Development and Testing of Water Quality Testing Device

Sanjay K Acharya

Abstract– Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact, and drinking water. Water quality is mainly categorized based on, human consumption, industrial and domestic use, etc. It is very important to know the water quality before drinking it, in order to achieve better social health, a device was developed which over comes the problems of conventional lab testing such as delayed results, bad user interface, cost effectiveness etc. the ultimate aim of the device is to reach water quality awareness even to a common thirsty man.
The device was developed and tested for repeatability, time per testing, etc. and found to be satisfactory. The construction, working process, testing on various water samples are discussed in detail.

Index terms – Turbidity, pH, Conductivity, water quality, Eutrophication, total suspended solids (TSS), real time water quality analysis.

1. INTRODUCTION

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact, and drinking water. Water quality is mainly categorized based on, Human consumption, Industrial and domestic use, Environmental water quality.

Internationally the World Health Organization (WHO) has published guidelines for drinking-water quality (GDWQ) in 2011.In India we have, Indian Council of Medical Research (ICMR) ISO 10500 [1] Standards for Drinking Water.

1.1. Need for Water Quality Testing

With the World Water Assessment programmed reporting that every day staggering two million tons of human waste is disposed into water courses, keeping tabs on quality is critical. At its core, the practice of a good water quality testing serves five major purposes.

- Results are used to pinpoint any changes or trends that appear in water bodies over a period of time. These can be short or long term developments.
- Regularly monitoring water quality is a crucial part of identifying any existing problems, or any issues that could emerge in the future
- When designing and developing pollution prevention and management strategies data collected from water quality monitoring efforts is hugely helpful.
- Today governments, communities and businesses are required to meet a range of water quality goals. Monitoring data is used to determine whether or not pollution regulations are being complied with.
- From oil spills and radiation leaks to floods and mass erosion, water quality monitoring data is a must while developing emergency strategies.

1.2 Major Causes of Water Pollution

1. Sewage and Waste Water: Discharge of sewage, garbage and liquid waste of households, agricultural lands and factories disposals, into rivers and lakes.

2. Industrial Waste: Industrial waste such as asbestos, lead, mercury and petrochemicals discharged into water bodies.

3. Oil Pollution: Sea water gets polluted due to oil

spilled from ships and tankers. The spilled oil does not dissolve in water and forms a thick sludge polluting the water.

4. Acid Rain*:* Acid rain is pollution of water caused by air pollution. When the acidic particles caused by air pollution in the atmosphere mix with water vapor, it results in acid rain.

5. Eutrophication*:* Eutrophication is an increased level of nutrients in water bodies. This results in bloom of algae in water. It also depletes the oxygen in water, which negatively affects fish and other aquatic animal population.

1.3 Problem at hand

Tests such as, Turbidity, Total Solids, pH Level, Temperature and Flow Rate, tests are performed on water to determine the water quality. But these tests consume time do not provide immediate results, common man can't understand the obtained results and also not cost effective.

1.4. Problem Strategy

To overcome the problem the above mentioned problems. A device was developed which can perform the water quality tests and provide the results within a small ample of time (within5-8seconds) with better user interface, so that a common man can understand the results.

2. METHODOLOGY

2.1 Development of sensors for detecting the parameters

This device basically tests the water conductivity and turbidity. Conductivity of water is directly proportional to the Total dissolved solids and pH level of the water [3]. For good quality water both of the parameters have to minimum as possible, in turn which means the conductivity of the water of the water has to be low as possible.

This device consists of silver electrodes to measure the conductivity of the water (as shown in Fig.1) the standard values are pre-set and calibrated. The device compares the conductivity of the sample water and the pre-set standard values to give out the results. Turbidity of a water sample is determined by the amount of suspended particles in the water. More suspended particles indicate more turbidity [4]. In order to measure the turbidity of water the device consists of a light dependent sensor (LDR-light dependent resistor) and a light emitting diode placed across the sensor [6]. Based on the amount of light falling on the sensor water turbidity is measured. Due to its simplicity it can be used by any average person with basic knowledge.

2.2 Component Specifications

1. IC: ATmega328P (Arduino UNO) is a high-performance Microchip Pico-power 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts [7]
2. Turbidity Sensor- it is used to measure the amount of light that is scattered by the suspended solids in water. As the amount of total suspended solids (TSS) in water increases, the water's turbidity level (and cloudiness or haziness) increases [4].
3. Conductivity sensor-Water conductivity sensors are used in water-quality applications to measure how well a solution conducts an electrical current. This type of measurement assesses the concentration of ions in the solution. Because more the ions in the solution, higher the conductivity [3].
4. 16x2 LCD Display screen- is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. It allows having a good user interface.
(As shown in Fig.1)

2.3 Circuit diagram

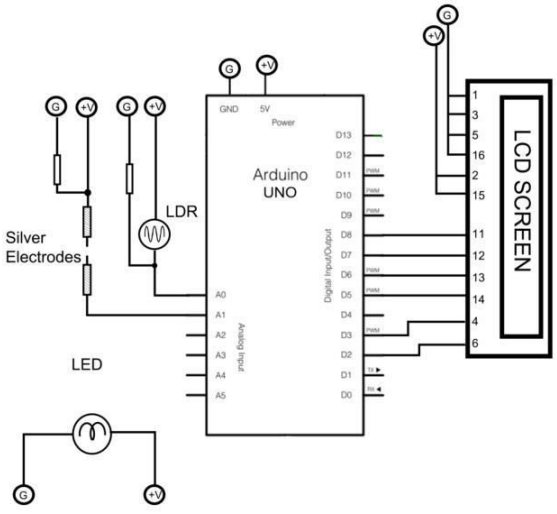

Fig.1 Circuit diagram of Water Quality Testing Device:

2.4 Calibration of device

1. Water sample: Water sample taken in the tube is 10-12 ml. The water sample added is left to settle for 5 seconds. The water sample should not contain particles of 0.4mm. Thus the water sample is sieved before being taken as sample.

2. Conductivity test*:* Water sample added after being settled is subjected to conductivity test. Current passes from one electrode to other. The microcontroller directly monitors the current passing through the water.

3. Turbidity test: The conductivity tests and turbidity are simultaneously tested. LDR sensor measures the intensity of light falling it. A LED is placed directly opposite to the LDR sensor. The light rays from LED pass through the water sample and are thrown on sensor. As the suspended particle concentration increases the amount of light rays falling on the sensor decreases also this is an indication in higher turbidity [4].

4. Microcontroller*:* Microcontroller uses ATmega328P, it receives signals from the silver electrodes and compares the obtained to standard values and displays the result on the LCD screen.

5. Display*:* The display is a 16x2 LCD screen. The RS pin Enable pins are controlled by the digital 2,3I/O pins of the microcontroller. The digital pins D4-D7 of LCD screen are controlled by 8-11 digital I/O pins of microcontroller.

2.5 Conducting the performance tests and test process.

Water sample is taken in a container and is sieved to remove the large particles (if present).
1. Device is turned on and waited for it to display
2. "ADD WATER" (as shown in Fig.2)
The outlet-valve cap is ensured to be closed.
The water is added to the inlet provided in the device.
3. The device waits for five seconds to let the water settle down and obtains the water conductivity and turbidity values from the respective sensors.
4. The sensor values are compared to the standard pre-set values by the microcontroller.
5. The microcontroller then displays the result as "Good Water, Drinkable", "Good Water, Domestic" or "Bad Water, Not for Use". After every test the water test tube should be rinsed with distilled water.
6. before every test reset button(R) (as in Fig.2) should be pressed test to conduct the next test.

2.6 Precautions before conducting test

- The Outlet valve cap should be closed.
- The device should be switch ON.
- Water sample should be free from macro suspended particles before testing.
- The water inlet tube should be rinsed well with distilled water.
- The LCD display should indicate "Add Water" after pressing reset button(R).

.

Fig.2- Addition of water sample into the device.

3. RESULT

After calibration of the device, it was tested for time consumed per test; it was observed that testing takes about 5-8 seconds for a water sample, which is better than the conventional lab testing which takes about minimum of 2 hours. So, we can test more than 400 water samples per hours using the device, which infers that the device can be used for real time water quality analysis with minimum cost as the device doesn't have any consumables.

The device was tested with different water samples for its repeatability, the TABLE1.shows the repeatability of the device for 10 trials.

TABLE 1: Data on repeatability check

Sl. no	Water Location	Test number									
		1	2	3	4	5	6	7	8	9	10
1	Tunga hostel Restroom Washbasin.	B	B	B	B	B	B	C	B	B	B
2	Tunga hostel Water purifier.	A	A	A	A	A	B	A	A	A	A
3	Water purifier adjacent to EEE department	A	A	A	A	A	A	A	A	B	A
4	Wash basin at Annapurna Mess	B	B	B	B	B	B	B	B	B	B
5	Drinking water provided at Annapurna Mess	A	A	A	A	A	B	A	A	A	A
6	Drinking water at Admission block Ground floor	A	A	A	B	A	A	A	A	A	A
7	Pure water(30 ml) mixed with 10g of soil as impurity	C	C	C	C	C	C	C	C	C	C
8	Pure water(30 ml) mixed with 10g of chalk power as impurity	C	C	C	C	C	C	C	C	C	C

A- Good Water, Usage – Drinkable.
B- Good Water, Usage – Domestic.
C- Bad Water Usage - Not for use.

4. CONCLUSION

This device can be used to determine the water quality for quick results which is better than conventional lab testing. The device is good in user interface; even a common man can use it with ease

And also with minimum cost per testing.

The various water samples were tested and their respective quality is determined but the results were not fully reliable as the sensors were locally developed. The device presently not installed with biological sensors. This device can be further developed to detect the Bio-pollutants also. It can be further improvised to monitor water quality using IOT technology for real – time water quality analysis.

5.ACKNOWLEDGMENT

Behind the success of anything, there would be many people whose guidance, suggestions and help rendered at the need of the hour is unforgettable ,Thanks to all.

A special thanks to 'ASPIRE 'project platform, Department of Mechanical Engineering, J.N.N college of engineering for funding and support to carry out the project.

6. REFERENCES

[1] Indian Standard for Drinking Water as per BIS specifications (IS 10500 1991) available at http://www.indiawaterportal.org/articles/indian-standard-drinking-water-bis-specifications-10500-1991

[2] J. Webster, the Measurement Instrumentation and Sensors Handbook, FL, Boca Raton: CRC, 1999.

[3] H. Ramos, L. Gurriana, O. Postolache, M. Pereira, P. Giro, "Development and characterization of a conductivity cell for water quality monitoring", *Proc. 3rd IEEE Int. Conf. SSD*, 2005-Mar

[4] P. Gales "A Comparison of Visual Turbidity with Turbidity Measured by Commercially Available Instruments" American Society of Brewing Chemist Journal pp. 101-107 February 2000

[5] Water quality - Wikipedia en.wikipedia.org

[6] T. Erickson "Turbidity sensing as a building block for smart appliances" IEEE Industry Appl. Mag. pp. 31-36 May/Jun. 1997

[7] A. M. Gibb, New media art, design, and the Arduino microcontroller: A malleable tool. PhD thesis, Pratt Institute, 2010.