Aquatic Plant Diversity of Manawar Tawi River with special reference to Periphyton, Jammu And Kashmir, India

Adhfur Sherwani and Dr. Malik Mukhtar

[1.] Research Scholar, Department of Environment Science
[2.] Professor, Department of Entomology SKUAST-K
showkat80ahmad@gmail.com

Abstract: Plant diversity is an important biotic component of any aquatic ecosystem. Huge biodiversity is found in Manawar water system. The Manawar Tawi is one of the most important rivers of Jammu region. It is one of the major tributaries of the Chenab River. In this study Periphyton, Phytoplankton and Macrophyte diversity was estimated. Members of Bacillariophyceae (diatoms) of periphyton among aquatic plants were found to be one of the most dominant components of the aquatic biodiversity of Manawar Tawi River. These components of aquatic biodiversity can act as one of the most appropriate and efficient bio indicators of aquatic habitats during the present study.

[Adhfur Sherwani and Malik Mukhtar. **Aquatic Plant Diversity of Manawar Tawi River with special reference to Periphyton, Jammu And Kashmir, India.** *Academ Arena* 2016;8(4):1-8]. ISSN 1553-992X (print); ISSN 2158-771X (online). http://www.sciencepub.net/academia. 1. doi:10.7537/marsaaj08041601.

Keywords: aquatic plant, diversity, manawar twai river, periphyton

Introduction

Biodiversity means variability among living organisms from all sources and the ecological complexes of which they are a part which includes diversity within species (genetic diversity), between species (species diversity) and of ecosystems (ecosystem diversity). It is a well known fact that life originated in water and above 70% of total world surface is covered with water. Therefore the aquatic ecosystems hold the largest biodiversity. However, the biodiversity holdings recorded from innumerable aquatic habitats are not yet fully understood.

India is one of the 12-mega diversity sites of the world. More than 46000 species of animals and 30 million species of microbes have been recorded from India. India with a varied geomorphic condition is provided with varieties of aquatic habitants from the Himalayan springs in the North to Kanyakumari in the south, where the three seas meet and on its innumerable islands. The aquatic habitats can be listed in to hard water springs, streams, river-lets and rivers on one side and wet lands,paddy fields swamps, ponds, lagoons, reservoirs and lakes on the other side in fresh water, estuary, backwaters, mud flats, sandy and muddy shores, pelagic zone, benthic zone, etc. in the marine habitats. Each one of these habitats holds diverse flora and fauna that contribute to the rich biodiversity of a region concerned.

Some of the important studies have been made in different parts of Indian subcontinent (Chakarbarty et al. 1959; Subramanyan 1962; Pahwa and Mehrotra 1966; Roy et al 1966; Goel et al. 1989; Tripathi 1989; Gopal 1990; Gusain 1991; Mittal and Sengar 1991; Shukla et al. 1994 Singh and Sinha 1994; Sharma 1984, 1991; Khan et al 2002; Sharma 2002, 2005).However, few studies have also been made on the aquatic plant diversity of water bodies of Jammu and Kashmir.

However, no work has been done so far on the plant diversity of Manawar Tawi River of Jammu region. Therefore, it was felt desirable to undertake the study on aquatic plant diversity of Manawar Tawi River.

Study Sites

The Manawar Tawi is one of the most important rivers of Jammu region. It is one of the major tributaries of the Chenab River. There are eight main tributaries of the Manawar Tawi River. These areas-Rajouri Tawi, Sukhtao, Khandal, Nallah, Jamola Wali Tawi, Dhelloriwali Tawi, Kalar Kas, Panda Kas, Nehari Tawi. The main water source of Manawar Tawi is snow and some perennial springs. There are about 20 high altitude lakes along the northern boundary of the district in the Pir-Panjal range.

'Manawar Tawi' derives its name from a town 'Manawar', which is in Pakistan. There are different names of this river in Rajouri district. Locals used to call the tributaries of this River as 'Nallahs', and the tributaries of 'Nallah' Manawar Tawi is a third stream order River. The head water stream of 'Manawar Tawi' rises on the southern slope of Pir-Panjal Mountains and is known as 'Thanna-Nallah'. Thanna-Nallah originates from a mountain (2,542m above m.s.l.). The head of Thanna-Nallah is located between $74^{0}22^{1/2}$ East longitude and $33^{0}32^{1/2}$ North latitude. It then flows southwards and is joined by another Nallah from the eastern side known as 'Darhali-Nallah'.

These two Nallahs meet each other between **74^0 18\'** East longitude and **33^0 24\'** North latitude 'Darhali-Nallah' originates from a mountain which is (3,555 m above m.s.I.). Its head is located between **74^0 30\'** East longitudes and **33^0 26\'** North latitude. After confluence of these two Nallahs the river passes through the Rajouri town. For this study three sites the substrate of sampling site S1 (Darhali Bridge), sampling site S2 (Salani Bridge) and site S3 (Badoon) The analysis of composition of bottom substrates of all the three sites revealed that the substrates of Manawar Tawi River were represented by boulders, cobbles, pebbles, sand and silt.

Material and Methods

Standard methodology was followed for estimation of following parameters as described below:

Periphyton: Periphyton of Manawar Tawi River was collected using a timed scrapping technique following ward (1974) with the help of a sharp knife for each replicate sample. A total of five quadrates were measured on each site (S1, S2 and S3).The upper surfaces of least five cobble sized stones were scrapped during a 5 minute period. The total algal mass collected was preserved immediately in 4% formalin. Analysis of stored material was done as soon as possible. The qualitative and quantitative analyses of periphyton was done by methods outlined by Prescott (1962); Wetzel (1979); Wetzel and Likens (1991); ward and Whipple (1992) and Sims (1996).

Phytoplankton: The sample water was filtered through silk plankton net of mesh size 20µm and immediately preserved in opaque sample bottles containing 4% formalin solution for further analyses. In the laboratory 1 ml of the preserved phytoplankton sample was diluted in 100ml of distilled water and centrifuged at 1500 rpm for 20 minutes to concentrate the plankton for quantitative analyses. The calibration of microscope was done before carrying out the analysis.

Primary Taxonomic references used for identification of phytoplankton, were Cleve-Euler (1968); Wetzel (1979); Ward and Whipple (1992**).**

Aquatic Macrophytes: Aquatic macrophytes were encountered in the side channels of Manawar Tawi River, where water was shallow and stable. The aquatic macrophytes were collected safely by handpicking and then making their herbarium during the study period. The aquatic macrophytes identification was done with the help of Stoke (1992) and Fasett (1997).

Statistical Treatment of Data:

Statistical analysis of various parameters was also taken in consideration**.**

Results

Aquatic plant diversity of Manawar Tawi river is represented by periphyton, Phytoplankton and macrophytes. Periphyton was mostly present in riffle zones of the river. However, the phytoplankton was present in the pools of river. Macrophytes were mainly present in the side water and intermittent zone of terrestrial aquatic ecosystem of the Manawa Tawi River.

Periphyton: In the Manawar Tawi River, Periphyton were represented by Bacillariophyceae (23 genera) Chlorophyceae (7 genera) and Cynophyceae (4 genera). The family Bacillophyceae was represented by *Achnanthes, Amphora ovalis, Cymbella cistula, Cymbella Cymbiformis, Cymbella Parva, Cymbella tumida, Cocconeis placentula, Cymatopleura solea, Ceratoneis amphioxys, Diotoma vulgare, Fragilaria capucina, Fragilaria mesolapta, Fragilaria virescens, Gomphonema germinatum, Gomphonema herculeanum, Gomphonema constrictum, Gyrosigma Kutzingii, Meridion circulare, Navicula, Nitzschia angustata, Nitzschia dissipata, Nitzschia recta and Tabellaria penestrta.*

The chlorophyceae was represented by *chlorella, Cosmarium, Closterium, Micropora, Stigeoclonium, Ulothrix and Zygnema.However, the Cyanophyceae was represented by Anabaena, Lyngbya, Oscillatoria tenuis and Rivularia.*

A) Bacillariophyceae: The Bacillariophyceae contribution ranged from 77% to 81% to the total periphyton during the period of study. Bacillariophyceae was observed to be the most dominating family in the Manawar Tawi River. The density of Bacillariophyceae was found to be maximum (1168 ind./sq.m) in February at S1 and minimum (173 ind. Sq.m) in August at S1 during the first year of observations It was found to be maximum (1146 ind./sq.m) in March at S1 and minimum (1926ind./sq.m) in August at S3 during the second year of observations. The members of Bacilariophyceae showed maximum density during spring and minimum during monsoon months.

B) Chlorophyceae: The chlorophyceae contribution ranged from 13% to 15% during the period of study. Chlorophyceae or green algae are an important contributor to the total periphytonic community next to the Bacillariophyceae in the Manawar Tawi River. The density of Chlorophyceae was found to be maximum (316 ind./sqm) during March at S3, while it was (34 ind./sq.m) at S3 during the first year of observations. It was found to be maximum (230 ind./sq.m) in January at S3 and It was absent in August at S1 and S2 during the second year of observations.

The mean seasonal density of Cholorophyceae was found to be maximum (267±70.04 ind./sq.m) at

S3 in spring season and minimum (53.08±18.34 ind./sq. m) at S2 in monsoon season during the first year of study (Fig. 5.2). It was found to be maximum (199.39±19.87 ind. /sq.m) at S1 in spring and minimum (34.44±48.70 ind./sq.m) at S2 in monsoon during the second year of study.

C) Cyanophyceae: The Cyanophyceae contribution ranged from 6% and 8% only during the period of observations. Its contribution was lowest to the total periphyton of Manawar Tawi. It was found to be maximum (159 ind./sq.m) in May at S1 and minimum (8 ind./sq.m) in July at S3 during the first year of observations. It was found to be maximum (101 ind./sq.m) in February at S2 and minimum (13 ind. /sq.m) at S1 in September during the second year of observations.

The mean seasonal density of Cyanophyceae was found to be maximum (115.12±19.68 ind./sq.m) in autumn at S2 and minimum (26.36±25.75 ind/sq. m) in Monsoon at S3 during the first year of observations. It was found to be maximum (116.26±13.44 ind./sq.m) in spring season at S3 and minimum (32.29±27.78 ind./sq.m) in autumn at S1 during the successive year of observations.

Statistical Treatment of Data:

Shannon-Weinner Diversity Index: The diversity index fluctuated from 3.974 at (S2) in the month of February to 3.211 at (S1) in the month of August in the first year of study. It was found to be maximum 4.004 at (S1), in the month of February and minimum 3.255 in the month of August during the second year of observations.

Seasonally, the diversity index for periphyton was recorded to be highest (3.92±0.03) in spring and lowest (3.42±0.06) in spring and minimum (3.45±0.04) in monsoon during the second year of study. The values Of diversity index for periphyton at all the three sites were>3 throughout the study period, indicating the good quality of River Manawar Tawi.

Alpha Diversity: The Alpha Diversity for River Manawar Tawi River has been. Alpha diversity index (α) for periphyton was calculated to be maximum 31 and minimum 12 during the entire period of study.

Seasonally, alpha diversity was found to be maximum (31) in Spring and minimum (16)in monsoon during the two year study period.

Beta Diversity: All the three sites of Manawar Tawi River represent equal no. of species during the study. Therefore, the beta diversity for periphyton was zero.

Concentration of Dominance: The monthly variations in concentration of dominance for periphyton in the Manawar Tawi River have been presented. The concentration of dominance for periphyton in the Manawar Tawi River was found to be maximum (0.1298) in the month of August at S2 and minimum (0.0391) in January at S3 during the first year of observations. It was found to be maximum (0.1346) in August at S3 and minimum (0.0370) at S3 during the successive year of observations.

Coefficient of Similarity: The data computed for evaluation the coefficient of similarity for periphyton showed that all the three sites (S1, S2 and S3) were 100% similar during the period of study.

Jaccard Evenness (J Eve): The Jaccard Evenness (J Eve) for periphyton was found to be maximum (0.227) at S1 in monsoon and minimum (0.122) at S1 and S2 in spring and summer seasons during the first year of study. It was found to be maximum (0.202) in monsoon at S2 and minimum (0.119) in summer at S1 during the second year of study.

Multiple Regression Analysis: The multiple regression analysis was computed between periphyton density and physic-chemical parameters. All the environmental variable parameter except conductivity, dissolved oxygen, alkalinity, chlorides and sodium showed significant relationship with periphyton density.

B. Phytoplankton

A total of 23 genera of Phytoplankton were encountered during the course of investigation. Phytoplankton were represented by the families of Bacillariophyceae (18 genera), Chlorophyceae (3 genera) and Cyanophyceae (12 genera).

The Bacillariophyceae was represented by *Amphora ovalis, Cymbella cistula, Cymbella cymbiformis, Cymbella tumida, Cocconeis placentula, Cymatopleura solea, Diatoma vulgare, Fragilaria capucina, Fragilari Mesolepta,Fragilaria virescens, Gomphonema germinate, Gomphonema herculeanum, Gyrosigma kutzingii, Meridion circulare, Nitzschia recta, Nitzschia angustata, Navicula, Tabellaria penestrata. Chlorophyceae was represented by Ulothrix, Cosmarium and Chlorella.* The Myxophyceae was represented by *Lyngbya* and *Rivularia.* The phytonplankton in the River Manawar Tawi showed minimum abundance during the monsoon months and maximum during spring and summer seasons.

A) **Bacillariophyceae**:The Bacillariophyceae was observed to be the most dominating family in Manawar Tawi River. The density of Bacillariophyceae was found to be maximum (867 units/l) in the month of March and minimum (19 units/l) in August during the first year of observations. However, It was found to be maximum in April (564 units/l) and minimum (74 units /l) in August during the second year of observations.

Seasonally, the Bacillariophyceae was found to be maximum (678 units /l) in the spring season and minimum (90 units/l) in monsoon season during the period of study.

B) **Chlorophyceae**: The chlorophyceae was found to be an important contributor to the Pytoplanktonic community next to Bacillariophyceae in thr Manawar Tawi River. Chlorophyceae was found to be maximum (142 units/l) in the month of May and complete absence in May and July during the first year of study. It was found to be maximum (114 units/l) in the month of December and complete absence in th month of August during the second year of study.

Seasonally, The Chlorophyceae was found to be maximum (107 units/l) in summer and minimum (11 units/l) In monsoon during the first year of study. It was found to be maximum (91 units/l) in winter and minimum (12 units /l) in monsoon season during the second year of study.

C) **Cyanophyceae**: The contribution of Cyanophyceae was minimum to the phytoplankton in the Manawar Tawi. The Cyanophyceae was found to be maximum (80 units/l) in the month of March and complete absence in December, July during the first year of study. It was found to be maximum (71 units/l) in the month of May and complete absence in the month of November, December and July during the second year of observations.

Seasonally it was found to be maximum (70 units /l) in spring and minimum (8 units/l) in monsoon season during the first year of study. It was found to be maximum (375 units/l) in summer and minimum (6 units/l) in monsoon during the second year of study.

Statistical Treatment of Data:

Shannon-Weiner Diversity Index: The diversity index for phytoplankton was found to be maximum (4.432) in the month of February and minimum (2.388). In the month of August during the first year of study. However, it was found to be maximum (4.381) in the month of January and minimum (2.918) in the month of August during the second year of study.

Seasonally, the diversity index for phytoplankton was recorded to be highest 4.31± 0.07 in spring and lowest 3.03±0.28 in monsoon during the first year of observations. However, it was found to be highest 4.04±0.04 in summer and lowest 3.40±0.26 in monsoon during the second year of observations. The value of diversity index was>3 which indicate the good quality of river water.

Alpha Diversity: Monthly variations in alpha diversity (α) for phytoplankton have been presented (pha diversity ranged from 11 to 22 during the period of study in Manawar Tawi River).

Seasonally, it was found to be maximum (22) in spring and summer season and minimum (12) in monsoon during the two year period of study.

Beta-Diversity: Beta diversity was found to be (1.01) during the first year and (1.0) during the second year respectively.

Concentration of dominance: The concentration of dominance was found to be maximum (0.303) in August and minimum (0.048) in January during the period of study of Manawar Tawi River.

Coefficient of Similarity: The data computed for evaluating the coefficient of similarity for phytoplankton showed that all the three sites (S1, S2 and S3) were 100% similar and there was homogeneity among all the sites.

Jaccard's Eveness: The Jaccard's eveness was found to be maximum (0.243) in monsoon and minimum (0.193) in spring during the first year of study. It was found to be maximum (0.285) in monsoon and minimum (0.210) in winter during the second year of observations.

C: Aquatic Macrophytes:

A total of 15 genera of macrophytes were found in the River Manawar Tawi. These were *Chenopodium ambrodies, Potamogeton crispus, Ageratum species, Ploygonum minus, Echinochloa colona, Bergia ammanniodes, Marchilia, Cardamine Flexuosa, Lactuca polcephala, Aponogeton, Bacopa monnieri, Ranunculus sceleratus, Scoparia species, Blumea and Arundinella metzii.*

Seasonally, macrophytes were most abundant during winter and summer seasons.

Discussion

Periphyton (attached algae) is the dominant primary producers in most temperate stream ecosystems (Biggs, 1995). They are often the fundamental primary producers or transducers of energy from sunlight to organic matter in un-shaded streams. The diversity of periphyton in any fluvial system acts as an indicator of climatic and environmental Conditions due to the fact that they are among one of the most adaptive floristic components. Description of periphyton assemblages has become an important part of most water quality assessment for defining aquatic environment. The functional role of periphyton in limnological process of aquatic biotopes is well known and their biomass production at various tropic levels together with the quality of the environment has been taken up as indicates of potential of any system.

The present study of Manawar Tawi River also revealed that the periphyton where the dominant primary producers. A total of 34 genera of periphyton were recorded from the river. Periphyton were represented by Bacillariophyceae (23 genera), Chlorophyceae (7 genera) and Cyanophyceae (4 genera). The members of Bacillariophyceae showed

maximum abundance (23) followed by Chlorophyceae and Cyanophyceae to the total periphyton of Manawar Tawi. Periphyton community in the Manawar Tawi River showed maximum density (1,376 ind.m^{-2}) during spring season and minimum (397.13 ind.m^{-2}) during monsoon season. Maximum biomass of periphyton was observed in the Danish lowland streams during spring season (Sand Jenson *et al.* 1998), Gusain (1991) studied the dominance of periphyton in the spring season in the Bhilangana River of Garhwal Himalayas. While, Shamsudin and Sleigh (1994) recorded maximum periphyton biomass during spring in Chalk stream and soft water stream. Moore (1997) recorded enhancement an increase in periphytic biomass in sub-arctic streams during summers, when low temperature was recorded. Summer and Fisher (1979) and Cox (1990) recorded a minimum biomass in winter and maximum biomass in spring in temperate streams. Lack (1971) studied the river Thames. All these workers have found that the Bacillariophyceae were dominant contributors to total periphyton in their studies. Several case studies undertaken in Europe and USA have also revealed that majority of diatoms (Bacillariophyceae) dominated among the algal communities.

In Manawar Tawi River, water temperature was found to have a significant positive relationship with periphytonic density. Water velocity showed a significant negative relationship with periphytonic density. Many aquatic populations living in the harsh environment of unpredictable flow suffer high mortality from physiological stress during high flow (Cushman 1985). Increased velocities flush and remove attached algae by abrasion from surfaces and may also break off long strands of filamentous algae (Biggs and Thomson 1995). Elevated velocities alone can be very destructive for stream periphyton (Homer et al 1990; Boulten et al 1992; Peterson and Stevenson 1990). Even rolling of stones occur during flash floods and creates an unstable habitat for periphyton. The periphyton density was found to be lowest during monsoon season when the water velocity reached the maximum value (2.84 m/s). Therefore it was inferred that low biomass of periphyton during monsoon was reasonably due to high water velocity and frequent disturbances (frequent flash floods and unstable bed sediments) in riverine ecosystems of Manawar Tawi.

Transparency of river water is also one o the important factors for the good growth of periphyton. Transparency of Manawar Tawi River was found to be highly positive correlated with periphyton density. Periphyton density is negatively correlated with turbidity. Turbidity of Manawar Tawi was recorded to be highest in monsoon season when the periphyton abundance and diversity was recorded minimum. Welch (1952) also pointed out an adverse impact of turbidity on algal populations. Homer et al. (1990) observed that periphyton loss rate increases as the concentration of suspended solids attained higher concentration. During high flows, increased sediment movement from the catchment areas and rainfall reduced the periphyton mass in the Manawar Tawi River.

The total dissolved solids (TDS) in the Manawar Tawi River showed a significant negative relationship with periphyton density. Biggs and Gerbeaux (1993) also noticed a negative correlation between temporal changes in periphyton biomass and dissolved inorganic nutrient in fresh water ecosystem of New Zealand. Inorganic nutrient supplies are also one of the important driving variables for primary production and potentially act in association with disturbance to set the overall habitat template for periphyton in stream ecosystems (Biggs, 1995).

The nitrates and phosphates were found in the trace amount in the disturbed ecosystem of Manawar Tawi and significantly influenced the periphyton abundance. Streams with high disturbance frequency often are also very low in nutrients Biggs, 1955); Hill and Knight (1988); Peterson and Grimm (1992) reported that nitrogen was a limiting factor for periphyton growth. However, nitrogen can often be found to be secondary limiting when phosphorus limitation is mitigated by phosphorus enrichment (Fairchild et al 1985; Winterbourne, 1990 and Marks and Lowe 1993). Nitrogen supply is reduced by denitrification (Lohman et al 1991; Bothwell (1989) stated that the higher concentration (25-50µ of Po4-$P1^{1}$ of phosphates is needed to attain maximum algal biomass, because a developing benthic mat impeded molecular and eddy diffusion of nutrients. Horner et al (1990) however found a low concentration (8µ Po4-$P1^{1}$) sufficient to achieve maximum biomass. The periphyton density was found to be minimum during monsoon season when nitrates and phosphates concentration were recorded maximum under the present study.

In the Manawar Tawi River, Bacillariophyceae (diatoms) was observed to be the most dominating family. Bhat and Yousuf (2002) also found Bacillariophyceae as the dominant family In their study on the springs of Kashmir Valley. Rashid and Pandit (2006) also found the similar results in their study of Ladakh Water bodies. Algal communities are dominated by diatoms in the unstable habitat or disturbed environment (Biggs et al 1998; Biggs 1995; and Power 1990) due to stress (high water velocities, low water temperature and physical abrasion).Velocity greater than (0.70 m/s) did not allow significant growth of periphyton communities (Biggs, 1995). Once established, as a dominant community in moderate low nutrient supply habitats, these taxa may

also monopolise the stream bed (Biggs and Gerbeaux 1993; Biggs, 1995). These evidences support the persistence of diatoms as a dominant group in the aquatic ecosystem of Manawar Tawi. Diatoms of Manawar Tawi River were recorded maximum during spring season and mimimum during monsoon season during the two year study. A spring diatom pulse is typical of temperate streams (Ward and Dufford, 1979).

Hendey (1997) working within above shore communities concluded that Shannon-Weinner's index provided a good indication of the imp[act of the environment upon the diatom community and suggested a scale for diversity value ranging from 0-4 where, 0-1 means severe pollution,1-2 means moderate pollution, 2-3 means slight pollution and 3-4 means slight passing to negligible pollution. In the River Manawar Tawi, the diversity indices were found to be more than 3 indicating negligible pollution in the river. The diversity index for periphyton was recorded to be highest (3.92±0.06) in spring season and minimum (3.42±0.07) in monsoon season during the present study. It indicated that the periphytic communities were most diverse during spring season (February-March).With increase in number of dominants, the diversity index values tend to be higher in the month of spring in the fluvial system of Manawar Tawi River. The alpha diversity (presence of total no. of genera) also showed the same trend of fluctuations in Manawar Tawi River. The environmental conditions are responsible for seasonal changes in diversity in any aquatic ecosystem (Bensen-Evans et al. 1995).

Jaccard Evenness for periphyton was recorded to be minimum in summer season and minimum in monsoon season. Which is due to fact that during summer season the density of periphyton and diversity were highest and they were not evenly distributed (heterogenous distribution). Whereas, during monsoon months, alpha diversity and density of periphyton were recorded to be low and they were evenly distributed (homogeneous distribution).

The concentration of dominance calculated for periphyton was found to be minimum during spring season and maximum during monsoon season. As the concentration of dominance increases (if any genus becomes dominant) it results in decrease in its diversity. Thus, the concentration of dominance was inversely proportional to diversity of periphyton in the Manawar Tawi River.

Most river planktons have their origin in still or gently flowing areas and can be consistently or frequently supplied to the river, where they may or may not reproduce significantly (Hynes, 1971). High altitude streams show very little plankton even in their lower course and true plankton are absent in the upper part of the stream ecosystem (Welch, 1952). A total of 23 genera of phytoplankton were recorded during the study in the fluvial ecosystem of Manawar Tawi. The phytoplankton of Manawar Tawi were represented by Bacillariophyceae (18 genera), Cholorophyceae (3 genera) and Myxophyceae (2 genera).

Bacillariophyceae were found to be the most abundant genera among phytoplankton. Phytoplankton was observed to be maximum In spring and summer season and minimum in monsoon season. Pandit (1998) also reported maximum development of phytoplankton community in spring and autumn seasons. Generally, phytoplankton community fails to survive at a very high water velocity. High water velocity increases the shear stress and shear strain which cause the abrasion in filaments of algae. Eddy (1934) reported that high level of turbidity can minimize the phytoplankton productivity. The capacity of an unpolluted stream to support good phytoplankton production is directly related to the ionic composition of river water (mainly to the supply of nutrient resource to the water).Headwater streams originating in hard rock mountainous region of high precipitation contain weak ions, nutrient poor waters, where algae may not proliferate. In such waters, algae, like diatoms are dominant (Reynold 1992).

The water velocity adversely influenced the density of phytoplankton in the river. The phytoplankton of fast running rivers are more distinct than those of any other type of aquatic habitat. Dobriyal and Singh (1988); Khanna et al (1992) and Wetzel (2001) also observed a highly negative relationship between phytoplankton and water velocity. Torned cells of phytoplankton were observed in water column during the monsoon season when water velocity attained the maximum value in the Manawa Tawi River.

Aquatic macrophytes were present in the side channels of Manawar Tawi River. A total 15 genera of Macrophytes were encountered in the Manawar Tawi River. Kumar and Pandit (2006) found the maximum density of macrophytes species richness in June and lowest in April in the study on Hokarsar wetland of Kashmir Himalaya.

It may be concluded on the basis of above discussion that the aquatic plant diversity of Manawar Tawi River is influenced by many factors. Members of Bacillariophyceae (diatoms) of periphyton among aquatic plants were found to be one of the most dominant components of the aquatic biodiversity of Manawar Tawi River. These components of aquatic biodiversity can act as one of the most appropriate and efficient bioindicators of aquatic habitats during the present study.

References

1. Bensen-Evans, E., Williams, K.P.F., Mc Clean, R.O. and Pranne, N. 1975. Algal communities in polluted rivers of South Wales, *Ver. Internat. Verein. Limnol.,* 19: 2002-2019.
2. Bhat, F.A and Yousuf, A.R. 2002. Ecology of periphytic community of seven springs of Kashmir. *J. Res. Dev.,* 2: 47-59.
3. Biggs, B.J.F. and Thomsen, H.A. 1995. Disturbance of stream periphyton by perturbations in shear stress: time to structure failure and differences in community resistance. *Journal of Phycology,* 31: 233-291.
4. Biggs, B.J.F., Stevenson, R.J. and Lowe, R.L. 1998. A habitat matrix conceptual model for stream periphyton. *Fresh, Hydrobiol.,* 143(1): 21-56.
5. Biggs, B.J.F. 1995. Relationship between benthic biota and hydrological indices in New Zealand streams. *Freshwater Biology,* 38: 327-342.
6. Biggs, B.J.F. and Gerbeaux, G. 1993. Patterns in benthic algae of streams. In: Stevenson, R. J., Bothwell, M.L. and Lowe, R. L. (eds.). *Algal ecology Freshwater Benthic Ecosystems:* Academic Press, New York. 1-789.
7. Bothwell, M.L. 1989. Phosphorus limited growth dynamics of lotic pariphytic diatom communities: Algal biomass and cellular growth rate responses; *Can. J. Fish. Aquat. Sc.,* 46: 1293-1301.
8. Boulten, A.J., Stibbe, S.E., Grimm, N.B. and Fisher, S.G. 1992. Invertebrate recolonization of small patches of defaunted hyporheic sediments in a Sonoran desert stream. *Freshwater Biology,* 26: 267-277.
9. Chakrabarty, R.D., Ray, P. and Singh, S.B. 1959. A quantitative study on plankton and the physic-chemical conditions of the River Jamuna at Allahabad in 1954-1955. *Indian J. Fish.,* 6: 186-203.
10. Cleve-Euler, A. 1968. *Die Diatomeen von Schweded und Finland.* Wheldon and Wesley Ltd. Strechtert-Hafner Services Agency, Inc. New York. 1-1193.
11. Cox, E.J. 1990. Studies on the algae of a small soft-water stream: I. occurrence and distribution with particular reference to the diatoms. *Arch. Hydrobiol. Suppl.,* 83: 525-552.
12. Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. *North American Journal of Fisheries Management,* 5: 330-339.
13. Dobriyal, A.K. 1985. Ecology of limno-fauna in the small streams and their importance to the village life of Garhwal Himalaya. *Uttar Pradesh J. of Zoology,* 5: 139-144.
14. Fairchild, G. W., Lowe, R. L. and Richardson, W. B. 1985. Algal periphyton growth on nutrient diffusing substrates: an *in-situ* bioassay. *Ecology,* 66: 465-472.
15. Fasset, N.C. 1997. *A Manual of Aquatic Plants.* Allied Scientific Publishers, Bikaner, India:1-382.
16. Goel, P.K., Kulkarni, A.V. and Khatakar, S.D. 1989. Species diversity in phytoplankton communities in a southern western Maharashtra. *Geobios* 15: 150-156.
17. Gopal, R., 1990. *Ecology and Management of Aquatic Vegetations in the Indian sub-continent,.* Klower Academic Publishers, Netherlands.
18. Gusain, O.P. 1991. *Limnology and Primary Productivity in a High Altitude River Bhilangana.* D. Phil Thesis submitted to H.N.B. Garhwal University, Srinagar Garhwal. 1-217.
19. Hendey, N.T. 1977. The Species diversity index of some inshore diatom communities and its use in assessing the degree of pollution inputs on part of the north coast of Cornwell. *Novo. Hedwigia Beith.* 54: 355-378.
20. Hill, R.W. and Knight, A.W. 1988. Nutrient and light limitation of algae in two norihren California streams. *J. Phycology,* 24: 125-132.
21. Homer, R.R., Welch, E.B. Seeley, M.R. and Jacoby, J.M. 1990. Responses of periphyton to changes in current velocity, suspended sediment and Phosphorus concentration. *Freshwater. Biol.*, 24: 212-32.
22. Khan, R.A. 2002. Diversity of freshwater macroinvertebrate communities associated with macrophytes. *Rec. Zool. Soc. India*, 30(1):79-86.
23. Khanna, D.R., Badola, S.P. and Dobryial, A.K. 1993. Plankton ecology of the river Ganga at Chandighat, Hardwar. In: Singh, H.R. (ed.) *Advances in Limnology*. Narendra Publishing House. 171-174.
24. Kumar, R. and Pandit, A.K. 2006. Species composition and distribution of rooted floating-leaf type vegetation in Elokarsar wetland of Kashmir Himalaya. *Journal of Research and Development*, 6: 43-47.
25. Lack, T.J. 1971. Quantitative studies on the phytoplankton of the rivers Thames and Kennet at Reading. *Freshwater Biol.,* 1: 213-214.
26. Lohman, K. Jones, J.R. and Baysinger-Daniel, C. 1991. Experimental evidence for nitrogen limitation in a northeren Ozark stream. *J. North. Am. Bentho. Soc.,* 19: 14-23.
27. Marks, J.C. and Lowe, R.L. 1993. Interactive effects of nutrient availability and light levels oil the periphyton composition of a large Oligotrophic lake, *Can. J. Fish Aquat. Sci.,* 50: 1270-1278.
28. Mittal, S. and Seneger, R.M.S. 1991. Studies on the distribution of algal flora of the polluted regions of Karwan River at Agra (India). In: Shastree N.K. (ed), *Current Trends in Limnology-I.* Narendra Publ. House, Delhi:221-230.
29. Moore, J.W. 1977. Ecology of algae in a subarctic stream. *Can. J. Rot.*, 55: 1838- 1847.
30. Pahwa, D.V. and Mehrotra, S.N. 1966. Observations on functions in abundance of plankton

in relation to certain hydrobiological conditions of river Ganga. *Proc. Nat. Acad. Sci.*, 36 (8): 157-189.
31. Pandit, A. K., Rather, S. A. and Bhat, S. A. 2001. Limnological features of freshwaters of Uri, Kashmir. *J. Res. Dev.,* 1: 20-29.
32. Pandit, A.K. 1998. Plankton dynamics in freshwater wetlands of Kashmir. 22-68. In: Mishra, K. D. (ed.) *Ecology of Polluted Waters and Toxicology*. Techno Science Publications, Jaipur, India: 22-68.
33. Peterson, C. and Stevenson, R.J. 1990. Post-Spate development of epilithic algal communities in different current environments. *Canadian Journal of Botany*, 68: 2092-2102.
34. Peterson, C. G. and Grimm, N.B. 1992. Temporal variation in enrichment effects during periphyton succession in a Nitrogen-limited desert stream ecosystem: *J. North. Am. Benthol. Society*, 11: 20-36.
35. Prescott, G.W. 1962. *Algae of the Western Great Lakes Area*. W.C. Brown Co. Publisher. Dubuque, Lowa. 1-977.
36. Reynold, C.S. 1992. Algae In: Caloci, P. and Petts, G.E. (eds.) *The Rivers Handbook*. Vol 1, Blackwell Scientific Publications, Oxford. 1-217.
37. Roy, P., Singh, S.B. and Sehgal, K.L 1966. A study of some aspects of the river Ganga and Jamuna at Allahabad, U.P. during during 1948-59 *Nat. Acad. Sci. Indi*a 36B, (3) : 237-272.
38. Sand-Jensen, K. Moller, J. and Olesen, B.H. 1988. Biomass regulation of microbenthic algae in danish lowland streams. *Oikos*, 53: 332-340.
39. Shamsudin, L. and Sleigh, M.A. 1994. Seasonal changes in the composition and biomass of epilithic algal florasa of a Chalk stream and a soft water streom with estimates of production. *Hydrobilogia*, 273: 131-146.
40. Sharma, A. 2002. *Aquatic Biodiversity and Mountain Fluvial Ecosystem of Chandrbhaga of Garhwal Himalayas*. D. Phil. Thesis submitted to H.N.B Garhwal University, Srinagar-Garhwal. 1-117.
41. Sharma, R.C. 1984. Potamological studies on lotic environment of the upland river Bhagirathi of Garhwal Himalaya. *Environment and Ecology*, 2: 239-242.
42. Sharma, R.C., Bhanot G., Singh D., 2005. Aquatic macroinvertebrate diversity in Nanda Devi Biosphere Reserve, India. *The Environmentalist*, 2: 211-221.
43. Shukla, S.N., Aggarwal, N.C., and Dubey, S. 1994. Chlorophyll as an indicator of trophic status of water body. *J. Freshwater. Biology*, 6(2): 121-126.
44. Sims, P.A. 1996. *An Atlas of British Diatoms*. Bio Press Limited, Bristol. 1-601.
45. Singh, M. and Sinha, R.K. 1994. Primary productivity and limnological profile of two ponds of Patna, Bihar. *J. Freshwater. Biology*, 6(2): 127-133.
46. Stoke, R. 1992. *Aquatic Macrophytes in the Trans and Lakes of Cumbria*. Occassional Publication No. 18. Freshwater Biological Association. The ferry House, Amblaside, Gumbria.
47. Subramanyam, K. 1962. *Aquatic Angiosprem*. A systematic Account of Common Aquatic Angiosperm. CSIR, N. Delhi.
48. Summer, W. I. and Fisher, S. G. 1979. Pcriphyton production in Fort river, Massachussetts. *Freshwater Biology*, 9:205-212.
49. Tripathi, C.K.M. 1989. Assessment of Ganga river at Varanasi: Studies on Phytoplankton Community Structure. *IJEH*.
50. Ward, H. B. and Whipple, G. C. 1992. *Freshwater Biology*. John Wiley and Sons (2nd edn). New York. 1-1248.
51. Ward, J.V. 1974. A temperature stressed stream ecosystem below a hypolimnial release mountain reservoir. Arch. Hvdrobiology, 74:247-275.
52. Welch, P. S. 1952. *Limnology*. McGraw Hill Book Co. Inc, New York.
53. Wetzel, R. 0. 2001. *Limnology: Like and River Ecosystems*. 3rd ed. Academic Press, Boston U.S.A. 1-1006.
54. Wetzel, R. L 1979. *Methods and Measurements of Periphyton Communities: A Review*. ASTM, Special Technical Publication. 1-183.
55. Wetzel, R.G. and Likens, G.E. 1991. *Limnological Analyses*. Springer-Verlag, New York. 1-175.
56. Winterbourne, M. J. 199. Interactions among nutrients, algae and invertebrates in a New Zealand mountain stream: *Freshwater Biology*, 23: 463-474.

2/1/2016