The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 4 | Issue 3 | March 2026
ISSN: 2583-973X (Online), SJIF IF: 5.6
Website: www.theacademic.in

*Spirulina C*ultivation for Industrial Waste Water Treatment and Its Application

Nikita Y. Shinde

Department Of Chemistry, Jamkhed Mahavidyalaya Jamkhed Ahilyanagar, Maharashtra. India. Pin Code - 413201., Email: -ys4238195@gmail.com

Dr. Niteen B. Tarate

Department of Chemistry, Jamkhed Mahavidyalaya, Jamkhed, Dist- Ahilyanagar (MS)

Email: niteentarate1986@gmail.com, tarate_niteen@rediffmail.com

DOI : https://doi.org/10.5281/zenodo.19500870

ARTICLE DETAILS

Research Paper

Accepted: 22-03-2026

Published: 10-04-2026

Keywords:

Microalgae, wastewater, Spirulina, extract, Spirulina

ABSTRACT

Microalgae is an autotrophic microorganism, live without carbon presence, utilized to digest the substances in wastewater especially for nitrogen substances. Spirulina sp is the type of microalgae selected to utilize the wastewater of energy drink, the selection criteria are the size of Spirulina sp is relatively larger easy to separate from its solution. The experiment conducted by cultivate the seeding microalgae with certain nutrients until the certain volume. Microalgal research has been an area of great interest as microalgae have higher productivities than land plants and can be used for the production of valuable commodities such as biofuel, animal feeds and agricultural fertilizers, among others. Industrial wastewater contains large amounts of nutrients such as nitrogen, phosphorus, and organic matter that cause environmental pollution. Cultivation of Spirulina (a blue-green microalga) in wastewater is a sustainable method for both wastewater treatment and biomass production [1]. The use of Spirulina and Aloe vera together provides both nutritional and therapeutic benefits. Spirulina supplies essential nutrients and antioxidants, while Aloe vera contributes healing, antimicrobial, and anti-inflammatory properties. Therefore, these natural resources are important in health supplements, pharmaceutical formulations, and

functional foods. Several medicinal plants such as Neem, Tulsi, Turmeric, Ginger, and Amla are commonly used with Spirulina and Aloe vera for health improvement. These plants contain bioactive compounds that provide antimicrobial, antioxidant, anti-inflammatory, and immune-enhancing effects, making them valuable in traditional medicine and modern herbal formulations. Absorbs nutrients from wastewater and converts them into valuable biomass rich in proteins, vitamins, and pigments [2]. Therefore, Spirulina-based wastewater A medicine made by combining spirulina with Aloe vera, turmeric, neem, Tulsi, ginger, and amla is generally called a: Polyherbal Spirulina Formulation systems can play an important role in environmental management and sustainable agriculture.

Introduction

Industrial wastewater often contains high levels of nutrients like nitrogen and phosphorus, which can cause pollution if not treated. In this study, we explore using this wastewater to grow Spirulina, a type of microalgae [3]. By doing this, farmers can both clean the water and produce Spirulina biomass, which can be sold as a nutritional supplement or animal feed. This approach provides farmers with extra income and supports a more sustainable and eco-friendly farming practice. Microalgal biomass contains high concentrations of protein, lipids, and vitamins. Therefore, besides being a valuable alternative to the conventional purification treatments, the use of microalgae offers several advantages Methodology: The cultivation of spirulina was optimized under controlled conditions, and extracts of Aloe vera, turmeric, neem, Tulsi, ginger, and amla were added in precise proportions [4-6].

The biochemical composition was analyzed, and the formulation's stability, bioactivity, and safety were assessed in vitro. the algal biomass can be recycled or used as fertilizers and livestock feeds. Furthermore, under photosynthetic conditions, algal growth allows oxygen to be released, thus enhancing the auto-depuration potential of water. In agricultural countries, algal biomass could be directly employed in soil inoculation to increase crop productivities [7,8]. They offer an alternative to the vicious cycle of chemical fertilizers, soil exhaustion and dependency on imports. Current methods undertaken include the use of physical settling of solid waste, filtration, aerobic and anaerobic microbes, and chemical treatments. Low removal of pathogens, dependence on the uninterrupted power supply, high maintenance

cost, generation of explosive biogas and bioaccumulation of chemicals are some disadvantages of activated sludge technology, one of the modern technologies used.

Hence, the focus has been shifted on organisms capable of metabolizing, immobilizing or absorbing toxic compounds from their environment, making it both environment-friendly and cost-effective [9]. This review provides perspicacity about the generation of sewage and the various methods available for its treatment Industrial wastewater, particularly from food processing, dairy, and agricultural sectors, can be used to cultivate *Spirulina* (*Arthrospira platensis*) because it offers a low-cost, sustainable alternative to conventional, costly synthetic media, facilitating effective, large-scale bioremediation of polluted water [10,11]. Spirulina (Arthrospira platensis) is a photosynthetic cyanobacterium widely used as a nutritional supplement due to its high protein and mineral content [12]. Spirulina can grow in nutrient-rich wastewater and remove pollutants through biological assimilation. This makes it a promising solution for industrial wastewater treatment and biomass production [13].

Experimental

1. Collection of Industrial Wastewater

Industrial wastewater was collected from nearby industries such as dairy or food processing units. The wastewater contains nutrients like nitrogen and phosphorus which support Spirulina growth.

2. Pretreatment of Wastewater

- The collected wastewater was first filtered to remove suspended particles.
- The pH of the water was adjusted to 8–9 which is suitable for Spirulina growth.
- If necessary, the wastewater was diluted with clean water.

3. Preparation of Culture Medium

For cultivation, the wastewater was mixed with nutrient medium in the following ratio:

- 75–85% industrial wastewater
- 25–35% nutrient medium (Zarrouk medium)
- This mixture provides sufficient nutrients for Spirulina cultivation.

4. Inoculation of Spirulina

- A pure culture of Spirulina was added to the prepared medium.
- About 15–20% Spirulina starter culture was inoculated into the cultivation tank.

5. Cultivation Conditions

- The culture was maintained under suitable conditions:
- Temperature: 31–36°C
- PH: 8–9
- Light: Sunlight for 11–13 hours daily
- Aeration: Continuous mixing or air supply
- The cultivation was carried out for 8–9days
- Growing Spirulina: Farmers can grow spirulina easily because it grows fast and is very nutritious.
- Adding Natural Plants: Along with spirulina, they can add other natural plants like aloe vera, moringa, or ashwagandha, which boost health benefits [14].
- Making Products: They can use this mixture to create spirulina tablets, which are good for health.
- Selling Locally: Once made, farmers can sell these tablets in local markets, earning a good income.
- Health Benefits: The natural ingredients provide a variety of health benefits, giving people a nutritious product.
- Spirulina is a type of blue-green algae that people take as a supplement. It's full of protein, vitamins (like B12), minerals (such as iron), and antioxidants. In medicine, it's used to help boost the immune system, lower cholesterol, and provide extra nutrients. Some research also suggests it might help with blood sugar levels and reduce inflammation, but more studies are still needed [15].

6. Harvesting of Spirulina

After sufficient growth, Spirulina biomass was collected by filtration using a fine cloth or filter paper. The biomass was washed with clean water and dried.

7. Economic Benefits for Farmers

The produced Spirulina biomass can be sold as:

- Health supplements
- Animal and poultry feed
- Aquaculture feed
- Biofertilizer
- Anti-Cancer Potential The antioxidant and anti-inflammatory compounds in Spirulina may help inhibit the growth of certain cancer cells.

To prepare a spirulina-based tablet with other natural plant powders, follow these steps in detail:

- Ingredient Selection: Choose spirulina powder, Tulsi (holy basil) powder, amla powder, turmeric powder, and ginger powder.
- Proportion by Percentage: A typical ratio might be:
- Spirulina powder: 40%
- Amla powder: 20%
- Tulsi powder: 15%
- Turmeric powder: 15%
- Ginger powder: 10%
- Mixing: Combine all powders thoroughly so the nutrients are evenly distributed.
- Binder Addition: Add a small percentage of a binder (e.g., 2–3% glucose or microcrystalline cellulose) to ensure the powder binds.
- pH Maintenance: Maintain the pH of the mixture around 6.5–7.0 to ensure stability.
- Tablet Compression: Use a tablet press machine to compress the blended powder into uniform tablets.
- Drying: Dry the tablets at a mild temperature to remove any moisture.
- Packaging: Seal tablets in airtight containers to prevent degradation.

- As for spirulina types, there are mainly two: spirulina maxima and spirulina platensis. Spirulina platensis is often considered the best due to its rich nutrient profile. Once the powders are blended in these percentages, the tablets can be used as a nutraceutical supplement, providing antioxidants, immune support [16].

1.Spirulina

- Spirulina is a blue-green microalga (cyanobacterium) commonly used as a nutritional supplement and medicinal food. It grows in alkaline water and is widely cultivated for health products.
- Chemical composition
- Protein: about 60–70 %
- Vitamins: Vitamin B_1, B_2, B_{12}, Vitamin E
- Minerals: Iron, Calcium, Magnesium
- Pigments: Phycocyanin, Chlorophyll
- Essential fatty acids such as gamma-linolenic acid (GLA)
- Medicinal uses
- Improves immunity: Phycocyanin and antioxidants stimulate the immune system.
- Reduces cholesterol: Regular consumption helps lower LDL cholesterol and improves heart health.
- Antioxidant activity: Protects cells from oxidative stress and free radicals.
- Treatment of malnutrition: High protein content makes it useful in nutrition programs.
- Anti-inflammatory effect: Helps reduce inflammation in the body.
- Blood health: Iron present in spirulina helps prevent iron-deficiency anemia.

2. Azadirachta indica (Neem)

- Active constituents: Azadirachtin, nimbin, nimbidin
- Medicinal uses
- Strong antibacterial and antifungal properties.
- Used in treatment of skin diseases and infections.
- Acts as a blood purifier in traditional medicine.
- Used in preparation of herbal pesticides and medicinal formulations.

3. Ocimum tenuiflorum (Tulsi)

- Active constituents: Eugenol, ursolic acid, rosmarinic acid

- Medicinal uses
- Used for treatment of cold, cough, and respiratory disorders.
- Shows antimicrobial and antioxidant activity.
- Helps improve immune response.
- Used in herbal tea and traditional medicines.

4. Curcuma longa (Turmeric)

- Active constituent: Curcumin
- Medicinal uses
- Strong anti-inflammatory and antioxidant agent.
- Used for wound healing and skin treatment.
- Supports liver function and digestion.
- Used in pharmaceutical and herbal preparations.

5. Zingiber officinale (Ginger)

- Active constituents: Gingerol, shogaol
- Medicinal uses
- Used for digestive disorders and nausea.
- Exhibits anti-inflammatory and antioxidant properties.
- Helps in treatment of cold and throat infections.

6. Phyllanthus emblica (Amla)

- Active constituents: Vitamin C, tannins, flavonoids
- Medicinal uses
- Strong antioxidant activity.
- Improves immune system and metabolism.
- Used in treatment of digestive disorders and general weakness.

Therefore, the Spirulina cultivation not only helps in wastewater treatment but also provides good income opportunities for farmers from the Spirulina cultivation. Herbal Medicine also prepared from Spirulina and Medicinal Plants. A medicinal formulation can be prepared by combining spirulina with several medicinal plants such as Aloe vera, turmeric, neem, Tulsi, ginger, and amla. This mixture

provides both nutritional and therapeutic benefits because each component contains important bioactive compounds. In pharmaceutical industry Bioactive compounds in Spirulina are used for [17-18]:

- Antioxidant drugs
- Immune-boosting supplements
- Anti-inflammatory medications

Combined Effect of the Formulation

1. When spirulina is mixed with these medicinal plant extracts, the formulation provides:
2. High nutritional value (protein, vitamins, minerals)
3. Antioxidant protection against free radicals
4. Anti-inflammatory and antimicrobial effects
5. Improved immunity and digestion
6. Potential use in herbal supplements and functional medicines

Farmers can grow the spirulina to some other increment of the plants mixed together and the form the new medicinal tablet for the good for the health

Application

Future Prospects: Spirulina has great potential in biotechnology, food science, and environmental sustainability. Future research may focus on changes and variation in biomass yield and chemical composition of spirulina should be considered for extraction bioactive compound or in application as food supplement or fertilizer spirulina plants in a potential organism for coast effect and environment friendly waste water treatment techniques

Waste Valorization in Agriculture: Using industrial waste from Spirulina production in farming turns a waste management issue into a valuable agricultural resource. The polyherbal spirulina formulation can be used as a nutraceutical supplement to support immunity, provide antioxidants, and reduce inflammation. It is intended for individuals seeking a natural, plant-based supplement to complement their diet. Potential applications extend to preventive healthcare, chronic disease management, and as a functional food in daily diet [19].

1. Uses Use in space missions as a sustainable food source
2. Use in space missions as a sustainable food source.
3. Produces high-protein Spirulina biomass can be sold as health supplement, fish feed, poultry feed, or biofertilizer
4. Provides extra income for farmers
5. Spirulina's main applied uses:

   biofertilizer/bio stimulant for crops, soil enhancer, and high-protein feed for livestock/fish.
6. Industrial wastewater treatment grown in effluent to absorb N, P, and contaminants; harvested biomass becomes feed, fertilizer, or bio-product, cutting treatment costs and
7. closing nutrient loops.
8. Additional Income for Farmers
9. Farmers can sell Spirulina as:
10. Health supplements
11. Animal and poultry feed
12. Aquaculture feed
13. Biofertilizer

Conclusion:

Spirulina cultivation using industrial wastewater is a promising green technology for wastewater treatment. Spirulina is used in wastewater treatment and carbon dioxide absorption due to its rapid growth and photosynthetic ability. The integration of spirulina with traditional medicinal plants like Aloe vera, turmeric, neem, Tulsi, ginger, and amla creates a powerful polyherbal formulation. Future work will focus on clinical trials to validate its efficacy and safety in human populations, paving the way for its potential commercialization. It reduces environmental pollution while producing economically valuable biomass.

Algae can accumulate pollutants on its cells and help to clean up the environment. S. Platensis is well suited for the removal of organic and inorganic compounds from aqueous solution, due to its rapid rate of biosorption as well as its high capacity of biosorption with several bioactive compounds and catalytic enzymes, this cyanobacterium has proven to degrade heavy metals as well as biological contaminants. Moreover, the biomass generated during sewage treatment can be utilized to extract commercially valued products (bioactive compounds) or nutrient-enriched food supply human and animal. Spirulina together with medicinal plants such as Aloe vera, turmeric, neem, and Tulsi can improve human health. These natural resources are widely used in medicine, nutrition, and traditional healthcare systems. source of the spirulina cultivations in farmer good economically profitable of industrial waste water use in spirulina cultivation more benefit for the farmer cultivation

References:

- Lim HR, Khoo KS, Chew KW, Chang CK, Show PL. Perspective of Spirulina culture with wastewater into a sustainable circular bioeconomy. Environ Pollut 2021; 284:117492.
- Al-Homaidan A, Husainy M, Shehata AI. Effects of temperature, pH and salinity on growth of two species of Spirulina isolated from Saudi Arabia. Saudi J Biol Sci 2005; 12:1-13.
- Al-Homaidan A. Large-scale cultivation of Spirulina in Saudi Arabia. Saudi J Biol Sci 2002; 8:2.
- Ogato T, Kifle D, Fetahi T, Sitotaw B. Evaluation of growth and biomass production of Arthrospira (Spirulina) fusiformis in laboratory cultures using waters from the Ethiopian soda lakes Chitu and Shala. J Appl Phycol 2014; 26:2273-82.
- Anwer, R., Khursheed, S., & Fatma, R. (2012). Detection of Immunoactivity Insulin in Spirulina. Journal of Applied Phycology, 24, 583-591. https://doi.org/10.1007/s10811-011-9757-1
- Barrón, B. L., Torres-Valencia, J. M., Chamorro-Cevallos, G., & Zúñiga-Estrada, A. (2007). Spirulina as an antiviral agent. In M. E. Gershwin & A. Belay (Eds.), Spirulina in Human Nutrition and Health (1st ed., pp. 227-240). CRC Press. Beauvais-Flück, R., Slaveykova, V., & Cosio, C. (2018).
- Molecular effects of inorganic and methyl mercury in aquatic primary producers: Comparing impact to a macrophyte and a green microalga in controlled conditions. Geosciences, 8(11), 393.
- Springer Nature. Nutritional improvement of Spirulina by fermentation.
- Bioresources and Bioprocessing. Cultivation of Spirulina biomass.

- M Ahsan, B Habib, Mashuda Parvin, Tim C Huntington, Mohammed R Hasan. A review on culture, production, and use of spirulina as food for humans and feeds for domestic animals and fish. Food and Agriculture Organization of the United Nations. 2008; 33:28-32.
- 11. Richard Kozlenko, Ronald H Henson. Latest scientific research on spirulina: Effects on the AIDS virus, cancer and the immune system; 2017.
- 12. Renata Konícková, Katerina Vanková, Jana Vaníková, Katerina Vánová, Lucie Muchová, Iva Subhanová et al. Anti-cancer effects of blue-green alga Spirulina platensis, a natural source of bilirubin-like tetrapyrrolic compounds. Annals of Hepatology. 2014; 13:273- 283.
- Behera S, Singh R, Arora R, Sharma NK, Shukla M, Kumar S. Scope of algae as third generation biofuels. Frontiers in Bioengineering and Biotechnology 2015; 2:1-13.
- 14.Bharathiraja B, Chakravarthy M, Kumar RR, Yogendran D, Yuvaraj D, Jaya Muthunagai J et al. Aquatic biomass (algae) as a future feed stock for bio-refineries: A review on cultivation, processing and products. Renewable and Sustainable Energy Reviews 2015; 47:634-653.
- Yanni Y, Elashmouny A, Elsadany A. Differential response of cotton growth, yield and fiber quality to foliar application of Spirulina platensis and urea fertilizer. Asian Journal of Advances in Agricultural Research 2020;12(1):29-40.
- Tredici MR, Materassi R. From open ponds to vertical alveolar panels: The Italian experience in the development of reactors for the mass cultivation of photoautotrophic microorganisms. Journal of Applied Phycology 1992; 4:221-231.
- 17.Dhandayuthapani S, Azad H, Rathinavelu A. Apoptosis induction by Ocimum sanctum extract in LNCaP prostate cancer cells. J Med Food 2015; 18:776-85
- 18.Gul A., Baig M.N., Ahmed D., Najam Z., Aslam T., Ali S. Green Synthesis of Silver Nanoparticles from Spirulina Platensis Extract: Antibacterial and Antioxidant Potential. Bio Nanoscience. 2024; 14:2327–2336. Doi: 10.1007/s12668-024-01473-2.
- 19.Al-Badwy A.H., Khalil A.M., Bashal A.H., Kebeish R. Polysaccharides from Spirulina platensis (PSP): Promising Bio stimulants for the Green Synthesis of Silver Nanoparticles and Their Potential Application in the Treatment of Cancer Tumors. Microb. Cell Factories. 2023; 22:247. Doi: 10.1186/s12934-023-02257-1.