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Saprobic status and Bioindicators of the river Sutlej

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ABSTRACT:

Saprobic status and bioindicators of river Sutlej was conducted at (S1) Ropar Headworks, (S2) downstream after the confluence with BudhaNallah, (S3) Harike before the confluence with river Beas, (S4) Harike before the confluence with river Beas. Water samples were collected on the monthly basis for two consecutive years (November, 2009-October, 2011), on the basis of saprobic classification given by Sladecek (1973), (S_1) could be categorized as oligosaprobic, (S_2) as polysaprobic, (S_3) as mesosaprobic, and (S_4) as meso-polysaprobic. Data on the Palmer's Algal Index values revealed that S_2 and S_4 were grossly polluted, S_1 was least polluted, whereas in S_3, there were chances of medium degree of organic pollution. Bioindicator organism may have higher frequency index and they are major peak forming organisms at different stations and in different seasons. The results also indicate that the bioindicator species may also behave as peak forming organisms and their abundant depends upon diverse parameters.

Keywords:
Saprobity, Bioindicators, River Sutlej, Palmer's Algal Index, BOD

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INTRODUCTION

Planktons are very sensitive to the change in the environment they inhabit. Any change in the habitat in terms of tolerance, abundance, diversity and dominance leads to the change in the plankton communities (Verma *et al.,* 2012; Sharma *et al.,* 2013; Jindal *et al.,* 2013). Biological assessment has emerged as a valuable alternative for aquatic ecosystems assessments; since planktonic species are cosmopolitan in distribution and inhabiting biological communities show the integrated effects of the environment including water chemistry (Singh *et al.,* 2013a; Thakur *et al.,* 2013; Singh and Sharma, 2014). Trivedy (1988) concluded the use of phytoplanktons for assessing the degree of pollution of different water bodies. Phytoplankton or microalgae are diverse group of chlorophyllous microorganisms with simple nutritional requirements, be they eukaryotes (for instance, green algae) or prokaryotes e.g. cyanobacteria (Singh and Ahluwalia, 2013). Nowadays, macrophytes are also considered as indicators of water quality (Singh *et al.,* 2013b,c). The change in environmental conditions and phytoplankton community further affects the zooplankton communities which also respond quickly to changes in environmental quality.

The use of bioindicators to evaluate trophic state of water bodies, have often been neglected in the contrast to physical and chemical methods for analysis of water (Thadeus and Lekinson, 2010). In the present investigation, the pollution load of river Sutlej was assessed on basis of bioindicators and saprobic assessment.

STUDY AREA

The prosperities of Punjab are based on its river system. The river Sutlej is the easternmost and longest river of Punjab. It originates near the Mansarowar Lake in Tibet. It flows west through deep Himalayan valleys entering India in the Kinnaur district, the Sutlej enters Punjab near Nangal, moves on to plains at Ropar, passes through district Ludhiana. Four stations (S_1, S_2, S_3 and S_4) were set up on the river to collect water samples.

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.).

MATERIALS AND METHODS

The collections were made monthly for a period of two year i.e. November 2009 -October 2011.

Physico-chemical analysis:

Physico-chemical parameters of the water were analyzed according to the standard methods given in Trivedy and Goel (1986) and APHA (2005).

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 the 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 phyto- and zooplankton are: Smith (1950), Edmondson (1959), Hynes (1960), Pennak (1978) and Kudo (1986).

(iii) Counting of plankton:

Counting of plankton was done with the help of 'Sedgwick-Rafter counting cell' as per the procedure given in Wetzel and Likens (2000).

(iv) Saprobic status:

Saprobic condition in the different stretches of the river Sutlej was determined on the basis of BOD_5 (organic pollution load) and by the use of Palmer's Algal Index (Palmer, 1969).

RESULTS AND DISCUSSION

Saprobic condition in the different stretches of the river Sutlej was determined on the basis of BOD_5 (organic pollution load) and by the use of Palmer's Algal Index (Palmer, 1969). To authenticate the relation between saprobes and bio indicators, we dealt them separately.

Saprobic status in the different stretches of the river Sutlej

Sanghu *et al.,* (1987) studied the impact of various human activities on the water quality of river Ganga at Garhmukteshwar. They reported high value of BOD (9.15 mg L^{-1}), indicats pollution stress in the river. Bhatnagar and Garg (1998) studied the interrelationship of plankton population and water quality of river Ghaggar (Sirsa in Haryana) and concluded that among all the factors DO and BOD appeared to be more important in effecting the biotic populations. Kaur and Saxena (2002) made water pollution studies of river Sutlej and reported that higher values of BOD (140-242 ppm), and lower values of DO (0.01-3.40 ppm), alkalinity (253-337 ppm) were due to mixture of industrial effluents in the river. Kumar *et al.,* (2009) assessed the pollution status of river Ganga at Kanpur. They reported that due to dumping of huge quantity of sewage and industrial effluents directly into the river, serious degradation in water quality with DO reducing to zero level and other chemical parameters including BOD and COD load increasing sharply were resulted. Thakur *et al.,* (2013) used Palmer's "Algal Species Pollution Index" for rating water quality of three lakes of Himachal Pradesh.

The monthly fluctuations in the values of BOD_5 and Palmer's Algal Index have been given in Table 1.

Monthly average value of BOD (mg L^{-1}) was 1.49 ± 0.74 (0.41-2.7), 31.18 ± 06.33 (21.13-40.12), 3.17 ± 0.97 (1.95-4.92) and 21.00 ± 4.29 (15.31-28.33) in 2009-10, and 1.54 ± 0.59 (0.35-2.48), 22.42 ± 3.92 (16.16-30.15), 2.43 ± 0.81 (1.2-3.65) and 19.17 ± 3.55 (15.2-25.41) in 2010-11 at S_1, S_2, S_3 and S_4 respectively.

On the basis of saprobic classification given by Sladecek (1973), Ropar Headworks (S_1) could be categorized as oligosaprobic, River Sutlej at village Wallipur (S_2) after the confluence of Budha Nallah as polysaprobic, at village Lohian before the confluence of East Bein with river Sutlej (S_3) as mesosaprobic, and after the confluence of East Bein with river Sutlej (S_4) as meso-polysaprobic.

The monthly average value of Palmer's Algal Index was 7 ± 1.37 (5-9), 19 ± 5.63 (13-30), 10 ± 4.33 (4–17) and 15 ± 2.99 (11–20) in 2009-10, and 5 ± 2.18 (1–8), 19 ± 4.16 (10–24), 8 ± 4.29 (3–16) and 18 ± 5.20 (10–27) in 2010-11 at S_1, S_2, S_3 and S_4 respectively. Data on the Palmer's Algal

Index values revealed that S_2 and S_4 was grossly polluted, S_1 least polluted, whereas S_3, there were chances of medium degree of organic pollution.

Bioindicators

Bio-indicators approach, using the responses of organisms to evaluate trophic state, have often been neglected in favour of physical and chemical analysis of water (Thadeus and Lekinson, 2010; Thakur *et al.,* 2013). Keeping this in view, present study was conducted on bioindicators of river Sutlej. On the basis of presence, absence, abundance and frequency of appearance and disappearance, the following organisms could be designated as bioindictors of saprobic status.

Frequency index of peak forming Phytoplankton at different stations of river Sutlej

At S_1, diatoms were mainly constituted by forms like *Cymbella affinis* (FI 0.50) and *Fragilaria* sp. (FI 0.75), *Pinnularia* sp. (FI 0.75), *Navicula* sp. (FI 0.92) and *Amphora pediculus* (FI 0.54). Chlorococcales was represented by *Pediastrum simplex* (FI 0.92), *Scenedesmus abundans* (FI 1). Volvocales were *Chlamydomonas* sp. (FI 0.75) and *Gonium pectorale* (FI 0.79). Zygnematales were *Cosmarium* sp. (FI 0.46) and *Hydrodictyon* sp. (FI 0.46). Euglenophyceae were *Trachelomonas lacustris* (FI 0.33), *Euglena tuba* (FI 0.83) and *Phacus longicauda* (FI 0.50). Cyanophyceae were *Oscillatoria subbrevis* (FI 1.00), *Calothrix* sp. (FI 0.42) and *Microcystis* sp. (FI 0.75).

At S_2, diatoms were *Synedra ulna* (FI 0.79), *Achnanthes* sp. (FI 0.67), *Navicula cuspidata* (FI 0.79) and *Nitzschia palea* (FI 0.46). Chlorococcales were constituted by species like *Ankistrodesmus falcatus* (FI 0.88), *Chlorella vulgaris* (FI 0.67) and *Scenedesmus quadricauda* (FI 0.79). Volvocales were *Eudorina elegans* (FI 0.75) and *Pandorina morum* (FI 0.54). Zygnematales were *Closterium acerosum* (FI 0.54), *Spirogyra* sp. (FI 0.71), *Ulothrix* sp. (FI 0.50) and *Cladophora glomerata* (FI 0.42). Euglenophyceae were *Euglena viridis* (FI 0.58), *Phacus pleuronectus* (FI 0.88) and *Lepocynclis ovum* (FI 0.50). Cyanophyceae were *Oscillatoria princeps* (FI 0.79), *Anabaena* sp., (FI 0.50) *Arthrospira jenneri* (FI 0.58) and *Spirulina gomontii* (FI 0.71).

At S_3, diatoms were *Navicula cryptocephala* (FI 0.38), *Cymbella* sp. (FI 0.0.54), *Navicula cryptocephala* (FI 0.42), *Gomphonema gracile* (FI 0.42) and *Syndera ulna* (FI 0.38). Chlorococcales were *Scenedesmus quadricauda* (FI 0.42), *s. dimorphous* (FI 0.63) and *Pediastrum tetras* (FI 0.63). Volvocales were *Chlamydomonas* (FI 0.38), *Chlorogonium* sp., (FI 0.63) and *Eudorina* sp. (FI 0.75). Zygnematales were *Closterium acerosum* (FI 0.92), *Cladophora glomerata* (FI 0.42), *Spirogyra* sp. (FI 0.58) and *Zygnema* sp. (FI 0.50). Euglenophyceae were *Euglena acus* (FI 0.63), *Lepocinclis* sp. (FI 0.50), *Phacus pleuronectus* (FI 0.83) and *Trachelomonas* sp. (FI 0.38). Blue-greens were *Oscillatoria princeps* (FI 0.88), *Microsystis* sp. (FI 0.46) and *Spirulina gomontii* (FI 0.63).

At S_4, diatoms were *Cymbella ventricosa* (FI 0.58), *Syndera ulna* (FI 0.50), *Navicula cuspidata* (FI 0.58) and *Melosira varians* (FI 0.54), *Diatoma vulgare* (FI 0.50) and *Navicula cryptocephala* (FI 0.50). Chlorococcales were *Ankistrodesmus falcatus* (FI 0.50), *Chlorella vulgaris* (FI 0.58), *Scenedesmus quadricauda* (FI 0.58) and *Pediastrum tetras* (FI 0.71). Volvocales were *Chlorogonium elongatum* (FI 0.71), *Eudorina elegans* (FI 0.46) and *Pleudorina* sp. (FI 0.38). Zygnematales were *Closterium acerosum* (FI 0.50), *Cladophora glomerata* (FI 0.50), *Stigeoclonium tenue* (FI 0.38), *Spirogyra* sp. (FI 0.54) and *Ulothrix* sp. (FI 0.29). Euglenophyceae were *Euglena acus* (FI 0.67), *Lepocynclis ovum*

Table: 1 Monthly fluctuations in the biochemical oxygen demand and Palmer's algal index at different stations during November 2009 to October 2011

Station	Index	Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.
S_1	Biochemical oxygen demand (mg L^{-1})	2009-10	0.41	0.62	0.85	1.21	1.35	1.66	2.41	2.70	2.03	2.30	1.45	1.00
		2010-11	0.35	0.98	1.24	1.40	1.67	1.86	2.48	2.13	2.00	1.84	1.63	0.96
	Palmer's Algal Index	2009-10	9.00	5.00	5.00	9.00	9.00	7.00	7.00	7.00	7.00	8.00	8.00	8.00
		2010-11	8.00	4.00	4.00	4.00	7.00	7.00	7.00	7.00	7.00	1.00	4.00	8.00
S_2	Biochemical oxygen demand (mg L^{-1})	2009-10	24.72	21.13	25.65	29.82	31.44	38.73	34.41	40.12	36.22	38.34	28.22	25.41
		2010-11	19.23	16.16.	18.43	20.72	25.41	23.00	30.15	26.43	24.72	21.73	19.43	17.42
	Palmer's Algal Index	2009-10	22.00	16.00	13.00	14.00	19.00	22.00	24.00	30.00	16.00	10.00	24.00	20.00
		2010-11	23.00	17.00	15.00	20.00	19.00	21.00	23.00	24.00	21.00	10.00	22.00	24.00
S_3	Biochemical oxygen demand (mg L^{-1})	2009-10	2.03	1.95	2.24	2.46	2.81	3.66	4.23	4.92	4.12	3.86	3.13	2.64
		2010-11	1.20	1.44	1.65	1.83	2.20	2.75	3.65	3.34	3.32	2.76	2.94	2.13
	Palmer's Algal Index	2009-10	6.00	5.00	4.00	6.00	11.00	11.00	11.00	11.00	10.00	15.00	16.00	17.00
		2010-11	6.00	3.00	4.00	4.00	9.00	13.00	7.00	7.00	7.00	9.00	15.00	16.00
S_4	Biochemical oxygen demand (mg L^{-1})	2009-10	16.24	15.31	16.63	18.94	20.83	24.21	26.44	28.33	25.14	22.46	19.63	17.88
		2010-11	16.05	15.20	16.21	17.89	19.46	22.37	24.11	25.41	22.12	19.31	16.43	15.55
	Palmer's Algal Index	2009-10	14.00	11.00	11.00	16.00	20.00	15.00	16.00	13.00	16.00	14.00	18.00	20.00
		2010-11	18.00	11.00	10.00	21.00	22.00	14.00	15.00	19.00	19.00	14.00	24.00	27.00

(FI 0.50), *Phacus pleuronectus* (FI 0.58) and *Trachelomonas* sp. (FI 0.38). Blue-green algae were *Oscillatoria princeps* (FI 0.67), *Phormidium* sp. (FI 0.38) and *Spirulina gomontii* (FI 0.42).

Frequency index of peak forming Zooplankton at different stations of river Sutlej

At S_1, Protozoa were *Coleps* sp. (FI 0.50), *Colpoda* sp. (FI 0.50) and *Vorticella* sp. (FI 0.67) and *Actinophrys* sp. (FI 0.46). Rotifera were *Anuraeopsis* sp. (FI 0.50), *Brachionus quadridentatus* (FI 0.46), *B. forficula* (FI 0.75), *Monostyla* sp. (FI 0.33) and *Notholca* sp. (FI 0.54). Copepods were *Cyclops viridis* (FI 0.83), *Diaptomus gracilis* (FI 0.58), *Mesocyclops leuckarti* (FI 0.75) and nauplii (FI 1.00). Cladocerans were *Daphnia* sp. (FI 0.75), *Moina brachiata* (FI 0.58) and *Diaphanosoma sarsi* (FI 0.63).

At S_2, Protozoa were *Colpidium* sp. (FI 0.63), *Epistylis* sp. (FI 0.63) and *Aspidisca* sp. (FI 0.46). Rotifera were *Brachionus angularis* (FI 0.42), *B. calyciflorus* (FI 0.71), *Asplanchna brightwelli* (FI 0.67), *Epiphanes senta* (FI 0.67) and *Rotaria rotatoria* (FI 0.50). Copepoda were *Cyclops strenus* (FI 0.63), *Mesocyclops leuckarti* (FI 0.63) and nauplii (FI 0.96). Cladocerans were *Daphnia pulex* (FI 0.79) and *Chydorus* sp. (FI 0.79).

At S_3, Protozoa were *Colpoda* sp. (FI 0.54), *Stylonychia* sp. (FI 0.67), *Vorticella convallaria* (FI 0.75) and *Colpidium* sp. (FI 0.92). Rotifera were *Brachionus quadridentatus* (FI 0.67), *B. calyciflorus* (FI 0.71) and *Asplanchna brightwelli* (FI 0.58). Copepoda were *Cyclops leuckarti* (FI 0.67), *Mesocyclops leuckarti* (FI 0.58) and nauplii (FI 0.92). Cladocerans were *Daphnia* sp. (FI 0.67) and *Moina brachiata* (FI 0.50).

At S_4, Protozoa were *Stylonychia* sp. (FI 0.58), *Epistylis* sp. (FI 0.67) and *Colpidium* sp. (FI

0.71). Rotifera were *Brachionus angularis* (FI 0.54), *B. calyciflorus* (FI 0.50), *Asplanchna brightwelli* (FI 0.71), *Filinia longiseta* (FI 0.50) and *Rotaria rotatoria* (FI 0.38). Copepoda were *Cyclops brevcornis* (FI 0.75), *Cyclops strenuus* (FI 0.58) *Mesocyclops leuckarti* (FI 0.83) and nauplii (FI 0.83). Cladocerans were *Daphnia pulex* (FI 0.67) and *Moina brachiata* (FI 0.46).

On the basis of presence, absence, abundance and frequency of appearance and disappearance, the following organisms could be designated as bioindictors of saprobic status.

Oligosaprobic- Phytoplankton:

Anomoenes sp., *Amphora* sp., *Asterionella* sp., *Ceratium* sp., *Cymbella affinis, Closterium* sp., *Dinobryon* sp., *Euastrum* sp., *Sorastrum* sp., *Peridinium* sp., *Meridion* sp., *Oscillatoria subbrevis, Pediastrum simplex, Phacus longicauda, Polybotrya gracilis, Scenedesmus abundance, Synura* sp., *Tetraedron minimum* and *Trachelomonas lacustrix*. **Zooplankton:** *Actinophrys* sp., *Anuraeopsis* sp., *Bosmina longirostris*, *Coleps* sp., *Cyclops bicuspidatus*, *Diaptomus gracilis, Daphnia* sp., *Difflugia* sp., *Keratella procurva*, *K. tropica, Notholca* sp. and *Vorticella* sp.

Polysaprobic- Phytoplankton:

Ankistrodesmus falcatus, *Chlorella vulgaris, Closterium acerosum*, *Cyclotella* sp., *Cymbella ventricosa, Euglena viridis*, *Gomphonema gracile*, *Melosira varians*, *Navicula cryptocephala*, *Oscillatoria princeps*, *Scenedesmus quadricauda*, *Lepocinclis ovum* and *Synedra ulna*. **Zooplankton:** *Aspidisca* sp., *Asplanchana brightwelli*, *Brachionus angularis*, *B. calyciflorus*, *Chydorus* sp., *Colpidium* sp., *Epiphanes senta, Epistylis* sp., *Eucyclops* sp., *Lecane* sp. and *Stylonychia* sp.

CONCLUSION

Based on our results, it has been concluded that there is a visionable correlation between saprobity and bioindicators, which is further strengthened by frequency index. But, it is not mandatory that abundant species may act as indicator or any indicator organism should be the peak forming species. This baseline data clearly explains that, station (S_1) could be categorized as oligosaprobic, (S_2) as polysaprobic, (S_3) as mesosaprobic, and (S_4) as meso-polysaprobic. But these findings are not appropriate to make a concrete conclusion and it need more time and diverse parameters along with their correlations to make an authenticate results, and this is now open for further studies.

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