# Comprehensive Reviewon Various Technologies of Water Quality Monitoring System

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**Abstract:**

Theincreased water pollution and deteriorating environmental pollution in modern world has stressed us to devise innovative ways to survive in the coming age of water scarcity. Such innovative solution pointtoward treatment of widespread availability of sea water. This treatment will involveIOT through sensor technologies. Network based on wireless systemis becoming an efficient way to keep a watch on various vital parameters of nature. The real time water quality monitoring system using an array of sensors for evaluating TDS, PH,Turbidity, Conductivity in desalination process provide the smart solution for testing the desalinated seawaterwith a measured value on display.There is a need to develop low cost, low power and efficient real time monitoring of water quality system. The main objective of this paper provides the insights given in the existing methodologies for real time seawater quality monitoring system. The various problem pertaining to the sensor node efficiency, self-sustained and ecofriendly power resources, low accuracy and low data transmission speed, lack ofeffective filter optimization and self-adaptive system also been identified and discussed. The solutions for the discussed problem suggested for future prospects.

**Keywords:** wireless sensor network, pH,Internet of Things.

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## Introduction

Effect of global warming and increase in population have led to depletion of glaciers and underground water. Water pollution isfurther aggravating this issue of water scarcity [1]. We are dumping all this polluted waste water in oceans or seas. The seawater is the only solution for this crisis but it is not fit for use due its high salinity, electric consumption, TDS and cost.Various techniques like R.O, Distillation, and Electro-dialysis etc. are being used to make it fit for use. All these techniques require a perfect monitoring, controlling and testing of water parameters.The development of water desalination technology has created a ray of hope and is a boon for water scarce areas which are having shortage of water [2]. The parameters of water quality depend on its properties. Though there are various properties deciding parameters of water quality but most important are those which detect water quality such as physical, chemical and biological [3]. The table 1 shown below classified the various water quality parameters values.

**Table 1.**Name ofparametersto measure water quality [4]

| SNo. | Name of Parameter | Maximum Allowable Concentration |
|---|---|---|
| 1 | Sodium | 200 mg/l |
| 2 | Temperature | 10-22 C |
| 3 | Nitrate | 10 mg/l |
| 4 | TDS | 1000 mg/l |



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| | | |
|---|---|---|
| 5 | Fluorides | 1.5 mg/l |
| 6 | DO | 4-6 mg/l |
| 7 | ORP | At least -50 mV |
| 8 | Turbidity | 5.0 NTU |
| 9 | Chlorides | 250 mg/l |
| 10 | pH | 6.5-8.5 moles/l |

Water testing technique used in laboratory are costly, time consuming and they contaminate the sample during sample collection and during its storage. Real time data collection and monitoring is not possible using traditional techniques. Therefore, there is a need for highly efficient and extensive monitoring method to monitorwater quality in real time [5,6]. Figure 1 and figure 2 shows the traditional water quality monitoring technique and real time water quality monitoring system based on WSN respectively [7].

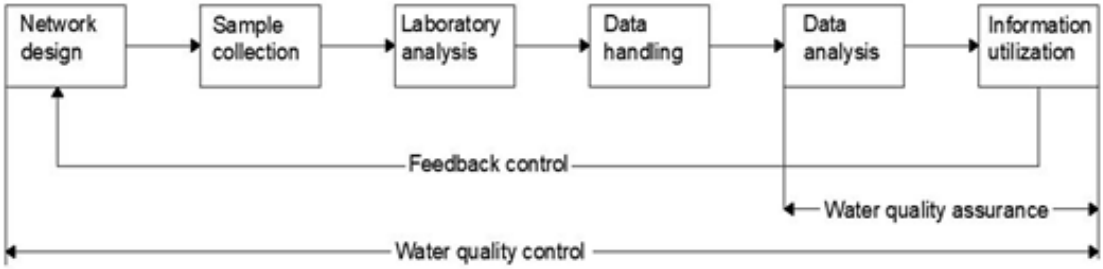


**Fig 1.**Traditional method of monitoring water quality

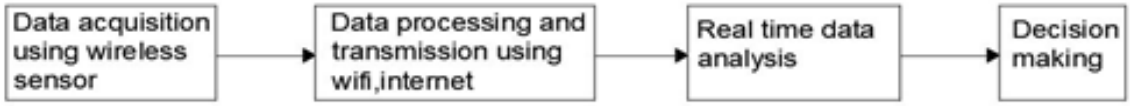


**Fig 2.** Real-time water quality monitoring system

**Table 2:**Comparison of Real time and traditional Monitoring Approaches

| Water monitoring approach | cost | Monitoring type | Size | Strength | Limitation |
|---|---|---|---|---|---|
| Traditional monitoring | costly | Off-site | Bulky | Widely used due to its recognition. | • It may not provide a true measurement.<br>• Difficult to operate<br>• Requires human intervention<br>• Interference from operators |
| Real time monitoring | Less Cost | Real time | Portable | Based on networking | • For long distance network may create problem<br>• It may lag by power consumption. |



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The wireless sensor network has the benefits of remote data monitoring, avoiding a lot of wiring, flexible to physical partition, addition of new device any time, low power consumption, also provides coverage of wide area and high monitoring precision. The emergence of WSN has provided the security of network, monitoring of environment in extreme and acute climatic conditions [8]. The internet of thing is the platform to transfer and monitor data of interconnected electronic devices in real time with high security. The basic building blocks of IOT are sensors, communication, processors, gateways and application [9]. Table 3 below shows the IOT communication technologies in terms of frequency, data rate, range and power usage [10].

**Table 3:** Various wireless network technologies

| Technology | Data Rate | Frequency | Power Usage | Range |
|---|---|---|---|---|
| 2G/3G | 10 Mbps | Cellular Bands | High | Several Miles |
| Bluetooth/BLE | 1,2,3 Mbps | 2.4 Ghz | Low | ~300 feet |
| 802.15.4 | 40, 250 kbps | Sub Ghz, 2.4 Ghz | Low | > 100 square miles |
| LoRa | < 50 kbps | subGhz | Low | 1-3 miles |
| LTE Cat 0/1 | 1-10 Mbps | Cellular Bands | Medium | Several Miles |
| NB-IoT | 0.1-1 Mbps | Cellular Bands | Medium | Several Miles |
| SIgFox | < 1 kbps | subGhz | Low | Several Miles |
| Weightless | 0.1-24 Mbps | subGhz | Low | Several Miles |
| Wi-Fi | 0.1-54 Mbps | subGhz, 2.4Ghz, 5Ghz | Medium | < 300 feet |
| WirelessHART | 250 kbps | 2.4Ghz | Medium | ~300 feet |
| ZigBee | 250 kbps | 2.4Ghz | Low | ~300 feet |
| Z-Wave | 40 kbps | subGhz | Low | ~100 feet |

For proper and long life of wireless sensor-based network of water quality monitoring system, energy harvesting technology using renewable energy sources like solar panel with rechargeable batteries is implemented [11].

The different parts of this paper are organized as follows. Section 2 reviews the development work related to water quality monitoring in detail, section 3 discusses the problems of present techniques and Section 4 discusses the proposed research's significance and conclusion.

## 1. Literature Review

Adamo and Attivissimo [12] proposed a space and time monitoring system for surface water bodies for reduction of the data handling complexity using free space loss and Fresnel-Kirchhoff diffraction. The probes in sea water sensesthe data, collect it and send it to web browser using ISO/IEC/IEEE 21451 based smart sensors network. VPN protocol is used for enhanced data security. The network security is event based and capable to raise an alert message. On the contemporary work, Karray et. al [13] suggested a new hybrid Earn pipe Water Pipeline Monitoring method using Leak detection, Predictive Kalman Filter and



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Modified Time Difference of Arrival, methods based on pressure to monitor the wastage of water in long distance leaky pipelines. Clustering type routing of the sensor is used to minimize the network power consumption. The sensor node collects the data at a frequency in every 5 minutes at a sampling rate 1000S/s. The LPKF filter algorithm detect the noise data and abnormalities at each of sensor node level and then forward it to a sensor cluster head and their data is sent to FTP server using GPS module. Figure 3 shows the complete diagram of the earn pipe water quality monitoring system



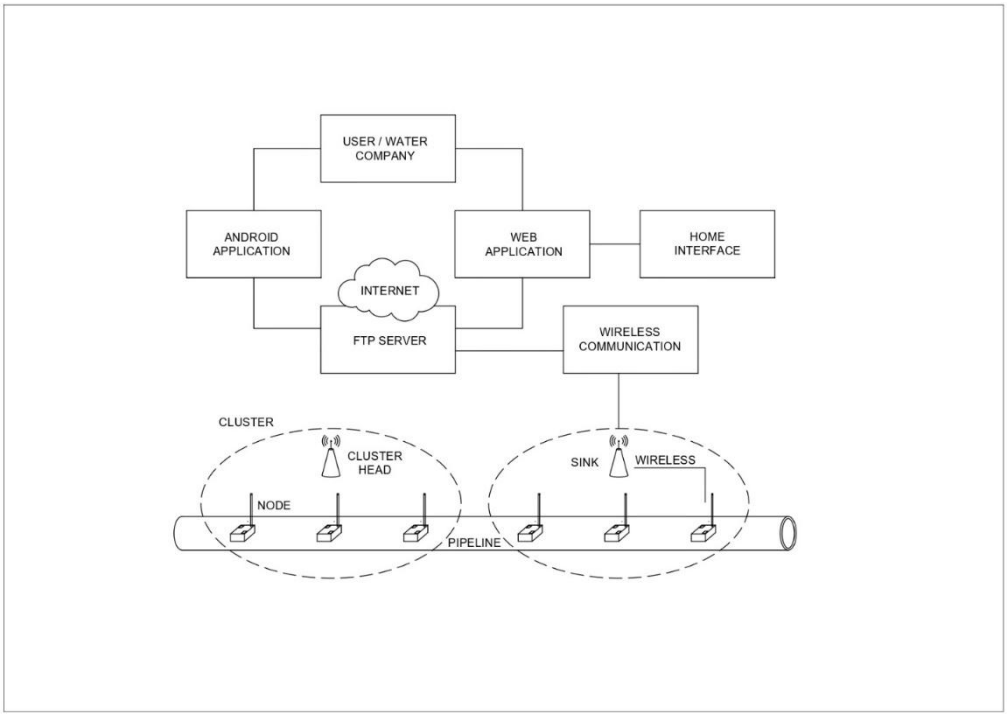


**Fig 3.** Earn pipe-based water quality monitoring

Mat et. al [14] used an IOT based wireless sensor network crop irrigation model in green house using feedback control. The volumetric and Gravimetric methods is used to detect soil water level content for different crops. They further discussed about contact and contact free methods. In contact-based method the sensor's detection area need to be touched directly while contact free does not touch directly to soil. The contact-based sensors are capacitive, heat pulse and fiber optics while contact free sensors are based on thermal methods, passive microwave and synthetic aperture radar. The temperature, humidity and soil moisture sensor nodes send the data wirelessly using Zigbee module for computer visualization.

Cloete and Malekian [15] developed a wireless monitoring system to find water contamination using various parameters such as oxidational reduction potential, temperature, pH, flow and conductivity sensors in comparison to WHO standards. As per author conductivity is directly related to TDS in many cases. The system is divided into four parts i.e., measurement node, wireless node, notification node and the sensing node. Zigbee module is used to transfer data to the notification node which was there displayed on a LCD with an alarm. In the similar way, Das and Jain [16] designed a monitoring system for water quality using parameters like pH, Conductivity, and temperature sensors. They used two data transmission modules i.e.,GSM and Zigbee for



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real time accurate data transfer. The data is processed with the help of LPC2148 microcontroller module resulting in low power consumption and small size. Their system module is based on embedded support and real time emulation of the data points.

Salim et. al [17] Designed a compact measuring device which was based on wireless sensor network to monitor water quality with historical data view facility. This system has three main parts which are low voltage system, portable main station and sensor node. The output of sensor node is sent to webserver and portable main station throughWi-Fi module. Ubuntu mate is chosen with raspberry Pi3 for maximization of the use of touch screen display. Seven parameters i.e., turbidity, dissolved oxygen, pH, temperature, conductivity, TDS and salinity are being worked on in this system. Figure 4 shows the Schematic system design with network



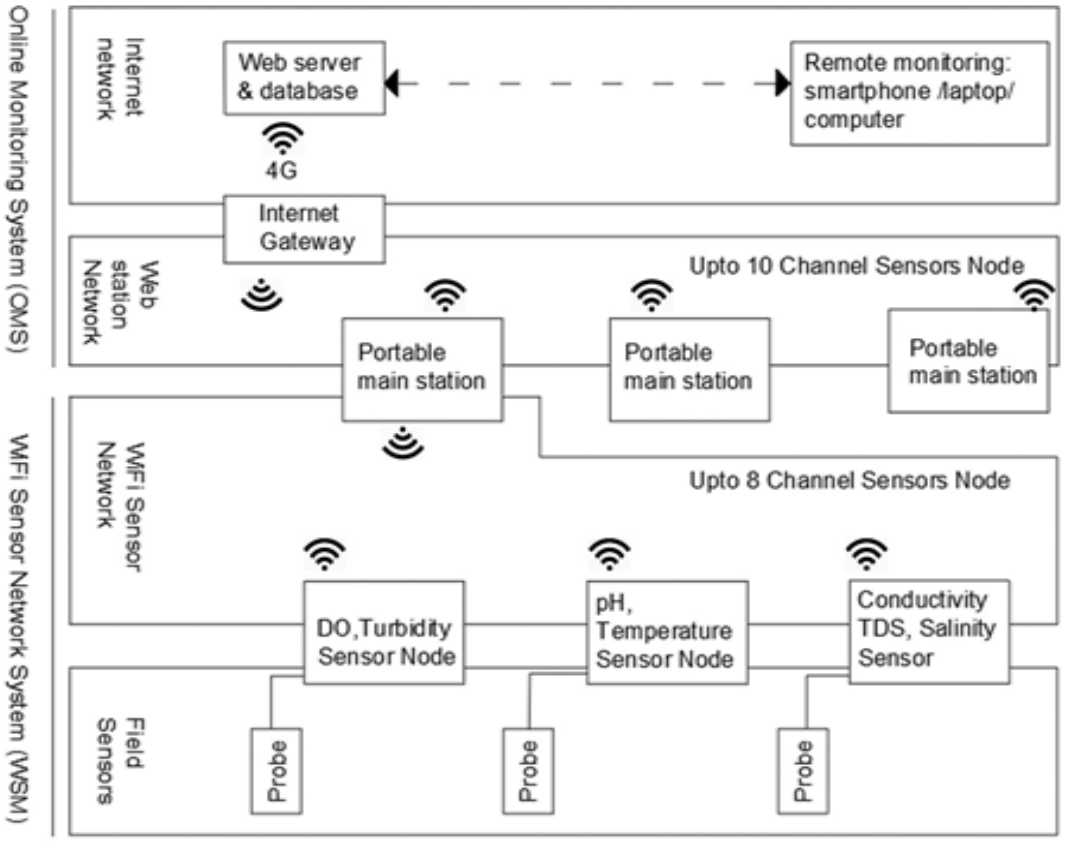


**Fig 4.** Full Scheme System

Ezhilazhahi and Bhuvaneswari[18] developed a plant health and soil health monitoring system. Zigbee technology is used for data transfer. Event detection algorithm is used to increase the lifecycle of wireless sensor network. At transmitter side PIC16F877A is used because it has built in analog to digital converter while Raspberry Pi3 is used at receiver side.Myint et. al [19] designed a interface device which isreconfigurable and smart. The device is based on FPGA board using properties like pH, turbidity, water level co2 and temperature sensors along with multiplexer. Their research has used VHDL and C programming language using Qsys tool and Quartus II software. The data transmission is



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with the help of two protocols i.e., RF and Zigbee. Sensors transmit the data to FPGA using RF module and FPGA send the data to web device using Zigbee module.

Pranata et. al [20] introduced a message queuing telemetry transport protocol-based system for water quality monitoring. It works on throughput for diverse message payload size and data latency. The sensors are connected to a relay node known as publisher and publisher transmits data to Gateway node using Zigbee which is known as Subscriber.Radhakrishnan and Wu [21] focused on active method involving measurement of water quality parameters in real time. A comparison of energy efficient system using energy harvesting method in water quality sensor is also suggested. They had discussed the role of IOT in water distribution system, pipe leakage detection, water waste monitoring, quality factor and energy efficient system.

Saravanan et. al [22] proposed Supervisory Control and Data Acquisition system to resolve thecontamination of water and leakage issue using water flow, color system and temperature sensors. The proposed system is divided into three modules namely sensor module, processing module and communication module. The SCADA system is used for data monitoring in multi-dimensional platform and to control GSM module. KM et. al [23] approached the concept of wireless sensor, IOT and cloud to work out on data computation of pH, turbidity and temperature. The system can be implemented in any surface water body. Keeping in view the robust water environment, the sensors are fabricated in an enclosure.

Simitha and Subodh [24] introduced low power wide area network to clarify sensor nodes range in water quality monitoring using pH, dissolved oxygen, temperature and turbidity. The proposed system performs water quality monitoring, Street light energy saving and air quality monitoring system. The sensors sense the data and the Lora transmitter transmit the data to lora receiver which is connected to Raspberrypi via Esp32 Wi-Figateway module. Figure 5 shows the schematic diagram of the proposed system

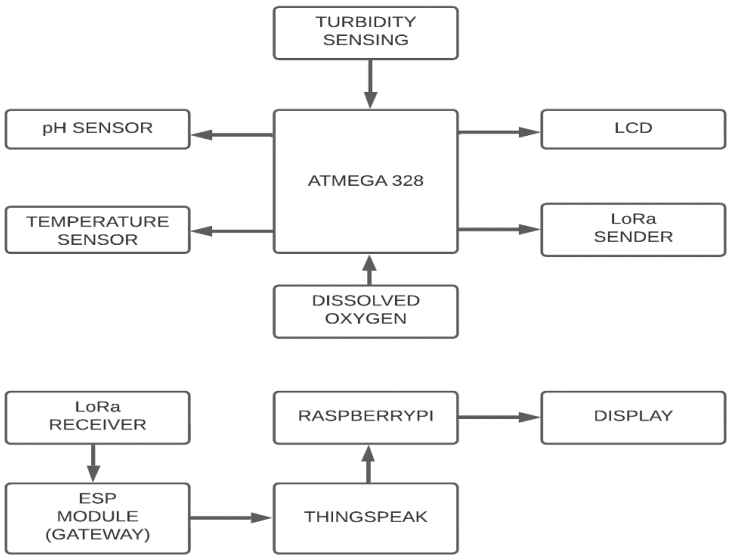


**Fig 5.**Lora based real time water quality monitoring



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Kadir et. al [25] developed a wireless sensor network with backend monitoring of sensor data to figure out the abnormalities in water level and flow rate by assessing temperature, pH, dissolved oxygen, flow rate, salinity and
water level. The author has done real analysis on river water and also worked on flood alert system using GPRS/4G. Carminati et. al [26] researched using long range radio system along with energy harvesting technique to resolve slime deposit inside the pipe and real time water management problem by analyzing slime, pH, conductivity, temperature, flow rate sensors. Their system is powered by kinetic energy harvested with the help of a turbine in pipeline. Think Speak cloud server is used for remote data analysis.

Jerom et. al [27] Introduced IOT for smart water quality monitoring of water bodies using deep learning to remove water pollutants by evaluating temperature, humidity, pH, Co2 emission, dissolved oxygen and soil moisture.Sensors are deployed with buoys and Esp8266 with sleep-awake protocol used for wireless data transmission. The Sleep and awake protocol is used to decrease consumption of power and to increase life of wireless network. Daud et. al [28] Implemented smart aquarium monitoring system based on IOT to resolve out fish feeding issue by assessing pH value. Node MCU and Arduino MEGA are utilized as a controller. BLYNK app is used for data monitoring and analysis which is based on android application. System significantly focuses on IR4.0 system for supporting fish breeding and fish pets.

Huan et. al [29] explored monitoring system of water qualitybased on the narrow band internet of things technology for aquaculture pond. They investigated water quality of aquaculture pond using dissolved oxygen, temperature, and pH. The constrained application protocol used to solve the problem limiting device resources in the internet of thing. NB-IOT technology is used for wireless communication.Feng et. al [30] used Bluetooth technology to provide solution to water quality problem by inspecting variables - conductivity, pH, turbidity and temperature. Design used Arduino ATMega328P with Bluetooth. The data is sensed by the sensor in the analog form and then converted into voltage form to obtain useful actual value. Afterwards, data is sent to smart phone using Bluetooth. The actual data and measured data is also compared to calculate data error.

Rekha et. al [31] suggested IOT based water quality monitoring system which uses GSM to fix the deviation in the quality of water by examining BOD, pH, turbidity, TDS and temperature. They provided remedial solution to the farmers and focused on the soil quality and crop cultivation. Memon et. al [32] used with think speak platform with wemosD1 mini to resolve water quality problem with help of pH, sound waves, turbidity and temperature. This paper discussed about the physical, chemical and biological properties of water. The data is being stored on cloud using think speak server.

Imran et. al [33] worked on wireless sensor network comprising MCU node with raspberry pi3 for data communication using parameters like pH, TDS, dissolved oxygen, turbidity, and temperature. Sensors deployed with a range of distance of 2 km to detect leakage in the pipe. Solar panel are used to improve battery life. Lora technology is used in communication between inter sensor nodes for long range data communication.

ALI J. RAMADHAN [34] analyzed water quality standard using statistic data analysis by



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comparing chlorides, pH, dissolved oxygen, nitrate, fluorides, TDS and temperature. The author discussed about the five-water station of Najaf and Iraq. Each water station has one sensor node and each node comprises of fourparts sensors, power supply unit and trans-receiver. The system is controlled using CONTROLLINO MEGA PLC. The proposed system communicated with central server using Wi-Fi module and provides high usability.

Akhter et. al [35] threw light on Electrochemical Impedance Spectroscopy for developing low-cost water quality sensors to measure nitrate, temperature, Phosphate, and pH. 3 D techniques are used for sensor fabrication. The sensor fabrication consists of four steps, first Design of module with 3D printing then electrode formation with help of MWCNT ink, then PDMS substrate formation on MWCNT electrodes and in the last step sensor is peeled off with curing. Think speak channel used to store, share and analyses data using Lora. The system helped farmers so that they can easily check the crop nutrients level. The main focus is to save cost, time, and labor of the farmers.

Mazharul .et .al [36] proposed the water pollutant tracking machine based on IOT to screen in real time the high-quality water with the help of TDS, pH, and temperature sensors. These are deployed to detect both surface and ground water quality. ESp8266 is used for data transmission. Google firebase API is deployed to monitor real time data and My SQL system is used for data storage.Figure 6 shows the complete proposed system.

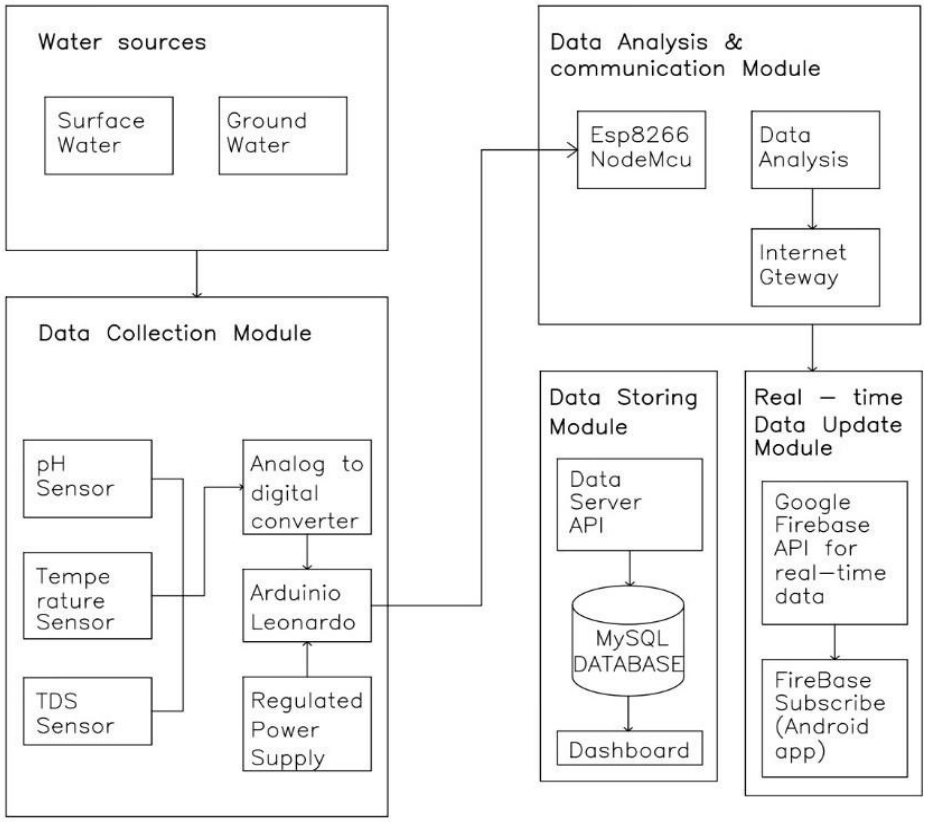


**Fig 6.** ProposedSchematic diagram to monitor water pollution



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Haque et. al [37] suggested Zigbee protocol system based on IOT for regular water quality monitoring that calculate dissolved oxygen, pH, turbidity, conductivity and temperature sensors. This advance system consists of three parts - cluster head node, sensor node and network gateway. Zigbee-proS3B is used for data communication.

Kumar et. al [38] explored an alert system for water quality monitoring based on IOT for measuring dissolved oxygen, pH, turbidity, conductivity and temperature sensors. Distilled water or deionized water is used for calibration of all sensors. The proposed system is integrated with cloud infrastructure through node MCU for database and also for an alert alarm.

Yang et. al [39] developed a water surface vehicle which carries water quality monitoring sensors to monitor water quality in real time. The vehicle is like double hull design boat with under water thrusters. As per author opinion monitoring of water quality at single point will not provide accurate data due to change in chemical and biological properties at different location of any water body. In order to adapt the control of vehicle autopilot system is installed with GPS/4G.

Di wu et. al [40] Proposed a smart data analysis scheme to predict water quality. The researcher has designed two models to analyze water quality i.e., adaptive learning rate with backpropagation and 2-step isolation and random forest. Pearson's correlation coefficient is used to define relationship between four water quality indicators(environmental, physical, chemical and biological).A quick summary of the preceding and some new contributions is included in tabular form below at table 4.

**Table 4:** Summary of the preceding, as well as some fresh contributions for water quality monitoring system

| Author's Name | Communication Technology | Main Contribution | Measured Parameters |
|---|---|---|---|
| Adamo and Attivissimo [12] | ISO/IEC/IEEE 21451, GPRS VPN | Sea water quality | Free space and Maximum link distance |
| Karraya et. al [13] | Bluetooth, GPS | Leakage detection and locating in long-distance pipelines | Pressure |
| Mat et. al [14] | Gateway Bee Connector | Wastage of water in irrigation system | Soil Moisture, humidity and temperature |
| Cloete and Malekian [15] | ZigBee | Notification and audio alert system to detect water contamination | Oxidation reduction potential, temperature, pH, conductivity and flow |
| Das and Jain [16] | Zigbee, GSM and UART | Water pollution detection using an alert message | Conductivity, TDS, Turbidity, pH Temperature |
| Salim et. al [17] | WiFi (Node MCU) | Historically measurement to trace water quality | Conductivity, TDS, Turbidity, DO, Temperature, Real time |



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| | | | |
|---|---|---|---|
| | | | historical data |
| Ezhilazhahi andBhuvaneswari [18] | zigbee | Soil moisture detection to check plant health | Soil moisture |
| Myint et. al [19] | Zigbee, RF | Reconfigurable smart sensor to monitor water quality | pH, water level, turbidity, Co2 and temperature |
| Pranataet.al [20] | Zigbee | Network Latency and throughput for diverse message payload size in data Handling | pH, temperature, DO |
| Radhakrishnan and Wu [21] | RF | Water contamination using active measurement | Turbidity, temperature, pressure, color, dissolved ions |
| Saravanan et. al [22] | GSM/GPRS | Contamination of water, Leakage in the pipe | Temperature, water flow, Color |
| Puneeth et. al [23] | Bluetooth, WiFi | Data Computation of water quality parameter | pH, turbidity and temperature |
| K M and M S [24] | LoRaWAN, Esp32 WiFi module | Conserve water using sensor nodes range | pH, Dissolved Oxygen, temperature, turbidity |
| Simitha et. al [25] | GPRS/4G | Water quality, Water level and flooding alert in river water monitoring system | Temperature, Dissolved Oxygen, pH, Flow rate, Salinity, water level |
| Carminati et. al [26] | GSM/GPRS | Estimation of Slime deposit in pipe and real time water management | Temperature, pH, Flow rate, Conductivity, pressure, slime |
| Manimegalai et. al [27] | Wi-Fi (Node MCU) | Data acquisition and Water pollutants | Temperature, humidity, Co2 emission, pH, Dissolved Oxygen, Soil moisture |
| Daud et. al [28] | Wi-Fi (Node MCU) | Fish feeding and water quality | pH |
| Huan et. al [29] | NB-IoT | Centralized management of data of aquaculture pond | Temperature, dissolved oxygen pH |
| Feng et. al [30] | Bluetooth | Judgement of Water quality parameters | pH, Turbidity, Conductivity, Temperature |
| Rekha et. al [31] | ESP8266 Wi-Fi and GSM Module | Deviation in water quality parameters | pH, turbidity, BOD, TDS, temperature |
| Memon et. al [32] | wemosD1 Wi-Fi Module | Water quality data management | Sound waves, pH, turbidity, temperature |
| Imran et. al [33] | Wi-Fi (Node MCU) | Weightless and collide free wireless communication over very long distance | Temperature, TDS, pH, turbidity |
| Ali J. Ramadhan [34] | ESP8266 Wi-Fi module | Remote and smart monitoring capabilities of | pH, Temperature, Dissolved Oxygen, TDS, Turbidity, |





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| | | | |
|---|---|---|---|
| | | Water quality | Nitrate, chlorides, Fluorides, Sodium |
| Akhter et. al [35] | Lora | Sensor's performance, stability and reliability | Temperature, Phosphate, Nitrate, pH, |
| Islam .et .al [36] | Node MCU module | Water pollutant tracking | pH, TDS and temperature |
| Haque et. al [37] | Zigbee | Regular water quality monitoring | pH, turbidity, Dissolved oxygen, conductivity and temperature |
| Kumar et. al [38] | ESP8266 Wi-Fi module | Water quality alert system | pH, turbidity, dissolved oxygen, conductivity and temperature |
| Yang et.al [39] | GPRS/4G | Water quality monitoring vehicle | Temperature, pH, DO and Conductivity |
| Di Wu et. al [40] | Not Specified | Data driven technology to predict water quality | Temperature, pH, Coliform, E. coli, Intestinal |

## 2. ProblemsIdentified

In the current research, the water quality monitoring techniques have been reviewed. There were several monitoring techniques classified by various researchers in the past but no technique was accurate in all circumstances. The water monitoring techniques were classified as manual monitoring and real time monitoring system. The following problems were identified during the literature review of past researches.

**Low Efficient Sensor Node:** Most of the existing methods did not work on efficient sensor node which can act as trans-receiver and can also create a pair of sensor nodes.

**Low Energy Efficient System:**The past research did not involvemuch in energy efficient methods and self-sustained ecofriendly power energy resources.

**Low Data Transmission speed:** Data transmission speed of most of the proposed system is low and are they battling with latency.

**Lack of Filter Optimization:** It is also noticed from the previous section that there is a requirement of filter optimization to reduce the issue of proper water filtration and health of filterin real time.

**Less Cost Effective:** From the previous section it is also noticed and analyzed that the approached methods cost is not life time optimized.

**Lack of Self Adaptive System:**The existing systems are not adaptive to resolve the issue of water filtration parameter and we say they are semi-automatic.

As studied above, in approached methods there may be a requirement of enhancement in wireless sensor implementation.

## 3. Conclusion

As discussedand analyzed in the last two sections the existing research methods for water quality monitoring system have low efficient sensor network, Lack of self-sustained and ecofriendly power resources, low data transmission speed, lack of filter optimization, less cost effective,low data transmission and accuracy, In order to make the sensor node



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efficient mesh network is suggested in which each sensor node will act as a trans-receiver. The proposed WSN system consists of a self-poweredecofriendly using both solar energy and tidal energy. To resolve the problem of accuracy and data transmission speed sensors are calibrated as per WHO standards and data collection is done on a cloud server IO Adda Fruit. In order to achieve filter optimization data comparison before andafter filtration is suggested.Apart from the above solution discussed the biggest issue of self-adaptive water monitoring system may be introduced using a micro controller Arduino pro-mini.

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