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Ecology of River Spiti, Lahaul-Spiti (Himachal Pradesh), India

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Abstract

The present study is conducted in view to appraise the ecology of Spiti River in the high altitude cold desert of Spiti valley, which is one of the fragile Himalayan Ecosystem. The diversity of planktonic, macrobenthic fauna along with physico-chemical parameters has been worked out. During monsoon season maximum density, diversity of planktons and diversity of benthic fauna was recorded. The maxima of wealth of biological parameters during monsoon in spiti valley are disparate from the low and mid- hills, where highest is noticed during the winter or summer. Simpson's diversity index was applied for calculation of species richness and species diversity.

Keywords: Altitude, Cold Desert, Planktons, Benthos, Species diversity.

1. Introduction

Spiti valley is fragile mountain ecosystem, desert mountain valley located high in the Himalayan mountains in the north-eastern part of Himachal-Pradesh. It is known as the land between India and Tibet. The Spiti River has its source far north on the eastern slopes of the mountain range between Lahaul and Spiti. The river is formed at the base of Kunzam range by the confluence of Kunzam La Togpo and the streams Kabzima and Pinglung. The River follows a long wide course and interlocked by spurs that project from the foot of the plateaus on both sides. The length of the River within the spiti on the south-east is about 130 km. It continues in Kinnaur district up to a place known as Namgia (Khabo) and is about 14 Km upstream of Pooh (Kinnaur), where it

joins the Satluj. The Sutlej river basin in Himachal Pradesh covers an area of about 6,553 square kilometers. Spiti is on the northern border of Kinnaur - the boundary being formed by the rivers Spiti and Pare Chu near the Indo-Tibetan border. It is one of the largest tributary of the Satluj River.

The Satluj River originates beyond Indian boarders in the Southern slopes of the Kailash mountainin near the Mansarovar Lake from Rakas lake, as Longcchen Khabab river (in Tibet) at 18500 ft. in the Tibetan Plateau. The Satluj is one of only three Trans Himalayan rivers originating in the high Tibetan Plateau that cuts across the mighty Himalayan ranges. The other two are the Indus and the Brahmaputra. It enters India through a fearsome gorge near the Shipki La (Mountain pass on India-China Boarder) at an altitude of 6, 608 m asl in district Kinnaur (Himachal-Pradesh), subsequently it flows through the cold tracts of Kinnaur to the hamlet of Wangtoo. It is one of the major tributaries of the Indus River system. In its passage across Kinnaur, the Sutlej River successively crosses three great mountain ranges - the Zanskar range, the Great Himalayan range and the Dhauladhar range. To the east of the Satluj the valleys are narrow while in the west, they are wide and open. Many tributaries join the main Sutlej River one after the other from the south. It is the largest among the five rivers of Himachal Pradesh. It enters Himachal at Shipkila (altitude is 6,608 meters) and flows in the South-Westerly direction through Kinnaur, Shimla, Kullu, Solan, Mandi and Bilaspur districts. Its course in Himachal Pradesh is 320 km from Rakastal, with famous tributaries viz. the Spiti, the Ropa, the Taiti, the Kashang, the Mulgaon, the Yula, the Wanger, the Throng and the Rupi as right bank tributaries, whereas the Tirung, the Gayathing, the Baspa, the Duling and the Soldang are left bank tributaries. Its total length is 1,448 km. It leaves Himachal Pradesh to enter the plains of Punjab at Bhakhra, where the world's highest gravity dam has been constructed on this river. Its total catchment area in Himachal Pradesh is 20,000 sq. km. The Satluj finally drains into the Indus in Pakistan. The catchment area of about 50,140 km. of Satluj River is located above the permanent snow line at an altitude of 4,500 metres. The upper tracts of the Satluj valley are under a permanent snow cover.

The main stream of the Spiti River, which is fed by the glaciers, is a perennial one, while some of the tributary streams disappear in the loose morain at the feet of the plateaus. During its course through the difficult, complex terrain, the Spiti is joined by a number of tributaries from both the sides. Those which join its right bank include: *Chiomo, Gyundi, Rahtang, Ulah, Pin, Lungze, Mane, Surahl, Pomograng, Mamdang and Sumra*; the left bank tributaries are: *Thamar, Hanse, Thumna, Tagting, Thumpa Lumpa, Shila, Kaza, Lingti, Poh, Tabo, Karati, Gimdo and Parechu*.

The demographic and physiographic characteristics of the catchments area of this tributary are identical to that of the Tibetan Plateau. Rainfall is scarce in this area. The altitude of the catchments area drained by river Spiti range between 3048m to 4570m. This catchments area is absolutely devoid of vegetation as a result the melting of snow from the glacier creates deep flow channels on the steep surface resulting enormous soil erosion. To promote the coldwater fisheries in this river it becomes necessary to study the physico-chemical and biological parameters of this high altitude river.

1.1 Study Area

The four sampling sites were selected on this river. The first three sites are located towards upstream near village Leo. As this river passes to deep gorges where it can not be approached as a result site 1 is located near the new bridge of Leo and site 2 is 1 km down stream from site 1 and this site receiving the enrich water passing through orchards and agricultural fields. The 3rd site is located near the confluence of river Spiti and rivulet Tobo. The river stretch is wide near site 1 to 3. The fourth site is at the confluence of river spiti and Satluj near Khab. The sampling has been made from aforesaid sites in different seasons during year 2009 and 2010.

2. Material and Methods

The analysis of different physico-chemical parameters and biological parameters was done by following the standard methods (APHA, 1998; Adoni, 1985: Wards and Wipple, 1959). Simpson's diversity index was applied for calculation of species richness and species diversity (Simpson, 1949).

3. Result and Discussion

3.1 Aquatic Ecology

River spiti is contributing a huge volume of water in River Satluj being main tributary and its flow is dependent on the 1st and 2nd order streams and thus contributing in shaping the current flow and nutrient composition. There is one rivulet "Tobo" joining the River near village Leo indicating the contribution of water to the river from other sources in the catchments area. The water current in the river Spiti is higher, which ecologically is considered to be fast. At this velocity the current will remove all particles less than 5 mm in diameter and will leave behind a stony bottom. The whole stretch of River under study has very less riparian vegetation.

4. Present status of physico-chemical and biological characteristic

Water temperature is an important parameter which directly influences the aquatic life in the ecosystem. It is one of the key water quality parameter in aquatic system (Vannote and Sweeney 1980; Ward 1985; Hawkins *et.al.* 1997). The surface water temperature varies between 6 to 25^0C and is greatly influenced by air temperature. The minimum water temperature during the sampling period was recorded in October and no collection of water sample could be made in this period due to frozen water. The maximum water temperature was recorded from Leo in the month of May and June, which depicts that water is suitable for cold water fisheries.

The colour of water in all the sampling sites was found colorless and odourless. It was recorded 1 and in some samples slightly more than 1 Hazan, and the optimum limit is up to 5 Hazan units.

pH is an important parameter for controlling the distribution of aqatic fauna and flora. pH of the sampling sites is alkaline and fluctuated narrowly between 6.95 to 7.23 and lowest is recorded in the monsoon season. The pH recorded is within the recommended range and sustenance of aquatic life.

Water velocity varies from 1.7 to 2.53m/sec. and considered as rapid one. The velocity more than 0.152 m/sec. is considered as rapid one (Legler, 1977).

Dissolved oxygen is required for aquatic organisms for respiration and is also used for decomposition of organic matter and other biological and chemical processes. The dissolved oxygen value ranges from 9.2 to 11.56 mg/l. Cold water holds more dissolved oxygen than the warm water. Higher dissolved oxygen recorded in post monsoon and is due to low water temperature. Dissolved oxygen showed inverse relationship with temperature in this season. The dissolved oxygen was recorded highest during the Post monsoon and minima in the monsoon season.

The TDS is combined content of all substances (organic as well as inorganic) present in water. The TDS values are high in all the sampling period. Its value ranges from 182 to 306 mg/l. Srrenivasan (1978) was of the opinion that waters containing less than 50mg/l total dissolved solid are unproductive waters.

Alkalinity is important for fish and aquatic life because it protects or buffers against pH changes (keeps the pH fairly constant) and makes water less vulnerable to acid rain. Maximum alkalinity was recorded during post monsoon and minimum in Monsoon. According to Moyle (1946), water bodies having total alkalinity >50mg/l can be considered productive. During the present studies alkalinity varies from 84.0 to 148.08mg/l and thus water is productive.

Total Hardness of water depends upon the amount of calcium and magnesium salts or both. Its value ranges from 38.0 to 210.0 mg/l. Its value is directly related with the TDS except during the Monsoon season where it is inversely related with Hardness. Higher value during the post monsoon suggests that water is more productive during this season.

The chloride value ranges from 7.96 to 14.74mg/l. The value of Chloride is comparatively more in the pre monsoon season.

Nitrate-Nitrogen in natural waters is between 0.9 to 3.15 mg/l and unpolluted waters less than 4.0 mg/l (http:// www.cess iupui.edu/). The value of nitrate-nitrogen ranges from 1.53 to 1.7 mg/l in the present study and is optimum for fishery.

According to Stumn and Morgan (1981), the ionic dominance for the water bodies are: Ca> Mg> Na> K and HCO_3 > SO_4 > Cl for fresh waters. The same ionic pattern is recorded in the present study.

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions.

BOD level varies 3.0 to 3.69. This implies that season did not have any significance influence on BOD. The range < 5 is optimum for fishery as well as for drinking purpose.

Table 1: Average of physicochemical parameters of River Spiti.

No.	Parameters	Pre monsoon	Monsoon	Post monsoon
1	Water temperature ^{0}C	18	13	10
2	Color (Hazen)	1.0	<1	1.0
3	pH	7.23	6.95	7.15
4	Water velocity(m/s)	2.53	3.25	1.7
5	Dissolved oxygen mg/l	10.5	9.2	11.56
6	TDS, mg/l	290.0	182.0	306.0
7	Alkalinity, mg/l	98.5	84.0	148.0
8	Hardness, mg/l	165.0	38.0	210.0
9	Chloride, mg/l	14.74	7.96	11.25
10	Nitrate, mg/l	1.65	1. 7	1.53
11	Calcium, mg/l	43.08	8.82	55.11
12	Magnesium, mg/l	14.32	5.59	18.85
13	Potassium, mg/l	12.71	6.54	12.23
14	Sodium, mg/l	27.00	10.5	23.93
15	BOD	3.0	3.69	3.10

5. Food chain organisms

The productivity of any aquatic water body depends on the amount of plankton and benthos present in the said water body. The seasonal abundance and distribution of Plankton is directly or indirectly related with the alkalinity, water temperature, water current, depth and organic nutrient available in the water body. In other way we can say that plankton (phytoplankton) growth and distribution depend on the carrying capacity of the environment and on the nutrients concentration both intracellular and extracellular. Plankton distribution and abundance are affected by season. The fish productivity of said water body is directly related with its productivity as plankton and benthos are the food of fishes.

5.1 Phytoplankton

The distribution of phytoplankton mainly depends on the temperature and nutrient supply. Diatoms, flagellates and algae normally constitute the bulk of the phytoplankton. A total of 27 species has been recorded. 15 species was reported during pre monsoon, 20 species in post monsoon and 21 in monsoon period. Table (2) depicted maximum diversity during monsoon. The phytoplankton species reported during study period are: *Amphora, Acharanthes, Cocconeis, Cymbella, Cyclotella, Fragillaria, Frustulia, Navicula, Synedra*; *Pinnularia, Diatoma, Gyrosigma, Nitzschia, Tabellaria* and *Gomphonema* of Bacillariophyceae, *Ankistrodesmus, Spirogyra,*

Ulothrix, Pediastrum, Mesotaenium, Spirataenia, Spirulina, Scenedesmus, Closterium, and *Cosmarium* of Chlorophycaea*; Oscillatoria* and *Agmerellum* of *Cynophyceae.* (Table-2). The abundance of *Navicula* was noticed in all the season but *Synedra* only in pre monsoon. The quantity of calcium is fairly good and which stimulates the growth of diatoms particularly in pre monsoon when temperature and alkalinity was also high and is in conformity with the view of Zafar (1964). The phytoplankton density is comparatively higher during monsoon. The percentage population of phytoplankton is higher than that of zooplankton which is the characteristics of a hill stream. The total population reported from this river is sufficient to support the aquatic life.

5.2 Zooplankton

These are the primary consumers and hence heterotrophs and secondary producers, which are important indicator of the health of the aquatic ecosystem. Zooplankton species found in the study area includes: *Keratella monospina*, *Brachonus caudatus*, *Arcella sp.* and *Colpidium colpoda*. The maximum diversity is recoded during the monsoon which is indicative of the fact that river is receiving organic matter this period (Table-2).

5.3 Benthos

Benthos is the aquatic animals without backbones that are larger than ½ millimeter (the size of a pencil dot). These animals are attached on rocks, logs, sediment, debris and aquatic plants during some period of their life cycle. Their distribution depends on water velocity, volume of water and nature of stream bed as well as presence of nutrients. Table- 4 revealed the frequency and abundance of different taxas as a result the percentage frequency of Ephemeropterans were varied from 18 to 47%. The highest frequency was encountered during pre monsoon and lowest in post monsoon. The Ephemeroptera were found most abundant which indicates good water quality as well as favorable for biotic communities. The second dominating group is Trichoptera and its frequency distribution was 8 to 53%. The highest frequency was reported in pre monsoon. The Diptera, Coleoptera and Odonata were dominated in post monsoon and their percentage of frequency was also high which may be due to deposition of organic matter. However, Diptera is associated with poor water quality as they are more resistant to pollution and is also observed by Depiereux *et al*. (1983). The Molluscs were rare and found only in pre monsoon. The total number of individuals per square meter was high in pre monsoon due to favorable physico-chemical parameters.

The density of individuals per square meter is high at site 2 and 3 during all the season (Table 5) whereas diversity index (Shanon-Weaver) was comparatively high during monsoon because the taxas richness increases with increasing habitat diversity, suitability and water quality (Plafkin *et al*. 1989). Thus the present study depicted the abundance of *Ephemeropterans* and *Trichopterans* in pre monsoon where as in post monsoon the dominating group was Dipterans which is presented by *Chaoborus* sp. The Odonates were dominating in post monsoon but only at Khab (Site-4). The high density of total benthos during pre monsoon depicted that there is no scarcity of food for fishes migrated in upstream for breeding purpose.

The physico-chemical parameters recorded were favorable for the productivity of the stream during all the season and directly correlated with abundance of planktons and benthos. It is elucidated from the present studies that during monsoon season comparatively higher density and diversity of planktons are recorded and diversity of benthic fauna is also recoded maximum for the period of the monsoon season except density of benthos which is recorded high in the pre monsoon. Mostly, the diversity and density of the planktonic and benthic fauna are minimum in monsoon season and maximum in the winter and summer in the low and mid- hills. But while working in the high altitude area of spiti valley the maxima of fauna is recorded in the monsoon season because the area is rain shadow zone and geomorphology of the stream greatly influence the hydrobiology of the stream.

5.4 Fish fauna and other fisheries activity

Spiti being one of the largest tributaries of the River Satluj with a characteristic fish faunal element constitute a distinct, large, clear, cold-water mountain tributary. A number of species reported from River Satluj (Tilak and Hussain 1977) while the fish faunal diversity of river Spiti comprises only a few species that is *Schizothorax richardsoni* (Gray) belonging to the families Cyprinidae, and hill loaches i.e. *Triplophysa sp.* belonging to family Cobitidae (Mehta and Uniyal, 2005 and Mehta and Sharma, 2008). The fish species observed during field survey in the Spiti River are - *Triplophysa stoliczkae* (Steindachner) and fry of *Schizothorax sp.* The dominant long distant migratory fish is Snow trout. The migratory phenomenon of the fish species is directly related to its life cycle as the fishes move from one habitat to other for spawning. The breeding migration starts with the onset of monsoon when a rise in water level in search of suitable breeding grounds up-river. Even winter migration takes place for the purpose of feeding in most of the fishes migrate towards down stream. It is usually the periods of fish migration when fishing activities intensify in the area. There is no fishing community but fishing is done by the riparian human populations as well as the migrant laborers using illicit method of poaching or some times hooks and line as well as cast net.

The studies in Cold Desert of Spiti valley has been undertaken for the first time and can be base line for further studies. The hydrobiological studies should be a continuous process for various reasons. One of the important is to know the impact of climatic changes since the cold desert, high altitudes are more vulnerable to ecological changes. Further, the loaches (*Triplophysa* spp.) reported are endemic and are important from conservation point of view.

Table 2: Planktonic diversity and abundance of River Spiti.

Taxas	Pre monsoon	Monsoon	Post monsoon
Phtoplankton **Bacillariopyhceae** Amphora	+	+	+
Acharanthes affinis	-	+	-
Coconeis	+	+	+

Cymbella sp.	+	++	+
Cyclotella meneghiana	-	+	-
Diatoma sp.	+	+	+
Fragilaria sp.	++	-	++
Frustulia sp.	+	+	+
Gomphonema sp.	+	+	+
Gyrosigma accuminatus	-	+	-
Navicula radiosa	+++	+++	+++
Nitzschia gracilis	-	++	_
Pinuularia braunii	++	++	++
Synedra tabulata	+++	++	++
Tabellaria sp.	_	+	+
Chlorophyceae Ankistrodesmus falcatus	-	+	-
Cosmarium sp.	+		+
Closterium sp.	+	++	+
Mesotaenium sp.	-	+	++
Pediastrum boryanum	-	+	-
Scenedesmus bijuga	-	++	_
Spirataenia	-	-	+
Spirogyra sp.	-	+	+
Spirulina princepes	-	+	+
Ulothrix sp.	++		+
Cynophyceae Agmenellum sp.	+	-	+
Oscillatoria sp.	++	-	++
Zooplankton **Rotifera** Keratella monospina Brachionus caudatus	- +	+ +	_ +
Protozoa Arcella sp. Colpidium colpoda	- -	+ +	- -

- = absent, += present, ++= common, +++= abundance

Table 3: Planktons density and diversity index during different season.

Phyto-planktons	**Density (individual/l)**			**Diversity Index**		
	Pre monsoon	**Monsoon**	**Post monsoon**	**Pre monsoon**	**Monsoon**	**Post monsoon**
Site1	74.4	41.2	58.2	2.8	2.91	2.75
Site 2	34.0	63.8	30.0	2.32	2.56	2.86
Site 3	37.5	55.3	37.3	2.0	2.89	2.3
Site 4	42.4	34.9	39.2	1.8	3.01	2.6
Zoo - planktons	**Density**			**Diversity Index**		
Location Code	**Pre monsoon**	**Monsoon**	**Post monsoon**	**Pre monsoon**	**Monsoon**	**Post monsoon**
Site1	0.4	0.4	0.4	0.2	0.8	0.49
Site 2	-	0.5	0.4	-	1.1	0.54
Site 3	-	0.4	0.6	-	1.0	0.5
Site 4	-	0.5	-	-	0.6	0.2

Table 4: Benthic diversity and abundance of River spiti.

	Pre Monsoon		**Monsoon**		**Post monsoon**	
	Frequency (%)	Abundance	Frequency (%)	Abundance	Frequency (%)	Abundance
Ephemeroptera*(Ephemerella sp)*	47	+++	35	+++	18	++
Diptera (*Chaoborus*)	-		10	+	40	+++
Trichoptera (*Hydroptila sp.*)	53.1	+++	45	+++	8	+
Coleoptera (*Ptillodactylidae*)	-		5	+	18	++
Odonata			5	+	16	++
Mollusca	1	+		-	-	
Total population (indv./sq.m)	**47**		**10**		**15**	

- = absent, += present, ++= common, +++= abundance.

Table 5: Benthic density and diversity index during different season.

Total benthos	**Density (individual/sq.m)**			**Diversity Index**		
	Pre monsoon	**Monsoon**	**Post monsoon**	**Pre monsoon**	**Monsoon**	**Post monsoon**
Site1	34	10	10	2.8	2.91	0.9503

Site 2	42	12	15	2.32	2.56	2.86
Site 3	84	15	20	2.0	2.89	2.3
Site 4	22	8	12	1.8	3.01	0.8196

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