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INFLUENCE OF THERMAL POWER PLANT ON DIVERSITY OF CYANOBACTERIA IN RAJASTHAN, INDIA

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Abstract

Cyanobacteria are also known as blue green algae which are the most primitive prokaryotic oxygen evolving algae. They also known as "blue-green algae" because of the dominance of phycocyanin pigment which imparts bluish colour to them. They evolved almost 3.5 billion years ago and existing on the planet earth even today with diverse habitats and a wide range of organization. During the production of energy thermal power plants utilize water from nearby source for cooling of condensers that gets heated in this process and is discharged back to the source. Phytoplanktons are exposed to this elevated water temperature from thermal discharge. As algae hold the first position in any aquatic food chain so any change in water or environmental conditions can be detected by their response towards any change. Hence, they can be used as bioindicators for bioassessment of aquatic ecosystem to assess the changes in environment. The study was conducted for winter season from November 2017 to February 2018 to study the cyanobacterial diversity under the influence of a thermal power plant.

Key words : cyanobacteria, diversity, bioindicator, thermal power plant.

Introduction

Cyanobacteria are the most primitive algae also known as blue green algae which have a close affinity with bacteria. They evolved almost 3.5 billion years ago. The evidence of which can be traced back through study of microfossils and carbon isotopic data that depicts their dominance during Precambrian period. They exist well in a variety of habitats from acidic to alkaline, water to soil, freshwater to marine, desert to snow all over the world (Smith, 1994). Some Cyanobacteria are even able to grow at temperature up to 73ºC-74ºC (Langford, 2001; Lee, 2008). Because of short life span the phytoplanktons react rapidly to changes in temperature. Not only cyanobacteria have various uses in diverse areas, they play an important role in global carbon cycles vide oxygenic photosynthesis (Lee, 2008; Whitton and Potts, 2002).

Rajasthan is the desert land and the largest state of India that receives maximum sunlight throughout the year. The state harnesses its large proportion of energy through solar plants and thermal power plants.

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Thermal power plants are generally situated on the bank of a lake, pond, canal river, bay, sea or ocean so as to utilize water from nearby source for cooling of condensers during the production of energy. During the production of energy, the water used for cooling gets heated and is discharged back to the source of water. Phytoplanktons are exposed to this elevated water temperature from thermal discharge (Cairns, 1971; Hill, 1972). Elevated water temperatures and thermal effluents impose a variety of detrimental effects on the aquatic ecosystem. It can alter the various physical and chemical parameters of water, can be lethal to fishes, cause shift in phytoplankton community, can reduce the amount of oxygen dissolved in water, cause algal bloom formation and may lead to loss the loss of biodiversity (Poornima *et al.,* 2005; Kaushal *et al.,* 2010 and Sahu *et al.,* 2012).

The diversity of algae in Chambal river has been studied by few workers like Bhatnagar and Bhardwaj (2013 a&b) while the water quality has been assessed by many workers (Saksena *et al*., 2008; Gupta *et al*., 2011; Jain, 2012; Chouhan, 2018; Gaur *et al*., 2014). The present study was performed with the aim to determine the physio-chemical properties of river water and to study the diversity of aquatic cyanobacteria under the influence of a thermal power plant in Rajasthan.

Materials and Methods

Study area

The study is conducted in the vicinity of a thermal power of plant in Kota city. The city is situated in the south of Rajasthan. It is located at 25°10'57.1" N latitude and 75°50'20.7" E longitude in south eastern part of Rajasthan (Geographic coordinates of India). Kota experiences extremes of temperature during summer and winter seasons. The thermal power plant is located on the left bank of Chambal river. The total installed capacity of Kota Thermal Power Plant is 1240 MW and was first commissioned in 1983. The plant is spread in an area of 204 hectares. The thermal power plant uses water from nearby Chambal river for the cooling purpose. The heated water is discharged back into the river (http://www.rvunl.com). Chambal river is the longest freshwater river of Rajasthan state that flows throughout the year. It originates from Janapao Hills of Vindhya range in south of Mhow town of Madhya Pradesh and is a tributary of Yamuna river (World Water Database).

Fig. 1: Picturesque view of Chambal river.

Research Design

The design for the research conducted is experimental.

Sampling method

Sampling was done by simple random probability sampling method.

Data

The data used is primary which was collected fresh during the study period by performing experiments and taking observations.

Sampling site

Three sampling sites were selected for the present investigation. Station 1 (S1) was selected near Akelgarh where the river enters the Kota city. Station 2 (S2) was selected in the vicinity of the thermal power plant situated near Kota Barrage. The Kota Barrage divides the flow of river as upstream and downstream. Station 3 (S3) was selected in the downstream behind Choti Samadh temple. Distance between Station 1 & 2 is about 7 km and it is 6 km approximately between Station 2 & 3.

Experimental work

The water sample was collected from the selected sites in one litre capacity plastic bottles to determine the physico-chemical characteristics of water. pH and temperature were determined on the collection site only immediately after the collection of sample. For the analysis of parameters like alkalinity, total hardness, chlorides, total dissolved solids etc., the samples were brought to the laboratory and tested. The prescribed standard methods were used for the determination of physico-chemical parameters of water (APHA, 1999; Aery, 2010).

The surface water samples were collected for the study of cyanobacterial diversity from same sampling stations during the winter season from November 2017 to February 2018 in the morning time. Within 48 hrs the collected samples were studied with the preparation of fresh mounts in laboratory. For further detailed examination the samples were also fixed and preserved using Lugol's solution. Observation of planktonic Cyanobacteria was done using Metzer research trinocular microscope (Model METZ-5000 DTM) and microphotographs were taken using imported camera MD500 attached to it. Identification of cyanobacteria is done with the help of available relevant literature, manuals and monograph (Bellinger and Sigee, 2010; Desikachary, 1959; Palmer, 1980; Prescott, 1954).

Results and Discussion

The water quality is determined by its physical and chemical properties.

Physico-chemical properties of water

Temperature is an important abiotic factor for the regulation of aquatic environment. A change in temperature is considered the major environmental factor for the growth of the algae (Palmer, 1980). Mean surface temperature of 25.4 ºC was observed in Chambal river water during the winter season which was contradictory to the observation done by Bhatnagar and Bhardwaj (2013a). The lowest surface water temperature of 20.1ºC was observed at S3 in the month of January which is due to its being the coldest month of winters in Rajasthan. The result was found in similarity with the findings of Chouhan (2018) in their study during winter season. The highest temperature was recorded in the month of November (34.3 ºC) at S2. The surface water temperature was found at higher side at Station S2 which is may be due to the discharge of thermal effluents from the thermal power plant.

Light is necessary for the process of photosynthesis by all groups of algae. The highest light intensity of 1052.3 lux was observed in the month of January at station S2 while the lowest light intensity was measured at S1 in the month of December (707.3 lux).

pH is the hydrogen ion concentration of water (Aery, 2010) and is one of the most important properties of water. The mean value of 7.5 units was obtained during the study period suggesting that the river water is slightly alkaline. Similarly, Bhatnagar and Bhardwaj (2013a) observed alkaline water with nearby pH in Chambal river during their study. The pH range of 7.1 to 8.1 units was observed during the study period that matches the reporting done by Sahu *et al*., (2012). This range is probably due to addition of sewage and the presence of carbonates and bicarbonates of alkali and alkaline earth metals.

Electrical conductivity (EC) is due to dissolved positive and negative ions of acids, bases and salts present in water (Maiti, 2004). In the month of January EC of 478 µS/cm was determined at station S3 which was the highest among all the three stations. A negative correlation (r= -0.61) was observed between temperature and EC but a positive correlation between TDS and EC (r= 0.98).

Total alkalinity is used as an indicator of concentration of carbonate, bicarbonate and hydroxide content of water (APHA,1999). The total alkalinity is mainly caused because of bicarbonates dissolved in water. Mean value of total alkalinity 127.1 mg/L was measured during the study period which is a slightly greater (117.5 mg/L) than that was studied by Bhatnagar and Bhardwaj (2013a). There was a negative correlation observed between temperature and total alkalinity (r= -0.55).

Total Hardness is the capacity of water to form lather which is due to complex of mixture of calcium and magnesium ions present in water. The mean total hardness of 148.2 mg/L was observed in the present study. On the other hand, Bhatnagar and Bhardwaj (2013a) observed the total hardness of 130.0 mg/L in the same season. An increase in the total hardness was observed in past few years.

A significant difference was observed in the chloride content at three stations. It was estimated lower at station S1 and highest at S3 which is may be due addition of sewage and human interference. As high chlorine concentration is a pollution indicator, the water at S3 can be said to be polluted.

Total Dissolved Solids (TDS) is a parameter that is because of carbonates and bicarbonates, chlorides, nitrates, sulphates and phosphates of elements like sodium, magnesium, iron etc. dissolved in water. It denotes the presence of dissolved organic and inorganic waste in water. The average TDS value of 287.8 mg/L was observed during the winter season which was almost similar to what Bhatnagar and Bhardwaj (2013a) reported in their study (240 mg/L).

The amount of oxygen dissolved in a water body, also known dissolved oxygen, is influenced by its chemical, physical and biological processes and is important for the maintenance of aquatic life. It determines the water quality. As the temperature increases the amount of oxygen dissolved in water decreases (Aery, 2010). The DO levels ranged from 3.9-8.5 mg/L in the studied time period which is in contradiction to the observation of Sahu et al. (2012). Bhatnagar and Bhardwaj (2013a) reported the mean value of 6.8 mg/L which are coincident with the findings during the study period. DO values at station S2 were lower than station S1. Eloranta (1983) also observed a low level of DO at site receiving heated water discharge in a study of pond near a thermal power plant in Finland.

Biological Oxygen Demand (BOD) is directly proportional to the amount of oxidizable organic matter present in water and is an important parameter for the determination of water quality. BOD values suggest the potential of self purification for a water body. Mean BOD value of 1.4 mg/L was examined during the study period which is lower than the examination done by Bhatnagar and Bhardwaj (2013a) during their study. BOD showed a negative correlation with DO (r= -0.77).

Chemical Oxygen Demand (COD) is also an important abiotic factor for the measurement of pollution. It is also a measure of oxygen required for chemical oxidation of organic compounds (Aery, 2010). The average COD value of 34.7 mg/L was observed in the present study. Chouhan (2018) observed the COD of 12.5 mg/L at S2 during 2017-2018 in their study which indicates a significant increase in the COD amount of water.

The data obtained for the determination of physico-chemical parameters are shown in table 1.

Table 1: Physico-chemical parameters of river water in winter season from November 2017 to February 2018.

S. No.	Parameter	Nov			Dec		
		S1	S2	S3	S1	S2	S3
1.	Temp (C)	28.0	34.3	25.4	24.0	30.1	21.0
2.	Light intensity (lux)	1007.3	886.3	780.0	707.3	802.3	764.7
3.	pH (units)	7.8	7.5	7.1	8.0	7.7	7.5
4.	EC (µS/cm)	294.7	305.0	406.0	281.3	302.3	394.3
5.	Total Alkalinity (mg/L)	96.7	116.7	153.3	99.7	106.7	156.7
6.	Total Hardness (mg/L)	96.7	106.7	186.7	103.3	110.0	176.7
7.	Chlorides(mg/L)	30.0	36.7	73.3	39.3	40.7	68.3
8.	TDS (mg/L)	238.3	245.7	355.0	233.0	240.0	339.0
9.	DO (mg/L)	7.5	5.7	4.9	8.5	7.6	5.0
10.	BOD (mg/L)	2.4	0.7	2.4	0.5	0.9	2.9
11.	COD(mg/L)	7.7	38.3	61.7	9.3	29.3	55.0

S. No.	Parameter	Jan			Feb			Mean and S.D.
		S1	S2	S3	S1	S2	S3	
1.	Temp (C)	21.8	29.5	20.1	22.7	27.5	21.5	25.49 ± 4.41
2.	Light intensity (lux)	763.3	1052.3	1047.0	980.0	871.3	918.3	881.67 ± 119.88
3.	pH (units)	7.9	7.6	7.3	7.8	8.1	6.8	7.5± 0.38
4.	EC (µS/cm)	324.0	320.3	478.0	329.3	339.3	453.7	352.35± 64.91
5.	Total Alkalinity (mg/L)	116.7	113.3	180.0	130.0	126.7	129.3	127.1± 24.99
6.	Total Hardness (mg/L)	150.0	143.3	196.7	148.3	160.0	200.0	148.2± 37.35
7.	Chlorides(mg/L)	30.7	31.3	66.7	40.0	40.7	80.0	48.14± 18.34
8.	TDS (mg/L)	260.0	256.3	382.0	267.0	272.0	365.3	287.8± 55.57
9.	DO (mg/L)	7.5	7.4	6.0	7.4	7.2	3.9	6.5 ± 1.40
10.	BOD (mg/L)	0.3	0.6	2.1	0.3	0.2	3.6	1.40±1.19
11.	COD(mg/L)	4.0	14.0	41.3	14.0	11.0	34.7	26.69± 19.52

Table 2: Correlation matrix between various physico-chemical parameters of Chambal river water.

Variable	Temp	Light	pH	EC	Total Alkalinity	Total Hardness	Chloride	TDS	DO	BOD	COD
Temp	1										
Light	0.0984	1									
pH	0.2238	-0.1803	1								
EC	-0.6182	0.2193	-0.7725	1							
Total Alkalinity	-0.5575	0.1333	-0.5211	0.8631	1						
Total Hardness	-0.6656	0.1158	-0.6375	0.9220	0.8357	1					
Chlorides	-0.5423	-0.0997	-0.8213	0.8904	0.7465	0.8154	1				
TDS	-0.6245	0.1168	-0.7822	0.9843	0.8847	0.9253	0.9329	1			
DO	0.2391	-0.0202	0.8853	-0.7759	-0.6164	-0.7056	-0.8549	-0.8106	1		
BOD	-0.3888	0.0866	-0.7843	0.6929	0.4393	0.5184	0.7922	0.7290	-0.7791	1	
COD	-0.1179	-0.1644	-0.7347	0.6392	0.7090	0.5348	0.8004	0.7223	-0.8057	0.6268	1

Cyanobacterial Diversity

Total 8 genera of Cyanaobacteria were observed during the study period at all the three sampling sites. Some genera of cyanobacteria like *Merismopedia*, *Synechococcus*, *Chroococcus* were found to be dominant under the influence of thermal power plant. *Planktothrix* and *Synechococcus* are reported for the first time in Chambal river water. Cyanobacteria observed during the study period are listed in table 3.

In the present study, the temperature is the most influencing factor on the diversity of cyanobacteria among all the physico-chemical parameters of river water

Table 3: Distribution of cyanobacteria at three stations in winter season from November 2017 to February 2018.

Cyanobacteria	S1	S2	S3
Aphanocapsa sp.	+	+	-
Chroococcus sp.	-	++	+
Gloeocapa sp.	-	-	+
Merismopedia sp.	+	++	+
Oscillatoria sp.	+	+	+
Planktothrix sp.	+	-	-
Spirulina sp.	+	+	-
Synechococcus sp.	-	++	-
Total No. of genera 8	Occurrence	- Absent, + Present, ++ Dominant	

analyzed. The surface water temperature was found higher at the site close to thermal power plant (S2) than the other two stations distantly located to it. The reason for this higher temperature of water can be attributed to the discharge of heated water from the nearby thermal power plant as thermal effluent. During the present study, 8 genera of cyanobacteria were reported in Chambal river water during winter season with the highest species diversity at station S2 in comparison to

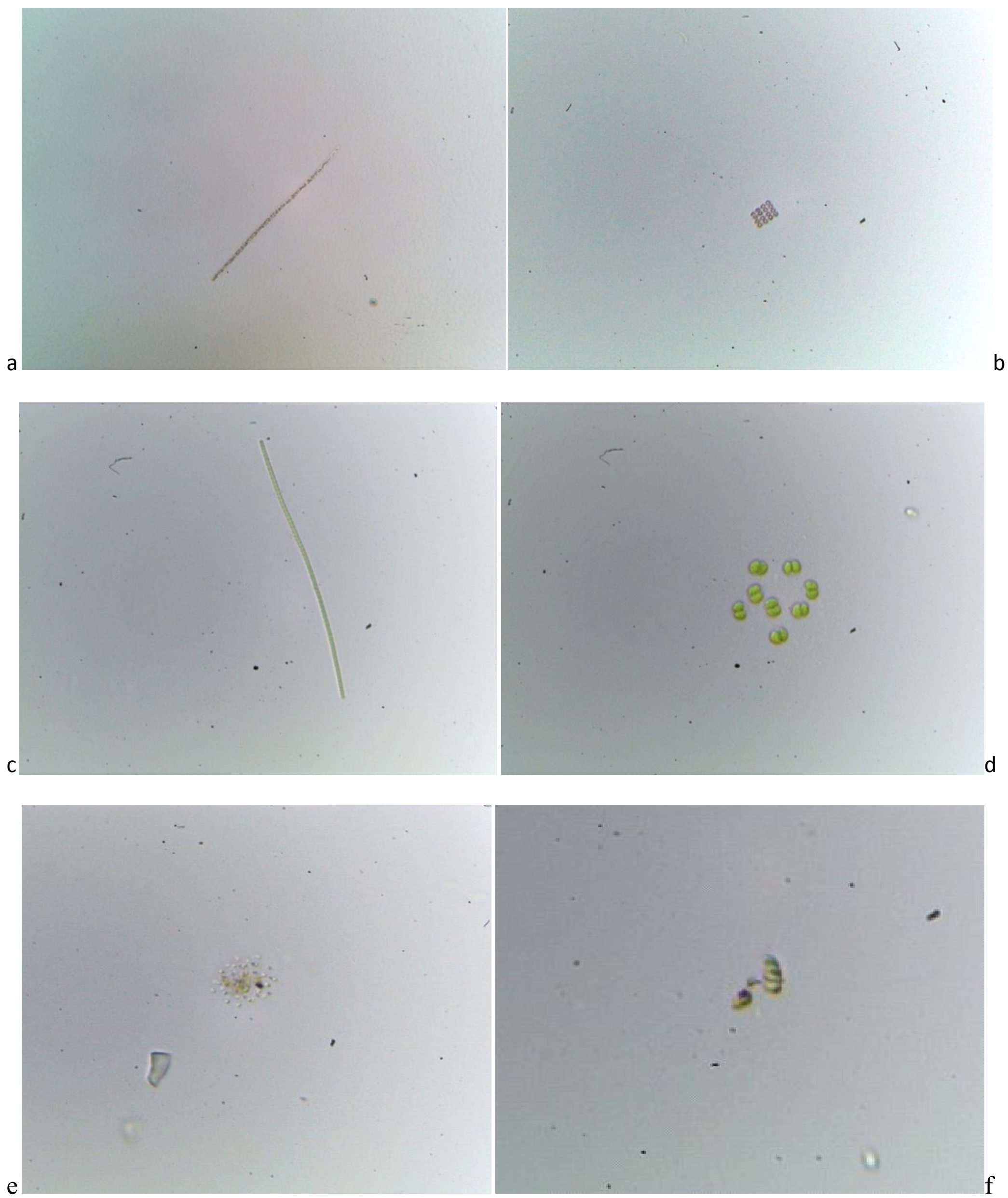

Plate 1: a. *Phormidium* b.*Merismopedia* c. *Oscillatoria* d. *Chroococcus* e. *Aphanocapsa* f. *Spirulina*.

other two stations. Lowest cyanobacterial diversity was observed at station S3 which is may be due to more human interference and input of sewage at this site. Out of 8 reported genera, 6 genera were observed at station S2. Hussein *et al*., (2012) noticed a increase in cyanobacterial diversity at discharge point in a canal near a electricity power station in Iraq. The result in the present investigation is found in accordance with their findings. Hence, it can be concluded that the higher temperature of the heated water from thermal power plant supports the growth of cyanobacteria at station S2 thereby increasing their diversity.

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