

“Preliminary Evaluation of an Eco-Friendly Anti-Algal Agent Prepared from *Syzygium cumini* (L.) Bark”

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Abstract

Harmful algal blooms (HABs) pose significant threats to freshwater ecosystems worldwide. This study developed an eco-friendly anti-algal agent derived from the bark of *Syzygium cumini* (L.) and evaluated its efficacy under controlled conditions. The formulation was prepared using natural extracts of bark and applied to algae-contaminated water samples. Over a 15-day period, treated water samples exhibited improvement in water quality parameters and reduced algal growth compared to controls. These findings provide baseline evidence for the potential of plant-based allelochemicals as sustainable alternatives to conventional algicides.

Keywords: *Syzygium cumini*, anti-algal activity, eco-friendly formulation, allelopathy.

Introduction

Algal blooms arise from the accelerated growth of phytoplankton in aquatic systems, often triggered by nutrient enrichment from agricultural runoff and wastewater discharge (Paerl *et al.*, 2018). Excessive algal proliferation leads to depletion of dissolved oxygen, production of harmful toxins, and degradation of water quality, posing serious ecological and human health risks (Anderson *et al.*, 2002).

Traditional chemical algicides such as copper sulfate and peroxide compounds are widely used to mitigate algal blooms, but their application can introduce toxic residues, disrupt non-target organisms, and lead to long-term ecological harm (Boyd, 2004; Matthiessen *et al.*, 2016). Consequently, there is increasing interest in natural and eco-friendly alternatives, particularly plant-derived allelochemicals, which can inhibit algal growth with reduced environmental impact.

Plant allelochemicals secondary metabolites such as phenolic acids, flavonoids, tannins, and terpenoids are known to interfere with algal physiological processes, including photosynthesis, enzyme activity, and cellular integrity (Gross, 2003; Inderjit & Duke, 2003). Allelopathy has been extensively studied in aquatic weeds and terrestrial plants for its potential to suppress competing organisms in shared environmental niches.

Syzygium cumini (L.), commonly known as Jamun, is a tropical tree valued in traditional medicine for its diverse pharmacological activities, including antioxidant, antimicrobial, and antidiabetic effects (Ayyanar & Subash-Babu, 2012). Phytochemical investigations have identified several bioactive compounds in *S. cumini*, such as ellagic acid, gallic acid, quercetin, and tannins, which exhibit strong bioactivity in a range of biological systems (Baliga *et al.*, 2011; Sharma *et al.*, 2013).

Although prior research has demonstrated the antimicrobial and antioxidant potential of *S. cumini* bark and leaf extracts, its application as a source of eco-friendly allelochemicals for algal bloom management remains underexplored. This study aimed to develop a bark-based anti-algal formulation and assess its effectiveness in controlling algal growth in water samples.

Collection and Preparation of Plant Material

Bark of *Syzygium cumini* was collected from mature trees in Nashik District, Maharashtra, India. The collected bark was washed with distilled water to remove dust and debris and then shade-dried for 10–12 days. The dried material was powdered using a mechanical grinder and stored in airtight containers until use.

Extraction of Bioactive Compounds

Powdered bark (50 g) was soaked in 250 mL of 70% ethanol and distilled water separately for 48 hours with intermittent shaking. The mixtures were filtered through Whatman No. 1 filter paper, and filtrates were concentrated in a rotary evaporator at 40°C to obtain crude extracts.

Formulation of Bark Tablets

Crude extracts of bark were mixed with natural binders (lemon juice and pH-adjusted water) to achieve a homogenous paste. The paste was compressed into tablets (~5 g each) and air-dried for 48 hours to ensure stability.

Experimental Design for Algal Control

Algae-contaminated water was collected from a local well known for periodic algal proliferation. Five 1-L glass bottles were prepared with the same initial water volume and algae content:

- **Bottle 1:** Negative Control (no treatment)
- **Bottle 2:** Positive Control (standard chemical algicide)
- **Bottle 3:** Low Dose 1 gm/100 Liter (bark agent)
- **Bottle 4:** Standard Dose 5 gm/100 Liter (bark agent)
- **Bottle 5:** High Dose 10 gm/100 Liter (bark agent)

The bark tablets were added according to treatment dose, and samples were incubated at room temperature under natural light for 15 days.

Monitoring of Water Quality Parameters

Water samples were monitored at 3-day intervals for the following parameters:

- **pH** — measured with a digital pH meter
- **Total Dissolved Solids (TDS)** — using a TDS meter
- **Turbidity** — assessed using a nephelometer
- **Algal Density** — estimated by optical density at 680 nm using a UV-Vis spectrophotometer

Results

Effect of Bark Formulation on Algal Growth

Distinct differences were observed among control and treated samples during the experimental period.

- **Negative Control (Bottle 1):** Clear water with no algal growth was observed throughout the study period.
- **Positive Control (Bottle 2):** Increased algal growth was recorded, accompanied by reduced water clarity and elevated turbidity and TDS.
- **Low Dose Treatment (Bottle 3):** Partial reduction in algal growth was observed compared to the positive control.
- **Standard Dose (Bottle 4):** Significant reduction in algal density was recorded along with improved water clarity.

- **Double Dose (Bottle 5):** Further reduction in algae was observed; however, slight alterations in water properties suggested possible undesirable effects of overdosing.

Water Quality Parameters

The bark-based anti-algal formulation demonstrated significant effects on water quality and algal reduction when compared with controls.

Table 1. Water Quality Parameters Before and After Treatment

Parameter	Before Treatment	After 15 Days
pH	6.0	7.0
TDS (mg/L)	1250	1080
Turbidity (NTU)	90	45
Algal Density (OD 680 nm)	0.85	0.10

Standard dose treatment exhibited the greatest reduction in algal density, while higher doses showed similar effectiveness without further substantial improvement.

Discussion

The observed reduction in algal density supports the hypothesis that phytochemicals in *Syzygium cumini* bark can act as allelochemicals against algal species. Phenolic compounds and flavonoids are known to compromise algal cell membranes and disrupt photosynthetic processes (Gross, 2003; Inderjit & Duke, 2003), explaining the observed decline in biomass.

The improvement in pH and decrease in turbidity and TDS in treated samples suggest that bark allelochemicals may enhance sedimentation of algal biomass and reduce dissolved organic loads. Similar observations have been reported for plant-derived algicidal agents in freshwater systems (Qamar *et al.*, 2022; He *et al.*, 2011).

Compared with conventional algicides, plant-based formulations are inherently biodegradable and pose minimal risk to non-target organisms, aligning with eco-toxicological principles for sustainable water management (Matthiessen *et al.*, 2016). Research on other plant allelochemicals has demonstrated their effectiveness in inhibiting algal growth without adverse ecological outcomes (Soliman & Rafat, 2014; Toppo *et al.*, 2015).

In summary, the bark formulation of *S. cumini* exhibits promising anti-algal activity, warranting further research including field applications and isolation of specific active compounds.

Conclusion

The eco-friendly anti-algal formulation prepared from *Syzygium cumini* bark effectively reduced algal density and improved water quality under controlled laboratory conditions. These results suggest significant potential for plant-derived allelochemicals as sustainable alternatives for managing harmful algal blooms. Future research should focus on detailed phytochemical characterization and field trials.

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