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Seasonal dynamics of cyanobacterial toxin producing algal species of two water ponds

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SUMMARY

The water quality and seasonal dynamics of toxin producing algal species were explored in order to evaluate the possibilities of qualitative and quantitative analysis of varied pollution level of two ponds(Kajrahwa pond and Seth pond) at Kajgaon, Jaunpur. Physico-chemical analysis of two ponds has been made seasonally. Twelve (*Microcystis* sp., *M. protocystis, M. incerta*, *M. aeruginosa*, *M. lotoralis*, *Oscillatoria* sp., *O. limosa*, *O. princes*, *Lyngbya* sp., *L. majuscula*, *Anabaena* sp. and *Nostoc* sp.), cyanobacterial toxin producing algal species were isolated from both ponds. Of these, six species (*Microcystis* sp., *M. protocystis*, *M. aeruginosa*, *M. lotoralis*, *Oscillatoria limosa* and *Anabaena* sp.) were found to be permanent dominant water blooms in all seasons under physico-chemical conditions. Correlation-coefficient was employed to see the relative importance of various physico-chemical variables on the dynamic abundance of toxin producing algal species in both ponds. Both ponds were found to be moderately polluted and showed a trend of increasing eutrophication. Possible correlations existed between algae and nutrient.

Key words : Toxin producing algal species, Seasonal dynamic, Physico-chemical analysis, Algal blooms,Kajrahwa and seth pond

The presence of heavy blooms of toxic cyanobacteria has been experienced worldwide (Sivonen *et al.*, 1990; Carmichael, 1994). Cyanobacteria exhibits remarkable physiological, morphological and biological adaptation and diversification in response to global evolution change, including the development of a modern day toxic biosphere.

The presence of toxin producing cyanobacteria in surface water used as drinking water or for recreational purposes poses a hazard to human being but has long been neglected or at most been treated on a local level. Scums of cyanobacteria accumulating along the shores of ponds and lakes also present a hazard to wild and domestic animals (Frazier *et al.*, 1998). Providing the human population with safe drinking water is one of the most important issues in public health and will gain more importance in the coming millennium.

The community structure and abundance of planktonic algae are dependent on the physico-chemical nature of the water body. Study of planktonic algae is essential as changes in the physico-chemical make up of the water is reflected by them in terms of either change in the type of association or dominance of a particular species.

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In bodies of water the most recognised causative factors for cyanobacterial occurrence are eutrophication, warm water, temperature, high light intensity and stable weather conditions. Surveys of these water blooms have shown that 25 to 95 per cent of them are toxic (Baker, 1994 and Sivonen *et.al.*, 1990; Baker and Humpage, 1994).

The importance of the algal distribution particularly their response to environmental changes and nutrient fluctuation is important to understand the factors influencing rise, fall and change in algal dynamic and to study the effect of anthropogenic pressure upon aquatic habitats (Sharma and Sharma, 1992; Harikrishnan *et al.*, 1999).

Some cyanobacterial species have been proved to be as diagnostic field test on which major water management practices, pollution studies and water analysis can be keyed. The subject of our work was to study the dynamic pattern of cyanobacterial species in the water ponds receiving different levels of polluted water. Since the studies are meagre therefore, in the present study an attempt has been made to examine the distribution of toxin producing algal species and its possible relation to nutrient influx in two ponds of this region.

MATERIALS AND METHODS

The present investigation was carried out in two ponds [Kajrahawa pond(A) and Seth pond(B)] of Kajgaon, Jaunpur. Physico-chemical and biological characteristic of both ponds were studied seasonally, Summer (February - May), Rainy (June - September) and Winter (October - January) of the year, May 2008 to June 2009. Water sample were analysed for different physico-chemical and biological parameters with the help of standard methods (APHA, 1999). The bloom forming algal species were collected from two ponds (A and B) in acid washed plastic bottles and preserved in 5% formalin separately and seasonally. One litre of sample of each pond was further collected in polythene can and in them 5 ml. of Lugol's solution was added for settlement of algal species. For quantitative enumeration of algal species Sedgewick Rafter (S-R) counting chamber was used. 1 ml. of sample of them was transferred to the counting cell and examined under a compound microscope. The total number of different algal species encountered were converted to their number per cubic meter and identification of algal dynamic species were done with the help of standard reference (APHA, 1999). Correlation-coefficient was done between toxin producing algal species and nutrient influx for the reality and significance of the result.

RESULTS AND DISCUSSION

Data on important physico-chemical parameters and distribution of toxin producing algal species in both ponds (A and B) are given in Table 1 and 2, respectively. The correlation coefficient (r) values between physico-chemical characters and toxin producing algal species of pond A and B have been presented in Table 3 and 4, respectively.

Table 1 represents the range of water characteristics of A and B pond throughout the study period. In the present investigation, temperature, pH, transparency, DO, BOD, total hardness, total alkalinity, Calcium, Magnesium, Chloride, Sulphate, Free-CO_2, TDS, Nitrate, Nitrite and Phosphate of A and B pond ranges from 22.90-27.67 and 23.89-26.70, 7.32-7.79 and 7.54-8.03, 12.35-15.83 and 12.35-16.03, 6.61-7.83 and 3.96-5.53, 78.73-108.42 and 91.07-131.68, 123.38-177.61 and 155.25-229.25, 115.83-142.06 and 152.53-179.50, 4.82-5.12 and 3.14-5.16, 6.37-7.98 and 4.52-5.38, 5.63-10.89 and 9.98-15.54, 1.66-2.83 and 1.86-2.80, 12.63-13.23 and 11.87-13.78, 188.86-285.48 and 219.00-333.90, 1.39-2.95 and 1.91-3.29, 1.15-1.72 and 1.37-2.31, 1.04-2.27 and 1.42-2.29, respectively.

Present study revealed that nitrogen (nitrate and nitrite), magnesium, calcium, sulphate existed richly in pond A. The concentration of nitrate, phosphate, sulphate, total alxalinity, chloride, TDS exceeded the permissible limits in pond B and showed high eutrophication.

Twelve toxin producing cyanobacterial algal communities were identified (*Microcystis* sp., *M. protocystis*, *M. incerta*, *M. aeruginosa*, *M. lotoralis*, *Oscillatoria* sp., *O. limosa*, *O. princes*, *Lyngbya* sp., *L. majuscula*, *Anabaena* sp. and *Nostoc* sp.) in pond A and B (Table 2).

Amongst 12 toxin producing algal species, six species

Table 1 : Physico-chemical characteristic of two ponds, Kajrahawa pond (A) and Seth pond (B)

Parameters	Summer Season		Rainy Season		Winter Season	
	A	B	A	B	A	B
1. Temp.	27.67±1.76	26.70±1.56	25.90±2.11	26.70±1.80	22.90±1.08	23.89±0.66
2. pH	7.79±0.37	8.03±0.50	7.32±0.57	7.54±0.48	7.60±0.27	7.70±0.34
3. Transparency	15.83±0.88	16.03±0.98	13.60±1.60	12.99±1.40	12.35±0.96	14.44±0.76
4. DO	6.61±1.08	3.96±0.95	7.67±1.47	5.53±1.07	7.83±1.08	4.72±0.38
5. BOD	108.42±6.68	131.68±3.92	92.57±6.44	107.29±4.00	78.73±5.94	91.072±2.54
6. Total hardness	161.10±3.87	173.20±5.57	177.61±5.60	229.25±5.42	123.38±2.63	155.25±2.35
7. Total alkalinity	142.06±3.35	179.50±1.65	115.83±3.44	160.52±3.31	117.92±1.70	152.53±1.62
8. Ca	4.82±0.78	5.16±0.30	5.07±0.88	3.14±1.11	5.12±0.14	3.31±0.29
9. Mg	6.37±0.88	4.98±0.85	7.98±0.58	4.52±0.91	4.49±0.43	5.38±0.34
10. Chloride	7.10±0.17	11.45±0.38	10.89±0.41	15.54±0.61	5.63±0.07	9.98±0.25
11. Sulphate	2.83±0.35	2.80±0.52	1.66±0.10	2.49±0.22	2.02±0.28	1.86±0.14
12. Free-CO_2	13.02±1.41	13.78±0.63	12.63±1.57	11.87±0.98	13.23±1.05	12.75±0.47
13. TDS	247.15±9.41	244.50±10.89	285.48±11.98	333.90±9.63	188.86±6.82	219.00±7.51
14. Nitrate	2.95±0.15	3.29±0.29	1.93±0.35	1.91±0.59	1.39±0.09	2.06±0.08
15. Nitrite	1.33±0.21	1.37±0.20	1.15±0.31	1.87±0.46	1.72±0.04	2.31±0.11
16. PO_4	1.04±0.313	1.42±0.40	1.66±0.10	1.88±0.95	2.27±0.10	2.29±0.31

Except temperature, pH and transparency all values are in mg/l (Mean ±SEM of three replicates)

Table 2 : List of toxin producing algal species recorded from pond, Kajrahawa pond (A) and Seth pond (B) (cell/ml.)

Algal species	Summer season		Rainy season		Winter season	
	A	B	A	B	A	B
1. *Microcystis* sp.	7900	8346	4046	4600	4456	6772
2. *M. protocystis*	3829	4306	1220	1204	1008	1280
3. *M. aeuroginosa*	7827	7982	4040	1709	1606	4812
4. *M. lotoralis*	2990	3040	4870	1208	1120	1272
5. *M. incerta*	2746	2840	890	614	572	980
6. *Oscillatoria* sp.	2126	2640	1102	1204	978	1398
7. *O. princeps*	2218	2460	806	890	872	1209
8. *O. limosa*	2438	2638	1780	1760	1460	2084
9. *Lyngbya* sp.	1843	2026	1274	—	756	780
10. *L. majuscula*	1289	1828	—	—	756	714
11. *Nostoc* sp.	780	864	414	878	782	878
12. *Anabaena* sp.	2426	2872	772	877	982	1010

Except temperature, pH and transparency all values are in mg/l (Mean ±SEM of three replicates)

Table 3 : Correlation-coefficient (r) values between physico-chemical parameters and toxin producing algal species of Kajrahawa pond (A)

	Parameters	a	b	c	d	e	f	g	h	i	j	k	l
1.	Temp.	0.96	0.91	0.86	0.62	0.48	0.92	0.42	0.71	0.41	0.41	0.51	0.50
2.	pH	0.84	0.85	0.87	0.78	0.12	0.39	0.22	0.32	0.21	0.31	0.20	0.41
3.	Trans.	0.40	0.92	0.60	0.70	0.81	0.96	0.31	0.51	0.41	0.41	0.91	0.41
4.	DO	0.98	-1.34	0.81	0.91	0.81	-1.00	0.71	0.71	0.60	0.12	0.79	0.79
5.	BOD	0.84	0.91	0.75	0.65	0.78	0.68	-1.01	-1.91	-1.12	0.32	0.81	-1.98
6.	Total hardness	0.69	0.59	0.89	0.12	0.59	0.68	0.41	0.62	0.50	0.39	0.89	0.41
7.	Total alkalinity	-1.05	-1.06	-1.91	0.57	0.12	-1.01	0.12	0.21	0.21	0.40	-1.08	0.48
8.	Ca	0.84	0.01	0.34	0.09	0.84	0.44	0.21	0.41	0.28	0.40	0.41	0.49
9.	Mg	0.97	0.82	0.61	0.68	0.79	0.71	0.31	0.51	0.41	0.38	0.71	0.38
10.	Cl	0.82	0.71	0.98	0.92	0.61	0.83	0.14	0.34	0.41	0.28	0.85	0.39
11.	SO_4	1.78	-1.31	-1.87	-1.78	0.78	-1.78	0.21	0.31	0.31	0.29	-1.98	0.36
12.	CO_2	0.48	0.69	0.64	0.84	0.68	0.76	0.29	0.68	0.31	0.28	0.64	0.31
13.	TDS	0.64	0.65	0.84	0.84	0.81	0.94	0.31	0.61	0.30	0.31	0.91	0.41
14.	Nitrate	0.91	0.97	-1.92	-1.02	-1.92	0.31	-1.41	0.62	0.43	0.47	-1.82	0.40
15.	Nitrite	-1.44	0.71	0.93	-1.09	0.31	0.31	-1.80	0.70	0.60	0.51	0.81	0.61
16.	PO_4	0.81	0.90	0.78	0.31	0.81	0.81	-1.31	0.22	0.41	0.51	-1.08	0.61

a - *Microcystis* sp., b - *M. protocystis*, c - *M. incerta*, d - *M. aeruginosa*, e - *M. lotoralis*, f - *Oscillatoria* sp., g - *O. limosa*, h - *O. princes*, i - *Lyngbya* sp., j - *L. majuscula*, k - *Anabaena* sp. and l - *Nostoc* sp.

(*Microcystis* sp., *M. protocystis*, *M. aeruginosa*, *M. lotoralis*, *Oscillatoria limosa* and *Anabaena* sp.) were found to be dominant species and its numerical abundance (cell/ml) was relatively high throughout the study period in A pond than B pond. These toxin producing algal species formed a permanent green bloom over all seasons in B pond while A pond exhibits in summer season only. This trend was comparable with the other ponds (Shukla *et al.*, 1989). Due to abundance of chlorophyceae algal species, A pond exhibits green blooms in rainy season only. In B pond, the dominance of cyanophyceae (blue green algae) ended abruptly in rainy season. Thereafter in winter season, Bacillariophyceae and later (summer season) green algae registered dominance. This is comparable with the results of Suvarana and Somasekhar (2000) in other pond. It is well known that higher organic matter and low DO influence the periodicity of cyanophyceae and promote their blooms. This was true at B pond, not in A pond. The numerically richness of species in B pond is due to inflow of sewage rich in organic matter and also nearby water outlet system pollutants discharged from a nearby waste water outlet system. It is of the similar situation in a eutrophic lake of Hidenvesi, Southern Finland and Kuttand wetland, Kerala

Table 4 : Correlation-coefficient (r) values between physico-chemical parameters and toxin producing algal species of Seth pond (B)

	Parameters	a	b	c	d	e	f	g	h	i	j	k	l
1.	Temp.	0.90	0.83	0.91	0.99	0.81	0.86	0.61	0.83	0.10	0.31	0.62	0.61
2.	pH	0.01	0.94	0.91	0.08	0.42	0.90	0.41	0.61	0.08	0.41	0.41	0.48
3.	Trans.	0.93	0.94	0.93	0.83	0.12	0.99	0.39	0.49	0.10	0.31	0.43	0.41
4.	DO	0.52	0.86	0.82	0.71	0.99	0.72	0.61	0.81	0.20	0.32	0.77	0.41
5.	BOD	0.99	0.92	0.99	0.64	0.98	0.96	0.28	0.47	0.29	0.31	0.38	0.39
6.	Total hardness	0.63	0.73	0.73	0.92	0.73	0.96	0.81	0.92	0.41	0.20	0.81	0.61
7.	Total alkalinity	0.97	0.65	-1.24	0.56	0.41	0.99	0.42	0.52	0.11	0.60	0.61	0.78
8.	Ca	0.83	-1.16	0.93	0.54	0.12	0.78	0.64	0.78	0.09	0.18	0.71	0.41
9.	Mg	0.57	0.61	0.97	0.98	0.37	0.91	0.41	0.51	0.10	0.29	0.57	0.41
10.	Cl	0.62	0.72	0.78	0.78	0.98	0.92	0.41	0.61	0.25	0.31	0.53	0.39
11.	SO_4	0.74	0.99	0.98	0.72	0.98	0.71	0.61	0.12	0.23	0.31	0.61	0.72
12.	CO_2	0.56	0.88	0.56	0.99	0.56	0.96	0.89	0.98	0.36	0.41	0.91	0.98
13.	TDS	0.63	0.49	0.63	0.55	0.92	0.21	0.91	0.91	0.41	0.57	0.71	0.61
14.	Nitrate	0.82	0.99	0.83	0.23	0.97	0.96	0.50	-1.70	0.10	0.60	-1.60	0.29
15.	Nitrite	-1.19	0.89	-1.09	0.74	0.49	0.86	0.60	-1.12	0.09	0.21	0.60	0.60
16.	PO_4	0.99	0.91	0.99	0.96	0.81	0.91	0.21	-1.10	0.99	0.31	-1.31	0.87

a - *Microcystis* sp., b - *M. protocystis*, c - *M. incerta*, d - *M. aeruginosa*, e - *M. lotoralis*, f - *Oscillatoria* sp., g - *O. limosa*, h - *O. princeps*, i - *Lyngbya* sp., j - *L. majuscula*, k - *Anabaena* sp. and l - *Nostoc* sp.

(Tallberg *et al.*, 1999 and Harikrishnan *et al.*, 1999).

The occurrence of *Anabaena* and *Lyngbya* sp. were appeared during mid-December to mid-May and reached maximum blooming in June in both ponds, then subsequently it decreased and minimum value observed in rainy seasons in B pond, while in A pond, minimum value was observed in winter season. This similar pattern was observed in other water bodies (Samantaray and Padhi, 1999).

Two species of moderately bloom forming toxin producing algal species (*Nostoc* and *Lyngbya majuscula*) observed in both ponds all over season while *L. majuscula* were found to be only in rainy season in A pond.

The correlation-coefficient (r) between physico-chemical parameters (temperature, pH, transparency, DO, total hardness, TDS, calcium, magnesium, etc.) and ten toxin producing algal species showed positive correlation in both ponds. *Microcystis* sp. and *Oscillatoria* sp. failed to show positive correlation with dissolved oxygen.

BOD existed positive with all toxin producing algal species in both ponds while *Oscillatoria* sp., *O.limosa*, *Lyngbya* sp. and *Nostoc* sp. showed negative correlation in A pond.

The important nutrients which affect the growth of nine toxin producing algal species is nitrite and showed positive correlation with *Microcystis* sp., *M. protocystis*, *M. incerta*, *M. lotoralis*, *Oscillatoria* sp., *O. princes*, *Lyngbya* sp., *L. majuscule*, *Anabaena* sp. and *Nostoc* sp. in A pond. Others, except *Microcystis incerta* and *Oscillatoria limosa* toxin producing algal species showed positive correlation in pond B with nitrite.

Correlation-coefficient between phosphorus and 10 toxin producing algal species showed to be highly positive in A and B pond while *Oscillatoria princeps*, *Anabaena* sp. and *Oscillatoria limosa* and *Anabaena* sp. showed negative correlation in pond A and B, respectively. These trend showed phosphorus in different forms causing explosive growth of toxin producing algal species leading to eutrophication. Similar observations were made by Parimalan *et al.* (1994).

Twelve toxin producing algal species behaved differently towards changes in the proportion of chemical components and seems to be adapted to a wide range of environmental conditions. As discussed earlier, moderate amount of higher DO, low organic matter, nitrate and phosphate are required by species found in A pond while those in B pond are adapted to eutrophic amount of these parameters, exhibited higher nitrate, phosphate and organic matter requirement and survived at low dissolved oxygen.

The study indicates that the high nutrient and pollution loaded ponds lead to development of toxin producing algal species in both ponds. This may have severe ecological consequences in long run if proper regulatory measure are not taken. More effective technology for waste minimization and waste water treatment are needed. The result showed that A pond is moderately polluted and showed a trend of increasing eutrophication through various anthropogenic activities in the surrounding area.

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