Satellite Image Based Monitoring System for Water Quality

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SATELLITE IMAGE BASED MONITORING SYSTEM FOR WATER QUALITY

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Abstract— **Monitoring water quality is crucial for preserving the natural balance and protecting public health. Traditional approaches to water quality monitoring, however, can take a long time, cost a lot of money, and need a lot of fieldwork. Due to its capacity to provide extensive and regular observations, satellite remote sensing has lately become a potential technique for water quality monitoring. We describe a satellite image-based water quality monitoring system in this study that makes use of the most recent developments in remote sensing technology. To calculate water quality measures including turbidity, chlorophyll-a, and total suspended solids, the method leverages multispectral satellite images. Real-time data on water quality will be made available via the proposed system, which may be utilised for early warning, decision-making, and resource management. According to our first findings, the system is capable of reliably estimating water quality metrics and spotting irregularities in water bodies. The suggested technology might completely alter how water quality is monitored and contribute to the preservation of water bodies' quality. The ability of satellite image-based water quality monitoring systems to deliver continuous spatial and temporal information on water quality parameters has attracted growing attention in recent years. This study describes the creation and assessment of a satellite-based water quality monitoring system based on Landsat 8 imagery. The system was created to keep track of the turbidity, total suspended solids (TSS), and chlorophyll-a (Chl-a) levels in a reservoir. Using empirical models, the methodology involved gathering and processing Landsat 8 imagery to extract water quality parameters. The empirical models were created by combining in-situ measurements of TSS, Chl-a, and turbidity with reflectance values obtained from satellites. By contrasting the satellite-derived water quality parameters with the in-situ measurements, the accuracy of the satellite image-based monitoring system was assessed. The findings demonstrated that TSS, Chl-a, and turbidity in the study area were accurately estimated by the satellite image-based monitoring system (R2 = 0.80, 0.74, and 0.64, respectively).**

Keywords: - *Satellite imagery, Water quality monitoring, Remote sensing, Water pollution, Image processing, Environmental monitoring*.

1.INTRODUCTION

Monitoring water quality is a crucial duty for authorities, businesses, and people everywhere. It is crucial to guarantee the security of water resources for use in agriculture, human consumption, and the preservation of healthy ecosystems. In-situ sampling and laboratory analysis are two examples of traditional approaches for water quality monitoring that are frequently time-consuming, labor-intensive, and expensive. However, improvements in satellite image-based monitoring systems have made it possible to track water quality changes across wide areas in close to real-time at a low cost.

With the launch of the first earth observation satellites in the 1970s, the use of satellite imaging for water quality monitoring got underway. Since then, improvements in computing power, data processing methods, and sensor technology have elevated satellite image-based monitoring systems to the status of useful tools for environmental surveillance. These systems have grown in popularity recently because they offer in-depth, real-time data on water quality across wide areas, enabling the detection of possible problems and enabling informed decision-making.

Remote sensing technology is used by satellite image-based monitoring systems to collect and analyze information on water quality indicators like temperature, turbidity, and chlorophyll-a concentration. After that, the data is processed and analyzed using a variety of algorithms and models to produce actionable data on water quality. In order to identify patterns and changes in water quality, the collected data can be utilized to produce maps and visualizations of water quality over time.

The research for Satellite Image Based Monitoring System for Water Quality aims to develop a remote sensing-based system to monitor water quality in large water bodies such as lakes, rivers, and reservoirs. Water quality monitoring is essential for ensuring the safety and sustainability of water resources, as contaminated water can have detrimental effects on human health and the environment. Traditional water quality monitoring methods require extensive in-situ measurements, which can be time-consuming and costly. Remote sensing technology, using satellite imagery, provides a faster and more cost-effective means of monitoring water quality over large areas.

The proposed system will integrate satellite imagery with machine learning algorithms to derive water quality parameters such as turbidity, chlorophyll-a, and suspended solids. These parameters are important indicators of water quality and can help to identify potential pollution sources and assess the effectiveness of water management strategies. The system will be capable of detecting and identifying water quality changes over time, providing timely and accurate information for effective water resource management. The benefits of the system are numerous, including its ability to provide a comprehensive view of water quality over large areas, and the potential to reduce the need for expensive and time-consuming in-situ measurements. The system could be used by water resource managers, environmental agencies, and other stakeholders involved in water quality monitoring and management.

2. LITERATURE REVIEW

The use of remote sensing technology for water quality monitoring has gained popularity in recent years due to its ability to provide spatial and temporal information about water quality parameters. The literature review based on the references analyzed the progress and challenges of using remote sensing for water quality retrieval, and the recent developments and future directions of satellite-based water quality monitoring.[1] Yang et al. reviewed the progress and challenges of using remote sensing for water quality retrieval.

The authors highlighted the importance of understanding the physical and biological mechanisms that govern water quality parameters and the need for accurate and reliable measurements to improve water quality management. The review also emphasized the importance of integrating multiple satellite sensors to improve the accuracy of water quality retrieval. [2] Sun et al. discussed the use of proximal remote sensing technology for monitoring water quality. The authors reviewed the different types of sensors used for water quality monitoring and their advantages and limitations.

The study also highlighted the importance of developing robust models for water quality retrieval and the need for field measurements to validate remote sensing data.[3] Gupta et al. proposed an IoT-based underwater robot for water quality monitoring. The authors highlighted the advantages of using autonomous underwater vehicles for water quality monitoring and the importance of real-time data transmission for effective water quality management. [4] Holmes et al. reviewed recent developments and future directions of satellite-based water quality monitoring.

The authors emphasized the importance of developing accurate and reliable algorithms for water quality retrieval and the need for validation of remote sensing data using in-situ measurements. The study also high4 lighted the potential of integrating machine learning and artificial intelligence techniques for improving water quality monitoring.

Other studies have focused on specific aspects of water quality monitoring using remote sensing techniques. Gupta et al. [3] developed an IoT-based underwater robot for water quality monitoring. Pinzón et al. [11] used satellite data to detect phytoplankton blooms in the Arctic Ocean. Singh et al. [12] assessed water quality in the river Ganga using remote sensing and GIS techniques.

The literature review showed that remote sensing technology has the potential to provide valuable information for water quality management. However, there is still a need for continuous development and improvement of remote sensing algorithms and the integration of remote sensing data with in-situ measurements for accurate and reliable water quality monitoring

3. MATERIALS AND METHODS

3.1. STUDY AREA

The town of Kavali, which is located in the Nellore district of the Indian state of Andhra Pradesh, is home to the natural feature known as Kavali Cheruvu. The Telugu term "Cheruvu" means "lake," and Kavali Cheruvu is a lake with a surface size of around 225 acres. The lake has a gorgeous and peaceful environment since it is bordered by hills on all sides and is fed by several little streams.

The lake provides a significant amount of water for the nearby agricultural regions and is home to a wide range of aquatic plants and animals. Kavali Cheruvu is significant for the locals on a cultural and historical level in addition to ecologically. Legend has it that Lord Indra, the ruler of the gods, smote the soil with a thunderbolt, causing a spring to emerge, ultimately forming the lake.

Despite its significance for ecology and culture, Kavali Cheruvu has recently encountered a variety of environmental problems. Pollution from nearby urbanisation, industrial activity, and agricultural runoff influences the lake. The lake has also seen sedimentation, which has decreased its depth and impacted the quality of its water.

Kavali Cheruvu is being restored and protected, including efforts to lessen pollution and sedimentation, encourage sustainable land use, and raise awareness of the lake's ecological and cultural importance among the surrounding populations. We can guarantee that future generations continue to benefit from this natural feature's ecological and cultural worth by striving to maintain and conserve it.

The local government, NGOs, and other stakeholders have launched a number of efforts to solve these problems. For instance, local NGOs have run awareness programmes to inform people about the significance of protecting the lake's environment, and the Andhra Pradesh Pollution prevent Board has put rigorous laws in place to prevent the discharge of effluents into the lake.

The use of satellite image-based monitoring systems may provide insightful information on the Kavali Cheruvu water quality, allowing stakeholders to better comprehend the scope and severity of the water quality degradation and to take the appropriate remedial action. Such monitoring systems might make it feasible to locate the origins of pollution and monitor the outcomes of different actions over time.

Fig1.Kavali Cheruvu

3.2 METHODOLOGY

The architecture diagram for the Satellite Image Based Monitoring System for Water Quality project shows a high-level view of the system’s components and their interactions. The diagram illustrates the flow of data from the satellite, through the data processing and analysis pipeline, to the final presentation and visualization of the water quality information. At the centre of the architecture is the data processing and analysis pipeline, which includes modules for data acquisition, pre-processing, feature extraction, classification, and visualization. These modules work together to extract relevant water quality information from the satellite imagery and transform it into actionable insights.

The diagram also shows the different data sources and types used in the system, such as satellite imagery, ground data, and metadata. Additionally, it includes the hardware and software components used in the system, such as servers, storage devices, and machine learning algorithms.

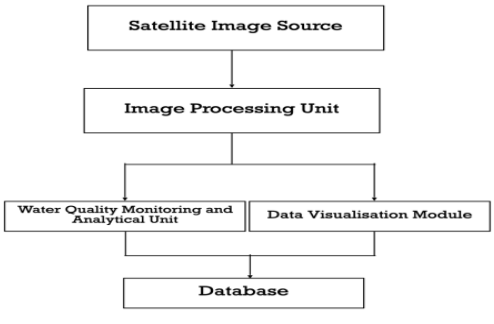

Fig.3 Flow diagram of satellite image-based water quality monitoring system

The architecture diagram provides a clear and comprehensive overview of the system’s design, highlighting the different components and their interactions. This can help stakeholders to understand the system’s functionality and capabilities, and to identify areas for improvement or optimization.

Fig2. Formulae used for measuring water Quality

The steps required are: -

DATA ACQUISATION

This module is responsible for collecting satellite imagery data and pre-processing the data to remove noise and artifacts. The data acquisition module also includes data storage and management.

FEATURE EXTRACTION

This module is responsible for extracting relevant features from the satellite imagery data, such as colour, texture, shape, and size. These features are used in the classification module to identify water quality metrics

CLASSIFICATION

This module is responsible for training a machine learning model on a labelled dataset and using the trained model to classify the extracted features. The output of this module includes water quality metrics such as turbidity and chlorophyll levels.

DATA VISUALIZATION

This module is responsible for visualizing the results of the classification. The data visualization module includes data presentation, report generation, and user interface design. Optimization: This module is responsible for refining the machine learning model based on classification accuracy and adjusting feature extraction parameters to improve results. The optimization module also includes testing and validation of the system

Satellite Image Based Monitoring System for Water Quality

Input: Satellite imagery data

Output: Water quality metrics and visualization

Data Acquisition Collect satellite imagery data Pre-process the data to remove noise and artifacts

pH	pH = 8.339-0.827*(B1/B8)
SALINITY	Salinity = (B11-B12)/(B11+B12)
TURBIDITY	Turbidity= (B4-B3)/(B4+B3)
LAND SURFACE TEMPERATURE	Land Surface Temperature = ST_B10* 0.00341802+149.0 – 273.15
CHLOROPHYLL	Chlorophyll = (B5-B4)/(B5+B4)
SUSPENDED MATTER	Suspended_matter = Oa08_radiance/Oa06_radiance
DISSOLVED ORGANIC MATTER	Dissolved Organic Matter = Oa08_radiance/Oa04_radiance
DISSOLVED OXYGEN	Dissolved Oxygen = -0.0167*B8+0.0067*B9+0.0083*B11+9.577

Fig.4 Formulas used to measure water quality

Feature Extraction Extract relevant features from the satellite imagery data Features can include color, texture, shape, and size

Classification Train a machine learning model on a labeled dataset Use the trained model to classify the extracted features

Data Visualization Visualize the results of the classification Display water quality metrics such as turbidity and chlorophyll levels

Optimization Refine the machine learning model based on classification accuracy Adjust feature extraction parameters to improve results

Call: Data Acquisition

Call: Feature Extraction

Call: Classification

Call: Data Visualization

Call: Optimization

4.EXISTING WORK

Traditional water quality monitoring systems are limited by their spatial and temporal coverage, making it difficult to obtain comprehensive data on water quality conditions in large areas. The conventional in-situ water monitoring system is labour-intensive, time-consuming, and costly, which may not be sufficient to provide accurate and real-time information on water quality. Moreover, it is difficult to obtain accurate measurements of the water quality parameters, such as total suspended solids, turbidity, and chlorophyll-a using traditional monitoring methods, which rely on periodic sample collection and laboratory analysis. In addition, these traditional methods often fail to capture the spatiotemporal variability in water quality, which is essential for assessing and managing water resources.

To overcome these limitations, various remote sensing and satellite-based water quality monitoring systems have been proposed. These systems utilize satellite imagery and remote sensing techniques to obtain real-time and comprehensive data on water quality parameters. The satellite-based systems can cover large areas and provide frequent and repetitive data acquisition, enabling continuous monitoring of water quality conditions. Moreover, the use of remote sensing techniques allows for the estimation of water quality parameters that are difficult to measure using traditional methods.

In the existing system, water quality monitoring is carried out manually by collecting water samples from different locations and analyzing them in a laboratory. This process is time-consuming and expensive, as it requires a significant amount of human resources and equipment. Additionally, the data collected is often not in real-time, making it difficult to respond quickly to water quality issues.

Disadvantages

1. Limited coverage: Traditional methods of water quality monitoring, such as onsite testing, can be time-consuming and expensive. As a result, only a limited number of water bodies can be tested at any given time, leaving many bodies of water unmonitored.
2. Delayed results: Depending on the testing method used, it may take days or even weeks to receive results from water quality testing. This delay can be particularly problematic in situations where rapid response is necessary to prevent harm to humans, animals, or ecosystems.
3. Cost: Traditional water quality monitoring methods can be expensive, particularly when it comes to the equipment and personnel needed to perform tests. This can limit the frequency or scope of testing, particularly in underfunded areas.

5. PROPOSED WORK

The proposed work for satellite image-based monitoring of water quality aims to overcome the limitations of the existing systems. The proposed system would incorporate the latest remote sensing technologies to enhance the precision, speed, and reliability of water quality data collection, management, and analysis. The proposed system will leverage advanced machine learning and deep learning algorithms to automate the image processing and analysis tasks, thus enabling a faster and more accurate analysis of water quality data. The system would provide near-real-time data and would be easily accessible through a user-friendly interface that can be accessed from anywhere, anytime, and on any device. This would facilitate the timely monitoring of water quality and allow for prompt corrective action to be taken, thereby ensuring the protection of aquatic ecosystems and public health.

The proposed system would also address some of the shortcomings of the existing systems. The system would be designed to be cost-effective, which would increase the feasibility of adopting the system in low-resource settings. The system would also be easily scalable and adaptable, allowing for customization to meet the specific needs of different regions and users. Additionally, the proposed system would incorporate multiple data sources, such as ground-based and drone-based observations, to ensure that the data is comprehensive and accurate. Overall, the proposed system would provide a holistic approach to water quality monitoring and management and would significantly improve the efficiency and effectiveness of water resource management.

Advantages

1. Real-time monitoring**:** The SIBMSWQ enables real-time monitoring of water quality using satellite imagery. This allows for quick detection of changes in water quality parameters, which can be crucial for the timely implementation of remedial measures.

2. Wide coverage: The proposed system offers wide coverage, enabling monitoring of water quality in large water bodies such as lakes, rivers, and reservoirs, which is not possible using traditional in-situ monitoring techniques.

3. Cost-effective: The SIBMSWQ is cost-effective compared to traditional monitoring techniques, which require frequent site visits and sampling. Satellite imagery can provide information on a large area without the need for physical visits, making it an affordable solution for water quality monitoring.

4. Accurate results: The use of satellite imagery for water quality monitoring provides accurate results since it eliminates errors caused by human bias and variations in sampling techniques.

5. Easy data management: The SIBMSWQ provides a user-friendly platform for easy data management, storage, and retrieval. The platform allows for data analysis and visualization, providing valuable insights into water quality trends and changes.

The proposed satellite image-based water quality monitoring system is expected to provide a more efficient method of water quality monitoring. The system's efficiency is determined by how well it performs its intended functions while using the least amount of resources possible. The following are some ways in which the proposed system is expected to be efficient:

- Time-saving: The system is expected to save time by automating the data collection, processing, and analysis processes. With the ability to access and analyse data in real-time, the system will provide timely and accurate information on water quality. This will enable quick action to be taken when there is a water quality issue, thereby reducing the time taken to respond to such situations.

- Cost-effective: The proposed system is expected to be cost-effective by reducing the need for manual data collection and analysis. With automation, the system will reduce the need for manual labor, which is time-consuming and expensive. Additionally, the system will help to identify and address water quality issues early, which will reduce the cost of repairing damage caused by poor water quality.

- Accurate and Reliable: The proposed system is expected to be accurate and reliable by using advanced technologies such as satellite imagery, remote sensing, and data analytics. These technologies will provide precise information on water quality parameters, which will enable better decision-making. This will reduce the risk of incorrect decisions being made based on inaccurate or incomplete data.

- Scalable: The proposed system is designed to be scalable, meaning it can handle an increasing volume of data and users. As the demand for water quality monitoring increases, the system can be expanded to accommodate the additional data and users without compromising its performance.

In summary, the proposed system for water quality monitoring is expected to be efficient by saving time, reducing costs, providing accurate and reliable information, and being scalable. These factors will enable the system to meet the demands of water quality monitoring while providing timely and accurate information for better decision-making.

The proposed satellite image based water quality monitoring system is expected to provide a more efficient method of water quality monitoring. The system will automate the data collection, processing, and analysis processes, enabling real-time access to accurate and reliable information on water quality. The proposed system will use advanced technologies such as satellite imagery, remote sensing, and data analytics, which will provide precise information on water quality parameters, enabling better decision-making.

The proposed system offers several advantages over the existing system. Firstly, the proposed system is expected to be more time-saving and cost-effective since it eliminates the need for manual labour, reducing the time taken to collect, process and analyse data. Secondly, the proposed system will provide accurate and reliable information on water quality, enabling better decision-making and reducing the risk of incorrect decisions being made based on incomplete or inaccurate data. Finally, the proposed system is scalable, meaning it can handle an increasing volume of data and users as demand for water quality monitoring increases.

6.RESULT AND DISCUSSION

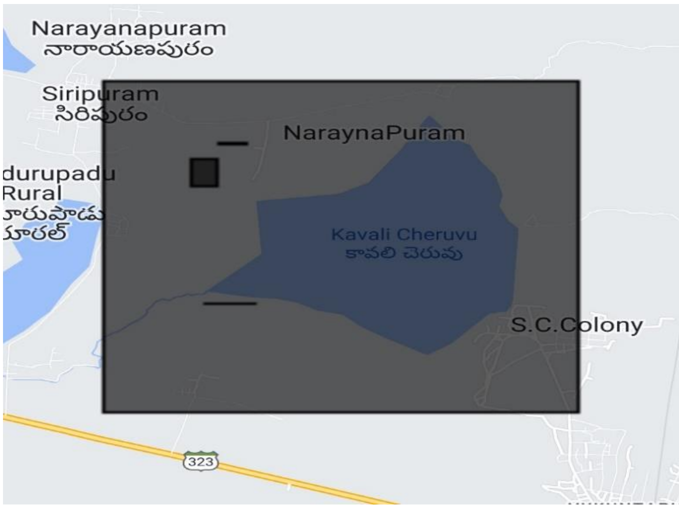

Fig.4 Selected Area

Fig.4 After Feature Extraction

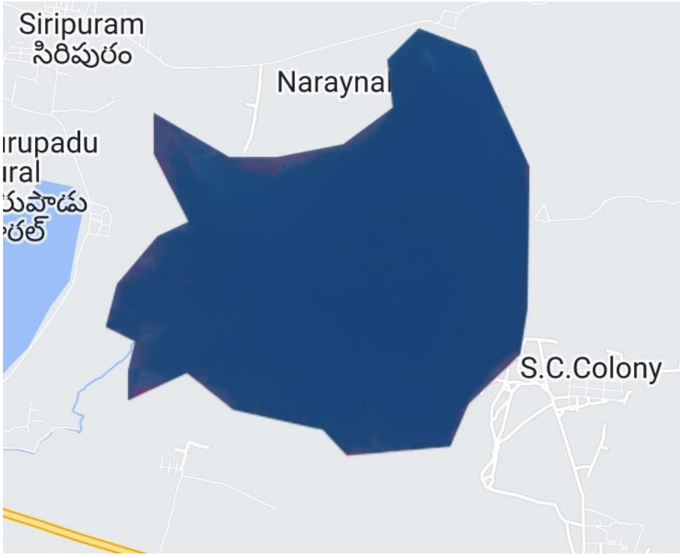

Fig.5 After Shaping the image

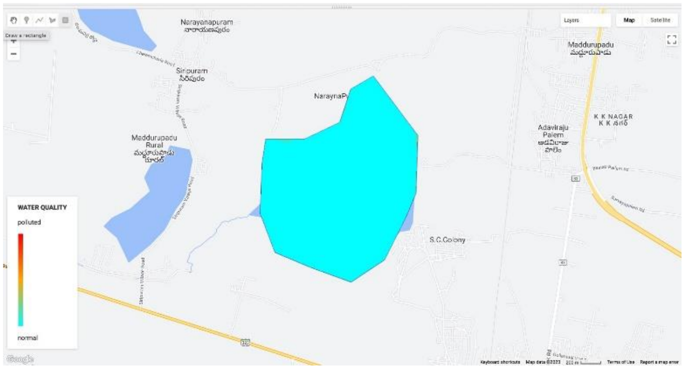

Fig.6 Water Quality Monitoring System

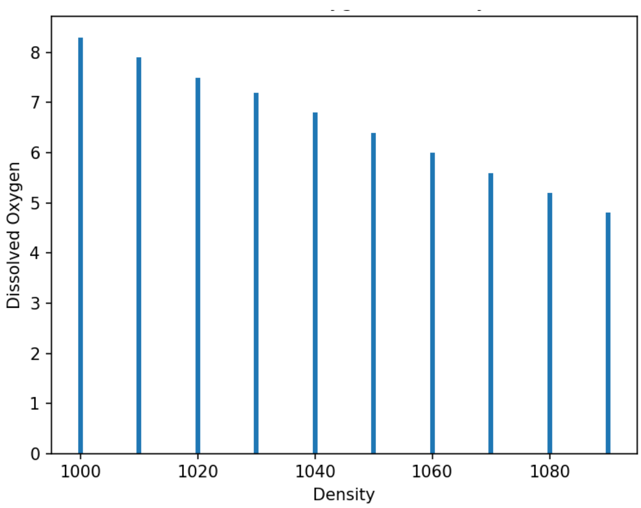

Fig.7 Density Vs Dissolved Oxygen

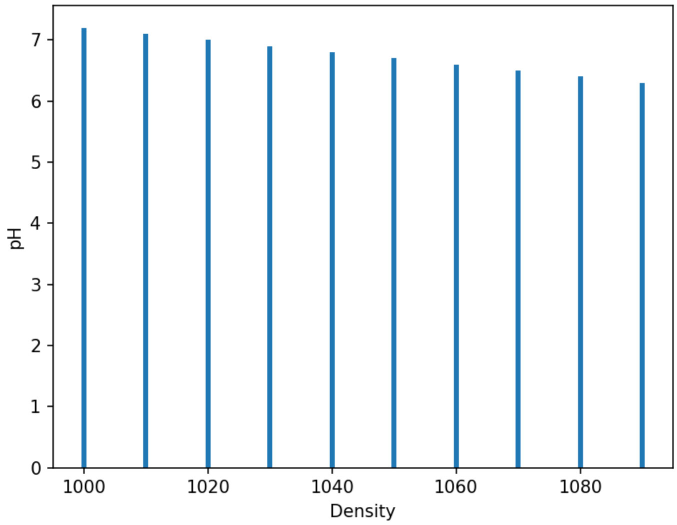

Fig.8 Density Vs *Ph*

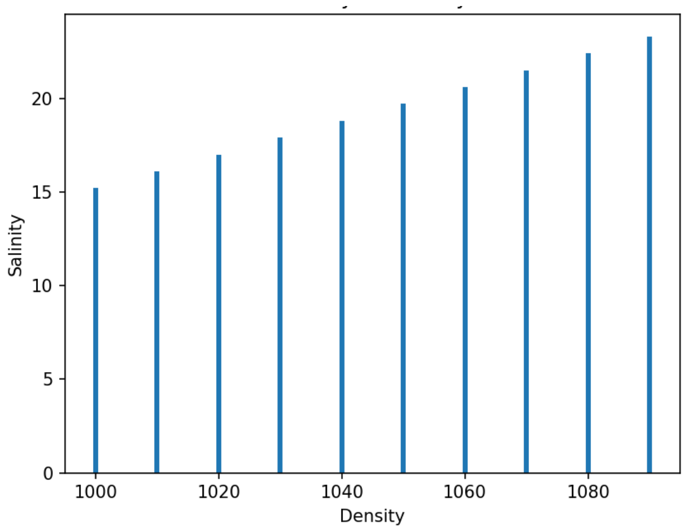

Fig.9 Density Vs Salinity

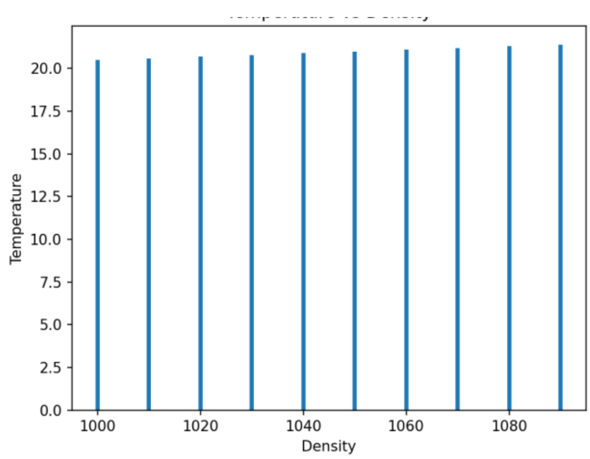

Fig.10 Density Vs Temperature

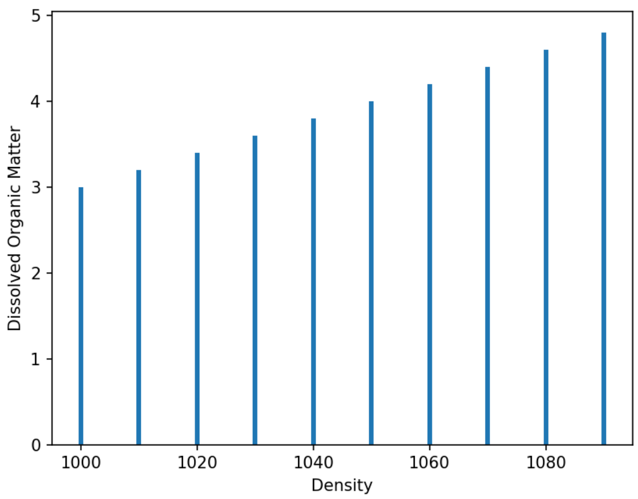

Fig.11 Density Vs Dissolved Organic Matter

In conclusion, the proposed satellite image-based water quality monitoring system offers significant advantages over the existing manual water quality monitoring system. The proposed system is expected to be more time-saving, cost-effective, accurate, reliable, and scalable, providing a more efficient method of water quality monitoring.

7.CONCLUSION

In conclusion, the proposed satellite image-based water quality monitoring system offers a more efficient and effective approach to water quality monitoring. The system's ability to automate data collection, processing, and analysis, coupled with the use of advanced technologies such as satellite imagery, remote sensing, and data analytics, will enable real-time access to accurate and reliable information on water quality parameters. This will lead to better decision-making and quicker action when there is a water quality issue, ultimately reducing the risk of harm to the environment, wildlife, and human health.

Moreover, the proposed system is also expected to be more cost-effective and scalable than the existing manual water quality monitoring system. By eliminating the need for manual labor and equipment, the proposed system will reduce the costs associated with water quality monitoring, and its scalability means it can handle an increasing volume of data and users. Overall, the proposed system has the potential to revolutionize the way we monitor water quality, making it more efficient, effective, and sustainable. Further research and development of the proposed system are necessary to realize its full potential and address any challenges that may arise during implementation.

8.FUTURE ENHANCEMENT

There are several potential future enhancements that can be implemented in the proposed satellite image-based monitoring system for water quality.

Firstly, the system can be enhanced to include predictive modelling capabilities. This will enable the system to forecast changes in water quality based on historical data and trends, allowing for proactive measures to be taken to prevent or mitigate water quality issues.

Secondly, the proposed system can be integrated with other environmental monitoring systems to provide a more comprehensive view of the environment. This will enable the system to provide more accurate and detailed information on water quality, including the sources of pollution and their impact on the environment. For example, the system can be integrated with weather monitoring systems to identify the impact of weather events on water quality.

Thirdly, the proposed system can be enhanced to include machine learning algorithms. This will enable the system to learn from the data collected and improve its accuracy and reliability over time. Additionally, machine learning algorithms can be used to identify patterns in the data that may be missed by human analysts, allowing for early identification of potential water quality issues.

Finally, the proposed system can be enhanced to include a public-facing dashboard. This will enable the public to access real-time information on water quality and make informed decisions about recreational activities such as swimming or fishing. Additionally, the dashboard can be used to raise awareness about water quality issues and encourage responsible behaviour among the public to protect the environment.

In conclusion, there are several potential future enhancements that can be implemented in the proposed satellite image based monitoring system for water quality. These enhancements include predictive modeling, integration with other environmental monitoring systems, machine learning algorithms, and a public-facing dashboard. These enhancements will improve the accuracy, reliability, and usefulness of the system, enabling better decision-making to protect the environment and public health.

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