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Physical and Chemical Conditions Affecting *Spirulina* Blooms in a Natural Waterbody in Rajshahi, Bangladesh

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Abstract:

Purpose: *Spirulina*, an organic source of protein, antioxidants, and vitamins, is consumable for humans, poultry, and fisheries. Growing awareness regarding organic and vegan diets has created a spotlight on the commercial production of *Spirulina*, even in Bangladesh. In Bangladesh, major pharmaceutical and feed companies already produce Spirulina products, but the raw materials (i.e. *Spirulina*) are imported from different countries. Entrepreneurs and investors are not interested in taking the risk of financing raw material bulk production. Even there is a knowledge gap that *Spirulina* can grow naturally in Rajshahi.

Methodology: The methodology used was a systematic literature review, which identified the knowledge gap. After that, a search was carried out to find Spirulina growing habitats. A waterbody with a *Spirulina* bloom was detected. Prescribed methods measured weekly data of physical-chemical conditions and cell density of *Spirulina*.

Findings: The first report of *Spirulina*, a cyanobacterial bloom, was reported from a waterbody in Rajshahi, Bangladesh in this study. During the study period, the abundance of *Spirulina* varied from 4.65 x 10^7 -5.7 x10^7 cells/L. The major physical-chemical factors of water during bloom were found to vary as air and water temperature 19- 25°C and 18-20.67°C, pH 8.00 -11.00, transparency 5-20 cm, dissolved oxygen 1.67 – 9.42 mg/l, alkalinity 28.20- 170mg/l, hardness 28.20 – 188mg/l and BOD 3.00 – 5.97mg/l. The water body in the urban area receives organic load from households nearby regularly.

Unique Contribution to Theory, Policy and Practice: The data and results support that Rajshahi's climate is suitable for producing *Spirulina*; thus, its commercialization is possible in this region of Bangladesh. The findings will inspire investors and entrepreneurs to invest in the Mass production of *Spirulina* for commercialization in northern Bangladesh. Even policymakers may formulate a long-term production strategy for *Spirulina* production to fulfil the local and international market demand.

Keywords: *Cyanobacterial Bloom, Spirulina, Physical-Chemical Conditions*

1. Introduction

Spirulina are multi-cellular and filamentous blue-green algae that gained considerable popularity in the human healthy food industry. In many countries of Asia, it is used as a protein supplement and as a health food (Habib et al., 2008) and vitamin supplement for aquaculture diets. The history of *Spirulina* consumption by humans dates back to the 19th century. People living adjacent to Lake Chad in the Kanem region had deficient levels of malnutrition despite living on a Spartan millet-based diet (Arulmoorthy et al.,). This traditional food, dihé, was rediscovered in Chad by a European scientific mission and is now widely cultured worldwide (Khatun et al., 2006).

Spirulina are aquatic organisms inhabiting freshwater alkaline lakes and can even grow in saline water. *Like other BGA*, *Spirulina* can grow in excess, causing blooms when warm water is enriched with nutrients, viz., phosphorus and nitrogen, in the concerned waterbody (Padmakumar et al., 2023). Dried *Spirulina* contains 5% water, 24% carbohydrates, 8% fat, and about 60% (51–71%) protein. Provided as in its typical supplement form as a dried powder, a 100g amount of *Spirulina* supplies 290 calories and is a rich source (20% or more of the Daily Value, DV) of numerous essential nutrients, particularly protein, B vitamins (thiamin and riboflavin, 207% and 306% DV, respectively), and dietary minerals, such as iron (219% DV) and manganese (90% DV) (4). The lipid content of *Spirulina* is 8% by weight, providing the fatty acids, gamma-linolenic acid, alpha-linolenic acid, linoleic acid, stearidonic acid, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and arachidonic acid. In contrast to those 2003 estimates (of DHA and EPA each at 2 to 3% of total fatty acids), 2015 research indicated that *Spirulina products* "contained no detectable omega-3 fatty acids" (less than 0.1%, including DHA and EPA). An in vitro study reported that different microalgae strains produced DHA and EPA in substantial amounts (Belay,2008).

Considering the tremendous potentiality, a search was undertaken to find *Spirulina* growing habitats in Rajshahi, Bangladesh. It is to be mentioned no such data is available on the bloom condition of *Spirulina* in Bangladesh. In 2024, a report was published projecting the market trends and size of the Spirulina market, which concluded, "The Spirulina Market was valued at $ 0.59 billion in 2023. This market is expected to reach $ 1.20 billion by 2031 from an estimated $ 0.64 billion in 2024 at a CAGR of 9.4 % during the forecast period of 2024-2031." After searching for 2months, several *Spirulina* growing habitats were detected. Among them, in one, the bloom of *Spirulina was* detected in natural conditions. Considering the significance, the present study was undertaken to study the physical and chemical characteristics of the specific waterbody.

2. Materials and Methods

The study assessed Spirulina's physical-chemical and biological condition growing in a waterbody from Binodpur, Rajshahi Bangladesh. Water and plankton Samples were collected weekly from the study zone in the morning between 7:30 and 8:30 AM. The data obtained from regular analysis of the chemical condition were shown in tabular forms. The estimations of limnological parameters have been done following the standard methods as stated in APHA (1976), and Welch (1948). These include the pH, Dissolved oxygen content [DO], Free carbon di-oxide [CO_2], Carbonate [CO_3^{2-}], Bicarbonate [HCO_3], Biological oxygen demand [BOD_5], Chemical oxygen demand [COD] and Total-hardness of water. All of the chemical parameters were observed at weekly intervals. pH meter (Model HANNA) was used to measure pH. The pH of the water samples was determined immediately after collection. Each time, ten readings were taken from each spot, and an average of the pH value was recorded. Air and water temperatures were recorded with the help of a mercury thermometer graduated up to 100°C. Secchi Disc was used to measure the transparency (cm). The surface water was green in colour with floating layers of green scum. The plankton net comprises bolting silk cloth no.30, mesh 48µm. During sampling, it was submerged in water and towed horizontally. Plankton samples were preserved in Transeau's solution and examined to identify them under a light microscope with the help of relevant literature Desikachary (1959).Cell density of the *Spirulina* was measured by APHA(1976) expressed in cells/l. Statistical analysis was carried out, and graphs were made following standard procedures in Microsoft XL.

3. Results and Discussion

pH value ranged from 8.0-11.01, with the highest pH recorded in February and the lowest in December **(Figure 2)**. According to Habib et al., (2008) and Arulmoorthy et al., (2017), the pH value in different culture media was between 8.0 to 10.0, which matches the naturally grown *Spirulina* in bloom conditions. The Mean and SD of pH were 9.03 ± 0.913. Dissolved oxygen (DO), essential for aquatic life, was found to fluctuate from 1.67 to 9.42 mg/l, showing its peak in January and reaching a minimum in December. The Mean and SD of DO was 4.56 ± 2.189. Biochemical oxygen demand (BOD), indicating organic pollution, ranged from 3.0 to 5.97 mg/l(Fígure3), with the highest values in December and the lowest in February. The Mean and SD of BOD are 4.12 ±0.901**.** Alkalinity, the capacity of water to neutralize acids, varied between 28.20 and 170 mg/l, with the maximum observed in December and the minimum in February. The Mean and SD of alkalinity were 60.8 ±40.77. Water hardness, caused by ions such as calcium and magnesium, ranged from 28.20 to 118 mg/l, with a maximum in December and a minimum in February (**Figure 4)**. The Mean and SD of Water Hardness were 67.21 ±50.07**.** Air temperature fluctuated between 19°C and 25°C, with the highest temperature recorded in early December and the lowest in mid-January. Water temperatures were slightly lower than the surface air, ranging from 18°C to 20.67°C, with the highest in late December and the lowest in early February (**Figure 5).**

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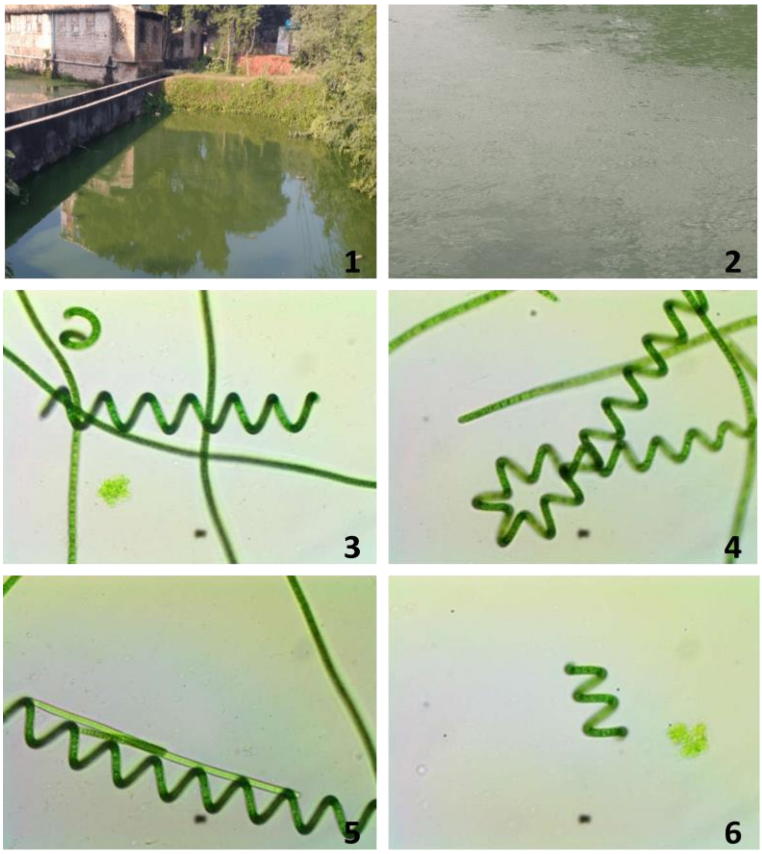

Figure1(1-6): *Spirulina* found in water body (Plate 1-6)

Water transparency, a crucial factor for light penetration and primary production by phytoplankton, ranged from 5 - 20 cm during the study period. The highest transparency occurred in mid-February, while the lowest was in late December. Padmakumar et al., (2023) while working on the control and management of *Spirulina platensis* bloom in a sacred pond from Kerala in India reported the same range of transparency as the bloom-forming factor of *Spirulina*. During the present study, Maximum cell/l density was recorded when the minimum value of transparency was observed (Table 1). TDS, indicating dissolved impurities in water, ranged from 102.30 mg/l to 129.00 mg/l, with the maximum in late February and the minimum in late December **(Figure 6).** The findings reflect the seasonal variation in water quality parameters and their ecological impact.

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Table 1: Physical -Chemical Parameters of water during the study period

Months	December				Mean	±	January				Mean	±	February				Mean	±
HCO_3 alkalinity (mg/l)	90	170	93	65	104.5	45.43	46.8	45.8	47.2	48.5	47.1	1.12	39.3	27	28	29	30.8	5.71
Total Hardness (mg/l)	60	120	65	205	112.5	67.39	61.5	58.5	59.7	53.3	58.3	3.52	39.5	27	28	29	30.9	5.81
DO (mg/l)	2.25	3.5	1.7	3.3	2.7	0.86	9.5	4.5	4.5	2.3	5.2	3.05	5.8	5.9	6.4	5.1	5.8	0.54
BOD (mg/ l)	6	3.2	3.5	5.7	4.6	1.45	3.9	4.2	4.1	3.7	4.0	0.22	4.2	3	3.7	4.2	3.8	0.57
pH	9.00	8.60	8.00	10.00	8.90	0.84	8.40	9.20	8.40	8.70	8.70	0.38	8.20	8.70	10.2	11.0	9.50	1.30
Transparency (cm)	19	10	10	5	11.0	5.83	19	17	18.35	18.4	18.2	0.84	12.5	20.5	20.5	12	16.4	4.77
TDS (mg/L)	127	126	125	100	119.5	13.03	120	123	125	122	122.5	2.08	121	120.5	127.5	129	124.5	4.38
Air Temp. (^0C)	25.8	25	23	22.8	24.2	1.48	23.2	20.5	19.5	20	20.8	1.65	22	22.5	23.5	23.5	22.9	0.75
W. Temp. (^0C)	20.2	19	19.3	20.7	19.8	0.79	23.5	20.1	20.1	19	20.7	1.95	18.8	19.2	19.5	18	18.9	0.65
Spirulina 10^7cells/L	4.8	4.90	4.92	**5.70**	5.1	0.36	4.80	**4.65**	4.75	4.75	4.74	0.06	4.98	4.70	4.70	4.98	4.84	0.16

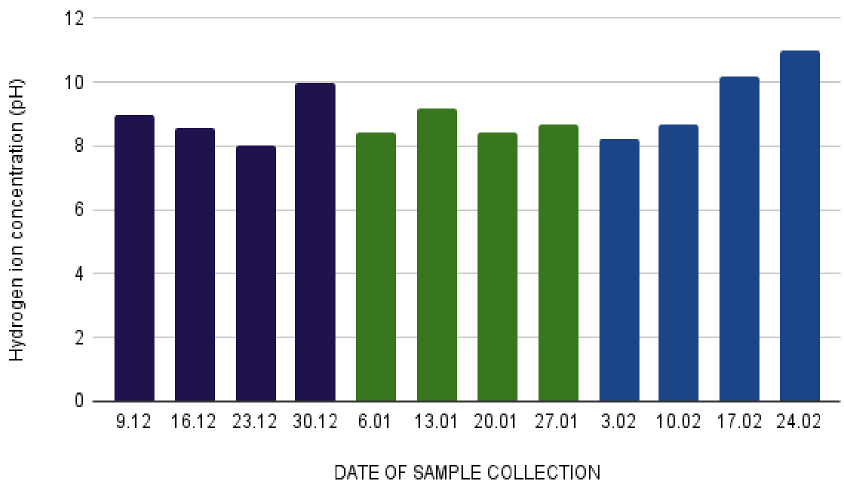

Figure 2: pH variation in the study area

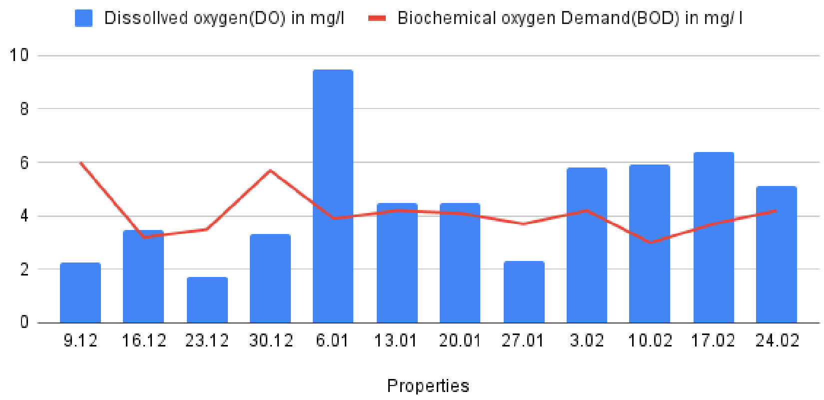

Figure 3: Dissolved oxygen and Biochemical oxygen demand variation in the study area

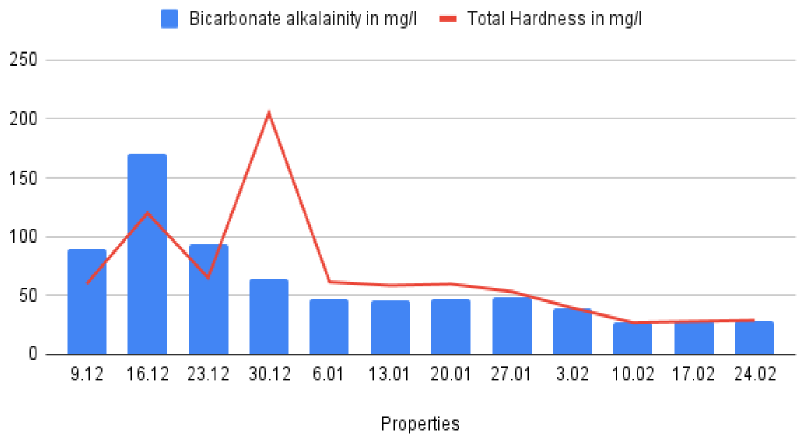

Figure 4: Bicarbonate alkalinity and Total Hardness variation in the study area

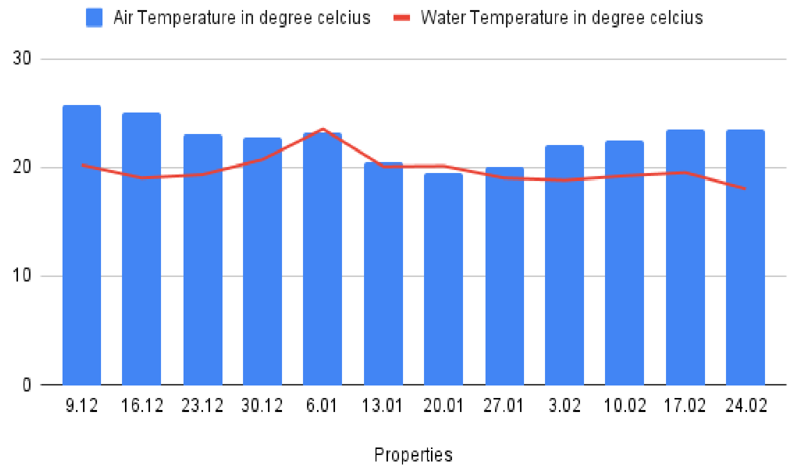

Figure 5: Air and Water Temperature variation in the study area

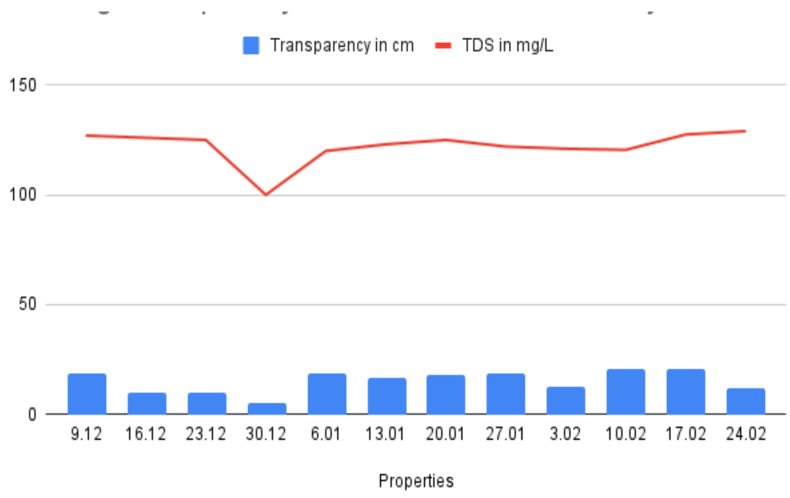

Figure 6: Transparency and TDS variation in the study area

Conclusion

The study results revealed that Spirulina bloom conditions suit physical and chemical regimes. *Spirulina* blooms typically flourish in low transparency, warm and slow-moving or stagnant water. Similar findings are supported by a study in Muttukadu backwater, Southeast coast of India (Arulmoorthy et al.,2017). Blooms were maximum when the transparency value was minimum. The waterbody understudy received considerable domestic waste, including detergent with wastewater from nearby homes. The rich nutrient concentration and water receiving high solar radiation might have created the ideal bloom-forming condition of *Spirulina*. Dissolved oxygen and biological oxygen demand variation (Fig.3) were found to go in hand with the abundance of *Spirulina* (Table 1). Whenever the abundance of *Spirulina* was high, the BOD value increased, confirming a heavy load of organic decomposition, which led to minimum values of dissolved oxygen in the water. The findings of the study confirmed that Rajshahi, Bangladesh, is climatically suitable for *Spirulina* commercialisation. The physical-chemical data collected from this study will enable the growers to formulate *Spirulina* culture conditions in the northern region of Bangladesh. The findings of this will be helpful for the commercialisation of *Spirulina* in Bangladesh.

Recommendations: *Spirulina's* mass production initiatives as raw material is important for pharmaceuticals and feed companies. The policymakers should provide incentives and motivation for investors and entrepreneurs to produce Spirulina as raw materials required by different industries at home. The pharmaceutical and feed companies that import Spirulina as raw material can be promoted with some tax benefits if they use locally produced Spirulina. This will also create a positive impact at the consumer level as the products produced will be available at a lesser price in the market. It could be considered a green export item as Spirulina's mass production benefits the environment's health.

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