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SEASONAL PHYTOPLANKTONIC DIVERSITY OF KALISIL RIVER IN KELADEVI WILDLIFE SANCTUARY, DISTRICT KARAULI, RAJASTHAN, INDIA

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ABSTRACT

Bio-monitoring is necessary to study the ecological quality of various ecosystems since biological communities incorporate the environmental effects of water quality. The water samples were collected for two years and the data on seasonal studies regarding water chemistry and phytoplanktonic variation of Kalisil River situated in and around the Keladevi wildlife sanctuary, district Karauli, Rajasthan (India) were recorded. Although, the results show fluctuations in the various physicochemical properties of water in different seasons, the values of all parameters are higher in summer except the dissolved oxygen. A total of 36 algal genera with 60 species belonging to four classes have been accounted from three sites of the river. A limited number of these were recorded throughout the year, while others were distributed in different seasons mainly in summer and winter seasons. During the summer season, Chlorophyceae (17 species) and Cyanophyceae (15 species) were the most dominant group. On the other hand, Bacillariophyceae (12 species) was most dominant during winter. The pollution of river is evident with the presence of algae like, *Chlorogonium euchlorm, Chlorella vulgaris, Gonium compactum*, *Scendesmus opoliensis, Merismopdia sp., Oscillatoria trichoides, Euglena acus and Navicula minusa* throughout the investigation.

KEY WORDS: **Kalisil River, Keladevi wildlife sanctuary, phytoplanktonic diversity, water pollution.**

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INTRODUCTION

Presently, a special attention is paid worldwide mainly to the investigation of the biodiversity in aquatic ecosystems, as an important characteristic of the natural resources, a major indication of the trend of its evolution[1]. Furthermore, the pollution of the aquatic environment is concerned as one of the most serious problems faced by human[2]. Water pollution occurs from many sources which create turbidity, hardness and alkalinity, bad taste and odour problems of the water, and also affects the growth of aquatic life-forms[3, 4]. Different water bodies exhibited their own peculiarities with regard to physicochemical characteristics and consequently their aquatic life-forms. In each such water body, the quality and abundance of aquatic flora is determined by the nature and composition of water, its temperature, oxygen content, pH and amount of organic and inorganic matter and various pollutants as well[3]. The presence of organic waste causes the anaerobic condition through depletion in dissolved oxygen and its effect on the aquatic flora. While the inorganic pollutants change the pH of water bodies through soluble and insoluble salts. The nutrient (like N and P) enrichment in water bodies by human activities through sewage, agriculture and industrial waste discharges is the main cause of water pollution which is known as eutrophication[3]. These nutrients encourage the growth of unwanted plants and algal blooms which make water unfit for human use[5, 6]. Phytoplanktons are primary producers and an ecologically important group in most water ecosystems. Phytoplanktons are of frequent occurrence in Indian water[7]. These plants serve as indicators of water quality and their distribution in time and space is used for detecting the characteristics of water[8, 9]. Several authors have studied the range and density of phytoplanktons and their association as biological indicators in the assessment of water quality in different water bodies in India[10-21].

Kalisil River is situated in and around the Keladevi wildlife sanctuary in district Karauli, Rajasthan state (India). The river, popularly known as Kalisil Nadi or Kalisil, is a slow flowing and perennial fresh water stream across the village Keladevi. The Kalisil, hereafter referred as Kalisil River, is originated from the Vindhyan hills and is the main source of water for the inhabitants of Keladevi town for drinking, washing, bathing and for irrigation. Since hundreds of years, millions of people are coming every year especially on Keladevi fair in the months of March-April, and also in September-October to visit the Keladevi temple to seek blessing for happiness and prosperity. The number of pilgrims is increasing every year and even thousands are visiting round the year. Most of the pilgrims take holy-bath before going to temple. Since last two decades, the Kalisil River has become polluted due to high pressure of human activities, sewage disposal, throwing of garbage in the river and new constructions for pilgrims in the village round the year. This river once used to increase the glory of the erstwhile Karauli State but now had got an ugly look and turned out into a main source of dumping sewage, drainage and other wastes. For the last few years, the river has also been invaded with the growth of phytoplanktons as well as aquatic angiosperms mainly, *Lemna, Ipomoea, Nymphaea, Typha*, *Trapa*, *Potamogeton* and *Hydrilla*. This situation is posing serious threat to the biological diversity of the river (paper under preparation).

Comprising over 70% of the Earth's surface, water is undoubtedly the most precious natural resource that exists on our planet. Hence, there is a need of investigation and bio-monitoring of the important water bodies. In this regard, the present study reveals, for the first time, the investigation on seasonal variation of phytoplanktons and the relevance of physicochemical characteristics of Kalisil River.

MATERIALS AND METHODS

(i) Investigation area

The Kalisil River is originated from the vindhyan hills and situated in and around the Keladevi wildlife sanctuary (KWS; http://www.rajforest.nic.in/keladevi.htm). The KWS is located 25 km from the city of Karauli in district Karauli towards the east of Rajasthan State (India). The sanctuary, brought under the Ranthambhor Tiger Reserve, is largely protected forest and sanctuary and was notified on 1983. The sanctuary is positioned at 76°37' E to 77°13' E longitudes and 26°2' N to 26°21' N latitudes covering an area of 676.40 sq km with vindhyan and aravali hills having 475 m highest point. The KWS had named after the famous and an ancient Goddess temple (popularly known as Keladevi temple) which is located at its main entrance and on the bank of the Kalisil River. It confined adjacent to Madhya Pradesh border. The sanctuary is famous for to see the wild animals and natural surroundings. There are other water bodies like lakes, ponds, anicuts, streams, rivers and dams also present in and around the KWS.

It is subtropical dry climate with distinct winter season extending from November to February, summer season from March to June and rainy season (monsoon) from July to October with average rainfall 700 mm annually. The summer temperature is maximum 45^{o}C, minimum 24^{o}C, and the winter temperature is maximum 31^{o}C, minimum 9^{o}C. The relative humidity on an average is 30-34% and strong winds in summer. The area of sanctuary is surrounded with subsidiary edaphic type of dry tropical forest having Dhok (*Anogeissues pendula*) and *Khair* (*Acacia catechu*) as dominant flora, and major fauna: Panther, Sambhar, Sloth Bear, Cheetal, Wild Boar, Hyena, Jackal, Chinkara.

(ii) Sampling sites and sample collection

The seasonal collections of water were made for a period of two years (September 2009-August 2011) to record the physicochemical and phytoplankton characteristics of Kalisil River. The water samples (one litre) were collected (between 10-11 am) in clean polythene bottles in every second week of each month from three different sites of the river (Fig. 1). Site 1, 2 and 3 are located within 0.25 to 2 km distance from the Keladevi temple. Site 1 (Kali Mandir Ghat) is situated near and behind the Keladevi temple at one side and mountains on the opposite side. There are houses, shops and other temples also situated on the bank of the river where majority of new constructions and sewage outfall and domestic utilization of water for worship, bathing, washing of clothes and utensils, cleaning of animals, and fishing. Pilgrims also give feed for fishes on this site. Site 2 (Kalisil Ghat) is located where main bus stand and other public utility buildings are situated near the bank of the river at one side and the agricultural land on the opposite side. The major activity on this site includes use of river water for bathing, washing of clothes, cleaning of animals, and fishing. This site is full with additional domestic wastes and lot of use of soap and detergents for bathing and washing (Fig. 2). The site 3 (Kalisil Bridge) is situated below the bridge at Keladevi-Karauli road. At this site, the river is mostly covered with agricultural land on both the sides. On this site, people also use the water for bathing, washing, and cleaning of animals, and cleaning of huge number of vehicles especially during the fair.

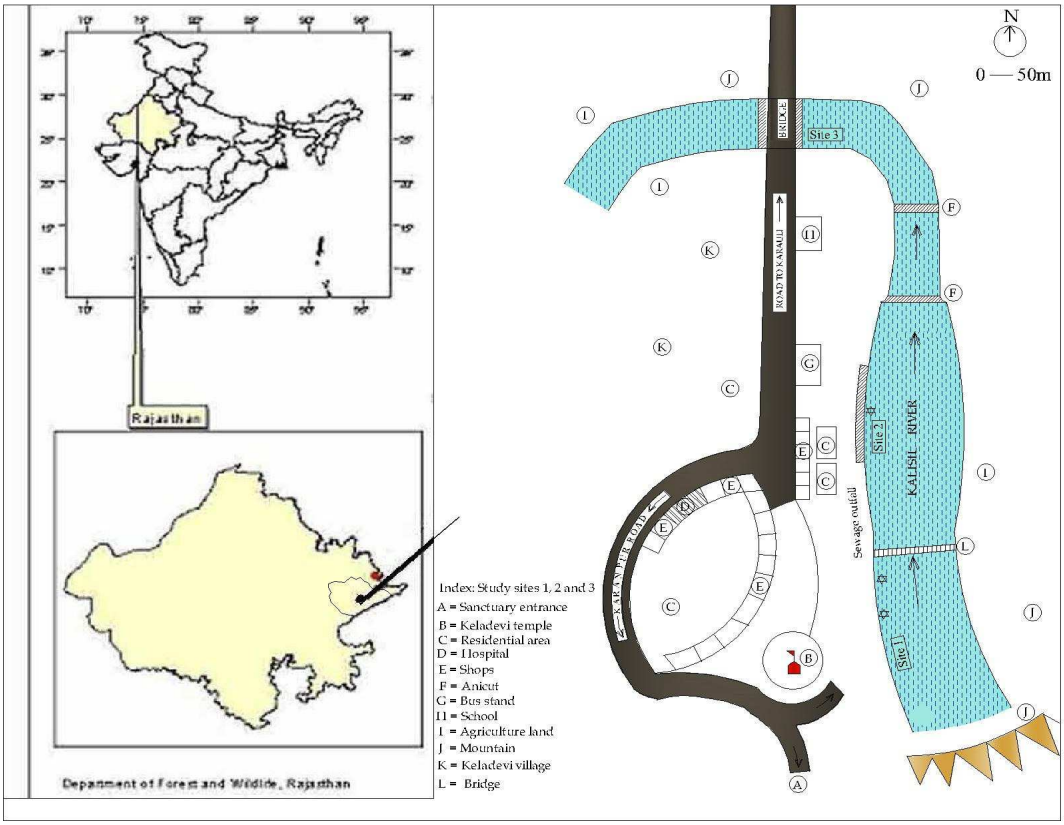

Figure 1
Map of study area showing district Karauli in Rajasthan state and location of Kalisil River and sampling sites. Sewage outfall is indicated.

(iii) Laboratory analysis

The preserved samples were immediately brought to the laboratory for quantitative and qualitative analysis. Water temperature was recorded regularly by digital thermometer at the site. Various physicochemical parameters of the river water were analysed using standard methods[22]. The Phytoplankton samples were concentrated by centrifuging a known volume of the sample and to this a drop of Lugol's solution was added for every 2-3 ml of algal sample for preservation. These were routinely examined microscopically and measurements were taken. Photomicrographs were taken for the majority of species. Counting of the planktons was done by using a Sedgwick-rafter cell method. The characteristics of the algae were studied based on their external appearance, colour, morphological characteristics, size, habit, cellular structure and pigments etc. The identification of algae was done with the help of standard books and monographs[23-29].

Figure 2
Kalisil River, district Karauli (Rajasthan)

RESULTS AND DISCUSION

Two years (September 2009-August 2011) data on the physicochemical characteristics and phytoplankton population in water samples of Kalisil River are presented in Table 1 and 2, respectively. The river water is light green in colour and quite clear in early winter while in late summer the water level decreases and become green in appearance. In rainy season, the water level increases and become brown and quite turbid.

The results of water chemistry show fluctuation in the values of various physicochemical parameters of the river in different seasons throughout the study period (Table 1). However, the values of all parameters are higher in summer except the dissolved oxygen. This might be possibly due to high rate of organic decomposition, rise in temperature, decrease in the water level and huge growth of macrophytes during the summer[7]. The values of phosphate (0.1-0.2 ml/l) were recorded similar in all three seasons. The direct relationship between various physicochemical factors and variation in phytoplankton diversity has been examined by many authors[3, 4, 13, 20, 21, 30]. The algal population of the river consisted of 36 genera with 60 species of which 23 species belong to Chlorophyceae, 20 Cyanophyceae, 04 Euglinophyceae and 13 Bacillariophyceae (Table 2). The highest population of Chlorophyceae, Cyanophyceae and Euglinophyceae was recorded in summer season (March-June) while Bacillariophyceae was isolated in winter season (November-February).

Table 1
Seasonal variation of physicochemical parameters of water* at Kalisil River from September *2009-August 2011

	Ranges		
Parameters	**Summer**	**Rainy**	**Winter**
Temperature (ºC)	24.0 – 33.5	28.5 – 32.0	16.0 – 25.0
pH	7.0 – 8.3	7.0 – 8.0	7.1 – 8.3
Colour	Green	Brown	Light green
COD (mg/l)	17 – 56	6 – 35	19 – 40
BOD (mg/l)	1 – 8	1 – 4	0.3 – 6
DO (mg/l)	2.2 – 6.0	3.6 – 5.7	3.1 – 7.0
Chloride (mg/l)	24 – 48	20 – 24	20 – 26
Calcium (mg/l)	18.0 – 35.5	16.0 – 24.0	27.0 – 33.6
Phosphate (mg/l)	0.1 – 0.2	0.1 – 0.2	0.1 – 0.2
Sodium (mg/l)	12 – 53	9 – 29	6 – 35
Hardness (as $CaCO_3$ mg/l)	112 – 160	64 – 90	86 – 120
TDS (mg/l)	157 – 444	110 – 256	132 – 284
Nitrate (mg/l)	6.0 – 12.0	2.0 – 8.5	5.2 – 6.7
Conductivity (25ºC µ/cm^2)	192 – 638	141 – 349	180 – 254

Summer: March-June, Rainy: July-October, Winter: November-February

In Chlorophyceae, although there is no much difference in population was observed in summer, rainy and winter season, the maximum population was recorded in summer season (Table 2). It may be due higher concentration of nitrate (6-12 mg/l), phosphate (0.1-0.2 mg/l), low dissolved oxygen (2.2-6.0 mg/l), adequate temperature (24-33.5 ºC) and pH (7.1-8.3) value, and slow water current. The phytoplankton species like, *Coelastrum reticulatum, C. microporum, Chlorogoinim euchlorm, Chlorella vulgaris, Chlamydomonas, Cosmerium quadriforium, C. decoratum, Closterium ehrenbergii, Gonium pectoral, Pediastrum tetras, P. constrictum, Scenedesmus opoliensis, S. quadricauda, Spirogyra angolensis* and *Volvox* constituted the maximum population during the summer period. Most of the species were also reported in Laddia Dam in district Sikar (Rajasthan)[20]. However, maximum species of Chlorophyceae have recorded during the winter months (24 species) in Kitham Lake (Agra) but with less population difference in summer season (23 species)[16]. Four species *Chlorogonium euchlorm, Chlorella vulgaris, Gonium compactum* and *Scendesmus opoliensis* are considered as indicator of organic pollution because they were observed during the whole year in polluted water. Similarly, previous studies were also explained the same findings[11, 16, 20].

The maximum number of Cynophyceae was isolated during summer period and least in the winter season. *Aphamizomenon flosaquae, Lyngbya* sps., *Microcystis flosaquae, Merismopedia* sp*., Nostoc muscorum, Oscillatoria sps.*, *Phormedium* sps*., and Spirulina* sps*.* were the most frequent during summer season due to favourable temperature and pH, abundant mineral nutrients and low dissolved oxygen (Table 1 and Table 2) that supports the Cynobacterial growth. Several authors have observed that high turbidity, pH, bicarbonate, orthophosphate, alkalinity, chloride may be responsible for the Cyanophycean growth

and bloom[31, 32]. Kumar and Saini[33] have recorded an inverse relationship between CO_2 and pH. It has also reported that higher diversity of the blue-green algae may be attributed to high nitrate values during the rainy season[34]. In the present study, 12 out of the total 13 species of diatoms (Bacillariophyceae) were recorded during the winter season (Table 2). Results clearly showed the presence of diatoms were more in winters than in summers and rainy season. These diatoms were *Cymbella ventricosa*, *Cyclotella sp., Diatoma vulgaris, Fragilaria pinnata, Gyrosigma attenuatum, Navicula sps., Nitzschia sps., Pinnularia major and Synedra ulna.* During present investigation, *Cymbella ventricosa*, most of the *Navicula sps., Pinnularia major* and *Synedra ulna* reported as dominance species which are good indicators of water pollution. The species of diatoms grow abundantly at high pH, low nitrate, high TDS, low quantity of phosphate, low levels of dissolved solids, low temperature and weak light. On seasonal basis, the winter months were more favourable for development of diatoms clearly evident from the reported literature[16, 20, 32, 35]

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Table 2
Seasonal variation of the phytoplankton in Kalisil River (Karauli) during the year September 2009- August 2011

S. No.	Name of the algal forms	Summer	Rainy	Winter
	Chlorophyceae			
1.	*Coelastrum reticulatum*	+	±	-
2.	*C. microporum*	+	+	-
3.	*Chara* sp.	-	-	+
4.	*Chlorogoinim euchlorm*	+	±	+
5.	*Chlorella vulgaris*	+	+	±
6.	*Chlamydomonas mucicola*	+	+	-
7.	*Cosmerium quadriforium*	+	±	-
8.	*C. decoratum*	+	±	-
9.	*Closterium ehrenbergii*	+	-	-
10.	*Drapernaldiopsis salishensis*	-	-	+
11.	*Gonium compactum*	+	±	+
12.	*G. pectoral*	+	-	-
13.	*Oedogonium pratense*	±	±	-
14.	*Pediastrum tetras*	+	-	+
15.	*P. simplex*	-	-	+
16.	*P. duplex*	-	-	+
17.	*P. constrictum*	+	-	+
18.	*Scenedesmus opoliensis*	+	+	+
19.	*S. quadricauda*	+	-	-
20.	*S. acuminatus*	-	+	-
21.	*S. dimorphus*	-	-	+
22.	*Spirogyra angolensis*	+	-	-
23.	*Volvox* sp.	+	-	-
	Cyanophyceae			
24.	*Aphamizomenon flosaquae*	+	-	-
25.	*Anabaena anomala*	-	-	+
26.	*Gloeotrichia echinulata*	-	+	-
27.	*Lyngbya aestuarii*	+	+	-
28.	*L. lachneri*	+	-	-
29.	*Microcystis flosaquae*	+	±	-
30.	*Merismopedia* sp.	+	±	+

Table 2 contd

31.	*Nostoc muscorum*	+	+	-
32	*Oscillatoria trichoides*	-	+	+
33	*O. principles*	+	+	-
34	*O. curviceps*	+	-	-
35	*O. simplicissima*	+	±	-
36	*O. limosa*	+	+	-
37	*O. vizagapateusi*	+	-	-
38	*O. anguina*	+	±	-
39	*Phormedium calcicola*	+	+	-
40	*P. retzii*	-	-	+
41	*P. bohneri*	-	-	+
42	*Spirulina sibsalsa*	+	-	-
43	*S. meneghiniana*	+	-	+
	Euglenophyceae			
44	*Euglena acus*	+	+	+
45	*E. spirogyra*	+	-	±
46	*Lepocinclis ovum*	+	-	±
47	*Phacus acuminatus*	+	+	-
	Bacillariophyceae			
48	*Cymbella ventricosa*	±	-	+
49	*Cyclotella* sp.	-	-	+
50	*Diatoma vulgaris*	-	-	+
51	*Fragilaria pinnata*	+	-	-
52	*Gyrosigma attenuatum*	-	-	+
53	*Navicula cuspidate*	-	+	+
54	*N. elginesis*	-	-	+
55	*N. minusa*	+	+	+
56	*N. mutica*	-	+	+
57	*Nitzschia palea*	-	-	+
58	*N. amphibia*	-	-	+
59	*Pinnularia major*	+	-	+
60	*Syndrea ulna*	-	±	+

+ present, - absent, ± rare

Similarly as reported earlier, the members of euglenoid were recorded least in number as compared to other phytoplanktons depicted in the present study. Maximum population of euglenoids were found during summer (Table 2) may be due to high water pollution in the summer. On the other hand, more abundant euglenoids in the winter season have reported in Khitam Lake[16]. Some euglenoids like Euglena was found at all the sites studied at Jaipur (Rajasthan) and these could be considered as pollution tolerant species[13]. The variation in the phytoplankton population and physicochemical parameters of different water bodies is clear because India has wide variation in climate factors in different months in different regions.

CONCLUSION

In the present study, it is clear that the summer season is more favourable for the Chlorophyceae, Cyanophyceae and Euglenophyceae. On the other hand, there is abundance of Bacillariophyceae during the winter season. The algal genera like *Chlorogonium euchlorm, Chlorella vulgaris, Gonium compactum*, *Pediastrum tetras, Scendesmus opoliensis, Merismopdia sp., Oscillatoria trichoides, Euglena acus and*

Navicula minusa were recorded throughout the study period. These pollution tolerant algal forms are good indicators of water pollution. In summer season, especially near the site 1 (Kali mandir Ghat) and site 2 (Kalisil Ghat), there were huge growth of aquatic macrophytes like, *Lemna, Ipomoea, Nymphaea, Trapa*, *Potamogeton, Marsilea* and *Hydrilla*. It is bad odour also in the polluted water during summer.

With this report we further conclude that if precautions are not taken, the river will become highly polluted, and as a result, it will turn into a swamp. Further research is also needed to predict quantitatively effect of phytoplankton on the environmental and ecological characteristics in Kalisil River

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