

Comparative Analysis of Physicochemical Water Quality of the Phalgu River in Pre-and Post-Monsoon Seasons

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Abstract - The Phalgu River is an important freshwater resource supporting domestic, agricultural, and ecological functions in Gaya and surrounding areas. However, increasing anthropogenic pressures—including agricultural runoff, urban waste disposal, and sand mining—have contributed to growing physicochemical pollution, posing risks to aquatic ecosystems and public health. During the pre-monsoon season, reduced flow conditions tend to concentrate contaminants such as nutrients and heavy metals, potentially lowering water quality and affecting aquatic life. This study examines seasonal variations in water quality during the pre- and post-monsoon periods, with a comprehensive assessment of key physicochemical parameters, including pH, dissolved oxygen, turbidity, nutrients, and selected heavy metals. The river stretch flowing through Gaya district was systematically monitored. Water samples were collected from eight strategically selected sampling stations during both seasons to evaluate spatial and temporal variations. Heavy metal concentrations were analyzed using Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS), ensuring accurate detection and quantification of trace elements. These advanced analytical techniques provided reliable insights into the presence and distribution of potentially toxic contaminants in the river water. The post-monsoon assessment revealed noticeable changes in physicochemical characteristics, primarily influenced by monsoonal runoff and sediment mobilization. Increased suspended matter and altered nutrient dynamics were observed in several locations, reflecting the combined impact of natural hydrological processes and human activities. Data processing and statistical evaluation were conducted using Python-based analytical tools to ensure systematic interpretation of seasonal patterns. Overall, the findings highlight clear seasonal fluctuations in water quality driven by hydrological variability and anthropogenic stressors. Continued long-term monitoring and effective pollution management strategies are essential to protect and sustain the ecological health of the Phalgu River.

Keywords: Physicochemical, Phalgu River, Pre and Post Monsoon, Atomic Absorption Spectroscopy, Inductively Coupled Plasma Mass Spectrometry, Water Quality

1. INTRODUCTION

The physicochemical dynamics of river systems play a vital role in understanding aquatic ecosystems, water quality, and overall environmental health. This study investigates the comparative dynamics of rivers during the pre-monsoon and post-monsoon seasons, emphasizing the significant changes that occur between these two hydrological periods. In the pre-monsoon phase, rivers typically experience lower water levels and higher temperatures, leading to increased concentrations of pollutants and nutrients due to reduced dilution. This period is often marked by altered physical properties, such as turbidity and flow rates, influenced by human activities like agricultural runoff and urban discharges [1-4]. These changes can adversely affect the chemical composition of the water, impacting dissolved oxygen levels and the overall health of aquatic organisms. Conversely, the post-monsoon season brings considerable changes. The arrival of rainwater increases river flow, often diluting pollutants and temporarily improving water quality [5-7]. However, this season may also introduce new challenges, including heightened sedimentation and additional contaminants from surface runoff. Understanding these dynamics is crucial for effective water resource management and pollution mitigation. This analysis utilizes a comprehensive methodology, incorporating both field measurements and laboratory tests to assess key parameters like pH, dissolved oxygen, turbidity, and nutrient levels [8-10].

The physicochemical variations between these two seasons, the study aim to provide insights into the ecological health of the river and guide future conservation efforts. Ultimately, this research highlights the necessity of ongoing monitoring to address the dynamic nature of river systems amid climatic changes and human influences. The dynamics of river systems are significantly influenced by seasonal changes, particularly between the pre-monsoon and post-monsoon periods [11-13]. These fluctuations can alter the physico-chemical properties of water, impacting aquatic ecosystems, water quality, and environmental health. However, there is insufficient comprehensive data on how these seasonal shifts affect river dynamics, leading to potential mismanagement of water resources and ineffective pollution control strategies. Understanding these dynamics is crucial for effective environmental management, especially in the face of increasing pressures from urbanization, agriculture, and climate change [14-

16]. The study aims to analyze and compare the physico-chemical properties of a river during both pre-monsoon and post-monsoon seasons, focusing on key parameters such as pH, dissolved oxygen, turbidity, and nutrient concentrations. By utilizing field measurements and laboratory analyses, the research seeks to identify significant variations between the two seasons and their implications for aquatic ecosystems. The goal is to provide data-driven insights that can inform effective water resource management, enhance conservation efforts, and support the development of policies to mitigate the impacts of human activities and climate change on river systems [17-20]. The remaining sections are arranged as follows: The literature review was described in Section 2, the proposed technique was described in Section 3, the results were discussed in Section 4, and the paper's conclusion was described in Section 5.

2. LITERATURE SURVEY

The literature survey on physicochemical pollution in the Kiul River highlights the critical impact of anthropogenic activities on water quality, particularly during varying seasonal conditions. Previous studies have documented fluctuations in key parameters, emphasizing the need for comprehensive assessments. This review aims to contextualize the current analysis within existing research, identifying knowledge gaps and areas for further investigation. Emeka C N et al., [21] demonstrated significant correlations ($p < 0.05$) with pH, while density exhibited significant relationships with temperature, salinity, and pH. The study highlights that changes in tidal cycles and current velocity are key contributors to the observed variations in the physicochemical properties of the Cross River estuary. Baruah D et al., [22] conducted from December 2019 to November 2021, the study aimed to investigate the seasonal relationships between physico-chemical parameters and the phytoplankton community in Sorbhog Beel, a significant wetland within the Eastern Himalayan Biodiversity Hotspot. The influence of physicochemical parameters on various groups of phytoplankton was analyzed using Canonical Correspondence Analysis. Yadav S et al., [23] contaminated with bacterial populations, particularly at location S4, which requires the most attention among all the lakes. The results of the bacterial analysis revealed the presence of coliform bacteria in all the lakes. Veeran Y et al., [24] The bacterial analysis findings indicated that coliform bacteria were present in all of the lakes. The comprehensive seasonal analysis of Masani Barrage Lake and JLN Canal in Rewari highlights the significant effects of seasonal variations on aquatic ecosystems. Sharma N et al., [25] examined the effects of both anthropogenic and natural factors on the physico-chemical and nutritional parameters. The findings indicate that flooding can degrade groundwater quality, leading to a decline in water quality and an increase in contamination levels, which may have harmful effects on both the environment and human health.

Mishra A P et al., [26] demonstrated acceptable water quality at the sampled stations. These findings offer insights into the changes in dissolved inorganic chemical loads and their sources across different sections of the basin, which are essential for addressing site-specific pollution in the river. Semwal N et al., [27] analyzed for both pre-monsoon and post-monsoon seasons, and point count surveys were conducted to evaluate species richness and waterbird density. The findings indicate a positive correlation between species density and water temperature, total dissolved solids, and dissolved oxygen during the pre-monsoon season. Lakhera K et al., [28] collected and tested for temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), and electrical conductivity (EC) from various sampling sites during the pre-monsoon, monsoon, and post-monsoon seasons. The investigation revealed a decline in the water quality of the Ganga. Zafar M M et al., [29] used to calculate the indices, and spatial maps were generated using ArcGIS software. The results indicated significant seasonal variations in several physico-chemical parameters. Kumar J et al., [30] improved due to precipitation and surface runoff hypothesized that a series of barrages modifies the hydrological characteristics of cascading reservoirs, which is linked to spatial and seasonal fluctuations in functional group (FG) diversity. As a result, Phytoplankton functional groups could serve as valuable bioindicators of water quality.

3. RESEARCH PROPOSED METHODOLOGY

Analysing the physicochemical dynamics of a river in the pre-and post-monsoon seasons involves a comprehensive approach that includes site selection, systematic sampling, and laboratory analysis. Initially, multiple sampling sites along the river will be identified, with water samples collected during the pre-monsoon (1-2 months before monsoon) and post-monsoon periods (immediately after and for several months thereafter). Key physicochemical parameters such as temperature, pH, dissolved oxygen, turbidity, and nutrient concentrations will be measured using standardized methods. Field measurements will be complemented by laboratory analyses to ensure accuracy and reliability. This methodology aims to evaluate the impact of monsoonal rainfall on river water quality, providing insights into seasonal variations and potential ecological implications..

(a) Study Area

The present study focuses on the Phalgu River as it flows through Gaya, an area experiencing increasing anthropogenic pressure. Sampling stations were strategically selected to represent diverse land-use settings, including rocky upstream stretches

used for water abstraction, agricultural fields, rural settlements, zones affected by intensive sand mining, and reaches receiving urban solid waste and wastewater discharge from Gaya city.

This spatially distributed sampling design enables a comprehensive evaluation of the river's physicochemical dynamics under varying environmental and human influences. Agricultural runoff contributes nutrients and agrochemicals; village settlements introduce domestic wastewater and microbial contaminants; sand mining activities enhance sediment load and turbidity; while urban dumping adds organic and inorganic pollutants. By integrating these contrasting site conditions, the study effectively captures both spatial heterogeneity and seasonal variability (pre- and post-monsoon) in water quality.

The investigation aims to quantify the extent to which agricultural practices, urban waste disposal, and mining disturbances alter key water quality parameters and ecological stability. Understanding these interactions is critical for assessing the river's environmental health and identifying pollution hotspots. The outcomes of this research provide a scientific foundation for sustainable river basin management, pollution control planning, and long-term ecological conservation of the Phalgu River ecosystem.

(b) Data Collection

Data collection for the study was conducted during the pre-monsoon and post-monsoon seasons in 2018,2019. Water samples were collected from eight strategically located sampling stations along the Phalgu River, representing diverse environments influenced by agricultural activities, urban waste, and natural features. The physicochemical parameters analyzed included pH, dissolved oxygen, turbidity, total dissolved solids (TDS), and other relevant characteristics. These measurements provided a comprehensive understanding of the river's water quality and highlighted seasonal variations. By comparing data across the three years, the study aimed to assess the environmental impacts of human activities and natural processes on the river ecosystem. This analysis not only identifies trends in water quality but also informs stakeholders about potential ecological issues, supporting efforts for effective river management and conservation strategies in the region. Additionally, it outlines various land use patterns adjacent to the river, illustrating how human activities interact with the natural ecosystem. This visual representation underscores the ecological significance of the Phalgu River as a vital water resource, influencing local biodiversity and supporting livelihoods through agriculture and fishing. By showcasing the interconnectedness of the river with its environment, this overview serves as a crucial reference point for understanding the river's role in local hydrology, ecology, and community dynamics.

(c) Sampling Procedure and Laboratory Analysis

Water samples were collected at each of the eight sampling stations during both the pre-monsoon (April-May) and post-monsoon (October-November) periods to capture seasonal variations in water quality. The sampling process utilized clean, sterilized containers to prevent contamination, ensuring the integrity of the samples. After collection, the samples were preserved and transported to the laboratory for a thorough analysis of various physicochemical parameters, allowing for an accurate assessment of the river's health over time. Samples were analyzed following established standard methods for water quality testing to ensure accuracy and reliability. For physicochemical parameters, techniques such as colourimetric, titrimetric, and gravimetric methods were employed, enabling precise measurements of key characteristics like pH, dissolved oxygen, and turbidity. Heavy metal concentrations were assessed using advanced analytical techniques, specifically atomic absorption spectroscopy (AAS) and inductively coupled plasma mass spectrometry (ICP-MS), providing detailed insights into the presence of harmful contaminants in the river water. This comprehensive approach facilitated a thorough evaluation of the water quality in the Phalgu River.

(i) Atomic Absorption Spectroscopy (AAS)

Atomic Absorption Spectroscopy (AAS) leverages the unique physicochemical properties of metals, such as their ability to absorb light at specific wavelengths, to quantify their concentrations in various samples. During the analysis, samples are prepared to ensure that heavy metals are in a soluble form, facilitating their atomization in a flame or graphite furnace. As light from a hollow cathode lamp passes through the atomized sample, free metal atoms absorb light at characteristic wavelengths, which is directly related to their concentration. This absorption is then detected and quantified against a calibration curve, allowing for precise measurement of heavy metal levels based on their distinct optical properties.

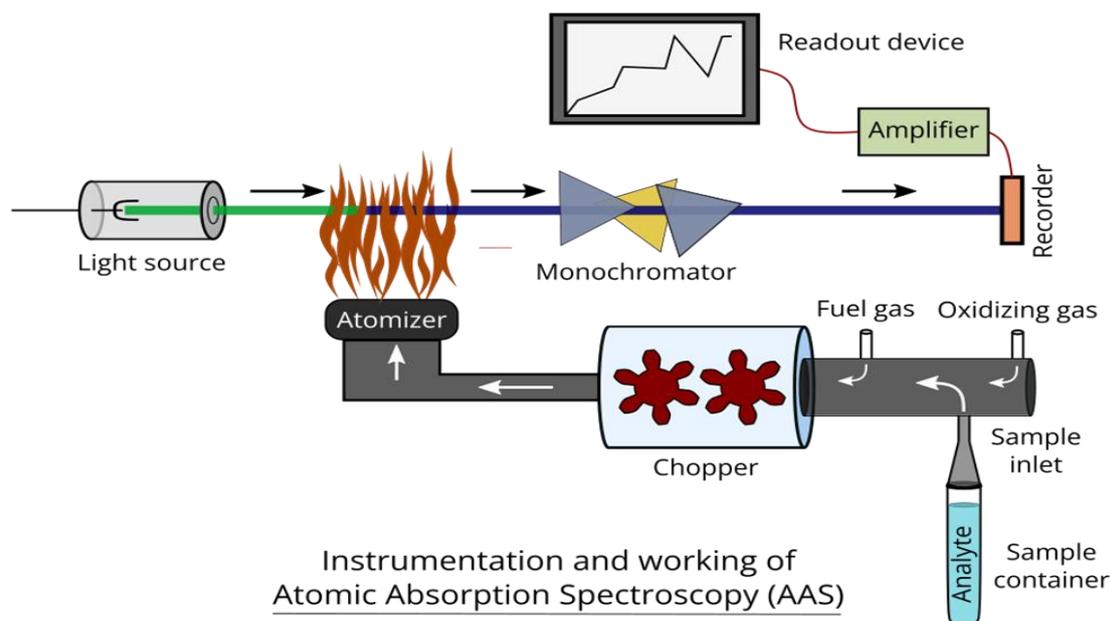


Figure 4: Instrumentation and Working of Atomic Absorption of Spectroscopy

In this study, a hollow cathode lamp serves as the light source for analyzing metal concentrations in refracting-based water samples. The lamp consists of a hollow cylindrical cathode made from the metal of interest, paired with a tungsten anode and housed in a quartz tube filled with inert gases like Argon and Neon at low pressure. When a voltage is applied, the noble gases ionize, generating ions that collide with the cathode and sputter metal atoms, which then become excited. A chopper device converts the continuous light into a pulsating form to eliminate larger droplets, ensuring only uniform ones enter the combustion zone. For sample introduction, pneumatic nebulizers are commonly employed to create a fine mist, which is atomized in either a flame or furnace. Temperature control is crucial, as excessive heat can lead to ionization. Fuel and oxidant gases mix before entering the burner, where a ribbon flame facilitates atomization. Monochromators selectively transmit specific wavelengths of light essential for measuring atomic absorption, with photomultiplier tubes converting this light into amplified electrical signals. Finally, readout systems display the data, allowing for comprehensive reporting of heavy metal concentrations in the water samples.

Significance of AAS

Atomic Absorption Spectroscopy (AAS) is a vital analytical technique due to its high sensitivity, allowing for the detection of trace levels of metals, which is particularly important for environmental monitoring. Its specificity enables the selective measurement of multiple elements based on their unique light absorption wavelengths, making it effective for a variety of applications, including liquid and solid samples in fields like environmental science, food safety, and clinical diagnostics. Additionally, AAS meets regulatory requirements for monitoring heavy metals, providing a reliable method to ensure compliance with health and safety standards. Overall, AAS plays a crucial role in assessing heavy metal concentrations and supporting efforts to safeguard environmental health.

(ii) Inductively Coupled Plasma Mass Spectrometry

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is a highly sensitive analytical technique used for determining the concentrations of metals and some non-metals in various samples.

Sample Introduction: The sample, typically in liquid form, is introduced into the ICP-MS system via a nebulizer. This device transforms the liquid into an aerosol, creating fine droplets that can be efficiently transported into the inductively coupled plasma for ionization, enabling accurate elemental analysis.

Ionization: The aerosol is directed into an inductively coupled plasma, where temperatures reach approximately 10,000 K. In this high-energy environment, the sample undergoes ionization, effectively breaking it down into elemental ions. This process is crucial for facilitating accurate detection and quantification of the elements present in the sample.

Mass Spectrometry: Once ionized, the particles are directed into a mass spectrometer, where they are sorted according to their mass-to-charge ratio. This separation is achieved through electric and magnetic fields, enabling the instrument to distinguish

between different ions. As the ions pass through, the mass spectrometer detects them, producing signals that correspond to each element's abundance. This precise sorting allows for both the identification and quantification of various elements in the sample, providing detailed insights into its composition and concentration.

Detection: The detector counts the ions generated in the mass spectrometer and produces signals proportional to their concentrations. These signals are then processed to deliver quantitative analyses of the elements present in the sample, enabling researchers to accurately assess the composition and levels of various analyses.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is a highly sensitive analytical technique used to detect trace elements and isotopes in various samples. This method merges mass spectrometry with an inductively coupled plasma source for effective ionization of the sample. The process starts with introducing the sample, typically in liquid form, which is nebulized into a fine aerosol. This aerosol is then fed into a plasma created by passing argon gas through a high-frequency electromagnetic field. The plasma reaches extremely high temperatures (around 10,000 K), effectively atomizing and ionizing the sample particles. Once ionized, the ions are directed into a mass spectrometer, which separates them based on their mass-to-charge ratios. This separation allows for the determination of the sample's elemental composition and concentration. ICP-MS is particularly efficient because it can analyze multiple elements simultaneously. One of the major advantages of ICP-MS is its sensitivity, capable of detecting elements at parts-per-trillion levels. It is versatile and widely used in fields such as environmental monitoring, food safety, clinical research, and geochemistry. ICP-MS can provide isotopic information, which is valuable for studies involving trace element sources and processes. However, some limitations exist, such as potential interference from other ions in complex samples and the need for careful sample preparation to prevent contamination. Despite these challenges, ICP-MS remains a powerful tool for elemental analysis, delivering rapid and accurate results across a broad range of applications. Its capability to handle diverse matrices and provide precise quantitative data solidifies its importance in modern analytical chemistry.



Figure 5: Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Figure 5 shows an ICP-MS (Inductively Coupled Plasma Mass Spectrometer) typically highlights its key components to demonstrate its functioning. The aerosol generator is responsible for converting liquid samples into a fine aerosol mist, often featuring a nebulizer that sprays the sample into tiny droplets. Central to the ICP-MS is the inductively coupled plasma (ICP) torch, where the aerosol is introduced; this torch contains a coiled copper tube through which argon gas flows, ionized by a radiofrequency (RF) field to create a high-temperature plasma. Following vaporization in the plasma, ions are extracted through a series of cones into the mass spectrometer, which separates them based on their mass-to-charge ratio. The mass spectrometer usually includes a mass analyzer, such as a quadrupole, and a detector like an electron multiplier that counts ions and generates analytical data. Additionally, images often display a computer interface for real-time data visualization and result interpretation, showcasing the modern usability of ICP-MS systems. Overall, an ICP-MS image encapsulates a sophisticated and efficient analytical system for detecting trace elements in various samples, underscoring its importance in research, environmental monitoring, and quality assurance.

(d) Characterization of Physicochemical Properties

The characterization of the physicochemical properties of a river during pre- and post-monsoon seasons involves analyzing a range of physical and chemical parameters, such as temperature, pH, dissolved oxygen (DO), turbidity, and nutrient

levels. These parameters provide insights into water quality and ecosystem health. In the pre-monsoon season, lower water levels can concentrate pollutants, while elevated temperatures may affect DO levels and promote algal blooms. Conversely, the post-monsoon season typically sees increased rainfall that dilutes pollutants but may also introduce new contaminants through runoff. Understanding these seasonal variations is crucial for effective water management and protecting aquatic ecosystems.

Physicochemical Properties:The physical properties of a river, such as temperature, turbidity, conductivity, and colour, play crucial roles in determining the aquatic ecosystem's health. Temperature affects gas solubility and the metabolic rates of organisms, while turbidity influences light penetration essential for photosynthesis. Conductivity serves as an indicator of dissolved ions, reflecting salinity and potential pollution, and colour can reveal the presence of organic matter or contaminants. Together, these factors help assess the overall water quality and ecological balance, guiding effective management and conservation efforts.

Chemical Properties:Chemical properties such as pH, dissolved oxygen (DO), nutrient concentrations, biochemical oxygen demand (BOD), and the presence of heavy metals and toxins are vital for assessing river health. pH influences nutrient availability and can indicate acidification or alkalinity, while dissolved oxygen is essential for aquatic life and can be diminished by organic matter decomposition. Elevated levels of nitrates and phosphates may signal eutrophication, leading to harmful algal blooms. BOD measures the amount of organic matter in the water, with high values indicating pollution. Lastly, monitoring heavy metals and toxins helps identify harmful substances that threaten aquatic ecosystems, informing necessary management actions.

(i) Seasonal Variations and Their Impact on Water Quality

Pre-Monsoon Season: During the pre-monsoon season, river water levels are generally lower, resulting in higher concentrations of pollutants and nutrients, which can degrade water quality. Elevated temperatures during this time can reduce dissolved oxygen (DO) levels, stressing aquatic life. Increased evaporation may further concentrate pollutants, exacerbating the impacts of pollution and potentially leading to detrimental effects on the ecosystem. Understanding these dynamics is crucial for managing water resources effectively before the influx of the monsoon season.

Post-Monsoon Season:In the post-monsoon season, increased rainfall can dilute existing pollutants, leading to temporary improvements in water quality. However, runoff can introduce new contaminants, posing risks to the ecosystem. As water levels rise, habitats may expand, benefiting some aquatic organisms, but this influx can also disrupt existing ecosystems and lead to shifts in species composition. Additionally, temperature changes and increased turbidity from sediment load can further impact photosynthesis and overall aquatic health, highlighting the complex interplay between hydrological changes and ecosystem dynamics during this season.

Ecological and Management Implications:Understanding the impact of seasonal changes on water quality is essential for effective management practices. By analysing seasonal data, stakeholders can develop targeted pollution control measures, implement habitat restoration projects, and enhance conservation efforts tailored to the specific needs of the ecosystem. Furthermore, long-term monitoring provides critical insights into trends and changes in aquatic health, enabling timely interventions to protect and sustain these vital environments. This comprehensive approach ensures that water resources are managed sustainably, benefiting both biodiversity and human communities.

(ii) Influence of Seasonal Changes on Physicochemical Properties

The influence of seasonal changes on the physicochemical properties of water bodies, such as rivers, can significantly impact water quality and ecosystem health.

Temperature

- Pre-monsoon in higher temperatures results in increased evaporation and reduced dissolved oxygen (DO) levels, which can stress aquatic organisms. This decline in DO affects fish and other aquatic life that rely on oxygen-rich water. Additionally, elevated temperatures accelerate the decomposition of organic materials, leading to the release of more nutrients into the water. This nutrient influx can contribute to algal blooms, further degrading water quality and creating a cycle of stress for the ecosystem.
- Post-monsoon cooler temperatures typically enhance dissolved oxygen (DO) levels, benefiting aquatic life. However, as the season progresses, rising water temperatures can still pose challenges, especially in shallow areas where the water heats up more quickly. These elevated temperatures can lead to reduced oxygen availability and increased stress on fish and other organisms. Additionally, warmer water can promote the growth of harmful algal blooms, further complicating the ecological balance and potentially harming aquatic ecosystems.

Water Levels

- During the pre-monsoon season, lower water levels concentrate pollutants and nutrients, resulting in elevated concentrations that significantly degrade water quality. This reduction in flow limits the natural dilution of contaminants, exacerbating the effects of pollution on aquatic ecosystems. As pollutants accumulate, they can create conditions that stress aquatic organisms, disrupt habitats, and lead to harmful algal blooms. Understanding these dynamics is crucial for implementing effective water management strategies to protect the health of the river and its ecosystems.
- In the post-monsoon season, increased rainfall raises water levels, temporarily diluting existing pollutants and improving overall water quality. This dilution can benefit aquatic life by enhancing dissolved oxygen levels. However, runoff from surrounding areas can introduce new contaminants, complicating the overall impact on water quality. This influx of pollutants can offset the benefits of dilution, leading to potential risks for the ecosystem. Monitoring these changes is essential to manage and protect aquatic environments effectively during this transitional period.

pH and Nutrient Levels

- During the pre-monsoon season, nutrient levels often rise due to evaporation and concentration of water. This creates conditions conducive to algal blooms, which can deplete oxygen levels and harm aquatic life. These blooms can disrupt ecosystems, making effective monitoring and management essential to protect water quality.
- Post-monsoon rainfall can help stabilize pH levels and lower nutrient concentrations in water bodies. However, nutrient runoff from surrounding land often results in spikes in nutrient levels, increasing the risk of eutrophication. This can harm aquatic ecosystems by promoting excessive plant growth and depleting oxygen levels.

Turbidity

- During the pre-monsoon season, lower water flow can lead to reduced turbidity. However, high temperatures may increase suspended solids and organic matter in the water, negatively affecting light penetration. This reduced clarity can hinder photosynthesis, impacting aquatic plants and overall ecosystem health.
- Post-monsoon, increased turbidity frequently arises from sediment runoff during heavy rains. This heightened turbidity can inhibit photosynthesis in aquatic plants, reducing their growth and productivity. Consequently, it disrupts the food web, affecting not only plant life but also the organisms that rely on them for sustenance.

4. EXPERIMENTATION AND RESULT DISCUSSION

The assessment of physicochemical parameters in the Phalgu River demonstrates noticeable seasonal variation between pre- and post-monsoon periods. During the pre-monsoon season, relatively higher temperature and slightly alkaline pH conditions favoured increased biological activity. However, elevated turbidity, nutrients, and oxygen demand values at certain stations indicate anthropogenic influences, particularly from agricultural runoff, sand mining disturbances, and domestic waste discharge.

In the post-monsoon season, rainfall-induced runoff altered the physicochemical characteristics. Although dilution effects reduced the concentration of some pollutants at specific stations, increased surface runoff contributed to sediment inflow, modifying turbidity and conductivity levels. Dissolved oxygen (DO) showed localized reductions where biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were comparatively high, suggesting organic enrichment. Nutrient enrichment, especially nitrates and phosphates at selected stations, indicates the potential risk of eutrophication during low-flow conditions. These seasonal shifts highlight the dynamic response of river water quality to hydrological changes and anthropogenic pressures.

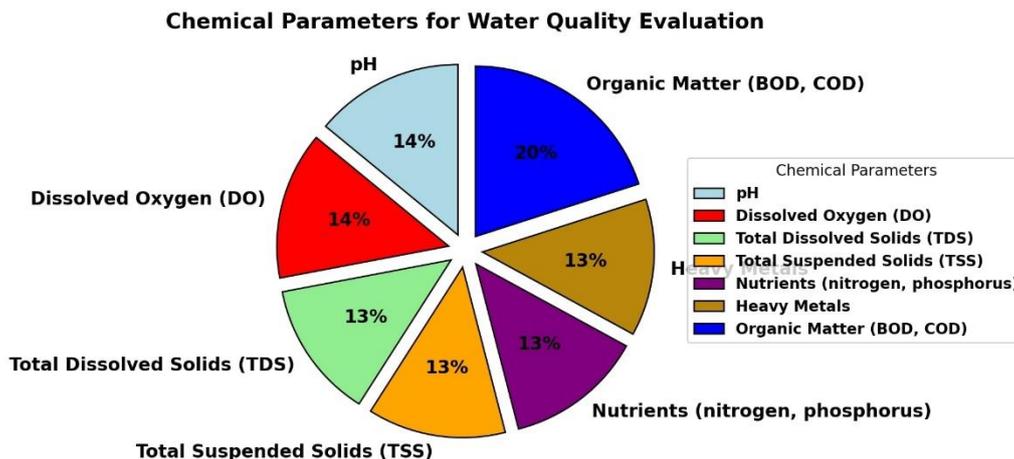


Figure 6: Assessment of Water Quality Parameters

Figure 6 presents the measured physicochemical and microbiological parameters. The recorded pH (6.2) falls within the acceptable range for freshwater ecosystems, indicating slightly acidic but tolerable conditions for aquatic organisms. Dissolved oxygen (6.2 mg/L) suggests adequate aeration and a generally supportive environment for aquatic life.

The BOD value (4.5 mg/L) reflects moderate organic pollution, indicating some biodegradable organic matter presence. Total Suspended Solids (TSS) at 35 mg/L signify moderate sediment load, possibly influenced by sand mining and surface runoff. Nutrient concentrations, including nitrates (2.2 mg/L) and phosphates (0.5 mg/L), indicate nutrient enrichment that may promote algal growth if concentrations increase further.

However, microbiological analysis reveals total coliform (120 MPN/100 mL) and faecal coliform (25 MPN/100 mL), suggesting microbial contamination likely associated with domestic sewage discharge. While most physicochemical parameters remain within permissible limits, the elevated coliform levels indicate potential public health concerns and the need for sanitation control measures.

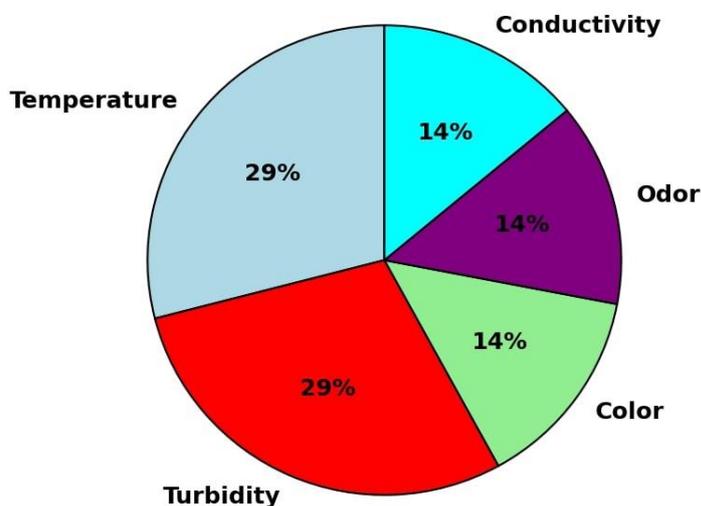


Figure 7: Analysis of Water Quality Indicators

Figure 7 illustrates the relative contribution of selected water quality indicators. Turbidity (29%) and temperature (29%) represent the dominant influencing factors among the evaluated parameters. Elevated turbidity can reduce light penetration, impair photosynthesis, and disturb benthic habitats. Temperature fluctuations influence metabolic activity, dissolved oxygen solubility, and species composition.

Conductivity (14%) indicates moderate ionic concentration in the river, reflecting dissolved salts and mineral inputs. Colour (14%) and odour (14%) may be linked to suspended sediments and organic matter decomposition. Although these parameters are

not critically high, the relatively greater contribution of turbidity suggests sediment influx as a primary concern, especially during and after the monsoon season.

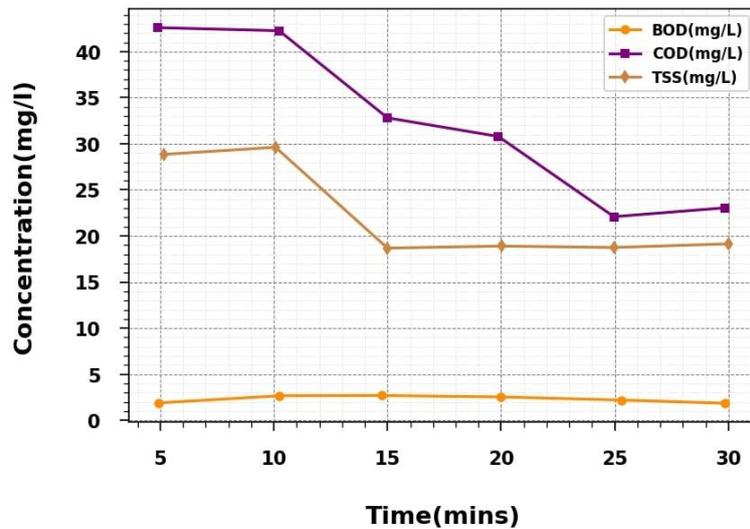


Figure 8: Temporal Dynamics of Water Quality: BOD, COD, and TSS Concentrations

Figure 8 depicts the relationship among BOD, COD, and TSS concentrations over time. The BOD value (5 mg/L) indicates moderate biodegradable organic pollution. COD (36 mg/L) is comparatively higher, suggesting the presence of both biodegradable and non-biodegradable oxidizable substances. The difference between COD and BOD values implies additional chemical pollutants beyond purely organic waste.

TSS (23 mg/L) reflects suspended particulate matter that may originate from soil erosion, sand mining activities, and runoff. Temporal fluctuations in these parameters demonstrate the influence of seasonal flow variations and anthropogenic disturbances. Higher COD relative to BOD suggests mixed pollution sources requiring targeted management interventions.

5. RESEARCH CONCLUSION

The seasonal assessment of physicochemical pollution in the Phalgu River reveals significant temporal variability influenced by hydrological processes and human activities. Pre-monsoon conditions exhibited relatively higher turbidity, BOD, and dissolved solids at certain stations, indicating concentrated pollutant levels under reduced flow conditions. Post-monsoon rainfall contributed to partial dilution of pollutants; however, it also introduced additional sediments and surface contaminants, modifying turbidity and nutrient concentrations. The observed organic load (moderate BOD and elevated COD) suggests mixed pollution sources, including domestic discharge and catchment runoff. Nutrient enrichment poses a potential risk of eutrophication if unmanaged. Microbial contamination further highlights sanitation-related impacts. Overall, while the river maintains moderate water quality status in several parameters, localized pollution hotspots require management attention. Continuous seasonal monitoring, regulation of sand mining, improved waste management practices, and community awareness programs are essential to maintain ecological integrity. A holistic river basin management approach will be critical to safeguarding the long-term environmental health and biodiversity of the Phalgu River.

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