International Journal of Academy of Engineering Research and Theory (IJAERT), ISSN: 2545-5931
SADIKU, AINA, ONALAJA, IDOWU-AGIDA & SULEIMAN
Open Access Vol. 3, Issue 1, July. 2024, Pp 5-8

Development of an IoT-Based Water Quality Monitoring System with Focus on Electrical Conductivity

SADIKU, I. B[1]., AINA, O. A.[2], ONALAJA. O. O. [2] , IDOWU-AGIDA E. O.[2], SULEIMAN A. O.[3]

[1, 2]Department of Computer Science, Gateway (ICT) Polytechnic Saapade, Ogun State, Nigeria
[3]Information and Technology Service, Gateway (ICT) Polytechnic Saapade, Ogun State, Nigeria

Email: sibsadiku@gmail.com

Abstract: *Water, a vital natural resource, is indispensable for sustaining life on Earth. However, rapid societal development and human activities have led to contamination and depletion of water resources, necessitating effective water quality monitoring systems. This article proposes an Internet of Things (IoT)-based approach for real-time monitoring of water quality parameters, with a specific focus on electrical conductivity (EC). Traditional methods of water quality assessment involve manual sampling and laboratory testing, which are time-consuming and often lack real-time data. The proposed system integrates a microcontroller, electrical conductivity sensor, and web tools to monitor EC levels in various water sources (Surface Water, Well Water, Factory Treated Water). The study discusses the development and testing of the IoT-based system, highlighting its potential applications in diverse sectors such as pharmaceuticals, drinking water production, and food processing. Additionally, recommendations for further research and implications for water management are discussed.*

Keywords: *Water, Monitoring, IoT, Electrical, Conductivity, Microcontroller, Sensor, Real-time.*

Introduction / Background Study

Water is a fundamental resource crucial for sustaining life and supporting various human activities. However, escalating pollution and over-exploitation of water sources pose significant challenges to water quality management (Simonoska et al., 2023)). Monitoring water quality parameters such as electrical conductivity (EC) is essential for ensuring safe consumption and environmental sustainability. Traditional water quality assessment methods often involve manual sampling and laboratory analysis, which are labor-intensive, time-consuming, and lack real-time data availability (Daramola et al. 2022). In response to these challenges, this study proposes an IoT-based approach for real-time monitoring of water quality, specifically focusing on EC. Electrical conductivity is a measure of the ability of water to conduct an electrical current and is often used as an indicator of the water's purity or the concentration of dissolved salts and ions. Research on IoT-based water quality monitoring systems, emphasizes the importance of real-time data acquisition and the role of EC as a key parameter. Previous studies have explored various sensor technologies and communication protocols for implementing IoT-enabled water quality monitoring systems (Mickelson & Tsvankin 2017; Olisa et al. 2021; Udanor et al. 2022). However, gaps exist in terms of cost-effectiveness, scalability, and integration with existing infrastructure. Furthermore, there is a need for comprehensive research addressing the specific requirements of different water sources and end-user applications. Nasto et al. (2022) used expert system to monitor water pH, temperature, and dissolved oxygen to provide real-time data for intervention against water pollution. The study however did not monitor EC. Fattoruso et al. (2015) proposed smart water network to integrates sensor data accessibility, and water quality management however the study failed to specify the water parameter that will be measured. Koleva et al. (2023) developed real-time monitoring of river water quality using inexpensive IoT system. While the system collects and presents data in real-time, there may be opportunities for more advanced data analysis techniques to extract meaningful insights from the collected data. Research focusing on data analytics algorithms for identifying trends, anomalies, and potential contamination events could enhance the utility of the monitoring system. Rostam et al., (2020) developed real-time water quality monitoring system for Malaysia seawater aquaculture but the report failed to provide detailed information about the specific sensors used. Singh et al., (2022)) used real-time water quality monitoring of River Ganga (India) using internet of things but there is a lack of discussion in the report on the system's design and data collection.

Methodology

The proposed IoT-based water quality monitoring system was setup using microcontroller (NodeMCU ESP8266) interfaced with EC sensor, and web interface for data visualization and analysis. The NodeMCU was programmed using arduino IDE instructing NodeMCU to collect sensor data and deposit the data value in Mysql database for future use. Water samples from surface water, well water, borehole water, and treated water sources were collected and tested for EC levels using the developed system. The experiment is conducted in Saapade area of Ogun State (Lat. N6°59'10", E3°40'15"), Nigeria, to assess the system's applicability in a real-world setting. Figure 1 showed the setup for the proposed Real-time water quality monitoring system. Three water sources were used for online reading for water quality using the proposed system. The first source was surface water, which includes sources like rivers, lakes, and streams. The second water source was well water (water drawn from underground wells) and the third water source was **tr**eated water which typically refers to water that has undergone some form of treatment process to make it suitable for consumption or other specific purposes, such as purification through filtration or chemical treatment and it serves as control experiment in the study. The mean values for the reading are presented in Figure 2.

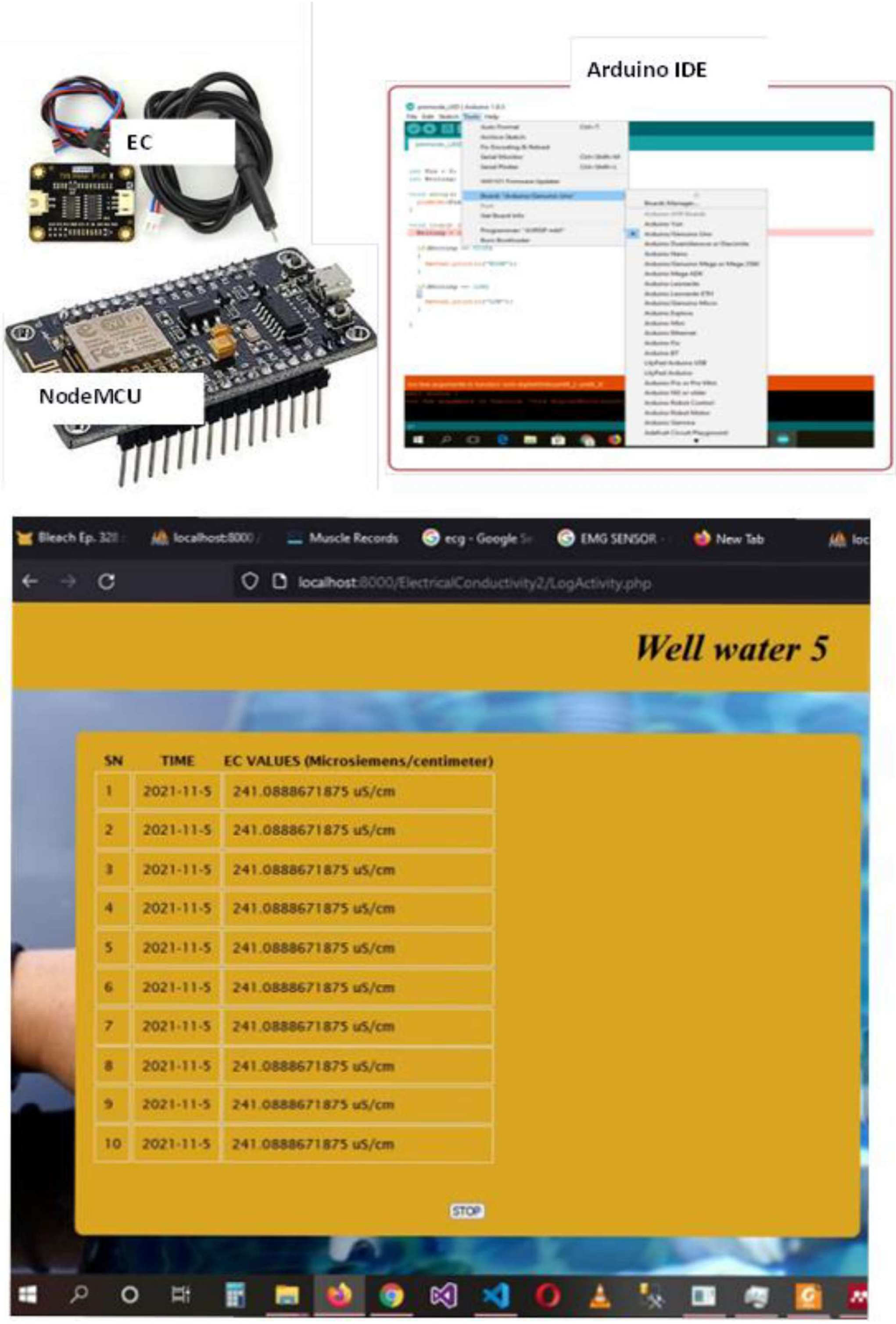

Fig. 1 Setup for the proposed Real-time EC monitoring system

Results and Discussion

The results on monitoring the electrical conductivity (EC) of different types of water sources over a period of five weeks are presented in Table 1 and Figure 2.

Table 1. Electrical conductivity (EC) of different types of water sources over a period of five weeks

	SURFACE WATER ((µS/cm)	WELL WATER (µS/cm)	TREATED WATER (µS/cm)
WK1 (1 to 7-11-2021)	276.18	247.19	47.3
WK2 (8 to 14-11-2021)	248.71	245.67	50.35
WK3 (15 to 21-11-2021)	248.71	257.87	48.83
WK4 (22 to 28-11-2021)	248.71	263.98	47.3
WK5 (29-11-2021 to 5-12-2021)	248.71	242.61	47.3

The EC values for surface water seem to be relatively consistent throughout the five weeks, hovering around 248.71 µS/cm. This stability suggests that the composition of dissolved substances in the surface water may not have changed significantly over the observation period. The EC values for well water fluctuate slightly over the weeks, ranging from 242.61 µS/cm to 263.98 µS/cm. The fluctuations might indicate variations in the dissolved solids content or changes in the groundwater composition, possibly due to factors such as rainfall, groundwater recharge, or nearby human activities. The EC values for treated water are consistently lower compared to both surface water and well water. This is expected because treatment processes of water often involve the removal of impurities and dissolved solids from it. The EC values for treated water range from 47.3 µS/cm to 50.35 µS/cm, indicating a relatively stable quality of treated water over the observed weeks. Across all weeks, well water generally shows lower conductivity compared to surface water. This is expected because surface water tends to have more dissolved solids and ions due to its exposure to various environmental factors. Treated water consistently shows significantly lower conductivity compared to both surface water and well water. This indicates that the treatment process effectively reduces the concentration of dissolved solids and ions in the water, which is desirable for safe consumption.

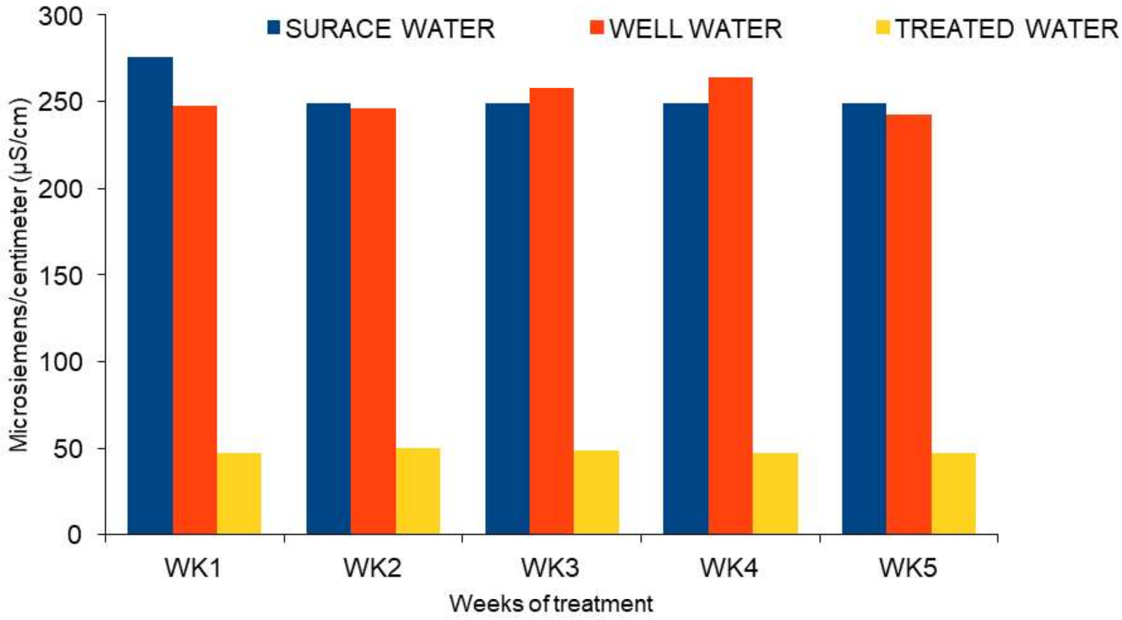

Figure 2. Mean Value for EC for Surface Water, Well Water, and Treated Water

There are some fluctuations in the conductivity values across the weeks, especially for well water and treated water. These fluctuations could be due to various factors such as changes in environmental conditions, variations in the treatment process, or differences in water sources. Notably, the conductivity of treated water remains relatively stable over the weeks, with minor fluctuations. This suggests consistency in the treatment process, which is crucial for ensuring the quality and safety of the treated water supply. While the conductivity values provide insights into the overall quality of water, they do not provide information about specific contaminants. It's essential to complement conductivity measurements with comprehensive water quality testing to ensure that the water is free from harmful substances. The results demonstrate the effectiveness of the IoT-based water quality monitoring system in providing real-time EC data for different water sources. The system's integration with existing infrastructure allows for remote monitoring and data access, facilitating informed decision-making. The results suggest that the treatment process effectively reduces the conductivity of water, indicating removal or reduction of dissolved solids and ions. However, consistent as well as regular monitoring, testing and analyzing of water are necessary to ensure that the water meets safety and quality standards as contained in available codes.

Conclusion

In conclusion, the study presents a novel IoT-based approach for real-time monitoring of water quality parameters, with a specific emphasis on EC. The developed system offers significant advantages over traditional methods, including cost-effectiveness, scalability, and real-time data availability. By addressing the limitations of existing water quality monitoring systems, the proposed IoT solution has the potential to contribute to improved water management practices and environmental sustainability.

References

Daramola, O. B.; Omole, R. K.; Omole, R. K.; Akinwale, I. V.; Otuyelu, F. O.; Akinsanola, B. A.; Fadare, T. O.; George, R. C. and Torimiro, N. (2022). *Bio-Receptors Functionalized Nanoparticles: A Resourceful Sensing and Colorimetric Detection Tool for Pathogenic Bacteria and Microbial Biomolecules*, Frontiers in Nanotechnology 4.

Fattoruso, G.; Tebano, C.; Agresta, A.; Lanza, B.; Buonanno, A.; Vito, S. D. and Francia, G. D. (2015). *A SWE Architecture for Real Time Water Quality Monitoring Capabilities Within Smart Drinking Water and Wastewater Network Solutions*, 9156 : 686-697.

Koleva, R.; Zaev, E.; Babunski, D.; Rath, G. and Ninevski, D. (2023). *IoT System for Real-Time Water Quality Measurement and Data Visualization*, : 1-4.

Mickelson, A. and Tsvankin, D. (2017). *Information Systems for Real-Time Water Quality Monitoring*, Encyclopedia of Sustainable Technologies : 105-114.

Nasto, I.; Zanaj, E.; Bakaj, A.; Bedinaj, L.; Sota, D.; Qarri, F.; Cipi, E. and Salihila, J. (2022). *Smart Water Quality Monitoring in Vlora: Design of an expert system for real-time monitoring of drinking water and detection of contamination in the aqueduct of the city of Vlora, Albania*, : 1-8.

Olisa, S. C.; Asiegbu, C. N.; Olisa, J. E.; Ekengwu, B. O.; Shittu, A. A. and Eze, M. C. (2021). *Smart two-tank water quality and level detection system via IoT*, Heliyon 7 : e07651-.

Rostam, N. A. P.; Malim, N. H. A. H.; Malim, H. and Abdullah, R. (2020). *Development of a Low-Cost Solar Powered & Real Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges*, : 86-91.

Simonoska, E.; Bogatinoska, D. C.; Dimitrievski, I. and Malekian, R. (2023). *Sensor System for Real-time Water Quality Monitoring*, : 114-119.

Singh, S.; Rai, S.; Singh, P. and Mishra, V. K. (2022). *Real-time water quality monitoring of River Ganga (India) using internet of things*, Ecol. Informatics 71 : 101770.

Udanor, C.; Ossai, N.; Nweke, E.; Ogbuokiri, B.; Eneh, A.; Ugwuishiwu, C.; Aneke, S.; Ezuwgu, A.; Ugwoke, P. and Christiana, A. (2022). *An internet of things labelled dataset for aquaponics fish pond water quality monitoring system*, Data in Brief 43 : 108400-.