AN ASSESSMENT OF PHYTOPLANKTON DIVERSITY AND POLLUTION INDEX USING PALMER'S INDEX IN 'KONDAKARLA AVA' LAKE, ANDHRA PRADESH, INDIA.

[1] **B.Vinay Sagar, [2]K.Kameswara rao,**

[1]Research Scholar, [2]Professor.
[1& 2] Department of Environmental sciences ,Andhra University, Visakhapatnam,India.

***Abstract*:** With the ever increasing human population and human induced stresses on the natural resources for their demands, there seem to be alteration in the quality of the natural ecosystems. Wetlands are of no exception to the above phenomenon as they continue to be degraded by the anthropogenic stresses. There is a be a immediate need to understand the state of such pristine ecosystems as they hold a great ecological significance and provide various services to the communities living in their vicinities. Thus the rationale of the present study lies in assessing the trophic status, of Kondakarla lake using Palmer's Index, which is the second largest fresh water lake in Andhra Pradesh , India.

Keywords: Wetlands, Kondakarla, Palmers index, Anthropogenic Stress, Ecology.

I. INTRODUCTION:

Wetlands are the ecosystems that provide many tangible and intangible services and that have an economic value, not only to the local population living in its periphery, but also to communities living outside the wetland area. They serve as are important sources for food, fresh water and building materials and provide valuable services such as water treatment and erosion control (Schuyt and Brander, 2004). Despite their importance and value, wetlands around the world are being modified or reclaimed. Wetlands are the most highly threatened ecosystems on the planet and unfortunately the degradation and loss of wetlands are continuing. Worldwide, around 50% of wetlands are estimated to have disappeared since 1900 (Wetland Internationals, 2006).

India is no exception to the global scenario. Indian wetlands are not only the home of a wide variety of plants and animals but they also provide livelihood to thousands of communities with a wide range of ecological services. Despite all these benefits from the wetlands, they have been mismanaged and are often neglected. Wetlands suffer from over-exploitation, overuse of their resources, drainage, alternative use and pollution. The Wildlife Institute of India's survey on the wetlands reveals that at present, only 50% of India's wetlands remain intact and they are disappearing at a rate of 2% to 3% every year. The loss of one km^2 of wetlands in India will have much greater impact than the loss of one km^2 of wetlands in low population areas of abundant wetlands (SACON, 2005a).

Thus to assess the health of the wetlands, there is great need to monitor the various ecological aspects associated intricately with it. Bio-monitoring is one such phenomenon which is gaining significant importance in assessing the health status of the water bodies and biological indicators include those species which are used for assessment of integrity of an ecosystem Planktonic microalgae can be considered to qualify as suitable indicators in that they are simple, capable of quantifying changes in water quality, applicable over large geographic areas and can furnish information and data on background conditions and natural variability (Onyema 2007).

II. LITERATURE SURVEY:

Many researchers such as Staker et al. (1974), Ratnasabapathy (1975), Gunale and Krishnan (1981), Wu (1984), Venkateswarlu and Reddy (1985), Verma and Mohanty (1994), Ramakrishnan (2015), Sharan and Rekha (2010), Bordoloi and Baruah (2014), Krishnan and Ajit (2015) and, have employed the algal indices to study and quantify the trophic state of various water bodies.

Different algal indices such as Palmer's Algal Index, Chlorophycean Index, Nygaard's phytoplankton indices, Myxophycean Index, Bacillariophycean Index, Euglenophycean Index and Compound Coefficient Index are used to study the trophic and pollution status of water bodies.

III. STUDY AREA:

''Kondakarla Ava' ' lake Ava wetland, a natural freshwater lake (stretches between latitudes 17°35'30" and 17° 36'02" N longitudes; 82° 59'27" and 83° 01'02" E) of *Visakhapatnam* district, Andhra Pradesh, India, was chosen as the main system for the study. The study area comprises of both the catchment and command areas along with the lake area.

''Kondakarla Ava' ' lake Ava wetland, the second largest natural fresh water lake of Andhra Pradesh, is 50 kms South west of *Visakhapatnam*, a port city on the East Coast of India, which is the second largest city in the state of Andhra Pradesh (Fig.3.1). The ''Kondakarla Ava' ' lake Ava wetland is a part of the Sarada riverine system and is classified as a perennial, warm, polymitic, euphotic, eutropic shallow fresh water lentic body.

This wetland is now assuming global significance, as it is a major stop over sites for many migratory birds in Andhra Pradesh. *''Kondakarla Ava' ' lake Ava* wetland was as a conservation site by the Asian Wetland Bureau and World Wild Life Fund in 1993. It is recognized as a priority site for Integrated Protected Area System (IPAS) by the Andhra Pradesh State Forest Department. The Andhra Pradesh Tourism Development Corporation has included the wetland as an important site for ecotourism development. Although the lake holds great ecological and cultural significance, rarely it has been studied on composition and seasonal variation of phytoplankton in the wetland.

Figure 3.1: Map showing the study area ''Kondakarla Ava' ' lake, in Andhra Pradesh, India

Venu (1981) was the first to report on the *''Kondakarla Ava' ' lake Ava* lake and reported limnology of the lake with especial reference to aquatic macrophytes; SeshAvatharam (1982) has reported the ecological state of the lake, while Rao (1984) reported on plankton and periphyton; Sankar (1992) studied on fish and fisheries; and Bharat lakshmi *et al*. (2001) on the Avian fauna. Owing to the lack of information on the phytoplankton diversity and abundance this study has been carried out to assess the planktonic diversity and the judge the pollution load of the lake on the lines of palmers index.

IV. METHODOLOGY:

Phytoplankton: One liter of water sample was taken in a glass bottle. 10 ml of Lugol's Iodine was added to the sample and this was allowed to stand for 24 hours. The supernatant (clear) liquid was taken out with the help of a pipette. The remaining sample was further concentrated to 100 ml. After shaking the concentrated sample, one drop (0.05 ml) was quickly put on a clear micro slide with the help of a standard dropper. The whole drop was covered with a cover glass. Phytoplankton were counted species wise. Planktonic estimations were worked out for 10 drops. Phytoplankton was identified using keys and monographs given in Adoni (1985) and APHA (1995). Algal Genus Pollution Index (Palmer 1969,Table 4.1) was used for rating wetland water for high or low organic pollution.

Table 4.1: Algal Genus Pollution Index (Palmer 1969):*

Genus	Index	Genus	Index
Anacystis	1	Micractinium	1
Ankistrodesmus	2	Navicula	3
Chlamydomonas	4	Nitzschia	3
Chlorella	3	Oscillatoria	5
Closterium	1	Pandorina	1
Cyclotella	1	Phacus	2
Euglena	5	Phormidium	1
Gomphonema	1	Scenedesmus	4
Lepocinclis	1	Stigeoclonium	2
Melosira	1	Syndra	2

*as given by Pearson, J. L. (1989)

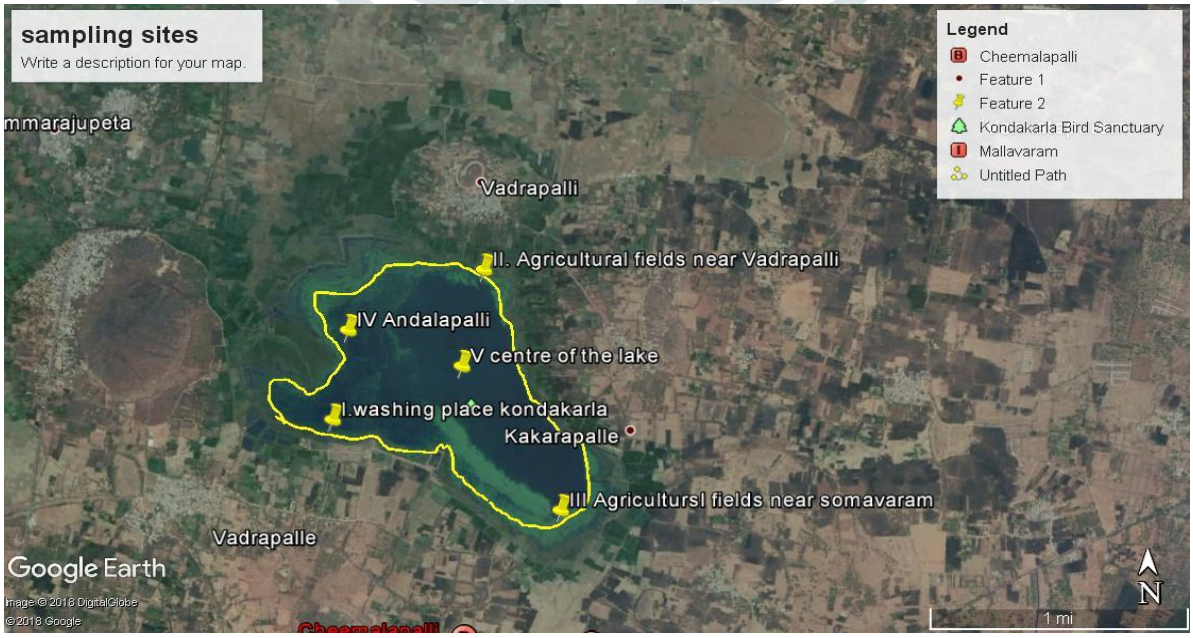
According to this method, if there are 5 or more cells of a particular kind of algae on a slide, the alga must be identified and recorded. The index numbers of the algae are then added. Any algae that are not listed have a pollution factor of zero.

If the pollution index score is 20 or more, the score is evidence of high organic pollution. A score of15-19 indicates probable organic pollution. Lower scores usually indicate less organic pollution, but they may also occur if something is interfering with algal growth.

For the study five sampling stations (or sites) were chosen across the wetland, which are situated along two main transects Station V is situated in the centre of the wetland intercepting the two transects. Station I, II, III and IV are situated near the periphery of the wetland. The sampling sites are depicted in figure 4.1.

- **Stations I** - Station I is situated at the littoral zone of the lake at ‘‘Kondakarla Ava’ ’ lake Andalapalli;
- **Stations II**- Station II is situated at the littoral zone of the lake at Vadrapalli village.
- **Stations III**- Station -III is situated at the littoral zone of the lake at somAvaram village.
- **Stations IV**- Station IV is situated at the littoral zone of the lake at H-Andalapalli
- **Stations V**- Station V is situated in the limnetic zone of the lake, at the centre of the wetland.

Figure 4.1: Google Earth Map showing the Sampling sites in the study area.



The waters from the five sampling stations were examined for phytoplanktonic studies and monthly compositions of the phytoplankton community as well as their population estimates were recorded.

V. RESULTS & DISCUSSION:

The analysis of the sampling sites revealed that 'Kondakarla Ava' lake supports a rich variety of phytoplankton. During the study period (July 2015 to June 2016), a total number of forty-two (42) genera of phytoplankton were observed and identified (Table 2). Out of these, twenty-two (23) belong to Chlorophyceae, seven (7) to Bascillariophyceae and twelve (12) to Myxophyceae. It was however noted that both quantitatively and quantitatively Chlorophyceae was the dominant one, followed by Myxophyceae .

Among Chlorophyceae, four orders were present which include Volvocales, Conjugales, Clorococcales and Oedogoniales. In Bascillariophyceae, only one Order, Diatoms, was present. In Myxophyceae, three orders (Chroococales, Hormogoniales and Nostocales) were present. The various genera belonging to different Orders and Classes, identified from the lake waters were as under:

Table 5. 1: Species Composition of Phytoplankton in the wetland

Class	Order	Genera
(i) Chlorophyceae	**Volvocales**	*Volvox sp.* *Eudorina sp.* *Gonium sp.* *Pandorina sp.* *Pleodorina sp* *Chlamydomonas sp*
	Conjugales	*Cosmarium sp.* *Spirogyra sp.* *Sirogonium sp.* *Closterium sp.* *Netrium sp.* *Staurastrium sp.* *Microsterias sp.*
	Clorococcales	*Coelastrum sp.* *Tetradon sp.* *Scendesmus sp.* *Ankistrodesmus sp.* *Pediastrum sp.* *Selenasrum sp.* *Oocystis colonie sp.*
	Oedogoniales	*Oedogonium sp.* *Mougeotia sp.* *Rhizoclonium sp.*
(ii) Bascillariophyceae	**Diatoms**	*Coscinodiscus sp.* *Navicula sp.* *Pinnularia sp.* *Synendra sp.* *Diatoma sp.* *Cymbella sp.* *Fragilaria sp.*
(iii) Myxophyceae	**Chroococales**	*Microcystis sp.* *Merismopedia sp.* *Chroococcus sp.* *Gloeocapsa sp*
	Hormogoniales	*Oscillatoria sp.* *Lyngbya sp.* *Spirulin sp*
	Nostocales	*Nostoc sp.* *Anabaena sp.* *Rivularia sp.* *Gloeotrichia sp.* *Cylindropse sp*

Seasonal Variation in Population Density of Phytoplankton :

Chlorophyceae: Clorophyceae showed the greatest diversity. This class was represented by four (4) orders *i.e*., Volvocales, Conjugales, Clorococcales, and Oedogoniales. Each group showed their own maximum and minimum peaks in different seasons and the results are presented in Table 5.2. **Volvocales** had a maximum density of 5690/l recorded at Station II during December and showed their peak values during the winter months; **Conjugales** had a maximum density of 21800/l recorded at Station V, and showed their peak values during the summer months. The maximum density of **Cloroccales** was recorded at 21600/l in Station IV during March and the occurrence of peaks in different stations had no pattern. The peaks occurred during different months in different sampling stations. **Oedogoniales** had a maximum density of 4570/l recorded at Station V during May and the peak densities in all the sampling stations had occurred during the pre-winter months, the only exception being at Station V, where the peak occurred during the summer months (Table 5.2).

Bascillariophyceae: Bacillariophyceae comprising a single Order, **Diatoms** was one of the members contributing most to the total phytoplankton density. The maximum density was recorded at 31000/l in Station IV during December and the density peaks occurred during the winter months, mostly December and January (Table 5.2).

Myxophyceae: The Myxophyceae population in the lake was mainly composed of three Orders *i.e*., Chroococcales, Hormogoniales and Nostocales. **Chroococcales** had a maximum density of 41800/l recorded at Station I during April and the peak densities occurred during the early summer months (March and April). **Hormogoniales** had a maximum density of 40090/l recorded at Station I during March, and the peak densities occurred during the early summer months (March and April) in Stations I, II and V and during December-January in case of Stations III and. **Nostocales** had a maximum density of 15640/l recorded at Station IV during March and the peak densities occurred during the early summer months (March and April) in Stations I, III, IV and V and during October in case of Station II (Table 5.2).

Table 5.2: Monthly Variation in Population Density of Phytoplankton of **''Kondakarla Ava' ' lake Ava Wetland during 2015-16 (organism/l)**

Station – I	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Volvocales	0	0	250	1160	3880	1267	2760	850	2130	0	0	430
Conjugales	0	280	320	4590	5230	5680	1240	3570	10440	18900	19560	8564
Cloroccales	160	240	650	4250	1285	950	1590	1450	1170	8780	5890	12850
Oedogoniales	0	0	150	870	1120	2670	3450	680	2250	1240	0	2430
Diatoms	100	470	870	4670	20680	20200	23000	18760	12700	1080	6700	4305
Chroococcales	180	650	5140	10200	7690	9880	9000	3670	21230	41800	37560	10680
Hormogoniales	0	450	3410	24500	31200	25800	24300	31000	40090	21500	18900	15340
Nostocales	0	0	240	2300	8780	7540	5570	4320	5670	12880	4080	1440
Total Phytoplankton	**440**	**2090**	**11030**	**52540**	**79865**	**73987**	**70910**	**64300**	**95680**	**106180**	**92690**	**56039**
Station – II												
Volvocales	0	0	0	270	2100	5690	2790	1120	0	0	0	0
Conjugales	110	210	1280	4680	6100	3780	3560	12600	15800	10900	8090	12000
Cloroccales	0	210	1200	12800	3270	4310	2250	12450	10500	12700	3200	2350
Oedogoniales	0	0	430	1260	2570	3370	480	2540	1000	0	1200	1260
Diatoms	230	480	2280	5680	15790	18700	27890	10800	12400	15600	14860	9560
Chroococcales	160	980	2800	6790	12700	18500	29460	18700	19870	29760	15600	10380
Hormogoniales	220	650	3500	9600	16700	8790	15700	25400	31700	19760	37800	11680
Nostocales	0	470	4590	8070	1780	1260	7680	4560	2300	5600	3240	2280
Total Phytoplankton	**720**	**3000**	**16080**	**49150**	**61010**	**64400**	**89810**	**88170**	**93570**	**94320**	**83990**	**49510**

Station – III	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Volvocales	0	0	430	0	860	1570	1890	0	0	560	0	0
Conjugales	340	870	1110	1760	3440	3290	4250	4110	12590	19800	10100	7500
Cloroccales	120	540	1450	11760	650	4380	12540	5680	15670	16840	6500	2670
Oedogoniales	0	0	560	1270	3040	1560	1650	1170	870	1260	860	1090
Diatoms	240	1140	8670	11900	17890	25800	19800	17890	14500	10500	5680	2410
Chroococcales	0	0	1120	2310	6120	1110	1360	5600	19800	15760	9750	5640
Hormogoniales	170	680	11280	25700	24300	30120	31500	22300	16800	15600	8790	7650
Nostocales	0	450	1120	3650	1110	7850	4580	2790	12540	2330	4750	1730
	870	**3680**	**25740**	**58350**	**57410**	**75680**	**77570**	**59540**	**92770**	**82650**	**46430**	**28690**
Station – IV												
Volvocales	0	0	650	1450	5500	4300	4100	1290	1110	870	0	560
Conjugales	280	450	1650	8700	11290	4100	11500	8160	10230	1180	21700	7140
Cloroccales	250	430	4090	12450	21600	14500	5540	9700	19800	17880	11200	8760
Oedogoniales	0	0	1110	4210	1120	1150	1000	890	1240	760	830	980
Diatoms	270	350	5600	10300	28900	31000	19800	22900	15490	11900	16780	13120
Chroococcales	180	450	5240	10000	8690	9180	9000	3770	22230	31900	29560	10780

Hormogoniales	0	450	3410	14500	21200	25800	24300	21000	20090	21500	12900	5340
Nostocales	0	0	1190	6590	14500	12390	6580	9640	15640	12000	4230	2180
Total Phytoplankton	**980**	**2130**	**22940**	**68200**	**112800**	**102420**	**81820**	**77350**	**105830**	**97990**	**97200**	**48860**
Station – V												
Volvocales	0	0	450	1640	2290	4120	1130	980	560	640	0	0
Conjugales	210	430	5600	5200	11210	13460	3780	6540	21800	5670	6590	5000
Cloroccales	180	560	9600	5000	7180	3620	2110	7080	10990	6590	4420	3210
Oedogoniales	0	0	0	1500	3070	1230	1150	1980	3080	3100	4570	2890
Diatoms	200	670	5400	10940	21700	16700	15690	15980	6500	12450	3400	5000
Chroococcales	0	470	4500	4160	7190	1870	200	3150	13500	17800	9040	15640
Hormogoniales	230	650	5700	7680	7000	15690	11090	11870	19800	22560	21500	3680
Nostocales	0	590	1560	5780	4020	3270	5440	6210	10000	4100	5150	5000
Total Phytoplankton	**820**	**3370**	**32810**	**41900**	**63660**	**59960**	**40590**	**53790**	**86230**	**72910**	**54670**	**40420**

Total Phytoplankton: On the whole, the total phytoplankton showed a bimodal distribution with one peak in the winter season and another during the summer season (Fig.5.9). The maximum density of Total Phytoplankton was recorded at Station IV as 112800/l during November (Table 5.2). The low values during the months of June to October, was perhaps due to a peculiar situation for the lake, because the lake waters began to accumulate after the lake bed had completely dried.

Figure 5.1: Monthly Variation in Population Density of Volvocales during July 2015 -June 2016.

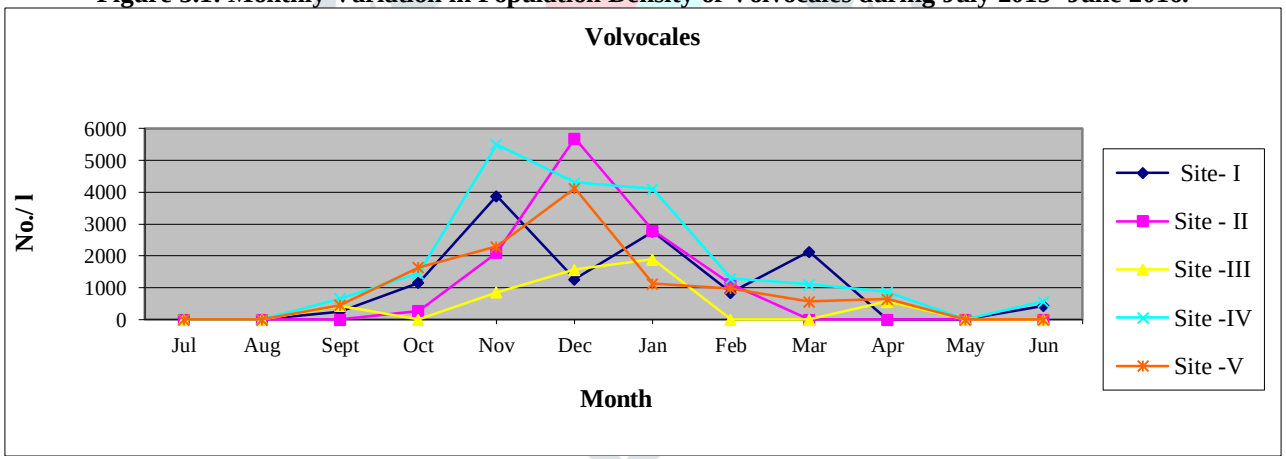


Figure 5.2:Monthly Variation in Population Density of Conjugales during July 2015 -June 2016

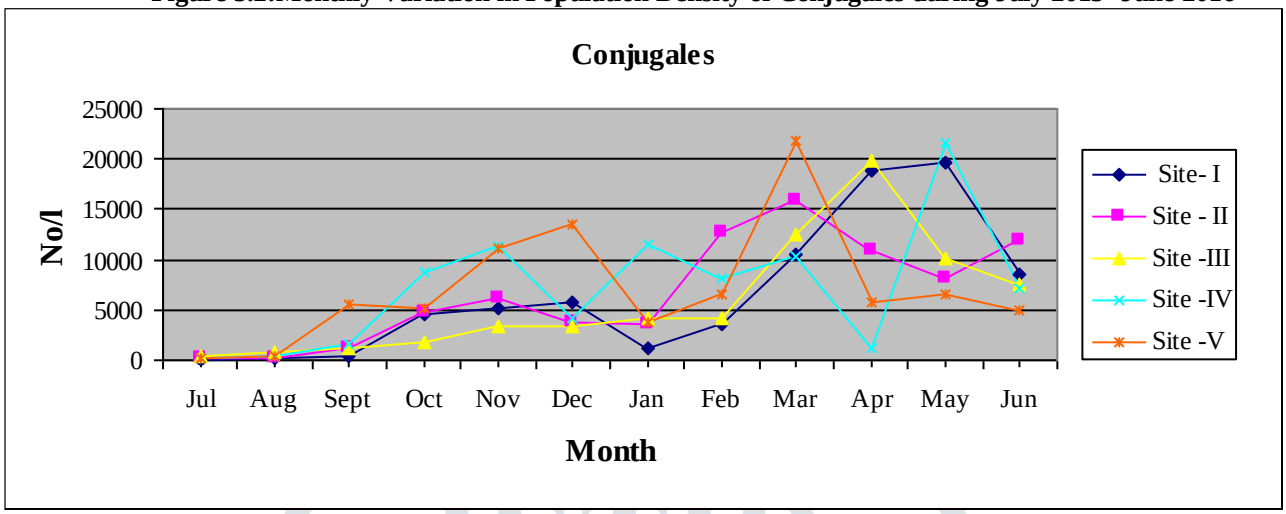


Figure 5.3: Monthly Variation Population Density of Clorococcales during July 2015 to June 2016

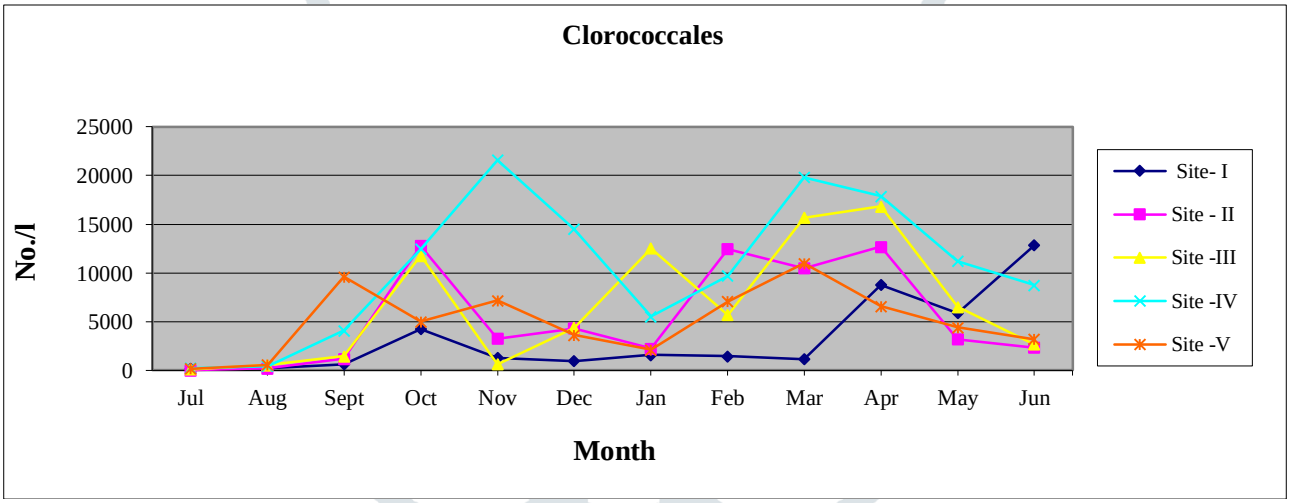


Figure 5.4: Monthly Variation Population Density of Oedogoniales during July 2015 to June 2016

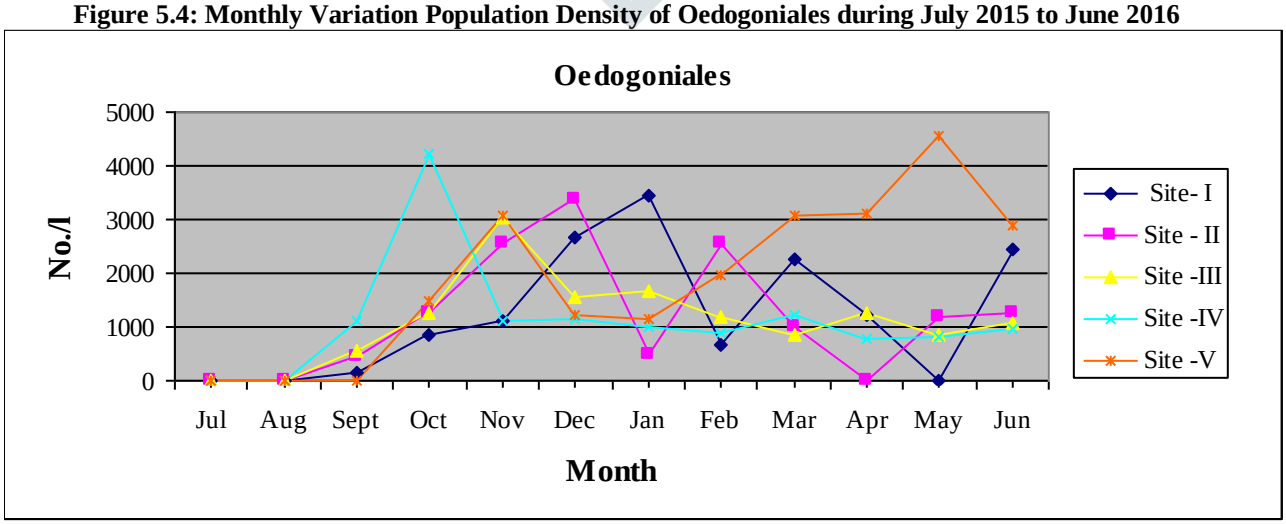


Figure 5.5:Monthly Variation in Population Density of Diatoms during July 2015 to June 2016

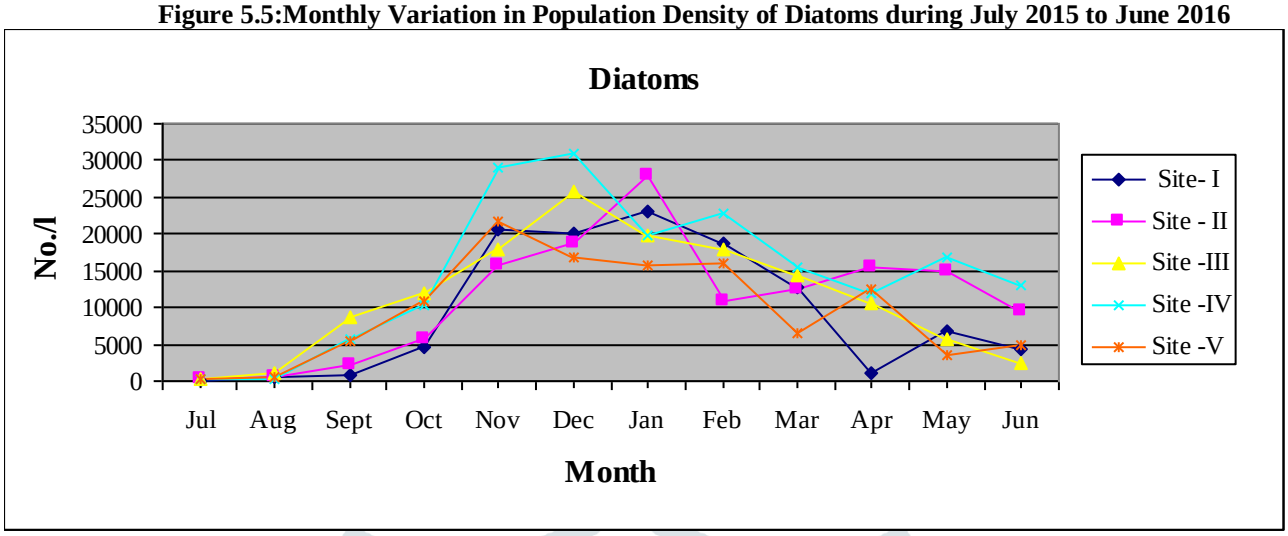


Figure 5.6:Monthly Variation in Population Density of Chroococcales during July 2015 to June 2016

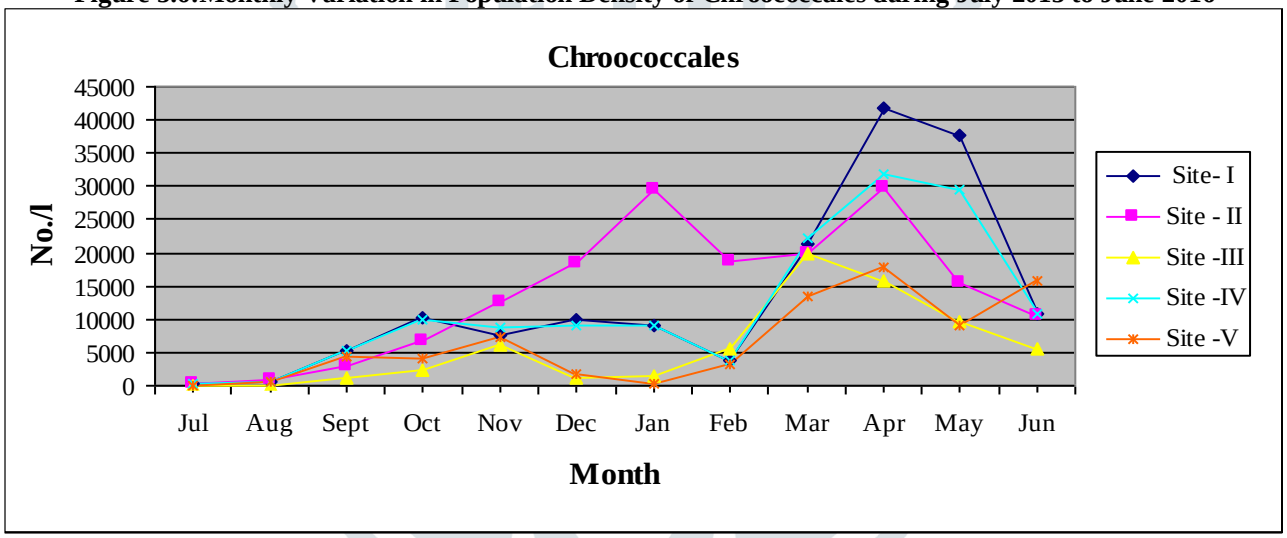


Figure 5.7:Variation in Population Density of Hormogoniales during July 2015 to June 2016

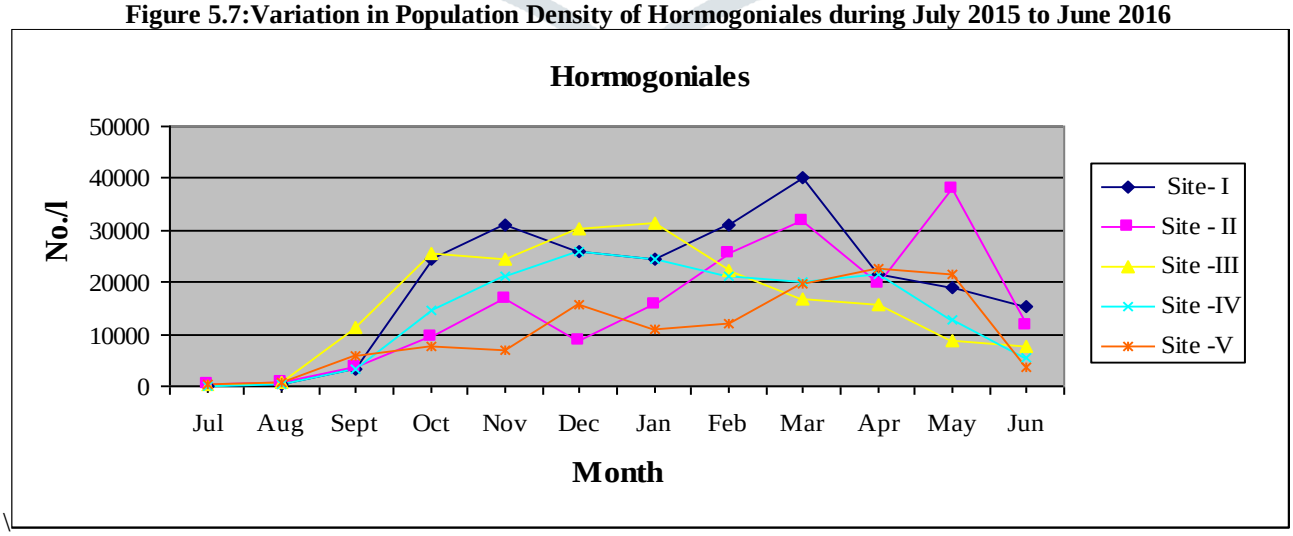


Figure 5.8:Monthly Variation in Population Density of Nostocales during July 2015 to June 2016

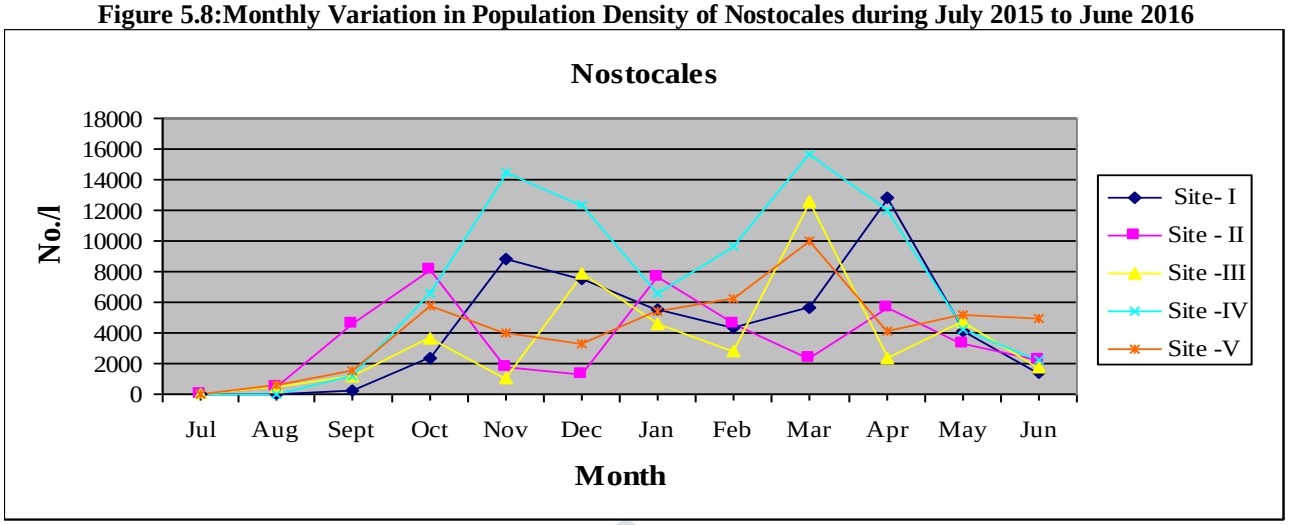
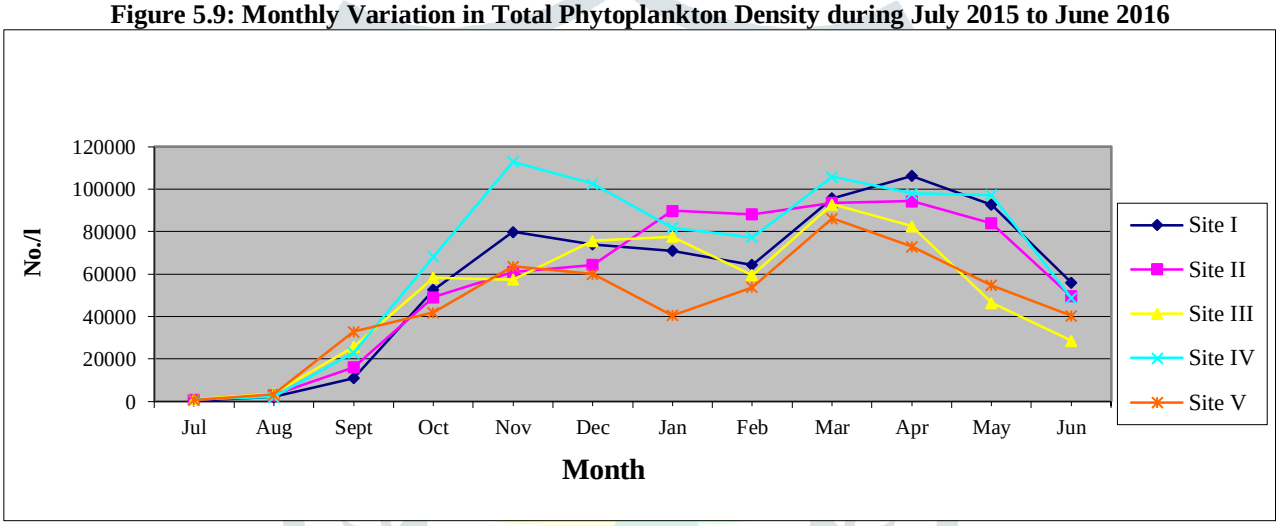


Figure 5.9: Monthly Variation in Total Phytoplankton Density during July 2015 to June 2016



As mentioned earlier, the lake supports a rich variety of phytoplankton. During the study period (July 2015 to June 2016), a total number of forty-two (42) genera of phytoplankton were observed and identified. Out of these, twenty-two (23) belong to Chlorophyceae, seven (7) to Bascillariophyceae and twelve (12) to Myxophyceae.

Table 5.3: Total phytoplankton in Kondarla Ava Lake (organisms/l):

Phytoplankton	**Study period**	
	Sp	Biomass
Chlorophyceae		
Volvocales	6	0-5690
Conjugales	7	0-21800
Clorococcales	7	0-21600
Oedogoniales	3	0-4570
Diatoms	7	100-31000
Cyanophyceae		
Chroococcales	4	0-41800
Hormogoniales	3	0-40090
Nostocales	5	0-15640
Total Phytoplankton	42	440-112800

As mentioned earlier Palmer (1969) has developed a pollution level index (*Palmer's Index)* using algal genera as indicator species. The Palmer's pollution index score for the algal groups of the ''Kondakarla Ava' ' lake Ava Lake was 22 (Table 5.4) that indicated high organic pollution. Eight (8) of the 20 genera of indicators existed in these waters as shown below:

Table 5.4: Palmer's Index for ''Kondakarla Ava' ' lake .

Class	**Order**	**Genus**	**Palmer's Index Number**
Chlorophyceae	Volvocales	*Pandorina*	1
		Chlamydomonas	4
	Chlorococcales	*Scenedesmus*	4
		Ankistrodesmus	2
	Conjugales	*Closterium*	1
Cyanophyceae	Homogonales	*Oscillatoria*	5
Bacillariophyceae	Pennales	*Navicula*	3
		Syndra	2
		Total	**22**

VI. CONCLUSION:

The occurrence of Algal diversities is a natural phenomenon in the water bodies, and they may occur with regularity depending upon water conditions of the river. However the excessive occurrences of phytoplanktons are harmful to the health of the water body and also for the organisms in the aquatic environment.

In view of the above the present study carried was carried out in the 'Kondakarla Ava' lake' and the study identified the phytoplankton present in the water body and also revealed that the lake is organically polluted and the lake is under severe ecological stress . Basing on the palmers index this study also confirms that phytoplankton serve as excellent Bio-indicators of organic pollution. And based on the, the planktonic compositions in the, it can be considered as organically polluted and is certainly moving towards eutrophy.

Thus in this era of degrading environment there is definite need to address the menace of pollution in a scientific manner. ''Kondakarla Ava'' lake which is the second largest fresh water lake in Andhra Pradesh is certainly under stress , so it is high time that the Government and as well as the individuals take necessary steps to protect the pristine ecosystems such as 'Kondakarla Ava' lake .

SUGGESTIONS TO SAFEGAURD THE QUALITY OF THE LAKE AND TO ENSURE IT'S SUSTAINABILITY AND FUTURE SCOPE OF RESEARCH:

1. Avareness creation and promotion of sustainable/ wise use practices
2. Capacity building of local communities to support their active participation in management of the lake
3. Afforestation at the denuded lands of the self catchment area alongwith soil and moisture conservation activities by local communities with the help of the Forest, Revenue and Agriculture Departments;
4. Development of Buffer Strips around the lake periphals to control siltation and sedimentation;
5. Developing a new site for the use of Washing Clothes
6. Control of noxious growth of aquatic macrophytes
7. Developing arborial habitats to attract the avian fauna and enhance the ecological and ecotourism opportunities, with the help of the Forest and Tourism departments;
8. Developing opportunities through tourism of ecological and educational importance and provide alternative livelihoods by building capacities among the natives;
9. Establishment of an Ecological Monitoring Station to guide the Lake User Groups and the government from time to time.

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