RESEARCH ARTICLE

PLANKTON COMPOSITION AND WATER QUALITY ANALYSIS OF BATTICALOA LAGOON AT SOLID WASTE DUMPING SITE, ERAVUR, SRI LANKA.

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ABSTRACT

Study was aimed to assess the composition, richness of plankton species with physico-chemical water quality parameters. Total of six sampling stations (L1-L6) were selected for this survey through a transect line along the lagoon from the land at different distance. Study was carried out for three months, fortnightly. The water quality parameters and plankton were measured by standard procedure. Total of 83 species of phytoplankton of six divisions were identified in which Bacillariophyceae is most diverse (50% composition) followed by Chlorophyceae, Charophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae. Total of 26 species of zooplankton of five divisions were recorded, in which rotifers account for most diverse group (63% composition). Nitrate, phosphate and dissolved oxygen level showing variation ($P < 0.05$) along the sampling points. The composition and abundance of plankton species were strong positively correlated with nitrate, phosphate, turbidity and electrical conductivity; pH, dissolved oxygen, temperature and salinity were negatively correlated. The presence of bio-indicators was evident that the lagoon is subjected to pollution. The sampling point near to land (L1) resulted nutrition rich condition than the sampling points distanced from land into lagoon (L2-L6). Proper mitigation ways against pollution inputs (solid-waste dumping) were needed to ensure lagoon utilization in sustainable manner.

Keywords: *Abundance, Bio-indicators, Correlation, Plankton, Water quality*

1. INTRODUCTION

Municipal solid waste is an increasing problem in urban areas of Sri Lanka [1]. Specifically, haphazard solid waste disposal is the major cause for environmental degradation in National Action Plan of Sri Lanka, where still open dumping remaining as

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common disposal method of Municipal Solid Wastes, leading to environmental and health problems [2]. Presently the Batticaloa Municipal Council operates open municipal solid- waste dumping sites at Kattankudy and Eravur. According to Eravur Urban Council Report (2014), due to lack of suitable landfill site and financial constraints all collected wastes were dumped close proximity to lagoon. Those wastes taken into the lagoon during flood and heavy rainy periods. Further they were dug out by animals and birds spread into the lagoon as well [3]. The important physico-chemical parameters of water body include temperature, salinity, dissolved oxygen, pH, nitrogen, phosphorus, total suspended solid, total dissolved solid which are function as limiting factors of aquatic life [4]. Biological organisms, especially planktons are the natural bioindicators due to their ability to respond rapidly to fluctuating environmental conditions [5]. Phytoplankton distribution, abundance, species diversity, species composition can be used as a tool to assess the biological integrity of lagoon ecosystem [6]. Any changes in species composition, abundance and distribution of zooplankton can indicate the environmental disturbances; therefore, they have the potential of used as pollution indicators [7]. This study focused on the effect of solid wastes on the lagoon water by analyze the species composition, abundance and diversity of planktons along with the water quality at solid-waste dumping site, because of their ecological and economical importance.

2. MATERIAL AND METHODS

2.1 Study area

The study area is located near to the urban council of Eravur, in Batticaloa district, East coast of Sri Lanka, in between the geographical coordinates of 7.7704463^0 N, 81.599996^0 E and 7.764025^0 N, 81.600969^0 E.

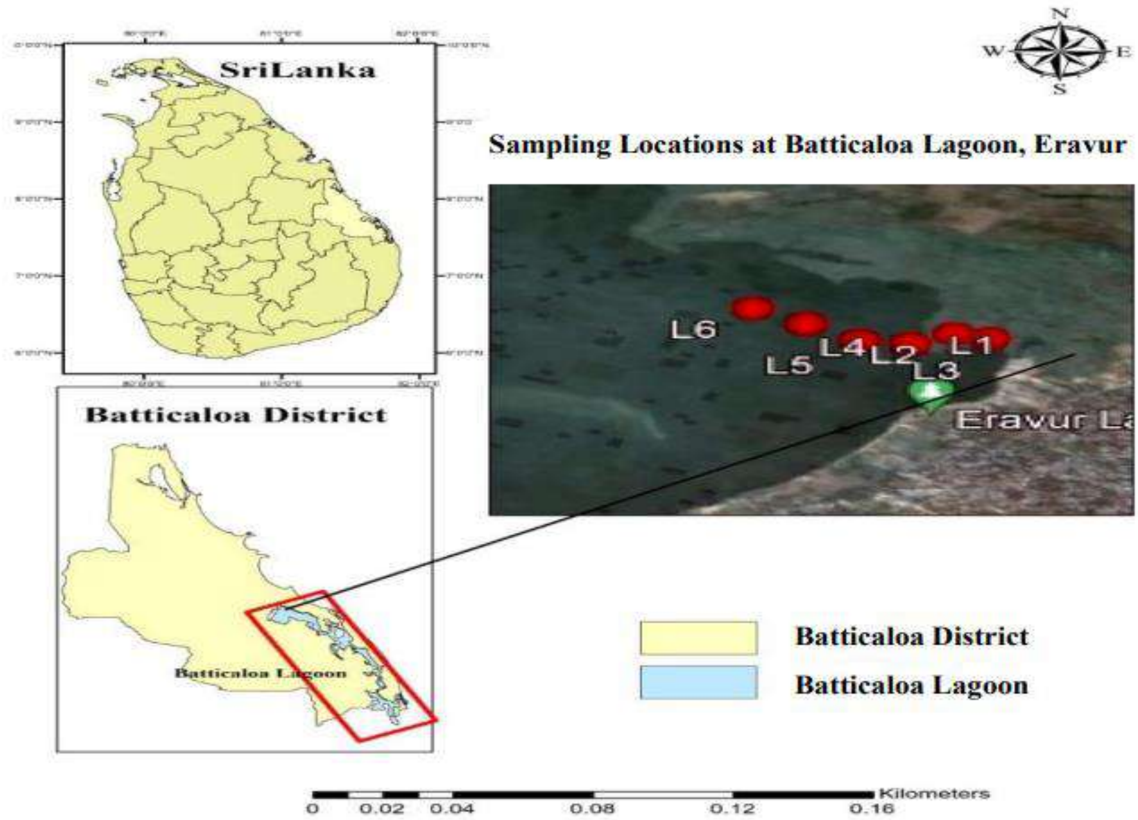

Figure 1: Study area with sampling stations

Samples were collected six stations from the shore towards the lagoon near to the municipal dumping site as shown in the Figure 1 using line transect method. The sampling stations were marked as L1 – L6. Except the L1, in between the other points 100 M distance maintained in order to avoid biased. L1 located in the shore of the lagoon. Remaining all points (L2-L6) within the lagoon.

2.2 Plankton sampling

Plankton samples were collected by using plankton net (55 µm mesh size, Hydro Bios, Germany) that towed horizontally in the surface layer of water for 10 minutes, at low speed as prescribed [8]. Then the net was hauled in and the water sample was transferred in to a labelled plastic container (250 ml). Phytoplankton sample were fixed immediately on Lugol's solution at the ratio of 100:1 [9]. Zooplankton samples were fixed in 4% formalin as per the reference [8]. The plankton samples were permitted to settle for 24 hours. Then the samples were concentrated to 10 ml by decanting supernatant aliquot.

Then a representative of 1ml of sample from each concentrated sample was added to a Sedgewick Rafter counting chamber, coverslip was added and all the individuals present in the sample were observed [10] under the binocular light microscope (OPTIKA, B-150) at different magnification levels (X40, X100 and X400). The photographs of observed planktonic organisms were taken at high magnification level (X400). The species in the samples were counted by observing at low, medium and high magnification level (X40, X100 and X400). The encountered planktons were identified to lowest taxonomic level using standard identification keys and relevant text books [2], [11], [12].

2.3 Water quality parameter analysis

Water samples were collected by dipping well labeled sterilized (500 ml) sample collecting glass bottle at each sampling stations about 10 to 15 cm below the surface water column as per the prescription [9]. Water quality parameters such as pH, nitrate (NIT), phosphate (PHO), dissolved oxygen (DO), salinity (SAL) were chemical parameters and total dissolved solid (TDS), electrical conductivity (EC), turbidity (TUR), temperature (TEM) were physical parameters in the water body. The samples were immediately transferred and measured.

2.4 Plankton diversity indices

Shannon-wiener diversity index [13]

$H' = -\sum \mathrm{P}i \, ln \, (\mathrm{P}i)$

Whereby,

Pi is proportion of total number of individuals.

ln (Pi) is logarithm of total number of species

Margalef's richness diversity index [3]

$M = (S-1) / ln \, \mathrm{N}$

whereby, S is total number of species

N is total number of individuals

2.5 Statistical analysis

The statistical analysis was performed by using Minitab 21.0 Geo-statistical version. The variation of water quality parameters collected at each sampling stations were done by using One-way unstacked ANOVA test. The relationship between plankton species abundance and composition with physico-chemical parameters of water was developed with Correlation test for the divisions Bacillariophyceae, Cyanophyceae, Chlorophyceae of phytoplankton and rotifers, arthropods of zooplankton.

3. RESULTS AND DISCUSSION

3.1 Analysis of water quality of parameters

According to the results, the nitrate, phosphate nutrient level of lagoon water gradually decreases from L1 to L6; whereby nitrate, in between the range of 1.39 ± 0.05 mg/L to 0.4 ± 0.03 mg/L and phosphate in between the range of 0.17 ± 0.006 mg/L to 0.01 ± 0.001 mg/L. As the waste accumulation with lagoon near to land (L1) is more; also, with increasing distance dilution of nutrients in water may occur. Therefore, dissolved oxygen value gradually increases 6.91 ± 0.07 mg/L to 8.97 ± 0.06 mg/L. some parameters fluctuate within L1 – L6; such as mean Turbidity of lagoon ranges in between 8.81 ± 0.17 NTU to 7.54 ± 0.12 NTU, Electrical conductivity of lagoon in between 8424.43 ± 16.88 µS/cm to 8878.43 ± 112.29 µS/cm, TDS level of lagoon in between 7.83 ± 0.03 ppt to 8.03 ± 0.03 ppt and pH level in between 7.0± 0.026 to 7.33 ± 0.038. salinity of water at study area ranged between 2.986 ± 0.309 ppt and 3.414 ± 0.334 ppt, indicates the same salinity water body. Temperature of lagoon remained to be ranges in between 32.29^0C ± 0.33^0 C to 32.84^0C ± 0.36^0C.

3.2 Phytoplankton analysis

From the present study a total of 83 individual species of phytoplankton belongs to six different divisions were identified along the sampling stations. Among them Bacillariophyceae is the most diverse representing 42 species (>50% of abundance). Followed by Chlorophyceae consist of 13 species, Charophyceae 10 species, Dinophyceae and Euglenophyceae each division consist of 5 species respectively. While Cyanophyceae represents 8 species only.

The phylum Bacillariophyceae is represented by the species *Chaetoceros* sp, *Navicula* sp, *Nitzschia* sp, *Coscinodiscus* sp (Figure 2); In the phylum Cyanophyceae species *Anabaena* sp, *Nostoc* sp, *Microcystis aeruginosa*, *Oscillatoria* sp; In the phylum Chlorophyceae species *Eudorina* sp, *Chlorella* sp were occurred at high abundance.

This abundance pattern of phytoplankton community is correlated with nutrient conditions of lagoon [14]. Therefore, composition and abundance pattern are the reliable parameters to assess the degree of pollution [15]. Their variation in existence, richness and distribution pattern reflects the polluted nature of lagoon [16], [17]. For this purposes Cyanophyceae, Chlorophyceae and Bacillariophyceae are widely used pollution bioindicators [18].

Table 1: Phytoplankton species and their occurrence along sampling stations

Division	Species	L1	L2	L3	L4	L5	L6
Bacillariophyceae	*Cyclotella* sp	3	2		1		
	Chaetoceros sp	45	23	35	15	9	7
	Campylodiscus sp	1	1		1		1
	Diatoma sp	1					
	Gyrosigma sp	5	3	2	3	1	2
	Pleurosigma sp	2	2	1		1	1
	Cymbella sp	3	1	1			1
	Coscinodiscus sp	35	28	30	24	15	13
	Fragilaria sp	3					
	Navicula sp	19	15	11	13	7	9
	Nitzschia sp	25	23	18	12	9	11
	Aulacosera sp	8	5	5	4	6	4
	Bacillaria sp	1					
	Pseudonitzschia sp	3		1	3		
	Thalassiora sp			4			
	Melosira sp		2				
	Pennate diatom	1					
	Pinnularia sp	3	1	1	2		
	Cymatopleura sp		1				
	Surirella sp	2					
	Stenopterobia sp	4		2			
Chlorophyceae	*Scenedesmus* sp	1					
	Desmodesmus sp		1				

	Eudorina sp	85	70	80	84	75	78
	Chlorella sp	45	48	35	40	30	35
	Crucigenia sp	4					
	Oocystis sp	1	2	1	1		
	Lagerheimia sp		2				
	Pediastrum sp	4	1	2	2	1	1
Charophyceae	*Spirogyra* sp	1	1			1	1
	Closterium sp	2	1				
	Sirogonium sp		1				
	Staurastrum sp	5	2	2	3	1	1
	Staurodesmus sp	2	1				
Cyanophyceae	*Anabaena* sp	45	44	43	40	40	35
	Nostoc sp	85	80	84	87	75	90
	Microcystis sp	43	40	33	25	35	20
	Merissmopedia sp		2		1		
	Lyngbya sp	5	5	3		3	1
	Spirulina sp	1		1		1	
	Oscillatoria sp	39	25	29	10	5	5
	Gloeocapsa sp		1				
Dinophyceae	*Trachelomonas* sp		2				
	Protoperidinium sp	1		2	1	1	
	Diplopsalis sp			1			
	Ceratium sp	1					
Euglenophyceae	*Euglena* sp	4	3	1	3	1	3
	Phacus sp	1			2		

As per the Table 1, L1 had higher number of species of phytoplankton in terms numbers. Further their occurrence showed a considerable decrease from L1-L6 with distance from dumping site. Also, class Cyanophyceae, Chlorophyceae and Bacillariophyceae are the important pollution indicators [18]. Higher occurrence of Cyanophyceae, Chlorophyceae and Bacillariophyceae form L1-L6 as a piece of evidence those sites subjected to contamination of organic pollutant from municipal leachate. Further analysis elucidated variation of individual counts and species number confirmed the degree of pollution are not same among the study sites.

The genera such as *Euglena* sp, *Oscillatoria* sp, *Scenedesmus* sp, *Navicula* sp, *Nitzschia* sp and *Microcystis* sp were commonly found in organically polluted waters [19]. Data represented in Table 1, also agreed with the above findings and favor the growth of those pollution tolerant species. Peak abundance of species recorded in L1. Their abundance showing decrease trend from L2-L6. This finding revealed that organic pollution load higher in close proximity of dumping site and decreases with the distance due the dilution by lagoon water.

Microcystis sp and *Ceratium* sp present in the high phosphate waters while the presence of *Anabaena* sp indicate the condition of water with slight Nitrogen content [20]. However, *Ceratium* sp only recorded in L1 for the entire sampling campaign. *Anabaena* sp shows common abundance in all sampling stations, which indicate the contamination of nitrogen rich organic nutrient common for all study sites. Further presence of *Oscillatoria* sp and *Spirulina* sp and its ability to fixing of dissolve nitrogen might be the one reason to decrease the trend form L1-L6 this finding also agreed with similar study [21].

Blue-green algae (notably *Oscillatoria* sp) common in fresh to low brackish water area [22] where, the occurrence of organic nutrition pollution is moderate to high level. L1 had relatively high abundance of *Oscillatoria* sp due to the solid waste contamination may favor their growth and proliferation. Relatively L2, L3 also having low salinity and had moderate abundance while L5, L6 were recorded with very least numbers. This findings agreement with above study [22].

The Euglenoids (*Euglena acus*, *Phacus* sp) associated with the freshwater conditions and areas with high nutrient level [22]. However, findings from the present study due to the lower abundance of Euglenoids across the study sites cannot be able to derive any concrete decision based on their existence.

In the class Chlorophyceae *Eudorina* sp, *Chlorella* sp and *Pediastrum* sp were high in number along L1-L6 sampling stations and highly dominant species among the class Chlorophyceae.

Among the Chlorophycea, *Eudorina* sp, *Chlorella* sp and *Pediastrum* sp were shows cosmopolitan distribution across the study sites meanwhile *Scenedesmus* sp reported only in L1 due to the low nutrient levels are not favored their proliferation. The occurrence and abundance of *Chlorella* sp also interpreted as an indicator of early warning to the aquatic ecosystem [23, 24]. If not regulated nutrient entry it will lead to higher proliferation in future.

The species *Melosira* sp and *Cyclotella* sp are usually found in clean water [25]. Even though these species were present in the study area cannot be interpret those sites were clean because they are not found in higher abundance.

Moreover, dominance of genera *Protoperidinium* sp, *Trachelomonas* sp were usually also associated with organic nitrogen content [26]. These species were present in L1-L5 in lower abundance. The dilution of dissolved nutrients from the shore to lagoon (L1-L6) found as decreasing trend this reflection determines the species abundance of bioindicator phytoplankton.

Shannon-Weiner’s diversity index shows that species distribution and diversity is comparatively decreased along with increase in distance of lagoon from land area of pollution source. L1 has high diversity index of 2.7, where L6 has low diversity index of 2.1. This indicated that the phytoplankton has relatively moderate to high species distribution and diversity. Margalef’s species richness values ranging from 5.882 in L1 to 3.296 in L6 sampling point. Where by high specie richness found in L1. L1 is subjected to high contamination with pollution and low value observed for L6.

3.3 Zooplankton analysis

Total of 26 individual species of zooplanktons belongs to five different phyla were recorded here. Among them Rotifers contributing major dominance in composition, it consists of 17 species (about 63% composition). Next major group is Arthropoda, that consist of 7 species (about 26% composition) in total. Other phylum such as Coelenterate (3% composition), Annelida (4% composition) and Mollusca (4% composition) each consist of only one species of respective group.

Table 2: Zooplankton species and their occurrence along sampling stations

Division	Species	L1	L2	L3	L4	L5	L6
Rotifer	*Brachionus* sp	94	95	110	95	109	108
	Keretella sp	155	145	148	135	140	125
	Lecane sp	4	3	3	1	2	1
	Asplachna sp	57	43	45	49	51	43
	Filinia sp	10	3	1	1	2	2
	Rotifer sp (1)	7					
	Rotifer sp (2)	5					
	Rotifer larva		1		1	1	
	Synchaeta sp	1					
	Polyarthra sp	3		3			
Coelenterate	*Actinula* larva	4	3	2		4	
Annelida	Tinnitids	2	2	1		3	2
Mollusca	Veliger larva				2		5
Arthropoda	*Cyclops* sp	22	17	18	18	18	15
	Acartia sp	4	2	2	1		3
	Calanoid sp	2	1	2		1	1
	Nauplius larva	33	25	28	18	20	15
	Cyclopidae sp	12	15	14	9	11	13
	Acrocalanus sp	1	2	1		3	

The phylum Rotifer consist with the species *Brachionus* sp, *Keretella* sp, *Lecane* sp, *Filinia* sp (shown in Figure 2); The phylum Arthropoda represented by the species Cyclops sp, Nauplius larva at high occurrence as shown in Table 2.

The sampling points L1 - L6 consist of high abundance of Rotifer and Arthropoda as recorded in Table 2. Along with, abundance of species was comparatively less in L6 than L1. Among the Rotifers *Keratella* sp has the highest occurrence followed by *Brachionus* sp, then by *Asplachna* sp. Among the Arthropods, nauplius stage of organism was more common, followed by cyclops sp and copepods. Results were showed that high species diversity of rotifers among other divisions of zooplankton in L1 – L6, despite the variation in nutrient status of lagoon and other factors along the sampling points, this may be due to the availability of food, less specialized feeding, high fecundity and favorable environmental conditions for their growth [27], [28].

Throughout this study period *Brachionus* sp and *Keratella* sp are observed in high abundance from L1 to L6, with *Keratella* sp high in L1 according to Table 2. *Lecane* sp also observed in all the locations but in very few numbers. The presence of rotifers is indicative of nutrition rich conditions. Here, the chance for the lagoon to become highly polluted and experiencing eutrophic in future is considerably being possible from these findings.

Shannon–wiener diversity index is directly related to the number, uniform distribution, and total abundance of species in a sample [4], [29]. Diversity index varies in between 1.896 to 1.524. Where high diversity index recorded in L1. This resulting diversity index values indicates the moderate pollution. According to the Margalef's richness index, species richness is high in L1 sampling point with 2.653 richness index.

Here, there was a gradual decrease occurred in nitrate, phosphate concentration and gradual increase in concentration of dissolved oxygen level along the sampling stations from L1 – L6; those greatly influence the plankton species composition and their abundance. Turbidity was high at L1 least at L6; within that fluctuations were recorded in turbidity as like in electrical conductivity; temperature and salinity were approximately same throughout the sampling area due to purposefully selected particular area for study; so, they influence the plankton composition but didn't affect the resulting variation in their composition.

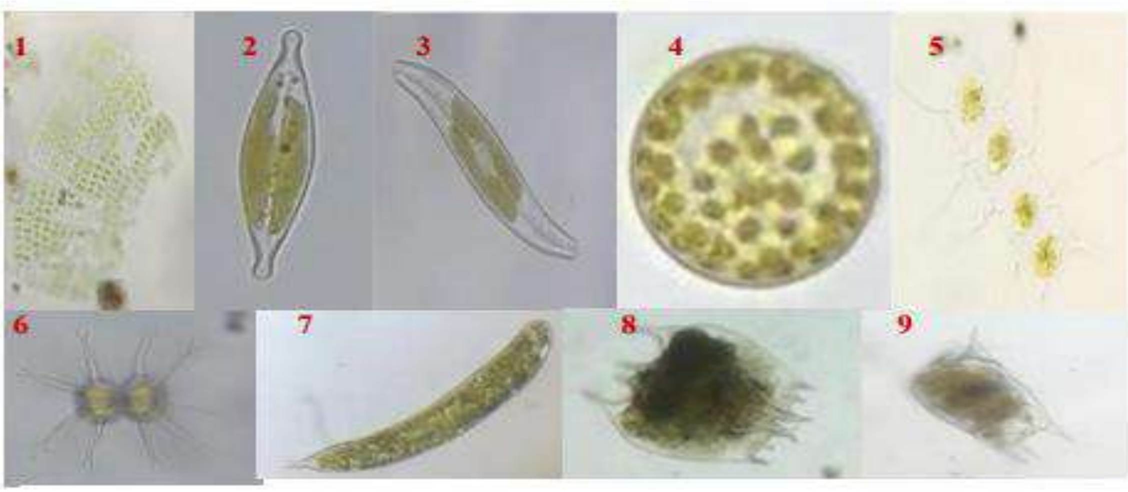

Figure 2: Micrograph of plankton species

1: *Merissmopedia glauca* (X400), 2: *Nitzschia acicularis* (X400), 3: *Gyrosigma parkerii* (X400), 4: *Coscinodiscus centralis* (X400), 5: *Chaetoceros affinis* (X400), 6: *Staurastrum leptacanthum* (X400), 7: *Euglena oxyuris* (X400), 8: *Brachionus quadridentatus* (X400), 9: *Keretella procurva* (X400)

3.4 Correlation between plankton species composition and water quality parameters

Pearson correlation study revealed that, DO, Temperature and pH shows strong negative correlation (r^2 > -0.7) with the abundance of both phytoplankton and zooplankton. Meanwhile strong positive correlation (r^2 > +0.7) found in Nitrate, Phosphate, Turbidity and Electrical conductivity. For the Total Dissolve Solid exhibit weak correlation (r^2 =0)

Table 3: Correlation between species composition of planktons and water quality parameters

Type	Division	DO	NIT	PHO	TUR	SAL	TEM	EC	TDS	pH
Phyto plankton	Bacillariophyceae	-0.873	0.971	0.976	0.616	-0.723	-0.658	0.928	- 0.043	-0.932
	Cyanophyceae	-0.613	0.990	0.420	0.254	-0.048	-0.087	0.525	0.086	- 0.518
	Chlorophyceae	-0.897	0.944	0.901	0.519	-0.746	-0.700	0.878	0.056	- 0.932
Zoo plankton	Rotifer	-0.760	0.855	0.890	0.733	-0.505	-0.525	0.797	- 0.241	- 0.787
	Arthropoda	-0.794	0.638	0.678	0.408	-0.313	-0.293	0.775	0.142	- 0.727

4. CONCLUSION

This study results revealed that Batticaloa lagoon, near to the Eravur, Municipal Solid Waste dumping site contaminated by the organic nutrient pollutants.; though the pollutants present the study area still can function to support the aquatic life. The analysis of physico-chemical parameters such as nitrate, phosphate and dissolved oxygen level showing variation along the sampling points. From the findings conclude not only water quality variation from the leachate of dumping site influence the species composition but also dilution effect of pollutant also contributes the assemblages.

Among the species composition, distribution and abundance Bacillariophyceae *(Nitzschia* sp, *Navicula* sp, *Chaetoceros* sp), Cyanophyceae (*Microcystis aeruginosa*, *Oscillatoria* sp and *Merismopedia* sp) and Euglenophyceae (*Euglena* sp) are performed as good biological indicators and evidently point out the pollution condition of particular lagoon site. Species composition and abundance of zooplanktons such as Rotifers, Arthropods also function as pollution indicators. The composition and abundance of planktons (specially phytoplankton) are correlated with some physico-chemical parameters of water particularly nitrate, phosphate.

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