CORRELATION BETWEEN PHYSICO-CHEMICAL FACTORS AND PHYTOPLANKTON GROWTH WITH REFERENCE TO *MICROCYSTIS* SP. IN THE HERITAGE TANK BINDUSAGAR, ODISHA

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Abstract: The relationship between the nutrient level and growth of different phytoplanktonic forms was studied in Bindusagar (Bhubaneswar,Odisha). Growth of *Microcystis* sp.in a water body is regarded as an indicator of water pollution.It is a notorious, potentially toxic Cyanobacteria that causes problems in freshwaters all over the world. It contains gas vesicles that make it lighter than water, so that it can accumulate at the surface of the water column, forming toxic scums.All the organic substances, after religious performances, are thrown into the tank,round the year and this organic nutrition, in water encourages bloom formation. *Microcystis* produces hepatotoxic as well as neurotoxic protein known as microcystin that is harmful for aquatic flora, fauna, domestic animals, birds as well as for human beings.

Keywords: Algal forms, *Microcystis* sp. Pollution, Temple tank

INTRODUCTION

Comprehensive character of a water body can be assessed by studying the Limnology and the phytoplankton diversity.The quality and quantity of water decides the status of the tank like eutrophic,oligotrophic or mesotrophic.Eutrophic is a nutrient rich and Oligotrophic is a nutrient poor condition of water (Swain *et al*., 1994a). Eutrophy is a consequence of lake's nutrition enrichment (Swain *et al*., 1994b; Saha and Wujek, 1989) and it leads to loss of bio diversity, poor water quality, loss of recreational potential as well as it pollutes (Fig. B) the ground water (Kodarkar, 2004). Quality of water can be established by studying the physico-chemical as well as the biological factors. Now-a-days the aquatic organisms are called as "biological Litmus Paper" (Nandan and More, 1999). Thus the algal bioassay, combined with physico-chemical characteristics can be carried out to assess the quality of water in fresh water bodies (Krishnamoorthi and Choudhury, 1990).

Some of the Microcystis species as reported to be found globally from time to time are, *Microcystis ichthyoblabe* Kützing 1843, *Microcystis aeruginosa* (Kützing) Kützing 1846, *Microcystisflos-aquae* (Wittrock) Kirchner 1898, *Microcystis firma* (Kützing) Schmidle 1902, *Microcystis viridis* (A. Braun in Rabenhorst) Lemmermann 1903, *Microcystis densa* G.S. West 1909, *Microcystis pseudofilamentosa* Crow 1923, *Microcystis protocystis* Crow 1923, *Microcystis natans* Lemmermann ex Skuja 1934, *Microcystis bengalensis* Banerji 1936, *Microcystis botrys* Teiling 1942, *Microcystis lamelliformis* Holsinger 1954, *Microcystis wesenbergii* (Komárek) Komárek in Kondrateva 1968, *Microcystis novacekii* (Komárek) Compere ex Komárek 1974, *Microcystis comperei* Komárek 1984, *Microcystis smithii* Komárek et Anagnostidis 1995, *Microcystis panniformis* Komárek et al. 2002. *Microcystis argentea* Schiller 1954, *Microcystis elongate* Desicachary 1959, *Microcystis maxima* Bernard 1908, *Microcystlis pallida* (Farlow) Lemmermann 1940, *Microcystis prasina* (Wittrock) Lemmermann in Frémy 1930, *Microcystis punctata* Schiller 1954, *Microcystis ramose* Bharadwaja 1935, *Microcystis robusta* (Clark) Nygaard 1925, *Microcystis rosea* Kufferath 1942 *Microcystis scripta* (Richer) Geitler 1925, *Microcystis supersalsa* Schiller 1956, *Microcystis toxica* Stephes 1949 (http://www.cyanodb.cz/).

In Puri and Bhubaneswar four types of Microcystis have been identified (Swain and Adhikary, 1990). Different species of *Microcystis* have also been identified from other parts of India like, Udaipur Lakes (Chaudhary and Meena,2007), Upper lake (UL), Lower lake (LL) and Mansarovar reservoir, (MR), Bhopal (Garg and Garg, 2002), Unkal lake, Dharward, Karnataka (Ansari *et al*., 2008). Thus the establishment of correlation between the nutrients and the phytoplankton growth with special reference to bloom forming *Microcystis* (Fig. C, D), is the aim of this study.

MATERIAL AND METHOD

Description of the Tank: The site is situated adjacent to the famous ancient Lingaraj Temple, which is visited by thousands of devotees and tourists every year. The geographical location of Bhubaneswar is 20° 25' N, 85° 15' E, at an altitude of 45 meters above sea level in the east coast of India. Once upon a time, Bindusagar tank (Fig. A) was bordered by over 7000 temples and today 500 still survive. People believe that when a person takes a dip in the sacred Bindusagar Lake, the Holy water washes away all his/her sins and he/she will also be free of diseases. This rectangular tank was built approximately during

7th / 8th Century A.D and is about 21.5 acres in area having breadth and length of 320 and 450 meters respectively.

Physico-Chemical Factors: Sampling was made at monthly interval on clear days between 8 to 10 a.m.from Jan – Dec 1992. Water temperature, transparency and dissolved oxygen were measured on the spot. Other parameters were measured in the laboratory within next 24 hours following APHA (1975) and Adoni (1985).

Phytoplankton Factors: Phytoplankton samples were collected using plankton net (NXX 13, 15µ, Rigosha and Co. Ltd. Tokyo) transferred to screw cap plastic bottles, fixed with Lugol's iodine on the spot and analysed in the laboratory. Quantitative analysis was done by haemocytometer (Fein-Optic, Germany) and qualitative analysis was carried out by using relevant literatures (Desikachary, 1959; Philipose, 1967 and Adoni, 1985).

RESULT AND DISCUSSION

The daily minimum and maximum air temperature of Bhubaneswar varies from 20.2 – 37.4 (ºC), 20.0 – 32.9 (ºC) and 10.5 – 30.9 (ºC) during Summer (March – June), Rainy (July – October) and Winter(November – February) season respectively. But water temperature showed variation of 25 – 34 (ºC) throughout the year which might be due to convection of currents (Table – 1). *Microcystis* (Fig. C, D) blooms often appear in eutrophic waters at high temperature (Yoshinaga et al., 2006) as it happened in this study site during summer season. Average transparency with standard error was found to be 36.4± 2.36and it was minimum during April and is positively correlated to growth of *Microcystis* (Vijayvergia, 2008). Annual average pH was 8.93±0.09 with a maximum of 9.4 during peak summer, showing its alkaliphilic nature (Devi *et al.*, 2010). Ideal pH range is 6.7 to 8.4 while pH below 5.0 and above 8.3 is detrimental to health as per ICMR Standards (7.0 to 8.5) (Gupta *et al*.,2011). Study on Unkal lake showed similar range of pH (Ansari *et al*.,2008). The alkaline nature of water due to high pH values can be attributed to high productivity of water as evident by high growth rate of algal population (Singh and Balasingh, 2011) which utilized CO_2 through photosynthetic activity (Kumar and Kapoor, 2006) on surface water (Gupta *et al.*, 2011). Free $CO_2$was totally absent throughout the year. Dissolved Oxygen varied between 4.4 – 7.3 (mg/l).During April higher dissolved oxygen was observed along with highest growth of *Microcystis* due to the conditions during these periods, which were more favourable for high rate of photosynthesis (Kumar and Kapoor, 2006). Due to this activity of the organism, alkalinity was diligently higher (Dwivedi, 2010). Maximum bicarbonate was observed during March and minimum during January where the range of chloride content was 48.8 – 79.5 mg/l. The increased concentration of chloride is considered as an indicator of eutrophication (Mahananda *et al.*, 2010). Average Ca-hardness was 59.9mg/l. Comparatively higher total phosphorus(soluble reactive phosphate, polyphosphate and soluble as well as insoluble organic phosphorus) was found throughout the year (Nayak and Behera,2004).But during May when the water temperature was highest (34 ºC), phosphate amount was reduced to a significant amount due to its immediate utilization by the overgrowth of phytoplankton. It is a major nutrient for the growth of phytoplankton and its concentration can be used to predict the total biomass of phytoplankton (Somek *et al*., 2008).The tank water was moderately hard (Kannan,1991), which might be due the utilization of these ions by the organisms (Parikh andMankodi,2012). Higher range of nitrate-nitrogen, organic – nitrogen and ammonia was found (Retnaningdyah *et al.*, 2010). During the month of October magnesium was totally absent even if the average annual value recorded was 5.54 ± 0.89.

A total of 45 species of phytoplankton were identified from the lake consisting of 27 Chlorophyta, 13 Cyanophyta, 5 Bacillariophyta, (Table.2). Analysis of chlorophyll-a showed 66.8mg/l during January which was increased up to 158.8 mg/l during April. Range of cellular carbohydrate was 18.4mg/l (September) to 38.0mg/l(April) and GPP was 1.8 mg C/l/h to 2.85 mg C/l/h. *Microcystis* was present abundantly throughout the year having highest density during summer. Temperature plays a major role in determining the diversity, productivity and periodicity of algae (Sedamkar and Angadi, 2003).The bloom of *Microcystis* is an indicator of organic pollution, as observed by Ansari *et al.*(2008). Relation between abiotic factors,total phytoplankton and *Microcystis*: *Microcystis* and, total phytoplankton showed negative correlation with transparency and positive correlation with pH(Pradhan and Shaikh, 2011). But this routine survey showed, extensive development of *Microcystis* blooms, during the months of summer season (March to May).Similar observation was also reported by Kumar *et al.*(2011).For the confirmation of significant level of the correlation of total phytoplankton as well as of *Microcystis* sp. with various physico – chemical characteristics of water of the study sites, t- value was also calculated and depicted in Table – 3.The Cyanobacterial species and dissolved oxygen, bicarbonate and carbonate showed positive correlations as also observed by Muthukumar, *et al*. (2007).The sulphate, nitrate and bicarbonate content was higher in Unkal lake as compared to Bindusagar whereas the situation was reverse in case of phosphate content. This may be the reason for predominance of Chlorophyta in Unkal lake and predominance of *Microcystis* in Bindusagar Tank. It is desired that greater number of extensive

works be undertaken in India to find out other species and varieties of this pollution indicator. Recently Indian government has started taking steps to conserve this sacred tank by approving a project titled 'Conservation of the Heritage Tank Bindusagar of Bhubaneshwar' under 'Urban Renewal Sector' during Feb 2007.

Table 1. Monthly values of Physico-chemical characteristics of water of Bindusagar tank of Bhubaneswar

Parameters	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
Water Temp. (^oC)	25	25	30	30.2	34	32.8	31	30.8	30.2	29.8	28	26.6
Sacchi Transparency	41.9	40.9	45.7	20.8	29.5	38.8	30.6	39.4	48	42	30	29
pH	9	9.2	9.3	9.4	9.3	8.8	8.5	8.4	8.8	8.8	8.8	8.7
Dissolved Oxygen (mg/l)	6.75	6	6.2	8.1	7.05	6.3	6.45	5.78	4.43	4.49	7.13	7.28
Free CO_2 (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0
Carbonate (mg/l)	22.5	28	46.5	58.5	45.5	41.5	31	23	14.5	16	11	15
Bicarbonate (mg/l)	23.8	32.5	58.8	43.3	39.6	32.9	27.9	16.7	8.33	20	29.6	22.5
Chloride (mg/l)	59.3	60.8	61.5	65.3	79.5	63.8	48.8	50.3	59	63.8	72	61.5
Ca-hardness (mg/l)	41.9	38.5	38	35.6	28.7	28.9	32.6	39.6	59.9	63.2	36.5	24.2
Total hardness (mg/l)	64	63.7	70	59.1	48	49.9	51.8	55.2	69	42	76	71.3
Phosphate(mg/l)	1	0.82	1.11	1.4	0.5	0.47	1.93	1.28	0.41	0.69	1.11	0.93
Nitrate-Nitrogen(mg/l)	0.95	0.97	0.99	1.2	1.1	1.3	1.6	.1.4	0.93	1.1	0.96	1.1
Nitrite-Nitrogen(mg/l)	0.022	0.015	0.013	0.024	0.033	0.029	0.031	0.04	0.022	0.031	0.041	0.034
Ammoniacal-Nitrogen (mg/l)	1.37	1.14	1.23	1.46	2.8	2.3	1.4	0.88	0.73	0.81	0.93	1.12
Total organic Nitrogen (mg/l)	4.7	5.9	6.15	3.58	2.8	2.41	3.09	2.88	2.72	3.35	4.05	5.9
Magnesium (mg/l)	5.37	6.12	7.78	5.71	4.69	5.08	4.68	3.78	2.22	0	9.59	11.5
Sulphate (mg/l)	1.14	0.94	0.67	0.6	0.47	0.53	5.89	4.65	3.25	0.71	0.59	0.65

Table 2. Monthly variation of Phytoplanton quality of Bindusagar Tank

PHYTOPLANKTON	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
CYANOBACTERIA												
Microcystis aeruginosa	OA	OA	DS	DS	DS	OA	OA	OA	OA	OA	OA	OA
Microcystis aeruginosa-flos-aquae	OA	OC	--	--	--	OC	OC	OC	OC	OC	OA	OA
Microcystis wessenberghii	OA	OC	OC	OC	OC	OC	OC	OC	OC	OA	OA	OA
Microcystis viridis	OC	OC	OC	OC	OC	--	--	--	--	--	OC	OC
Dactylococcopsis	--	OC	--	--	--	--	--	--	--	--		OC
Merismopedia	OC	OC	OC	OC	OC	OC	OC	OC	--	OC	OC	OC

PHYTOPLANKTON	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
punctata												
Lyngbya contorta	--	--	--	--	--	--	--	OC	--	OC	OC	OC
Occilatoria boryana	--	--	--	--	--	--	--	--	--	OC	OC	OC
Aphanizomenon flos-aquae	--	--	--	OC	--	--	--	--	--	--	--	OC
Anabaena flos-aquae	OC	OC	OC	OC	OC	OC	OC	--	--	OC	OC	OC
Anabaenopsis circularis	OC	OC	OC	OC	--	--	--	--	--	--	--	--
CHLOROPHYTA												
Pandurina sp	--	--	--	--	--	--	--	OC	--	--	--	--
Shoederia setigera	--	--	--	--	--	--	--		--	--	OC	OC
Coelastrum sphaericum	--	--	--	--	--	--	--	--	--	--	OC	OC
Pediastrum boryanum	--	--	--	--	--	--	--	--	--	--	--	OC
Chlorella conductrix	OC	--	--	--	--	--	--	--	OC	--	--	--
Chlorella parasitica	--	--	OC	--	--	--	--	--	--	--	--	--
Chlorella vulgaris	--	--	--	--	--	--	--	OC	OC	--	--	--
Ankistrodesmus convolutus	OC	OC	OC	--	--	--	OC	OC	--	--	--	--
Chlosterdium bengalicum	--	--	--	--	--	--	--	OC	--	--	--	OC
Chlosterdium obesum	--	--	--	--	--	--	--	--	--	--	OC	OC
Tetraedron minimum	--	--	--	OC	--	--	OC	OC	OC	OC	OC	OC
Tetraedron pentadricum	OC	--	--	--	--	--	--	--	--	--	--	--
Tetraedron regularae	--	OC	--	--	--	--	--	--	--	--	--	--
Tetraedron trilobulatum	--	--	--	--	--	--	--	OC	--	--	--	--
Selenastrum gracile	--	OC	OC	--	--	--	--	--	--	--	OC	--
Scenedesmus acuminatus	OC	OC	OC	OC	--	--	OC	--	--	--	OC	OC
Scenedesmus bijugatus var. bicellularis	--	--	--	--	OC	--	--	--	--	--	--	--
Scenedesmus bijugatus var.graevenitzii	OC	OC	OC	OC	OC	OC	--	--	--	--	--	--
Scenedesmus longus	--	--	--	--	--	--	--	--	--	--	OC	OC
Scenedesmus prismaticus	--	--	--	--	--	--	--	OC	--	--	--	--
Scenedesmus quadricauda var.longispina	--	OC	OC	OC	OC	OC	OC	--	--	--	OC	--

PHYTOPLANKTON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Scenedesmus quadricauda var.quadrispina	--	--	OC	OC	--	--	--	OC	OC	OC	OC	OC
Crucigenia apiculata	--	--	--	OC	OC	--	--	--	--	--	OC	--
Cosmarium sp.	--	--	OC	--	OC	OC	OC	--	--	--	OC	--
BACILLARIOPHYTA												
Mastogloia danseii	--	--	--	OC	--	--	--	OC	--	--	--	--
Pinnularia nobilis	--	--	--	--	--	--	--	OC	--	--	--	OC
Stauroneis phoenicentron	--	--	--	--	--	--	--	--	--	--	--	OC
Cymbella cistata	--	OC	--	--	--	OC	--	--	--	--	--	--
Stephandiscus nigarae	--	OC	--	--	--	--	--	--	--	--	--	--

OC: Occurred, OA: Occurred Abundantly, DS: Dominant Species, AB: Absent

Table 3. Correlation coefficient (r) value and test of significance (t) value of cell number of *Microcystis* sp.and Number of Phytoplankton with Physico-chemical Properties of water of Bindusagar tank of Bhubaneswar

S.No.	Physico-chemical characteristics	Cell number of *Microcystis* sp.		Number of Phytoplankton	
		(r)	(t)	(r)	(t)
1	Water Temperature (°C)	-0.049	-0.155	-0.052	-0.165
2	Sacchi Transparency	-0.163	-0.522	-0.163	-0.522
3	pH	+0.784	+3.999	+0.783	+3.983
4	Dissolved Oxygen	+0.230	+0.748	+0.241	+0.784
5	Free CO_2	0	0	0	0
6	Carbonate	+0.489	+1.776	+0.485	+1.755
7	Bicarbonate	+0.408	+1.412	+0.416	+1.447
8	Chloride	+0.086	+0.971	+0.299	+0.992
9	Ca-hardness	+0.177	+0.567	+0.162	+0.518
10	Totalhardness	+0.145	+0.464	+0.169	+0.542
11	Phosphate	-0.006	-0.02	-0.006	-0.019
12	Nitrate-Nitrogen	-0.380	-1.281	-0.383	-1.312
13	Nitrite-Nitrogen	-0.440	-1.531	-0.425	-1.487
14	Ammoniacal-Nitrogen	-0.080	-0.264	-0.086	-0.274
15	Total organic Nitrogen	+0.127	+0.404	+0.132	+0.421
16	Magnesium	-0.055	-0.175	-0.031	-0.097
17	Sulphate	-1.364	-1.234	-0.369	-1.257

Fig. A. The Heritage Tank Bindusagar Located in the vicinity of Lingaraj Temple of Bhubaneswar.

Fig. B. Thick scum of *Microcystis* bloom along with the left over after religious performances thrown into the tanks by pilgrims.

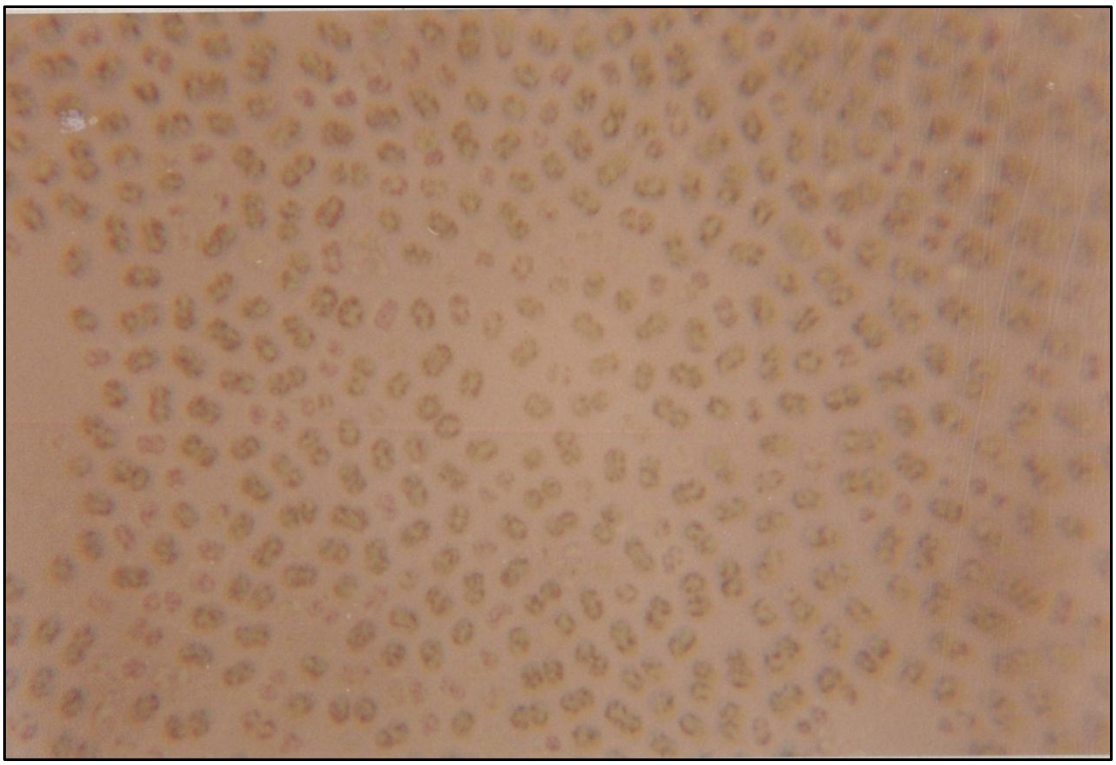

Fig. C. Light microscopic photograph of pure culture of *Microcystis aeruginosa* isolated from Bindusagar tank (x 1860).

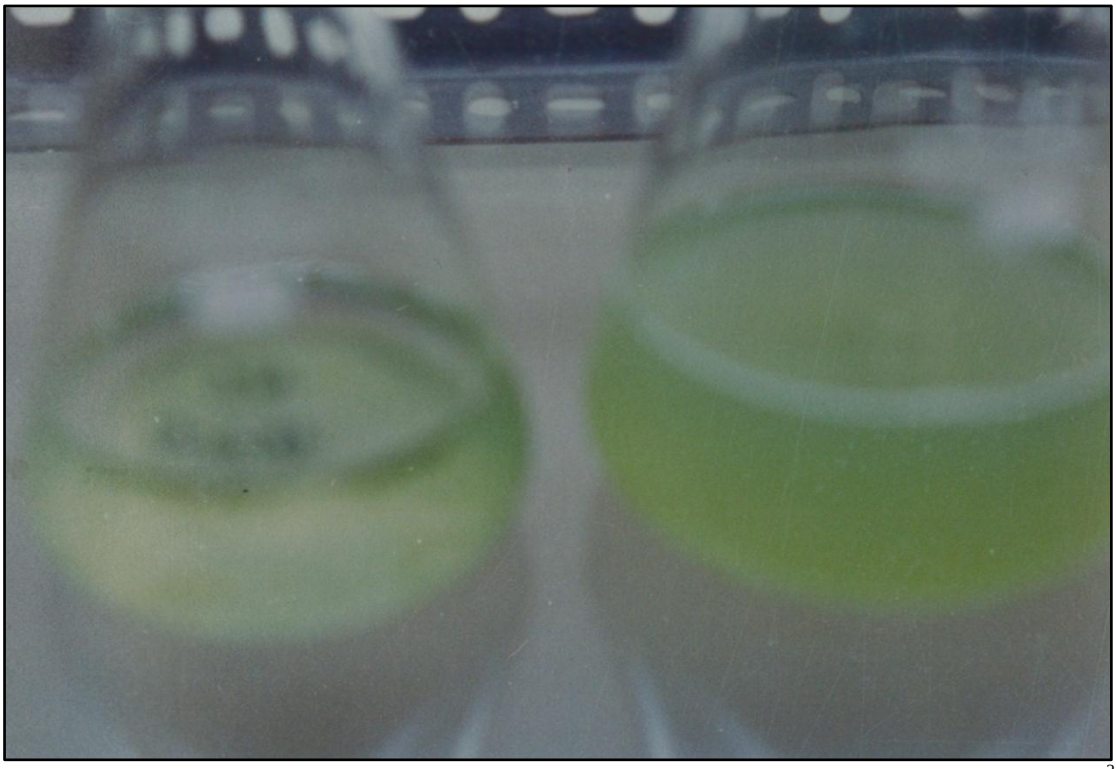

Fig. D. Photograph of (i) 10 days (ii) 12 days old *Microcystis aeruginosa* culture at 26 + 1 (ºC) under7.5 w/m^2.

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