J. Biol. Chem. Research. Vol. 29, No. 1: 52-66 (2012)
(An International Journal of Life Sciences and Chemistry)
ms 19/1-2/13/2012,
ISSN 0970-4973

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RESEARCH PAPER

Received 27/June/2012 Revised 05/July/2012 Accepted 05/July/2012

Biological Tools for Computation of Physico-Chemistry of a Wetland affected by Pulp and Paper Mill Effluents

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ABSTRACT

The Nagaon Paper Mill(NPM) discharges their heavily loaded waste effluents @2100 m3/h into the natural wetland system called Elenga Beel(wetland) located in Morigaon district of Assam(India).Due to higher chemical diversity of Paper Mill Effluents (PME) it affects the diversity and dominance of algal flora along with water quality parameters. The enrichment effect of effluents some time impairs the water body which is changing its nature from oligotrophic to eutrophic. . The diversity indics like PPI, Shannon Index (H) and TSI index was applied for evaluation of pollution status of the Beel. The index value signify that the wetland shifted from oligotrophic to eutrophic due to paper mill effluents.A horizontal variation of pollution load in the trend of E>S1>S2>S3>S4>S5>S6 was recorded in entire skretch with increasing distance from the pollution source.
Key words: Elenga Beel, NPM, PME, Algae, PPI, H, TSI

INTRODUCTION

Water system in India is greatly polluted by Pulp and paper mill effluents. During the past few decades, this activity has experienced a significant boost worldwide, and it is expected to increased by 77% from 1995 to 2020 (OECD, 2001). Pulp and paper mill liberates heavily loaded waste in to surrounding environment (Anonymus, 1999; Baruah and Das, 2001) mainly arising out from pulping and bleaching process. Broad categories of effluents from pulp and paper industry are 8 (eight) types of effluents: 1] Colouring substance, 2] Turbidity and Sediments, 3] Oxygen Consuming substance, 4] Nutrients, 5] Malodorous substances and those affecting taste, 6] Acidity/alkalinity, 7] Chlorate and 8] toxic substances (Duncan, 1989). The effluents influence environment by imparting large BOD, toxicity and color. The lignosulphonate components of the waste may inhibit the growth of phototrophic plankton, algae and plants by reducing the transmission of sun light in water (Poole et al., 1977). Other ecologically parameters such as increased conductivity, PH, temperature, high suspended particulate matter, dissolved particulate matter sometimes impair the oxygen balance of the water body and sediments. The excess of nitrogen (N) and phosphorus (P) nutrients in the effluents may support eutrophication process which might lead to anoxic condition (Poole et al., 1977) for aquatic life. Among aquatic organism algae contribute to approximately 50% of global photosynthetic activity and over 70% of the world's biomass (Andersen, 1996). They appear and colonize on earth 2.5Gaλ (= Years X 109λ) ago and have broad habit range from polar region to tropical coral reef (South and Whittick, 1987). Any alteration in aquatic environment may leads to the change in algal communities in terms of **tolerance, abundance, diversity and dominance** in their habitat. Therefore, they may be used as an indicator for assessment and evaluation of water quality of diverse habitats (Dwivedi 2010, Saikia et al, 2010 &2011).

One of Asia's biggest paper factories NPM is located in Assam (India). Goswami (1998) reported that Nagaon Paper Mill (NPM) established in 1985 at Jagiroad, Assam (India) has been affecting the air, water and soil quality of adjoining areas through the disposal of solid, liquid and gaseous emission. Mainly the problem aroused from the disposal of its effluents in to nearby Land or wetland system. Among various wetlands of Assam, Elenga Beel was identified by CPCB, New Delhi as most polluted one due to dumping of paper mill effluents. **Elenga Beel** is located between $92^{0}3'51''$ E-$92^{0}17'7''$ longitude & $26^{0}8'2''$ – $26^{o}11'41''$N latitude**.** Two drains carrying PME drains to Elenga Beel which after traveling at a distance of 25 km downstream meets River Kolong/Kopili a tributary of mighty river Brahmaputra. The confluence of paper mill effluents in the nearby fresh water bodies reported to cause gradual environmental degradation their by affecting the crops, livestock's and aquatic life of the district (Anonymus, 1999; Bora, 1998, Saikia et al, 2010 & 2011, Saikia and Lohar, 2012). The impact of paper mill effluents on aquatic bodies has been assayed to a certain extent (Bhattacharyya and Ahmed, 1995; Baruah and Das, 2001; Kalita et al, 2002), but detailed information is not yet available. Considering above study undertaken.

MATERIAL AND METHODS

The algal and water quality samples were collected from predetermined sample sites prepared by Arc.9.3 GIS software as shown in the **Map-1.** Samples were analyzed as per methodology of APHA (1989), Trivedy and Goel (1986), Golteman et al.(1978), Greenberg et al.(1985).The numerical counting and identification of algae was done following Lackey's (1938), Desikachay (1959) Prescott (1951); Smith, (1950) . Three pollution indices namely **Palmer Pollution indics (PPI)** [Palmer,1969] , **Shannon Diversity (H)** [Shannon and Weaver,[1963] equation: $H = -\Sigma pi \; Log_2 \; pi$ **[**Where, D= Diversity Index, Pi= ni /N (where, ni =number of individuals in species), N= (total number of individual in the sample) and **Trophic State Indices (TSI**)[Carlson's equation (Maki et al, 1984; Carlson, 1977)] is used to calculate TSI. TSI = 10 [6-(log (48/TP)/log2)].Their scores were compared with reference value at different sites and seasons to get meaningful evaluation of the water body. The statistical analysis of water samples corresponding to sample sites and seasons was done using **SPSS 9.0.**

RESULT AND DISCUSSIONS

In the entire stretch of the Elenga Beel all together 45 species of algae belonging to 26 genera were recorded. Of which 15 species belongs to Cyanophyceae, (33.17%), 15 belong to Chlorophyceae, (32.56%), 13 belong to Baccillariophyceae (5.18%) and 2 belong to

Euglenophyceae. (29.07%) These species have showed an interesting pattern of their distribution based on pollution load at different locations and seasons. The characteristics of algal flora and their seasonal fluctuation trend at different sampling stations of Elenga Beel have shown in the **Table 1** while their yearly averages values were given in **Figure 1 (A&B).** The Pearson (r) correlation of different pollution indices with their physico-chemical parameters depicted in **Table-6.**

The abundance of algal flora in Elenga Beel wetland showed a wide displacement from those occurring in natural unpolluted water bodies. It deviates from normal conditions. A horizontal variation of algal flora of different classes was observed in the trend of E> S1> S2>S3 >S4>S5> S6.The knowledge of plankton species composition and distribution with time and space are of great value especially in any running water system. Plankton distribution and abundance are affected by seasons and variations of physico-chemical variables (Ezra and Nwankwo, 2001). In this investigation, station E and S1 has perfect positive correlation between them (r = 1.000) and did not allow large number of species to encounter. A significant decline of species number was noticed in these stations. Gradual increase of species number was observed from S_2 to S_6 due to dilution or increase the distance from the mill. Phytoplankton numbers also registered higher during non-rainy season at all the stations. The phytoplankton population's count was comparatively higher in summer (39.57%) and low during rainy (28.50%) season. Similar type of observation was recorded by Sadguru et al. (2002) while working on Caveri River with reference to pollution. It was evinent from that at the sampling stations E and S_3 characterized with polluted water by the paper mill effluent which favours the growth of Cyanophyceae and Euglenophyceae where as station S4 to S6 Chlorophyceae and Bacillariophyceae. This finding agrees with the findings of Sudhakar and Venkateswarlu (1991a), Venkateswarlu (1969) in Godavari River affected by paper mill effluents.

The basic approaches to evaluate the effect of pollution on aquatic life are first to make qualitative assessment of spices present or absence. Then compare it reference sites to ascertain pollutants. In the present study, three indices namely Palmer's Pollution Index (PPI), Shannon Weaver Diversity Index (H) and Trophic State Index (TSI) were applied for evaluation of pollution status of Elenga Beel. The two indices are of biological origin and one is of Physico-chemical in nature. The total scores of each individual index were given in **Table -2-5 and Figure 2-6 .**The correlation coefficient (r) values of each individual index corresponding to each physico-chemical parameters were given in **Table 6-7**

Palmer pollution Index **(PPI):** The palmer's genus index value for all stations was higher than the species index value. The occurrence of higher value of genus index in polluted water was supported by Shaji and Patel (1991), Adhikari (1997), Baruah (1995), Nandan and Patil (1994), Jafari and Gunale (2006) , Saikia et al (2010). A perusal of **Figure 5** reveals that palmer pollution index showed their maximum value in summer and minimum in rainy and winter season coinciding with algal population **[Figure 1 A&B**]. The lowering of PPI in rainy and winter seasons due to low high nutrient content during rainy and winter seasons. Similar observations were recorded by Saikia and Bordoloi (1994), Sahu et al, (1996). The increase of phytoplankton's population along with PPI index in summer season might be due to temperature The correlation coefficient (r) analysis between palmer's pollution index and temperature (r = 0.767, p<0.044) [**Table: 6**] showed a positive correlation which support the observation of temperature effect during summer season. Similarly, in summer temperature is negatively correlated with TN (r = -0.586) and TP (r = -0.720). Nutrients like N and P attained its maximum values during the rainy and winter seasons as compared to summer due to inflow of rainwater. This is in conformity with the result of Singh (1993), Mishra and Yadav (1978). The algal flora of Elenga beel were subjected to Palmer's Pollution Index (Palmer, 1969) for rating water quality. The result revealed that the station E, S_1, S_2, S_3 were highly polluted having index value above 20 indicating high organic pollution. Whereas station S_4, S_5 and S_6 has index value below 20 indicating moderate to low organic pollution. These findings again are in conformity with the observed value of physico-chemical data table (**Table-7**). A similar type finding was also recorded by (Cairns and Dickson, 1971; James and Evison, 1979; Rana and Palria, 1988; Adhikari, 1995; Dubey et al, 2011).

Shannon Diversity Index (H): The basic principle behind the application of Shannon diversity index is that polluted water bodies harbour low species diversity as compared to unpolluted water. The Shannon index calculated for Station E and S_1 was less than<1.00 (**Table 4.**) indicating high organic pollution. From station S_2 to S_4 the index value increases slightly and falls in the range 1.00 to 2.00 indicating moderate pollution. From station S_5 to S_6 the index was found in the range 2.00 to 3.00, which is an indication low pollution level. The results reflect that diversity index increased with decreasing pollution load in the downstream direction which is in conformity of the observations of Nandan and Patel (1986), Barua (1995), Adhikari (1997), Ramakrishnan (2003), Mathivanon et al (2007) Dash (1996) and Khan (1991). The gradual increase in species diversity towards downstream with simultaneous decrease of pollution load may be due to dilution or self-purification of capacity of the beel or may be due to bacterial decomposition of organic pollutants. Tarzwell and Gaufin (1953) demonstrated that organic waste were decomposed by the action of bacteria at septic zones and recovery zones which may be the reason for the gradual building up of the phytoplankton population in this zones. The low value of Shannon index (0.89) near the effluent discharge site (station E) and highest mean value (2.81) at the farest sampling site (station S_6). Low values of Shannon index were recorded during rainy season and higher value in summer season at all sites. This may be due to downpour of rainfall in the rainy season. Adesalu and Nwankwo (2008) and Rajagopal et al (2010) also reported that the low value of Shannon's index for phytoplankton population in rainy season is due to dilution of medium, water loss through outlet and silting. Bajpai and Agakar (1997) reported that the species diversity would be low following disturbances such as flood, regular inflow and out flow of water. The correlation analysis between Shannon index and physico-chemical parameters [**Table-5-7]** showed that Shannon diversity is negatively correlated with most of the chemical parameter of water. But has positive correlations with pH ($r = 0.337$), TSS ($r = 0.941$), Turbidity ($r = 0.979$) and DO ($r = 0.957$) [**Table-6**]. This means that the water quality parameters such as temperature, pH, turbidity and dissolved oxygen play a vital role in altering the phytoplankton species diversity of Beel.

Trophic State Index (TSI): The trophic level of an ecosystem is generally evaluated from the content of nitrogen, chlorophyll, transparency and biological parameters. The total nitrogen (N) and phosphorus (P) ratio (TN/TP) is considered as an important parameter in calculating the Trophic State Index of an ecosystem. In our study, the TN/TP ratio was utilized to ascertain TSI based on which Elenga Beel wetland can be classified. For this Carlson's equation were used. Higher values of TSI (60-100) were recorded at station E to S_4 which indicated eutrophic nature of the water body. The lower values of TSI (<60) at station S_5 to S_6 is the indicative of oligotrophic nature of the beel. In Elenga Beel, both nitrogen and phosphorus act as limiting factors to some extent for phytoplankton growth. The relative abundance of Cyanophyceae and Bacillariophyceae were closely related to N: P ratio. In this investigation, Cyanophycean algae was found to be dominant at stations E to S_4 where N: P = <7:1. Bacillariophyceaen algae was dominant at station S_5 and S_6 where N: P= > 7:1. Similar results were observed by Tonno and Noges (2003), and Havenes et al. (2003). It was observed that in all the sampling site of Elenga Beel TN/TP ratio is <10:1 which indicates that the ecosystem is nitrogen limited with much more phosphorus that is found in natural wetland. Although paper mill effluent (untreated) is deficient in nitrogen (N) and phosphorous (P), solution of urea and super phosphate are added in the ratio **BOD: N: P=100:5:1** for biological treatment of effluents in aerated lagoon or polishing pond system to feed the microorganisms (Kalita et al., 2002). This may be the reason for entry of excess amount of N and P nutrients into the Beel water which may lead to excessive growth of BGA at station E to S_4 leading to eutrophic state of water. The occurrence BGA in station E to S_3 was also evident from algal data as shown in **Table 1.** Thus from the foregoing discussion it can be concluded that Elenga Beel (wetland) shifted from oligotrophy to eutrophic due to entry of effluents from Nagaon Paper Mill (NPM). Lowering of TSI at station S_5 and S_6 may also be due to the self-purification process or dilution of beel water. Berthon et al. (1996) states that bloom of Cyanobacteria are due to the drop of N/P ratio below 7, which is the threshold level for algae. When the ratio reaches below 5, algae collapse giving way to cyanobacteria which accept low N/P ratio. In our study, the ratio on N/P is <5 at Station E which support Cyanobacterial growth in paper mill effluents as observed by Venkateswarlu (1991) as earlier. Thus based on result **conclusions** can be drawn that Elenga Beel wetland an ecosystem was greatly affected by the discharge of effluents from Nagaon Paper Mill (NPM) which need further investigation. . For achieving this, short term and long term objectives should be formulate by the mill authority with much R & D work primarily in the area of Environmental biotechnology for enhanced bioremediation.

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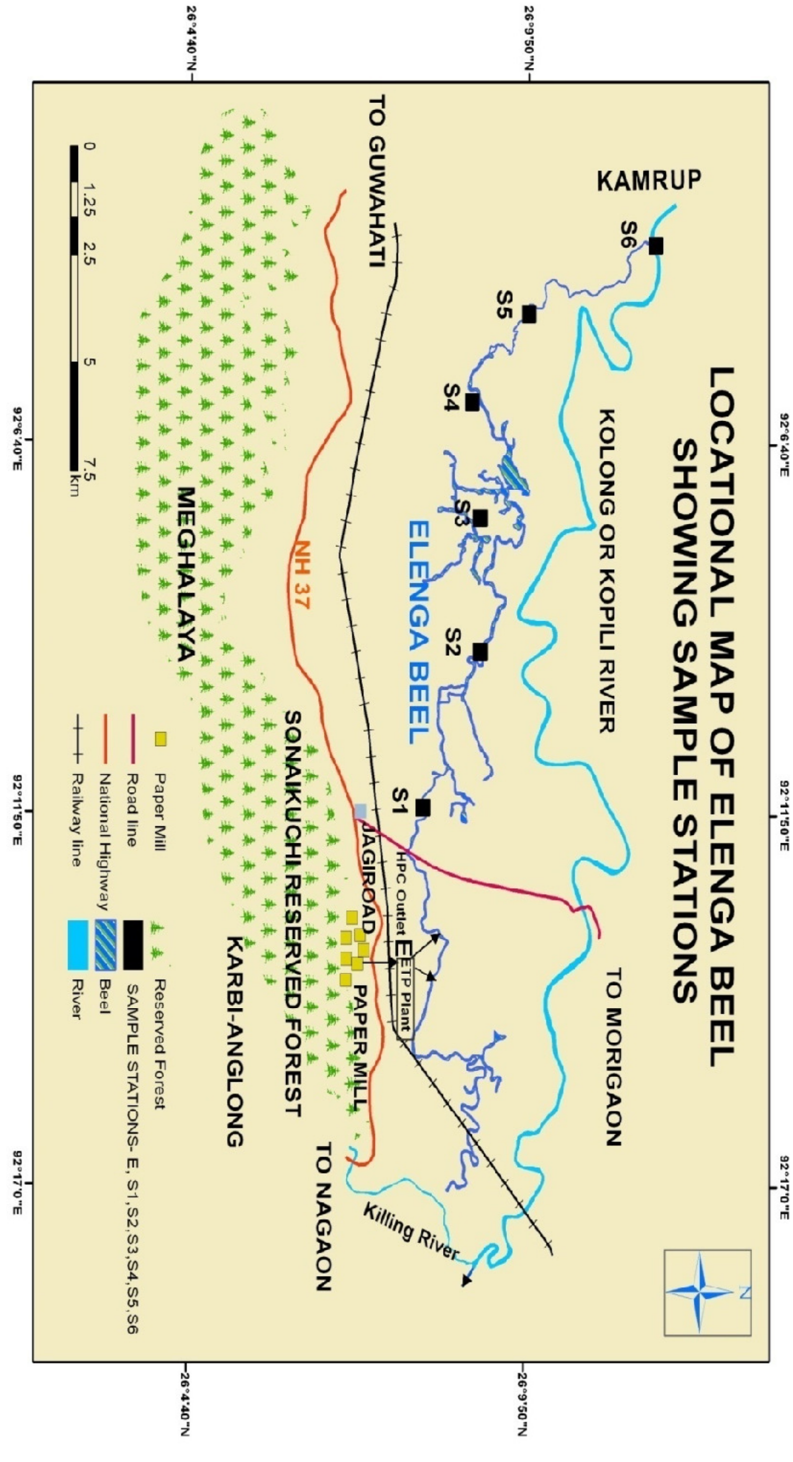
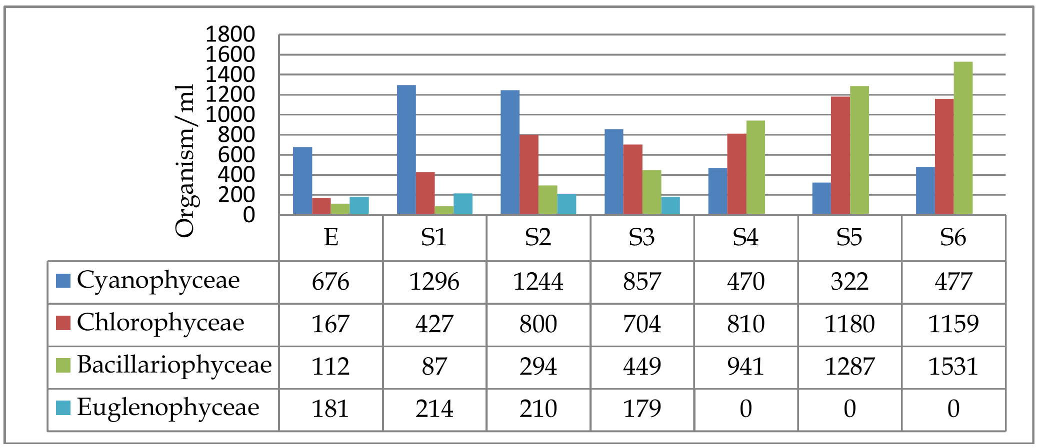


Map 1. Location Map of Elenga Beel (Wetland) showing Sampling Stations (E-S6)[map prepared by using Arc 9.3 GIS software).

Table 1. Summary Data: Total Phytoplankton's counts during the study period.

Taxa	E	S1	S2	S3	S4	S5	S6	Annual average Org/ml
Cyanophyceae	676	1296	1244	857	470	322	477	5342
Chlorophyceae	167	427	800	704	810	1180	1159	5247
Bacillariophyceae	112	87	294	449	941	1287	1531	4701
Euglenophyceae	181	214	210	179	0	0	0	784
Total	1136	2024	2548	2189	2221	2789	3167	16074

A



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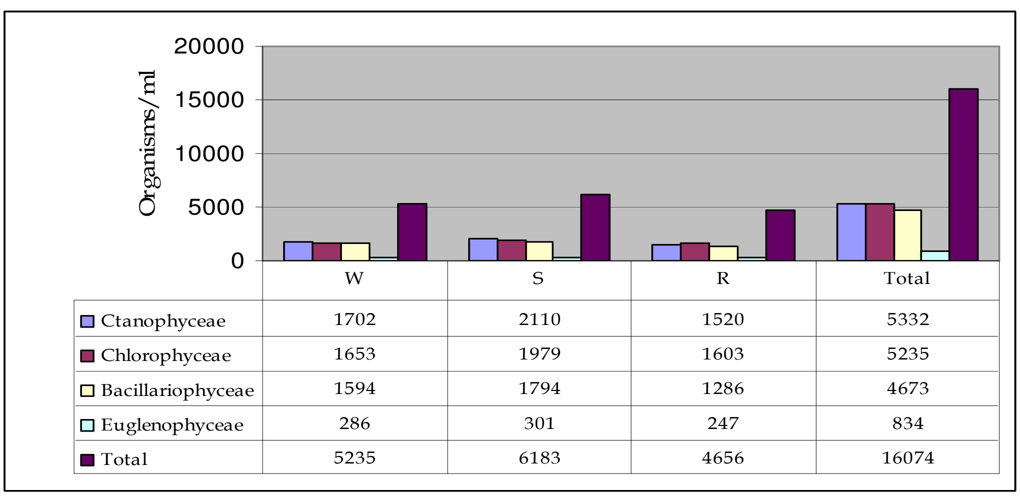


Figure 1 A & B. Yearly average (A) and Seasonal mean (B) value of different algal Groups encountered during the study period.

Table 2. Palmer Pollution tolerant genera (palmer, 1969) of algae found in different sampling Station of Elenga Beel (wetland).

Algal Genera	PPI	S A M P L E S T A T I O N						
		E	S1	S2	S3	S4	S5	S6
Oscillatoria	4	+(4)	+(4)	+(4)	+(4)	-	-	-
Phormidium	1	+(1)	+(1)	-	-	-	-	-
Anabaena	-	+	+	+	+	+	+	+
Microcystis	1	+(1)	+(1)	+(1)	+(1)	+(1)	+(1)	+(1)
Spirulina	-	-	+	+	+	+	-	-
Chroococus	-	-	+	+	+	-	-	-
Lyngbya	-	-	+	+	+	-	-	-
Ankistrodesmus	2	-	+(2)	+(2)	+(2)	+(2)	+(2)	-
Chlorella	3	+(3)	+(3)	+(3)	+(3)	-	-	-
Scenedesmus	4	-	+(4)	+(4)	+(4)	+(4)	+(4)	+(4)
Cosmerium	-	-	-	-	-	+	+	+
Spirogyra	-	-	-	+	+	+	+	+
Actinostrum	-	-	-	+	+	+	-	-
Ulothrix	-	-	-	-	-	+	+	-
Pediastrum	-	-	-	-	-	+	-	+
Closterium	1	-	-	-	-	+(1)	+(1)	+(1)
Navicula	3	+(3)	+(3)	+(3)	+(3)	+(3)	+(3)	-
Nitzschia	3	+(3)	+(3)	+(3)	+(3)	+(3)	+(3)	+(3)
Gomphonema	1	+(1)	+(1)	+(1)	+(1)	+(1)	-	-
Syndra	2	-	-	-	+(2)	+(2)	-	-
Pinnularia	-	-	-	-	+	+	+	+
Fragillaria	-	-	-	+	+	-	-	-
Euglena	5	+(5)	+(5)	+(5)	-	-	-	-
Phacus	2	+(2)	+(2)	+(2)	+(2)	+(2)	-	-
No. of Pollution Tolerant Genera		**10**	**15**	**17**	**18**	**17**	**11**	**09**
No. of Pollution Index genera		**9**	**11**	**10**	**10**	**9**	**6**	**4**
Pollution Index for algal genera		**23**	**29**	**28**	**25**	**17**	**14**	**9**

+ (Present), - (Absent) Figures in parentheses indicate respective pollution indices

Table 3. Palmer Pollution tolerant (Palmer's 1969) species of algae found at different sampling Station of Elenga Beel (wetland).

Algal Species	PPI	S A M P L E S T A T I O N						
		E	S1	S2	S3	S4	S5	S6
Oscillatoria chlorine	**4**	+(4)	+(4)	+(4)	+(4)	-	-	-
Oscillatoria princeps	**1**	+(4)	+(4)	+(4)	+(4)	-	-	-
Oscillatoria tenuis	**4**	+(4)	+(4)	-	-	-	-	-
Oscillatoria amoena	**-**	+	+	+	+	-	-	-
Anabaena naviculoides	**-**	+	+	+	+	+	+	+
Microcystis robusta	**-**	+	+	+	+	+	+	+
Ankistrodesmus falcatus	**2**	-	+(2)	+(2)	+(2)	+(2)	+(2)	-
Chlorella vulgaris	**2**	+(3)	+(3)	+(3)	+(3)	-	-	-
Scenedesmus quadricauda	**4**	-	+(4)	+(4)	+(4)	+(4)	+(4)	+(4)
Pediastrum duplex	**-**	-	-	-	-	+	-	+
Cloterium moniliferum	**-**	-	-	-	-	+(1)	+(1)	+(1)
Navicula andrium	**-**	-	-	-	-	+	+	+
Nitzchia linearis	**-**	-	-	-	+	+	+	+
Gomphonema parvulum	**1**	+(1)	+(1)	+(1)	+(1)	+(1)	-	-
Syndra ulna	**3**	-	-	-	-	+(3)	+(3)	-
Euglena acus	**-**	+	+	+	-	-	-	-
Phacus pleuronectes	**-**	+	+	+	+	+	-	-
Number of Tolerant Species		**10**	**12**	**11**	**11**	**11**	**8**	**7**
Number of pollution index species		**5**	**7**	**6**	**6**	**5**	**4**	**2**
Pollution Index for algal Species		**16**	**22**	**18**	**18**	**11**	**10**	**5**

Table 4. Shannon Diversity values of different Sample Stations of Elenga Beel wetland (Annual & Seasonal Mean).

Sample Stations	**Shannon Diversity**			**Annual mean**
	Winter	Summer	Rainy	
E	0.87	0.98	0.83	0.89
S1	0.92	1.04	0.80	0.94
S2	1.07	1.26	0.96	1.09
S3	1.62	1.86	1.54	1.67
S4	1.87	1.93	1.69	1.83
S5	1.88	2.47	2.26	2.20
S6	2.64	3.23	2.58	2.81

Table 5. Trophic State Index (TSI) of different sampling station of Elenga Beel (Annual Mean) during 2007-2009.

Sample Station	TN & TP		TN/TP	TSI	Wetland Type
	N	P			
E	4.68	1.02	4.58	82	Eutrophic
S1	4.14	0.84	4.92	78	Eutrophic
S2	4.84	0.76	6.36	77	Eutrophic
S3	5.07	0.75	6.76	67	Eutrophic
S4	3.75	0.54	6.94	64	Eutrophic
S5	2.62	0.33	7.93	56	Oligotrophic
S6	2.04	0.24	8.50	37	oligotrophic

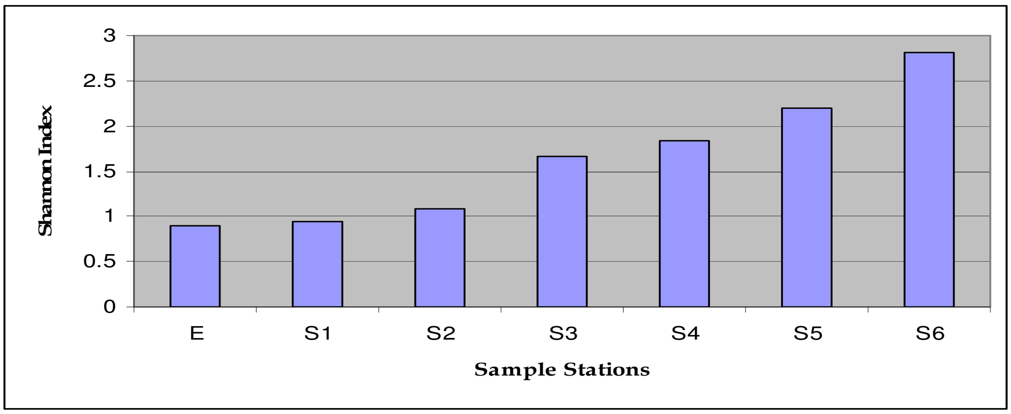


Figure 2. Shannon Diversity Index at Different Sample Stations of Elenga Beel during 2007-2009 (Annual Mean).

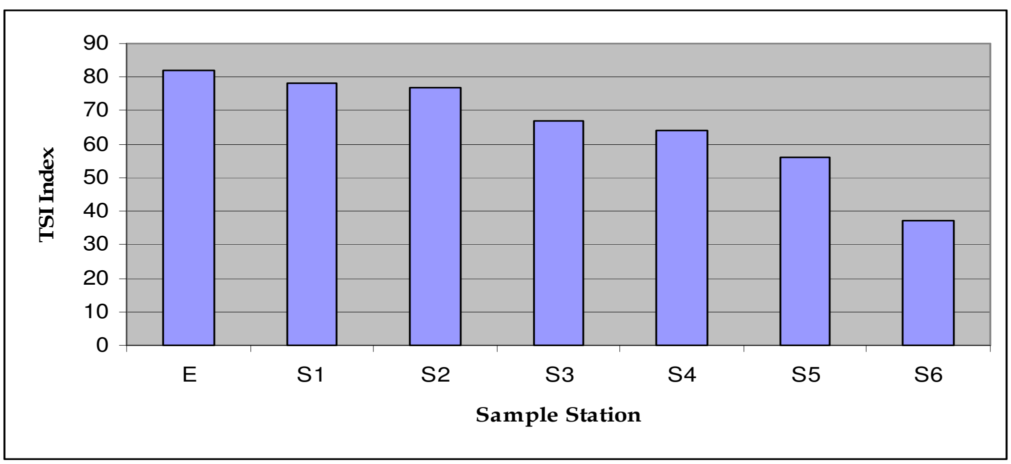


Figure 3. Trophic State Index (TSI) at different sample Station of Elenga Beel period 2007-09 (Annual mean).

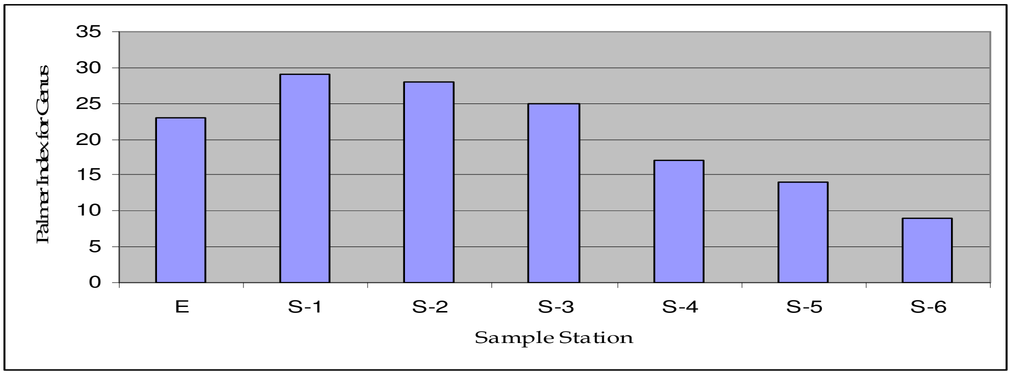


Figure 4. Palmer pollution Index for Genus at different Sample Station of Elenga Beel wetland (Annual mean).

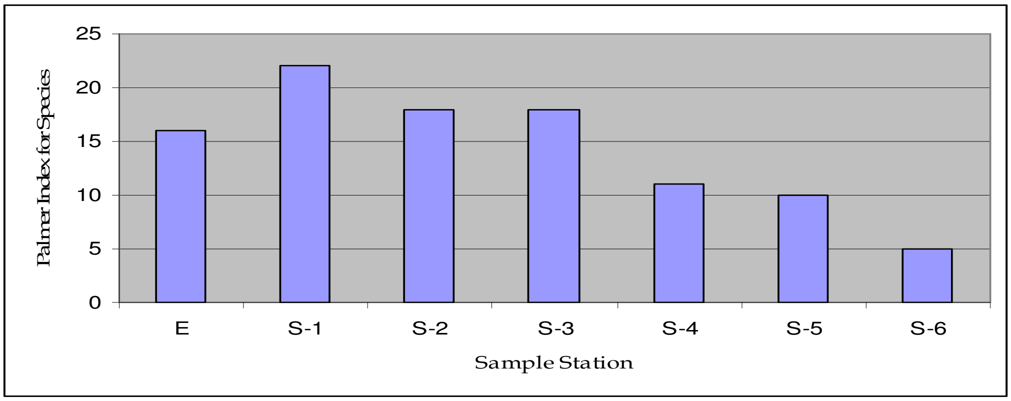
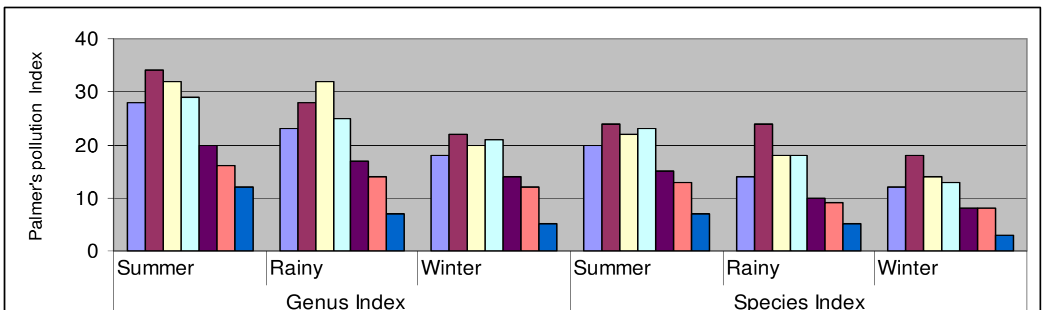


Figure 5. Palmer pollution Index for Species at different Sample Station of Elenga Beel wetland (Annual mean).



	Summer	Rainy	Winter	Summer	Rainy	Winter
	Genus Index			Species Index		
E	28	23	18	20	14	12
S1	34	28	22	24	24	18
S2	32	32	20	22	18	14
S3	29	25	21	23	18	13
S4	20	17	14	15	10	8
S5	16	14	12	13	9	8

Figure 6. Palmer pollution Index scores for Genus and species at different stations (seasonal mean).

Table 6. Correlation between Pollution Indices and Physico-Chemical parameters of Elenga Beel wetland [Using SPSS 9.0].

Parameters	Palmer Pollution Index(PPI)			Shannon Diversity Index			TSI			Mean	SD
	Pearson Correlation	Significant (2-tailed)	N	Pearson Correlation	Significant (2-tailed)	N	Pearson Correlation	Significant (2-tailed)	N		
Temperature	.767*	0.044	15	-.917**	0.004	15	.902**	0.005	15	28.62	2.7
P^H	-0.405	0.367	15	0.337	0.46	15	-0.244	0.598	15	8.3	0.14
Conductivity	.925**	0.003	15	--.980**	0	15	-.984**	0.003	15	1.27	0.04
TSS	.919**	0.003	15	.941**	0.002	15	.936**	0.002	15	3.78	0.13
TDS	-.936**	0.002	15	-945**	0.001	15	.958**	0.001	15	1180.86	93.84
TS	.922**	0.003	15	-.992**	0	15	.982**	0	15	1690.05	54.59
Turbidity	-.923**	0	15	.979**	0	15	-.993**	0	15	25.54	45.45
Dissolve Oxygen(DO)	-.929**	0.002	15	.957**	0.001	15	-.959**	0.001	15	0.76	0.03
BOD	.932**	0.002	15	-.987**	0	15	0.963	0	15	389.29	5.16
COD	.944**	0.001	15	-.954**	0.001	15	.932**	0.002	15	538.57	14.48
Total alkalinity	.889**	0.001	15	-.837*	0.019	15	.865*	0.012	15	309.38	11.42
Total Nitrogen(N)	.863*	0.012	15	-.948**	0.001	15	.938**	0.002	15	3.88	1.09
Total Phosphorus(P)	.865*	0.012	15	-.978**	0	15	.963**	0.001	15	0.64	0.27
Sulphate	.820*	0.024	15	-.960**	0.001	15	.922**	0.003	15	151.52	10.94
Total Hardness	.786*	0.036	15	-.947**	0.001	15	.897**	0.006	15	543.05	61.78

*** Correlation is significant at the 0.05 level (2-tailed).**
**** Correlation is significant at the 0.01 level (2-tailed).**

Table 7. Physico-Chemical characteristics water quality of Elenga Beel wetland at different locations and seasons. (Annual mean and ± SD).

Parameters	E	S-1	S-2	S-3	S-4	S-5	S-6
Temperature	30	29	29	28	27	27	26
	±4.00	4.00	3.00	3.60	3.60	2.64	3.00
P^H	8.5	8.43	8.36	8.3	8.25	8.20	7.50
	±0.346	0.115	0.02	0.05	0.15	0.5	0.5
Conductivity. mmho/cm	1.34	1.31	1.29	1.22	1.10	1.09	0.90
	0.010	0.01	0.01	0.025	10.78	0.04	6.65
Total Suspended Solids	3.91	3.89	3.84	3.51	3.25	1.94	1.76
(TSS) mg/L	0.021	0.01	0.030	0.08	0.01	0.09	0.18
Total Dissolved	1311	1264	1240	1231	981	641	385
Solids(TDS)mg/mL	28.431	64.00	48.12	110.02	74.48	89.47	81.14
Total Solids(TS)	1761	1630	1563	1286	1007	729	367
	52.82	50.90	55.51	40.50	14.46	41.78	48.86
Turbidity,NTU	133	130	127	215	231	307	452
	4.725	6.00	7.09	4.041	31.37	18.90	42.25
Dissolve Oxygen(DO)	0.75	0.76	0.77	1.05	1.22	2.04	2.36
mg/mL	0.058	0.06	0.015	0.09	0.14	0.14	0.2
Biochemical Oxygen	396.33	388	370	315	262	206	167
Demand(BOD)mg/mL	2.516	7.57	10.00	10.14	21.77	13.45	0.13
Chemical Oxygen	553	493	423	376	302	241	147
Demand(COD)mg/mL	7.57	37.85	49.32	19.07	22.72	25.00	19.65
Alkalinity,mg/mL	322	315	303	287	208	192	161
	6.65	5.56	6.11	11.50	6.02	11.01	5.6
Total Nitrogen(TN) in ppm	4.68	4.14	4.84	5.07	3.75	2.62	2.04
	0.02	0.15	0.011	0.01	0.02	0.20	0.2
Total phosphorus(TP) in	1.02	0.84	0.76	0.75	0.54	0.33	0.24
ppm	0.02	0.03	0.009	0.0025	0.04	0.06	0.4
Sulphate in ppm	168	158	137	117	108	94	83
	3.05	5.29	4.93	12.34	5.50	15.39	6.55
Total	610	586	514	264	303	204	156
Hardness in ppm	49.72	57.71	13.79	10.06	19.42	28.37	26.50

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