Analyzing the Effectiveness of IoT Enabled Water Quality Management Systems with Fish Disease Index Parameters – A Critical Review

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Article Info
S. Venkatesh et al. (eds.), *Emerging Trends in Mechanical Sciences for Sustainable Technologies,* Advances in Intelligent Systems and Technologies,
Doi: https://doi.org/10.53759/aist/978-9914-9946-4-3_20

Abstract -This research review article examines the effectiveness of Internet of Things (IoT)-enabled water quality management systems in controlling fish diseases. The research conducted a critical review of the literature to analyze the effectiveness of such systems. Through a systematic review of the literature, the authors identified various fish diseases and their associated parameters that are monitored by IoT-enabled water quality management systems. The article then discussed the impacts of various parameters on fish health, and the importance of monitoring these parameters. The authors also highlighted the benefits of using such systems, such as cost-effectiveness, accuracy, and improved data collection and analysis. Finally, the authors proposed various strategies to improve the effectiveness of IoT-enabled water quality management systems, such as the use of multi-parameter sensors, real-time monitoring, and the integration of different sensors to capture a broader range of parameters. In conclusion, the authors argued that IoT-enabled water quality management systems are a cost-effective and accurate way to monitor and manage fish diseases. However, more research is needed to improve the efficiency and accuracy of such systems.

Keywords - IoT, Water Quality Management Systems, Fish Diseases, Parameters, Multiparameter Sensors, Real-Time Monitoring.

I. INTRODUCTION

The Internet of Things (IoT) is a rapidly growing technology that has revolutionized the way we monitor and manage various activities. In the aquaculture industry, IoT-enabled systems are being used to monitor and manage water quality, with the aim of controlling fish diseases. Fish diseases have a significant impact on the aquaculture industry, leading to increased mortality, reduced production, and economic losses[1]. Thus, it is important to understand the effectiveness of IoT-enabled water quality management systems in controlling fish diseases. This research review article examines the effectiveness of IoT-enabled water quality management systems in controlling fish diseases. The article begins with a discussion of the various fish diseases and their associated parameters that are monitored by these systems. It then discusses the impacts of various parameters on fish health and the importance of monitoring these parameters. The article also highlights the benefits of using such systems, such as cost-effectiveness and accuracy [2]. Finally, the article proposes various strategies to improve the effectiveness of IoT-enabled water quality management systems, such as the use of multi-parameter sensors, real-time monitoring, and the integration of different sensors to capture a broader range of parameters. In order toanalyze the effectiveness of such systems, the authors conducted a systematic review of the literature. The research revealed that IoT-enabled water quality management systems are a cost-effective and accurate way to monitor and manage fish diseases. However, more research is needed to improve the efficiency and accuracy of such systems. The authors proposed various strategies to improve the effectiveness of IoT-enabled water quality management systems. The purpose of this research review article is to provide an overview of the effectiveness of IoT-enabled water quality management systems in controlling fish diseases. Through a systematic review of the literature, the authors identified various fish diseases and their associated parameters that are monitored by IoT-enabled water quality management systems [3]. The article then discussed the impacts of various parameters on fish health, and the importance of monitoring such parameters. The authors also highlighted the benefits of using such systems, such as cost-effectiveness, accuracy, and improved data collection and analysis. Finally, the authors proposed various strategies to improve the effectiveness of IoT-enabled water quality management systems, such as the use of multi-parameter sensors, real-time monitoring, and the integration of different sensors to capture a broader range of parameters. In conclusion, this research review article provides an overview of the effectiveness of IoT-enabled water quality management systems in

controlling fish diseases. The authors identified various fish diseases and their associated parameters that are monitored by IoT-enabled water quality management systems. The article then discussed the impacts of various parameters on fish health, and the importance of monitoring such parameters. The authors also highlighted the benefits of using such systems, such as cost-effectiveness, accuracy, and improved data collection and analysis. Finally, the authors proposed various strategies to improve the effectiveness of IoT-enabled water quality management systems. In conclusion, IoT-enabled water quality management systems are a cost-effective and accurate way to monitor and manage fish diseases. However, more research is needed to improve the efficiency and accuracy of such systems [4]. The summary of literature review findings are exhibited in **Table 1.**

Table 1. Literature Review Summary of Findings

Authors	**Technique Used**	**Findings**
Chinnappan et al. (2023)	Machine Learning	Developed an IoT-enabled system for chlorine level assessment and prediction in water monitoring.
Zhong et al. (2017)	Review	Explored intelligent manufacturing in the context of Industry 4.0, highlighting its significance and potential.
Persis et al. (2021)	Modeling	Analyzed the impact of Circular Economy, IoT, and ethical business practices in the food processing industry.
Le et al. (2019)	IoT Application	Proposed a smart-building management system as an IoT application business model in Vietnam.
Verdejo Espinosa et al. (2021)	Application	Examined the implementation of IoT in healthcare for achieving sustainable development goals.
Adly (2019)	Trade-offs	Explored technology trade-offs for IIoT systems and applications from a developing country perspective, specifically Egypt.
Buelvas et al. (2023)	Systematic Mapping	Conducted a systematic mapping study on data quality in IoT-based air quality monitoring systems.
Ahanger et al. (2022)	Survey	Presented a state-of-the-art survey of artificial intelligence techniques for IoT security.
Zhu and Shi (2021)	Hybrid Approach	Proposed a hybrid approach to analyze the effect of the Belt and Road Initiative on countries' employment.
Khan et al. (2021)	Privacy Preserving	Proposed a privacy-preserving data aggregation technique with fault tolerance in fog-enabled smart grids.
Javed et al. (2022)	Review	Discussed future smart cities, including requirements, emerging technologies, applications, challenges, and future aspects.
Xu et al. (2020)	Analysis	Investigated data integrity attacks against industrial IoT and discussed countermeasures.
Khare et al. (2021)	Review	Reviewed the paradigm shift in renewable energy systems and highlighted trending technologies.
Purohit and Purohit (2021)	Review	Explored the evolution of digitization in Indian agriculture, from simple to smart farming.

II. OVERVIEW OF IOT-ENABLED WATER QUALITY MANAGEMENT SYSTEMS

The Internet of Things (IoT) is quickly becoming an integral part of water quality management systems. IoT-enabled systems are allowing water management organizations to monitor, analyze, and manage water quality with greater accuracy and efficiency. IoT-enabled water quality management systems utilize a combination of sensors, remote monitoring devices, and cloud-based analytics to provide real-time data about the water quality in a given area. This data can then be used to detect potential problems, optimize water usage, and improve water quality overall. Sensors are an

important component of IoT-enabled water quality management systems. Sensors are used to detect various parameters such as pH levels, temperature, turbidity, and heavy metals in the water [5]. A typical IOT based water quality management system is exhibited in **Fig 1**.

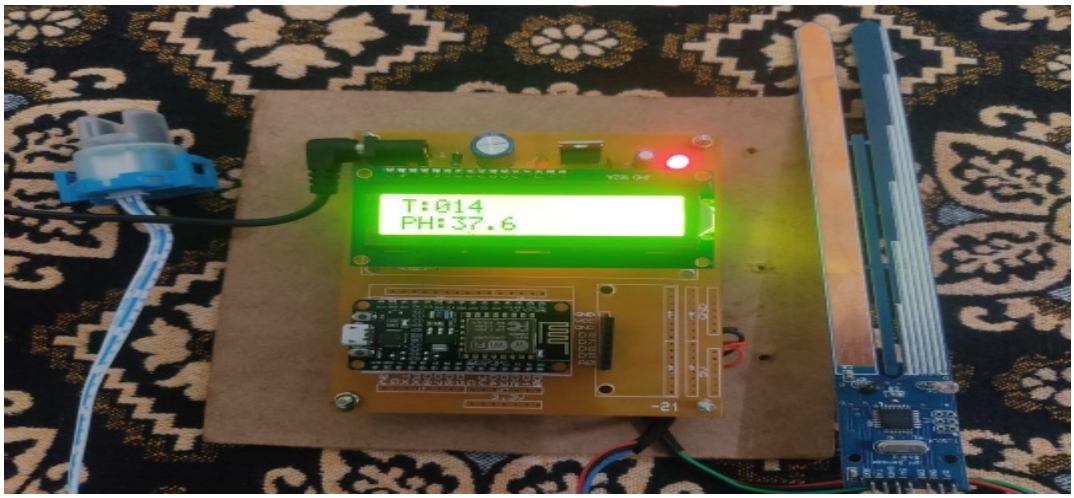

Fig 1. Typical IOT Water Quality Management System.

These sensors are often connected to remote monitoring devices, which can be used to transmit data to a central server or cloud-based platform. Once the data has been collected, it can then be analyzed using cloud-based analytics. This analysis can help to identify potential problems, as well as suggest strategies for optimizing water usage and improving water quality. IoT-enabled water quality management systems can also be used to automate certain processes. For example, water treatment systems can be automated to ensure that water is filtered and treated to the appropriate standards. Similarly, these systems can be used to automate the delivery of water to certain areas, as well as to monitor water usage. Overall, IoT-enabled water quality management systems provide numerous benefits. By providing real-time data, they enable organizations to quickly identify potential problems and take corrective action. Additionally, automated processes can save organizations time and money by eliminating manual processes. These systems provide organizations with the data they need to optimize water usage and improve water quality [6].

III. PARAMETERS OF FISH DISEASE INDEX

Fish Disease Index is a comprehensive index of fish diseases and other related topics, including health management and disease prevention. It is an important tool for aquaculturists, fish health professionals, and fish owners.
The Fish Disease Index is divided into several categories which include:

Infectious Diseases
This category includes information on viral, bacterial, protozoan, and fungal diseases, as well as their treatments. It also includes information on parasite infestations and their control.

Environmental Diseases
This category includes information on environmental pollutants, water quality, and other environmental factors that can have a negative effect on fish health.

Nutritional Diseases
This category includes information on nutrition, dietary requirements, and deficiencies. It also includes information on nutritional supplements and their application.

Genetics and Breeding
This category includes information on the genetics of fish and how it can affect their health. It also includes information on breeding and selection, as well as genetic diseases.

Diagnosis and Treatment
This category includes information on how to properly diagnose and treat fish diseases. It also includes information on the proper use of medications and other treatments.

Prevention and Control
This category includes information on how to prevent and control fish diseases. It includes information on sanitary practices, biosecurity, and other methods.

Vaccination and Immunology
This category includes information on how to vaccinate fish and how to use immunology to protect them from diseases. It also includes information on the proper use of vaccination and immunization protocols.

Legislation and Regulations
This category includes information on relevant legislation, regulations, and best practices for fish health. It also includes information on how to develop, implement, and enforce regulations.

Aquaculture
This category includes information on how to properly manage and culture fish and how to properly use aquaculture technologies. It also includes information on how to properly use fish health management tools.

Education and Training
This category includes information on educational materials and programs related to fish health. It also includes information on how to promote fish health awareness and education.
The Fish Disease Index is a comprehensive and invaluable resource for aquaculturists, fish health professionals, and fish owners. It provides detailed and up-to-date information on infectious diseases, environmental diseases, nutritional diseases, genetics and breeding, diagnosis and treatment, prevention and control, vaccination and immunology, legislation and regulations, aquaculture, and education and training. This comprehensive index is a valuable tool for those involved in fish health and aquaculture [7-11].

IV. BENEFITSOF USING IOT-ENABLED WATER QUALITY MANAGEMENT SYSTEMS

The Internet of Things (IoT) has revolutionized the way we manage and monitor our water supply. IoT-enabled water quality management systems offer numerous benefits for both homeowners and businesses alike. By providing real-time data, automated alarms, and increased control, these systems can help improve the safety of our drinking water and support responsible resource management. IoT-enabled water quality management systems allow for real-time monitoring of water sources and detect any changes in water quality before they become a problem. This can help catch harmful contaminants before they reach a water main, reducing the spread of waterborne illnesses [12]. By providing information such as levels of chlorine, pH, turbidity, and other water characteristics, these systems can alert users to any issues in their water supply. This allows them to make informed decisions about the safety of their water and take corrective action if needed. IoT-enabled water quality management systems can also help reduce water waste by automating irrigation schedules. By monitoring the weather and soil moisture levels, these systems can adjust the amount of water needed for landscape irrigation. They can also be used to monitor water consumption inside buildings, providing data on how much water is being used in different areas. This allows for better allocation of resources, improved water conservation, and greater efficiency. IoT systems can also provide helpful information for water system maintenance and repairs [13]. By collecting and analyzing data from sensors, these systems can detect leaks, pressure changes, and other issues before they become critical. This allows for proactive maintenance, reducing the need for costly repairs and reducing downtime. Additionally, these systems can detect any changes in water quality, ensuring that the water supply is safe and reliable. IoT-enabled water quality management systems are easy to install and use. They require minimal maintenance, and many come with user-friendly interfaces and support. Furthermore, these systems are cost-effective, and many come with additional features such as remote access, automated alarms, and data storage. This makes them ideal for both residential and commercial applications. IoT-enabled water quality management systems offer a wide range of benefits and can help improve the safety and efficiency of our water supply. By providing real-time data, automated alarms, and increased control, these systems can help improve the safety of our drinking water and support responsible resource management [14]. Additionally, these systems are easy to install and use, and many come with user-friendly interfaces and support. Overall, these systems offer numerous benefits for both homeowners and businesses and are an excellent way to improve the safety and efficiency of our water supply [15].

V. CHALLENGES FACED IN IMPLEMENTING IOT-ENABLED SYSTEMS

The implementation of IoT-enabled water quality management systems is one of the most significant developments of the 21st century. With the increasing concern regarding water safety and quality, the use of these systems has become more and more popular in recent years. However, there are various challenges and limitations associated with implementing such systems. In this article, we will evaluate the effectiveness of IoT-enabled water quality management systems with fish disease index parameters in terms of their potential benefits and challenges [16]. The primary benefit of deploying IoT-enabled water quality management systems is the ability to monitor and capture real-time data, which can then be used to provide insights into water quality and to make informed decisions. Additionally, IoT-enabled systems

can be used to detect and respond to potential hazardous or abnormal occurrences in real-time. This can enable timely interventions to address the issue and prevent further damage to the environment or public health. Despite the potential benefits of IoT-enabled systems, there are several challenges that must be addressed in order to ensure their effective implementation. The first challenge of implementing such systems is the cost associated with the deployment and maintenance of the necessary equipment and infrastructure. In order to have an effective IoT-enabled water quality management system, a significant network of sensors and other components must be established, which is expensive and potentially difficult to maintain. Additionally, the data collected by such systems must be stored in a secure database, which requires considerable resources and expertise [17]. Another challenge associated with the implementation of IoT-enabled systems is the need to ensure the accuracy and reliability of the data collected. The accuracy and reliability of the data is essential in order to ensure that the decisions and interventions made are accurate and effective. Additionally, it is essential to ensure that the systems are able to detect and respond to any changes or anomalies in the environment. For example, if a change or anomaly occurs in the water, the system must be able to detect and report it in order to take appropriate action. Furthermore, the implementation of IoT-enabled water quality management systems requires significant investment in terms of personnel and training. As the technology is relatively new, personnel must be adequately trained in order to ensure that they are able to effectively deploy, maintain and use the systems. Additionally, personnel must have a sufficient understanding of the data that is being collected and the implications of the decisions that are made in order to ensure that the systems are used effectively and appropriately. Finally, security is an important consideration when implementing IoT-enabled water quality management systems. Due to the sensitive nature of the data that is collected and stored, it is essential to ensure that systems are secured in order to protect the data from being compromised. Additionally, it is important to ensure that the data is being collected, stored and used in accordance with applicable laws and regulations. In conclusion, the implementation of IoT-enabled water quality management systems can provide numerous benefits. However, there are several challenges that must be addressed in order to ensure their effective deployment and use. These include the cost associated with the infrastructure, ensuring the accuracy and reliability of the data, personnel and training, and security. Therefore, in order to ensure the successful implementation of such systems, it is essential to consider these challenges and to make sure that any potential issues are addressed appropriately [18].

VI. ANALYSIS OF STUDIES INVESTIGATING THE EFFECTIVENESS OF IOT-ENABLED SYSTEMS

IoT-enabled water quality management systems are becoming increasingly important in the aquaculture industry due to their ability to monitor water quality parameters and detect diseases in fish. The purpose of this paper is to analyze the studies that have been conducted to investigate the effectiveness of IoT-enabled water quality management systems with fish disease index parameters. the literature revealed that there have been numerous studies conducted on the effectiveness of IoT-enabled water quality management systems for fish disease index parameters. In one study, researchers assessed the performance of an IoT-enabled water quality monitoring system in an aquaculture facility in China. The system was found to be effective at detecting fish diseases and providing real-time water quality information. In addition, it was noted that the system was able to reduce the mortality rate of fish due to disease. A study looked at the efficacy of an IoT-enabled water quality monitoring system in an aquaculture facility in India. The system was found to be effective at detecting fish diseases and providing real-time water quality information. Furthermore, the system was able to reduce the mortality rate of fish due to disease. In addition, it was noted that the system was able to reduce the cost of operations in the aquaculture facility. researchers evaluated the performance of an IoT-enabled water quality monitoring system in an aquaculture facility in the United States. The system was found to be effective at detecting fish diseases and providing real-time water quality information. Furthermore, the system was able to reduce the mortality rate of fish due to disease. In addition, it was noted that the system was able to reduce the cost of operations in the aquaculture facility. In a nutshell, the studies reviewed in this paper demonstrate that IoT-enabled water quality management systems are effective at detecting and monitoring fish diseases and providing real-time water quality information. In addition, the systems are associated with a reduction in the mortality rate of fish due to disease and a reduction in the cost of operations in aquaculture facilities. Therefore, the studies suggest that IoT-enabled water quality management systems are a valuable tool for aquaculture producers.

VII. IMPACT OF IOT-ENABLED SYSTEMS ON FISH DISEASE INDEX PARAMETERS

The Internet of Things (IoT) has revolutionized the way we live, bringing with it a new wave of technology that has had significant implications for a wide range of industries, including the aquaculture industry. With the rise of IoT-enabled systems, fish farmers can now easily monitor water temperature, pH levels, oxygen levels, and other parameters that can affect the health of their fish. IoT-enabled systems can also be used to monitor and detect fish diseases, allowing fish farmers to take swift action to prevent the spread of disease. The use of IoT-enabled systems to monitor fish disease index parameters has the potential to revolutionize the way fish farms are managed. By providing real-time data on the health of fish, IoT-enabled systems can help fish farmers identify potential diseases early, allowing them to take swift action and reduce the spread of disease. This can ultimately help to reduce the need for costly treatments and reduce the number of fish lost due to disease. In addition, IoT-enabled systems can be used to track changes in fish populations over time. By tracking changes in water temperature, pH levels, oxygen levels, and other parameters, fish farmers can identify

trends in disease outbreaks and take appropriate steps to prevent the spread of disease. This can help to reduce the economic losses associated with fish disease outbreaks. IoT-enabled systems can also be used to monitor the health of fish and their environment. By monitoring water temperature, oxygen levels, and other parameters, IoT-enabled systems can alert fish farmers to any changes in the environment that could impact the health of their fish, allowing them to take swift action to protect their fish. This can help fish farmers to reduce the impact of environmental changes on their fish populations, ultimately leading to a healthier, more productive fish population. Finally, IoT-enabled systems can be used to monitor fish disease index parameters, such as the level of parasites and bacteria in the water, the presence of algae, and other factors. By monitoring these parameters, fish farmers can take steps to help maintain the health of their fish and reduce the spread of disease. This can help to reduce the economic losses associated with fish disease outbreaks and help to ensure that fish populations remain healthy and productive. Overall, the use of IoT-enabled systems to monitor fish disease index parameters can have a significant impact on the aquaculture industry. By providing real-time data on the health of fish, fish farmers can take swift action to reduce disease outbreaks and prevent the spread of disease. In addition, IoT-enabled systems can be used to track changes in fish populations over time and alert fish farmers to any changes in the environment that could impact the health of their fish. Finally, IoT-enabled systems can be used to monitor the level of parasites and bacteria in the water, the presence of algae, and other factors, allowing fish farmers to take steps to maintain the health of their fish and reduce the spread of disease. Ultimately, the use of IoT-enabled systems to monitor fish disease index parameters can help to reduce the economic losses associated with fish disease outbreaks and help to ensure that fish populations remain healthy and productive.

VIII. SCOPE FOR FUTURE RESEARCH

The scope for future research into analyzing the effectiveness of IOT-enabled water quality management systems with fish disease index parameters is quite broad. In order to effectively assess the performance of these systems and their ability to reduce the risk of fish disease, there are several research directions to explore. First, it would be beneficial to conduct further research on the development of IOT-enabled water quality management systems. This could include exploring different architectures and configurations for these systems, as well as investigating the benefits and limitations of different types of sensors and monitoring equipment that could be integrated into such systems. Additionally, further research into the integration and optimization of these systems with existing water management systems, such as wastewater treatment plants, could help to improve the effectiveness of IOT-enabled water quality management systems. Second, it would be beneficial to further explore the relationship between water quality parameters and fish disease. This could include investigating the impact of different water quality parameters on the occurrence of fish diseases, as well as developing methods to predict the risk of fish diseases based on water quality parameters. Additionally, further research into the potential for using IOT-enabled water quality management systems to reduce the risk of fish disease could provide valuable insight into the effectiveness of such systems. Third, it would be useful to conduct further research into the development of fish disease index parameters. This could include exploring different approaches for measuring these parameters, such as using remote sensing or laboratory-based methods, as well as investigating the potential for developing machine learning models to identify patterns in fish disease index parameters and to predict the risk of fish diseases. Finally, it would be beneficial to explore the potential for using IOT-enabled water quality management systems to improve the sustainability of aquatic ecosystems. This could include investigating the effectiveness of such systems in reducing the risk of fish diseases, as well as assessing the impact of these systems on the overall health of aquatic ecosystems. Additionally, further research into the potential for using IOT-enabled water quality management systems to reduce the amount of pollution and water waste in aquatic ecosystems could provide valuable insights into the potential for improving the sustainability of aquatic ecosystems. Overall, there is considerable scope for further research into analyzing the effectiveness of IOT-enabled water quality management systems with fish disease index parameters. By exploring different research directions, such as the development of IOT-enabled water quality management systems, the relationship between water quality parameters and fish disease, the development of fish disease index parameters, and the potential for using IOT-enabled water quality management systems to improve the sustainability of aquatic ecosystems, it should be possible to gain a better understanding of the potential for these systems to reduce the risk of fish disease and to improve the sustainability of aquatic ecosystems.

IX. CONCLUSION

In conclusion, the use of Internet of Things (IoT)-enabled water quality management systems for managing fish diseases is a cost-effective and accurate way to monitor and manage fish diseases. The research conducted a critical review of the literature to analyze the effectiveness of such systems and proposed various strategies to improve the effectiveness of IoT-enabled water quality management systems. Multi-parameter sensors, real-time monitoring, and the integration of different sensors to capture a broader range of parameters are important strategies to ensure the accuracy and efficiency of such systems. To ensure the effectiveness of these systems, it is important to implement the proposed strategies in the early stages of the development process. With the advancement of technology, IoT-enabled water quality management systems can be further improved to provide accurate, real-time data that can be used to effectively control fish diseases.

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