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Study of IoT Based Smart Water Quality Monitoring System

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Abstract: ***IoT based water quality parameter monitoring system is a significant interest in the field of cost-effective smart water quality monitoring systems. As we know that the population growth of your country is high in last few decades. In India, the demand for freshwater for drinking purposes, agriculture, and other activities is much higher than compared to other countries. The requirement of a smart water quality parameter monitoring system is necessary to reduce the time required in the traditional approach of water quality monitoring, and for real time monitoring. This literature survey work has been conducted in the field of smart water quality parameter monitoring systems. Sensor-based smart water quality parameter monitoring in past some research carried out which is deployed in the water.***
Keywords: IoT, Sensor, Water, Smart monitoring

I. INTRODUCTION

Without water survival of life on the earth is impossible. Due to rapid industrialization and pollution, surface and subsurface resources of freshwater are depleting rapidly, water gets polluted day by day, industrial effluents, discharge of untreated domestic sewage, and agriculture runoff are measure sources of pollution. The availability of portable freshwater has been assumed critical in terms of quality and quantity. the demand for freshwater is increasing because of the rise in population, so management and utilization of freshwater become essential for a safe future.

Freshwater for drinking becomes the most precious matter on this earth, Due to the pollution of water, many water-borne diseases spread. Microorganisms present in water are capable of infection and transmitting the disease to a human being and animal, which is harmful to human and animal health. Organic and inorganic solids are responsible for turbidity, taste, odour, and colour in water. Multivalent metallic cation present in water leads to the formation of Hardness. Due to minerals or due to atmospheric CO2, mixed in water or due to microbial decomposition of organic matter leads to the formation of Alkalinity in water. The presence of chloride indicates the pollution of water due to sewage or industrial waste. Free Nitrogen indicates recent pollution due to organic matter and Organic Ammonia signifies a complex organic matter in water. Nitrite is highly dangerous as it signifies partial decomposition of organic matter and nitrate presence in water is not so much dangerous as Nitrite, because it signifies complete decomposition of organic matter, but if its concentration is more than 45 mg/l then cause Methemoglobinemia.

In this paper, we have given an idea on IoT based monitoring system of water, which can help in rapid monitoring of water quality parameters for reducing the chance of epidemic out the beak, related to contamination of water, because according to WHO, about 80% of all the diseases in the human being are caused by water (N. Giljanovic et al). This paper is organized into five main sections as follows: In the first section, introduction of topic and problem in the traditional way of water quality monitoring and its solution is discussed. In the second section commonly used drinking water parameter is discussed. In the third section of the paper, we discuss the existing system of water quality parameters monitoring. The fourth section of the paper discusses literature survey on smart water quality parameter monitoring based on the Internet of things. The last section of the paper concludes how IoT can help in real-time monitoring of drinking water quality parameters.

A. Problem In Traditional Way of Water Quality Monitoring

Water quality parameters are classified as Physical, Chemical, and Bio-logical content. Monitoring of water quality parameters is traditionally done in a lab, this type of monitoring involves mainly water sampling, testing, and investigation, field experts manually do it. In these steps, a considerable amount of cost and time is involved, although these steps are conducted by field experts, accurate monitoring of water quality by using chemical reagents and various equipment in the laboratory is difficult, and not fully reliable.

B. Solution To the Problem

In the modern world Many problems related to the monitoring of various factors as air quality monitoring, noise level monitoring, and flood monitoring has been solved by the Internet of things. Sensor-based devices connected to the Internet are used in real-time monitoring, for flood control, Sewer monitoring, and garbage control. IoT based monitoring can be used for water quality monitoring of River, Lake and underground water. In water quality monitoring various issues, such a collection of data, data transfer from sensor to the monitoring station, data analysis, and early warning of pollution can be easily done Using smart monitoring techniques based on Internet of Things.

II. DRINKING WATER QUALITY PARAMETERS

The quality of drinking water is measured through different water quality parameters. The commonly used parameters for water quality monitoring are listed below-

A. pH

Measurement of how acidic or alkaline water is, done by using a scale termed pH. For acidic water range of pH lies between 0 to 6 and or alkaline water range is between 8 to 14, the acceptable range of pH is 6.5-.8.5 for drinking water as per Indian standard. pH meter, electrometry pH electrodes are used for its measurement. It is significantly correlated with electrical conductivity, total hardness, sulphate, and total suspended solids (EPA 2001; Bhandari & Nayal 2008; Verma & Singh 2012; Ali & Qamar 2013; Patel & Vaghani 2015)

B. Turbidity

Turbidity is a measure of the dirtiness or haziness in water caused by suspended solids and colloidal material (e.g clay, silt, sediment, algae). Turbidity is measured in Nephelometric Turbidity Units (NTU) and is measured using a relationship of light reflected from a given sample. Turbidity is very variable in the Lower Lakes and is influenced primarily by wind events. The lower and upper range of turbidity as per Indian standard IS: 10500- 2012 is 1 to 5 NTU.

C. Hardness

Hardness is caused by multi valent cations of calcium and magnesium, and by a variety of other metals. General guidelines for classification of waters are 0 to 60 mg/L (milligrams per liter) as calcium carbonate, is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard. Water systems using groundwater as a source are concerned with water hardness since as water passages through soil and rock it dissolves small amounts of naturally occurring minerals and carries them into the groundwater supply.

D. Dissolved solids

Dissolved solids refer to any minerals, salts, metals, cations, or anions organic or inorganic in nature, dissolved in water. Total dissolved solids (TDS) include inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some insignificant amounts of organic matter that are dissolved in water.The range of Total dissolved solid for drinking water is 500mg/l to 2000mg/l.

E. Colour

colour means a true colour that is the colour of the water from which turbidity has been removed. The true colour of the water is due to dissolved solids, apparent colour is due to the suspended solids as well as due to substances on solution removed by filtration. Colourless water is acceptable for drinking (Aesthetic as well as toxicity reasons). Hazen unit is used for measurement of colour in the water, the range for colour in drinking water is 5 to 15 Hazen units.

F. Temperature

One of the most important parameters of water is temperature, which has a great effect on aquatic life. The quantity of dissolved oxygen present in water get reduces with an increase in temperature, gas transfer is also affected by the temperature. Celsius is a commonly used unit for temperature measurement, the range of temperature for drinking water is 10 to 25 Celsius. It is highly correlated with electrical conductivity and loosely correlated with pH (EPA 2001; Verma & Singh 2012; Ali & Qamar 2013; Khatoon et al. 2013)

G. Chlorides

Chlorides are found as salts such as sodium chloride (NaCl), potassium chloride (KCl), and calcium chloride (CaCl2). Existence of Chlorides indicate pollution of water either due to sewage or industrial waste. Chloride levels in unpolluted waters are generally below 10 mg/l and sometimes even below 1 mg/l. Chloride in water may be significantly increased by treatment processes in which chlorine or chloride is used. The range of chlorides content for drinking water is 250-1000mg/l. It is highly correlated with total hardness, electrical conductivity, and chemical oxygen demand (EPA 2001; Bhandari & Nayal 2008; Khatoon et al. Patel & Vaghani 2015).

H. Dissolved Oxygen

The oxygen solubility in water is indicated by the amount of oxygen dissolved in it. For the survival of aquatic life in water, body DO content should be sufficient, the limit of DO for the survival of aquatic animals is 4.2mg/l. In the lab, Winker titration is used for dissolved oxygen measurement. It is highly correlated with electrical conductivity, biological oxygen demand, and sulphates (EPA 2001; Patel & Vaghani 2015).

I. Total Coliform

Total coliforms give an idea about the fecal coliforms and similar another type of non-fecal bacteria which is mostly found in soil. The membrane filter test, the Most probable number test (MPN) is used to check coliform in water.

TABLE 1
Organoleptic and Physical parameters of Drinking water as per IS:10500: 2012

SI NO.	Characteristic	Requirement (Acceptable limit)	Permissible limit in the absence of Alternate source
1.	Colour, Hazen units, Max	5	15
2.	Odour	Agreeable	Agreeable
3.	pH	6.5-8.5	No relaxation
4.	Taste	Agreeable	Agreeable
5.	Turbidity, NTU	1	5
6.	Total dissolved solids, mg/l max	500	2000

III. THE EXISTING SYSTEM OF WATER QUALITY MONITORING

The traditional method of water quality parameter monitoring 3 main steps:

1) Sampling
2) Testing
3) Investigation

These 3 steps used in the existing system of water quality monitoring are difficult, consume a significant amount of cost, and are time-consuming. A skilled person is required for testing the water sample in the lab, by titration of water with reagent generally test is performed, the result of the experiment is noted manually, it may contain some error. For real-time monitoring of water quality parameters IoT based monitoring technology is required for better monitoring of water quality parameters.

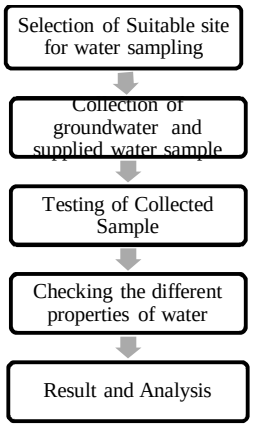

Fig. 1 Block diagram of existing system of water quality monitoring

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IV. LITERATURE SURVEY

Shruti Sridharan developed a low-cost wireless sensor network for monitoring water quality parameters such as turbidity, temperature, the pH level of water, in real-time. This wireless sensor network is based on the high power Zigbee technology with IEEE 802.15.4 [1]

Troy, S M et al. (2002) use Eco Mapper an underground vehicle for mapping the quality of underground water. The drawback of this system is that it has a small life span of 8-14 hours with a low speed of traveling. For the operation of this system, human help is required, in underground contaminated water monitoring is not safe for human health. [2]

Peter, G (N.d) introduced a digital camera for monitoring protozoa and biological pollution which is placed in sampling water. By this system o monitoring, the classification of pollution cannot be performed without applying further analysis. Robotic fish can be used for the better monitoring of biological and chemical pollution in underground water.[3]

R Karthik Kumar, et al. investigated underwater wireless sensor network technology for monitoring water quality parameters, which is powered by a solar panel. Through wireless sensor network data such as pH Turbidity and oxygen level in water is collected, and send to the monitoring station. At the monitoring station receiver collect the data and displays, data collected by the sensor is further analysed by using the simulation technique.[4]

Daudi S. Simbeye and Shi Feng Yang presented, a wireless sensor network for aquaculture to detect and control the water quality parameters such as temperature and water level in real-time. Zigbee wireless communication standard is used for transmitting the data collected by node of sensor, host computer uses lab view software platform for data analysis, processing, and presentation. The owner receives the data of water quality parameters in form of short notification from the base via the Global system of module notification. If due to the temperature rise, the dissolved oxygen gets depleted then the pump can be auto-started, to maintain the oxygen level and water level in a pond, for avoiding fish kills. The system has the advantage that the water quality parameter can be monitored by reducing the cost of monitoring.[5]

Brinda Das, P.C. Jain proposed "Real-Time water quality monitoring using internet of things. They suggested the traditional way of water quality parameter testing requires, any number of samples of water and then tested in the lab by a skilled person. This method of water quality parameter monitoring is time-consuming and requires a skilled person and the cost of monitoring is more compared to the monitoring of water quality parameters by using the various sensor. They used the Zigbee module to transfer the data from the sensor to the microcontroller wirelessly, and further, the data is transferred by the microcontroller to a smartphone by using the GSM module. An official can monitor the change in the water quality parameter, if water quality gets polluted then immediate action can be taken.[6]

Nikhil R, et al. presented a smart device for water quality parameter monitoring based on IoT technique, the quality of water is easily monitored utilizing collecting the water parameter data. They use a pH sensor, water level sensor, turbidity sensor, and conductivity sensor for collecting the data of parameters. The sensor used in the system collects the data and sends it to Arduino Uno, Wi-Fi -module is used for transmission of data to the user. This system minimizes the time and cost required for the detection of water quality parameters.[7]

Punit et al. proposed IoT based water quality monitoring system based on Raspberry Pi3 development board programmed with python framework, and Mat plot lab library is used for plotting water quality parameters. They used temperature, pH, electrical conductivity, and dissolved oxygen sensor for water parameter monitoring, all sensors are calibrated with reference solution before testing to reduce the measurement uncertainty. The advantage of the proposed system is that they use Raspberry Pi for IoT implementation which consumes low power by using real-time monitoring for various applications such as pound lake and river water rapid monitoring and contamination detection can be done easily.[8]

Mohammad Salah et al. (2019) presented a water quality monitoring system based on a wireless sensor network in which real-time monitoring is done by data collection at remote areas by the sensor, the monitoring can be done at a remote area by accessing the data of water quality. If obtain a value of the parameter is above the threshold value an alert notification will be sent to the authorized person. neural network classification on water parameters is used to predict the water quality as good or bad. Classification is based on the Hadoop cluster neural network which has the advantage that neural networking is based on an artificial neural network that is good for nonlinear relationships and learning.[9]

Vaishnavi et al. (2017) developed low-cost devices based on IoT for real-time monitoring of water quality for real-time, monitoring of water quality, they use the various sensor for measuring the water parameter as a chemical parameter, physical parameter, and flow, measurement of these parameters is done by using the various sensor as temperature sensor turbidity sensor and flow sensor core controller Arduino model is used for the processing the data, by using Wi-Fi module, water parameter at an instant can be view

on screen with the help of internet. Arduino used in this system is programmed on embedded C language which converts the analog value given by the sensor into a digital value and display shows the output value.[10]

Gowthamy J et al. (2018) they developed a real-time monitoring system of drinking water by using IoT technology various sensors as flow sensors for flow measurement temperature, turbidity, and ultrasonic sensor for monitoring physical quality parameter monitoring and pH sensor for detection of how acidic and basic water is used, data generated by the sensor is control and process with the help of Arduino, a Wi-Fi module transfer the data to the user internet which is connected to Arduino. change in water quality parameters can be easily observed and data collected by the system can be used for analysis. [11]

A. IoT System for Water Quality Monitoring

Internal of things, is any system in which the data is collected by using various sensors and transfer data over a user system without any manual intervention. In the internet of things all devices are connected to the internet and can communicate with each other over the internet, IoT techniques are used in Civil engineering projects for water and air quality monitoring in real-time.

IoT system fundamental element are Sensor, Connectivity unit, Data processing and User interface these elements are connected to each other by internet. Sensor is device which is used for collecting data from the surrounding, for communication Wi-Fi, Bluetooth, wide area networks are used by connecting sensor to the cloud, various software is used for data analysis and processing and give notification to the user, in form of text or mail.

For monitoring of the water quality parameter, various sensors as pH sensor turbidity sensor, flow sensor temperature sensor are connected to the controller unit for processing, between the MCU and GPRS module series of communication unit act as a phase. With the help of the GPRS module, the data is transferred to the control unit, and data is stored in the cloud for further analysis. The block diagram of the water quality monitoring system is shown below-

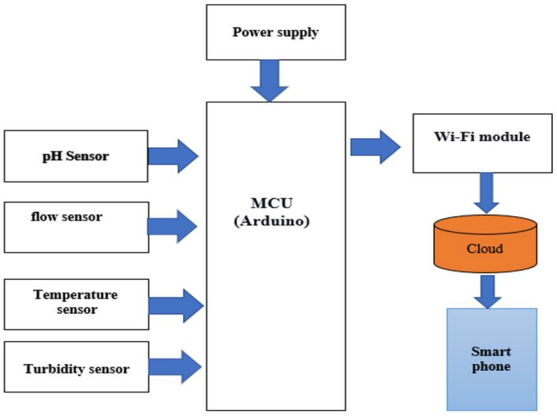

Fig. 2 Block diagram of IoT based water monitoring system

1) first of all, critical parameters for the drinking water is determined, the critical parameter for the drinking water can be used as pH, temperature, turbidity, and hardness, for collection of these parameter data sensor is used.
2) In the next step data collected by the sensor is transmitted to a microcontroller, for the next step of processing.
3) foremost of the sensor used in IoT based water quality monitoring will grant the analog output the ADC used within the controller will convert into digital and transmit the measured information utilizing GPRS module connected to the microcontroller utilizing UART convention, the information gotten is passed onto the server through GPRS and a short message is sent into the authorized person device.

B. Advantage of IoT Based Water Quality Monitoring

The advantage of water quality monitoring are as follows:

1) IoT-based water quality parameter monitoring has a very low cost in operation as compared to the traditional way of water quality testing.
2) Real-time monitoring can be done by using IoT through this system authorized person can take immediate action if the pollution level in water increases.
3) Pollution levels in water bodies as lake river pond can be monitored from a base station.

V. CONCLUSION

IoT-based water quality parameter monitoring by using multiple sensors can be used for monitoring of water quality at a node of water supply gride, for better management of water for safe future. The traditional method of water quality monitoring requires more time and money as compare to IoT-based water quality monitoring systems. Accuracy in water quality parameter monitoring can be increased by adopting IoT based smart water quality monitoring system. Data collected by IoT-based systems can be used for development of Artificial intelligence-based water quality monitoring systems. Additionally, we found IoT based system of water quality monitoring can be used for designing of smart water tank for smart city.

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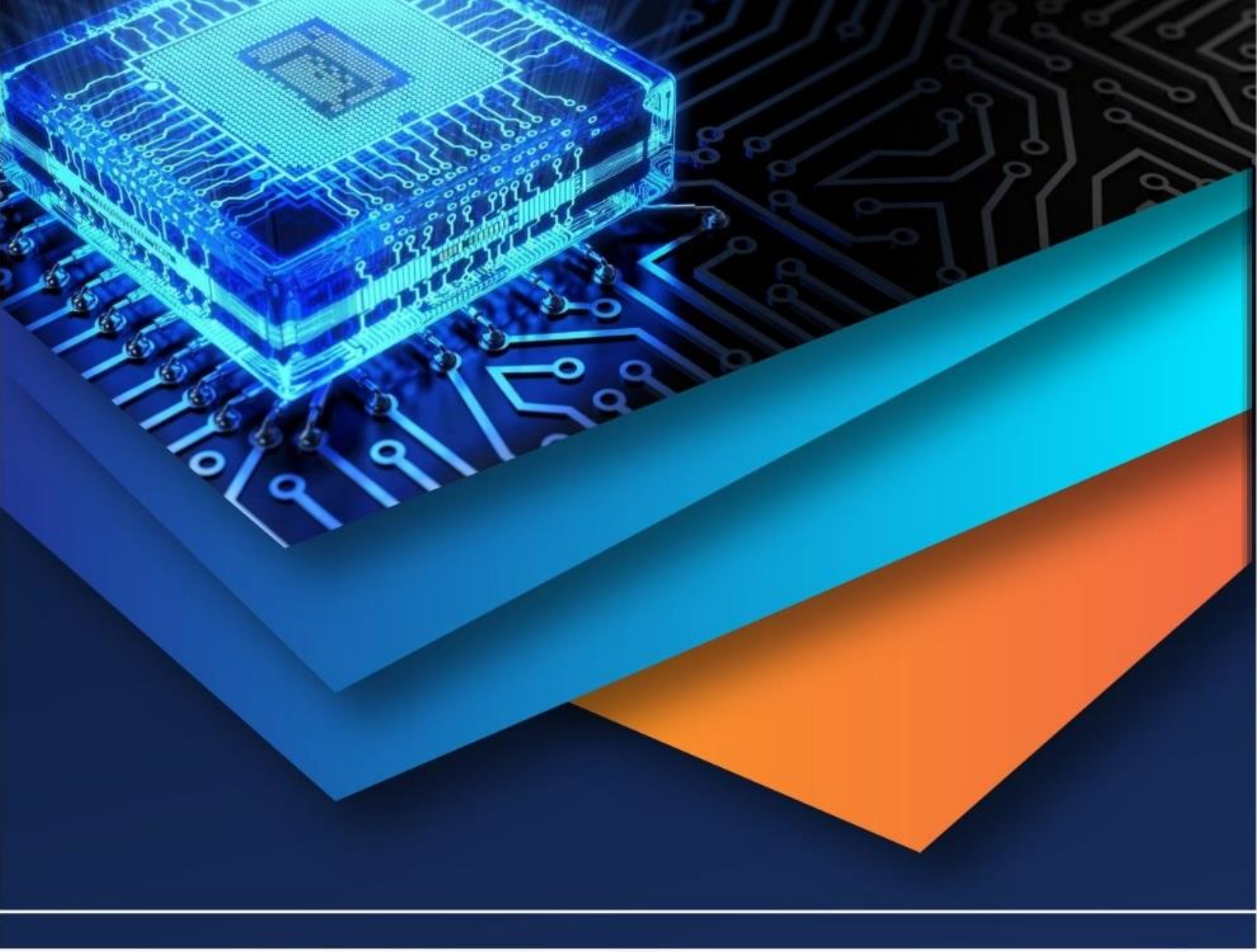

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