British Biotechnology Journal
1(3): 61-67, 2011

SCIENCEDOMAIN *international*
www.sciencedomain.org

Studies on Cyanobacterial Biodiversity in Paper Mill and Pharmaceutical Industrial Effluents

Sanjay Kumar Dubey[1*], J. Dubey[1], A. J. Viswas[1] and P. Tiwari[1]

[1]Laboratory of Phycology, Department of Botany, Dr. H. S. Gour University, Sagar, M.P. 470003, India.

Research Article

Received 22nd May 2011
Accepted 11th June 2011
Online Ready 5th July 2011

ABSTRACT

A thorough knowledge of the physical, chemical and biological characteristics of an industrial waste is a crucial requirement for any attempt at chemical and/or biological treatment of the waste. Hence the present study was aimed to assess the physicochemical characteristics and cyanobacterial study on different industrial effluents. In the present study, effluents from two different places, paper mill and pharmaceutical industries, were selected to determine the cyanobacterial biodiversity. It was revealed that the physicochemical characteristics of both effluents studied were more or less similar. Total 25 species of cyanobacteria were found to be distributed in two different effluents in which twenty two were found in paper mill and fourteen were in pharmaceutical industries. Some of the species of cyanobacteria like *Microcystis aeruginosa, Oscillatoria curviceps, O. princeps, Phormidium ambiguum, P. corium* and few more were recorded in both the effluent analyzed. The dominant genus was recorded to be *Oscillatoria* and among themselves its six species were recorded. The abundance of cyanobacteria in these effluents was due to favorable contents of organic matter, rich calcium and nutrients such as nitrates and phosphates with less dissolved oxygen. Therefore, it can clearly stated that physicochemical characters together with biological monitoring of industrial effluents provided converging lines of evidences for evaluation of polluted habitats in this case as in some other studies reported by many researcher. This type of study would be valuable for future pollution abatement programmes.

Keywords: Cyanobacteria; paper mill; pharmaceutical industry; *effluents; nutrients;*

**Corresponding author: Email: dubeysanjay83@gmail.com;*

1. INTRODUCTION

Cyanobacteria are also known as blue- green algae. They are a major group of bacteria that occurs throughout the world. These photosynthetic prokaryotes are found in almost every aquatic and terrestrial environment (Castenholz, and Waterbury, 1989). They show specific growth pattern in a specific environment and therefore the distribution, ecology, periodicity, qualitative and quantitative occurrence of cyanobacteria differ widely. They are pioneer oxygenic prototroph on earth whose distribution around the world is surpassed only by bacteria. Their diversity ranges from unicellular to multicellular, coccoid to branched filaments, nearly colorless to intensely pigmented, autotrophic to heterotrophic, psychrophilic to thermophilic, acidophilic to alkylophilic, planktonic to barophilic, freshwater to marine including hyper saline (Yoo et al., 1995; Broady, 1996; Makandar et al., 2010). It is said that they flourish well either in nutrient rich and warm water or at times in water with apparently low nutrient concentrations, subjected to higher temperature and bright light conditions (Philipose, 1960; Sawyer, 1962; Munawar, 1970; Fogg, 1975; Bhatnagar, 2008). In addition, pH, carbon dioxide, organic matter, alkalinity, nitrates and phosphates are important factors in determining the distribution of Cyanobacteria. However, the study of physical, chemical and biological characteristics of industrial effluents is so great that each waste water habitat requires a separate study. A thorough knowledge of the physical, chemical and biological characteristics of an industrial waste is a preliminary and essential requirement for any attempt at chemical and/ or biological treatment of the waste. Hence the present study was aimed to assess the physico-chemical characteristics and cyanobacterial study on two different industrial effluents such as, paper mill, and pharmaceutical industry.

2. MATERIALS AND METHODS

Survey of different sites of industrial effluent for identification of different algal forms from taxonomic point of view was undertaken. The effluent and cyanobacteria's sample were collected from Paper mill, Esarbara, Sagar, M.P. and Pharmaceutical industries, Mandideep, Bhopal, M.P., India. Effluent samples and cyanobacteria were collected in large sterilized containers and polythene bags respectively. Physicochemical characteristics of waste waters were carried out by standard methods (APHA, 1995). Standard microbiological methods were followed for the isolation of cyanobacteria. Algal samples were microscopically examined and these were maintained in $BG\text{-}_{11}$ medium under controlled illumination (4000 lux) with16/8 h light/dark cycle at $28\pm2^{0}C$. Identification was confirmed based upon the keys given by (Geitler, 1932; Desikachary, 1959) for microscopic parameters. The isolated Cyanobacteria were identified with the help of classical manuals (Rippka et al., 1979).

3. RESULTS AND DISCUSSION

The abundance of Cyanobacteria is attributed due to favorable contents of oxidizable organic matter and less dissolved oxygen (Table 1), an observation which supports the observations of Munawar (1970a,b), Thajuddin et al., (2005) and Kannan (2006) who suggested that cyanophyceae grow luxuriantly with great variety and abundance in ponds rich in calcium.

The present data in the two effluents also showed that calcium is possibly one of the factors (Table 1). Whether it plays its role individually or in combination with other factor complexes can only be understood by culture studies. Besides calcium, high amounts of oxidizable organic matter, traces of dissolved oxygen, considerable amounts of nitrate and phosphates in all the effluents were probably the factors favoring the growth of Cyanobacteria as suggested by Singh (1969), Venkateswarlu (1969b, 1976), Burch (2001), Murugesan (2005), and Ozer (2006), who reported that high values of BOD, COD, phosphates and nitrates with very low DO favoured the growth of cyanobacteria than any other algae. Their findings were supported by the observations of Jeganathan (2006) in different industry effluents.

Table 1. Physicochemical characteristics of industrial effluents

Sl. No.	Parameters	Industrial Effluent	
		Paper mill	**Pharmaceutical**
1.	Colour	Pale brown	Colourless
2.	Temperature	35	28
3.	pH	6.8	7.0
4.	BOD (mg l^{-1})	240	280
5.	COD (mg l^{-1})	700	672
6.	DO (mg l^{-1})	2.1	2.2
7.	Ammonia (mg l^{-1})	210	59
8.	Nitrite (mg l^{-1})	65	67
9.	Nitrate (mg l^{-1})	150	150
10.	Inorganic phosphate (mg l^{-1})	21	22
11.	Organic phosphate (mg l^{-1})	24	20
12.	Calcium (mg l^{-1})	55	78
13.	Chloride (mg l^{-1})	1581	1599
14.	Magnesium (mg l^{-1})	41	65

Except pH and temperature, all values are expressed in mg $l^{-1.}$

In the present study, all the effluents showed a considerable amount of nitrates and phosphates, with increased level of BOD and COD along with very low DO level. In the present study, 25 species of Cyanobacteria distributed in two different effluents were recorded (Table 2). Effluent from paper mill recorded twenty two and pharmaceutical effluent recorded fourteen spices of Cynobacteria among them. In which *Heterocystous* forms were identified in paper mill and pharmaceutical effluent does not show their presence. *Heterocystous* cyanobacteria in paper mill effluent recorded only *A. fertilissima* and *N. calcicola.* Among them a total of 11 species of Cyanobacteria were recorded to be common to all the effluents analysed. Among the common species, *Oscillatoria* was found to be dominant in nature with its six spices followed by three spices of *Phormidium,* while *Lyngbya* and *Microcystis* were recorded with their single spices.

Stewart and Parson (1970) observed rapid growth of cyanobacteria in the micro aerophilic conditions. Fogg et al. (1973) inferred that the correlation between abundance of planktonic cyanobacteria and high concentration of dissolved organic matter may be due to the depletion of oxygen. *Heterocystous* cyanobacteria have not been recorded in polluted waters rich in nitrogen (Rai and Kumar, 1976b). However, in the present study *heterocystous* forms such as *A. fertilissima, N. calcicola* and *A. fertilissima* shows their presence in paper mill. Genus *Oscillatoria* has been found to be very tolerant to pollution which frequently inhabits the polluted water. Similarly, Singh et al. (1969) also found that *Oscillatoria* and *Phormidium* were the most dominant genera in sewage.

Table 2. **Distribution of Cyanobacterial floras in various industrial effluents**

Sl. No.	Name of organism	Various industrial effluents			
		Paper mill	**%**	**Pharmaceutical industry**	**%**
1	**Chroococcaceae**				
	Microcystis aeruginosa Khtz	+	80	+	48
2	*M. flos-aquae* (Wittr.) Kirchker	+	33	-	0
3	*Synechococcus elongatus* Nag.	-	0	+	35
4	**Oscillatoriaceae**				
	Oscillatoria acuminata Gomont	+	31	+	16
5	*O. chalybea* (Mertens) Gomont	+	75	-	0
6	*O. chlorine* Khtz ex Gomont	+	42	+	23
7	*O. clarisentrosa* Gardner	+	36	-	0
8	*O. cortiana* Meneghini ex Gomont	+	32	+	41
9	*O. curviceps* Ag. ex Gomont	+	54	+	51
10	*O. earlei* Gardner	-	0	+	54
11	*O. martini* Fremy	+	41	+	51
12	*O. princeps* Vaucher ex Gomont	+	43	+	76
13	*O. salina* Biswas	+	60	-	0
14	*Phormidium ambiguum* Gomont	+	34	+	71
15	*P. anomala* Rao, C.B.	-	0	+	75
16	*P. corium* (Ag.) Gomont	+	58	+	55
17	*P. uncinatum* (Ag.) Gomont	+	11	+	24
18	*Phormidium* sp.	+	42	-	0
19	*L. majusculla* Harvey ex. Gomont	+	22	-	0
20	*L. mesotricha* Skuja	+	41	-	0
21	*L. spiralis* Geitler	+	45	+	41
22	*L. martensiana* Menegh. ex. Gomont	+	61	-	0
	Nostocaceae				
23	*Nostoc calcicola* Brebission ex. Born et. Flash	+	34	-	0
24	*Anabaena fertilissima* Rao, C.B.	+	23	-	0
	Scytonemataceae	+	43	-	0
25	*Plectonema radiosum* (Schiederm) Gomont				

+ observed; - Not observed.

The observation of present study confirms the presence of *Oscillatoria* and *Phormidium* with *Lyngbya*, with their dominant nature in all effluents studied. Palmer (1969, 1980) emphasized the use of algae as reliable indicators of pollution. There are certain members of Cyanophyceae which are tolerant to organic pollution and resist environmental stress caused by the pollutants.

In the present study, effluents of paper mill with 5 cyanobacteria species, and pharmaceutical industry with 2 cyanobacteria species, having the percentage values of which were 60 and above, should be considered as indicators of the respective effluents. Similar observation of the indicator species in different effluents was also reported by Somashekar and Ramaswamy (1983). *O. curviceps* and *Microcystis aeruginosa* were found with more than 60 per cent representation in all the effluents and thus considered as the indicators of the effluents analyzed (IAPME, 2005). Compared to other species they were seen growing and multiplying profusely. Their higher representation indicates their capacity to thrive in this type of manmade habitat. From the foregoing discussion, it is concluded that physicochemical characters together with biological monitoring provided converging lines of evidences for evaluation of polluted habitats in this case as in some other studies (Cairns and Dickson, 1971; James and Evison, 1979).

4. CONCLUSION

The intensified disruption of the natural settings of many industrial area ecosystems is altering the benthic biota worldwide, and the consequences of this are expected to accelerate the biodiversity loss. Macroscopic identification of species represents the main focus of studies investigating the impact of biodiversity. Our results provide evidence that some species dominant in the industrial effluent .study of cyanobacteria in paper mill and pharmaceutical industries were selected in different places in India. Total 25 species of cyanobacteria distributed in industrial effluent were recorded. Some species of cyanobacteria were recorded in common to both effluent analyzed. Therefore, the cyanobacteria species investigated in the present study are highly recommended for beneficial bioremediation applications for in-situ and off-site removal of pollutants. The most promising species should help in optimization of the self-purification and remediation of polluted contaminated effluents before discharging into surface aquatic systems, providing a low-cost and naturally renewable technology.

ACKNOWLEDGEMENTS

The authors acknowledge grants from FINEP/CTPetro, FAPEMIG, and CAPES, and wish to thank the Brazilian National Research Council (CNPq) for the scholarship awarded to AGP.

REFERENCES

APHA. (1995). Standard Methods for the Examination of Water and Waste Water, 19th Edn., American Public Health Association., Washington D.C.

Broady, P.A., Garrick, R., Anderson, G.M. (1996). Diversity, distribution and dispersal of Antartic terrestrial algae. Biodiversity Conserv., 5, 1307-1335.

Bhatnagar, A., Makandar, M.B., Garg, M.K., Bhatnagar, B. (2008). Community structure and diversity of cyanobacteria and green algae in the soils of Thar Desert (India). J. Arid Environ., 72, 73-83.

Burch, M.D., Chow, C.W.K., Hobson, P. (2001). Algaecides for control of toxic Cyanobacteria. Proceedings of the 2001 Water Quality Technology Conference, American Water Works Association, Nashville Tennessee

Cairns, J. Jr., Ddicson K.L. (1971). A simple method for the biological assessment of the effects of waste discharge on aquatic bottom dwelling organisms. J. Wat. Poll. Control Fed., 43, 722-725.

Castenholz, R.W., Waterbury, J.B. (1989). Oxygenic photosynthetic bacteria, group É. Cyanobacteria. In Bergey's Manual of Systematic Bacteriology (eds Staley, J. N. et al.), Williams and Wilkins Co., Baltimore, 1710–1728.

Desikachary, T.V. (1959). Cyanophyta. Indian Council of Agriculture Research, New Delhi.

Fogg, G.E. (1975). Algal culture and phytoplankton ecology. The University of Wisconsin Press. U.S.A.

Ebtesam EL-Bestawy (2008). Treatment of mixed domestic- industrial wastewater using cyanobacteria. J. Ind. Microbiol. Biotechnol., 35, 1503-1516.

Fogg, G.E., Stewart, W.D.P., Fay, P., Walsby A.E. (1973). The Blue-green Algae. Academic Press Inc., (London) Ltd. London.

Geitler, L. (1932). Cyanophaceae. In: Rabenhorst's Kryptogamen flora. Akademische Verlags -gesellschaft Lepzig., 1196.

I.A.P.M.E. Profile of the pulp and paper industry in India. (2005). (http:// www. Indian agro paper millsassociation.com / IAPME / html)

James, A., Evision, L. (eds.) (1979). Biological indicators of water quality. John Willey and Sons., New York.

Jeganathan, K. (2006).Bioremediation studies on oil refinery industry effluent using *Oscillatoria earli* Gartner. M.Phil. dissertation. Bharathidasan University., Tiruchirapalli.

Kannan, S. (2006). Biodiversity of cyanobacteria in freshwater ponds of Poondi. Thanjavur. M. Phil. dissertation. Bharathidasan University., Tiruchirapalli.

Makandar, M.B., Bhatnagar, A. (2010). Morphotypic diversity of microalgae in arid zones of Rajasthan. J. Algal Biomass Utln., 1(2), 74-92.

Munawar,M. (1970[a]). Limnological studies on freshwater ponds of Hyderabad, India. II. The Biotype. Hydrobiologia., 35(1), 127-162.

Munawar,M. (1970b). Limnological studies on freshwater ponds of Hyderabad. India. II. The biocoenose-distribution of unicellular and colonial phytoplankton in polluted and unpolluted environments. Hydrobiologia. 36 (1), 105-128.

Murugesan, S., Sivasubramanian, V. (2005). Cyanobacteria of Porur lake.Chennai. Tamil Nadu. Indian Hydrobiol., 8(1), 49-54.

O¨zer, A., Akkaya, G., Turabik, M. (2006). The removal of acid red 274 from wastewater: combined biosorption and biocoagulation with *Spirogyra rhizopus*. Dyes and Pigments, 71, 83–89.

Palmer, C.M. (1969).Composite rating of algae tolerating organic pollution. British Phycol. Bull., 5, 78-92.

Palmer, C.M. (1980). Algae and Water Pollution. Castelhouse Publications Ltd.,USA.

Philipose, M.T. (1960). Freshwater phytoplankton of inland fisheries. Proc. Symp. Algalogy. ICAR. New Delhi. pp. 272-291.

Prasad, B.N., Saxena, M. (1980). Ecological study of blue-green algae in river Gomati. Indian J. Environ. Hlth., 22(2), 151-168.

Rai, L.C., Kumar, H.D. (1976b). Systematic and ecological studies on algae of some habitats polluted with fertilizer factory effluent. Nova Hedwigia., 27, 805-813.

Rippka, R., Deruelles, J., Waterbury, J.B., Herdman M., Stanier, R.Y. (1979). Generic assignments. Strain histories and properties. pure cultures of cyanobacteria. J. Gen. Microbiol., 111, 1-61.

Singh, V.P., Saxena, P.N. (1969). Preliminary studies on algal succession in raw and stabilized sewage. Hydrobiologia, 34, 503-512.
Sawyer, C.N. (1962). Causes, Effects and Control of Aquatic Growths. J. WPCF., 34, 279-288.
Somashekar, R.K., Ramaswamy, S.N. (1983). Algal indicators of paper mill waste water. Phykos., 22, 161-166.
Stewart, W.D.P., Parsons, M.W. (1970). Effect of aerobic and anaerobic conditions on growth and metabolism of bluegreen algae. Proc. Roy. Soc. Bok., 175, 293-311.
Thajuddin, N., Subramanian, G. (2005). Cyanobacterial Biodiversity and potential application in Biotechnology. Curr. Sci., 89(1), 47-57.
Tarar, J.L., Bodhke, S.S., Charjan, V.Y. (1998). Ecological studies on freshwater and polluted water euglenoids of Nagpur. Intl. J. Mendel., 15(3-4), 127-128.
Venkateswarlu, V. (1969b). An ecological study of the algae of the river Moosi. Hyderabad (India) with special reference to water pollution. II. Factors influencing the distribution of algae. Hydrobiologia., 34, 352- 362.
Venkateswarlu, V. (1976). Taxonomy and ecology of algae in the river Moosi. Hyderabad (India). Nova Hedwigia., 27, 661-676.
Yoo, R.S., Carmichael W.W., Hoehn, R.C., Hrudey, S.E. (eds.) (1995). Cyanobacterial (Blue-green Algal) Toxins: A Resource Guide. AWWA Research Foundation and American Water Works Association, Denver, 229.
