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Study of bio-physico-chemical parameters of Mothronwala swamp, Dehradun (Uttarakhand)

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Abstract: *Aquatic biodiversity is one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change. The entire stretch of the Mothronwala swamp has rich riparian vegetation for providing conducive environment for the growth of aquatic organisms. The present work has been undertaken to study the bio-physico-chemical characteristics of the swamp. The data on physico-chemical environmental variables (temperature, total dissolved solutes, size and composition of substratum, pH, dissolved oxygen, alkalinity, chlorides, and hardness) have been given under the present contribution. A total of 16 genera of aquatic insects belonging to orders Trichoptera, Coleoptera, Hemiptera, Ephemeroptera, Odonata and Phylum Mollusca represented the macroinvertebrates of Mothronwala swamp. The fresh water swamp of Mothronwala is under threat due to human interference and other anthropogenic activities. Some of the natural and anthropogenic environmental problems of the Mothronwala swamp have been identified and the ameliorative measures for the protection of aquatic environment and the conservation measures for the swamp have been suggested. The qualitative study revealed the present status of the aquatic biodiversity of the swamp and also about the physico-chemical parameters, which would be very helpful for policy makers to take precautionary measures to save the swamp.*

Key words: *Aquatic biodiversity, Wetlands, Bio-physico-chemical characteristics, Swamp*
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Introduction

India has a rich variety of wetlands habitats. The total area of wetlands (excluding rivers) in India is 18.4% of the country. Wetlands are one of the most productive water resources in maintaining rural development projects and play an important role in the freshwater system. They positively contribute to the quality of both surface and ground water supplies (Miller, 1990). Swamps are marshy areas where water oozes out in perennial streams at constant level through out the year. They support characteristic vegetation because of specialized edaphic conditions, as influenced by free water accumulation. Unfortunately, these habitats have not been explored sufficiently from ecological point of view. The Doon valley is known for its rich area of swamps. There was a time when low-lying areas of the valley were having a chain of swamps but human interference once started in the name of 'Malaria's Climate' (King, 1871) still persists. The trees were cut at that time and the openings created resulted in the extinction of most of the swamps. The enormous value of wetlands-from providing natural flood control and water filtration services to supporting populations of fish and wildlife on which people depend for food, employment, and recreation-is increasingly appreciated. Wetlands are one of the most productive ecosystems and thus subjected to human greed, which is yet another reason for their extinction.

The Mothronwala swamp of Doon valley is a "Hot Spot" of biodiversity due to topographic and edaphic variations (Rao, 1996). Such sensitive hot spots could be areas that support a high level of biodiversity. Aquatic insects are among the most prolific animals on earth, but are highly specialized and represent less than 1% of total animal diversity (Pennak, 1943). Aquatic insects have been used to assess the biological integrity of stream ecosystem in various studies (Rosenberg and Resh, 1993; Duran and Suicmez, 2007). Majority of works have been done on the number of streams at global level (Clausen and Biggs, 1997, 2000; Collier, 2000; Walsh *et al.,* 2001; Joshi *et al*., 2002; McIntosh *et al*., 2004) and at national level (Sharma, 1984, 1986) Present work has been taken up to evaluate the bio-physico-chemical properties of Mothronwala swamp of the Doon valley in Uttrakhand.

Materials and Methods

Study area: The Mothronwala swamp is located at 600m above mean sea level in the Doon valley of the Uttarakhand state. The Doon valley lies between latitude 20° 35' 30" to 30° 30' 30" N and longitude 77° 35' to 78° 19' E. The entire area of 22 acres of Mothronwala swamp is 5.0 km South-East to Dehradun town. The Mothronwala village is located on the east of the swamp, from which the swamp derives its name. In the north lies Banjarwala Tea Estate. On the west lies the Suswa river. The stream coming out of the swampy zone drains into the river Suswa that ultimately discharges into the Ganga through Rispana river. On the south Clement Town Water works is situated. Three sampling sites were selected in the Mothronwala swamp to study the physico-chemical parameters. The first sampling site (S1) lies in the streambeds of the swamp covered with original hydrophytic and amphibious vegetation. The second sampling site (S2) lies in the upper portion of the swamp where water oozes out in the form of perennial streams.The third sampling site (S3) was selected at the periphery (ridge) of the swamp with no water and sparse herbaceous vegetation.

The swampy area of Mothronwala is humid and green. The maximum rainfall ranges between 600-800 mm during the months of July-August and minimum during April-May. The maximum temperature reaches upto 40°C during the months of May and June whereas minimum ranges 2-3°C during December-January (Kumar and Nandwani, 2003). Hence it experiences sub-tropical climate. The ridge of Mothronwala swamp is about 10-11 m above the surrounding level. The slope along the ridge is approximately 20-30°. The northern part of the ridge is drier than the southern area, which is slushy. Inside the swampy area, the sub-soil water level is quite high and remains so throughout the year. The slush in marshy place is knee deep. During rains, the water infiltrate through the gravelly soil extending over a very large area of the terrain oozes out here in series of deep but narrow ravines giving rise to a number of streams, which unites, into a few main channel pour into the Suswa river.

Analysis of bio-physico-chemical parameters: Swamp water samples were collected from two points while soil samples were collected from three points selected in the immediate surroundings of the area covered by swamp water, during the entire winter season *i.e.* from the month of November to February. The samples were collected in between 10 am to 11am. One composite sample from each site was collected per month during the period of study. Physico-chemical parameters such as temperature, Total dissolved solids, hardness, pH, alkalinity, nitrogen, dissolved oxygen, biological oxygen demand, organic carbon, potassium, sodium and available phosphorus of the swamp water, soil and biological parameters of swamp water were determined following standard methods given in Welch (1952), Wetzel and Likens (1991) and APHA (2005), Trivedy and Goel (1984). Data obtained were compiled to get mean and standard deviation (Gupta, 2000).

Collection of aquatic flora and fauna: Aquatic flora were collected from all the sites of the Mothronwala swamp and identified. Insects attached to stones were collected by a fine forceps and brush. Insects inhabiting the shallow areas of the streams below stones were collected by enclosing 1m^2 of the substratum with fine square-mesh netting cloth and sweeping the area completely. The insects were collected in the cloth and picked up. The collected organisms were preserved in 4% formalin and identified.

Results and Discussion

The first sampling site (S1) lies in the streambeds of the swamp covered with original hydrophytic and amphibious vegetation and has stagnant deep water.

The second sampling site (S2) lies in the upper portion of the swamp and bank of channel where in the near by water oozes out in the form of perennial streams.

The third sampling site (S3) was selected at the periphery (ridge) of the swamp with no water and sparse herbaceous vegetation. Water samples were collected from two sites *i.e.* S1 and S2 during the entire winter season. At site S1 water was stagnant while at site S2 water was continuously oozing out. Samples were collected from both the sites from the month of November to February *i.e.* during the entire winter season. All the parameters studied *i.e.* temperature, pH, hardness, alkalinity, chloride, total dissolved solids, dissolved oxygen and BOD revealed significant variation at both the sites in different months (Table 1and Fig. 1) Water temperature ranged from 19 °C to 22 °C at site S1 whereas at site S2 temperature varied from 18°C to 24 °C. Very little pH variation could be observed at S1 and S2 sites. At site S1 it ranged from 7.25 to 7.55 and at site S2 it was found to be less than S1 but varied from 7.15 to 7.34. Maximum hardness (412 mg/l) was reported at site S2 in the month of December and minimum hardness (344 mg/l) could be observed at site1 in the month of November. Water alkalinity revealed more values at site S1 as compared to site S2. Maximum alkalinity (114 mg/l) was observed at site S1 in the month of February while site S2 showed minimum value *i.e.* 78 mg/l in the month of November. Total chloride exhibited maximum value (35.5 mg/l) at site S2 in the month of January while minimum value (18.46 mg/l) was found at site S1 in the month of December. Site S2 revealed maximum value (0.88 mg/l) of total dissolved solids in the month of November while minimum value (0.46 mg/l) was exhibited at the site S1 in the month of February. Dissolved oxygen and BOD was evaluated only in the month of November at both the sites. DO and BOD were found to be more at site S1 than site S2.

Soil temperature, pH, organic carbon, nitrogen, sodium, potassium, phosphorus and electrical conductivity were estimated at three sites selected in the immediate surroundings of the swamp (Table 2 and Fig. 2, 3). Organic carbon, sodium, potassium, phosphorus and electrical conductivity were estimated only in the month of November at all the three sites. All the soil parameters exhibited significant variation at different sites. Maximum soil temperature (20°C) was found at site S2 and site S3 in the month of November, while minimum temperature (10°C) was observed at site S1 in the month of January. Soil pH was found to be maximum (8.00) at site S2 in the month of December while it was minimum (6.51) at the same site in the month of January. Maximum soil organic carbon (4.50%) and nitrogen content (0.41%) were found at site S2 while maximum potassium (110 ppm) and phosphorus (2.61ppm) were reported at site S3. Maximum sodium content (145 ppm) in the soil was found at site S1. Electrical conductivity was maximum (0.40 mmho/cm) at site S2 while it was lowest (0.11 mmho/cm) at site S1. Air temperature was also recorded at these three sites. Maximum air temperature (25°C) was recorded at site S3 in the month of November while the same site revealed minimum air temperature (11.5°C) in the month of February.

Among the macroivertebrates identified in the swamp water (Table 3), *Hydropsyche* of the order Trichoptera, *Ephemerella* of order Ephemeroptera, *Hespercorixa* of the order Hemiptera and *Gyraulus convexiusculus, Cerithidea* and *Lymnaea acuminata* of the Phylum Mollusca were found to occur abundantly in the Mothronwala swamp. The diversity of macroinvertebrates was found to be maximum at site S1 due to the presence of phytoplankton and algal blooms, because they are the food resources for macro-invertebrates. They provide them shelter and nesting site for breeding.

Table - 1: Physico-chemical parameters of water recorded at different sites of Mothronwala swamp during winter season (Nov. 2004 - Feb. 2005)

Parameters	Sites	Months				X ± SD
		November	December	January	February	
Temperature(°C)	S1	22.00	22.00	20.00	19.00	20.75±1.29
	S2	18.00	24.00	24.00	22.00	22.00±2.45
pH	S1	7.25	7.46	7.55	7.55	7.45±0.12
	S2	7.15	7.26	7.34	7.21	7.24±0.07
Hardness (mg/l)	S1	344.00	400.00	404.00	358.00	376.5±26.01
	S2	350.00	412.00	408.00	372.00	385.50±25.74
Alkalinity(mg/l)	S1	85.00	105.00	112.00	114.00	84.00±45.73
	S2	78.00	87.00	98.00	82.00	86.25±7.50
Chloride (mg/l)	S1	19.88	18.46	32.66	31.24	25.56±6.43
	S2	29.82	24.14	35.50	24.14	28.40±4.71
TDS (mg/l)	S1	0.84	0.68	0.52	0.46	0.62±0.14
	S2	0.88	0.70	0.56	0.74	0.72±0.35

Table - 2: Soil parameters recorded at different sites of Mothronwala swamp during winter season (Nov. 2004 - Feb. 2005)

Parameters	Sites	Months				X ± SD
		November	December	January	Febuary	
Temperature (°C)	S1	19.00	17.00	10.00	15.00	15.25±3.34
	S2	20.00	18.00	15.00	14.00	16.75±2.38
	S3	20.00	19.00	15.00	14.00	17.00±2.55
Air temperature (°C)	S1	23.00	21.00	13.00	13.00	17.56±4.55
	S2	24.00	22.00	15.00	12.00	18.25±4.91
	S3	25.00	31.00	18.00	11.50	21.37±7.33
pH	S1	7.02	6.76	7.29	7.95	7.25±0.44
	S2	7.92	8.00	6.51	7.52	7.48±0.59
	S3	6.90	7.70	6.60	6.95	7.03±0.40
Electrical conductivity	S1	0.11	0.14	0.14	0.16	0.13±0.27
(mmho/cm)	S2	0.36	0.40	0.38	0.40	0.38±0.58
	S3	0.12	0.19	0.15	0.12	0.14±0.32

It was observed that number of algae at site S1 was more than site S2, which is due to the presence of stagnant water and favourable pH range of 7.25-7.55 at site S1. Nandan and Patel (1992), Dwivedi and Pandey (2002) opined that a higher pH value promoted the growth of algae and phytoplankton. *Tabelleria* and Sp*irogyra* were in abundance in the swamp water. Some other algae like *Cymbella, Synedra, Pinnularia, Meridion, Gomphonema, Oscillatoria etc.*, were also found to be present in the swamp water (Table 4). Biological diversity of the swamp develops in response to the hydrological regime, physical and chemical characteristics and biological interactions. Thus the total environment of the swamp is the result of interaction among a number of factors, some of which play a pivotal role in determining the structure and function of the swamp ecosystem.

There exists a close relationship between the water quality and bottom substrates. Most aquatic habitats particularly free flowing water streams and waters with acceptable water quality and substrate conditions support diverse aquatic insect communities. The nature of bottom substrates is one of the most significant environmental parameters in influencing the biodiversity of stream (Minshall, 1984).

Table-3: Abundance of macroinvertebrates at Mothronwala swamp

S.No.	Species	Order / Phylum	Abundance
		Order	
1	*Molanna* sp	Trichoptera	++
2	*Hydropsyche* sp	Trichoptera	+++
3	*Plannaria* sp	Trichoptera	+
4	*Economus* sp	Trichoptera	+
5	*Hydroptila* sp	Trichoptera	+
6	*Amphizoa lecontes*	Coleoptera	++
7	*Anchycetus* sp	Coleoptera	+
8	*Gerris fossarum*	Hempitera	++
9	*Hespercorixa* sp	Hempitera	+++
10	*Heptagenia* sp	Ephemeroptera	++
11	*Ephemerella* sp	Ephemeroptera	+++
12	*Enallagma* sp	Odonata	++
13	*Agrion* sp	Odonata	+
		Phylum	
14	*Gyraulus convexiusclus*	Mollusca	+++
15	*Cerithidea* sp	Mollusca	+++
16	*Lymnaea acuminata*	Mollusca	+++

+++ abundant, ++ common, + rare

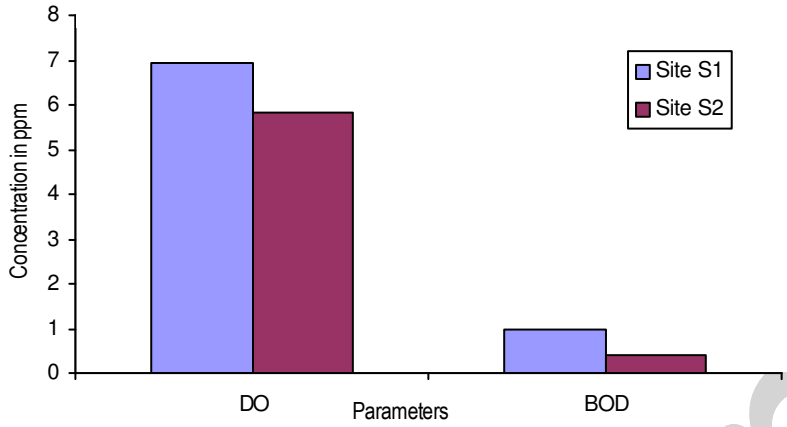

Fig. 1: Dissolved oxygen (DO) and biological oxygen demand (BOD) of Mothronwala swamp water at dirrerent sampling sites

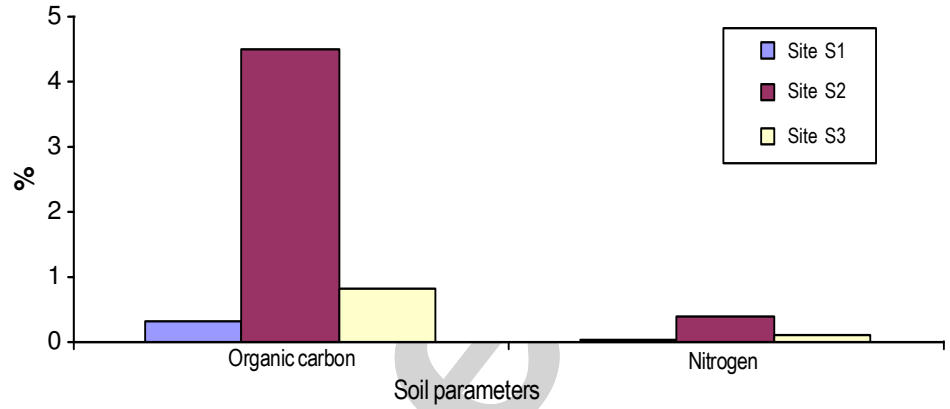

Fig. 2: Organic carbon and nitrogen content in the soil samples of different sampling sites of Mothronwala swamp area

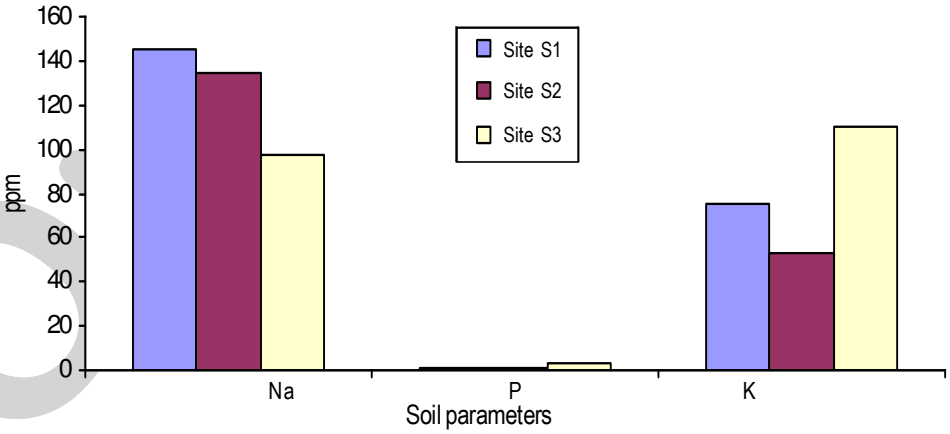

Fig. 3: Soil parameters recorded at different sampling sites of Mothronwala swamp

Table - 4: Algal components of Mothronwala swamp

S.No.	Species	Family	Abundance
1	*Cymbella* sp	Bacillaripophyceae	++
2	*Synedra* sp	"	++
3	*Pinnularia* sp	"	++
4	*Meridion* sp	"	++
5	*Diatoma* sp	"	+
6	*Achnathes* sp	"	+
7	*Gomphonema* sp	"	++
8	*Cocconeis placentula*	"	++
9	*Melosira granulata*	"	+
10	*Nitzchia* sp	"	+
11	*Tabelleria* sp	"	+++
12	*Stauroneis* sp	"	+
13	*Flagilaria* sp	"	+
14	*Naviculla* sp	"	++
15	*Licmophora* sp	"	+
16	Spi*rogyra* sp	Chlorophyceae	+++
17	*Chlorella vulgaris*	"	+
18	*Oscillatoria* sp	Myxophyceae	++

+++ abundant, ++ common, + rare

More complex the substratum, more diverse is the aquatic insect fauna. There is a great importance of litter from riparian vegetation as trophic basis for stream communities, particularly those of forested streams. In these systems, algal production is limited by low intensity of light, organic matter being the trophic basis for secondary production (Kaushik and Hynes, 1971; Fisher and Likens, 1973; Petersen and Cumins, 1974; Sachidanandamurthy and Yajurvedi, 2006). Changes in the riparian vegetation, varying the amount and the quality of organic matter entering the stream may have a strong impact on invertebrate communities (Cummins and Klug, 1979; Stout *et al*., 1993; Grubbs and Cummins, 1994).

Several factors were known to influence the density and abundance of the aquatic insects but the important likely factors are water temperature and dissolved oxygen. Ward and Stanford (1979) also suggested that temperature pattern influences the life cycle phenomenon of insects such as emergence, which leads to increase in density. A significant difference in the diversity of aquatic insects may be attributed to the fluctuations in water temperature, high values of dissolved oxygen, pH and alkalinity in addition to the natural and anthropogenic disturbances. In the swamp there were several factors responsible for more aquatic biodiversity in site S1 including high pH and velocity at site S2 the water was stagnant with almost zero velocity. Periphyton development in relation to geology and velocity parameters was investigated in New Zealand (Biggs, 1989). The nature of bottom substrates in the Mothronwala swamp is also one of the major factors influencing the diversity pattern of aquatic insects. The entire ecosystem of Mothronwala swamp is encountered with many anthropogenic pressures (deforestation, intensification of agriculture, speeding of human settlement, soil erosion in the swamp area). These factors have direct and indirect impact on the diversity of aquatic insects. The conservation and management of the swamp is very important for proper functioning of the ecosystem.

The freshwater must be recognized as the blood of society (Wetzel, 2000), despite the extensive discussion and evolution of human needs for water of reasonable quality, it is essential to know how aquatic ecosystem function in order to manage them successfully. Management of swamp must be determined in consideration of its significance for conservation on the basis of which management priorities and objectives need to be clearly spelt out.

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