A SURVEY OF WATER QUALITY MEASUREMENT SENSORS

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Abstract

Water is an essential factor for sustaining life on earth andits adequate and safe supply must be accessible to all. As improved water quality is beneficial for health. Every possible effort should be made in that direction. Water quality depends on various physical and chemical standards such as color, turbidity, pH, temperature, DO (dissolved oxygen), conductivity and TDS (total dissolved solid).This paper presents a systematic survey of existing water quality measurement techniques which consist of traditional and modern approach of water quality analysis. It also includes a list of different water quality parameters and sensors used for quality analysis along with the standard quality range.

Keywords: *Water Quality Analysis, Turbidity, pH, DO, TDS and Water Quality Sensors etc*

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1. INTRODUCTION

Safe water is primary condition for health and also a basic human right but yet it is not accessible to all human kind. Due to which water related diseases increases day by day which causes 3.4 million deaths a year, mostly among children. Since there are many efforts made by government but still many people do not have access to improved water sources. In many developing countries contaminated water is being used for drinking without any proper former treatment. One of the reasons for this is unawareness in public and administration and the lack of water quality monitoring system which creates serious health issues. As water is the most important factor for all living organisms it is necessary to protect it and water quality analysis is first step taken in rational development and management of water resources [4].

Water quality is measure of suitability of water for particular use. It depends on various physical, chemical and biological parameters. Generally measured water quality parameters are temperature, turbidity, pH, conductivity, dissolved oxygen (DO) and total dissolved solid (TDS).These parameters are measured routinely in order to maintain the good water quality.

2. WATER QUALITY PARAMETERS

Following are some of the important parameters which need to be measured for analyzing water quality:

Temperature:
Water temperature is one of the five important factors for water quality testing. It controls the rate of metabolic and reproductive activities and hence aquatic life cycle. If water temperature increases, decreases or fluctuate, these activities may speed up, slow down or stop. Thermoelectric power and heat resistance temperature sensor are most commonly used to detect water temperature. Water temperature is generally measured in Celsius (ºC).

Turbidity:
Turbidity is a measure of suspended particles present in water also called as cloudiness of water. It is mainly caused by suspended solids like soil particles and plankton (microscopic plants). These particles block the incident light and scatter or diffuse it. Therefore photoelectricity sensor is used to detect the turbidity of water. Turbidity sensor measures the turbidity level of water by measuring the amount of light scattered at 90 degree. Moderately low levels of turbidity indicate a healthy and safe water to drink while higher level of turbidity poses several problems. Higher turbidity of drinking water can provide food shelter to microbes and thus pathogens are more likely to present in such water. More turbid water can also raise the water temperature above normal as suspended particles in water absorb the heat from sunlight. Turbidity of water measured in unit called 'NTU' i.e. nephelometric turbidity unit. For water to be pure its turbidity should lie in range of 0 to 5 NTU.

pH:
pH is an important chemical factor of water. It is measure of acidity or basicity of a solution. It is based on concentration of H+ or OH- ions present in water. pH scale is a logarithmic scale in which value changes in factor of 10. The pH scale ranges from 0 to 14.If pH of a solution is less than 7 then the solution is acidic on the other hand ifpH value is greater than 7 then the solution is basic or alkaline and if pH of a solution is 7 then the solution is neutral. Normal water generally has pH value in between 6 to 9. The most common way of measuring pH of solution involves the use of pH sensitive glass electrode, a reference electrode and a pH meter which measures the difference in electrical potential between the pH electrode and the reference

electrode and display the result converted into equivalent pH value.

Conductivity:
Conductivitydefines the ability of water to conduct electricity. This type of measurement accesses the concentration of ions in a solution.More the ions higher will be the conductivity. For water to be pure it's conductivity should be poor. Generally there are two types of conductivity sensors: two electrodes and multiple electrodes from which two electrodes sensor is commonly used. It is made by using two platinum plates deposited on two parallel glass or inner wall of glass tube. Conductivity of water measures in µs/cm or mA.

Total dissolved solid (TDS):
Total dissolved solids refer to the amount of minerals and salts present in the water. It combines the sum of all ion particles that are smaller than 2 microns. This includes all the disassociated electrolytes that increase the salinity concentration of water and other compounds such as dissolved organic matter. This term can be obtained by multiplying the conductivityterm by a factor usually taken as 0.67. TDS of water is measured in unit mg/L. Freshwater can have maximum TDS as 2000 mg/L.
TDS = 0.67 × conductivity

Dissolved oxygen (DO):
It is amount of oxygen dissolved in water. DO measurement provide one of the best indicator for water ecosystem, as oxygen is essential for all forms of life. Oxygen enters water at water surface through direct exchange of with the atmosphere. The decrease in DO level indicates organic pollutant. DO levels vary in accordance with the weather and temperature. It is measured in unit mg/L. For safe water standard range of dissolved oxygen is 0-20 mg/L.

3. EXISTING TECHNIQUES

There are different techniques available for water quality measurement which involves mainly two approaches traditional and modern.

3.1 Traditional Approach

Intraditional method, water parameters are detected by collecting samples manually and then send them to the well-equipped laboratories for further analysis where the testing equipments are stationary and samples are provided to the testing equipments. But this is a manual method with a tedious process and it has many disadvantages.

Disadvantages:
1) Require too much manpower and material resource.
2) Time consuming.
3) It has limitations of sample collecting.
4) Aging of experiment equipment.
5) Less reliable.
6) Lack of real time water quality information.
7) No on field monitoring.
8) It has relatively high costs (labor, operation and equipment).

3.2 Modern Approach

In order to overcome above mentioned disadvantages there is need to have autonomous, low cost, reliable and flexible water quality measurement system. Various advanced technologies for measuring water quality have been proposed in the recent years.

A sensor based wireless water quality monitoring system is proposed in which the data from monitoring nodes is send to the base station consisting of ARM controller and then sent to the remote monitoring station and then displayed on a server PC [4]. Now a days a wireless sensor network system is also becoming more popular which consist of high power Zigbee based technology together with the IEEE 802.15.4 compatible transceiver [5]. Most of the systems uses sensor circuitry for acquiring water quality parameters and send this data to the controller unit. The controller unit performs necessary actions and then delivers this data to the GSM module so that the data will be sent to the monitoring center in the form of SMS [1][4][6][9][10].

3.2.1 Water Quality Sensors

Temperature Sensor
LM 35
LM 35 is commonly used temperature sensor whose output voltage is linearly proportional to Celsius temperature. It is more accurate than thermistor. It does not require any external calibration or trimming to provide typical accuracies at room temperature over range -55ºC to 150º C. It possesses low self-heating and does not cause more than 0.1º C temperature rise or fall. The output varies by 10mV with respect to every ºC rise or fall in ambient temperature which means its scale factor is 0.01V/ºC [8][10].

DS18B20
It is a digital temperature sensor, using single bus protocol. Operating temperature range is -55ºC to +125ºC and accuracy between -10ºC~+85ºC is ±0.5º [1][7].

PT100
PT100 sensor is a temperature dependent component. Its resistance rises linearly with the temperature. Its operating temperature range is -50ºC to +230ºC. It is low weight precise temperature measuring device with ±0.5 ºC accuracy. Its nominal resistance is 100Ω at 0ºC and has no self-heating. It is available in 2 wire, 3 wire and 4 wire package [6].

WQ 101
WQ101 is a rugged reliable water temperature sensor that has two wire configurations for minimum current draw in which red wire is for supply and black is for output signal. Its operating temperature range is -50ºC to +100ºC with accuracy of ±0.1ºC. It operates on 10 to 36 V DC supply. It requires 5 seconds of warm up time.

Table -1: Comparison of different temperature sensors

Sr. No.	Name	Operating Range	Accu-racy	Applications
1	LM 35	-55 to 150ºC	±0.5 @ 25ºC	Soil & water temperature measurement
2	NTC Thermistor	-40 to 125ºC	±0.5 to ±3 @50ºC	Temperature measurement sensing & control in Industrial and Consumer electronics
3	DS18B20	55 to 125ºC	±0.5ºC @-10~85ºC	Temperature measurement which requires 9 to 12 bits of resolution.
4	RTD PT100	-50 to 130ºC	±0.5ºC	Temperature monitoring control & switching in windings, bearings, machines, motors, transformers & many industrial applications
5	WQ101	-50 to 100ºC	±0.1ºC	Open water environmental monitoring applications such as stream & lake monitoring or aquaculture studies

Turbidity Sensor

Photoelectricity sensor

It works on phenomenon that, when light rays passed through waterthe amount of light scattered is equal to the turbidity of water. More the suspended particles more will be light scattered that means higher the turbidity of water. Photoelectricity sensor consists of LED at transmitter side and LDR at receiver side. When LED emits light the rays passes through water and scattered due to suspended particles present in water. LDR detect the scattered light rays and likewise measures the turbidity of water [6].

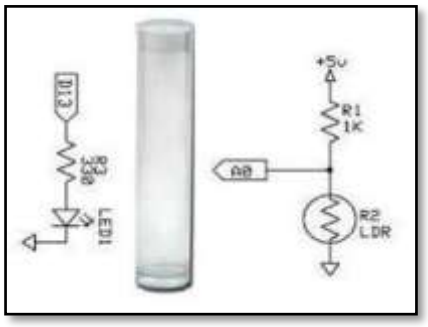

Fig -1: Turbidity sensor

TSD 10

This sensor also uses light to convey information about turbidity of water.As shown in Fig-2,it has two horns like structure having top to bottom mono material body with a black colored cap at the bottom. The thick alloyed contact legs provide means for various connectors to hold the sensor. TSD 10 turbidity sensor is shown below:

Fig -2: TSD 10 sensor

A white plastic slab protects the legs from damage and acts as fixture for good clamping. Outer part is covered with plastic so that it can survive high variations and mechanical abrasion. It works on 5 V DC supply and current up to 30mA. It operates on temperature ranging from -10ºC to +90ºC.

TSW 10

It is an optical sensor which is used as measuring product for turbid water density or an extraneous matter concentration using the refraction of wavelength between photo transistor and diode. By using an optical transistor and optical diode this sensor measures the amount of light coming from source of light to the light receiver in order to calculate water turbidity. It works on 5V DC supply and current max. Up to 30mA over operating temperature range of -30ºC to +80ºC. Internal structure of TSW 10 sensor is shown below:

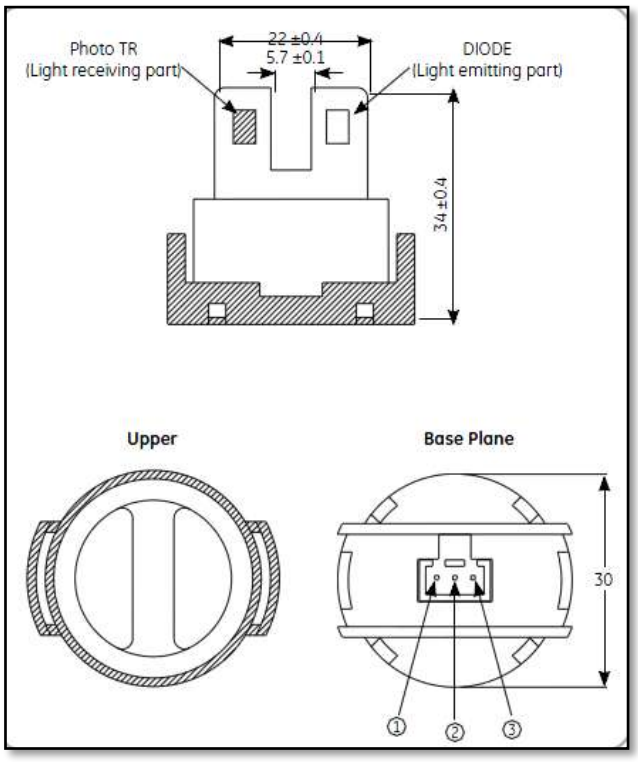

Fig -3: Internal structure of TSW 10

pH Sensor

A pH glass probe is made up of special glass that can conduct electricity and allow only hydrogen ion. When glass probe touches the hydrogen ion the potential is produced. Likewise different pH in water generates corresponding potential [1]. It has pH value ranging from 0 to 14. It operates on temperature range of 5 to 60ºC.The combined electrodes (glass and reference) are fitted with BNC type connector as in pH sensor module. Below the cap a hole is provided for filling the solution in internal reference electrode. It operates on 5V DC supply and current of 5 to 10mA. Its response time is 5 sec. and stability time is 60 sec. It has service life of 3 years and has analog voltage signal output.

Conductivity Sensor

Conductivity sensor circuit is same as that of photo resistor circuit. A voltage divider circuit consists of the conductivity sensor and a 10kΩ resistor which is energized by setting high digital output. Some portion of 5V dropped across sensor while remaining portion dropped across the 10kΩ resistor. Conductivity sensor circuit is shown below:

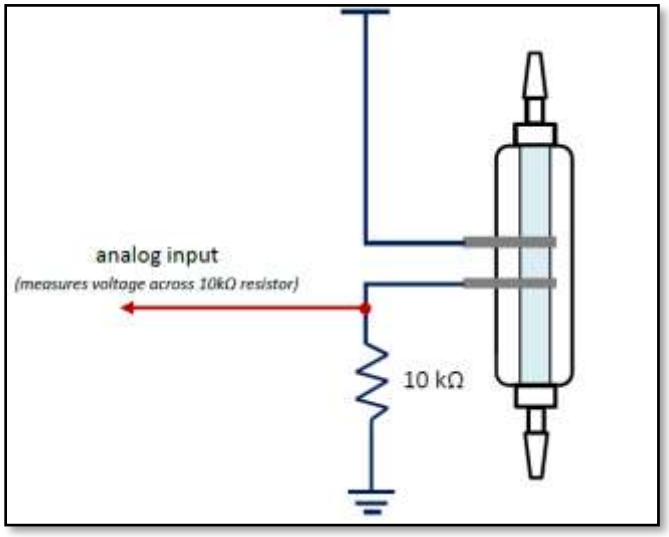

Fig -4: Conductivity sensor circuit

Voltage drop across 10KΩ resistor is measured by an analog input on ADC while voltage drop across conductivity sensor can be easily measured by making it the resistor closest to ground.

DO Sensor

WQ 401

It is a dissolved oxygen sensor which has three electrode structure and three wire configuration. If electrolyte deteriorates, the sensor can diagnose itself. Its temperature compensation can reach up to 25º C with output 4-20 mA. Its testing range is 0-8 ppm, accuracy is ±0.5% of full scale, and operating temperature is -40 º C to +55 º C. It is removable and easy to maintain [1].

3.2.2 Water Quality Range

Following table shows important water quality parameters as per IS 10500-2012 standards:

Table -1: Treated water standards

Sr. no.	Parameter	Acceptable	Cause of rejection
1	pH	6.5 to 8.5	<6.5 or >9.2
2	Odour & Taste	Unobjectionable	Objectionable
3	Turbidity (NTU)	5	10
4	Total Dissolved Solid (mg/lt)	500	2000
5	Conductivity (µS/cm)	500	1000
6	Total Hardness (mg/lt)	300	600
7	Dissolved oxygen (mg/lt)	20	<5

4. CONCLUSIONS

Water quality measurement system measures the parameters of water like pH, turbidity, temperature, conductivity, total dissolved solids and dissolved oxygen in order to detect the quality of water for deciding whether it is safe for drinking or not. From existing techniques available for quality measurement sensor based system is efficient, economical, convenient and fast than the traditional method. The sensor based system also has good flexibility as only by replacing sensors and small change in software programming this system can be used for measuring other water quality parameters as per their applications in industry or agriculture.

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