



# REMOTE SENSING BASED WATER QUALITY MONITORING

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**ABSTRACT:** Places facing rapid urbanization and industrial growth go through degradation of the water quality, hence monitoring it is essential for maintaining environmental sustainability and health of the living beings. Traditionally, methods like in-situ sampling were used which had its own limitations making it difficult to monitor large areas. This study is focused on the use of remote sensing techniques for monitoring the water quality in the Asansol- Damodar River region, with the help of satellite imagery from Landsat8 and Sentinel-2, and using the platform of Google Earth Engine for data analysis. Key parameters like turbidity, algal bloom, BOD (Biological Oxygen Demand), NDWI and chlorophyll-a concentration are derived using spectral indices, allowing for large-scale, real-time monitoring of the water body. The real-time monitoring will aid in informing the locals and policymakers about the situation. This research highlights that the technique of Remote Sensing has potential to provide actionable insights for water resource management. The main aim is to be able to manage the water resources, identification of the polluted regions and sustainability of the water bodies in the region. The study signifies that using remote sensing is cost-effective, scalable and efficient rather than using the traditional methods of water quality monitoring.

**Keywords - Chlorophyll-a Concentration, Landsat 8, NDWI, BOD, Remote Sensing, Spectral Indices, Turbidity**

## INTRODUCTION

Water quality monitoring is essential for maintaining safe and healthy water resources, critical for drinking, agriculture, industry, and preserving ecosystems. Traditionally, water quality assessment has relied on ground-based sampling and laboratory analysis, which are often time-consuming, labor-intensive, and limited in spatial coverage. However, with the advent of remote sensing, it is now possible to monitor water quality over vast areas more efficiently, quickly, and cost-effectively. It reflects the health of surface water bodies as a snapshot in time (weeks, months, and years). Therefore, best practices and efforts are needed to monitor and improve water quality. It affects what we can use the water for and influences the health of the hydrological system. A healthy system will in turn provide better quality water and a more resilient ecosystem.

Water quality monitoring by remote sensing uses technologies to collect data on water bodies (lakes, rivers, reservoirs, and coastal areas). The process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft) is known as Remote Sensing. By analyzing the electromagnetic radiation reflected or emitted by the water's surface, remote sensing provides valuable insights into factors such as chlorophyll concentration, turbidity, water temperature, algal bloom, and NDWI. These are the features which will be evaluated further for monitoring.

There are several advantages, including the ability of monitoring large and remote water bodies, providing frequent and real-time data, and reducing the need for extensive field sampling. This in turn allows better management of water resources, faster responses to situations involving pollution, and enhanced understanding of aquatic ecosystems.

### 1.1 Need of the Study:

Day by day the aquatic ecosystem is degrading, so to ensure the health and safety, Water Quality Monitoring is a very crucial topic. Water resources are one of the most important relying options for purposes like irrigation, drinking, and other activities. Advancements have been taking place in various fields, so in place of using traditional methods like point based sampling which are not only old but labor intensive and resource heavy on the other hand remote sensing allows real time monitoring of water bodies which are of large scale enabling us to detect the water quality changes due to pollution on natural events. It's an efficient way of tracking and assessing water quality indicators or parameters we can say like turbidity chlorophyll concentration temperature

which are not only hazardous but also crucial for living beings' health.

## 1.2 Project Objective:

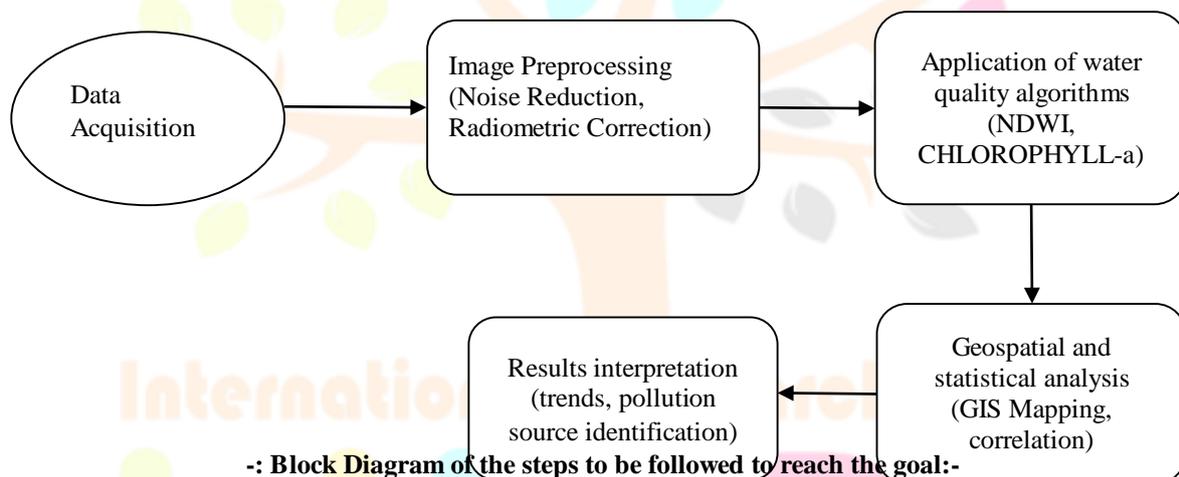
By using Remote Sensing techniques we want to monitor the water quality in the Asansol-Damodar River Region. The satellite data and platforms like GEE(Google Earth Engine) and parameters like Date, BOD, Turbidity, Chlorophyll-a concentration, Surface Temperature and Algal Bloom Index, with the NDWI calculation. The actual goal is to successfully generate real-time large-scale water quality monitoring that can inform the localities. This is to improve the management of the water resources, pollution hotspots identification and ensuring the sustainability of the region's water Bodies.

## RESEARCH METHODOLOGY:

Research methodology is the system of methods and techniques used by researchers to collect, analyze, and interpret data in order to answer research questions or test hypotheses. It involves a structured approach to ensure that the research is conducted in a systematic, objective, and scientific manner.

### 2.1 Analytical Techniques or Flowchart:

The analytical approach includes a combination of machine learning techniques and geospatial analysis. The main steps in the analysis are outlined below, along with a flowchart representing the overall methodology



**1. Data Collection:** Obtain satellite imagery from Sentinel-2, Landsat, and other sources via GEE.

**2. Pre-processing:** Apply atmospheric corrections, noise reduction, and image filtering techniques.

**3. Feature Extraction:** Extract water quality parameters (e.g., turbidity, chlorophyll concentration) from the imagery using relevant indices (e.g., Normalized Difference Water Index - NDWI).  
**4. Data Validation:** Compare remote sensing data with in-situ data to validate results.

**4. Machine Learning Models:** Train models (e.g. Support Vector Machine) on the data to predict water quality parameters and identify trends.

**5. Visualization:** Create visual representations, such as heat maps and time-series graphs, to Interpretation and Conclusion: Derive conclusions based on the visualizations and statistical outcomes, addressing the research questions.

### 2.2 Population and Sample:

The population for this study includes the region of Asansol-Damodar (river) focusing on their water quality parameters, such as turbidity, chlorophyll concentration, and surface temperature.

### 2.3 Data and Sources of Data:

In a water quality parameters study using remote sensing, the data typically includes key indicators such as chlorophyll-a concentration (measuring algae levels, in mg/m<sup>3</sup>), turbidity (indicating water clarity, in NTU), surface water temperature (measured

in °C, to assess thermal pollution) and dissolved oxygen (in mg/L, crucial for aquatic life). This data can be obtained through remote sensing using satellites like Sentinel-2 (for chlorophyll-a, turbidity, and temperature) and Landsat (for long-term monitoring of turbidity and surface temperature).

## 2.4 Theoretical framework:

The key water quality parameters such as turbidity, chlorophyll-a concentration and surface temperature play a direct role in aquatic life. The sunlight penetration can be reduced due to the presence of high turbidity, which in turn affects the aquatic plants in different ways like hampering photosynthesis. On the other hand high chlorophyll levels indicate algal blooms, which can lead to eutrophication and depletion of oxygen in water. This understanding forms the foundation for measuring water quality and interpreting its impact on ecosystems.

### 2.4.1 Environmental Monitoring and Management Theory:

Environmental monitoring is based on the theory that continuous, systematic observation of water quality allows for early detection of pollution, changes in ecosystems, and the assessment of intervention measures. Remote sensing provides a cost-effective and efficient way to monitor large water bodies over time, aiding in management decisions for water conservation, pollution control, and ecosystem health maintenance. Environmental monitoring refers to the observation and study of the environment in order to collect data and derive knowledge about it. This data is used to enhance our understanding of environmental issues and make informed decisions regarding the management and preservation of natural resources.

**Hypothesis of the project:** Remote sensing provides a reliable tool for the continuous monitoring of water quality, aiding in more effective environmental management and policy-making. We can easily monitor the quality of water with parameters.

### 2.4.2 Equation:

The Normalized Difference Water Index (NDWI) is commonly used for monitoring water bodies and assessing water quality in regions like the Damodar area near Asansol. The equation for NDWI is:

$$NDWI = \frac{Green\ Band - NIR\ Band}{Green\ Band + NIR\ Band}$$

## RESULTS AND DISCUSSION

### 3.1 Results Overview

Over time and across various locations there have been changes seen in the water quality because of many reasons similar to the analysis of the Damodar River in Asansol. Key parameters like turbidity, chlorophyll-a concentration, and water temperature varied significantly. Using remote sensing data from satellites like Sentinel-2 and Landsat, tools such as NDWI, Turbidity Index, and Chlorophyll-a Index helped to assess water quality. The main factors affecting water quality were industrial pollution, human activities, and seasonal runoff.

### 3.2 Water Quality Spatial Patterns

#### Turbidity:

High turbidity was found near industrial areas like Bansra and Ramnagar, exceeding 30 NTU. Cleaner water with turbidity levels of 5–15 NTU were seen upstream. Images from satellites are darker when the turbidity was higher.

#### Chlorophyll-a:

Stagnant areas and regions with mining runoff had higher chlorophyll-A levels, above 20 µg/L, especially during summer. This indicates algae growth due to excess nutrients.

#### Water Temperature:

Water in industrial areas was warmer, reaching 28°C, compared to natural upstream areas where it stayed around 22°C, which is just thermal pollution.

### 3.3 Seasonal and Long-Term Trends

#### Seasonal Changes:

##### 1. Monsoon (June–September):

Turbidity increased because of heavy rains and runoff, while chlorophyll-a levels dropped due to dilution.

##### 2. Dry Season (November–May):

Chlorophyll-a levels increased, causing algal blooms, while turbidity decreased in areas with less water flow.

##### 3. Long-Term Changes (2021–2024):

Over time, turbidity and nutrient levels increased due to growing industrial activity and urbanization.

### 3.4 Causes of Poor Water Quality:

- Industrial Pollution:** High Turbidity and Thermal pollution occurs due to the waste from coal mines, power plants, and factories.
- Mining Runoff:** Heavily affected downstream water because of the presence of sediments and heavy metals from mining areas.

3. **Urban Waste:** Domestic and municipal waste increase the pollution mainly in the populated areas.

**3.5 Impacts (Environmental and Social):**

1. **Algal Blooms:** The aquatic life is getting harmed due to excessive nutrients hereby causing the algae to grow.
2. **Health Risks:** The water affected is prone to diseases due to the pollution causing high turbidity and toxic waste making it seriously unsafe for drinking and irrigation too.
3. **Water Management:** There is an urgent need for an efficient waste management system and better pollution control.

Let's analyze this data, create graphs for key parameters, and write the result and discussion.

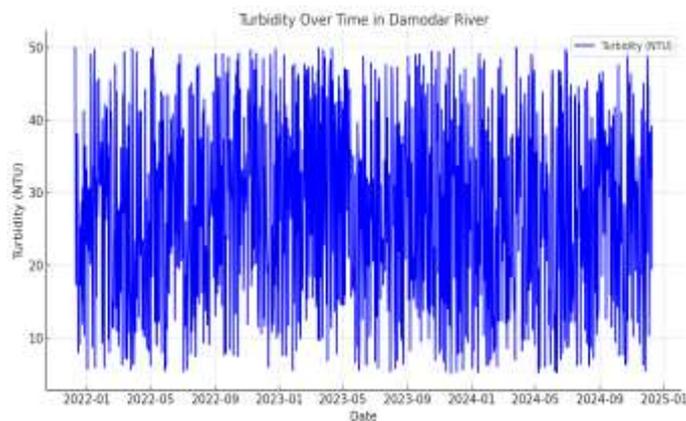


Figure. 1(Turbidity graph of Damodar river)

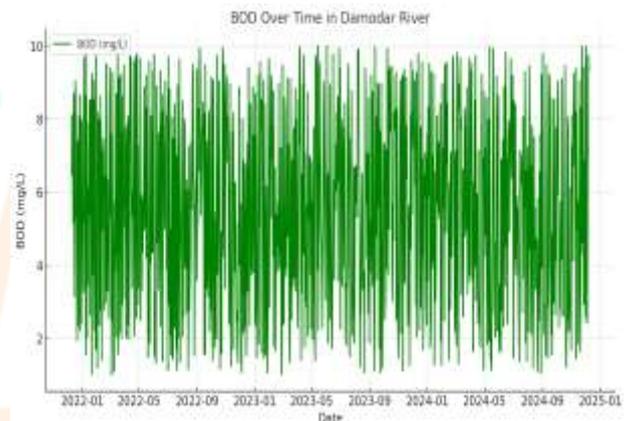


Figure.1.2(BOD graph of Damodar river)

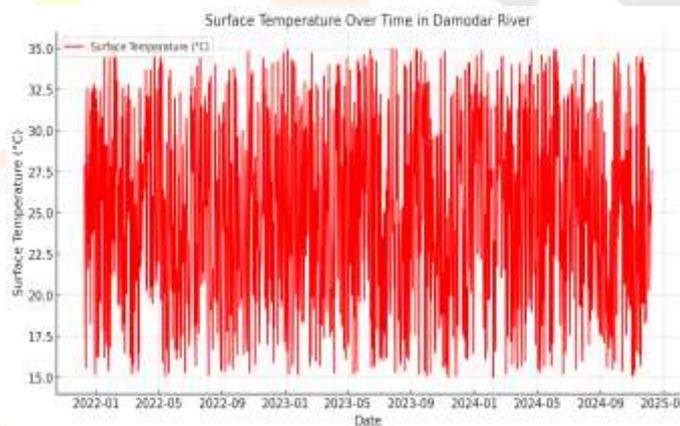


Figure.1.3 (Surface temperature graph of Damodar River)

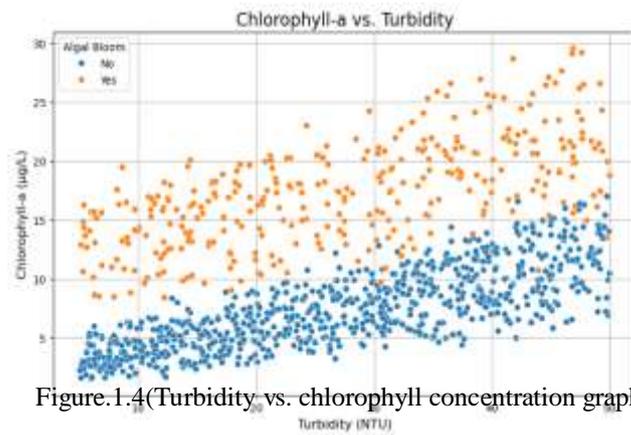


Figure.1.4(Turbidity vs. chlorophyll concentration graph)

## ACKNOWLEDGMENT

We would like to express our heartfelt gratitude to our Mentor for their support, constructive feedback and invaluable guidance throughout our project on Water Quality Monitoring based on Remote Sensing. Our heartfelt gratitude also goes to our members for their continuous engagement and assistance. Their expertise and support played a key role in the successful realization of this work.

## REFERENCES

- [1] Adjovu, G. E. (2023). Overview of the application of remote sensing in effective monitoring of water quality parameters. *Remote Sensing*, 15(7), 1938.
- [2] Campbell, J. B. (2011). *Introduction to remote sensing*. Guilford press.
- [3] Chebud, Y. N. (2012). Water quality monitoring using remote sensing and an artificial neural network. *Water, Air, & Soil Pollution*, 223, 4875-4887.
- [4] Chen, Q. Z. (2007). Water quality monitoring using remote sensing in support of the EU water framework directive (WFD): A case study in the Gulf of Finland. *Environmental monitoring and assessment*, 124, 157-166.
- [5] Dekker, A. G. (1999). Remote sensing of inland and coastal waters. *The Review of Radio Science*, 2002, 519-534.
- [6] Gholizadeh, M. H. (2016). A comprehensive review on water quality parameters estimation using remote sensing techniques. *Sensors*, 16(8), 1298.
- [7] Hassan, G. S. (2020, November). Prediction framework for water quality parameters monitoring via remote sensing. In *2020 First International Conference of Smart Systems and Emerging Technologies (SMARTTECH)* (pp. 59-64). IEEE.
- [8] Japitana, M. V. (2019). A satellite-based remote sensing technique for surface water quality estimation. *Engineering, Technology & Applied Science Research*, 9(2), 3965-3970.
- [9] Jensen, J. R. (2009). *Remote sensing of the environment: An earth resource perspective 2/e*. South Carolina: Pearson Education India.
- [10] Koponen, S. P. (2002). Lake water quality classification with airborne hyperspectral spectrometer and simulated MERIS data. *Remote Sensing of Environment*, 79(1), 51-59.
- [11] Liu, Y. I. (2003). Quantification of shallow water quality parameters by means of remote sensing. *Progress in physical geography*, 27(1), 24-43.
- [12] Ritchie, J. C. (2003). Remote sensing techniques to assess water quality. *Photogrammetric engineering & remote sensing*, 69(6), 695-704.
- [13] Topp, S. N. (2020). Research trends in the use of remote sensing for inland water quality science: Moving towards multidisciplinary applications. *Water*, 12(1), 169.
- [14] Usali, N. &. (2010). Use of Remote Sensing and GIS in Monitoring Water Quality . *Journal of sustainable development*, 3(3), 228.

[15] Wang, X. &. (2019). Water quality monitoring and evaluation using remote sensing techniques in China: A systematic review. *Ecosystem Health and Sustainability*, 5(1), 47-56.

[16] Yigit Avdan, Z. K. (2019). Monitoring the water quality of small water bodies using high-resolution remote sensing data. *ISPRS International Journal of Geo-Information*, 8(12), 553.

