AI-Driven Clean Water Quality Detection via Mobile Microscopy

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***Abstract*—**Traditional methods for testing water quality are usually slow, expensive, and require advanced lab equipment, which makes them hard to use in rural or less developed areas. This paper introduces an AI-based method for checking if water is clean using a smartphone microscope. The system uses deep learning combined with mobile microscopy to take pictures of water samples and then uses a Convolutional Neural Network (CNN) to determine if the water is clean or polluted. This approach allows for quick, on- site testing without needing special skills or equipment, which helps improve public health by lowering the risk of water-related diseases. The paper also looks at existing research and shows how AI and portable imaging can be used to create affordable, scalable, and effective solutions for monitoring water quality.

I. INTRODUCTION

Access to clean and safe drinking water is a fundamental human necessity, yet more than two billion people worldwide still lack this basic resource. Traditional water testing methods, while accurate, often rely on laboratory-based chemical or biological analysis, which demands skilled personnel, expensive equipment, and significant time investment. Such limitations make them impractical for use in rural, remote, or resource-constrained environments where water contamination poses serious health risks. With the rapid advancement of artificial intelligence (AI), mobile imaging, and edge computing, innovative solutions have emerged to bridge this accessibility gap. AI-driven water quality detection systems integrate machine learning models with portable mobile microscopy to analyze microscopic images of water samples in real time. By leveraging convolutional neural networks (CNNs) for image-based contaminant classification, these systems enable on-site, cost-effective, and rapid detection of microbial and particulate impurities. This paradigm shifts from centralized to decentralized testing not only empowers individuals and organizations to assess water safety instantly but also contributes to global public health surveillance and environmental sustainability. The present review explores recent developments, methodologies, and challenges in AI-based water quality monitoring using mobile microscopy, highlighting its potential to revolutionize how communities ensure access to safe drinking water.

Recent years have witnessed a surge in research combining artificial intelligence with microscopic image analysis for environmental monitoring and water safety assessment. Various studies have demonstrated that AI models, particularly convolutional neural networks (CNNs), and deep learning frameworks, can efficiently classify waterborne contaminants such as bacteria, algae, and suspended particles with remarkable precision. Unlike traditional optical or chemical sensors, AI-based image recognition systems rely on pattern detection and feature extraction from microscopic visuals, reducing the dependency on laboratory reagents or complex instrumentation. Furthermore, the integration of AI algorithms with mobile applications and cloud computing platforms has enhanced real-time decision-making, allowing users to obtain immediate contamination reports through smartphone interfaces. These advancements not only reduce operational costs and testing delays but also make large-scale water monitoring feasible in low-income and remote regions. Consequently, AI-driven water analysis represents a transformative shift toward smarter, faster, and more inclusive public health and environmental management systems.

Despite significant progress, several challenges remain in the practical implementation and scalability of AI-driven water quality monitoring systems. Many existing models are trained on limited or non-diverse datasets, which reduces their ability to generalize across different types of contaminants, lighting conditions, and water sources. Variations in image quality due to differences in smartphone cameras, microscope lenses, and environmental lighting can also affect model accuracy. Additionally, real-time deployment on mobile or embedded devices demands lightweight and optimized AI architectures that balance computational efficiency with detection precision. Data privacy, model interpretability, and the need for standardized benchmarks further complicate widespread adoption. Addressing these issues requires interdisciplinary collaboration among AI researchers, environmental scientists, and hardware developers to create robust, transparent, and scalable systems capable of functioning reliably in diverse real-world settings.

Looking ahead, the integration of advanced technologies such as Internet of Things (IoT), cloud computing, and edge AI is expected to further enhance the accuracy and scalability of mobile microscopy–based water quality monitoring.

IoT- enabled networks can facilitate continuous data collection from multiple locations, while cloud platforms can store and analyze large datasets for long-term environmental assessment. At the same time, edge AI allows on-device processing, enabling faster and more energy-efficient detection without requiring constant internet connectivity. These innovations can contribute to the development of intelligent water monitoring ecosystems capable of early contamination warnings and predictive analytics. As research continues to evolve, the convergence of AI, mobile imaging, and environmental science holds immense potential to redefine global standards for clean water access, offering an affordable, portable, and sustainable solution for both developing and developed regions.

The primary purpose of this review paper is to provide a comprehensive understanding of how artificial intelligence, particularly deep learning, and mobile microscopy, is transforming water quality monitoring and public health protection. It aims to compile, analyze, and compare existing research efforts in AI-driven water testing systems, highlighting the strengths, limitations, and emerging trends in this rapidly developing field. By examining recent technological advancements, practical implementations, and research challenges, the paper seeks to identify gaps in current methodologies and propose future directions for improvement. Ultimately, this review serves as a foundation for researchers, developers, and policymakers to design more reliable, accessible, and sustainable AI-based solutions for ensuring clean and safe drinking water worldwide.

II. LITERATURE REVIEW

In recent years, several researchers have explored the use of artificial intelligence and image-based analysis to enhance the accuracy, efficiency, and accessibility of water quality monitoring. Traditional laboratory testing has gradually been supplemented by AI-powered tools capable of identifying microbial contamination, turbidity levels, and chemical impurities directly from digital or microscopic images. The combination of machine learning, deep learning, and mobile microscopy has proven to be an effective approach for automating water analysis while minimizing human error and operational costs.

Some of the reviewed papers include:

[1] Water quality analysis using an inexpensive device and a mobile phone (Timo Toivanen, Sampsa Koponen, Ville Kotovirta, Matthieu Molinier & Peng Chengyuan 2013) [1]

The paper "Water Quality Analysis Using an Inexpensive Device and a Mobile Phone" by Timo Toivanen and colleagues introduces a cost-effective and practical approach to water quality monitoring. It presents a mobile-based system that connects an optical sensor to a smartphone to measure key parameters such as turbidity and color variations in water samples. This design eliminates the need for expensive laboratory equipment while ensuring accurate and real-time analysis. The study highlights the growing potential of smartphones in environmental monitoring and demonstrates that such low-cost solutions can effectively support water quality assessment in rural and low-resource areas.

[2] AquaSight: Automatic Water Impurity Detection Utilizing Convolutional Neural Networks (Ankit Gupta & Elliott Ruebush 2019) [2]

This project, AquaSight, is a smartphone-based system that identifies impurities in water through image analysis. Using a Convolutional Neural Network (CNN), it evaluates water samples by examining turbidity, color, and visible particles to determine whether the water is clean or contaminated. The approach offers a fast, cost-effective way to monitor water quality, helping to ensure safe drinking water for users.

[3] Smartphone-based turbidimeter reader (Hatice Ceylan Koydemir, Simran Rajpal, Esin Gumustekin, Doruk Karinca, Kyle Liang, Zoltan Göröcs, Derek Tseng & Aydogan Ozcan (Scientific Reports, 2019) [3]

This project is a portable turbidimeter that uses a smartphone to measure the clarity of water. It features an opto-mechanical attachment with LEDs and lenses to capture light passing through the water sample. The device operates in both nephelometry and transmittance modes to provide accurate turbidity readings. It delivers rapid results, detecting a wide range of turbidity levels in under two minutes. Its affordability, portability, and ease of use make it suitable for field-based water quality monitoring.

[4] A smartphone microscopic method for simultaneous detection of Cryptosporidium and Giardia (oo)cysts (Retina Shrestha, Rojina Duwal, Sajeev Wagle, Samiksha Pokhrel, Basant Giri, Bhanu Bhakta Neupane ,PLOS Neglected Tropical Diseases, 2020) [4]

This project presents a smartphone-based microscopic method for detecting Cryptosporidium and Giardia (oo)cysts in water and vegetable samples. Utilizing a 1 mm ball lens, white LED illumination, and Lugol's iodine staining, the system achieves magnification and contrast suitable for identifying these parasites. The method demonstrated recovery rates comparable to commercial microscopy techniques. In testing, 42% of vegetable and 39% of water samples were found contaminated with Cryptosporidium, while 31% of vegetable and 33% of water samples contained Giardia. This approach offers a low-cost, portable alternative for parasite detection in resource-limited settings.

[5] Efficient Prediction of Water Quality Index (WQI) Using Machine Learning Algorithms (Md. Mahedi Hassan, Laboni Akter, Md. Mushfiqur Rahman, Sadika Zaman, Khan Md. Hasib, Nusrat Jahan, Raisun Nasa Smrity, Jerin Farhana, M. Raihan, Swarnali Mollick 2021) [5]

This project uses machine learning algorithms to predict the Water Quality Index (WQI) from multiple water parameters like pH, dissolved oxygen, nitrate, and turbidity. Different models, including Random Forest and Neural Networks, were tested, with Multinomial Logistic Regression achieving the highest accuracy. The study identifies key factors affecting water quality and provides a fast, reliable method for monitoring water safety. The model effectively highlighted the most influential factors contributing to water quality variation, helping in the assessment and management of aquatic environments. The proposed approach offers an efficient, data-driven framework for real-time water quality monitoring, which can assist environmental agencies in making informed decisions to ensure safe and sustainable water resources.

[6] IoT-GSM-Based Controlling and Monitoring System to Prevent Water Wastage, Water Leakage, and Pollution in the Water Supply (Abdullah Al Shahid Chowdhury, Yasir Arafat, M. Shafiul Alam, 2022) [6]

This project introduces an IoT-GSM-based system designed to control and monitor water tanks, aiming to prevent water wastage, leakage, and pollution. Utilising an ESP32 microcontroller and the Blynk mobile application, the system allows users to remotely check water levels and control water pumps. It also features water quality monitoring and leakage detection, sending real-time alerts to users via SMS. The system is particularly beneficial for residential areas lacking automated water management solutions. By reducing water wastage and enhancing water quality monitoring, it contribute to more efficient and sustainable water usage.

[7] Towards Synoptic Water Monitoring Systems: A Review of AI Methods for Automating Water Body Detection and Water Quality Monitoring Using Remote Sensing (Liping Yang, Joshua Driscol, Sarigai Sarigai, Qiusheng Wu, Christopher D. Lippitt, Melinda Morgan, 2022) [7]

This review article examines the application of artificial intelligence (AI) and computer vision techniques in automating water body detection and water quality monitoring using remote sensing data. It systematically analyzes various AI methods, including machine learning and deep learning algorithms, employed to extract water information from satellite and aerial imagery. The study discusses the challenges and limitations associated with these technologies and identifies research priorities to enhance their effectiveness in water resource management. By integrating AI with remote sensing, the review highlights the potential for more efficient and scalable water monitoring systems.

[8] Internet of Things (IoT) for Water Quality Monitoring and Consumption Management (Mehedi Hasan Jewel, Abdullah Al Mamun, 2022) [8]

This project introduces an Internet of Things (IoT)-based system designed to monitor water quality and manage consumption effectively. Utilizing sensors to measure parameters such as pH, turbidity, and temperature, the system provides real-time data accessible via a mobile application. The integration of GSM modules allows for immediate alerts on water quality issues and consumption anomalies. A cloud-based platform facilitates data storage and analysis, enabling predictive maintenance and efficient water usage. This approach aims to enhance water resource management, particularly in regions facing water scarcity and quality challenges.

[9] Real-time Water Quality Monitoring Using AI-Enabled Sensors: Detection of Contaminants and UV Disinfection Analysis in Smart Urban Water Systems. (Md. Ariful Islam, Faisal Anwar, Mohammad Rezaul Islam, Tanvir Hossain, and S. M. Nahiduzzaman (2024) [9]

This research presents an AI-enabled sensor system designed for real-time water quality monitoring in urban settings. It employs machine learning algorithms to detect contaminants and assess the effectiveness of UV disinfection processes. The system provides continuous surveillance, offering immediate alerts on water quality issues. By integrating advanced sensing technologies, it aims to enhance public health safety and optimise water treatment operations in smart cities. The study underscores the potential of AI in revolutionising urban water management practices.

[10] Real-time water quality monitors installed at wild swimming spots in southern England (Linda Geddes, 2024) [10]

This initiative involves installing real-time water quality monitors at wild swimming spots and beaches across southern England to assess the immediate risk of illness from water polluted with bacteria. Wessex Water has implemented sensors at three freshwater sites in Dorset, Somerset, and Hampshire, as well as two coastal sites in Bournemouth, following a successful pilot study at Warleigh Weir near Bath. The AI-based system at Warleigh Weir correctly predicted high bacterial levels 87% of the time. Southern Water is trialing a different monitoring system at Tankerton in Kent and Langstone Harbour in Hampshire, with plans to expand to Hayling Island. This approach aims to provide swimmers with timely information on water quality, enhancing public health safety.

[11] AI Techniques for Near Real-Time Monitoring of Contaminants in Coastal Waters on Board Future ΦSat-2 Mission (Francesca Razzano, Pietro Di Stasio, Francesco Mauro, Gabriele Meoni, 2024) [11]

This research introduces an innovative approach to near real-time monitoring of contaminants in coastal waters using artificial intelligence (AI) techniques onboard the future Φsat-2 mission. By integrating satellite remote sensing data with AI algorithms, the study aims to provide rapid detection of water quality parameters such as turbidity and pH, which are critical for both human and aquatic health. The methodology involves onboard processing to enable timely responses to environmental changes. This initiative addresses significant gaps in current water quality monitoring practices and holds promise for enhancing environmental protection and resource conservation. The research is a part of the European Space Agency's Orbital AI Challenge and contributes to advancing satellite-based environmental monitoring technologies

[12] Design and Implementation of IoT-based Water Quality and Leakage Monitoring System for Urban Water Systems Using Machine Learning Algorithms (U G Sharanya, Koushalya M Birabbi, B.H Sahana, D Mahesh Kumar, N Sharmila, S Mallikarjun swamy, 2024) [12]

This research presents the design and implementation of an IoT-based water quality and leakage monitoring system for urban water systems, utilizing machine learning algorithms. The system employs real-time sensors to monitor parameters such as pH, turbidity, and dissolved oxygen, enabling rapid detection of water quality issues. Machine learning models analyze the collected data to predict potential leakages and assess water quality trends. By integrating these technologies, the system aims to enhance the efficiency and reliability of urban water distribution networks. This approach contributes to sustainable water management practices in urban environments.

[13] Microbial drinking water monitoring now and in the future (Thomas Pluym, Fien Waegenaar, Bart De Gusseme, Nico Boon, 2024) [13]

This review by Pluym et al. (2024) examines the evolution and future directions of microbial drinking water monitoring. It critiques traditional culture-based methods, highlighting their limitations in detecting viable but non-culturable (VBNC) organisms. The authors advocate for integrating advanced technologies such as flow cytometry, environmental DNA (eDNA) analysis, and high-throughput sequencing to enhance detection sensitivity and speed. They also emphasize the importance of real-time monitoring and data integration for proactive water quality management.

[14] Water Quality Management in the Age of AI: Applications, Challenges and Prospects (Shubin Zou, Hanyu Ju, Jingjie Zhang, 2025) [14]

This review article examines the application of artificial intelligence (AI) in water quality management, focusing on its integration with technologies like the Internet of Things (IoT), remote sensing, and unmanned monitoring platforms. It highlights how AI enhances real-time monitoring, predictive modeling, and intelligent regulation of water quality. The study discusses the challenges of data quality, model interpretability, and system integration. It also explores future prospects, including the development of high-quality datasets, explainable AI models, and the coupling of AI with process-based models. The research underscores the transformative impact of AI in advancing smart water quality governance and achieving sustainable development goals.

[15] Data-Driven Approaches to Water Quality Monitoring: Leveraging AI, Machine Learning, and Management Strategies for Environmental Protection (Aparna Ponnuru, J. V. Madhuri, S. Saravanan, T. Vijayakumar, 2025) [15]

This research explores data-driven approaches to water quality monitoring, focusing on the integration of Artificial Intelligence (AI), Machine Learning (ML), and Internet of Things (IoT) technologies. The study implements four AI algorithms—Support Vector Machines (SVM), Decision Trees, Artificial Neural Networks (ANN), and Random Forests—to predict and analyze water pollution levels. Among these, ANN achieved the highest accuracy at 95.2%, followed by Random Forests at 92.8%, SVM at 89.5%, and Decision Trees at 87.3%. The AI-driven models resulted in a 30% reduction in error rates and a 40% improvement in real-time monitoring efficiency. The research highlights the transformative potential of AI-powered water quality monitoring for sustainable environmental protection.

[16] Transforming Water Quality Assessment: A Quantum AI Approach (C. Kishor Kumar Reddy, Akshitha Katta, Thandiwe Sithole,R. Madana Mohana, 2025) [16]

This study introduces a pioneering approach to water quality assessment by integrating quantum computing with artificial intelligence (AI). The authors discuss the fundamental concepts of quantum computing and its potential applications in water quality monitoring and prediction. By leveraging quantum AI, the research aims to process and analyze extensive and complex datasets, including real-time sensor data and satellite imagery. This integration allows for the identification of patterns and relationships that classical AI may overlook, enabling timely detection of contaminants and prediction of water quality changes.

[17] Low-Cost IoT-Based Potable Water Quality Monitoring for Rural Communities (Marvellous Emmanuel, 2025) [17]

This research presents a low-cost, IoT-based potable water quality monitoring system tailored for rural communities. The system integrates low-power sensors to measure key water parameters such as pH, turbidity, temperature, and total dissolved solids. Data collected by these sensors is wirelessly transmitted to a centralized dashboard, enabling real-time monitoring and early detection of contamination. By leveraging affordable components and scalable technology, this solution offers a practical and sustainable approach to improving water safety and public health in underserved regions. The study emphasizes the potential of such systems in enhancing access to clean and safe drinking water in rural areas.

[18] IOT-Based Water Quality Monitoring System using ESP32 (M. Mahendiran, C. Kabilan, R. Santhosh, E. Yathav, Mr S. Sugumar, Dr R. Manikandan, Dr P. Selvakumar,2025) [18]

This research presents an IoT-based water quality monitoring system utilizing the ESP32 microcontroller. The system integrates sensors to measure parameters such as pH, turbidity, total dissolved solids (TDS), and temperature. Collected data is transmitted to a cloud platform, enabling real-time monitoring and analysis. In cases where parameter thresholds are exceeded, the system triggers alerts via SMS or email to notify users promptly. This approach aims to enhance water quality management through continuous, remote monitoring.

[19] A Review of Water Quality Forecasting and Classification Using Machine Learning Models and Statistical Analysis (Amar Lokman, Wan Zakiah Wan Ismail, Nor Azlina Ab Aziz, 2025) [19]

This comprehensive review by Lokman et al. (2025) examines the application of machine learning (ML) models and statistical methods in forecasting and classifying water quality, with a particular focus on surface waters in Malaysia. The study categorizes various ML approaches—including regression, classification, and hybrid models—and evaluates their performance using metrics like RMSE, R^2, accuracy, and F1-score. It also discusses statistical techniques such as residual analysis, principal component analysis (PCA), and feature importance assessment to enhance model interpretability and reliability. The review identifies challenges in data quality, model interpretability, and the integration of spatio-temporal and fuzzy logic techniques, proposing future directions for developing transparent, adaptive, and accurate models for sustainable water quality management.

[20] Artificial intelligence in water quality monitoring: A review of water quality assessment applications (Rodica Mihaela Frincu, 2025) [20]

This review by Rodica Mihaela Frincu (2025) explores the application of artificial intelligence (AI) in water quality monitoring, focusing on machine learning and deep learning techniques. It examines how AI can enhance the calculation and modelling of water quality indexes (WQIs) and classification tasks, offering more accurate and efficient alternatives to traditional methods. The study discusses the use of AI in integrating diverse water quality parameters and implementing real-time monitoring systems. Challenges such as data availability, model transparency, and system integration are also addressed. The review highlights the potential of AI to significantly contribute to water quality management and suggests directions for future research in this field.

III. DISCUSSION

This project highlights the effectiveness of AI, particularly Convolutional Neural Networks (CNNs), in analysing microscopic images of water samples to determine water quality. The CNN automatically identifies patterns and features in the images, enabling reliable classification of water as clean or contaminated. The use of a mobile microscope makes the system portable, allowing real-time monitoring directly at the sampling site, which is valuable in remote or resource-limited areas.

Key observations indicate that image clarity, diverse datasets, and careful training of the CNN model are crucial for accurate detection. Although the system performs well, challenges include detecting multiple types of contaminants and maintaining consistent imaging conditions. Overall, the combination of mobile microscopy and AI provides a fast, cost-effective, and scalable approach for water quality assessment, with promising applications in public health monitoring.

Future improvements could include adding image preprocessing steps, such as noise reduction and contrast enhancement, to help the CNN extract features more accurately. Expanding the dataset to cover a broader range of water contaminants and microorganisms would make the model more robust across diverse conditions. Incorporating explainable AI techniques could allow users to understand how the system makes predictions, increasing trust in automated assessments. These enhancements would strengthen the system's accuracy, reliability, and practical usefulness for real-world water quality monitoring.

Sr No.	Title	Author	Year	Paper Description	Research Gap
[1]	Water quality analysis using an inexpensive device and a mobile phone	Timo Toivanen, Sampsa Koponen, Ville Kotovirta, Matthieu Molinier & Peng Chengyuan	2013	The study presents a low-cost mobile phone-based tool for determining the transparency and turbidity of water.	Easy, field-based water quality monitoring is limited by the cost and subjectivity of current instruments.
[2]	AquaSight: Automatic Water Impurity Detection Utilizing Convolutional Neural Networks	Ankit Gupta & Elliott Ruebush	2019	The study suggests AquaSight, a CNN-based system that can identify water contaminants in photos and classify them as clean or contaminated with an accuracy of roughly 96%.	The model's generalization and practical application are limited by its small dataset, lack of real-world testing, and ability to detect only visible impurities.
[3]	Smartphone-based turbidimeter reader	Hatice Ceylan Koydemir, Simran Rajpal, Esin Gumustekin, Doruk Karinca, Kyle Liang, Zoltan Göröcs, Derek Tseng & Aydogan Ozcan	2019	The study introduces a smartphone-based turbidimeter that measures water turbidity precisely and economically in field conditions using two light detection modes.	Existing turbidimeters are costly, non-portable, and limited in range, making them unsuitable for on-site water quality testing in low-resource areas.
[4]	A smartphone microscopic method for simultaneous detection of Cryptosporidium and Giardia (oo)cysts	Retina Shrestha, Rojina Duwal, Sajeev Wagle, Samiksha Pokhrel, Basant Giri, Bhanu Bhakta Neupane	2020	The study describes a smartphone-based microscopy system that uses a straightforward ball-lens setup to identify Cryptosporidium and Giardia in water and vegetables.	The method has limited recovery efficiency and lacks large-scale field validation for diverse samples
[5]	Efficient Prediction of Water Quality Index (WQI) Using Machine Learning Algorithms	Md.Mahedi Hassan, Laboni Akter, Md. Mushfiqur Rahman, Sadika Zaman, Khan Md. Hasib, Nusrat Jahan, Raisun Nasa Smrity, Jerin Farhana, M. Raihan, Swarnali Mollick	2021	The study uses physicochemical parameters and machine learning models to predict the water quality index (WQI) with an accuracy of up to 99.8%.	It is based on static datasets and ignores biological contamination, a variety of environmental conditions, and real-time monitoring.
[6]	IoT-GSM Based Controlling and Monitoring System to Prevent Water Wastage, Water Leakage, and Pollution in the Water Supply	Abdullah Al Shahid Chowdhury, Yasir Arafat, M. Shafiul Alam	2022	Through remote control, the paper suggests an IoT-GSM system to monitor water tanks and stop waste, leaks, and pollution.	There is no discussion of scalability in a variety of real-world scenarios or extensive testing.

[7]	Towards Synoptic Water Monitoring Systems: A Review of AI Methods for Automating Water Body Detection and Water Quality Monitoring Using Remote Sensing	Liping Yang, Joshua Driscol, Sarigai Sarigai, Qiusheng Wu, Christopher D. Lippitt, Melinda Morgan	2022	The study examines deep learning and artificial intelligence techniques for satellite and aerial imagery-based water quality monitoring and detection.	Lack of real-time monitoring systems, integrating data from multiple sources, and the scarcity of labeled datasets are among the difficulties.
[8]	Internet of Things (IoT) for Water Quality Monitoring and Consumption Management	Mehedi Hasan Jewel, Abdullah Al Mamun	2022	In order to prevent waste, leaks, and pollution, the paper suggests an IoT-GSM system for remote monitoring and control of water tanks.	Scalability in a variety of scenarios and extensive real-world testing are not covered
[9]	Real-time Water Quality Monitoring Using AI- Enabled Sensors: Detection of Contaminants and UV Disinfection Analysis in Smart Urban Water Systems.	Md. Ariful Islam, Faisal Anwar, Mohammad Rezaul Islam, Tanvir Hossain, and S. M. Nahiduzzaman	2024	The paper presents an AI-enabled sensor system for real-time water quality monitoring, detecting contaminants and evaluating UV disinfection.	Its performance across diverse water conditions and large-scale deployment has not been tested.
[10]	Real-time water quality monitors installed at wild swimming spots in southern England	Linda Geddes	2024	To measure the amount of bacteria present, real-time AI-based monitors were set up at untamed swimming areas in southern England.	They have not been tested for wider scalability and effectiveness in a variety of conditions.
[11]	AI Techniques for Near Real-Time Monitoring of Contaminants in Coastal Waters on Board Future ΦSat-2 Mission	Francesca Razzano, Pietro Di Stasio, Francesco Mauro, Gabriele Meoni	2024	The study introduces a system that uses artificial intelligence (AI) on the ΦSat-2 satellite to swiftly identify contaminants in coastal water, combining data from remote sensing to assess water quality in real time.	It is still unknown how well the system works in a variety of coastal conditions and on a large scale.
[12]	Design and Implementation of IoT-based Water Quality and Leakage Monitoring System for Urban Water Systems Using Machine Learning Algorithms	U G Sharanya, Koushalya M Birabbi, B.H Sahana, D Mahesh Kumar, N Sharmila, S Mallikarjun swamy	2024	In order to monitor urban water quality and leaks, the paper suggests a smart Internet of Things system that gathers sensor data and uses machine learning for real-time analysis.	It has not been tested for large-scale deployment or performance in various infrastructures.

[13]	Microbial drinking water monitoring now and in the future	Thomas Pluym, Fien Waegenaar, Bart De Gusseme, Nico Boon	2024	The study examines emerging methods for identifying and controlling microbiological pollutants in drinking water.	Method standardization, integrated data management, and real-time monitoring are still scarce.
[14]	Water Quality Management in the Age of AI: Applications, Challenges and Prospects	Shubin Zou, Hanyu Ju, Jingjie Zhang	2025	Using IoT, remote sensing, and hybrid models, the study examines AI applications in water quality management, emphasizing real-time monitoring, prediction, and pollutant tracking.	Real-time monitoring, method standardization, and integrated data management across various conditions continue to present challenges.
[15]	Data-Driven Approaches to Water Quality Monitoring: Leveraging AI, Machine Learning, and Management Strategies for Environmental Protection	Aparna Ponnuru, J. V. Madhuri, S. Saravanan, T. Vijayakumar	2025	Using algorithms like SVM, ANN, and Random Forest, the study assesses AI and IoT-based systems for real-time pollution prediction and water quality monitoring.	In regions with limited resources, scalability and deployment continue to be difficult.
[16]	Transforming Water Quality Assessment: A Quantum AI Approach	C. Kishor Kumar Reddy, Akshitha Katta, Thandiwe Sithole, R. Madana Mohana	2025	The study suggests using quantum artificial intelligence (AI) to evaluate intricate water quality data in order to quickly identify and forecast contaminants.	It has not yet been tested for efficacy in actual water monitoring systems.
[17]	Low-Cost IoT-Based Potable Water Quality Monitoring for Rural Communities	Marvellous Emmanuel	2025	A low-cost Internet of Things system for monitoring the quality of drinkable water in rural areas in real time is presented in the paper.	It has not yet been tested for scalability, long-term dependability, or integration with predictive analytics.
[18]	IOT Based Water Quality Monitoring System using ESP32	M. Mahendiran, C. Kabilan, R. Santhosh, E. Yathav, Mr.S. Sugumar, Dr.R. Manikandan, Dr.P. Selvakumar	2025	An ESP32-based Internet of Things system for real-time monitoring of water quality parameters like temperature, turbidity, and pH is presented in the paper.	Untested are scalability, long-term dependability, and AI integration for predictive analysis.
[19]	A Review of Water Quality Forecasting and Classification Using Machine Learning Models and Statistical Analysis	Amar Lokman, Wan Zakiah Wan Ismail, Nor Azlina Ab Aziz	2025	The study examines machine learning models that use sensor and remote sensing data to predict and monitor water quality.	Large-scale scalability, standardized datasets, hybrid models, and real-time data integration are still unexplored.

[20]	Artificial intelligence in water quality monitoring: A review of water quality assessment applications	Rodica Mihaela Frincu	2025	The study examines the use of AI in water quality monitoring, including predictive analytics and real-time assessment using machine learning and deep learning.	There are still issues with system integration, monitoring difficult-to-measure contaminants, data quality, and model interpretability.

Table 1: Literature Survey

IV. CONCLUSION

Integrating AI and deep learning with mobile microscopy provides an effective, low-cost, and portable approach for real-time water quality monitoring. These methods can accurately identify and classify contaminants, offering a practical alternative to traditional lab tests, especially in remote or resource-limited areas. Advances in AI and imaging technology hold significant potential to improve global water safety and accessibility.

Ongoing challenges, such as limited training data, inconsistent image capture, and computational limits, hinder large-scale adoption of AI-driven mobile microscopy. Extensive field testing is still needed to validate its practical scalability. Addressing these issues through collaboration between computer scientists, environmental experts, and public health specialists can advance clean water management worldwide.

V. REFERENCES

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[5] Efficient Prediction of Water Quality Index (WQI) Using Machine Learning Algorithms —Md.Mahedi Hassan, Laboni Akter, Md. Mushfiqur Rahman, Sadika Zaman, Khan Md. Hasib, Nusrat Jahan, Raisun Nasa Smrity, Jerin Farhana, M. Raihan, Swarnali Mollick (2021).

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