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Pollution Status of River Sutlej in the Region of Punjab (India): Based on Species Diversity Indices

C. Sharma[1] and UdayBhan Singh[2*]

[1]Department of Zoology, Panjab University, Chandigarh-160 014, India

[*2]Laboratory of Algal Biology and Diversity, Department of Botany, Panjab University, Chandigarh-160 014, India

ubsday@gmail.com

Abstracts

Plankton species diversity of river Sutlej was conducted at River Sutlej (S1) at Ropar Headworks, (S2) downstream after the confluence with BudhaNallah, (S3) at Harike before the confluence with river Beas, (S4) at Harike before the confluence with river Beas. Water samples were collected on the monthly basis for two consecutive years (November, 2009-October, 2011), Data on the different species diversity indices viz., Simpson index, Shannon-Wiener species diversity index, Berger-Parker index, Margalef richness index revealed that that higher values (4.11) of Berger-Parker index was at S_3, Simpson index (0.72) at S_1 and (0.16) at S_3; Shannon-Wiener index (2.97) at S_1 and (2.53) at S_3; and Margalef richness index (4.85) at S_1 and (4.11) at S_3 were recorded, whereas lower values of Shannon-Wiener Index (2.39) at S_2; Simpson index (0.14) at S_2 and Margalef index (3.67) at S_2 were observed. Higher values S_1 and S_3 indicated healthy status of these stations and lowest values at S_2 showed polluted status/ deteriorated condition of the habitat.

Keywords: Simpson index, Shannon-Wiener index, Berger-Parker index, Margalef index, River Sutlej.

Introduction

Due to rapid urbanization, industrialization and unplanned use of freshwater resources, the water quality of freshwater reservoirs is subjected to the natural degradation, processes of eutrophication and the impacts of anthropogenic activities. No individual factor like physical or chemical is singly responsible for the fluctuations of phytoplankton or zooplankton populations. Thus number of physical, chemical and biological environmental factors affecting simultaneously must be taken into consideration in understanding the fluctuation of plankton population [1-3]. The recent works on planktons used as bioindicators of environmental conditions in aquatic ecosystems [4-9] are worth mentioning. Some authors even have emphasized the importance of macrophytes for the assessment of the water quality of freshwater [10-11]. Information on species diversity, richness, evenness and dominance evaluation on the biological components of an ecosystem is essential to understand detrimental changes in environment [12-13]. Diversity indices are good indicators of pollution in an aquatic ecosystem [14-15]. Species diversity has been determined by monthly changes in number of species and by calculating different species diversity indices viz., Simpson index, Shannon-Wiener species diversity index, Berger-Parker index, Margalef richness index, and the data on the indices calculated at different observation stations on the river Sutlej.

Study area

S_1: River Sutlej at Ropar Headworks: This is located at Ropar Headworks (lat. 30°59'N; long. 76°31' 12"E; alt. 272m above m.s.l.) in Punjab.

S_2: River Sutlej downstream after the confluence with Budha Nallah: It is 95 km downstream S_1, where Budha Nallah joins river Sutlej at village Wallipur (lat. 30°58'N; long. 75°37'49"E; alt. 228 above m.s.l.).

S_3: River Sutlej upstream before the confluence with East Bein: This is located at village Lohian before the confluence of East Bein with river Sutlej (lat. 31°07'N; long. 75°06'58"E; alt. 209m above m.s.l.).

S_4: River Sutlej at Harike before the confluence with river Beas: It is downstream S_3 after the confluence of East Bein with river Sutlej and before the confluence of river Beas (lat. 31°08'N; long. 74°59' 13"E; alt. 211m above m.s.l.).

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Materials and methods

The collections were made monthly for a period of two year i.e. November 2009 -October 2011. Four stations (S_1, S_2, S_3 and S_4) were set up on the river to collect water samples.

Biological analysis:

(i) Collection: For the collection of biota 100 L of water was sieved through a ring type bolting silk net (24 meshes mm^{-2}), fitted with a wide mounted glass bottle. The samples collected were preserved in 4% formaldehyde solution on the spot for counting of plankton. For living study and identification of the biota, separate water sample was collected in the similar manner.

(ii) Identification: The books consulted for the identification of phytoplankton and zooplankton are: [16-19]. In addition, recent publications in various journals have been consulted to update the information available on the taxonomy of various organisms.

(iii) Counting of plankton: Counting of plankton was done with the help of 'Sedgwick-Rafter counting cell' as per the procedure given in [20].

Results and discussion

Species diversity has been determined by monthly changes in number of species and by calculating different species diversity indices viz., [21-24], and the data on the indices given in Table 1.

Monthly average values of Simpson index and its range was 0.72 ± 0.02 (0.05-0.11), 0.14 ± 0.05 (0.07-0.24), 0.14 ± 0.05 (0.06-0.27) and 0.11 ± 0.02 (0.07-0.16) in 2009-10, and 0.72 ± 0.02 (0.05-0.11), 0.15 ± 0.04 (0.11-0.22), 0.21 ± 0.19 (0.10-0.80) and 0.17 ± 0.21 (0.06-0.84) in 2010-11 at S_1, S_2, S_3 and S_4 respectively.

During present investigations, monthly average and range of Shannon-Wiener index was 3.00 ± 0.18 (2.66-3.25), 2.43 ± 0.25 (2.03-2.83), 2.54 ± 0.31 (2.02-3.12) and 2.61 ± 0.19 (2.33-3.00) in 2009-10 and 2.94 ± 0.19 (2.64-3.27), 2.36 ± 0.24 (2.01-2.67), 2.52 ± 0.28 (2.13-3.06) and 2.65 ± 0.26 (2.35-3.22) in 2010-11 at S_1, S_2, S_3 and S_4 respectively.

Monthly average values of Berger-Parker index and its range was 0.17 ± 0.05 (0.11-0.26), 0.25 ± 0.10 (0.13-0.45), 0.26 ± 0.10 (0.11-0.48) and 0.21 ± 0.05 (0.15-0.33) in 2009-10, and 0.16 ± 0.04 (0.09-0.23), 0.28 ± 0.07 (0.19-0.43), 0.30 ± 0.07 (0.17-0.41) and 0.22 ± 0.05 (0.14-0.30) in 2010-11 at S_1, S_2, S_3 and S_4 respectively.

Monthly average values of Margalef richness index and its range was 5.04 ± 0.88 (4.05-6.60), 3.62 ± 0.55 (2.89-4.46), 4.13 ± 0.71 (3.30-5.77) and 3.83 ± 0.77 (2.49-5.22) in 2009-10 and 4.67 ± 0.79 (3.67-6.34), 3.72 ± 0.77 (2.69-5.03), 4.09 ± 0.75 (3.08-5.32) and 3.84 ± 0.89 (2.63-5.72) in 2010-11 at S_1, S_2, S_3 and S_4 respectively.

Table 1: Monthly fluctuations in different biodiversity indices at different stations

Index	Station	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean ± S.D.	Range
Simpson Index	S_1	2009-10	0.08	0.06	0.06	0.06	0.07	0.05	0.08	0.11	0.07	0.10	0.07	0.07	0.07 ± 0.02	0.05 – 0.11
		2010-11	0.07	0.08	0.07	0.11	0.07	0.06	0.08	0.06	0.09	0.09	0.05	0.06	0.07 ± 0.02	0.05–0.11
	S_2	2009-10	0.16	0.16	0.14	0.11	0.07	0.09	0.12	0.12	0.22	0.24	0.11	0.14	0.14 ± 0.05	0.07–0.24
		2010-11	0.14	0.18	0.12	0.22	0.13	0.12	0.11	0.14	0.21	0.21	0.16	0.11	0.15 ± 0.04	0.11–0.22
	S_3	2009-10	0.27	0.17	0.14	0.13	0.12	0.09	0.13	0.14	0.16	0.19	0.07	0.06	0.14 ± 0.05	0.06–0.27
		2010-11	0.20	0.19	0.15	0.12	0.10	0.15	0.19	0.15	0.16	0.19	0.80	0.10	0.21 ± 0.19	0.10–0.80
	S_4	2009-10	0.11	0.16	0.13	0.11	0.08	0.11	0.13	0.13	0.09	0.12	0.10	0.07	0.11 ± 0.02	0.07–0.16
		2010-11	0.11	0.13	0.10	0.08	0.09	0.13	0.14	0.12	0.13	0.12	0.84	0.06	0.17 ±0.21	0.06–0.84
Shannon-Wiener	S_1	2009-10	2.94	2.98	2.96	3.19	3.22	3.25	2.96	2.74	2.89	2.66	3.08	3.14	3.00 ± 0.18	2.66–3.25
		2010-11	2.98	2.82	2.85	2.64	3.01	3.06	2.91	3.05	2.74	2.73	3.27	3.22	2.94 ± 0.19	2.64–3.27

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	S_2	2009-10	2.19	2.08	2.32	2.56	2.83	2.73	2.52	2.55	2.19	2.03	2.62	2.51	2.43 ± 0.25	2.03–2.83
		2010-11	2.43	2.04	2.42	2.15	2.57	2.58	2.64	2.44	2.02	2.01	2.35	2.67	2.36 ± 0.24	2.01–2.67
	S_3	2009-10	2.02	2.23	2.46	2.53	2.69	2.74	2.48	2.44	2.42	2.28	3.02	3.12	2.54 ± 0.31	2.02–3.12
		2010-11	2.13	2.17	2.44	2.64	2.83	2.57	2.28	2.42	2.43	2.43	3.06	2.86	2.52 ± 0.28	2.13–3.06
	S_4	2009-10	2.66	2.33	2.41	2.66	2.86	2.72	2.52	2.56	2.63	2.37	2.66	3.00	2.61 ± 0.19	2.33–3.00
		2010-11	2.67	2.35	2.63	2.85	2.90	2.46	2.51	2.55	2.44	2.37	2.96	3.22	2.65 ± 0.26	2.35–3.22
Berger-Parker Index	S_1	2009-10	0.18	0.11	0.11	0.16	0.18	0.12	0.19	0.26	0.15	0.24	0.16	0.20	0.17 ± 0.05	0.11–0.26
		2010-11	0.17	0.16	0.15	0.23	0.15	0.14	0.16	0.13	0.16	0.21	0.09	0.13	0.16 ± 0.04	0.09–0.23
	S_2	2009-10	0.24	0.20	0.25	0.21	0.13	0.17	0.21	0.24	0.44	0.45	0.21	0.29	0.25 ± 0.10	0.13–0.45
		2010-11	0.25	0.28	0.24	0.43	0.27	0.22	0.20	0.23	0.37	0.37	0.31	0.19	0.28 ± 0.07	0.19–0.43
	S_3	2009-10	0.48	0.28	0.24	0.23	0.27	0.19	0.27	0.25	0.37	0.32	0.12	0.11	0.26 ± 0.10	0.11–0.48
		2010-11	0.34	0.30	0.29	0.25	0.20	0.35	0.38	0.31	0.35	0.41	0.17	0.25	0.30 ± 0.07	0.17–0.41
	S_4	2009-10	0.24	0.33	0.27	0.22	0.15	0.21	0.23	0.28	0.15	0.19	0.17	0.16	0.21 ± 0.05	0.15–0.33
		2010-11	0.24	0.27	0.19	0.14	0.22	0.26	0.30	0.23	0.26	0.22	0.20	0.14	0.22 ± 0.05	0.14–0.30
Margalef Richness Index	S_1	2009-10	5.00	4.05	4.05	5.67	6.60	5.47	4.85	4.80	4.17	4.05	5.58	6.24	5.04 ± 0.88	4.05–6.6
		2010-11	5.05	4.08	3.67	4.32	5.46	4.60	4.50	4.97	4.05	3.71	5.31	6.34	4.67 ± 0.79	3.67–6.34
	S_2	2009-10	3.49	2.89	2.93	3.23	3.91	4.14	3.91	3.93	3.35	2.95	4.21	4.46	3.62 ± 0.55	2.89–4.46
		2010-11	4.53	2.69	2.96	3.18	4.09	4.08	4.23	4.11	3.00	2.77	4.1	5.03	3.73 ± 0.77	2.69–5.03
	S_3	2009-10	3.99	3.53	3.65	3.94	4.85	3.95	4.09	3.99	3.30	3.57	4.90	5.77	4.13 ± 0.71	3.30–5.77
		2010-11	3.87	3.08	3.53	4.65	5.04	4.02	3.67	3.67	3.68	3.42	5.21	5.32	4.09 ± 0.75	3.08–5.32
	S_4	2009-10	4.36	3.46	2.90	3.76	4.61	4.16	3.92	3.97	2.98	2.49	4.10	5.22	3.83 ± 0.77	2.49–5.22
		2010-11	4.35	2.97	3.06	3.78	4.62	3.10	3.65	3.68	3.70	2.63	4.82	5.72	3.84 ± 0.89	2.63–5.72

At all the sampling sites, higher values of biodiversity indices were observed during summer and post-monsoon seasons, and less during monsoon and winter seasons. On comparing the data on species diversity indices of river Sutlej, it has been observed that higher values (4.11) of Berger-Parker index was at S_3, Simpson index (0.72) at S_1 and (0.16) at S_3; Shannon-Wiener index (2.97) at S_1 and (2.53) at S_3; and Margalef richness index (4.85) at S_1 and (4.11) at S_3 were recorded, whereas lower values of Shannon-Wiener Index (2.39) at S_2; Simpson index (0.14) at S_2 and Margalef index (3.67) at S_2 were observed. Higher values S_1 and S_3 indicated

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healthy status of these stations, and lowest values at S_2 showed polluted status/ deteriorated condition of the habitat.

Odum [25] observed that when stress occurs in a community dominated by a few species, a large number of dominated species get eliminated and evenness increases. In present study maximum diversity and species richness was observed during summer and post-monsoon when conditions were relatively stable. Results obtained also indicated low diversity and richness during the monsoon period, could be attributed to environmental stress. Hawkes [26] also opined that low diversity is reflection of environmental stresses. High species diversity during post-monsoon could be attributed to factors like higher values of temperature, light, pH and richness of nutrients [27-28]. It has also been noticed that though the perennial forms showed their presence in all the seasons, yet they showed their abundance during their favourable period. Diversity is the best means to assess the biological integrity in the freshwater systems. It is based on the principle that in natural clean water diversity is high, while in polluted water the diversity is low. During present investigation it was found to be true, as maximum species diversity was recorded at S_1 and S_3, whereas, minimum at S_2.

Conclusion

Minimum diversity at S_2 and S_4 could be attributed to industrial effluents and high organic pollution load brought by Budha Nallah at S_2 and East Bein at S_4. Low diversity in polluted water might be due to the fact that many pollution sensitive species were eliminated from the community and only a few pollution tolerant organisms flourished in the absence of competition and in the presence of abundant food supply.

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