ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 3, Issue 1, pp: (13-22), Month: January - March 2015, Available at: www.researchpublish.com

Changes in Physico Chemical Features of Three Tanks of Hunagud Taluka

[1]Shri.Sajjanar G.M, [2]Dr.J.L.Rathod

[1]PhD Research Scholar, Department of Marine Biology, KUPG Centre, Karwar- 581309, Karnataka.
[2]Associate Professor, Department of Marine Biology, KUPG Centre, Karwar- 581309, Karnataka.

***Abstract*: Phytoplankton group appropriation depends generally on the microhabitat attributes of the water body. It has been accounted for those phytoplanktons that give microhabitats to zooplankton. Still, studies have concentrated on the general influence of microhabitat on phytoplankton. The morphological attributes of phytoplanktons have not been seriously contemplated. To bridge this gap in learning, the present study explored phytoplankton plenitude and differences, phytoplanktons qualities and physicochemical parameters by utilizing the 1 × 1 m quadrat system. During the present work some wetlands in Hunagud Taluka were studied. Designing phytoplankton circulation was fulfilled utilizing a Self Sorting Guide (SSG). The present study utilized 15 info variables (phytoplankton genera) to prepare the model. The conveyance of five plant propensity parameters (no plant, rising, free-floating, floating-leaved, and submerged) was researched with a prepared SSG plane, by environment information covering. In view of a U-framework, three groups were identified from the model. Phytoplankton collections were emphatically identified with macrophytes attributes (i.e., dry weight, species number, and plant sort). Specifically, free-floating plants upheld rotifers, for example, Testudinella, and cladocerans, for example, Alona, Chydorus, Diaphanosoma, and Ilyocryptus (generally epiphytic). Submerged plants were connected with planktonic rotifers, for example, Filinia, Ploesoma, Synchaeta, cladocerans, for example, Daphnia, and copepods, for example, Eucyclops and Macrocyclops. On the premise of these results, we recommend that the microhabitat structure, made by phytoplanktons, is an imperative component in deciding the assorted qualities and wealth of zooplankton groups, on the grounds that the distinctive species creations of phytoplanktons backing differing zooplankton genera in these living spaces. The results show that phytoplanktons are the key segments of lentic freshwater environment heterogeneity, and the consideration of assorted plant species in wetland development or rebuilding plans will bring about biologically.**

***Keywords*: Phytoplankton, Hunagud Taluka, U-framework, Lentic water bodies and zooplankton.**

I. INTRODUCTION

The scrabble of natural assets also relates perpetually expands by the common people, it has been in charge of acquainting a few undesirable alterations with sea-going situations. The majority of the new assets square measure beneath the strain of urbanization and expansive scale industrialization. The occasion of most recent ecological issues as aftereffects of this has offered climb to new ideas inside the field of recognition and appraisal of sea-going environments. The general condition or soundness of sea-going biological systems is situated by the communication of all its physical, concoction and natural parts that summon its framework. Data on and understanding of ecological revision is basic to allow for the security and cure of environments [1][2]. Biological evaluation considering all parts of the framework helps in internal at relevant preservation routines and rebuilding methodologies towards the protection, administration and property utilization of natural assets.

In this setting, the protection and reclamation of this valuable asset is picking up vitality and requires coordinated administration approaches. The water assets have been terribly fumbled to suit the grouped human cravings prompting declined water quality and sizeable loss of water assets. The grouped effects attributable to anthropogenic exercises became evaluated at standard interims for its rebuilding and protection. Perceiving the essentialness of water assets to the planet's future, the United Nations General Assembly proclaimed the year 2003 the 'Universal Year of Freshwater' to handle the vitality of water, the ramifications [11] of its botch and to encourage systems to oversee, restore and monitor this snappy corrupting asset, it gets to be vital to handle its environmental standing and certain procedures identified with water.

II. MATERIALS AND METHODS

Hunagud Taluka is located in Karnataka state and has a calm atmosphere. Four unique seasons lead to the element progression of natural communities in the freshwater biological communities in Hunagud Taluka. Yearly, the mean precipitation is calculated as 1150 mm and more than 60% of yearly precipitation occurs from May to ahead of schedule September. The lentic new water biological communities included in this study are found in the southeast of Hunagud Taluka. Generally, there were various riverside wetlands in the stream bowl (Son and Jeon, 2002), in any case, substantial territories of wetland have vanished, because of the extension of human culture (Burkett and Kusler, 2000). Agrarian area [7] overwhelms regions encompassing the remaining wetlands in the stream bowl, and nonpoint source (e.g. supplement) continuously influence the wetland biological communities.

The present study is on 3 lentic frameworks, the wetlands are ruled by different plant sorts, for example, new, free-floating, floating-leaved, and submerged plants; on the other hand, the advancement and development of phytoplankton is hindered in the repositories because of their impermeable floors. Moreover, a few wetlands help just a couple of plant animal varieties in view of high water levels and low supplement focuses. Consequently, the study destinations incorporated an extensive variety of ecological attributes regarding microhabitats (i.e., diverse sorts of lentic frameworks and different examples of their constituent plant.

Present study was carried out from May 2008 to June 2009, before the midyear rainstorm and storms. This was to abstain from flooding aggravation (Park et al., 2002), and to get information under steady conditions. We secured three to five inspecting areas in littoral zones at each one site. At each one inspecting point, three quadrats (1 m × 1 m) were utilized to quantify physico-chemical parameters, zooplankton abundance, and the presence of phytoplankton.

Water temperature, disintegrated oxygen, conductivity, ph, turbidity, total acidity and Chlorophyll were measured at each site. Water specimens were collected at a profundity of 0.5 m. We utilized a DO meter to quantify water temperature and disintegrated oxygen and conductivity was measured utilizing a conductivity meter. The chlorophyll is focused and turbidity was measured in the research center. Turbidity was measured utilizing a turbid meter (Model 100b). We took an extra 10 L of water for zooplankton accumulation from the surface layer using a 10 column sampler. This water was filtered through a tiny fish net (68-µm lattice size), and the filtrate was saved in formaldehyde [8][9].

The present study identifies all types of phytoplankton inside every quadrat. After species identification, distinctive parts of the plants were taken so as to gauge dry weight; just the submerged parts of the plant were utilized for the dry weight estimation. For rising plants, stalks over the water surface were uprooted. The whole mass of free-floating, or submerged plants, was utilized for dry weight estimation, but if free-floating plants had above-water and gans.

In this study, the phytoplankton gatherings identified were utilized as data variables as a part of the SSG. Phytoplankton species that represented more than 5% of the aggregate phytoplankton wealth were incorporated. Along with the preparation, the quantity of hubs that the SSG plane comprised was resolved as from a mixed bag of guide structures of distinctive sizes, we chose the ideal structure focused around the scaled down non- function quantization and topographic[9][10]. The prepared SSG plane utilizing phytoplankton information was veiled utilizing the physic-chemical attributes of water and phytoplankton characteristics. The dispersion example of phytoplankton information on the guide was contrasted and the covered natural information and the influence of diverse plant sorts (rising, free-floating, floating-leaved, and sub-Combine).

III. RESULTS

3.1 Regression Analysis

There was moderately little distinction in the physico-chemical characteristics of water among the study locales. Despite the fact that there were some study locales that had astoundingly high or low values, the co-efficient of variety. The conductivity has highest CV, but the variation was lesser than 68%. There were contrasts in both phytoplankton species and dry weight between the locales [11][12]. The co-efficient variety is calculated as:

Co-efficient Variety: [(Standard Deviation) / mean] * 100 %

Here three tanks are considered namely Shivanagutti Kere, Balaguzdi Kere and Chikkakodagali Kere. The analysis of phytoplanktons is presented as follows:

AT- Atmospheric Temperature, WT- Water Temperature, EC- Electrical Conductivity, TDS- Total Dissolved Solids, TUR- Turbidity, DO- Dissolved Oxygen, BOD- Biochemical Oxygen Demand, CO_2- Free carbon dioxide, Cl- Chloride, Ca-Calcium, Mg- Magnesium, TH- Total Hardness, T. Aci- Total Acidity

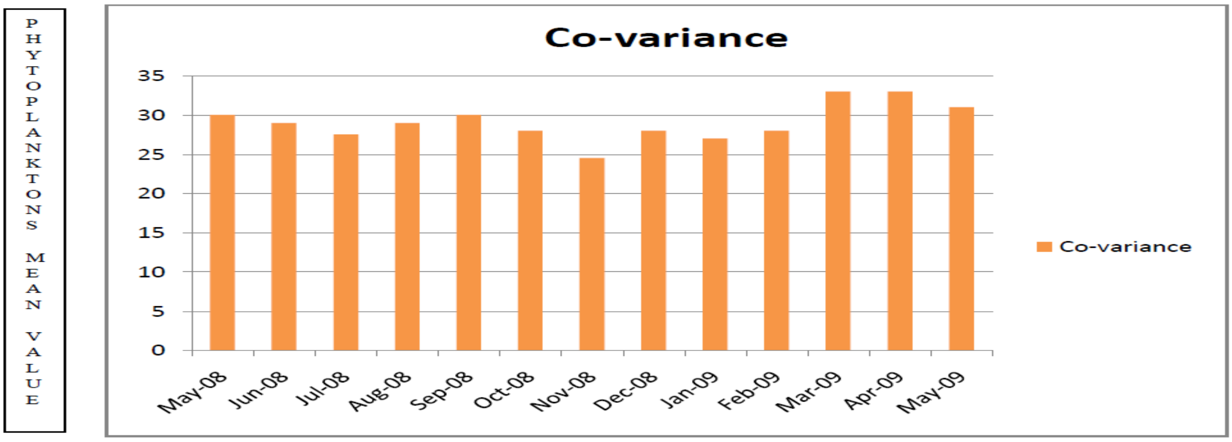

Fig.1 Co-variance of Chikkakodagali Kere Tank

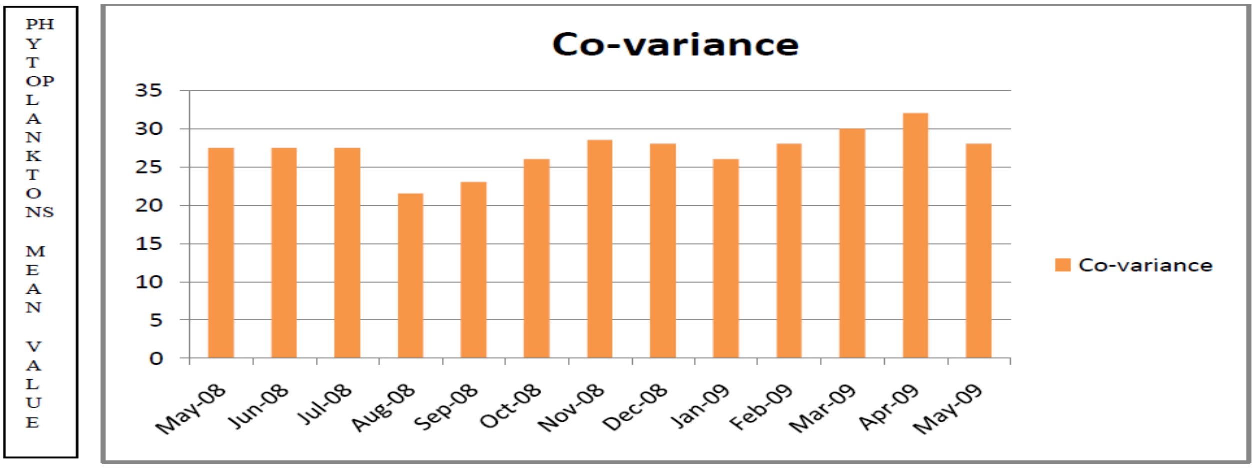

Fig.2 Co-Variance of Shivanagutti Kere Tank

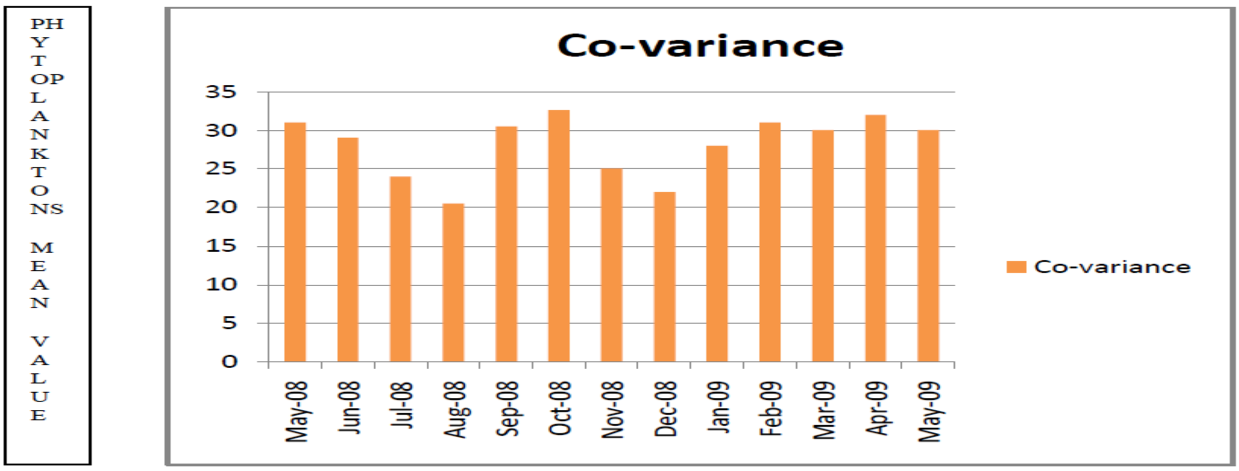

Fig.3 Co-Variance of Balakudi Kere Tank

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 3, Issue 1, pp: (13-22), Month: January - March 2015, Available at: www.researchpublish.com

Table 1: Presence of Chlorococcales in all the tanks from May 2008 to May 2009

SL.NO	Organisms	Shivanakudi Kere	Balakudi Kere	Chikkakodagali Kere
1	Ankistrodesmus falcatus	P	P	P
2	Ankistrodesmus convolutes	P	P	P
3	Arthodesmus convergens	A	A	P
4	Coelastrum microporum	P	P	P
5	Cruzigenia cruficera	P	P	P
6	Cruzigenia tetrapedia	P	P	P
7	Cruzigenia rectangularis	P	A	A
8	Dimorphcoccus lunatus	A	P	A
9	Korshikoviella Limnetica	P	A	A
10	Kirchneriella lunaris	P	A	A
11	Oocystis gigas	P	P	A
12	Oedogonium species	P	A	A
13	Pediastrum duplex	P	P	P
14	Pediastrum var gracillimum	P	P	A
15	Pediastrum var clathratum	P	P	P
16	Pediastrum simplex var duodenarium	P	P	P
17	Pediastrum tetras var tetraodon	A	P	A
18	Pediastrum tetras var excisus	P	P	A
19	Pediastrum tetras	P	P	P
20	Scenedesmus accuminatus	P	P	A
21	Scenedesmus armatus	P	A	A
22	Scenedesmus bujugatus var bi cellularis	p	p	p

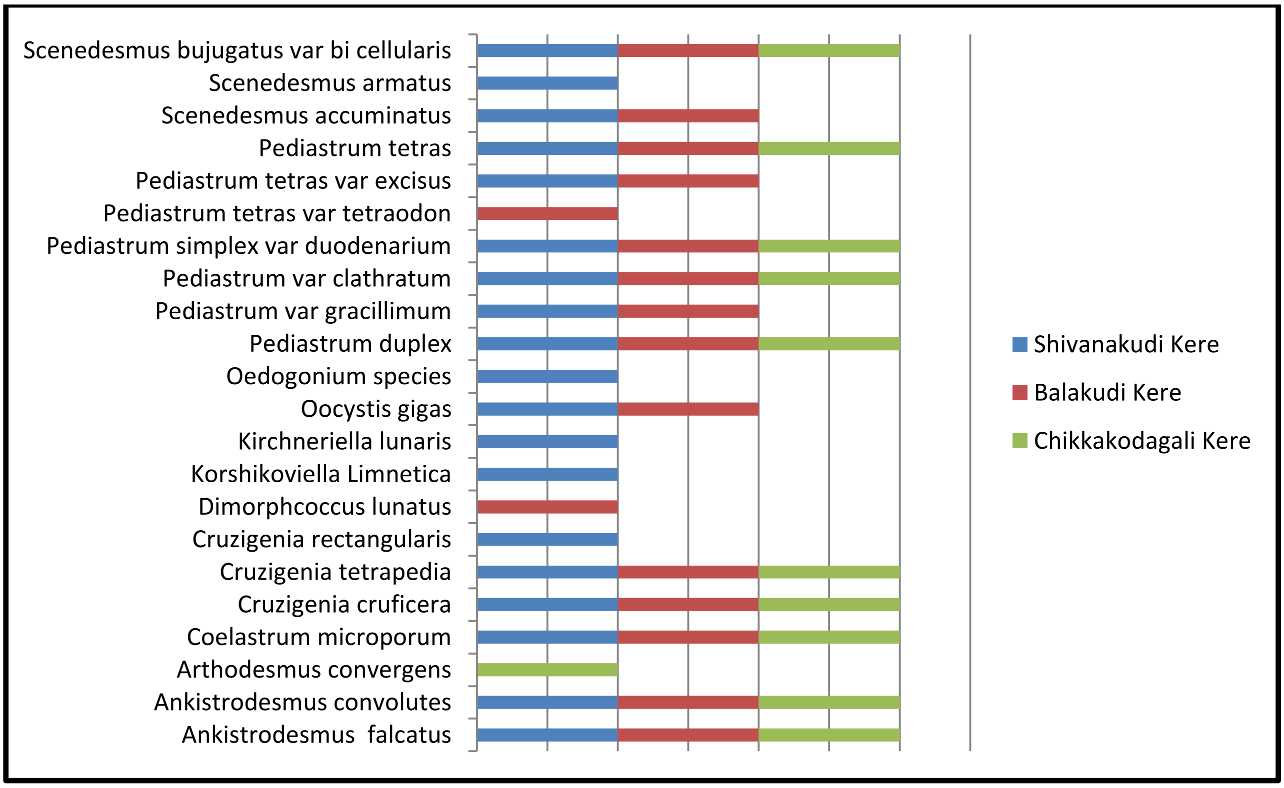

Fig.4 Presence of Chlorococcales in all the tanks from May 2008 to May 2009

Table 2: Presence of Desmids in all the tanks from May 2008 to May 2009

SL.NO	Organisms	Shivanakudi Kere	Balakudi Kere	Chikkakodagali Kere
1	Closterium acerosum	P	P	P
2	c.gracile	A	P	P
3	c.lanceolatum	P	P	P
4	c.liblenii	P	P	A
5	c. Monoliferum	P	P	P
6	c.acerosum	P	A	P
7	Cosmarium acerosum	P	P	P
8	Cosmarium angulosum	P	A	P
9	Cosmarium bipunctuatum	P	A	P
10	Cosmarium contratum	P	P	P
11	Cosmarium dezticulatum	P	A	P
12	Cosmarium depressium	P	P	P
13	c. lund varapetrum	P	P	P
14	c. hammeri	P	P	A
15	c. lundell	P	A	P
16	c. pyramridatus	P	P	P
17	c. snudum	A	P	P
18	c. subspeciosum	P	A	P
19	c. spiruliferum	P	A	P
20	c. turmiduez	P	A	P
21	c. cucurbita	P	p	p

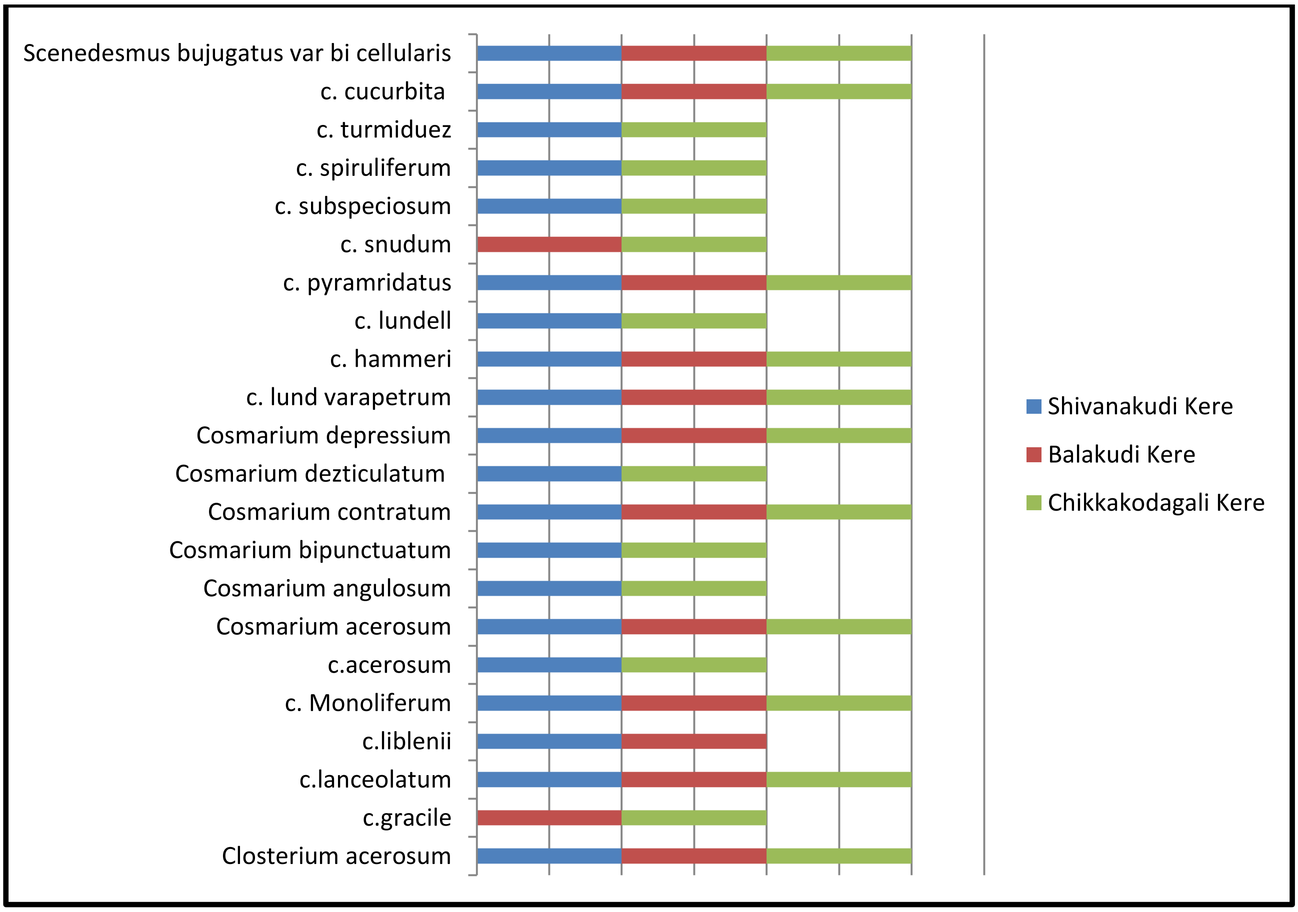

Fig.5 Presence of Desmids in all the tanks from May 2008 to May 2009

ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 3, Issue 1, pp: (13-22), Month: January - March 2015, Available at: www.researchpublish.com

Table 3: Presence of Diatoms in all the tanks from May 2008 to May 2009

SL.NO	Organisms	Shivanakudi Kere	Balakudi Kere	Chikkakodagali Kere
1	Amphora Species	P	P	P
2	Amonnoeoneis Sphaerophora	P	P	P
3	Cocconeis placentula	P	P	P
4	Cyclotella Kuetzingiana	P	P	P
5	Cymbella cuspidate	P	P	P
6	Kutzing	A	P	A
7	c.cymbiformes	P	P	P
8	c.Lancealatus kutz	A	P	A
9	c.turoida	P	P	P
10	Diatoms species	P	P	P
11	Fragilaria capucina	P	A	P
12	Fragilaria pinnata	P	P	A
13	Fragilaria viroscens	A	P	A
14	Gomphonema gracile	A	P	A
15	Gomphonema subapicatum	A	P	A
16	Gomphonema intricatum	A	P	A
17	Gomphonema acuminatum	P	P	P
18	Melosira granulate	A	P	A
19	Melosira islandica	P	P	P
20	Navicula angulatum	A	P	A
21	Navicula hustedtii	P	P	A
22	Navicula aicephala	P	P	P

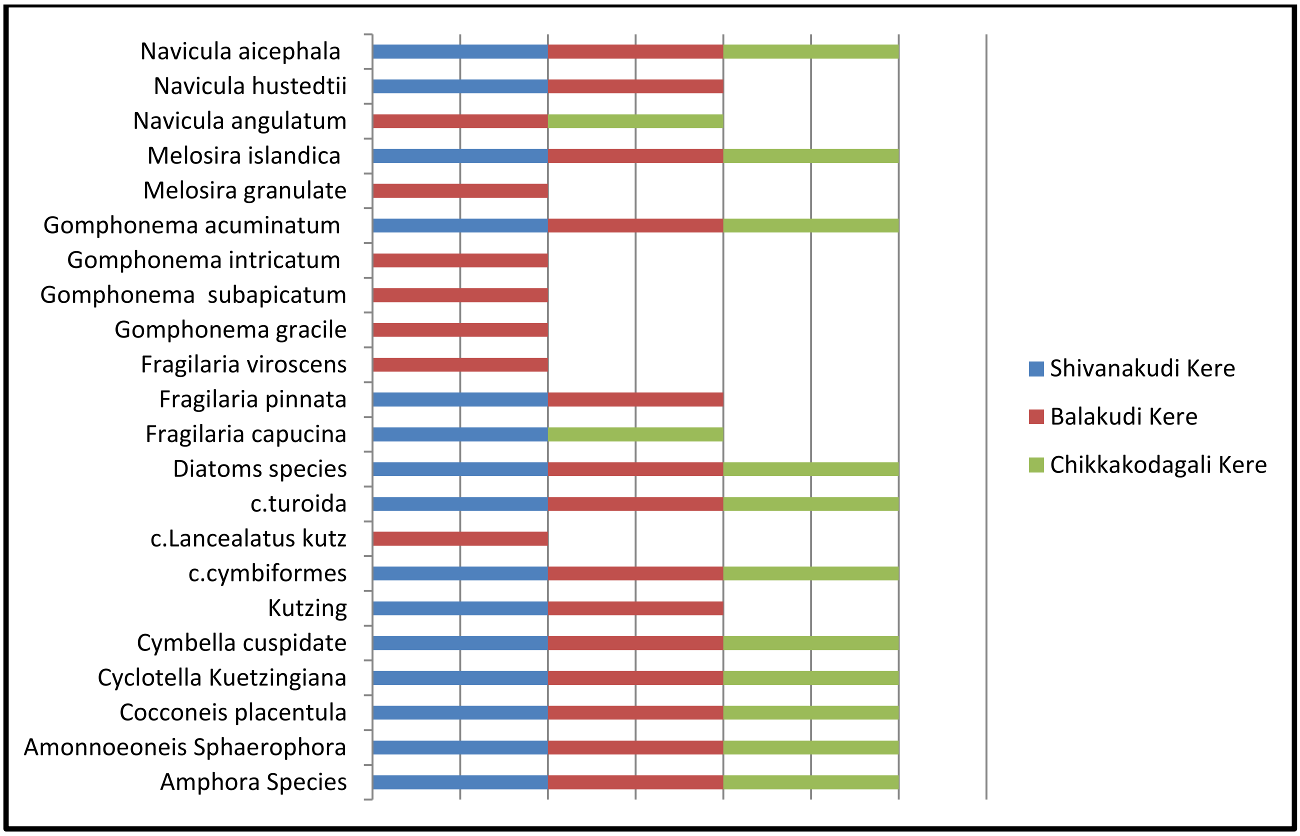

Fig.6 Presence of Desmids in all the tanks from May 2008 to May 2009

3.2. SSG features:

The SSG model was adaptively fitted to the data information. For simplicity of understanding, the 22 groups of phytoplankton were displayed separately, and the cluster matrix was contrasted with every segment plane. The U-framework identified three unique bunches, in light of the ash color slope of Euclidian separation. Utilizing the bunching guide and dendrogram, features of all the variables were distinguished between the upper (cluster1) and the lower parts (clusters2 and 3) of the guide. The characteristics of each one bunch removed from the Somare showed in Table S1, which presents mean values of each variable. Every phytoplankton gathering showed diverse shapes and slopes on the guide plane, however most phytoplankton groups were appropriated in the lower parts of the guide. For instance, a substantial extent of phytoplanktons species,[13][14][15] for example, Ankistrodesmus falcatus, Ankistrodesmus convolutes, Arthodesmus convergens etc and of plant sorts was observed. The study sites without phytoplanktons or with just rising plants had a place in group 1, though the destinations with free-floating and submerged plants had a place in groups 2 and 3.

After environmental data masking was applied, the physico-chemical parameters did not demonstrate any evident association with the distribution of phytoplankton. Water temperature, conductivity, and ph did not show inclinations on the guide. Notwithstanding, broke up oxygen, chlorophyll and turbidity had a directional distribution. In contrast to the physico-synthetic parameters, phytoplanktons sorts were non- differentiated on the guide plane. When we veiled the phytoplanktons vicinity or non appearance information over the prepared SSG plane, a distribution pattern of the plant types were observed.

The U- framework identified in three unique clusters using Euclidian separation. Utilizing the grouping guide and dendrogram, features of all the variables were distinguished between the upper (cluster1) and the lower parts (clusters2 and 3) of the guide. The characteristics of each clusters removed from the Somare which presents mean values of each variable. Every phytoplankton gathering showed diverse shapes and inclinations on the guide plane, however most phytoplankton groups were circulated in the lower parts of the guide. Some phytoplankton species were habitually watched just in group 3.

3.3. Influence of phytoplankton type

The plenitude and species number of every phytoplankton gathering was influenced by a combination of phytoplankton, based on the some clustering results. The notable consideration is the quantity of phytoplankton sorts presents the higher the phytoplankton plenitude and species number. The study locales overwhelmed by 'no plants' or 'developing plants' had low zoo-microscopic fish wealth and species number. Interestingly, the locales with two or more phytoplankton species backed higher phytoplankton and species number. The study destinations containing three diverse plant sorts (free-floating, floating-leaved, and submerged) had the phytoplankton collection.

IV. DISCUSSION

4.1. Characterization of clusters

A significant influence of microhabitat on phytoplankton assemblage such as diatoms, desmids and Chlorococcales were depicted in our present studies. The present study clustered [16] the field-surveyed data relatively well by using a SOM model, and the results suggest a relationship between microhabitat characteristics and phytoplankton genus. The characteristics of the clusters were as follows:

- Cluster 1: The sites with emergent plants, some floating-leaved plants, or without macrophytes (indicated as ‘absence’), resulting in a very low dry weight of macrophytes, and a very low abundance of phytoplankton groups. The highest dissolved oxygen and chlorophyll a was observed in this cluster.
- Cluster 2: No specific pattern. We suggest that this is a transitional category, because most variables were intermediate in both numerical scale and topological position on the map. The abundance of phytoplankton was the second greatest in this cluster. In particular, Amphora species and cymbella were dominant.
- Cluster 3: The sites belonging to this cluster were dominated by free floating and submerged plants. The abundance of phytoplankton was highest among the clusters. Dissolved oxygen and chlorophyll a were lower than those in the other clusters. Based on the above points, we suggest that both macrophytes biomass and type affect the abundance of phytoplankton. In particular, free-floating and submerged plants are important in sustaining high abundances of phytoplankton.

4.2. Phytoplanktons type

The study destinations with differing phytoplankton sorts underpinned a high wealth and animal group's differences of zooplankton. In freshwater eco-frameworks, phytoplanktons are known to give suitable microhabitats to zooplankton. Moreover, their high biomass gives multifaceted nature to the territory structure. We found that the more striking the phytoplankton dry weight, the more copious the phytoplankton group. This was especially valid for epiphytic phytoplankton species. Epiphytic species oblige substrates, for example, submerged stems or leaf surfaces for connection and have favorable element over planktonic species owing to their little size and low action, which make them more averse to be located by predators.

This clarifies the high plenitude of epiphytic phytoplankton where extensive phytoplankton biomass was discovered. Conversely, planktonic species are less focused in light of the fact that they can be effortlessly detected by predators because of their persistent development, especially the jumping movement showed by species. Besides, high plant wealth can meddle with the swimming and encouraging conduct of planktonic phytoplankton. Thus, the vegetated territories are ruled by epiphytic phytoplankton.

Not just vicinity or nonattendance of phytoplankton additionally the structure and kind of phytoplankton were urgent to phytoplankton distribution. We found four types of phytoplankton and every phytoplankton gathering had an alternate example of space occupation in the water, which is an imperative element in deciding microhabitat structure. For instance, just the stem of emanate plants is submerged, and this has a basic structure. Additionally, submerged parts of floating-leaved plants have a comparative structure to emanate plants. Conversely, free-floating or submerged plants typically have a mixture of stem and leaves below the water surface; hence, they provide a relatively complex substrate, as well as pore likespaces, that allow zooplankton to occupy. Submerged plants give a more unpredictable environment in the water, and may help a high plenitude of phytoplankton. We discovered the most unpredictable phytoplankton collections in mixtures of submerged plants than in mixtures of different plants. From these results, we suggest that phytoplankton morphology influences the species composition of phytoplankton, and the more prominent surface zone and space gave by a mixture of phytoplankton empower zooplankton to make utilization of them as microhabitats. Complex microhabitats contain more specialties and diverse methods for misusing the accessible assets, which subsequently expand species differing qualities.

In this study, we discovered substantial wealth of epiphytic phytoplankton species; for example, diatoms, desmids and Chlorococcales in the ecosystems. The previous studies reported that these epiphytic species frequently were prevailing in freshwater environments where zooplanktons were abundant. The SSG focus on the group 3 gathered information tests with expansive plenitude of phytoplankton, and this bunch was plainly connected with free-floating and submerged plants. In view of phytoplankton class insightful correlations with environmental information concealing, free-floating plants principally backed rotifers. By and large, submerged plants are all the more effectively disturbed by wind and water flows than are free-floating plants, so they are less suitable for the connection of epiphytic phytoplankton. Board tonic phytoplankton moves ceaselessly; thus, littler spaces will block their development. Moreover, the capacity to swim into deeper water permits the phytoplankton to extend their environment to submerged plants.

4.3. Wetland management strategies to increase animal biodiversity

Our study examined the relationship between phytoplankton communities and the part of phytoplanktons as microhabitats, utilizing information from different water bodies having the same climatic conditions, to make a "preview" overview. This review gathered fundamental data on the security and reclamation estimations of phytoplanktons in connection to keeping up high phytoplankton biodiversity and plenitude. In this study, the differences and plenitude of phytoplankton was nearly identified with zooplanktons a quality which is found in the different creatures. The amalgamation of creature species number infers that it is important to find ideal phytoplanktons species differing qualities to fulfill both parts of stylish and biological function in wetlands rebuilding or administration. Consequently, we proposed the presentation of fitting phytoplanktons species for restoring or making wetlands, so as to expand biodiversity in the wetland, as well as to manage a biologically sound sustenance web. We propose the presentation of free-floating or sub-consolidated plant species. Additionally, contemporaneous conjunction of free-floating or submerged plant can underpinned more wealth and species assorted qualities of zooplankton. The emanate plants are popularly used in wetland restoration process, due to their relatively solid suitability and simple to oversee the qualities. Presenting other phytoplanktons sorts will bring out diversified plant species in wetlands, and is relied upon to strengthen differing qualities.

V. CONCLUSION

The clustering of phytoplankton gatherings were effectively envisioned onto the SSG and exhibited clear examples of gathering in connection to phytoplanktons. The SSG gave another model of visualization for environmental information investigation with discrete gathering of the complex dataset as a non-straight speculation. A sum of 3 zooplankton group gatherings was grouped into three classes. The SSG result showed clear phytoplankton conveyance examples parceled by the plant sort (no plants, developing, free-floating, floating-leaved, and submerged plants). Specifically, the epiphytic phytoplankton gatherings showed an acceptable association with free-floating, floating and submerged plants. Since free-floating, floating or submerged plants have more intricate structures than other plant sorts, they can help a high wealth. Thus, we propose that microhabitat structure by phytoplankton is a pivotal element influencing zooplankton gatherings in lentic biological systems, as opposed to water quality parameters. Specifically, the species creation of phytoplanktons is an imperative component in keeping up the assorted qualities of creatures that live and feed on plants.

REFERENCES

[1] Ahn, C., Joung, S.H., Park, C.S., Kim, H.S., Yoon, B.D., Oh, H.M., 2008. "Comparison of sampling and analytical methods for monitoring of cyanobacteria-dominated surface waters", Hydrobiology 596, 413–421.

[2] Alexandrova, V., Moncheva, S., Slabakova, N., Stefanova, K., Doncheva, V., 2007"Application of biotic indices and body size descriptors of phyto- and zooplankton communities in Varna lagoon for ecological status assessment".

[3] Transit Waters Bull. 3, 17–21, http://dx.doi.org/10.1285/i1825229Xv1n3p17, ISSN 1825-229X http://siba2.unile.it/ese/twb.

[4] Bae, D., Kumar, H., Han, J., Kim, J., Kim, K., Kwon, Y., An, K., 2010. "Integrative ecological health assessment of an acid mine stream and in situ pilot tests for wastewater treatments". Ecol. Eng. 36, 653–663.

[5] Basset, A., Barbone, E., Borja, A., Brucet, S., Pinna, M., Quintana, X.D., Reizopoulou, S.,Rosati, I., Simboura, N., 2012. "A benthic size spectra index for the Water Framework Directive implementation in coastal lagoons, within Mediterranean and Black Sea ecoregions". Ecol. Indicat. 12 (1), 72–83.

[6] Bec, B., Husseini-Ratrema, J., Collos, Y., et al., 2005. Phytoplankton seasonal dynamics in a Mediterranean coastal lagoon: emphasis on the picoeukaryote community. J. Plankton Res. 27, 881–894

[7] Borja, A., Barbone, E., Basset, A., Borgersen, G., Brkljacic, M., Elliott, M., Garmendia, J.M., Marques, J., Mazik, C., Muxika, K., Neto, I., Norling, J.M., Rodríguez, K., Rosati, J.G., Rygg, I., Teixeira, B., Trayanova, H.A., 2011. "Response of single benthic metrics and multi-metric methods to anthropogenic pressure gradients in five distinct European coastal and transitional ecosystems. Mar. Pollut. Bull. 62, 499–513.

[8] Brown, J.H., Gillooly, J.F., Allen, A.P., Savage, V.M., West, G.B., 2004. "Towards a metabolic theory of ecology". Ecology 85, 1771–1789.

[9] Calow, P., 1989." Proximate and ultimate responses to stress in biological systems".Biol. J. Linn. Soc. 37, 173–181.

[10] Carletti, A., Heiskanen, A.S., 2009" Water Framework Directive Intercalibration Technical Report. Part 3. Coastal and Transitional Waters". European Commission, Joint Research Centre, Institute for Environment and Sustainability, JRC Scientific and Technical Reports.

[11] Devlin, M., Barry, J., Painting, S., Best, M., 2009." Extending the phytoplankton tool kit for the UK Water Framework Directive: indicators of phytoplankton community structure". Hydrobiology 633, 151–168.

[12] Fleming-Lehtinen, V., Laamanen, M., Kuosa, H., Haahti, H., Olsonen, R., 2008. "Longterm development of inorganic nutrients and chlorophyll a in the open Northern Baltic Sea". Ambio 37, 86–92.

[13] Pereira, G.C., de Figuiredo, A.R., Jabor, P.M., Ebecken, N.F.F., 2010. Assessing the ecological status of plankton in Anjos Bay: a flow cytometry approach. Biogeosci. Discuss. 7, 6243–6264.

[14] Pérez-Ruzafa, A., Gilabert, J., Gutiérrez, J.L., Fernández, A., Marco Sabah, S., 2002. Evidence of a planktonic food web response to changes in nutrient input dynamics in the Mar Menor coastal lagoon, Spain. Hydrobiology 475/476, 359–369.

[15] Peter, R.H., 1983." The Ecological Implication of Body Size", Cambridge University Press, Cambridge, 352 pp. Zalack, J., Smucker, N., Vis, M., 2010. Development of a diatom index of biotic integrity for acid mine drainage impacted streams. Ecol. Indicat. 10, 287–295.

[16] Zarauz, L., Irigoien, X., 2008. Effects of Lugol's fixation on the size structure of natural nano–microplankton samples, analyzed by means of an automatic counting method. J. Plankton Res. 30 (11), 1297–1303.

[17] Zhao, M.Y., Cheng, C.T., Chau, K.W., Li, G., 2006. Multiple criteria data envelopment analysis for full ranking units associated to environment impact assessment. Int.J. Environ. Pollut. 28 (3-4), 448–464