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Relationship Between The Occurrence Of *Noctiluca Scintillans* Bloom And Physicochemical Characteristics Of Seawater Off Bhatye Beach, Ratnagiri, Maharashtra

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Abstract

Harmful algal blooms (HABs) pose a significant threat to marine ecosystems, impacting both aquatic organisms and coastal communities. Noctiluca scintillans, a bioluminescent dinoflagellate, is a substantial contributor to HABs worldwide, particularly along the coastal regions of Bhatye Beach, Ratnagiri. This research explores the intricate relationship between the occurrence of Noctiluca scintillans blooms and the physicochemical characteristics of seawater in the specified region. Conducted from November 2022 to January 2023, the study involved comprehensive field investigations and data analysis, focusing on elucidating the environmental factors influencing the proliferation of Noctiluca scintillans. Physicochemical parameters assessed included phosphate, nitrate, nitrite, silicate, temperature, salinity, pH, and Dissolved Oxygen. The findings provide valuable insights into understanding the dynamics of Noctiluca scintillans blooms in the coastal waters of Bhatye Beach, Ratnagiri, and lay the foundation for developing effective monitoring and management strategies to mitigate the impact of HABs in this ecologically sensitive region.

Keywords: Noctiluca scintillans, physicochemical parameters, Bhatye beach.

1. INTRODUCTION

Marine dinoflagellates, particularly *Noctiluca scintillans*, constitute a significant and successful group of eukaryotic microorganisms in the world's oceans. These microorganisms, adapted to a diverse range of pelagic and benthic habitats, are influenced by environmental factors such as temperature, salinity, light, water circulation patterns, and nutrients (Hasle *et al.,* 1997).

Noctiluca scintillans is a notable bloom-forming marine dinoflagellate with a global presence. Displaying remarkable bioluminescence, these organisms, often referred to as 'sea sparkle,' form patches or blooms. While reports in the literature highlight the common occurrence of Noctiluca blooms in coastal waters of the Indian subcontinent (Sreekumar *et al*., 1992; Naqvi *et al*., 1998; Sahayak *et al*., 2005), the underlying causes of these blooms remain insufficiently understood. Some researchers suggest a potential link to environmental pollution,

while others, such as the Indian National Centre for Ocean Information Services and the US's National Oceanic and Atmospheric Administration, consider 'Global warming conditions' as a potential factor (Hasle *et al.,* 1997).

Recent studies (Altieri *et al*., 2017; Breitburg *et al.,* 2018) have indicated a decline in dissolved oxygen levels in oceans and coastal waters worldwide, impacting coastal ecosystems. Increased nutrient inputs and warming waters, as reported by Altieri *et al.,* (2017), contribute to reduced oxygen levels in global waters. Hypoxia, characterized by low dissolved oxygen levels, affects marine organisms by altering behavioural and physiological responses, reducing growth rates and fecundity, and, if prolonged or severe, may lead to mortality (Hughes *et al.,* 2020; Nelson and Altieri, 2019; Le Henaff *et al*., 2019; Keoloha *et al*., 2020).

Climate change has been linked to increased frequencies of algal blooms, especially *Noctiluca scintillans*, in the Indian Ocean and Indian waters in recent decades (D'Silva *et al.,* 2012; Gomes *et al.,* 2014). *N. scintillans* blooms can manifest as red or green tides, with the former being heterotrophic and the latter having a photosynthetic symbiont, *Pedinomonas noctilucae* (Harrison *et al.,* 2011). While red tides are reported to be harmful, green tides are considered less harmful despite causing low dissolved oxygen levels (Gomes *et al.,* 2014).

Despite the annual observation of *Noctiluca scintillans* blooms in the Arabian Sea, the nutrient mode, triggering mechanisms, and seasonal variations of *N. scintillans* in coastal waters remain poorly investigated. Notably, the appearance of *N. scintillans* is observed between November and January, correlating with seawater temperatures between 16 and 27 °C. The disappearance of blooms occurs as temperatures rise above 27 °C after March. This observation supports the hypothesis that the bloom of *Noctiluca scintillans* is influenced by variations in the physicochemical characteristics of water due to environmental changes.

In light of these environmental concerns, the present research aims to elucidate the relationship between various physicochemical characteristics of seawater samples from the study site, Bhatye Beach, and the occurrence of *Noctiluca scintillans* blooms. This bioluminescent dinoflagellate, known for illuminating the wakes of boats and breaking waves on beaches, raises questions about its potential environmental implications. The study seeks to contribute to our understanding of how the physicochemical conditions of seawater may influence the occurrence of *Noctiluca scintillans*, with a focus on the potential consequences for the aquatic food chain.

2. MATERIALS AND METHODS

Study Area

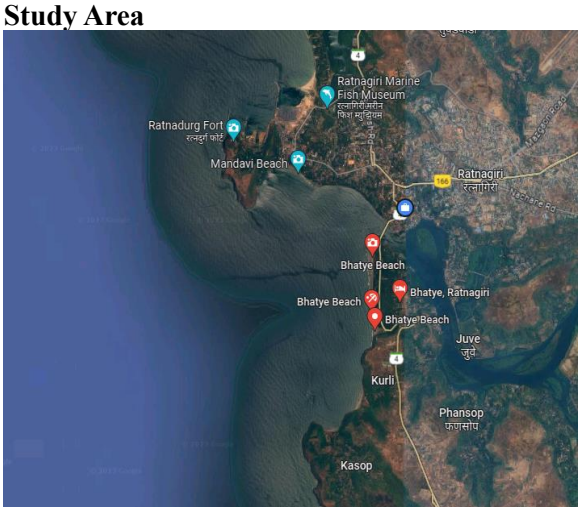

Fig. 1 Geographical position of Bhatye beach.

Fig. 2 Noctiluca bloom at Bhatye beach.

Ratnagiri, situated in the Maharashtra state of India, lies on the western coast at coordinates 16.99020N, 73.31200E. Within this district, the Ratnagiri tehsil encompasses numerous sea beaches, among which the well-known Bhatye beach stands out as a popular tourist destination near Ratnagiri town. Despite its status as a tourist spot, the region is not immune to anthropogenic activities. Gradual tourism development and the presence of some industries along the Ratnagiri city coast contribute to seawater pollution.

Bhatye Beach, recognized for its scenic beauty, has been a subject of interest due to the observation of *Noctiluca scintillans* blooms, particularly during the winter season in recent years. To gain insights into the physicochemical characteristics of the seawater and their potential relationship with the occurrence of *Noctiluca scintillans*, water samples were systematically collected from Bhatye beach. The sampling period extended from November 2022 to February 2023, aligning with the observed bloom periods.

The water sampling process was conducted with precision, targeting the surface, mid-depth, and bottom (at a depth of 6–7 meters). The collection took place at fortnightly intervals between 10 and 11 a.m. Clean polythene bottles were utilized for sample collection. Subsequent analysis of the collected water samples involved a comprehensive assessment of various physicochemical parameters. These parameters included temperature, dissolved oxygen (DO), salinity, nitrite, nitrate, silicate, phosphate, conductivity, and turbidity. Standard methods, as outlined by the American Public Health Association (APHA, 2005), were employed for these analyses.

3. RESULTS

Table 1 Physico-chemical properties of the study sites from November 2022 to January 2023.

Parameter	November	December	January	February
Salinity (PSU)	37.0	36.4	36.3	35.5
pH	8.08	8.06	8.01	8.01
DO(mg l^{-1})	1.50	1.48	1.48	1.54
Phosphate (µ M l^{-1})	0.50	0.54	0.56	0.51
Nitrate(µ Ml^{-1})	6.06	6.26	6.26	5.13
Nitrite(µ Ml^{-1})	2.18	3.22	3.27	2.30
Silicate (µ M l^{-1})	0.20	0.19	0.19	0.22
Sea water temperature (ºC)	26.2	25.3	23.3	22.4
Conductivity (mS/cm)	36.2	37.5	37.3	36.0
Turbidity (NTU)	28.3	30.3	30.3	30.0

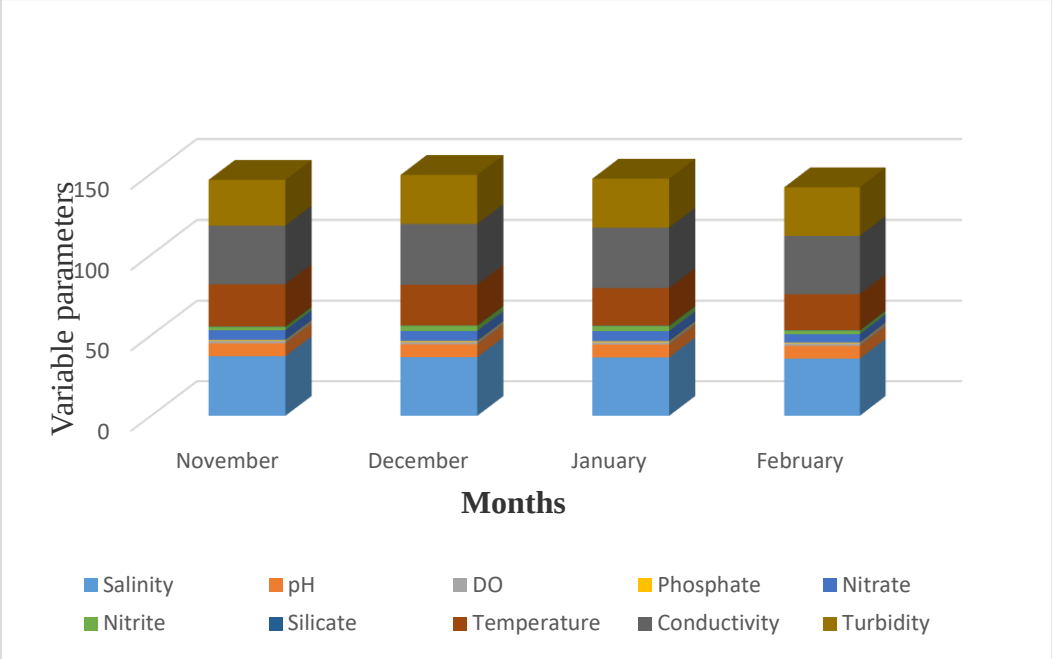

Fig.3 Graph showing fluctuations in physicochemical parameters with respect to subsequent months

4. DISCUSSION

The occurrence of *Noctiluca scintillans* blooms in coastal waters of the Indian subcontinent has been noted, yet the specific causes for these blooms remain poorly understood. The global increase in the frequency of such

blooms has raised concerns among scientists, leading to the belief that human-induced alterations to coastal zones may be influencing marine planktonic ecosystems on a global scale.

Noctiluca scintillans, characterized by its adaptation to a heterotrophic mode of nutrition, tend to thrive in environments with elevated concentrations of plankton, its primary food source. These increased plankton levels are often attributed to environmental conditions such as nutrient-rich waters, primarily containing nitrogen and phosphorus, as well as runoff from agricultural pollution. The stability of temperatures and humid weather without rainfall is considered favourable for the initiation and sustenance of Noctiluca blooms (Rajesh *et al.,* 2002). Furthermore, a relatively low temperature is suggested to be conducive to triggering the appearance of these blooms (Mishra and Panigrahy, 1995; Sasamal *et al.,* 2005; Mishra *et al.,* 2006).

Consistent with prior research findings, the present study aligns with the notion that low temperatures are favourable for the initiation of *Noctiluca scintillans* blooms. During the study period, the recorded maximum and minimum temperatures were 26.2°C and 22.4°C, respectively—comparatively low when considered in the context of the entire year. Low temperatures are thought to favour Noctiluca blooms (Mishra *et al.,* 2006). This observation reinforces the significance of temperature as a contributing factor to the appearance of Noctiluca blooms in the coastal waters off Bhatye Beach, Ratnagiri. The correlation between temperature, salinity, and the occurrence of *Noctiluca scintillans* blooms highlights the need for further investigation into the complex interplay of environmental factors influencing these phenomena.

Previous research indicates that upwelling events along coasts can deliver substantial nutrient influx, triggering blooms of diatoms and dinoflagellates (Dela-Cruz *et al*., 2002). Nitrate, a stable nitrogenous nutrient crucial for phytoplankton metabolism and growth, exhibits significant variations in level due to its ready assimilation by these organisms. High initial concentrations of nutrients at the surface water may deplete as phytoplankton, consumed by Noctiluca, undergo autotrophic production (Mishra *et al.,* 2006). Fluctuations in phosphate, nitrate, and nitrite levels are consistent with nutrient dynamics during the bloom period. The value of phosphate found in December (0.54 µ M l -1) and January (0.56 µ M l -1) was relatively higher than the phosphate content of February (0.51µ M l -1) when the bloom disappeared. An increase in phosphate levels during the bloom period may be due to the decomposition of plankton, resulting in oxygen consumption and liberation of phosphate. The same observations were made with other nutrients also which include Nitrate and Nitrite. The fluctuations in their amount were seen, which are mentioned in Table No.1.

Observations of pH (8.01-8.08) and salinity (35.5-37.0 PSU) variations were noted during the study, suggesting an interconnected relationship with Noctiluca bloom dynamics. The variations in the values of pH (ranging from 8.01-8.08) and Salinity (ranging from 35.5- 37.0 PSU) were also observed during the study period. Dissolved oxygen reduction during the bloom, as found in our study, is in line with prior research by Mohanty *et al.,* (2007), indicating rapid oxygen consumption by *N. scintillans*. According to them, a decrease in dissolved oxygen (DO) was observed in the bloom area compared to the non-bloom areas studied, which could be due to the rapid consumption of oxygen by *N. scintillans.*

Silicate levels, exhibited low values (0.19 µ M l -1) during the study period. Silicate is utilized for the formation of siliceous frustules of diatoms and other phytoplankton (Kealoha *et al.,* (2020), on which Noctiluca feeds. Therefore, low values of silicates (0.19 µ M l -1) were found during the study period.
Therefore, based on the prior and present research work which has been done in this particular domain, one may conclude that the nutrient-rich conditions with lowered temperatures boost the appearance of the blooms of Noctiluca in the seawater. Therefore, the present study is inclined towards the fact that the appearance of the Noctiluca bloom is related to fluctuations in the physicochemical parameters of the seawater. At present, Global warming, changing climatic conditions, and anthropogenic activities are some factors that contribute to these fluctuations in the physicochemical parameters of the seawater. Although these blooms are non-toxic, they surely disturb the aquatic food chain and thereby they cause harm to the ecosystem. Therefore, in conclusion, continuous and long-term monitoring of this organism along with physicochemical parameters, should be carried out along the coastal waters, to discover the factors triggering such harmful algal blooms.

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