International Research Journal of Environment Sciences ISSN 2319–1414
Vol. **3(2),** 1-7, February **(2014)** *Int. Res. J. Environment Sci.*

Phytoplankton Diversity of Western Yamuna Canal and River Yamuna in Yamunanagar, Haryana, India

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Available online at: www.isca.in, www.isca.me
Received 14th December 2013, revised 1st January 2014, accepted 8th February 2014

Abstract

Phytoplankton contributes significantly to the productivity of aquatic ecosystem. Any effect on the quality of water is reflected in the community structure and diversity of phytoplankton. The present communication deals with the qualitative and quantitative analysis of phytoplankton in Western Yamuna Canal (WYC) and Yamuna river which receives industrial effluents and domestic sewage from point and non-point sources. Odum algal index was also used for analyzing the *constituent diversity of algal species and monitoring the water quality. Sixteen taxa from western Yamuna Canal and thirty five taxa from river Yamuna have been observed belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae and Dinophyceae. The abundance, distribution, total population, group percentage and species diversity were studied and correlated with pollution indicating water quality characteristics. Species diversity values indicated a decrease from pre effluent point to effluent discharge channel and post effluent discharge point. Maximum value of Odum's algal index was observed for Cladophora spp. at WYC and for Micrasterias spp. and Navicula spp. at river Yamuna indicating them as tolerant taxa.*

Keywords: Odum algal index, Phytoplankton, Riverine pollution, Species diversity.

Introduction

Rivers play a major role in assimilating or carrying industrial and municipal waste water, manure discharge and runoff water from agriculture fields, road ways and streets which are responsible for river pollution[1]. Changes in the quality of water manifest themselves in several ways in the biota, viz., changes in the pattern of distribution, elimination of sensitive species, dominance of tolerant species, changes in diversity and subtle morphological and physiological changes. This forms the basis of biomonitoring water quality. Biomonitoring based on ecology of flora and fauna has been recognized as an excellent and inexpensive tool for measuring pollution levels in water.

Phytoplankton are the autotropic component, securing its place at the basal level of the aquatic food chain supplying all the needed ecological functions for aquatic life. They are the foundation of the riverine food chain and can influence earth's climate. Any disturbance in their community structure directly decreases its productivity[2].

In natural and unpolluted streams, the flora and fauna is represented by a high number of taxa, most of them with relatively small populations. A progressive decrease in the number of individual of each taxa is generally observed with an increase in pollution. Phytoplankton has been used with success in estimation of water pollution. Species diversity is the number of species in a community and their relative abundance. Diversity index takes into account the relative abundance of species that are present in the community. Diversity and assemblages of algae are used to assess ecological health of habitats. Odum algal index is a mathematical tool which helps in analyzing the constituent diversity of algal species and monitoring water quality. The industrial belt of Haryana is mainly situated along the north-eastern part of the state along with Yamuna. Yamuna's pollution starts from Tajewala in Haryana in the upper segment. Here two canals, the western Yamuna canal (WYC) and the eastern Yamuna canal (EYC), divert river water into Haryana and Uttar Pradesh (U.P.). The WYC cross Yamunanagar, Karnal and Panipat before reaching the Haiderpur treatment plant (which supplies part of Delhi's water), receiving waste water from Yamunanagar and Panipat. The river Yamuna receives the effluents from many small and big industries like paper mills, timber industries, sugar industry situated in district Yamunanagar and city sewage and waste effluents. Some studies have been undertaken to assess the water quality of WYC[3,4] and river Yamuna[5,6] in our laboratory. However, studies dealing with biomonitoring of western Yamuna canal, Yamuna river with special reference to phytoplankton community are very scanty. Hence the present investigation has been carried out to assess the diversity of phytoplankton of western Yamuna canal and river Yamuna.

Material and Methods

Western Yamuna canal and Yamuna river meander through/ along the city Yamunanagar and are subjected to sewage and industrial effluent input through several point and non-point sources. Keeping in view the pollution sources, these two lotic water bodies, viz., western Yamuna canal and Yamuna river were selected for present studies.

Three sampling stations were established and numbered W1, W2 and W3 on western Yamuna canal and Y1, Y2 and Y3 on river Yamuna consecutively downstream (figure 1) based on pollution load.

Plankton samples were collected by filtering 25 L of water through plankton net of mesh size 50µm with demarcating collecting tube. These samples were collected in 100 ml plastic bottles and concentrated samples were then made up a standard volume of 50 ml with distilled water. Samples were preserved with 4% buffered formalin.

Plankton's density was expressed as organisms per litre. The organisms were counted by drop count method.

The abundance of Phytoplankton was expressed as organisms L^{-1}. The organisms counted by drop count method were expressed per litre using formula:

$$\text{Total Planktons } L^{-1} = \frac{\text{Number of Organisms per drop X Vol. of conc. sample in ml}}{\text{Volume of original sample in litres X Vol. of one drop}}$$

Species Diversity of phytoplankton was determined using Shannon and Weaver diversity index method[7,8].

$D = - \sum ni/ N \log_2 ni/N$, D = Species Diversity, ni = Number of individuals of i^{th} species, N = Total number of individuals in the sample.

Odum's algal index was calculated according to Pranitha et al.[9]. Odum[10] determined algal index per thousand individuals and established certain principles to determine the quality criteria of water.

Odum's algal index was calculated by formula:

$$\text{Odum's Index} = \frac{\text{Total number of species encountered in the sample}}{\text{Total number of individuals of all the species}} \text{X} \, 1000$$

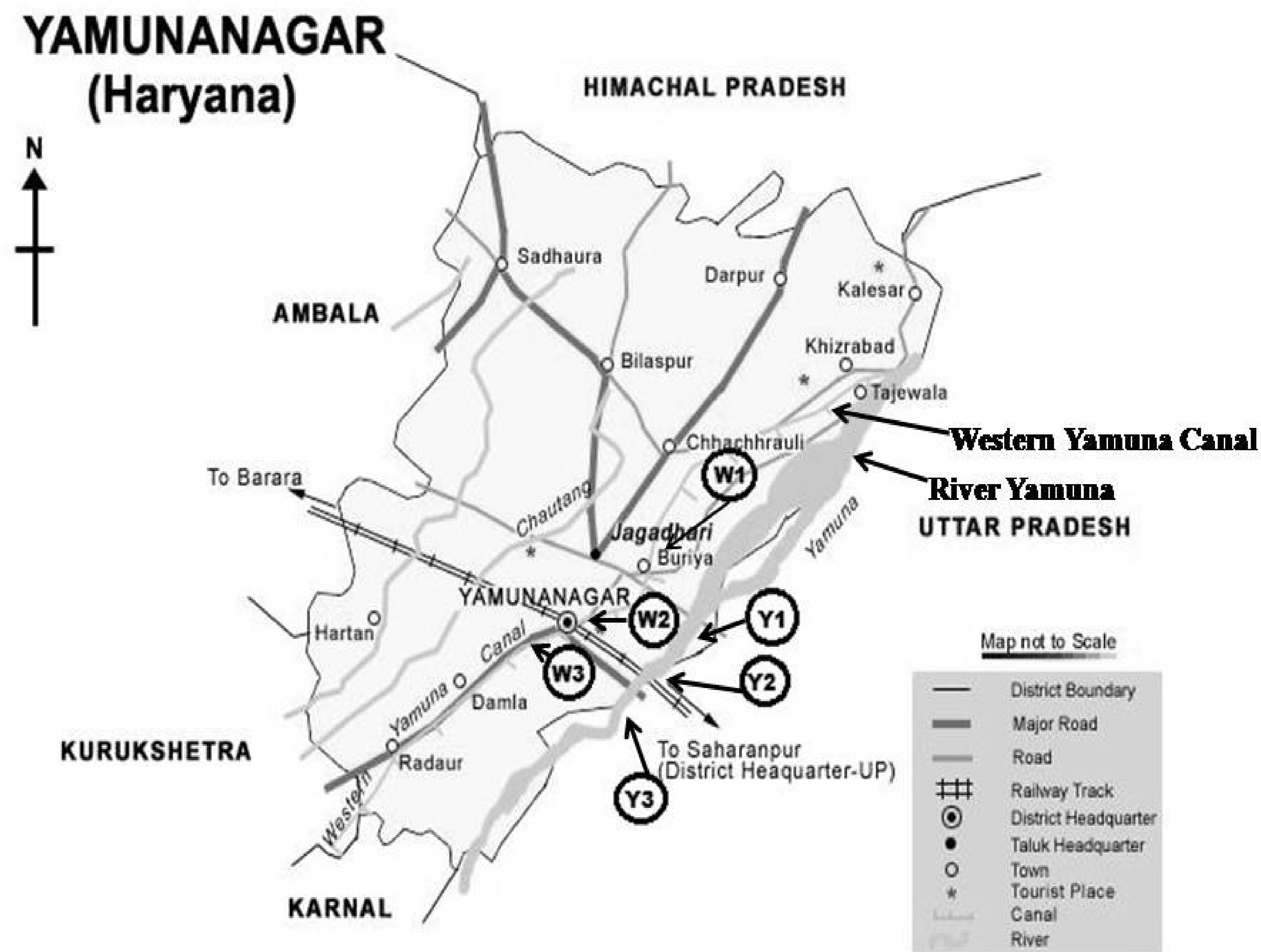

Figure-1
Map showing location of selected stations on western Yamuna canal and river Yamuna

Results and Discussion

Wester Yamuna canal: Sixteen taxa of phytoplankton belonging to three main groups, viz., Chlorophyceae, Bacillariophyceae and Cyanophyceae were encountered. Out of total 16 taxa, maximum 8 taxa were contributed by Chlorophyceae followed by Bacillariophyceae (5) and Cyanophyceae (3).

An analysis of monthly variations showed that maximum density (636±14.1 L^{-1}) was present at station W1 during April and minimum (125±5.31 L^{-1}) at station W3 during February. The number of phytoplankton continuously decreased from station W1 to W3 (figure 2).

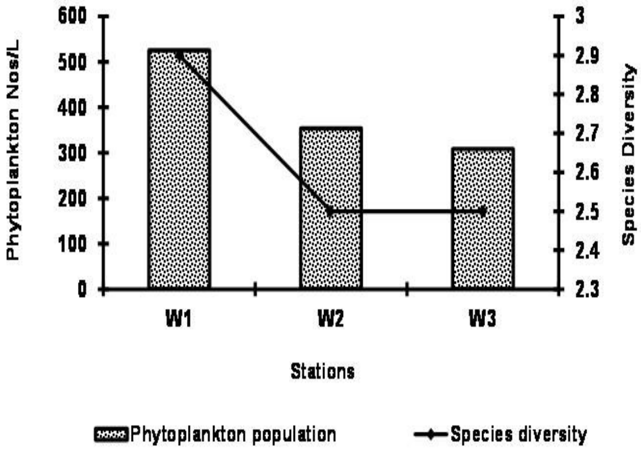

Figure-2
Graph showing total population and species diversity of western Yamuna canal

In the present studies, phytoplankton density significantly (P<0.05) decreased from station W1 to W3, this may be due to influx of effluents. Consequently, the increased phosphate concentration at station W2 did not result in higher phytoplankton production probably due to the distinctive characteristics of the canal's water, i.e, significant increases in discharge, low DO and high BOD[11]. Statistically also, phytoplankton density showed a significant positive correlation with DO (r = 0.636, P<0.05) and negative with BOD (r = -0.622) advocating the low phytoplankton diversity at station W2.

Maximum numbers of phytoplankton in the present studies were observed during April at station W1 and W2 (figure 2). Farahani et al.[12] and Chowdhury et al.[13] estimated that density of phytoplankton was greater during summer supporting the present studies.

The percentage distribution of Chlorophyceae, which was most abundant group ranged between 38.6% to 49% at station W1, 37% to 46.5% at W2 and 40.8% to 61.6% at W3 (table 1). Somani and Pejaver[14] also noticed higher percentage distribution of Chlorophytes. Among the members of Chlorophyceae, Volvox spp., Cladophora spp., Netrium spp. and Ulothrix spp. were common forms. The percentage distribution of Bacillariophyceae, the next major group, was between 38.8% to 52.2% at station W1, 45.8% to 57.2% at station W2 and 31.6% to 51.7% at station W3. Synedra spp., Navicula spp., Surirella robusta, Diatoma spp. and Spirulina spp. were common taxa recorded from all the three stations. Cyanophyceae, the third group, ranged from 5.83% to 50.4% at station W1, 4.02% to 14.3% at station W2 and 2.4% to 8.33% at station W3. It was noticed that number of phytoplankton taxa decreased from station W1 (15) to W2 (11) and W3 (10).

According to Oritz and Cambra[15] phytoplankton community is generally dominated by members of Bacillariophyceae perhaps because of their capability of utilizing the nutrients. In the present studies Bacillariophyceae is the second dominant group. Members of Dinophyceae were totally absent indicating their inefficiency in competing for nutrients as reported by Tifman[16]. Total population and species diversity clearly depicted a decline at station W2.

Species Diversity Index: The mean values of Shannon and Weaver's species diversity index was significantly (P<0.05) high at station W1 (2.9±0.2) as compared to station W2 (2.5±0.1) and W3 (2.5±0.2) (figure 2). Species diversity of phytoplankton was found maximum in the month of April at station W1 (3.8), July at station W2 (2.9) and February at station W3 (3.0). Senthikumar and Sivakumar[17] also reported increased value of phytoplankton density during summer and post monsoon seasons and number was at peak during April month. Species diversity of phytoplankton decreased from station W1 to W2 and then remained the same at station W3. This may be due to nutrient richness and moderate temperate[17].

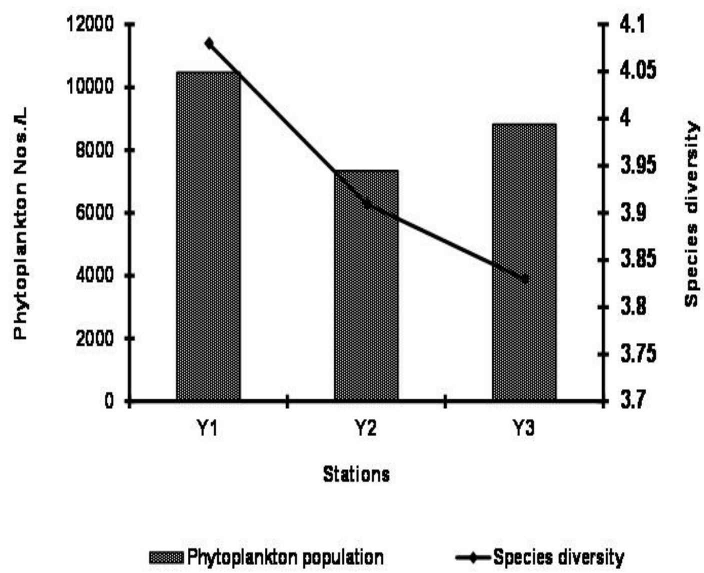

Figure-3
Graph showing total population and species diversity of river Yamuna

Odum's Algal Index: The maximum value of Odum's algal index was calculated for Cladophora spp. at station W1 (173±7.72), W2 (227±10.3) and W3 (221±11.6) while the minimum values was for Nostoc spp. at station W1 (8.46±1.81), W2 (0.85±0.59) and W3 (0) (figure 4). The highest range of Odum's algal index with Synedra spp., Navicula spp., Cladophora spp. and Spirulina spp. was in between 150 to 230. The moderate range of this index (70-150) was with Surirella robusta, Oscillatoria spp., Diatoma spp., Synedra spp., Navicula spp., Cladophora spp., Ulotrix spp. and Spirulina spp.. The lowest range of algal index (less than 70) was witnessed with Diatoma spp., Volvox spp., Netrium digitus, Dactylococcus spp., Ulothrix spp., Chlorella spp., Ankitodes spp., Chaetophora spp., Spirulina spp., Synechococcus spp., Nostoc spp., Oscillatoria spp. and Surirella spp.. Maximum value of Odum's algal index was observed for Cladophora spp. indicating it as tolerant taxon. Zulkifly et.al.[18] has also reported similar results.

River Yamuna: Thirty five taxa contributed to the phytoplankton community at river Yamuna belonging to Chlorophyceae (21), Bacillariophyceae (10), Cyanophyceae (3) and Dinophyceae (1).

The percentage distribution of phytoplankton showed that Chlorophyceae was dominant at all the stations. Negi and Rajput[19], Patil et al.[20] and Hamaidi-chergui et al.[21] also reported highest composition of this group.

Table-1
Percentage distribution of phytoplankton of western Yamuna canal

	Chlorophyceae			**Bacillariophyceae**			**Cyanophyceae**		
	W1	W2	W3	W1	W2	W3	W1	W2	W3
Nov	40.6	38.4	40.8	51.1	57.2	51.7	8.25	4.34	7.38
Dec	38.6	37.7	43.1	52.2	56.4	49.6	5.83	5.78	7.27
Jan	41.5	42.8	60.0	50.0	51.1	31.6	8.49	4.02	8.33
Feb	49.0	46.5	61.6	40.3	47.1	36.0	10.5	6.28	2.40
Mar	45.7	45.6	-	38.8	47.2	-	15.4	7.14	-
April	40.7	41.9	-	44.2	46.1	-	14.9	11.9	-
May	43.9	41.7	-	43.8	45.8	-	14.4	12.3	-
June	41.5	37.6	-	44.9	49.0	-	50.4	12.8	-
July	40.9	37.0	-	43.1	48.5	-	15.8	14.3	-

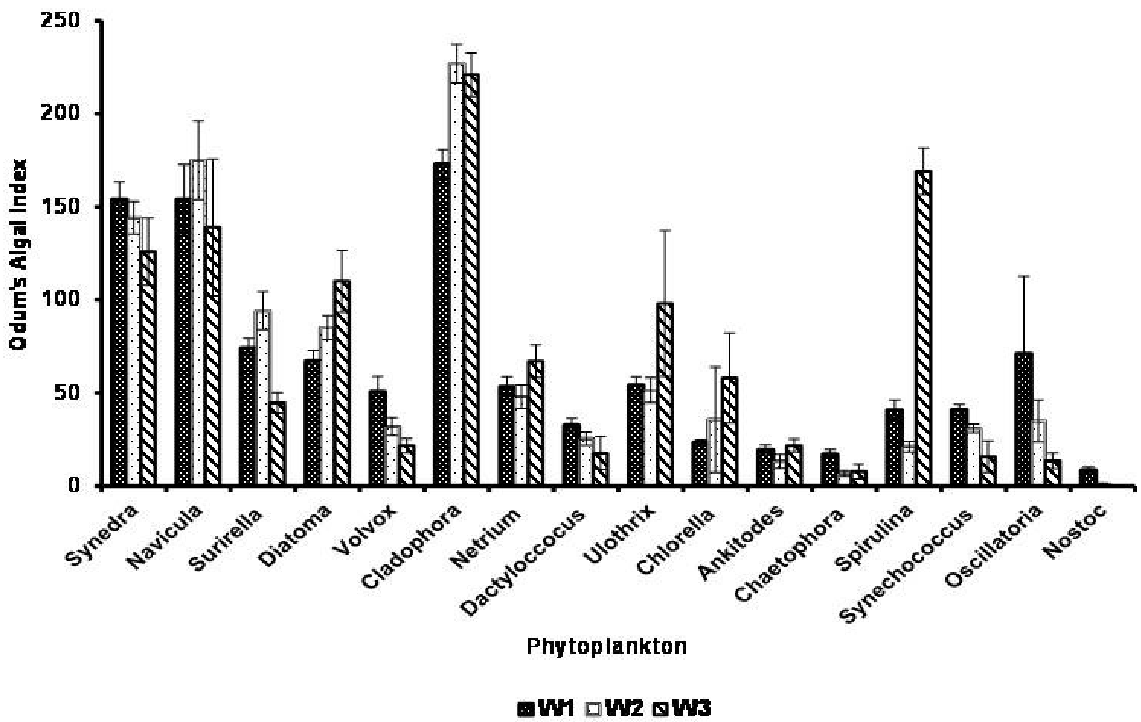

Figure-4
Graph showing Odum algal index of Western Yamuna canal at various stations

The total number of phytoplankton at various stations varied from 14840±281 L^{-1} to 4876±356 L^{-1}(figure 3). The mean number of phytoplankton was 10473±600 L^{-1} at station Y1, 7347±636 L^{-1} at station Y2 and 8822±582 L^{-1} at station Y3. A decrease in phytoplankton population was observed from station Y1 to station Y2, which is the area where the channel carrying the effluents joined the river. Tabasum and Trisal[22] and Piirsoo et al.[23] have also observed decline in phytoplankton population with the influx of effluents. Maximum number of total phytoplankton were found during July at all the stations with Y1 (14930 L^{-1}), Y2 (13050 L^{-1}) and Y3 (12750 L^{-1}). Hamaidi-chergui et al.[21] also reported a sharp increase in the number of phytoplankton during July. Navicula spp. (6470 L^{-1}) was the dominant at station Y1 and Micrasterias spp. (4840 L^{-1}) at station Y2 while Chlorella spp. and Micrasterias spp. (5510 L^{-1}) were dominant at station Y3. Chellappa et al.[24] and Ramesha and Sophia[25] have also described dominance of Navicula spp..

The percentage distribution of Chlorophyceae, the most abundant group was 63±1.25% at station Y1, 66.8±1.58% at Y2 and 62.9±1.09% at Y3 (table 2). Among the members of Chlorophyceae Closterium spp., Micrasterias spp. and Dactylococcus spp. were the common forms at all the stations. Higher values of nitrogen and phosphorous for river Yamuna indicated an enriched nutrient status, favouring Chlorophytes as reported by Wilk-Wozniak and Marshall[26] and Singh and Jangde[27]. The percentage distribution of Bacillariophyceae, the next major group was 25.7± 1.10% at station Y1, 24.9±1.40% at Y2 and 27±1.05% at Y3. Navicula spp. and Cocconeis spp. were common taxa recorded from all the stations.

Cyanophyceae ranged from 6.90 to 12.1% at station Y1, 3.81 to 10.2% at Y2 and 3.99 to 11.2% at Y3 during the study period. Dinophyceae was recorded in the range of 1.34 to 3.52% at Y1, 1.37 to 3.67% at Y2 and 1.63 to 3.92% at Y3.

Species Diversity Index: The mean values of Shannon and Weaver's species diversity index was found maximum at station Y1 (4.08±0.14) and minimum at station Y3 (3.83±0.04) (figure 3). The species diversity of phytoplankton showed a gradual decrease from station Y1 to Y3, indicating the stress because of industrial pollution and sewage waste. Bhatnagar and Garg[28] and Ramesha and Sophia[25] have emphasized the role of species diversity index in pollution and stated that decrease in species diversity values point to polluted waters.

Odum's Algal Index: The maximum value of Odum's algal index was calculated for Chlorella spp. at station Y1 (53.2±3.71) and Micrasterias spp. at station Y2 (55.9±5.68) and Y3 (53.8±5.36) (figure 5). The minimum value of Odum's index was calculated for Desmidium spp. at stations Y1 (13.3±2.93) and Y3 (13.6±2.92) and Gomphonema spp. and Phormidium spp. at station Y2 (12.9±3.60). The highest range of Odum's algal index with Navicula spp., Oscillatoria spp., Closterium spp., Spirogyra spp., Micrasterias spp., Chlorella spp., Scenedesmus spp., Closteridium spp., Ulothrix spp. was in between 40 to 60. The moderate range (20-40) of algal index was with Synedra spp., Cocconies spp., Surirella spp., Glenodinium spp., Stauroneis spp., Synecoccous spp., Zygnema spp., Volvox spp., Eudorina spp., Ulothrix spp., Scenedesmus spp., Closteridium spp., Sirocladium spp., Netrium spp., Pleurosigma spp., Rhizicolonium spp., Closteriopsis spp., Dactylococcus spp., Botrycoccus spp., Mougeotia spp., Synedra spp., Tabellaria spp., Neidium spp., Nodularia spp., Cyclotella spp., Gomphonema spp., Closterium spp. and Penium spp.. The least range (less than 20) of algal index was witnessed with Cyclotella spp., Tabellaria spp., Neidium spp., Glenodinium spp., Stauroneis spp., Gomphonema spp., Synecoccous spp., Nodularia spp., Rhizocolonium spp., Bulbochaete spp., Desmidium spp., Penium spp., Botrycoccous spp., Mougeotia spp. and Phormidium spp..The highest value of Odum's algal index was found for Micrasterias spp. and Navicula spp. indicating them as tolerant taxa[29].

Table-2
Percentage distribution of phytoplankton of river Yamuna

	Chlorophyceae			Bacillariophyceae			Cyanophyceae			Dinophyceae		
	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3
Aug	59.1	70.0	59.6	26.7	23.7	29.2	10.4	6.16	9.64	1.63	-	2.06
Sep	66.1	71.6	65.7	24.2	17.6	23.1	8.03	9.13	8.87	1.49	2.16	2.16
Oct	65.6	73.0	64.5	24.1	18.6	22.5	8.74	6.77	11.2	1.47	2.07	1.63
Nov	56.8	63.5	64.6	33.9	26.1	26.3	7.31	10.2	7.37	1.93	-	1.63
Dec	58.9	62.2	64.8	25.9	27.6	26.1	12.1	7.66	6.98	3.02	2.41	1.99
Jan	69.5	70.2	67.9	23.5	25.9	24.9	6.90	3.81	7.66	-	-	-
Feb	61.3	74.2	58.2	62.2	21.5	35.0	11.0	4.15	3.99	1.34	-	2.76
Mar	68.7	58.4	67.3	18.5	31.7	22.6	10.7	9.80	8.03	1.88	-	1.98
April	64.8	73.8	55.2	26.0	18.0	32.3	6.91	5.38	9.87	2.18	2.69	2.49
May	67.8	63.2	64.5	21.4	31.4	26.4	9.29	3.90	7.04	1.46	1.37	1.95
June	57.4	60.2	58.8	30.2	30.4	27.6	8.81	8.0	10.9	3.52	1.18	2.59
July	60.8	62.4	64.6	28.2	26.5	28.0	8.77	7.27	7.37	2.14	3.67	3.92

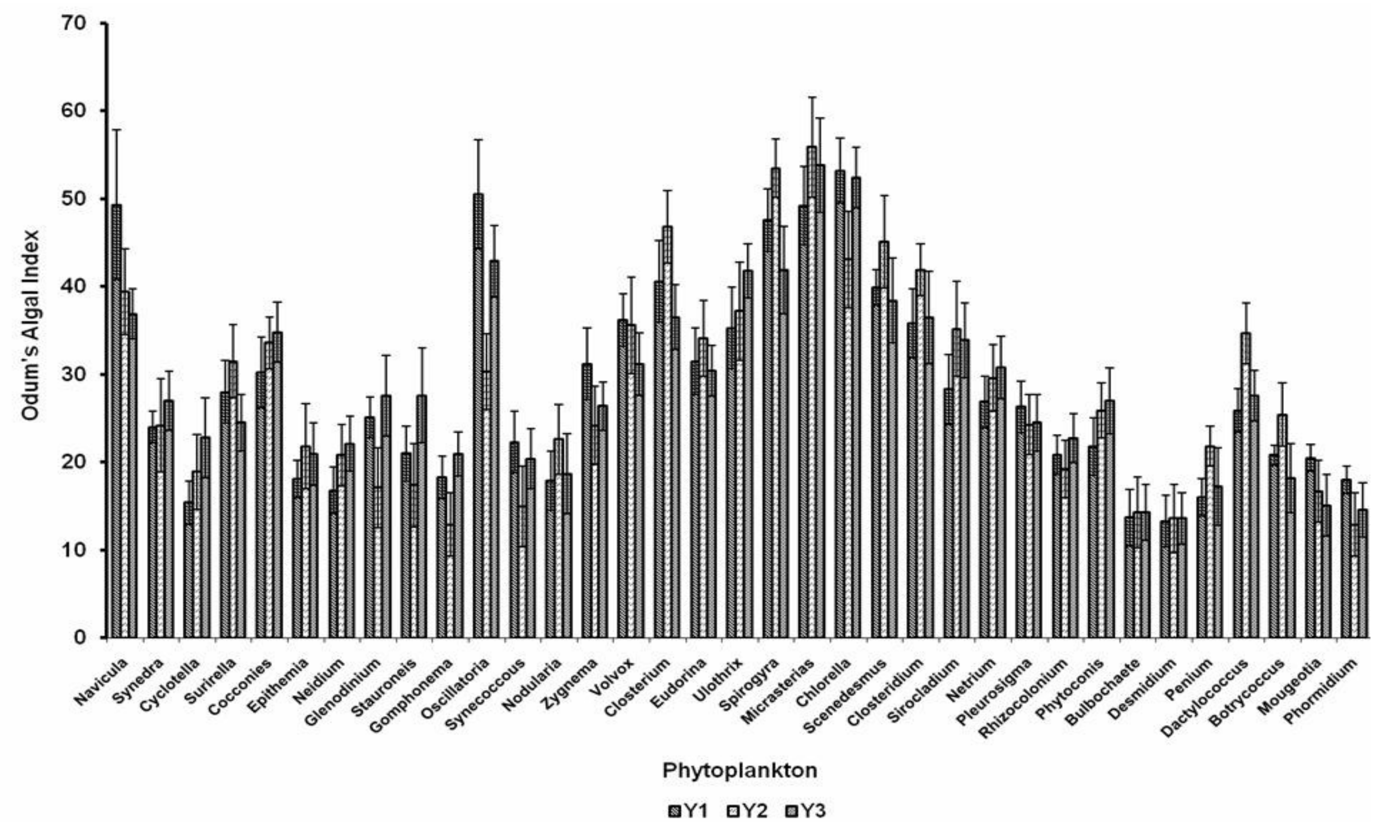

Figure-5
Graph showing Odum algal index of river Yamuna at various stations

Conclusion

Although river Yamuna and western Yamuna canal has rich biodiversity, yet the effluents from various industries and anthropogenic activities are adversely affecting the ecology of both the systems as indicating the low species diversity and percentage distribution of phytoplankton at the point getting effluents.

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