Occurrence of Organic Pollutants Associated with Toxic Algal Bloom in Aquatic Habitats of Central India

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Abstract

Central India is a second largest region of India, the dependable water source are lake, dame and rivers are natural water resource in and around the city which managed as dynamic vibrant life systems also suitability for drinking and irrigation purposes was carried out by local peoples. Assessment of organic pollution by Palmer's Algal Genus Index and physico-chemical and biological characters of different aquatic habitats of central India which effectss aquatic environmental quality, ecological health as well as human health is demanded. Analysis of physico-chemical parameters like pH, electrical conductivity, total dissolved solids, dissolved oxygen, chloride, sulphate, total hardness, calcium, magnesium, sodium and potassium has been carried out. The organic pollution was analyzed and observed that all the sampling points wre dominated by toxic algal bloom in different aquatic habitats, the physico-chemical parameters supported enrichment of aquatic water with nutrients due to direct function of the environment. Direct microscopic examination of the water were used to determine the various types of algal genus which indicate different degrees of pollution as bioindicator and nutrient enrichment in water quality of central India.

keywords: *Physicochemical, Palmers Algal Pollution Index, cyanobacterial diversity*.

I. INTRODUCTION

Globally accepted fact is that the environmental disturbance such as pollution induces changes in structure and function of the biological system and also changes the physico-chemical characteristics of the natural water quality, human beings, animals and crops need good quality water for their survival. The transmission of disease through drinking water is one of the primary concerns for safe water supply, the water quality is mainly influenced by the natural and the anthropogenic processes particularly in the urban areas and agricultural activities around the rural areas [2] , which lead to the contamination of water. The global incidence and severity of algal blooms have expanded during the past decades due to the eutrophication of many freshwater ecosystems and of the climate warming [11] . Under certain environmental conditions cyanobacteria outcompete other phytoplanktonic microorganisms due to their high adaptive capacities for nutrient, light harvesting and their cellular organization in colonies or filaments [3]. The pollution index is based on the relative number of total points scored by each alga, the index has been used by several researchers till date [20] . However, as time progressed many new algal genera or species indicating organic pollution, the algal appearance in polluted waters changes from region to region [7] . As bio indicator the algae are involved in water pollution in a number of important ways due to the enrichment of inorganic phosphorous and nitrogen which is responsible for the growth of algae of water bodies with quick response to pollutants and easy to determine their numbers. The major water resource are lake, dame and rivers of central India, where the conditions have changed towards saprobity and toxicity of the water, and the phytoplankton biomass has increased which has hazardous impact on human and animals. In present study Algal Genus Pollution Index, Physicochemical studies and pollution indicator genera were enumerated with reference to aquatic resources of central India, to alarm for quality assessment of water bodies.

II. MATERIALS AND METHODS

A. Study Area and Sampling Sites:

The total 30 water samples were collected from different aquatic resources of central India, during March-2015 to February-2016, the sample sites are listed in the Table-1, samples were collected (as per different anthropogenic activities and geographical condition separated) between 8.30 am to 5.30 pm in clean glass bottles, labelled properly and brought to the laboratory for analysis [14].

Table-1: Sampling station and different aquatic resource of central India, code, Bhopal- Motia lake (MTL), Munshi Husain lake(MHL), Sarangpani lake (SPL), Char Imli lake (CIL), Lower lake (LWL), Siddki Husain lake (SDL), Sahpura lake(SPRL), Laharpur Dame(LPD), Hathaikheda dam(HKD), Kaliasote dame(KSD),Ayodhya nagar pond(AYP),Neelbad tank(NBT),Ladiya Talab(LDT). Ujjain: Rudra Sagar Lake(RSL), Vikram Sarovar Lake(VSL), Kalidas Academy lake(KAL). Gwalior- Tighara Lake (TGRL), Tikamgarh - Mahindra Sagar Lake(MSL), Shail Sagar lake(SSL), Vrandavan Talab (VDT), Hanuman Sagar Talab(HST), Maharajpura Tal(MPT). Rewa- Beehar river(BHR), Bichhia river (BCR), Gorama Dam(GMD), Jarmohara Dam(JHD), Chachai Dam(CCD) , Govindgarh lake(GVL), Rani Lake(RNL), Tamasa Kund(TKL),L-lake,D-Dame,R-River,P-Pond.

S. No.	Station	Name of Isolate	Aquatic resource	Catchment area (km²)	Location
1.	Bhopal	MTL	L	4.7	23.16°N77.36°E
		MHL	L	3.3	23.18°N77.36°E
		SPL	L	6.3	23.16°N77.38°E
		CIL	L	6.2	23.16°N77.13°E
		LWL	L	5.7	23.16°N77.31°E
		SDL	L	4.3	23.16°N77.32°E
		SRL	L	6.3	23.16°N77.16°E
		LPD	D	8.6	23.16°N77.23°E
		HKD	D	7.2	23.16°N77.33°E
		KSD	D	12.6	23.16°N77.31°E
		AYP	P	8.5	23.16°N77.30°E
		NBT	L	6.3	23.16°N77.31°E
		LDT	L	7.7	23.16°N77.11°E
2.	Ujjain	RSL	L	6.4	23°N57.1°E
		VSL	L	4.3	23°N57.18°E
		KAL	L	4.3	23°N78.11°E
3.	Gwalior	MPT	L	13.2	26.22°N78.1°E
		TGL	L	7.3	26.22°N78.8°E
4.	Tikamgarh	MSL	L	11.2	24.26°N25.34°E
		SSL	L	9.7	24.22°N78.18°E
		VDT	L	9.3	24.26°N78.12°E
		HST	L	6.7	24.22°N78.10°E
5.	Rewa	BHR	R	17.3	24.18°N25.12°E
		BCR	R	19.6	24.12°N25.18°E
		GDM	D	18.6	24.22°N18.18°E
		JHD	D	17.5	24.22°N17.18°E
		CCD	D	21.8	24.22°N78.1°E
		GVL	L	11.3	24.2°N11.18°E
		RNT	L	9.7	24.20°N7.18°E
		TKL	L	8.3	24.2°N8.18°E

B. Culture of cyanobacteria:

The BG-11 liquid media was prepared [16;9]. Culture plates were placed at 26 $\pm 2^0$C under illumination with cool light fluorescence tube (intensity approximately 10-50w/m^2) for 15 day, maintained under photoautotrophic growth conditions with slight modification procedure [13] .

C. Microscopy Examination:

The isolated cyanobacterial culture were placed under light microscopy (Leica Image Analysis System) under 40X magnifications [14].

D. Preliminary Identification of samples:

The each experimental sample observed by help of light microscope (Leica analytical system) using oil emersion under 100X magnifications, the cyanobacterial genus were identified on the base of taxonomically using morphological characteristics, cell shape and surface areas following literatures and monograph [4].

E. Diversity of Algal Genera in Freshwater Environment :

The percentage frequency [19] and diversity of cyanobacterial genera was calculated by Shannon and Simpson index [15;17].

Frequency:

$$\% F = \frac{\text{Total no. of quadart in which species occurred}}{\text{Total no. of quadart station}} \times 100$$

Diversity:

$$^{q}D = \frac{1}{M_{q-1}} = \frac{1}{\sqrt[q-1]{\sum_{i=1}^{R} p_i p_i^{q-1}}} = \left(\sum_{i=1}^{R} p_i^q\right)^{1/(1-q)}$$

Denominator M_{q-1} equals, the weighted generalized mean exponent q-1, R is richness, the proportional abundance of the ith type is p_i.

Shannon index:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i = -\sum_{i=1}^{R} \ln p_i^{p_i}$$

The p_i is often the proportion of individuals belonging to the ith species in the dataset of interest

Simpson Index:

$$l = \frac{\sum_{i=1}^{R} n_i(n_i - 1)}{N(N-1)}$$

Calculated true diversityt $1/\lambda$ equals ^{2}D, i.e. true diversity as calculated with $q = 2$.

F. Physicochemical Analysis:

The total 30 collected samples were analyzed in Quality assurance Laboratory, M.P. Council of Science and Technology, Bhopal (An ISO 9001:2008 Certified Laboratory). The physico-chemical parameters such as : temperature of water was recorded with the help of thermometer (76MM, Immersion, Zeal, England) The pH of water was also measured with the help of pH meter (µpH system 361 India). Free carbon dioxide was estimated, alkanity was determined by titrating the sample with 0.01 N sulphuric acid in the presence of phenolphthalein (for carbonale) and methyl orange (for bicarbonates) as indicators. The average of the alkalinity was done to get the total alkalinity. The chloride content was estimated by Argentrometric method, dissolved oxygen was analyzed using Winkler's Iodometric method and results were expressed in mg^{-L}, turbidity and dissolved oxygen was analyzed using Winkler's Iodometric method and results were expressed in mg^{-L}, light irradiance and rainfall were collected from the Meteorological Centre, Bhopal (M.P.), Indian Meteorological Department, Nagpur, (Maharashtra), Govt. of India, data for precipitation, temperature, snowfall were collected from the Accuweather forecast for Madhya Pradesh, India and data for light irradiance (Direct Normal Irradiance Data) collected from the Natural Renewable Energy Laboratory (NREL) and The National Solar Radiation Database (NSRDB), Solar Energy Centre, Ministry of New and Renewable Energy, New Delhi, Govt. of India, the physicochemical and meteorological data were recorded from March-2015 to Feb.-2016.

G. Organic Pollution Analysis of Sample

In different seasons summer (March-June), rainy(July-Oct.) and winter(Nov.-Feb.) organic pollution status of different aquatic resources were calculated according to the chart of Palmer pollution algal index [12] , which is use as reference.

H. Data Presentation and Statistical Analysis

The significant values were calculated of total 30 samples in different season (March-2015-Feb.2016) using SYSTAT software 13.0.

III. Result and discussion

A. *Preliminary Screening of Cyanobacteria:*

The screening of cyanobacteria from the collected samples of five different sampling station of central India all indicated in Table-1, the 30 samples were collected for morphological examined under the light microscope and identified genus of cyanobacteria as Microcystis, Spirulina, Synechocystis, Synechococcus, Anabaena, Oscillatoria, Chlorococcum, Scenedesmus (Fig-1), out of these identified cyanobacterial Microcystis genus dominated in all sample.

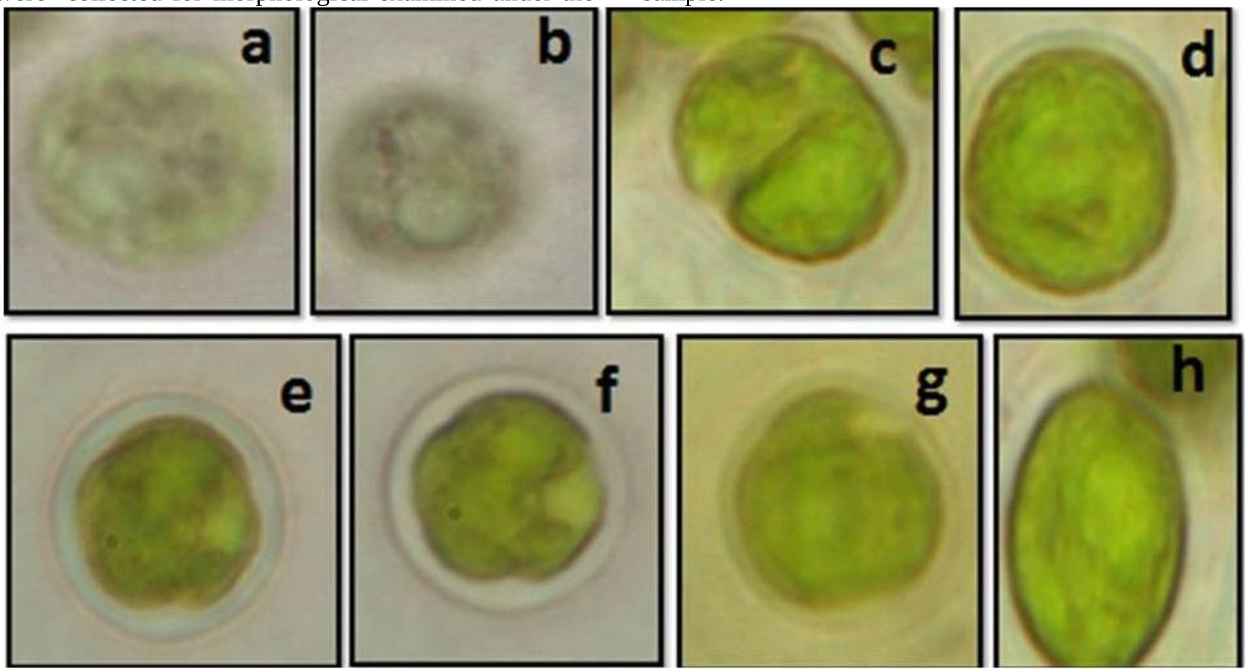

Fig-1: Occurence of Morphotypes from Diferent Genera of Cyanobacteria from Collected Genera Samples of Central India: (a)*Microcystis* (b) *Spirulina* (c) *Synechocystis* (d) *Anabaena* (e) *Synechococcus* (f) *Oscillatoria* (g) *Chlorococcum* (h) *Scenedesmus*, (under 100X magnification).

B. *Diversity of Cyanobacterial Genera in Fresh Water of Central India:*

Fig.-1 revealed how frequently pollution produces potential algal genera in the collected 30 samples. It was exhibited that samples showed 94% of *Microcystis* in all seasion, and *Spurulina, Synechocystis, Anabaena, Synechococcus, Oscillatoria, Chlorococcum, and Scenedesmus* appeared in 49% frequently in summer, 63% in rainy and 70%, in winter, respectively (March-2015 to Feb.2016).Similarly it was also found that the algal genera were observed in high frequency, which may lead to eutrophication, due to change in physical, chemical or biological condition which affect human life and animal’s life [6] .

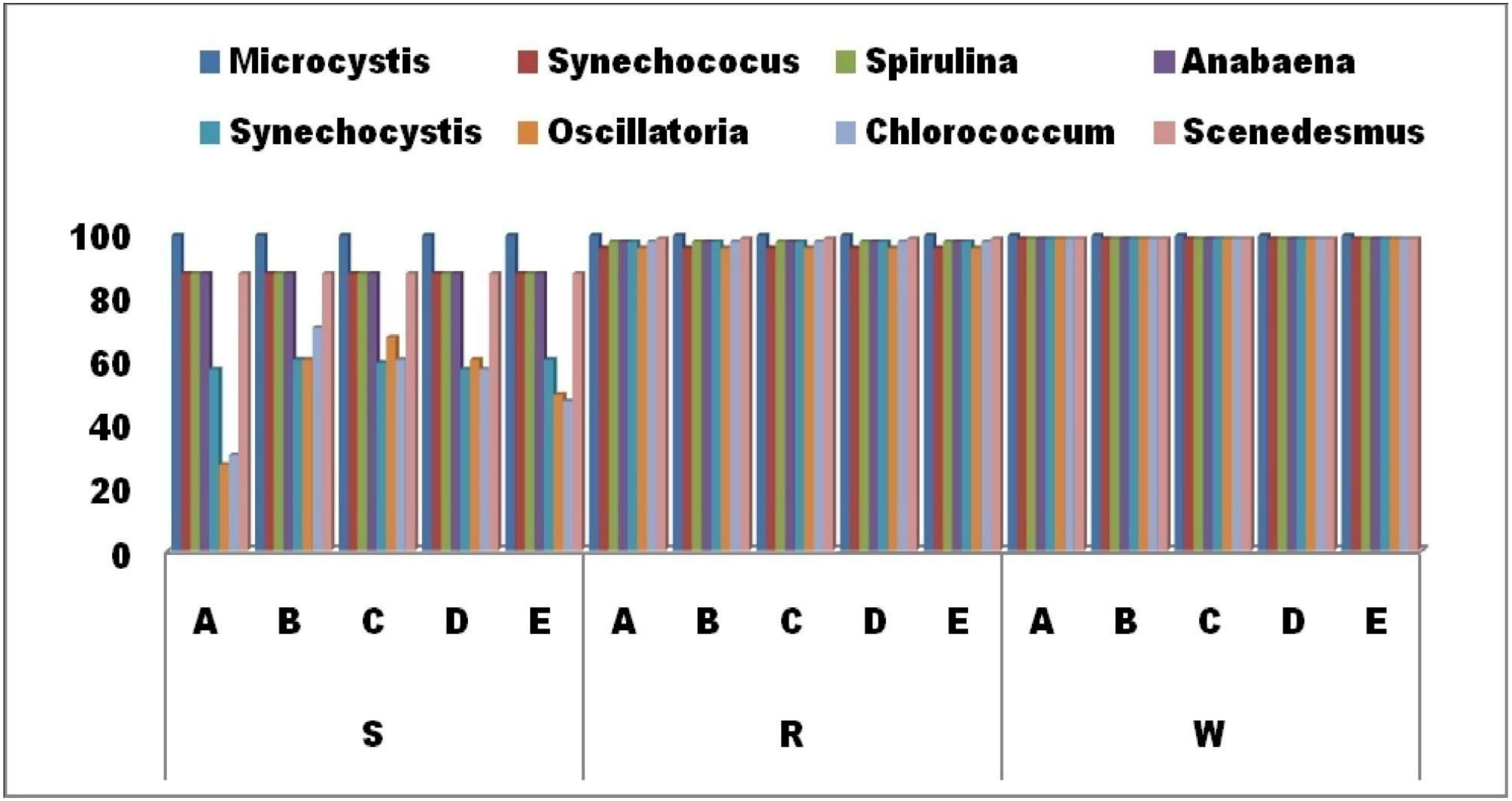

Fig-2: Seasonal Occurrence of Algal Genera in Different Aquatic Resources of Central India,(A-Bhopal,B-Ujjain,C-Tikamgarh,D-Gwalior,E-Rewa,S-Summer,R-Rainy,W-Winter)

Table-2: Average Diversity Indices and Dominance of Cyanobacteria for Different Sampling Station

Diversity indices	Bhopal	Ujjain	Tikamgarh	Gwalior	Rewa
Shannon- Weiner's Diversity Index	1.976	1.230	1.130	1.350	1.976
Simpson's Diversity index	0.52	0.47	0.47	0.47	0.61
Simpson's Dominance	0.48	0.32	0.38	0.37	0.49
Cyanobacterial richness	8	7	7	7	8

In diversity study, richness relates to abundance of different genera of a group of cyanobacteria in an area and stands as a measure of number of different kinds of genera/species in that particular area. The values of Shannon-Weiner's diversity, Simpson's Diversity and Simpson's Dominance indices recorded as a whole from all sites was found to be 1.976, 0.52, 0.48 and 0.32 respectively. The highest diversity was recorded from Bhopal and Rewa where richness was only 8 cyanobacterial genus in all season (March-2015 to Feb.2016) thereby indicating richness be a function of diversity in these regions (Table-2), The data obtained is in accordence to [10] who supported that the identification and diversity calculation of cyanobacterial geneus/species from different regions of India

C. Pollution Status in Freshwater Environment of Central India:

The Palmer index was calculated for Bhopal (13 lakes 3dames), Ujjain (4 lakes), Rewa (3 lakes, 3dames,2 river) ,Gwalior (2 lakes and Tikamgargh (4 lakes) station and it was foundout that out of 8 genus, 4 genus were present with total index value of 19 which has indicated organic pollution in all sampling station (Fig-3 and Table-3).

Table-3: Scoring and Pollution Status Through Palmer's Pollution Index of Sampling Stations.

S. No.	Station	Site	Rainy (July-oct.)		Winter (Nov.-Feb.)		Summer (March-June)	
			Score	Status	Score	Status	Score	Status
1.	Bhopal	MTL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		MHL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		SPL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		CIL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		LWL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		SDL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		SRL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		LPD	**13**	**Light Organic pollution**	**14**	**Light Organic pollution**	**5**	**Light Organic pollution**
		HKD	**13**	**Light Organic pollution**	**14**	**Light Organic pollution**	**5**	**Light Organic pollution**
		KSD	**13**	**Light Organic pollution**	**14**	**Light Organic pollution**	**5**	**Light Organic pollution**
		AYP	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		NBT	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		LDT	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
2.	Ujjain	RSL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		VSL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		KAL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
3.	Gwalior	MPT	16	Organic pollution	16	Organic pollution	5	Light Organic pollution
		TGL	16	Organic pollution	16	Organic pollution	5	Light Organic pollution
4.	Tikamgarh	MSL	18	Organic pollution	18	Organic pollution	8	Light Organic pollution
		SSL	16	Organic pollution	19	Organic pollution	5	Light Organic pollution
		VDT	16	Organic pollution	19	Organic pollution	8	Light Organic pollution
		HST	18	Organic pollution	19	Organic pollution	8	Light Organic pollution
5.	Rewa	BHR	16	Organic pollution	17	Organic pollution	5	Light Organic pollution
		BCR	16	Organic pollution	16	Organic pollution	5	Light Organic pollution
		GDM	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		JHD	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		CCD	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		GVL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		RNT	19	Organic pollution	19	Organic pollution	8	Light Organic pollution
		TKL	19	Organic pollution	19	Organic pollution	8	Light Organic pollution

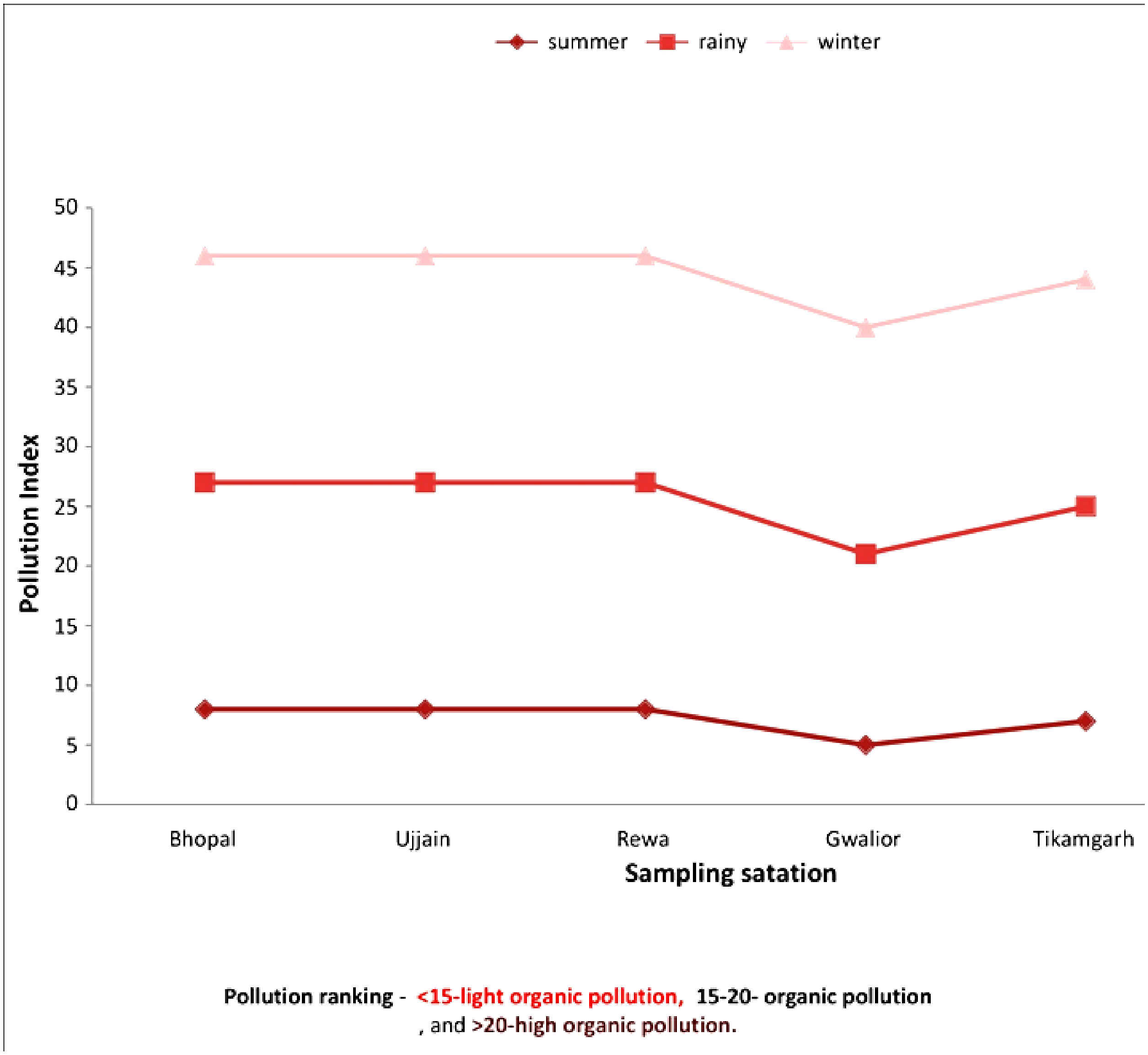

Fig-3: Pollution Index of Different Aquatics Resource of Central India.

The organic pollution status were calculated throughout the year it was found that all sampling stations, in rainy and winter season 19. The least index is observed in all sampling station in summer season 8 which indicated the light organic pollution since they have a score less than 15.While in all sampling stations freshwater from dame organic pollution score in rainy season r 13 and winter season was 14 and in summer 5 indicated the light organic pollution throughout the year, due to increasing severity of water eutrophication and excessive nutrients load in water [5;18] . According to the index, a score of 20 or more for a sample is an indication of organic pollution, while a score of 15 to 19 is taken as probable evidence of high organic pollution [19], it was observed that all the twenty seven freshwater sources are organically polluted, since they have a score above 15. It was also reported in many studies that seasonal variation of organic pollution is due to variation of organic load in water [19;21] .

D. Seasonal Variation in Physicochemical Parameters:

There are several abiotic factors, which directly or indirectly affect the biodiversity of aquatic environments and some relatively important factors are: temperature, light, penetration, pH, alkalinity, Dissolved oxygen and level of nutrients, the significant values listed in Table-4, which showed significantly different (P<0.05) in results in all sampling station. Temperature known to influence pH and DO the water ,which significantly varies physiochemically as well as biologically, the metabolic rate and reproductive activities of aquatic life control by water temperature and varies with season, elevation, geographical location and climatic condition, the seasonal variations for pH, turbidity, TDS[20;1] , alkalinity were significantly different. Nitrate is naturally occurring form of nitrogen, which found in the soil and water, it is most important to monitor nitrate concentration in water because in excessive concentration, it causes algal bloom formation which leads to eutrophication [8] , Nitrate, were significantly different and nutrients and organic input varied due to altered rainfall and light irradiation. The findings showed that the concentration of chloride in water sample of all sampling station varies seasonally which revealed that chloride content is within the permissible limit of WHO,2000. In the statistical assessment of result, it was observed that TDS along with turbidity dominated and were not significantly different in all sampled stations of central India.

Table-4: Analysis of different physicochemical variables in selected sampling station, (Temp. - Temperature, DO - dissolved oxygen, TA-Total Alkality, COD-Chemical oxygen demand, Turb.-Turbidity, TDS-Total Dissolve Solid, Cond. - Conductivity),(n = 30),Significant values ($p < 0.05$) are in bold type.

Station	**pH**			**Cond. (mg^{-L})**			**Nitrate(mg^{-L})**			**TDS (mg^{-L})**			**Turb. (mg^{-L})**			**TA (mg^{-L})**			**Free CO_2 (mg^{-L})**			**DO(mg^{-L})**			**Chloride (mg^{-L})**		
	Sumer	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**	**Sumer**	**Rainy**	**Winter**
Bhopal	**0.053**	0.387	**0.001**	0.776	0.801	**0.101**	**0.090**	**0.006**	**0.011**	0.16	2.2	0.165	0.67	**0.001**	**0.001**	0.156	0.534	0.595	**0.028**	**0.025**	**0.098**	0.502	0.861	**0.016**	**0.088**	**0.094**	**0.092**
Ujjain	**0.053**	0.387	**0.001**	0.776	0.801	**0.101**	**0.090**	**0.006**	**0.011**	0.16	2.2	0.165	0.67	**0.001**	**0.001**	0.156	0.534	0.595	**0.028**	**0.025**	**0.098**	0.502	0.861	**0.016**	**0.088**	**0.094**	**0.092**
Gwalior	**0.053**	0.387	**0.001**	0.776	0.801	**0.101**	**0.090**	**0.006**	**0.011**	0.16	2.2	0.165	0.67	**0.001**	**0.001**	0.156	0.534	0.595	**0.028**	**0.025**	**0.098**	0.502	0.861	**0.016**	**0.088**	**0.094**	**0.092**
Tikamgarh	**0.053**	0.387	**0.001**	0.776	0.801	**0.101**	**0.090**	**0.006**	**0.011**	0.16	2.2	0.165	0.67	**0.001**	**0.001**	0.156	0.534	0.595	**0.028**	**0.025**	**0.098**	0.502	0.861	**0.016**	**0.088**	**0.094**	**0.092**
Rewa	**0.053**	0.387	**0.001**	0.776	0.801	**0.101**	**0.090**	**0.006**	**0.011**	0.16	2.2	0.165	0.67	**0.001**	**0.001**	0.156	0.534	0.595	**0.028**	**0.025**	**0.098**	0.502	0.861	**0.016**	**0.088**	**0.094**	**0.092**

III. CONCLUSION

Present study provides information regarding the pollution status of different aquatics habitats of central India, the cyanobacteria are best bioindicators of pollution which employed for monitoring of water quality and assessment pollution status, the obtained data indicated that of 8 genus of organically pollutant cyanobacteria found in selected sampling station , in rainy and winter season. The degree of organic pollution seasonally varies to a greater extent due to organic load in aquatic water and geographical distribution of sampling stations. The different isolated cyanobacteria can be employed as bioindicator of organic pollutants status of aquatic system.

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