Minireview Article

Reducing the Carbon footprint by cultivating and consuming Spirulina- A mini review

Abstract:

Increased carbon emissions have increased the global warming resulting in tremendous changes in the climate factor. Climate change has brought drought, cyclones, floods, tsunami ,irregular rain fall patterns threatening food security, clean water ,etc... To reduce the impacts of global warming that are detrimental to humanity and biosphere, global nations have agreed to reduce carbon emissions and go for low carbon footprint in all industrial and commercial activities. This study analyzes cultivation and consuming *spirulina (Arthospira platensis)* as a win- win situation for sustainable development in terms of GDP as well as carbon capture &storage (CCS).

Keywords:

Sustainability, carbon capture, blue green algae, nutrient rich bioresource, phycocyanin.

Fig. 1. *Spirulina* culture

Fig. 2. Collection technique **Fig. 3. Role of *Spirulina* in different sectors**

1.Introduction:

Herzog et al.,(2001) Natural ways of carbon sequestration are by vegetation in soil, in forests, in oceans as natural sinks. Artificial carbon capture can be done in Geological sinks that can hold thousands of gigatons of carbon in depleted oil and gas reservoirs, deep saline formations, unminable coal seams. CO2 injection into geological formations for enhanced oil recovery (EOR) is a prominent technology that reduces the viscosity of heavy oil resulting in release of trapped oil. **Song et al.,(2016)** Phytoliths are silicified forms of plants that get accumulated in soils and sediments for hundreds to thousand years **.**Organic carbon present in phytoliths is mainly captured from atmospheric carbon di oxide during photosynthesis. Phytolithic carbon sequestration in croplands, grasslands, forests, bamboo lands can be an efficient measure for carbon capture. **Sayre et al.,(2010)** Micro algae are recognized as the most productive biological systems for biomass production than terrestrial systems due to their short maturation cycle. Carbon di oxide or bicarbonate capturing efficiencies in their cell structure make them apt for carbon capture from stationary point sources like cement kilns or power stations and from non point sources like atmospheric carbon. **Schipper et al.,(2013)** Constructing algal ponds near industries is a necessary step followed by industries to reduce carbon foot print. **Vonshak et al.,(2004)** *Spirulina* is a blue green algae with spiral filaments under genus *Arthrospira*, and phylum Oscillatoriaceae. It is a cyanobacteria and contains two pigments green (chlorophyll) that does photosynthesis and fixes carbon di oxide and blue (phycocyanin) in its cell structure. It is a unicellular micro algae growing in high alkaline conditions 10-12 pH introduced to modern society by Kanembu tribes of Africa, near Lake Chad. In 1965, the botanist Jean Leonard confirmed that *dihe* consumed by Kanembu tribe is made up of *spirulina*, and he cultured it in a sodium hydroxide production facility in laboratory conditions. From that time till date *spirulina* is cultured and consumed by trillions of people as it is a GRAS level edible algae. This study involves the particular species *Arthospira platensis* biomass useful to humanity in infinite ways.

2.Nutrient profile of *Spirulina*:

Capelli et al.,(2010), Grosshagauer et al.,(2020),*Spirulina* is rich in exopolysaccharides (15-21%), fatty acids and easily digestible protein (60-70%). It contains a wide array of micro nutrients and vitamins. GLA- gamma linolinic acid present in mother's milk is an important constituent that makes *spirulina* nature's mothers milk to humans. As it is rich in chlorophyll, a pigment resembling structure of hemoglobin in blood it can fight anemia. It is a rich vegetative source of vitamin B12, cyanocobalamin and rich in other vitamins also. The micro nutrients present are calcium, potassium, chromium, copper, iron, magnesium, manganese, phosphorus, selenium, sodium, zinc, molybdenum, chloride, germanium and boron. Phycocyanin the blue polypeptide present in *spirulina* regulates production of white blood cells and stem cells thus imparting immuno regulatory nature to the microalgae. Phycocyanin also helps in formation of blood- hematopoiesis. This versatile nutrient profile of *spirulina* has its approval by WHO as an efficient tool against malnutrition and anemia in children and women. Beta carotene an anti oxidant is present that improves eye health and other anti oxidants rich property helps to fight free radicals reducing cancer risk and heart attacks. **Yücetepe et al.,(2016)** In this study compares conventional protein sources like egg and soybean with the nutritional benefits of bioactive peptides present in *spirulina* based upon the reports of FAO. All these qualities have given *spirulina* the nutraceutical value making it the **Great king of micro algal kingdom**.

Amino acid	Per 10 gm	% of total	Amino acid	Per 10 gm	% of total
Isoleucine	350 mg	5.6	Cystine	60 mg	1.0
Leucine	540 mg	8.7	Arginine	430 mg	6.9
Lycine	290 mg	4.7	Histidine	100 mg	1.6
Phenylalanine	280 mg	4.5	Threonine	320 mg	5.2
Tyrosine	300 mg	4.8	Proline	270 mg	4.3
Methionine	140 mg	2.3	Valine	400 mg	6.5
Glutamic acid	910 mg	14.6	Alanine	470 mg	7.6
Aspartic acid	610 mg	9.8	Glycine	320 mg	5.2
Tryptophan	90 mg	1.5	Serine	320 mg	5.2

Table 1 : "Aminoacids present in *Spirulina*"

3.Spirulina in Aquaculture:

Calcium-Spirulan is a unique polymerized sugar that does not allow virus to penetrate the cell membrane to infect the cell and other polysaccharides of *spirulina* are involved in DNA repair mechanisms and enzymes synthesis in cells (Fig. 1). Thus supplementing *spirulina* as a feed, prevents the animal from viral attack increasing its immune system. **Vonshak et al.,(2004)** By using *spirulina* as fish feed reduces the major production cost which is the feed cost(40-60%) in aquaculture. It also improves heath of the cultured species, makes the fish species more fit for human consumption by reducing antibiotics and hormones use in the culture, increase disease resistance, and survival rate of the larvae. **Cardoso et al.,(2021)** The *Spirulina* sp. LEB 18 was cultivated in aquaculture waste water supplemented with 25% zarrouks medium to obtain biomass of T-25 assay with highest concentrations of protein (65.73%), phycocyanin (16.60 mg/mL), PUFA (38.20%), and γ-linolinic acid GLA (23.29%). It also showed 90% bioremediation potential with the removal of COD, sulphate, phosphate, bromine and proved to be ideal for biodiesel applications.

4.Spirulina as animalfeed:

Holman et al.,(2013) *Spirulina* is a promising new feed resource supporting rations of agriculturally significant animals like cattle, cow, pigs, rabbits ,poultry showing improvements in productivity, health and product quality. **Panjaitan et al.,(2010)** Approximately 20% of dietary *Spirulina* bypasses rumen degradation and is available for direct absorption within the abomasum and increases microbial crude protein production and reduces its retention time within the rumen. **Jin et al.,(2020)** observed *spirulina* powder supplement in feeds for 125 days culture of abalones and found enhancement in the shell size and protein content of abalones.

5.Spirulina as a Biofertilizer:

Dineshkumar,et al.,(2018) This study used *chlorella vulgaris* and *spirulina platensis* for sustainable agriculture reducing the use of chemical fertilizers polluting the environment to get 7-20.9% increased yield in rice crop by nitrogen fixation by the micro algae. **Mahapatra et al.,(2018)** Cultivation of Spirulina sp. isolated from urban wastewater-fed lakes in outdoor rooftop batch cultures with concentrated wastewaters are a typical zero waste economy converting macronutrients C,N,P in the waste water into algal biomass with 100% efficiency making them potential biofertilizers. **Jadhav,et al.,(2020)** studied enhancement of soya bean plant growth in terms of plant height, number of branches, number of leaves by applying BGA fertilizer and obtained positive results. **Dinesh kumar et al.,(2019)** applied *spirulina* and *chlorella* along with cowdung to the seeds of crops Maize, Onion, Green gram, Black gram, Tomato and Paddy and concludes that shifting to organic agriculture is possible .Thus sustainable agriculture is close to our hands by using BGA biofertilisers. **Wuang, et al.,(2016)** By applying *spirulina* fertilizer observed enhanced growth of Chinese Cabbage, Chinese broccoli, and Protea White Crown plants from seed germination. **Hamouda et al.,(2022)** Agricultural lands are degraded mostly due to extensive use of chemical fertilizers for long term and also groundwater table going very low in certain areas causing salt water penetration .The study was conducted *with Triticum aestivum L.* against salinity concentrations of sea water 10% and 25%.With 2% liquid extracts from A.platensis, there was enhancement in protein, antioxidants, carbohydrates and total phenols of the plant in both concentrations of the sea water .Thus *spirulina* biofertiliser can be effective against salinity stress in crop growth. **Gonçalves et al.,(2021)** In this review discusses in detail about different mechanisms involved in applying *spirulina* biofertiliser for plant growth**.** Polysaccharides, long chain fatty acids and enzymes secreted by *A.platensis* are antagonistic to plant pathogens as a biocide. It can act as a biostimulant by secretion of growth promoting phyto hormones like auxins. Various bioactive molecules and antioxidants secreted by the micro algae can act as stress tolerance boosters. Bioremediation potential of *spirulina* improves soil quality by chelating toxic metal ions and the presence of surplus micronutrients and P and nitrogen fixing capacity enhances plant growth . Improving *spirulina* biofertiliser using nanotechnology as algal biochar nanofertiliser is an upgrowing field that improves the phycoprospects of the fertilizer leading to sustainable agricultural practices (Fig. 2).

6.Spirulina in the cosmetics industry:

Ragusa,et al.,(2021) in their detailed study of *spirulina* extracts in wide range of wound healing, antiageing, anti acne, skin care products concludes it as a booster in all products with no side effects. In beauty parlours *spirulina* face pack and lip balms are used as anti wrinkle agents. **Costa,et al.,(2017**) The biologically active metabolites in *spirulina* are interesting ingredients for nutricosmetic formulations and are important for skin care and anti ageing.

7.Spirulina in the Pigments industry:

The pigments present in spirulina are Phycocyanin (Blue): 14%, Chlorophyll (Green): 1% , Carotenoids (Orange/ Red): 47%.(**Ciferri, 1983**) *Spirulina* contains two biliproteins with high economical value: c-phycocyanin and allophycocyanin with absorption maxima at 615-620nm and 650nm in the visible region respectively. The chromophore is phycobilin, an open tetrapyrrole. **Boussiba and Richmond (1980)** Lina blue is commercialized by Dainippon Ink & Chemicals of Japan which constitutes of spirulina Phycocyanin . It is used as a food colorant in coloring of candy, ice cream, dairy products and soft drinks as well as in cosmetics like eye shadow, eye liner and lipstick and in textiles as natural blue. **Ranjitha et al.,(2020)** used phycocyanin pigments from *spirulina* as natural photosensitizer for bio sensitized solar cells(BSSC). Silver doped TiO2 nanoparticles were prepared by sol-gel technique and along with pigments of phycocyanin extracted from *A.platensis* was fabricated in solar cell to obtain high efficiency making this combination ideal for future BSSC applications. **Moldovan et al.,(2022)** Sustainability in textile industry leads us to shift in use of phycocyanin blue from *A.platensis* than chemical and traditional dyes. The pre-mordanted cotton and bleached wool with phycocyanin-rich extract, representing the sustainable blue dye was tested for color characterization and fastness . The results validated the sustainable character of spirulina-based phycocyanin in the dyeing process yielding low oxygen demanding effluent waste according to the international standards thus less polluting the environment. **Jeyaraja et al.,(2022)** The authors observed photocatalytic degradation of organic dye Malachite green of concentration 25ppm by phycocyanin extracts of *A.platensis* in sunlight. After 3hours, 100% of the dye was degraded that is confirmed by UV absorbance studies which showed no peak in 620nm proving dye degradation. **Ho et al.,(2019)** The light harvesting pigment phycocyanin of *spirulina* residue was converted into biochar by pyrolysis at 900 degrees and it is activated by peroxydisulfate to obtain an efficient long durable carbo green catalyst for waste water treatment that showed marvelous bactericidal properties on *Escherichia coli*.

8.Spirulina vs Global warming –The Conclusion:

Global algal biodiesel market is approximately USD 6.95 billions in the year 2020 with annual growth rate of 8%. Dueto the richness of nutrients, *Spirulina* can be used as a prominent substrate for industrially important biomolecules production. The ease of production and its capacity to harvest sun's energy makes this micro algae a renewable source of energy. As a biofertiliser, it enhances the agricultural productivity and its metal binding nature and presence of long chain fatty acids, holds it a special place in water treatment methods (Fig. 3). Thus one species of this microalgae can achieve seven sustainable development goals -7SDGs like sustainable agriculture yielding **food** security, clean **water**(used in WWT),clean **energy** production, upgrading degraded **land** (heavy metal removal and salt tolerance),Clean **air**(carbon sequestration& mitigation of **climate change**),good **health**(nutraceutical value),**eradicating poverty** by improved economy. This wonder product can be produced in larger quantities by exploring novel methods like symbiosis and co culturing techniques with other micro organisms like Rhodotorula yeast, Pseudomonas stutzeri, Azospirillum brasilense, Lacto bacillus plantarum…which enhances the yield manifolds so that it reaches every human hand at a low cost. Literature says 1gram of spirulina biomass uses 0.4-2grams of carbon di oxide. In other words, one acre of algae can remove 2.7tonnes of carbon di oxide which is 10-50% more efficient than terrestrial plants. If we follow the footprints of SPIRULINA in anyone of the above aspects, it will reduce carbon footprint which is our prior duty to mother EARTH.

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