An Assessment of Phytoplankton Communities of Various Freshwater Habitats of Gulmarg Area in Kashmir Valley

Arif Ahmed, Umara Qayoom, Inam Sabha, Sheikh Tajamul Islam and Sami Ullah Bhat*

Department of Environmental Science, University of Kashmir, Hazratbal, Srinagar, 190006, J & K, India
**Corresponding authors Email address:* samiullahbhat11@gmail.com

ABSTRACT

Phytoplankton constitutes an important component of the aquatic ecosystems, both lentic as well as lotic. They are vital for the functioning of aquatic food chain and also contribute significantly to the total oxygen production in the world. Thus, knowledge of phytoplankton availability in an ecosystem is of utmost importance. The present study was carried out to assess the phytoplankton communities in various freshwaters habitats of Gulmarg wildlife sanctuary. Five study sites were selected for the purpose and sampling was done from May to December 2012. A total of 30 genera belonging to Bacillariophyceae, Chlorophyceae and Cyanophyceae were identified. Bacillariophyceae being dominant in both diversity and density included 14 taxa contributing 60% of total population followed by Chlorophyceae with 11 taxa contributing 31% of total phytoplankton population and Cyanophyceae represented by 5 taxa contributing about 9% of total phytoplankton population respectively. The most common species encountered were *Cyclotella* sp., *Cymbella* sp., *Diatoma* sp., *Fragilaria*s sp., *Navicula* sp., *Nitzchia* sp., *Chlorella* sp., *Closterium* sp., *Spirogyra* sp., *Oedogonium* sp., *Anabaena* sp., *Microcystis* sp. and *Oscillatoria* sp. It was also concluded that the density in phytoplankton was maximum in spring season due to presence of nutrients. Presence of similarity in most of the taxa indicated that the streams in the area share common microclimate.

Keywords: *Bacillariophyceae, Chlorophyceae, Cyanophyceae, Diatom, Streams*

INTRODUCTION

Fresh water habitats occupy a very small portion of earth's surface as compared to marine water habitats. Riverine ecosystems are prime examples of such ecosystems. These water bodies range from springs- only a few centimeters wide to major rivers- kilometers in width, and are typically characterized by unidirectional flow, state of continuous physical change, high degree of spatial and temporal heterogeneity at all scales (microhabitats).

According to Odum (1971) the plankton are assumed to be absent from streams, since such organisms are at the mercy of current, they are soon destroyed as they pass through rapids. He believed Plankton to be of least importance in stream ecology, but in slow moving pools of streams and rivers, they can rapidly grow and multiply.

Living in flowing water can be beneficial to plants and algae, because the current is usually well aerated and it provides continuous supply of nutrients which are essential for their survival, growth and reproduction. The major limiting factor in aquatic ecosystem is nitrogen and phosphorus, besides which these organisms are also limited by flow, light, water chemistry, substrate and grazing pressure.

Although benthic algae typically dominate rocky streams and smaller rivers, phytoplankton becomes important in larger rivers and lowland streams (Rosemarin, 1975; Reynolds and Descy, 1996). Much of the early research focused on whether a true phytoplankton community (populations that survive and reproduce within rivers) actually existed, as opposed to dislodged benthic forms or plankton washed in from lakes within the watershed. Indeed, plankton in most rivers consists of all three components in varying proportions (Reynolds, 1988), but in a single river sample, it is difficult to distinguish these sources, although certain algal taxa may be considered typical of each. Abundance of most species is usually negatively related to discharge with exceptions of some colonial cyanobacteria (e.g., *Aphanocapsa saxicola*) and certain diatoms (e.g., *Stephanocyclus* sp., *Cyclotella meneghiniana*) (Peterson and Stevenson, 1989: Wehr and Thorp, 1997). Two major limitations to survival and growth of river phytoplankton are the continuous removal of organisms by downstream flow (so-called washout) and mixing within the water column, which places cells in variable and often aphotic light fields. Hence, most studies conclude that riverine phytoplankton production is controlled by discharge (Baker and Baker, 1979; Soballe and Kimmel, 1987; Cole *et al*., 1992; Reynolds and Descy, 1996). Assuming no other limiting resources, rivers must be sufficiently long and/or the flow rate sufficiently low for net positive algal growth rates (Greenberg, 1964).Planktons, particularly phytoplankton, for a long time have been used as indicators of water quality (Palmer, 1969). Some species flourish in highly eutrophic waters while others are very sensitive to organic and/ or chemical waste. Some species develop noxious blooms, sometimes creating offensive taste and odors (Prescott, 1968) or anoxic or toxic conditions resulting in animal deaths or human illness (Carmichael, 1981). Keeping the above noted importance and scenario a small and preliminary study was carried out to study the species composition and population dynamics of phytoplankton in different streams of Gulmarg wild life Sanctuary.

STUDY AREA

Gulmarg Wildlife Sanctuary is located 26 Km to the South West of district Baramulla of Jammu & Kashmir and its boundaries are located within geographical coordinates of 74°.17' to 74°.79' N, 34°.55' to 34°.60' E and at an altitude of about 2400-4300 asl (Fig. 1). The area of Gulmarg Wildlife Sanctuary is about 180 Km^2. Gulmarg Wildlife Sanctuary abodes rich faunal and floral bio-diversity with various species like Musk Deer (*Moschus cupreus)*, Common Leopard (*Felis unica*), Barking Deer (*Muntiacus vaginalis)*, Asiatic Black Bear (*Ursus thibetanus*), Indian Wolf (*Canis lupus pallipes*), Snow Cock (*Tetraogallus himalayensis)* and Chukar (*Alectoris* chukar) etc. and is one of the best world renowned tourist destination for its famous meadows, rocky cliffs, dense birch forests and a home for bird watcher. The area is surrounded in North by Jhelum Valley Division-Baramulla, in South by Forest Division of Poonch and Pir Panjal, while on Eastern side it is flanked by village of Drang and Badrakoot forests of Special forest Division-Tangmarg and on the West by Special Forest Division Tangmarg and Baba Reshi village. The alpine and subalpine areas covered with snow and glaciers act as water reservoirs to feed various nallahs which provides water downstream for various purposes like irrigation for large population of Baramullah and Budgam districts Gulmarg is 57 km southwest from the capital city of Srinagar located at 34° 03′ 00″ N and 74° 22′ 48″ E at an average altitude of >2,680m asl in the Baramulla district of Jammu and Kashmir state (Fig.1). A total of five sites were selected to study the phytoplankton community of Gulmarg ecosystem.

Site I (Tangmarg Canal)

Tangmarg is located with geographical coordinate of N 34°03′ 30.5″ and E 74°25′ 29.9″, having altitude of about 2153m asl. The canal is surrounded with lot of rural settlements and restaurants and hotels. It has highest water flow in mid-summer i.e., July and lowest in December.

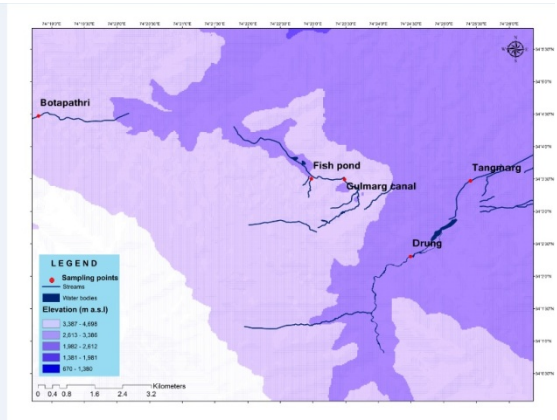

Fig. 1. Map of study area

Site II (Drang)

It is located with geographical coordinates of N 34°02′ 14.9″ and E 74°24′ 26.0″ having altitude of about 2226m asl. The place is isolated surrounded by dense forests and is used for the trout (*Oncorhynchus mykiss*) culture by the fisheries department. The flow of water body is more in summer i.e., during July and less in winter i.e., December.

Site III (Botapathri)

Botapathri is 5 km away from Gulmarg. The stream which passes there is known as Ningal Nallah with the geographical coordinate of N 34°04 ′28.7″ and E 74°18′48.7″ having altitude of 2,781m asl. The stream is surrounded by the forests and almost devoid of human interference. The bottom of the stream is enriched with large boulders, sand and stones, etc.

Site IV (Gulmarg Canal)

This site has geographical coordinate of N 34°03′31.2″ and E 74°23′01.0″ having altitude of about 2,630m asl. The canal is positioned on the road side and surrounded by meadow and forest nearby.

Site V (Fish Canal)

Fish canal is located on the other side of Gulmarg canal with geographical coordinate of N $34^{0}03^{'}29.2$” and E 74°22′ 58.6″ with altitude of 26340 m asl. The water from a nearby reservoir and surface runoff is the source of water of this canal.

MATERIAL AND METHODS

For the qualitative estimation of phytoplankton in the river ecosystem 400 liters of water was sieved through phytoplankton net of bolting silk having mesh size 65 of µ. The content was then preserved with Lugol's solution and 4% formalin (APHA, 1998). The identification was done with the help of microscope by adopting standard taxonomic works of Prescott (1939), Pennak (1978), Edmondson (1992), Cox (1996), APHA (1998) and Biggs and Kilroy (2000). For quantitative study, the preserved planktonic samples were subsequently reduced to known volumes by concentrating in a centrifuge for about 5 minutes at 3000 rpm. The concentrated samples were used for quantitative enumeration by using Sedgwick Rafter cell (1 ml capacity) under the microscope. The unicellular algae were counted as individuals where as in the filamentous form, each filament was taken as unit and in colonial forms like *Volvox* sp. and *Microcystis* sp.. The counting unit was a colony (Jumppanen, 1976). Number of various genera and total phytoplankton in 1 L of water were calculated by the following formula

$$\text{Number/L} = \frac{Cx1000}{LxDxWxS}\ mm^3$$

Where,

C = Number of organisms counted

L = Length of each strip (mm)

D = Depth of strip (mm)

W = Width of a strip (mm)

S = Number of strips counted

The species similarity between various sites was calculated by Sorensen similarity coefficient (Sorensen, 1948) by using the following formula:

$$\mathbf{S} = \frac{\mathbf{2C}}{\mathbf{A+B}}$$

Where,

C = common genera between the two sites

A = species present at site A.

B = species present at site B.

Shannon-Wiener, 1963) was used to calculate the species diversity between various sites

$$H = - \Sigma\ (ni/N)\ \ln\ (ni/N)$$

Where,
ni = number of individuals.
N = total number of taxa.
H = Shannon Weiner diversity index.

RESULTS AND DISCUSSION

The phytoplankton community of various streams of Gulmarg Wildlife Sanctuary was represented by 30 genera belonging to Bacillariophyceae (14), Chlorophyceae (11) and Cyanophyceae (5) (Fig. 2). The most common species at various study sites among Bacillariophyceae were, *Cyclotella sp*., *Cymbella* sp., *Diatoma* sp., *Fragilaria* sp., *Navicula* sp. and *Nitzchia* sp. Among Chlorophyceae., *Chlorella* sp., *Closterium* sp., *Spirogyra* sp. and *Oedogonium* sp., were the common species. Cyanophyceae was represented by the common species of *Anabaena* sp., *Microcystis sp.* and *Oscillatoria* sp. Among Baccillariophyceae, *Navucula* sp. showed the highest numerical dominance followed by *Diatoma* sp. The diatoms were found to have the highest number which may be due to wash out of periphytic diatoms caused by high flow of water. As stated by Townsend and Gell (2003) benthic diatoms form an abundant component of Periphyton in rivers and streams. Likewise from Chlorophyceae *Spirogyra* sp. and from Cyanophyceae *Oscillatoria* sp. showed the highest numerical dominance. The high abundance of Chlorophyceae after Bacillariophyceae could be due to their short doubling time being less than 48 hours (Basu and Pick, 1995). The Cyanophyceae had a noticeable increase in terms of their abundance in the month of June which could be due to better light, temperature, nutrient availability and even water flow.

During the entire study, the Phytoplankton density was recorded to be highest in Spring season at all study sites which is in accordance to the findings that in temperate regions phytoplankton communities usually follow a distinct seasonal pattern (Round, 1981; Reynolds *et al.*, 1984; Sommer *et al.*, 1986). The phytoplankton biomass is typically low in winter, and as it responds to increasing temperature and light, its biomass increases during spring when the nutrient availability is still high (Sommer *et al.*, 1986).

Amongst the study sites the highest value of Shannon-Weiner index (Fig.3) was found at Fish Canal (3.00) followed by Gulmarg canal (2.80), Tanmarg canal (2.78), Drang (2.59) and least at Botapathri (2.45). Sorenson’s similarity index (Fig.4) indicated the highest value between Tangmarg canal and Fish canal (0.82) and lowest between Drang and Botapathri (0.41).

Table 1. Monthly variations in the population (ind.l^{-1}) of the phytoplankton community at five different sites during May to Dec 2012

S.No.	Class	Sites	May	June	July	Oct.	Dec.	Total	Mean
			Spring	Summer		Autumn	Winter		
				Bacillariophyceae					
1	*Amphora* sp.	Site I	2	1	3	1	2	9	1.8
		Site II	-	-	-	-	-	-	-
		Site III	2	3.5	-	-	-	5.5	2.7
		Site IV	1	3	5	4	2	15	3
		Site V	1	4	2	1	0	8	1.6
2	*Cyclotella* sp.	Site I	1	5	3	0	1	10	2
		Site II	3	4	2	3	1	13	2.6
		Site III	-	-	-	-	-	-	-
		Site IV	3	2	5	2	0	12	2.4
		Site V	2	1	3	3	1	10	2
3	*Diatoma* sp.	Site I	3	6	8	9	5	31	6.2
		Site II	2	4	5	3	2	16	3.2
		Site III	5	7	-	-	-	12	6
		Site IV	5	6	4	3	2	20	4
		Site V	10	9	14	8	4	45	9
4	*Gomphonema* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		SiteIII	-	-	-	-	-	-	-
		SiteIV	-	-	-	-	-	-	-
		Site V	0	2	1	3	2	8	1.6
5	*Navicula* sp.	Site I	3	15	12	13	5	48	9.6
		Site II	5	7	12	10	6	40	8
		Site III	7	8	-	-	-	15	7.5
		Site IV	6	8	9	10	7	40	8
		Site V	3	5	15	10	7	40	8
6	*Pinnularia* sp.	Site I	-	-	-	-	-	-	-
		Site II	0	1	2	4	3	10	2
		Site III	0	2	-	-	-	2	1
		Site IV	2	3	1	2	1	9	1.8
		Site V	4	3	2	1	0	10	2
7	*Synedra* sp.	Site I	1	4	3	2	1	11	2.2
		Site II	1	4	5	3	2	15	3
		Site III	-	-	-	-	-	-	-
		Site IV	4	2	3	1	2	12	2.4
		Site V	1	3	5	4	2	15	3

8	*Amphipleura* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	3	5	7	2	3	20	4
9	*Cymbella* sp.	Site I	2.5	3	4.5	4	3	17	3.4
		Site II	2	5	3	2.5	0.5	13	2.6
		Site III	3	4	-	-	-	7	3.5
		Site IV	5	4	10	8	6	33	6.6
		Site V	7	9	13.5	5	5.5	40	8
10	*Fragilaria* sp.	Site I	5	6	3	5	1	20	4
		Site II	-	-	-	-	-	-	-
		Site III	2	3	-	-	-	5	2.5
		Site IV	3	2	5	2	4	16	3.2
		Site V	5	3	6	5	1	20	4
11	*Meridion* sp.	Site I	2	3	5	4	3	17	3.4
		Site II	1	3	4	1	1	10	2
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	-	-	-	-	-	-	-
12	*Nitzschia* sp.	Site I	5	2	3	1	2	13	2.6
		Site II	2	4	6	5	3	20	4
		Site III	-	-	-	-	-	-	-
		Site IV	8	6	2	3	1	20	4
		Site V	2.5	5.5	10	12	5	35	7
13	*Surirella* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	0	3	2	0	1	6	1.2
14	*Tabellaria* sp.	Site I	0	1	3	2	1	7	1.4
		Site II	-	-	-	-	-	-	-
		Site III	-	-	-	-	-	-	-
		Site IV	0	2	4	2	1	9	1.8
		Site V	0	1	3	2	1	7	1.4
Chlorophyceae									
1	*Closterium* sp.	Site I	3	5	2	1	0	11	2.2
		Site II	1	2	4	1	2	10	2
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	3.5	6	9.5	8	3	30	6
2		Site I	4	5	6	4	1	20	4

	Chlorella sp.	Site II	-	-	-	-	-	-	-
		Site III	3	2	-	-	-	5	2.5
		Site IV	2	3	2	1	1	9	1.8
		Site V	2	4	7	3	2	18	3.6
3	*Cladophora* sp.	Site I	-	-	-	-	-	-	-
		Site II	2	3	1	0	1	7	1.4
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	-	-	-	-	-	-	-
4	*Microspora* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	-	-	-	-	-	-	-
		Site IV	5	8	7	6	4	30	6
		Site V	-	-	-	-	-	-	-
5	*Spirogyra* sp.	Site I	3	4	2	1	0	10	2
		Site II	2	6	8	4	1	21	4.2
		Site III	1.5	2	-	-	-	3.5	1.7
		Site IV	4	6	5	3	2	20	4
		Site V	1	3	5.5	3.5	2	15	3
6	*Vaucheria* sp.	Site I	-	-	-	-	-	-	-
		Site II	4	5	4	2	1	16	3.2
		Site III	-	-	-	-	-	-	-
		Site IV	0	1	3	0	2	6	1.2
		Site V	0	1	3	2	1.5	7.5	1.5
7	*Cosmarium* sp.	Site I	4	2	5	2	2	15	3
		Site II	-	-	-	-	-	-	-
		Site III	1	2.5	-	-	-	3.5	1.7
		Site IV	-	-	-	-	-	-	-
		Site V	2	3.5	7	5	2.5	20	4
8	*Chlorococcus* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	2	5	-	-	-	7	3.5
		Site IV	-	-	-	-	-	-	-
		Site V	-	-	-	-	-	-	-
9	*Mougeotia* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	-	-	-	-	-	-	-
		Site IV	1	5	3	7	6	22	4.4
		Site V	2	6	8	4	2	22	4.4
10	*Oedogonium* sp.	Site I	2	5	3	0	2	12	2.4
		Site II	4	5	7	4	2	22	4.4
		Site III	-	-	-	-	-	-	-

		Site IV	4	7	6.5	2.5	2	22	4.4
		Site V	0	5	3	2	3	13	2.6
11	*Zygnema* sp.	Site I	2	5	3	1	0	11	2.2
		Site II	-	-	-	-	-	-	-
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	3	5	7	2	1	18	3.6
Cyanophyceae									
1	*Anabaena* sp.	Site I	0	1	0	2	0	3	0.6
		Site II	-	-	-	-	-	-	-
		Site III	1	3	-	-	-	4	2
		Site IV	2	4	3	2	1	12	2.4
		Site V	1	3	1	2	1.5	8.5	1.7
2	*Oscillatoria* sp.	Site I	4	5	3	2	1	15	3
		Site II	0	1	2	1	3	7	1.4
		Site III	-	-	-	-	-	-	-
		Site IV	-	-	-	-	-	-	-
		Site V	3	5	2	1	4	15	3
3	*Microspora* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	0.5	1	-	-	-	1.5	0.75
		Site IV	-		-	-	-	-	-
		Site V	-	-	-	-	-	-	-
4	*Microcystis* sp.	Site I	2.5	1.5	2	1	3	10	2
		Site II	3	5	2	1	4	15	3
		Site III	-	-	-	-	-	-	-
		Site IV	0	3	1	1	0	5	1
		Site V	0	0	0.5	1	0	1.5	0.3
5	*Sphaerocystis* sp.	Site I	-	-	-	-	-	-	-
		Site II	-	-	-	-	-	-	-
		Site III	0	3	-	-	-	3	1.5
		Site IV	3	2	4	2	1	12	2.4
		Site V	2	0	1	0	3	6	1.2

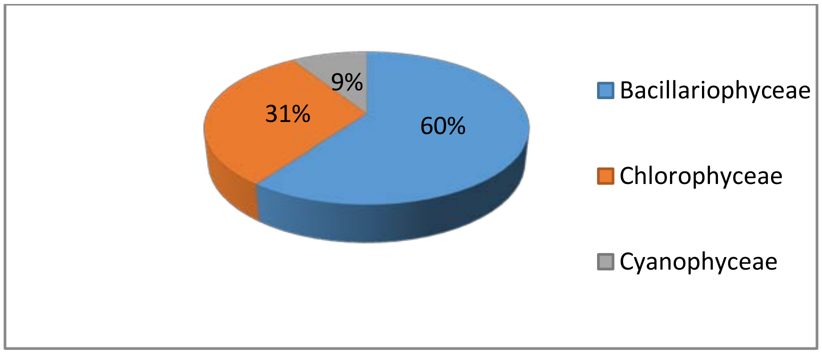

Fig.2. Percentage composition of phytoplankton

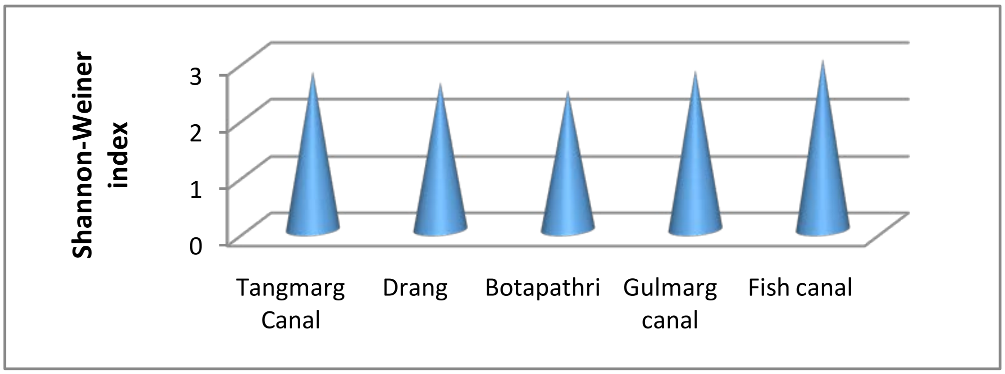

Fig.3. Shannon-Weiner diversity Index of various study sites

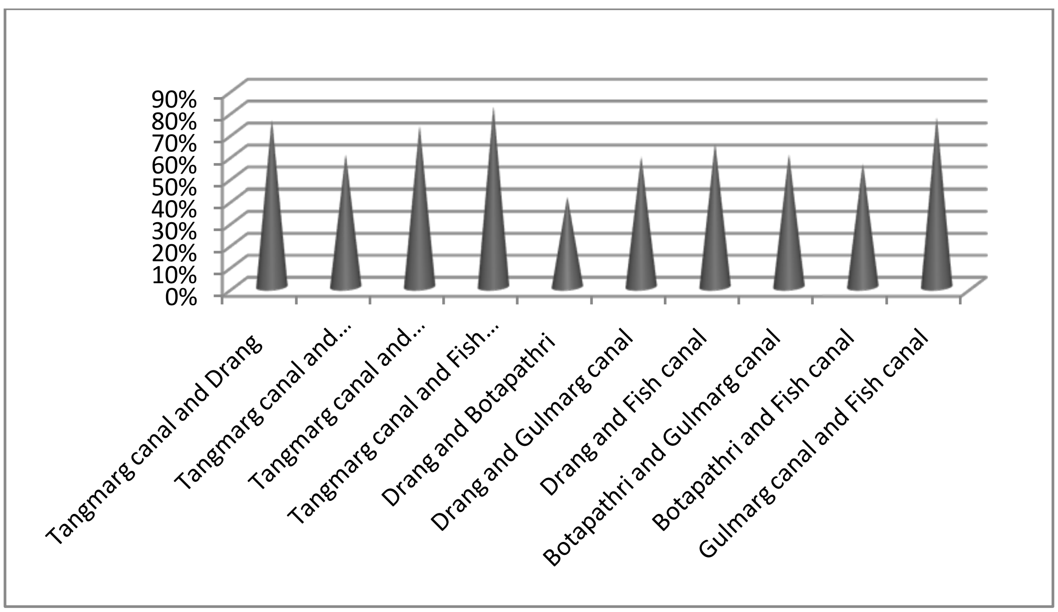

Fig.4. Sorenson's Similarity Coefficient between various study sites

CONCLUSION

From the present study it revealed that the Bacillariophyceae was dominant over Chlorophyceae and Cyanophyceae both qualitatively and quantitatively. The monthly variation in the density pattern of various genera was marked and evident. The streams in the area share common macro as well as microclimate thereby having most of the taxa common as is evident from similarity index.

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