

## Medicinal properties of sambhar lake algae: potential applications and conservation challenges

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### Abstract

Sambhar Lake, the largest inland saltwater lake in India, hosts a unique algal biodiversity that thrives under hypersaline and extreme environmental conditions. These algae produce a variety of bioactive compounds with immense medicinal potential. Algal species such as *Dunaliella salina*, *Spirulina platensis*, and *Chlorella vulgaris* exhibit antioxidant, antimicrobial, anti-inflammatory, and anticancer properties. This review explores the medicinal properties and potential applications of Sambhar Lake algae in pharmaceuticals, nutraceuticals, and environmental remediation. It also highlights the pressing conservation challenges posed by pollution, climate change, and unsustainable resource extraction. Strategies for sustainable management and future research directions are discussed to promote the conservation and biotechnological utilization of this valuable natural resource.

**Keywords:** Sambhar lake, algal biodiversity, bioactive compounds, medicinal applications, conservation challenges

### 1. Introduction

Sambhar Salt Lake is India's largest inland salt lake, located in the state of Rajasthan. It spans across the Jaipur, Ajmer, and Nagaur districts, approximately 80 km southwest of Jaipur and 64 km northeast of Ajmer Figure 1 (Wadhawan, 2018)<sup>[19]</sup>. The lake is elliptically shaped, measuring about 35.5 km in length and varying between 3 km to 11 km in width, covering an area of approximately 190 to 230 square kilometers depending on the season (Anderson, 1983)<sup>[11]</sup>. It is surrounded by the Aravalli hills and receives water from six rivers: Mantha, Rupangarh, Khari, Khandela, Medtha, and Samod (Sharma, 2013)<sup>[13]</sup>.

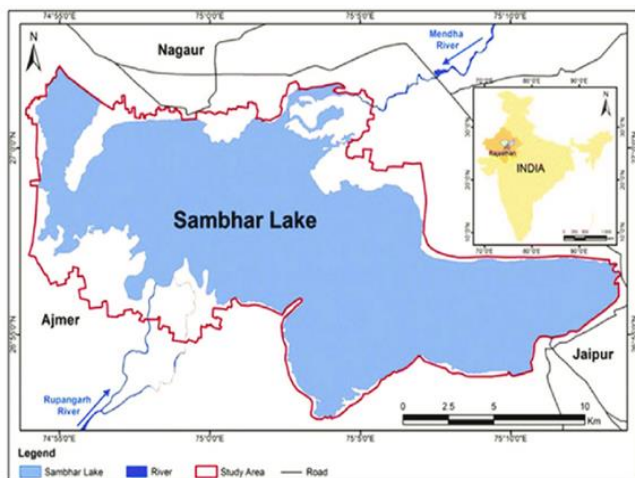


Fig 1: Location map of the Sambhar Salt Lake, Rajasthan

Sambhar Lake, a designated Ramsar Site, is a vital wetland supporting thousands of migratory birds, notably

pink flamingos from Asia and Siberia (Szabo, & Mundkur, 2017)<sup>[17]</sup>. Its hypersaline and alkaline waters foster extremophilic algae, crucial for maintaining ecological balance (Gaur, 2015)<sup>[6]</sup>. These algae produce a range of bioactive compounds—including polysaccharides, fatty acids, vitamins, phenolics, and pigments—with proven therapeutic benefits (Michalak & Chojnacka, 2015)<sup>[9]</sup>. Their ability to thrive under stress enhances their biosynthetic potential, making them valuable in drug discovery and biotechnology (Singh et al., 2017)<sup>[16]</sup>. Sambhar's unique environment thus holds ecological and pharmaceutical significance, emphasizing the need for conservation and sustainable utilization of its biological resources (Rawal, 2013)<sup>[12]</sup>.

This review aims to (i) document the algal diversity of Sambhar Lake, (ii) explore the medicinal properties and applications of identified species, (iii) examine the conservation challenges affecting this unique ecosystem, and (iv) outline future directions for sustainable bioprospecting and conservation efforts.

### Importance of Sambhar Lake

#### 1. Ramsar Site

Sambhar Lake was designated as a Ramsar site in 1990, recognizing its international importance as a wetland ecosystem. It supports large populations of migratory birds, including flamingos, pelicans, and avocets (Sharma, 2011)<sup>[14]</sup>. As part of the Ramsar Convention's mission, it plays a vital role in maintaining global wetland biodiversity and ecological balance (Halls, 1997)<sup>[7]</sup>.

## 2. Wetland Site

Sambhar Lake is the largest inland saline wetland in India, located in Rajasthan. Fed by rivers like Mendha, Rupangarh, and Kharian, it spreads across Jaipur and Nagaur districts. Its brackish water and dynamic salinity levels support a unique blend of aquatic life, halophytic vegetation, and specialized microbial and algal communities (Yadav et al., 2007)<sup>[20]</sup>.

## 3. Rich Biodiversity Site

The lake is a biodiversity hotspot in an arid landscape. It harbors diverse species of algae (*Dunaliella salina*, *Spirulina*, *Chlorella*), halophytes, cyanobacteria, and medicinal plants (*Calotropis gigantea*, *Euphorbia caducifolia*). It also supports numerous migratory birds, making it an important breeding and feeding ground under the Central Asian Flyway (Walker, & Kendrick, 1998)<sup>[18]</sup>.

## 4. Commercial Site

Sambhar is a significant commercial site for salt production, contributing a major share of India's inland salt. The lake is operated by Sambhar Salts Ltd., and the salt pans are a key source of local employment. However,

unregulated commercial extraction poses ecological threats, necessitating sustainable management practices to balance economy and ecology (Dane, 1924<sup>[4]</sup>; Bhat et al., 2015)<sup>[2]</sup>.

## 3. Diversity of Algae in Sambhar Lake

The algal community in Sambhar Lake is composed predominantly of cyanobacteria (blue-green algae), green algae (Chlorophyta), and some representatives of red algae (Rhodophyta). Due to high salinity, the dominant genera include *Dunaliella*, *Spirulina*, *Anabaena*, *Oscillatoria*, *Chlorella*, and *Nostoc* shown in the Table 1. These species have evolved adaptive mechanisms to survive in high osmotic stress, UV exposure, and nutrient fluctuations (Sharma et al., 2011)<sup>[14]</sup>. Algal diversity and biomass in Sambhar Lake fluctuate with the seasons, largely influenced by salinity gradients, temperature, and hydrological cycles. During monsoon, freshwater input dilutes salinity, allowing a wider diversity, while in summer, hypersaline conditions favor halophilic species like *Dunaliella* shown in the Table 2 (Ponce-Palafox et al., 1997)<sup>[11]</sup>.

**Table 1:** Key Algal Species those found in Sambhar Lake

S. No.	Algal Species	Key Characteristics
1.	<i>Dunaliella salina</i>	Known for high $\beta$ -carotene production under stress conditions.
2.	<i>Spirulina platensis</i>	Cyanobacterium rich in protein, phycocyanin, and essential fatty acids.
3.	<i>Chlorella vulgaris</i>	Fast-growing green alga with antioxidant and detoxifying properties.
4.	<i>Anabaena</i> and <i>Nostoc</i>	Nitrogen-fixing cyanobacteria aiding in primary productivity and bioremediation.

**Table 2:** Key Plant species found in Sambha lake area

S. No.	Plant Species	Key Compounds	Medicinal Properties
1	<i>Calotropis gigantea</i>	Calotropin, Uscharin, Calotoxin, Calotropin (cardiac glycosides)	Used in traditional medicine for treating asthma, skin diseases, digestive disorders, and as an antidote for snake bites. Exhibits cytotoxic activity against certain cancer cell lines.
2	<i>Euphorbia caducifolia</i>	Phorbol esters, Alkaloids	Traditionally used for wound healing and as an anti-tumor agent. The latex promotes healing by forming a protective layer over wounds.
3	<i>Samadera indica</i>	Samaderin (quassinoids), Triterpenes (Lupenone, 18 $\alpha$ -Oleanan-19 $\alpha$ -ol-3-one)	Employed in treating fevers, rheumatism, skin diseases like leprosy and scabies. Exhibits antimicrobial and anti-leukemic activities.

## 4. Medicinal Properties and Potential Applications Bioactive Compounds

derived from algae and plants from the Sambhar Lake region hold immense pharmaceutical potential due to their rich secondary metabolites. Algal species such as *Dunaliella salina*, *Spirulina platensis*, *Chlorella vulgaris*, and *Anabaena* produce essential bioactive compounds like  $\beta$ -carotene, phycocyanin, and polysaccharides, exhibiting antioxidant, anti-inflammatory, and immunomodulatory properties (Nisa et al., 2015)<sup>[10]</sup>.

These compounds help reduce oxidative stress, support organ health, and show promise in treating cancer and

infectious diseases. Similarly, medicinal plants like *Calotropis gigantea*, *Euphorbia caducifolia*, and *Samadera indica* contain potent metabolites such as calotropin, phorbol esters, and samaderin, known for wound healing, antimicrobial, and anti-leukemic effects. The harsh saline ecosystem of Sambhar Lake triggers the production of these defense molecules, enhancing their therapeutic efficacy. These bioactive compounds are now being explored for applications in pharmaceuticals, nutraceuticals, and environmental bioremediation, offering sustainable solutions for public health and ecological challenges (Borowitzka, 2013)<sup>[3]</sup>.

## 1. Bioactive Compounds and Medicinal Properties

**Table 3:** Algae from Sambhar Lake a wide range of secondary metabolites

S. No.	Algal Species	Key Metabolites / Compounds	Medicinal Properties
1	<i>Dunaliella salina</i>	$\beta$ -carotene	Powerful antioxidant, anticancer, supports eye and skin health
2	<i>Spirulina platensis</i>	Phycocyanin, proteins, essential fatty acids (GLA)	Anti-inflammatory, antioxidant, immune-boosting, supports cardiovascular and brain health
3	<i>Chlorella vulgaris</i>	Chlorophyll, carotenoids, vitamins (B12), antioxidants	Detoxifying, immune-stimulatory, antioxidant, supports liver function
4	<i>Anabaena, Nostoc</i>	Phycobiliproteins, polysaccharides	Nitrogen fixation, bioremediation, anti-inflammatory, immunomodulatory

Bioactive Compounds are naturally occurring chemical substances produced by algae and plants that exert biological effects on living organisms. Found in Sambhar Lake species, these compounds—such as  $\beta$ -carotene, phycocyanin, and alkaloids—offer antioxidant, anti-

inflammatory, antimicrobial, and anticancer properties, making them valuable for pharmaceuticals, nutraceuticals, and ecological restoration efforts shown in the Table and Table4 (Eze et al., 2017) <sup>[5]</sup>.

**Table 4:** Algae from Sambhar Lake a wide range of secondary metabolites

S. No.	Plant Species	Key Metabolites / Compounds	Medicinal Properties
1	<i>Calotropis gigantea</i>	Calotropin, Uscharin, Calotoxin (cardiac glycosides)	Treats asthma, skin diseases, digestive disorders; used as antidote for snake bites; cytotoxic against cancers
2	<i>Euphorbia caducifolia</i>	Phorbol esters, alkaloids	Wound healing, anti-tumor, latex used as a protective and healing agent
3	<i>Samadera indica</i>	Samaderin (quassinoids), triterpenes (e.g., lupenone, 18 $\alpha$ -oleanan-19 $\alpha$ -ol-3-one)	Used in treating fevers, rheumatism, skin diseases; has antimicrobial and anti-leukemic properties

## 5. Conservation Challenges Sambhar Biodiversity

Sambhar Lake, India's largest inland saline wetland, hosts unique biodiversity including halophytic vegetation, migratory birds like flamingos, and medicinal algae and plants (Naik Meena, 2017) <sup>[8]</sup>. However, its fragile ecosystem faces numerous conservation challenges:

- **Overextraction of Salt and Groundwater:** Unregulated salt mining and excessive groundwater withdrawal disturb the natural hydrology, leading to habitat degradation.
- **Pollution:** Effluents from nearby settlements and salt industries introduce heavy metals and other pollutants, affecting aquatic flora and fauna.
- **Loss of Habitat:** Encroachment, urbanization, and agricultural expansion have led to the destruction of native vegetation and wetlands.
- **Decline in Migratory Birds:** Altered water quality and shrinking wetland area have drastically reduced the number of migratory birds, especially flamingos.
- **Climate Change:** Rising temperatures and erratic rainfall patterns are altering the lake's saline ecosystem, impacting species adapted to specific salinity levels.

- **Lack of Awareness and Enforcement:** Inadequate implementation of conservation laws and low public awareness hinder long-term ecological protection.

## 6. Conservation Strategies for a Sustainable Future

Sambhar Lake, India's largest inland saline wetland, is a critical habitat for diverse algae, medicinal plants, and migratory birds. Sustainable conservation requires integrated strategies such as habitat restoration through regulated salt mining, wetland hydrology management, and pollution control. Promoting ex situ conservation of rare algal and plant species, alongside in situ biodiversity monitoring using GIS and remote sensing tools, enhances protection. Community participation, eco-tourism initiatives, and awareness campaigns are essential for long-term stewardship. Scientific research on bioactive compounds from native species can promote sustainable bioprospecting. Effective policy enforcement and climate-resilient wetland management will ensure the ecological and economic sustainability of Sambhar Lake's unique biodiversity (Shukal & Rahaman, 2006) <sup>[15]</sup>.

## 7. Conclusion

Sambhar Lake algae offer a promising frontier in medicinal research, with their ability to synthesize bioactive compounds of pharmaceutical relevance. Their antioxidant, antimicrobial, anti-inflammatory, and

anticancer properties open avenues for novel drug discovery and nutraceutical development. However, this biological wealth is under serious threat from environmental degradation, unsustainable exploitation, and weak governance.

The integration of ecological monitoring, policy reform, sustainable bioprospecting, and community engagement is critical to conserving this fragile ecosystem. By balancing conservation with innovation, Sambhar Lake can emerge as a model for utilizing wetland biodiversity for health and sustainability.

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