

A Comprehensive Review- Water Quality Monitoring Using Internet of Things (IoT) and Blockchain

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Abstract— Clean water is crucial for all living things. The unavailability of it affects the whole system and the existence of humankind. There were many studies conducted on the quality of water and how a quality water management system works. This article is a review of the water quality management system's mechanism. Our aim is to identify any better implementation of the existing systems integrating IoT and Blockchain. IoT's widespread deployment has been hampered by a severe security problem. Blockchain technology may be able to deal with the scalability and security issues facing the IoT. We will be analyzing the current IoT Systems and Blockchain implementations for Water Quality Management using different parameters and evaluating the impact if any of the parameter value changes. Hence, this review will help highly cost-effective selection of the appropriate water quality managing methods for the many kinds of water quality issues.

Index Terms—Water, Water Quality, Water Quality Assessment, Internet of Things, Blockchain

I. INTRODUCTION

Water is the most striking feature for life on earth [1] and it covers approximately 71% of the earth's surface [2] in both fluid and frozen forms. Technologies are expeditiously growing which points to an effects and tremendous transformation of mankind in daily life. Human actions that generate pernicious waste and domestic sewage cause water pollution and it is the main factor in a lot of epidemics around the world. In non-rural areas, the water bodies like river, stream etc. may be polluted by unsanctioned discharge of domestic sewage, industrial effluent etc. [3]. By 2026, approximately 19% of the world's inhabitants would be directly impacted by water scarcity, according several UN reports and it will indirectly influence the whole ecosystems. Water quality shows the availability of water to help various processes [4] such as irrigation, drinking water etc. The Integral part of drinking water supply is Water quality Management that contains multiple variables that encompass a very complex process, Set up a monitoring programme is a more complex task due to the work required to establish the

monitoring objectives as well as the technical, human and financial capabilities, and choosing the sampling points, water quality parameters, sampling priorities and frequencies and legal consent (compliance).

Water quality prediction and assessment based on input from research work is of great implication to watershed management/operations, because it exposes temporal and spatial vagaries in water quality as well as enables water managers to make informed operational choices and evaluate the drawbacks of water managing approach [5]. According to Tchobanoglous and Schroeder (1985), water quality is classified as hydro morphological, physiochemical, and biological quality. Physiochemical Water quality factors are frequently utilised for river Water quality modelling in addition to other variables (Wan Mohtar, 2019). Only a few chemical and physical characteristics were first taken into account, but later on, several substances that alter water quality were found [6]. Along with various other environmental elements, physical and chemical components have synergistic impacts on water quality that might lead to unexpected outcomes (Wilhm and Dorris, 1968). Water quality analysis is a crucial kind of managing water resource and must be taken care of right away to prevent contamination that could harm the ecosystem and make sure that environmental criteria are being followed [7].

Today, The Internet of Things (IoT) provides new remedy for remodelling water management, to spice up efficient handling of this precious resource [8]. Comprehensive water management methods can cut water costs by up to twenty percentages, which has a real a noticeable effect on metropolis. Due to the size of numerous water company networks and the reality that their pumps and treatment appliances are often spread out over wide areas, IoT provides an opportunity to gather information for water management on a far larger scale than was previously possible. Water management strategy can be very complex since numerous metropolises rely on aging infrastructure/framework, and the IoT also instant opportunities for municipalities to reduce functional charges around construction, maintenance, and more. Technology for water management improves transparency and control throughout the board. Commencing with a freshwater reservoir and ending with the collection and

recycling of wastewater. This class comprises IoT technologies, software tools, and equipment for water management aid in streamlining water production, handling, distribution, and consumption to enable agile procedures for treating water [9]. The blockchain can keep track of data collected by the sensors for IoT security, stopping them from being copied by any incorrect data. Utilizing the help of Blockchain technology, sensors may also interrelate data without the aid of a reliable intermediary.

II. WATER QUALITY CHARACTERISTICS

Water quality refers to the main four features to be considered and they are Physical features, Chemical features, Microbiological features and Radiological features based on standards of its usage [10]. Physical features is relevant to water quality for domestic use and there some physical aspects that helps the water quality to determine whether water is polluted or not they are Temperature, Colour, Taste and Odor , Foam and Turbidity. Temperature is very essential factor that determines water quality and it is not used to immediately determine whether water is fit for drinking. In natural water bodies, if temperature increases the solubility of oxygen in water decreases. Pure water is colourless and the adequate level for colour of drinking water is 15 True Color Unit - TCU. Chemical properties in water may occasionally vary due to significant pollution factor. Water's chemical properties include its pH level, hardness, nitrogen content, dissolved gases, total solids, suspended solids, metal content, and other chemical substances. Because they are crucial to public health, bacteria, protozoa, viruses, worms, and fungi fall under the category of microbiological characteristics. Radium and uranium are tested upon entry and exit to ascertain whether radioactive materials may be present [11]. The following water quality monitoring metrics are important in determining water quality because they allow for the recording and monitoring of overall changes in water quality at the specified intervals.

III. WATER QUALITY MONITORING PARAMETERS

Results should be clear and concise. The dramatic environmental change that has a serious impact on water quality management has led to an increase in urbanisation [12]. Some of the significant measurable parameters of water quality that are monitored in aquaculture are chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, turbidity, electrical conductivity (EC), dissolved oxygen (DO), temperature, oxidation-reduction potential (ORP), salinity, total nitrogen (TN), and total phosphorus (TP)[13][14]. COD is the equivalent number (amount) of oxygen used in the chemical oxidation of all organic and oxidisable inorganic substances present in a sample water, expressed in mg/l. BOD is the total amount of oxygen that all the organic material in water needs to stabilize over the course of three to five days, typically. The measurement of the acidity or alkalinity of water is known as pH. For drinking water pH levels of 6.5 to 8.5, it is neutral at 7 [15]. DO, or the amount of dissolved oxygen in a water sample, is a crucial requirement for aquatic

species to survive. Turbidity is the term used to describe the dispersion of light in water caused by suspended objects. Nephelometric Turbidity Units, or NTUs, are a unit of measurement for water cloudiness. When calculating the concentration of soluble ions in water, the term "EC" refers to the amount of electricity that may pass through or flow through water (measured in Siemens). The degree to which the water is hot or cold is the definition of temperature, and it is commonly expressed in degrees Celsius (°C) or Kelvin (K). The potential, sometimes referred to as OPR, requires electrons to go from the oxidant to the reductant and serves as a qualitative measure of the level of oxidation in water. What is meant by salinity is the amount of salt present in the water. As a measure of the water's capacity to avert eutrophication or an algal bloom, total nitrogen (N) content is expressed as milligrams per liter, or TN. The likelihood of eutrophication or an algal bloom is indicated by the water's total phosphorus (TP) level, which is expressed in mg/l [16]. The data collected from the previously described water quality monitoring indicators is analyzed using IoT, and stringent procedures are utilized to look at water contamination.

IV. WATER QUALITY ASSESSMENT USING IoT

Now, the Internet of Things has applications in a variety of human activities, both domestically and commercially. These include monitoring water quality, smart homes and workplaces, tourism, transportation and logistics [17]. The traditional approach of monitoring water quality involves having people use devices to take readings. The traditional approach is ineffective, expensive, and difficult. When compared to traditional techniques of water sampling and analysis, adopting IoT for water quality evaluation and monitoring has a number of benefits. They are Water quality and monitoring using IoT is cheaper than conventional method i.e. hands-on personnel conducting assessment and monitoring. It will reduce the cost of human resources and it is easier to control the whole water supply chain using IoT. Real time monitoring [18] is most significant advantage in water quality assessment and monitoring using IoT i.e. At any given time primarily based totally on the different indicates the status of water quality will be easily acquire. Automated water quality evaluation and monitoring is possible with the Internet of Things, which eliminates the need for human staff to take reading and logging data.

V. IOT BASED WATER QUALITY MOINTORING – BASIC DESIGN

Using the IoT (Internet of Things), a system called "water quality monitoring" is effective and economical [19]. The traditional way of determining quality involved manually gathering water samples and transfer them to labs for analysis; this method does not offer data in real-time and requires a share of time, human resources, and money. The Basic Design of IoT-based water quality observing is shown in Fig. 1. In order to enable web (internet) connectivity, monitoring (local side) includes edge nodes that integrates the data from controllers like Arduino, Raspberry PI, and ARM. Analytics and cloud storage are two components of the cloud/remote side that are used to assess the water quality and implement

the appropriate controls.

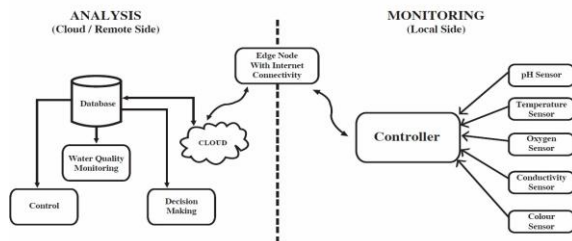


Fig. 1. Basic Design of IoT based Water Quality Monitoring

Data is collected from monitoring nodes (local side) using sensors like pH Sensor, Temperature Sensor etc. by a processor/controller (ARM). A pH Sensor measures the hydrogen ion concentration in water to determine whether it is more acidic (acidity balancing test) or more alkaline (alkaline balancing test). Temperature of water is measured/monitored using temperature sensor. Turbidity Sensor calculates clearness of water. pH, temperature, turbidity and conductivity parameters are sent to internet/wireless link to remote stations. ARM/ (Core controller) is integrated with various above given sensors and these sensors' leads are fixed in the water. The values from the sensor are processed by Analog to Digital Converter. ARM scans the value it will be uploaded on the cloud and these values will be monitored constantly by determining if the values exceed or are equal to threshold. If the value is more than or same to threshold then it returns to the concerned end user for further actions. The parameters are again checked for different water sources, if the value is lower than threshold. Using any software application like MATLAB to monitor the water quality in a visual format with the recognised data from distant locations [20].

VI. SOLUTIONS FOR WATER QUALITY MONITORING BASED ON IOT AND BLOCKCHAIN

With the advent of the Internet of Things in the modern era, numerous issues have been resolved. IoT-based water quality monitoring is very important for sustainable development. A base station and sensor nodes make up the Fish Farm Monitoring System, which is entirely grounded on a Wi-Fi sensor network [21]. Through Wi-Fi connectivity, the sensed parameters and their actual values are sent to the looking station (monitoring station), where the administrator keeps an eye on key areas. An indicator will alert you when any parameter is found to be above the threshold value [22]. Main advantages of this system are more flexible, Low Power consumption etc. Monitoring Water Quality using RF module [23], here water is continually monitored through the taps through different sensors like pH, temperature sensors. It has been implemented as a real-time project. Send the information accessible to remote base station utilizing a 2.4 GHz RF module which makes it advantageous to screen/monitor at a far-off area and requires less labour [22]. The main benefits of this technology include more flexibility

and low power consumption. Monitoring Water Quality Using an RF Module; in this case, the water is continuously monitored through the taps via various sensors, including pH and temperature sensor. It has been implemented as a real-time project. Use a 2.4 GHz to send the information available to the distant base station and the RF module that enables screening or monitoring at a remote location and consumes less power working [22] [23]. Water quality can be predicted with accuracy using Support Vector Algorithms (SVM), Deep Neural Networks, single layer neural networks, k-Nearest Neighbour machine learning algorithms, as well as Long Short-Term Memory and Deep Learning Neural Network [7] [24]. IoT-based water quality monitoring for aquaculture uses wireless sensor networks for real-time monitoring and to observe the water's quality based on observations [25][26].

Despite the enormous comprehensive growth of the Internet of Things (IoT) and blockchain in recent years, their integration is still in its early stages. IoT is used to monitor water quality in water resources and find any violations. By using blockchain, it is possible to retain the accuracy, reliability, and transparency of the records of breaches. This system will be able to gauge the water's quality in real-time and allow for the quick identification of any violations necessary to commit the crime. In order to design innovative systems and create smart irrigation systems, advanced methodologies might be used. The various criteria are chosen for irrigation system monitoring based on soil characteristics, water amount and quality, and weather. The blockchain technology allows for the tracking of food supply chain. The use of blockchain technology in smart farming, agricultural insurance, and food supply chains, the difficulties of recording transactions performed by small-scale farmers are examined, and an ecosystem for employing blockchain technology in the food industry is developed. The IoT-based solutions for precision irrigation are primarily theoretical and have only a few proof-of-concept cases. They don't cover the issue of deploying reliable systems to speed up and facilitate the introduction of new systems. Water management offers cutting-edge characteristics; connecting lone projects to the current systems is not necessary [27]. In Saudi Arabia, there are many different industries, many of which are in the high category and produce hazardous products on a regular basis. The industry is thought to be breaking the rules set forth by the General Authority for Meteorology and Environmental Protection (GAMEP) by releasing polluted materials into water. A strategic structure is recommended to address the pollution of all living things, and the easiest approach to doing this is to start with one of the primary sources of water pollution, which is industry. Owing to the physical method of gauging industrial water tanks at the moment, it is challenging to detect companies that are breaking these restrictions. This makes it harder to collect a sample for measurement. A system that not only detects water pollution but also takes action to stop it has been suggested to address the aforementioned problem. The system now incorporates the merging of two technologies. In order to effectively handle the security of violations, this work uses IoT sensors and blockchain to

identify water pollution in industrial effluent and determine if it contains components that violate GAMPE requirements. All of these elements were combined into a web application, which the administrator may access to trail the progress of water measurements for recorded businesses and analyse the information about water violations in simple graphs [28]. Water distribution systems (WDS) may simulate blockchain using a MATLAB toolbox called WDSchain. Data can be imported into WDSchain from Excel and the EPANET water modelling programme. It expands EPANET to provide hydraulic data for blockchain modelling at any designated node. Utilizing WDSchain will improve WDS network security and automation. WDSchain has two simulation models for processing time-series data: (1) static blockchain, which accepts all nodes' interval data as input and outputs shackled blocks one at a period, and (2) dynamic blockchain, which accepts all nodes' simulated time-series data as input and creates chained blocks at the controlled time. Using PoW, PoT, PoV, PoA, and PoAuth, five consensus approaches have been developed in WDSchain to provide data at different security levels. WDSchain evaluates performance by simulating five distinct WDS sizes. WDSchain provides insights into the best consensus mechanism based on the five performance evaluation metrics, the required security, and the system's physical level. Furthermore, water operators, experts, and academics can further develop their own consensus mechanisms, data mapping, or contemplate extra functionalities in the blockchain technique because this toolkit is open-source. It is suggested that water researchers, professionals, and operators implement their system utilizing blockchain platforms (such Ethereum and Hyperledger Fabric) after simulating it using WDSchain[29]. Medical waste and waste water are regularly produced by healthcare procedures. Healthcare and water waste management strategies, however, can also pose a risk to public health and the environment if the many approaches in the management process are not executed effectively. This makes it possible to govern these wastes using the blockchain and Internet of Things to effectively manage, coordinate, and monitor their disposal.

Blockchain technology makes it possible to organise operations in novel ways, ensures traceability, cuts down on the time and costs of using intermediaries, and boosts stakeholder confidence. IoT and the Blockchain are being proposed by various stakeholders, including governments and international environmental and health enforcement agencies, to monitor hospital waste and reduce the environmental impact of the terrible consequences of this type of waste. An analytical approach to handling waste data is provided by this sort of integrated inner hospital and water waste information system. It also supports the hospital's intricate waste flow system and provides a broad overview of the effectiveness of hospital waste management. Additionally, it will be recycled as a tool to measure the efficiency of waste management and based on the results; optimistic modifications and alterations may be made in order to meet the specific objectives and quality criteria set by international health and environmental organizations [30].

VII. CONCLUSION

One of the fundamental factors of the life is water and it is a very scanty resource which must be used efficiently without wastage. According to a UN World Water Development report, by 2026, water scarcity directly affects 19% of the global population. To avoid Water scarcity, water resources are essential to be handled more firmly. In-depth discussion of contemporary technologies using IoT's and Blockchain capabilities and potential for managing and monitoring water quality is discussed in this paper, the current IoT Systems with blockchain implemented for Water Quality Management using various parameters is verify that the system achieved the feasibility and reliability of applying it for the actual monitoring purposes.

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