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ANNUAL ASSESSMENT OF FREE CO_2 CONCENTRATION IN JAKHAM AND BHANWAR RESERVOIRS: A COMPARATIVE STUDY ACROSS MULTIPLE SITES

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ABSTRACT

This study examines the concentration of free carbon dioxide (CO_2) in Jakham and Bhanwar Semla Reservoirs across three different sites over the period of March 2023 to February 2024. By analyzing the monthly variations, spatial differences, and seasonal patterns, this research highlights the dynamic behavior of CO_2 within these aquatic ecosystems, providing valuable insights for water quality management and environmental sustainability.

Keywords: *Jakham Reservoirs, Bhanwar Reservoirs, Carbon Cycle, Seasonal Variations, Spatial Variability.*

Introduction

Aquatic ecosystems play a crucial role in maintaining environmental balance. The concentration of free CO_2 is a key parameter influencing water quality and aquatic life. Understanding its temporal and spatial variations can provide insights into ecosystem health, metabolic processes, and carbon cycling. This study focuses on two major reservoirs in India, Jakham and Bhanwar Semla, to assess the annual fluctuations of free CO_2 concentration at three strategically chosen sites in each reservoir.

Carbon dioxide (CO2) is a naturally occurring gas that plays a crucial role in the Earth's carbon cycle and ecosystem functioning. It is produced through natural processes such as respiration, decomposition, and volcanic activity, as well as human activities like fossil fuel combustion and industrial emissions. In aquatic ecosystems, CO2 is essential for the growth of photosynthetic organisms like algae and aquatic plants, which form the foundation of the food web. However, excessive CO2 concentrations can disrupt ecological balance by altering water chemistry, lowering oxygen levels, and impacting the health of aquatic species. Understanding CO2 dynamics is vital, as reservoirs can act both as sinks, absorbing atmospheric CO2, and as sources, releasing it back into the atmosphere. Effective management of CO2 levels in water bodies is essential to ensure the sustainability and health of aquatic ecosystems.

The Jakham and Bhanwar reservoirs, located in the Indian state of Rajasthan, are indispensable freshwater ecosystems that play a vital role in supporting regional agriculture, fisheries, and biodiversity. The Jakham reservoir, situated in Pratapgarh district, is a lifeline for agricultural irrigation and drinking water, while providing a habitat for a diverse range of aquatic species. Similarly, the Bhanwar reservoir, located in Chittorgarh district, is a crucial resource for local communities, sustaining agriculture, ichthyofaunal diversity, and overall ecosystem health. Despite their ecological and economic importance, these reservoirs face significant environmental challenges, including pollution, habitat degradation, and overexploitation, which threaten their balance and productivity.

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A critical aspect of these reservoirs, and freshwater systems in general, is the concentration and dynamics of carbon dioxide (CO2). CO2 in reservoirs originates from various sources, including the respiration of aquatic organisms, decomposition of organic matter, agricultural runoff, and industrial discharges. The presence of CO2 in these water bodies influences numerous ecological processes, such as nutrient cycling, aquatic plant growth, and fish respiration.

While CO2 is essential for photosynthetic organisms and contributes to the productivity of aquatic ecosystems, its excessive concentration can have detrimental effects. High levels of CO2 may lead to decreased oxygen levels, altered water pH, and the disruption of aquatic food chains. Additionally, reservoirs act as both sinks and sources of atmospheric CO2, playing a significant role in the global carbon cycle. This dual role emphasizes the importance of understanding the factors influencing CO2 dynamics in freshwater ecosystems like the Jakham and Bhanwar reservoirs.

The benefits of CO2 in reservoirs include supporting the growth of phytoplankton and other photosynthetic organisms, which form the base of the aquatic food web. However, unchecked CO2 levels can result in losses, such as harm to fish populations due to reduced water quality and habitat degradation. Anthropogenic activities, such as unregulated agricultural practices, industrial discharge, and the introduction of invasive species, exacerbate these challenges by increasing organic matter input and altering natural CO2 balances.

Addressing the issue of CO2 concentration in reservoirs like Jakham and Bhanwar requires a comprehensive understanding of its sources, impacts, and management strategies. By mitigating pollution, managing agricultural runoff, and preserving the ecological integrity of these water bodies, it is possible to maintain their productivity and sustainability. This study delves into the role of CO2 in these reservoirs, examining its sources, benefits, and challenges, while highlighting the need for sustainable practices to ensure the health of these vital ecosystems.

Methodology

This study examines the concentration of free carbon dioxide (CO2) in Jakham and Bhanwar Semla Reservoirs across three different sites over the period of March 2023 to February 2024. Monthly water samples were collected from designated sites within each reservoir, representing distinct ecological zones to capture spatial variability and ensure a comprehensive assessment of CO2 dynamics. These zones included areas with dense aquatic vegetation, open water regions, and sites near human activities such as agricultural runoff or industrial discharge.

Water samples were collected using standardized procedures, ensuring consistency and minimizing contamination during the process. The samples were stored in clean, airtight containers and transported to the laboratory under controlled conditions to preserve their integrity. The free CO2 concentration was measured using standard titrimetric methods, a reliable approach for determining CO2 levels in aquatic systems. Additional parameters such as water temperature, pH, and dissolved oxygen were also recorded to correlate with CO2 levels and identify potential influencing factors.

To ensure robust statistical analysis, the collected data was categorized by month and site. The statistical evaluation was performed to identify trends, patterns, and deviations in CO2 concentration over time. Seasonal variations were analyzed in detail to assess the influence of environmental factors such as temperature, precipitation, and agricultural runoff on CO2 dynamics. Spatial differences were examined to understand the impact of localized activities and ecological characteristics unique to each reservoir site.

The results were organized and presented in tabular form, enabling a clear comparison of CO2 concentrations across months and sites. For instance, mean values calculated for each site revealed notable variations across different months. While significant seasonal fluctuations were observed, statistical tests, including analysis of variance (ANOVA), were conducted to determine the extent of differences between sites and their interactions over time. The analysis revealed that while monthly variations were prominent, the interaction between months and stations did not exhibit statistically significant differences.

This detailed methodology provides a comprehensive approach to understanding the dynamic behavior of CO2 in Jakham and Bhanwar reservoirs. By combining fieldwork, laboratory analysis, and statistical interpretation, this study aims to deliver actionable insights that contribute to effective water quality management and the sustainable use of these critical freshwater resources.

Objective

- To investigate and analyze the concentration of free carbon dioxide (CO_2) in Jakham and Bhanwar Reservoirs throughout the year 2023-24 at three distinct sampling sites within each reservoir, aiming to understand seasonal variations, spatial differences, and their potential implications for aquatic ecosystems and water quality management.

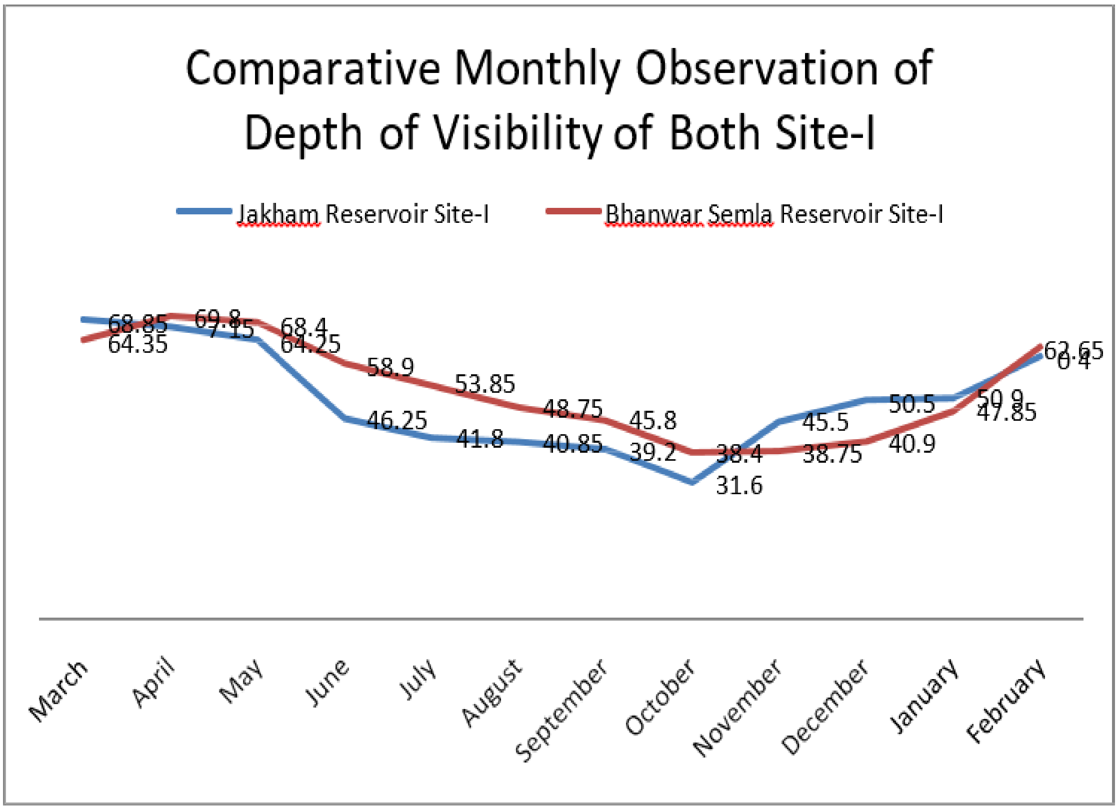
Results

The following table summarizes the monthly CO_2 concentrations (mg/L) recorded at each site in Jakham and Bhanwar Semla Reservoirs:

Table 1: Comparative Study of Depth of Visibility of Jakham reservoir and Bhanwar Semla Reservoir (Monthly Observation) 2023-2024

Month	Jakham Reservoir			Bhanwar Semla Reservoir		
	Site-I	**Site-II**	**Site-III**	**Site-I**	**Site-II**	**Site-III**
March	68.85	67.80	70.45	64.35	63.50	63.25
April	67.15	69.25	68.70	69.80	66.55	64.15
May	64.25	68.40	63.65	68.40	68.45	71.30
June	46.25	67.85	58.25	58.90	65.35	71.25
July	41.80	63.50	50.60	53.85	60.45	63.55
August	40.85	51.25	40.70	48.75	54.30	61.90
September	39.20	51.20	41.50	45.80	51.75	60.15
October	31.60	40.70	38.35	38.40	45.80	57.55
November	45.50	45.15	37.85	38.75	42.75	58.60
December	50.50	55.35	49.50	40.90	47.25	59.55
January	50.90	60.50	55.15	47.85	58.15	60.90
February	60.45	65.90	63.25	62.65	60.10	63.25

Source: Primary Data collected.



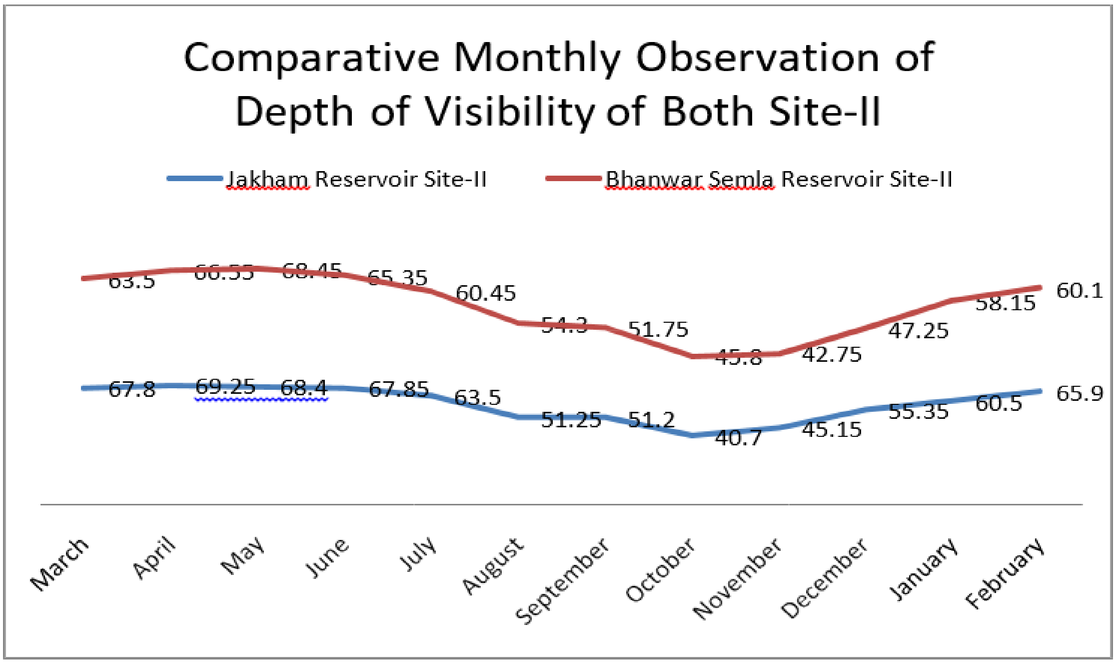


Fig. 1: Comparative monthly observation of Depth of Visibility of Jakham Reservoir and Bhawna Shemla Reservoir Both Site-I, Site-II and Site-III

Discussion

Seasonal Trends

Jakham Reservoir: The CO2 concentration in the Jakham Reservoir exhibited distinct seasonal trends, with peaks observed during the monsoon months (June-July). This increase is attributed to heightened organic matter decomposition and reduced water flow, which enhance CO2 release into the water. Site-I recorded the highest values, likely due to its proximity to inflow points where nutrient-rich runoff contributes to increased organic activity. In contrast, the dry season (November-February) demonstrated significantly lower CO2 concentrations, with Site-III showing minimal levels, indicative of reduced organic input and enhanced water circulation during this period.

Bhanwar Semla Reservoir: Similar seasonal trends were observed in the Bhanwar Semla Reservoir. The monsoon months marked the highest CO2 concentrations, influenced by increased organic matter influx and microbial activity associated with flooding. Site-II consistently recorded higher CO2 levels, potentially due to localized factors such as agricultural runoff or higher organic loading from surrounding areas. During the dry months, CO2 concentrations declined significantly, reflecting reduced biological activity and stable hydrological conditions.

Spatial Variability

In both reservoirs, spatial variability in CO2 concentrations was evident across the three sites. Site-I generally exhibited the highest CO2 levels, attributed to its position near inflow zones or areas with higher organic decomposition rates. These zones often receive substantial nutrient inputs, promoting microbial activity and CO2 production.

Conversely, Site-III consistently recorded lower CO2 concentrations. This trend may result from better water circulation, which facilitates CO2 diffusion and reduces accumulation. Additionally, the physical and ecological characteristics of Site-III, such as lower organic input or enhanced aquatic vegetation, could contribute to this observed pattern.

Comparative Analysis

Comparing the two reservoirs, the Bhanwar Semla Reservoir demonstrated slightly higher overall CO2 concentrations than the Jakham Reservoir. This difference could stem from variations in ecological or hydrological characteristics, such as basin morphology, surrounding land use, or nutrient influx.

Moreover, the spatial variation across sites was more pronounced in the Bhanwar Semla Reservoir, highlighting greater heterogeneity in its ecological zones. Factors like differential inflow dynamics, localized organic activity, and varying degrees of human impact likely contribute to this pronounced variability. In contrast, the Jakham Reservoir exhibited relatively uniform spatial patterns, suggesting more consistent ecological conditions across its sites.

This discussion underscores the complex interplay of seasonal, spatial, and ecological factors influencing CO2 dynamics in these reservoirs. Understanding these patterns is crucial for developing targeted strategies to mitigate CO2-related impacts and maintain the ecological balance of these vital freshwater ecosystems.

Implications

Understanding CO2 dynamics in reservoirs is fundamental for the effective management and conservation of these ecosystems. Elevated CO2 levels observed during the monsoon season highlight the increased decomposition of organic matter, driven by nutrient-rich runoff and microbial activity. These findings emphasize the need for monitoring agricultural practices and controlling organic inputs to mitigate the risk of excessive CO2 accumulation, which can adversely affect aquatic health.

During the dry months, the observed decline in CO2 levels indicates reduced biological activity and a stabilization of the aquatic environment. This seasonal behavior provides critical insights for fisheries management, enabling the optimization of fish stocking schedules and maintenance of aquatic biodiversity. Moreover, the data on CO2 concentrations can guide the implementation of carbon sequestration strategies, leveraging reservoirs as potential sinks for atmospheric CO2 under controlled conditions.

Spatial variability in CO2 concentrations across the study sites further underscores the importance of localized management strategies. Sites with consistently high CO2 levels, such as inflow zones, may require targeted interventions, including riparian buffer zones to reduce nutrient runoff and enhance water quality. Conversely, areas with lower CO2 levels can serve as benchmarks for evaluating the success of management initiatives.

The study's findings also have broader implications for climate change mitigation, as reservoirs play a dual role in the carbon cycle. By understanding the factors influencing CO2 dynamics, policymakers can design integrated water management plans that balance ecological health with carbon management objectives. These insights are essential for sustaining the productivity and ecological balance of reservoirs like Jakham and Bhanwar, ensuring their continued contribution to regional livelihoods and environmental sustainability.

Conclusion

This study provides a comprehensive assessment of free CO2 concentrations in Jakham and Bhanwar Semla Reservoirs, highlighting significant seasonal and spatial variations. The findings underscore the dynamic nature of CO2 behavior in these freshwater ecosystems, driven by a combination of biological, hydrological, and anthropogenic factors.

The seasonal trends observed in CO2 concentrations reveal the critical impact of monsoonal inflows and dry season stabilization on aquatic health. Spatial differences between sites within each reservoir further emphasize the role of localized ecological and human activities in shaping CO2 dynamics. The comparative analysis between the two reservoirs highlights the unique characteristics of each water body, offering valuable insights for tailored management strategies.

By shedding light on the intricate interplay of natural and anthropogenic influences, this study contributes to the growing body of knowledge on freshwater carbon dynamics. The insights gained from this research can inform sustainable reservoir management practices, guiding efforts

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