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Ecological characteristics of Sahastradhara stream at Dehradun (Uttarakhand)

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Abstract

Sahastradhara sulphur stream is a natural perennial hill stream which originates from the upper mountainous terrains of Mussoorie in Garhwal region. The climate of Garhwal region depends on the temperature variability. on monthly and seasonally changing patterns. Sahastradhara stream had a cool and pleasant climate but at current stage it has changed at a great extent due to natural and anthropogenic factors. In the present study, the changes were recorded as annual average temperature (3.4 °C – 38.3 °C), wind velocity (0.9 km - 2.5 km), rainfall (225 mm – 371 mm), precipitation and sedimentation rate just double from two decay periods. Twenty tree genera of macrobenthic organisms in sediments and other existed native species of macrophytic vegetation in littoral zones of stream. The physico-chemical characteristics of Sahastradhara hill-stream showed seasonal variations and influenced the distributional patterns of macrobenthic communities. Presently, eco-biological characteristics of Sahastradhara stream exhibited continuous degradation nature in and around stream ecosystem in terms of biological productivity and macro-benthic diversity.

Keywords: *Stream variables, Sulphur spring, Macro-benthic diversity*

Introduction

Hill streams are generally the important source of clear crystal water on earth. The process of economic growth & development, virtually have inverse relationships with hill stream resources and quality of aquatic environment. Hill streams are unique habitats, which sustain substantial biodiversity and provide many tangible and intangible benefits on a sustainable basis, not only to a local society but also to the associated dependent ecosystems. Sahastradhara hill stream situated in foothills of Dehradun in Garhwal Himalayas is a major tributary of River Song which flows downwards through Dehradun Valley. Sahastradhara stream is situated on the globe at 29°57'-31°20' N Latitude and 77°35'-79°20' E Longitude in Garhwal region.Macro-benthic diversity and water quality are interrelated to each other, as they are potential indicators of water quality of any aquatic system or a body. Benthic macro-invertebrates are one of the most common group of organisms used to assess the health of aquatic ecosystem (Rosenberg and Resh, 1993). Benthic aquatic organisms are sensitive indicators to environmental changes in streams because they express long term changes in water and habitat quality rather than instantaneous conditions (Armitage *et al.*, 1983). The presence and absence of such macro-invertebrates indicates the degree of pollution, though specific causative physico-chemical pollutant may be identified by physico-chemical methods. Due to anthropogenic activities and heavy soil erosion from surrounding fragile hill terrains, could add nutrient load in aquatic ecosystem of the stream which would result in eutrophication. The main focus of the study is to describe the degradation of water quality in Shastradhara stream.

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Materials and Method

The sampling sites were selected in Sahastradhara valley at a distance of 15 km far away from Dehradun. The five sampling stations were selected for ecological study. The water samples were collected monthly from different sampling stations during May, 2009 to April, 2010 in morning period (9:00 AM). The samples were examined on site for selected parameters and brought to the laboratory for remaining physical and chemical analysis. The selected variables of the stream were analyzed with the help of the procedure described by APHA

(1995), Trivedi and Goel (1984). The sample of benthic organisms were collected between 8:00 to 10:30 AM on seasonal basis with an Ekman's Dredge Sampler and sieve having size US No. 60 cms and preserved in 4.0 % formalin. In laboratory, the benthic organisms were sorted out and identified to genus/species level with the help of identification keys (Edmondson, 1992).

Results and Discussion

Ecological study of hill stream significantly contributed in assessment of existed nutrient load and their impacts on distribution and abundance of aquatic organism in aquatic ecosystem. The physico-chemical observations of Sahastradhara stream in different seasons were observed at different sites S_1, S_2, S_3, S_4 and S_5 during the year 2009 – 2010 (Table-1). In the present study, the maximum water temperature (23.5 °C) was recorded during summer at site S_5 and minimum (15.6 °C) at site S_1 during winter. Lower temperature was recorded during winter and higher during summer may be due to extreme cold and extreme sunshine period. The flow of stream is directly related to the amount of water flowing off watershed into the stream channel. The maximum velocity (0.74 m/s) was recorded at site S_1 during monsoon and minimum (0.32 m/s) recorded at site S_4 during summer season due to magnitudes of stream slope gradients.

The pH was maximum (8.5) during monsoon at site $S_1$and minimum (7.8) during winter at site S_3 indicates that water was alkaline. Similar observation was observed by Sharma (1986 and Joshi (1996)) in the Bhagirathi river and other hills rivers in Garhwal Himalaya.

Table 1: Physico-chemical characteristics of Sahastradhara Stream at different sampling stations during 2009 – 2010

Parameters	Karligarh Upstream (S_1)		Main tourist spot (S_2)		Kalirov Downstream (S_3)		Kalagaon Downstream (S_4)		Bajhat Confluence point (S_5)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Temp. ˚C	15.6 - 21.9	19.1	15.7 - 21.8	18.7	15.9 - 22.1	19.2	16.2 - 22.6	19.3	16.2 - 23.5	19.9
Velocity m/s	0.37 - 0.74	0.59	0.39 - 0.71	0.58	0.35 - 0.62	0.53	0.32 - 0.61	0.49	0.37 - 0.69	0.54
pH	8.5 - 7.9	8.1	8.3 - 7.9	7.9	7.8 - 7.9	7.8	7.7 - 7.9	7.8	8.1 - 8.2	8.1
Alk. (mg/l)	39.4 - 54.4	37.3	40.4 -51.2	45.07	40.1 - 46.3	43.7	41.5 - 52.1	45.9	43.1 - 62.1	51.2
Free CO_2 (mg/l)	1.1 - 1.9	1.7	0.87 - 1.12	0.94	0.91 - 1.67	1.2	2.13 - 2.27	2.25	1.86 - 2.43	2.18
DO (mg/l)	7.28 - 10.87	8.64	7.29 - 9.13	8.08	7.26 - 8.64	7.81	7.24 - 8.37	7.68	7.71 - 8.45	8.13
BOD (mg/l)	0.84 - 2.39	1.55	0.95 -2.42	1.61	1.05 - 2.33	1.62	1.13 - 2.45	1.71	1.45 - 3.12	1.89
Calcium (mg/l)	83.62 - 85.15	84.42	83.8 - 85.18	84.55	83.92 - 85.11	84.4	84.79 - 87.16	84.64	84.07 -88.64	84.74
Mag. (mg/l)	50.51 - 53.97	51.78	50.7 - 54.3	52.14	49.61 - 55.12	51.24	50.45 - 53.57	51.64	50.92 -53.81	52.08
Sod. (mg/l)	14.92 - 16.97	15.85	15.21 - 17.31	16.24	15.66 - 17.77	16.49	16.06 - 18.77	17.22	15.16 - 17.7	16.34
Pot. (mg/l)	7.66 - 10.97	9.09	7.9 - 11.3	9.39	8.62 - 11.6	9.85	9.7 - 12.73	10.9	8.81 - 11.53	9.9
Chl. (mg/l)	14.43 - 16.42	15.33	14.6 - 16.5	15.49	14.76 - 16.67	15.56	14.99 - 16.86	15.87	15.76 - 6.23	15.93

Alkalinity of water was strongly correlated with pH value, which was recorded maximum (62.1 mg/l) at site S_5 during mansoon, due to increase in the concentration of bicarbonates by runoff and domestic waste discharge near by the village of stream and minimum (39.4 mg/l) at site S_1 during winter season. Streams with limestone soil characteristics have high alkalinity and good

buffering capacity along with domestic sewage effluents drained directly into stream contributed the high alkalinity. The free CO_2 ranged from 0.87-2.96 mg/l during the study period. Higher free CO_2 in water samples in monsoon season was due to discharge of domestic waters, inflow of sewage and mostly due to decomposition of organic wastes on the site by enormous tourism activities. A similar trend of free CO_2 was reported by Khannna *et al.* (2006) in Suswa and Khanna *et al.* (2008) in Nalhota stream at Dehradun. Dissolved oxygen is an important factor to assess the biological productivity and ecological health status. Maximum DO (10.87 mg/l) was recorded during winter at site S_1 due to continue flow of stream with low temperature and minimum (7.24 mg/l) during monsoon at site S_4 due to increase in the temperature after the rainfall and decaying of macro-vegetations in the water. Mishra and Yadav (1978) reported same seasonal fluctuation of DO in river and lake water in Central India. Biochemical oxygen demand has contributed in estimating the pollution level and water quality of a particular water body. In the present investigation, BOD value ranged between 0.84 mg/l to 3.12 mg/l. The fluctuation in the value may be due to accumulation of maximum load of organic substances with microbial reactions at the littoral zone and bottom of stream. Similar trend of microbial degradation and increasing trends of BOD was obtained by William *et al.* (1993) The maximum value (88.64 mg/l) of calcium was reported at site S_5 during monsoon due to runoff water from rocks and constriction hotels and shops near the stream and minimum (83.62 mg/l) was recorded at site S_1 during winter. Similarly, Khanna and Singh (2000) reported the fluctuation in calcium and magnesium ion in Suswa river at Dehradun. Magnesium is also an essential and beneficial element but it is toxic at higher concentration. The maximum concentration (55.12 mg/l) of magnesium was recorded at site S_3 during monsoon and minimum (50.45 mg/l) recorded at site S_4 during summer. Jenkins *et al.* (1995) recorded similar findings in the streams of middle hills and high mountains of the Himalaya. Sodium is one of the most common cations has no adverse effect on human health at low concentration. The maximum concentration (18.77 mg/l) of sodium was observed at site S_4 during monsoon due to runoff in downstream and minimum (14.92 mg/l) was recorded at site S_1 during winter. Pande and Mishra (2000) observed similar trend of potassium deposition in Sahastradhara at Dehradun. Potassium is naturally occurring element, released by clay minerals; weathering and leaching from growing vegetation and decomposition of organic matter (Berndtsson, 1990). The potassium was recorded maximum (18.77 mg/l) at site S_5 during monsoon and minimum (7.66 mg/l) at site S_1 during winter. Bond (1979) observed similar nutrients concentration pattern in a stream ecosystem in Utah. Miller *et al.*, (1997) in Potomac river and Cameron (1996) reported sodium accumulation in aquatic system in their study. Chloride generally occurs in the form of chloride ion and is major inorganic anion present in natural water. The chloride was recorded maximum (16.86 mg/l) at site S_4 due to the runoff during monsoon and minimum (14.43 mg/l) at site S_1 during winter. Khanna and Singh (2000) found similar trend in River Suswa at Raiwala. Chopra and Patric (1994) reported the similar observation in the Ganga river at Rishikesh. Water temperature showed negative correlation with DO (-0.76) and Magnesium (-0.113), Free CO_2 and Chloride showed negative correlation with DO (-0.89). However, a positive correlation was found between Free CO_2 and water temperature (0.39) (Table-3).

Total 23 genera of macro-invertebrates were encountered in the stream (Table-2). The macro-invertebrates were represented by different groups *e.g. Oligochaeta*, *Plecoptera*, *Trichoptera*, *Diptera*, *Ephemeroptera*, *Odonata* and *Hemiptera*. Maximum contribution to total macro-invertebrates were observed by *Ephemeroptera* (23.94 %), followed by *Oligochaeta* (21.15 %), *Hemiptera* (14.89 %), *Odonata* (12.48 %), *Diptera* (10.13 %) *Plecoptera* (10.85 %) and *Trichoptera* (6.56 %). During study period high abundance of aquatic organisms were reported during winter season it may be due to low velocity of water, high dissolved oxygen, low hydro-median depth and low turbidity. However, the minimum abundance of aquatic organisms were observed in Sahastradhara stream during monsoon season which may be due to increased water velocity, high turbidity, low DO and low primary productivity. A significant difference in the density of macro-invertebrate was recorded between the sampling sites S_2 and S_3 which may be attributed to the anthropogenic disturbance by mass bathing activities, tourist movement, drainage of waste water from the near

by the hotels and restaurants into stream water at site S_2 and S_3. Such types of observation was also observed by Mitra (1999) and Sharma and Rawat (2009) with respect to the dragonflies (Odonata) of Asan wetland in the Central Himalayas. The macrophytes vegetation were observed near the stream from upstream to downstream were *Slix tetraspherma, Arundodonex, Epomoea carnea,*

Table-2: The distributional pattern of benthic organisms (ind./m^2) in Sahastradhara stream at Dehradun.

OLIGOCHAETA	S_1	S_2	S_3	S_4	S_5	Total %
Tubifex sp.	++	+++	++	+	+	21.15
Branchiora sowerbyii	++	++	+	++	++	
Limnodrillus hoffmeisteri	+	+++	+++	++	++	
PLECOPTERA						
Pteronarcys	+	-	++	++	++	10.85
Acroneuria	++	-	+++	++	+	
Isoperia	++	-	++	++	+	
TRICHOPTERA						
Hydrosyche	+	+++	++	++	++	6.56
Leptocella	++	+++	++	+	+	
Ochrotrichia	++	++	++	+	++	
DIPTERA						
Chironomous plumosus	++	+++	+++	++	++	10.13
Tendipestentans	+	++	++	++	+	
Culicoides	++	+++	++	++	+	
Alabesmyia	+	++	++	++	+	
EPHEMEROPTERA						
Adult Mayfly	+	+++	++	++	++	23.94
Stenononema	++	++	++	++	++	
Leptophlebia	+	++	++	++	+	
Ephemeralla indica	+	+++	+++	++	+++	
Cinygma	++	++	++	++	++	
ODONATA						
Epicordulia (Dragonfly)	+	+++	++	++	-	12.48
Macromia	++	++	+++	++	+	
HEMIPTERA						
Aquarius remigis (Water striders)	+	+++	+++	++	++	14.89
Sigara mckinstryi (Water boatmen)	+	++	+++	+	-	
Notonecta unifasciata (Backswimmers)	+	++	++	++	+	

+++: Abundant; ++: Common; +: Rare, -: Absent

Vitex negundo, Leucaena leucaena, Lannea grandis, Erythrina-suberosa, Bouhinia retusa, Giant napier, Eulaliopsis binata. Among all the species *Slix tetraspherm, Leucaena leucaera* and *Giant napier* were abundant and common near and n littoral zone of Sahastradhara stream.The proper monitoring of the stream is essential to know the current status of stream water quality for sustainable, holistic solid waste management and to treat the untreated domestic sewage wastes, which is directly drain into the stream water which is degrading the quality of the Sahastradhara stream water.

Table- 3: Correlation between physico-chemical parameters of Sahastradhara stream during 2009 – 2010

Parameters	Temp. ˚C	WV m/s	pH	Alk	CO_2	DO	BOD	Ca	Mg	Na	K	Cl
Temperature (˚C)	1											
Water Velocity (m/s)	-0.69	1										
pH	0.04	0.69	1									
Alkalinity (mg/l)	0.08	0.67	0.99	1								
Free CO_2 (mg/l)	0.39	0.41	0.94	0.95	1							
DO (mg/l)	-0.76	0.049	-0.68	-0.71	-0.89	1						
BOD (mg/l)	0.46	0.33	0.91	0.92	0.99	-0.92	1					
Calcium (mg/l)	0.27	0.51	0.97	0.98	0.99	-0.83	0.98	1				
Magnesium (mg/l)	-0.113	0.79	0.99	0.98	0.87	-0.56	0.83	0.93	1			
Sodium (mg/l)	0.37	0.42	0.94	0.95	0.99	-0.89	0.99	0.99	0.88	1		
Potassium (mg/l)	0.29	0.49	0.97	0.98	0.99	-0.84	0.98	0.99	0.92	0.99	1	
Chloride (mg/l)	0.39	0.39	0.93	0.95	0.99	-0.89	0.99	0.99	0.87	0.99	0.99	1

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