ADS1262)

It has high resolution and accuracy. It has low-noise PGA and two channel input Mux. It has inherently stable modulator with fast responding over range detection. The ADS1282 is an extremely high performance, single chip analog-to-digital converter (ADC) with an integrated, Low-noise programmable gain amplifier and two channel input multiplexer. It is suitable for the demanding needs of the energy exploration and seismic monitoring environments. The converter uses a fourth-order, inherently state, delta sigma modulator that provides outstanding noise and linear performance.

(c) ATmega328 Microcontroller

It has high performance and advance RISC structure. It has 1.8V -5.5V operating voltage. Temperature range is -40^0C to 85^0C.It is a low power CMOS 8- bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega 328 achieves throughputs approaching 1MIPS per MHz

(d) IRF530 MOSFET

It is designed to minimized input capacitance and gate charge. So it is suitable as primary switch in this project. It is operated upto 175^0C.

(e) ARMSTR912 microcontroller

It has 512Kb internal flash memory, 96Kb internal RAM.ARMSTR 912 controller which combines

a16/32 bit ARM966E-S RISC processor core, dual bank flash memory, large SRAM for data or core and rich peripheral set to form a ideal embedded controller for a wide variety of application.

IV. WORKING PRINCIPLE

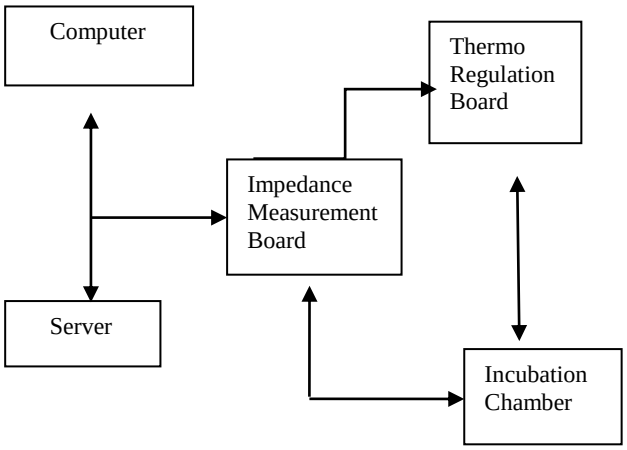
It consists of Thermoregulation board, Impedance measure board, Incubation chamber. Impedance measure board enables the thermoregulation board after receiving the start signal. Then thermoregulation board waits for 30 minutes for the SUT temperature to stabilize. Then, it measures electrical parameters of the SUT at time intervals of 5 minutes When the variation is above 5% when compared to baseline value, it calculates the detect time. The SUT electrical parameters have been measured using the impedance measure board.

A sinusoidal waveform which is generated by waveform generator is given to the electrode in the incubation chamber and the current is drawn from it. Then the current is converted into voltage by I to V converter.

Then input voltage and converted voltage were filtered and these analog values converted into digital data by analog to digital converter. Then it is given to ARMMSTR912 microcontroller for processing the data. Incubation chamber is composed of permanent housing electrodes, peltier cell with heat sink, thermal spreader, thermal insulation, temperature sensor and interconnection of thermoregulation board and impedance measure board .In this chamber bacterial screening will also take place.

Thermo regulation board is used to sense the temperature of the incubation chamber. Thermo regulation board consist of Temperature sensor, analog to digital converter, microcontroller, MOSFET and peltier cell. Temperature sensor along with zener diode connected to SUT in the incubation chamber to sense temperature of SUT.

The data is given to analog to digital converter to convert the input value in digital form. Then digital value is given to ATmega 328 microcontroller which is programmed with PID algorithm to switch ON the MOSFET depending upon the sample temperature. The Peltier cell is controlled by MOSFET depending upon the output of microcontroller.



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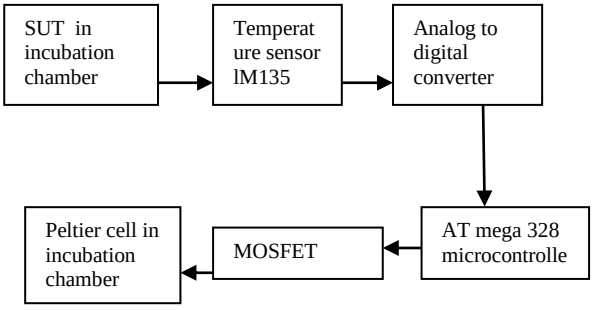

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III. RESULTS AND DISCUSSION

A. Software Discussion

In our this work, the program was executed in arduino software and after getting the result shown figure (1), finally the program will be dumped in arduino board.

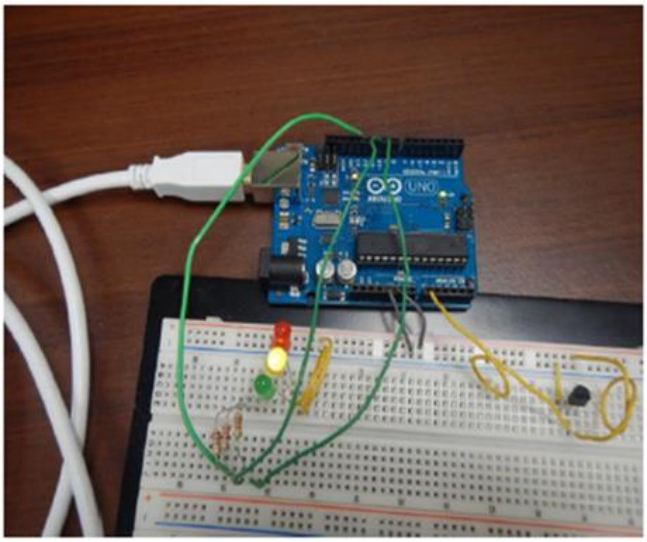

Figure 2. Microcontroller board with temperature sensor

B. Conductivity Tests

The signal obtained using the conductivity output for the water solutions is shown in fig(2) As can be seen, the signal is stable for all conductivities. Besides, a clear correlation between values of potential and the resistivity(σ, inverse of conductivity) obtained with the commercial conductivity meter was observed Conductivity is also affected by temperature being the temperature coefficient of 2.17%/°C

Figure 3. Conductivity Circuit

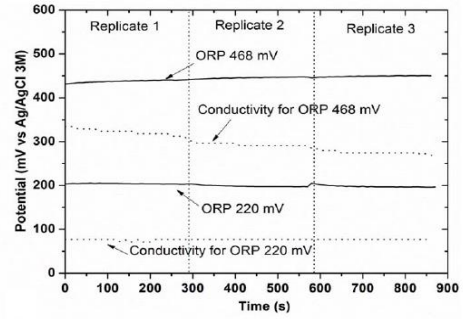

Figure 4. Clear Correlation between Time and potential

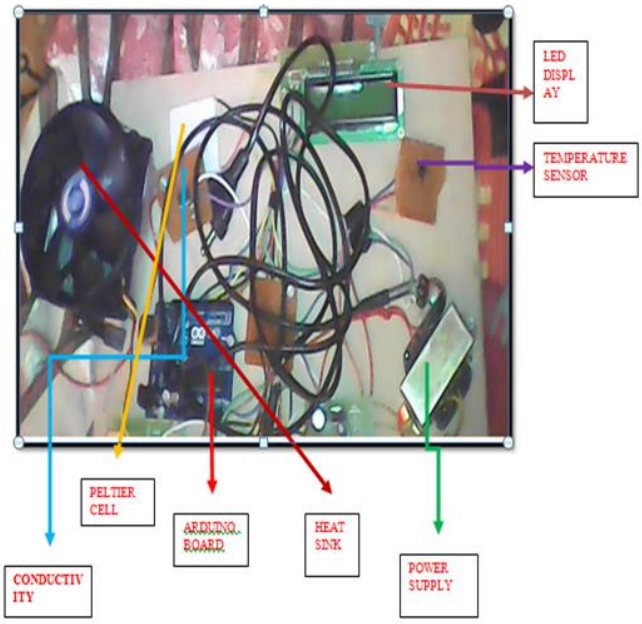

Figure 5. Complete overview photo

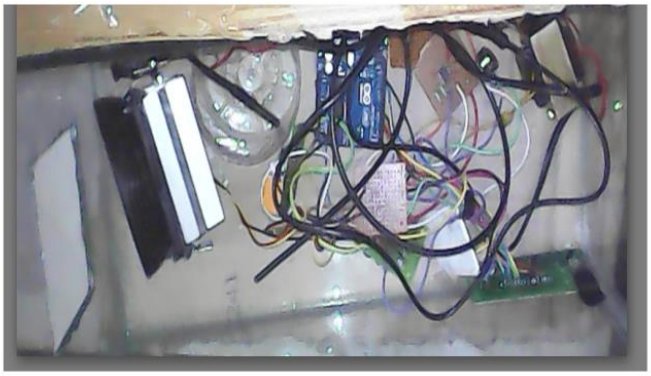

Figure 5. Complete system work

Figure 6. LCD Display Output

IV. CONCLUSION

In this project, we have made in-situ detection of bacterial concentration in water samples and with the standard technique in terms of periodic and possibility to develop an automatic system. The sample bacterial concentration can be measured using simple algorithm based on the electrical parameters.

The sample bacterial concentration can be easily estimated by transform the measured data using a simple algorithm based on the calculation of the first and second time derivatives of the monitored electrical parameter. The results show good correlation between the microbial concentration estimated with the biosensor and the value obtained with the standard technique.

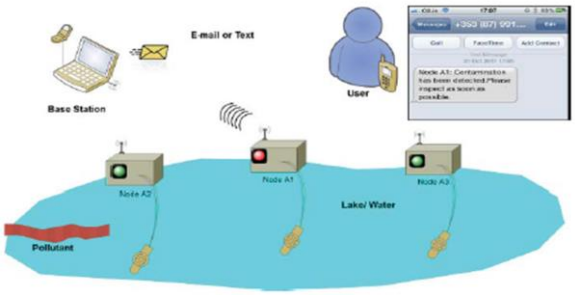

Figure 7. Overview of Future Work

- To implement an incubation chamber consisting of water purity detecting components.
- To develop an android application for updating the status of water frequently

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