Physico-Chemical Environmental Variables of Manawar Tawi

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Abstract: Aquatic biodiversity is an essential characteristic for the stability and residence of ecosystem. The physico-chemical environmental characteristics of water have a great role over the distribution and abundance of living organisms. After a perusal of data on physico-chemical parameters and in depth discussion on their relationships, it was inferred that the high altitude fluvial system of Manawar Tawi is represented by extreme environmental conditions. Physico-chemical parameters like air temperature, water temperature, turbidity, hydro median depth and total dissolved solids remained low during winters. However, the free carbon dioxide and sodium showed higher values during monsoon. All these environmental variables have a direct bearing on the aquatic biodiversity of Manawar Tawi of Jammu region.
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Introduction

The knowledge of physico-chemical environmental variables of a fresh water body is of great significance, as these play a vital role in confining any species within a certain range of ecosystem habitat. The water quality and habitat variables explain the patterns of community composition in a best manner of any fluvial system. The frequency and abundance of biotic components in aquatic ecosystem varies considerably with the fluctuations in abiotic components and their interactions with each other. Each of biotic components has its individual physiological, biochemical and genetic boundaries within the dynamic variations of physical and chemical parameters of the ecosystem at a given time (Wetzel 2000).

Measurement of physico-chemical parameters provides valuable information about the biological and biochemical reactions going on in river waters, which affect aquatic life. The physical variables within river ecosystem of head water fluvial system present a continuum gradient of physical conditions. This gradient elicits a sense of response within the constituent population resulting in a continuum of biotic adjustments along the length of river (Gregory 1983; Holmes and Whiton 1975 and Vannote et al. 1980).The water quality and habitat variables explain the patterns of community composition in a best manner of any fluvial ecosystem but the extensive biological degradation and the loss of biological diversity from river exploitation is eliciting wide spread concern for conservation and restoration of healthy river ecosystems among scientists and lay public alike (Williams 1966). Different streams segment displays characteristics that reflect the relative proportions of the different run off sources: glacier melt and spring flow (Brittain and Miller, 2001). Each source generates the characteristics seasonal hydrological signature and run off (Sharp et al. 1998; Brittain et al. 2000). The high altitude mountain fluvial systems are unstable and simple and characterized by poor biodiversity than the complex lowland streams. The headwater stream systems are unique among the lotic ecosystems and the physico chemical variables are more dominant over other parameters in determining community structure in these fluvial ecosystems.

Study Area and 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.I.). 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.

Materials and Methods

Aquatic biodiversity is an essential characteristic for the stability and residence of ecosystem. For in-depth analysis of aquatic biodiversity, an appropriate and standardized methodology is pre-requisite. For this a survey was done of the entire watershed of Manawar Tawi River for identifying the sampling sites keeping in view their accessibility and locations at different altitudes. Three sampling sites (S_1, S_2 and S_3) were selected for obtaining the data on physico-chemical parameters of the Manawar Tawi River. Regular monthly sampling was undertaken between 0900 hrs to 1100 hrs at each site for a period of two years (November 2009-October 2011). Five replicates were obtained for each parameter and the results were integrated and recorded.

Analysis of Physico-Chemical Parameters

Physico-chemical parameters of Manawar Tawi was determined following the standard methods outlined in Welch (1952), Wetzel and Likens (1991). Some of physico-chemical parameters were determined at the spot and the rest were analysed at the Freshwater Biology laboratory of the Department of Entomology SKAUST- Kashmir depending on the requirement and time. The following parameters were taken in consideration:

1) Substrate Analysis: Analysis of the composition of substrates of all the three sampling sites was made following the standard size classes of sediment given by Friedman and Sanders (1978). Sediment particles range from a fraction of microns to huge boulders measuring many meters in diameter. From smallest to largest they are categorized in clay, slit, sand, pebbles, cobbles and boulders collectively form gravel. The size of bottom substrate was measured following the phi (Ø) scale.

Ø= -log2 d

Where d= diameter of particles in mm.

2) Air Temperature: The centigrade thermometer (0-100◦c) was used to measure the air temperature above the surface of water and values were expressed as degree Celsius (◦c).

3) Water Temperature: Water temperature was also measured using centigrade thermometer by directly immersing it 10 cm into water close to the substrate. Five replicates were taken at each sampling site and mean values were expressed as degree Celsius (◦c).

4) Water Velocity: The water velocity was determined by using the float method. A float (a piece of cork) was floated on water surface and was allowed to drift along the stream current. The time taken by float to travel at a given distance and time was recorded and average velocity was estimated. The values were expressed in m/s.

5) Hydro median Depth (HMD): A graduated nylon rod with a weight hung was used for measuring hydro median depth (HMD) in Manawar Tawi River. It was dipped up to bottom holding at it firmly at the bottom in vertical position at different points of the width of the river. The values were expressed in meter.

6) Transparency: Transparency in Manawar Tawi River was measured by immersing the Sacchi Disc directly into the river water. Transparency estimated in this way, is the mean of the depth at which the Sacchi disc disappears, and at which it reappears upon raising after it has been lowered beyond visibility. It was expressed in meter. The calculations were made as follows.

$$\text{Sacchi Disc transparency (m)} = \frac{A+B}{2}$$

Where,

A=Disappearing point when the disc was lowered

B=Reappearing point when the disc was uplifted

7) Turbidity: Suspended inorganic and organic matters present in water cause turbidity. Turbidity of river water was measured with the help of Metzer's Digital Turbidity Meter (Model-5DIM) at the laboratory. The turbidity meter was calibrated with 40 NTU standard suspension of hydrazine sulphate, $(NH2)_2$ H_2SO_4 and Hexamethylene tetra mine, $(CH_2)_6$ N_4 before determining the turbidity values for the sample water. Then, the sample water, after shaking thoroughly, was placed in the sample cuvettes and the values were recorded directly. Turbidity was expressed as Nepthalometeric Turbidity Unit (NTU) following the equation:

Turbidity (NTU) = Nepthalometer reading x 0.4x dilution factor

8) Conductivity: Conductivity (k) is a measure of the ability of an aqueous solution to carry an electric current. The ability depends on the presence of ions: on their total concentration, mobility, and valence; and on the temperature of measurement. Solutions of most inorganic compounds are relatively good conductors. Conversely, molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly. If at all conductivity of water samples of the River Manawar Tawi was measured at the laboratory with the help of the Digital Control Dynamics Conductivity Meter (Model-APX185).It was expressed as mS.C/m.

9) Hydrogen Ion Concentration (pH): Measurement of the pH is one of the most important and frequently used tests in analyzing physico-chemical characteristics of water. pH is used for alkalinity and carbon dioxide measurements and many other acid base equilibria. At any given temperature, the intensity of the acidic and basic character of a solution is indicated by pH or hydrogen ion activity. The pH of any aqueous solution is sugge3stive of the acid base equilibrium achieved by various dissolve compounds. The pH of water was measured by the control dynamics the pH Meter (model-APX-15/C)at the laboratory.

10) Total Dissolved Solids: The presence of total dissolved solids (TDS) in natural waters is due to various kinds of minerals, e.g. carbonates bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, etc. The amount of total dissolved solids in the river water was estimated at the laboratory by evaporating 100 ml of sample water in pre-dried (at 550±50◦Ctemperature in a furnace) pre-weighed evaporating dish on a hot plate having temperature up to 98◦C. After complete evaporation of the water sample from the dish it was then dried at 103-105◦C in an oven before final weighing, the evaporating dish was cooled in a desiccators for about an hour. The values were expressed in mg/l using the following formula:

$$\text{Total dissolved Solids (mg/l)} = \frac{A \; x \; B \; x \; 1000 \; x \; 1000}{v}$$

Where,

A=Final weight of the dish in g

B=Initial weight of the dish

v=Volume of sample taken in ml

11) Dissolved Oxygen: the modified Winkler's Iodometric method was used for the estimation of dissolved oxygen concentration in the river water.

12) Free Carbon Dioxide: The free Carbon dioxide in water was estimated by titrating the sample using a strong alkali to pH 8.3.The analysis was made on spot. 8-10 drops of neutralized Phenolphthalein indicator were added to 100 ml of water sample taken in an Erlenmeyer's flask, and titrated with N/44 sodium hydroxide (NaOH) until a pink colour appears. The volume of the titrant was noted down and free carbon dioxide was calculated and expressed as mg/l.

$$\text{Free CO2 (mg/l0)} = \frac{\text{(mlxN) of titrant x1000x44}}{\text{ml of sample}}$$

13) Total alkalinity: The alkalinity is the expression of the total quantity of base (usually in equilibrium with carbonates and bicarbonates) that can be determined by titration with a strong acid (Hutchinson 1957). The milli equivalents of acid necessary to neutralize the hydroxyl, carbonate and bicarbonate ions in a litre of water is known as total alkalinity

a. **Carbonate Alkalinity:** To determine carbonate alkalinity of 100 ml of water sample was taken in an Erlenmeyer's flask and to it were added 8 to 10 drops of phenolphthalein indicator turning the sample of water pink. This was titrated with 0.1 N HCL till the disappearance of the colour. Following method of calculation was done to find out the carbonate or phenolphthalein, alkalinity:

$$\text{Phenolphthalein Alkalinity (mg/l)} = \frac{\text{(AxN)of HCl x 1000 x 50}}{\text{ml of sample}}$$

b. **Bicarbonate Alkalinity**: When the solution used to determine carbonate alkalinity, it remained colourless; 2-3 drops of methyl orange indicator were added to the sample and titrated with 0.1 N HCL until the colour changes to pink at the end point. This is total alkalinity. The values were calculated as follows:

Total Alkalinity (mg/l) = (BxN) of HCL x 1000x50

Where,

A=ml of HCL used only with Phenolphthalein

B=ml of total HCL used with phenolphthalein and methyl orange

14) Chlorides: 100 ml of river water was titrated against N/35.46 Silver Nitrate solution using potassium chromate as the indicator. The chloride content was estimated by multiplying the amount of $AgNO_3$ used by a factor of 10 and the result was expressed in mg/l.

15) Nitrates: Nitrates are the products of oxidation of organic nitrogen by bacteria present in soil and water where significant oxygen is present (WHO, 1984).Because of its role in the synthesis, maintenance of proteins and productivity of water, the estimation of nitrogen is important for aquatic ecosystems.

The concentration of nitrates was estimated spectrophotometrically at 410-nm wavelength with the help of the Spectrophotometer (Model-Spectronic 20 D series). 50 ml of water sample was taken in an Erlenmeyer's flask adding same amount of Silver sulphate solution to it so as to remove the chloride contents from the sample. It was then heated slightly

in a hot plate and the precipitate of AGCL was filtered with the help of filter paper. The filtrate was then dried in a porcelain basin. After cooling in desiccators, it was dissolved in 2 ml Phenol disulphonic acid and the contents were diluted to 50 ml with distilled water to develop yellow colour, 6 ml of liquid Ammonia was added to it. The samples were then analyzed spectrophotometrically. The readings were noted at concentration mode and direct values were obtained. The values were expressed in terms of mg/l.

16) Phosphates: Phosphorus is found to play an important role in governing primary productivity of any ecosystem (Hutchinson 1957). In natural fresh water bodies, phosphorus is present mainly in inorganic form e.g. H_2PO_4, HPO^{-2} and PO^{-3}. It is also be present in an organic form. The important sources of phosphorus to enter fresh water ecosystem are atmospheric precipitation and ground water surface run off. Phosphate was estimated with the help of the spectrophotometer (Model-Spectronic 20 D series).

The phosphates present in water react with Ammonium molybdate and form complex heteroploy acid, Molybdophosphoric acid, which gets reduced to a complex of blue color in the presence of $SnCl_2$ Hence; stannous chloride method was followed for estimating phosphate in water sample. 2 ml of ammonium molybdate solution followed by 5 drops of $SnCL_2$ solution was added to 50 ml of filtered clear sample in a clean Erlenmeyer's flask, developing blue colour. The absorption of light by this blue colour in a sample was measured at 690 nm on a spectrophotometer using blank solution with similar amount of the chemicals. The readings were taken after 5 minutes but before 12 minutes of the addition of the last reagent. The readings were noted at concentration mode and direct values were obtained. The values were expressed as mg/l.

17) Sodium and Potassium: Sodium and potassium were estimated by Electronics India digital Flame Photometer (Model-1381 E) by sodium and potassium filters for their respective estimation.

Statistical Treatment of Data:

Statistical analysis of various physico chemical environmental parameters were also taken in consideration**.**

Results

Analysis of physico-chemical profile carried out at three different sampling sites (S_1, S_2 & S_3) located at different altitudes for the period November 2009 to October 2011.The analysis of physical and chemical environmental variables of Manawar Tawi has been given below:

1) **Bottom Substrates**: 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. The substrate of sampling site S1 (Darhali Bridge) was comprised of boulders (50 %), cobbles (25%), pebbles (15 %), sand (9%) and slit (1%). The bottom substrates of sampling site S2 (Salani Bridge) was contributed by boulders (45%), cobbles (25%), pebbles (20%), sand (8%) and slit (2%).The bottom substrates of sampling site S3 (Badoon) encompassed boulders (42%), cobbles (25%), pebbles (20%), sand (11%) and slit (2%).

2) **Air Temperature:** The air temperature at Manawar Tawi River was found to be maximum (30.0ºC) at S2 in the month of July and minimum (10.50ºC) in January at S1 during the first year of observations. The peak in air temperature was recorded in the month of June (28.0ºC) at S3 and minimum (7.50ºC) during February at S1 & S2, during the successive year.

3) The seasonal air temperature was found to be maximum (28.75±0.35ºC) at S3 in monsoon and minimum (12.67±2.25ºC) at S1 in winter during the first year of observations. It was recorded to be maximum (26.75±1.77ºC) in monsoon at S3 and minimum (9.75±3.18ºC) at S1 and S2 in spring season during the successive year of observations.

The annual mean air temperature was recorded to be 19.57±6.14ºC, 20.58±6.65ºC and 20.58±6.53ºC during first year and 16.96±6.44ºC, 17.46±6.92ºC and 18.24±7.43ºC during second year respectively at all three sites.

4) **Water Temperature**: The peak in water temperature of Manawar Tawi was recorded to be the month of July (19.50ºC) at S3 and the minimum (9.0ºC) in the month of January at S1 during the first year of observations. It was maximum (19.50ºC) in the month of August at S1 and minimum (7.0ºC) in the month of January and February at S1 in Manawar Tawi River during the second year of observations.

5) The seasonal water temperature was found to be maximum (19.25±0.35ºC) at S3 during the monsoon and minimum (11.50±1.41ºC) during spring season at S1 in the first year of observations. However, it was recorded to be maximum (19.0±0.71ºC) during monsoon at S1 and minimum (8.0 ±1.41ºC) during spring at S1 n the successive year of observations. The annual mean water temperature was recorded to be maximum (15.42± 3.25ºC) and minimum (13.08 ±4.41ºC) during the study period.

6) **Water Velocity**: The water velocity was found to be maximum 2.81 m/s in August at S1 and minimum (0.76 m/s) in the month of January at S2 during the first year of observations. It was recorded maximum (2.84 m/s) in August at S1 and minimum

(0.74 m/s) in January at S2 in the successive year of observations.

Analysis of seasonal water velocity of Manawar Tawi River revealed that it was highest (2.29±0.18m/s) at S3 in monsoon and lowest (0.90 ± 0.16m/s) at S3 in winter months during the first year of observations (Table 4.9 and 4.10).however, it was found to be maximum (2.35± 0.13 m/s) in monsoon at S1 and minimum (0.90±0.17m/s) at S2 and S3 in winter during successive year of study.

The annual mean values of water velocity at all three sites were recorded to be (1.27±0.48 m/s) at S1, (1.25±0.50 m/s) at S2 and (1.25±0.50 m/s) at S3 during first year and (1.29±0.51 m/s) at S1, (1.24±0.49 m/s) at S2 and (1.25±0.50 m/s) at S3 during the second year of study.

7) **Hydromedian Depth (HMD):** Hydro median depth (HMD) was found to be maximum (0.58m) at S2 & S3 in August and minimum (0.45 m) in the month of January at S1 during the first year. It was maximum (0.60m) at S3 in August and minimum (0.45 m) n the month of January at S1 & S3 in the second year of study period.

The seasonal HMD was found to be maximum (0.58±0.01 m) during monsoon season at S3 and minimum (0.47± 0.02 m) during winter season at S1 in the first year of observations. It was recorded to be maximum (0.59±0.02m) during monsoon at S3 and minimum (0.47±0.02 m) during winter at S1 during the successive year of observations.

The annual mean values of HMD were estimated to be 0.50±0.03 m to 0.52±0.04 m in the fluvial system of Manawar Tawi River.

8) **Transparency**: The transparency of Manawar Tawi river was found to be maximum (0.60m) at S3 during December and minimum (0.0.) at S1 and S3 in July during the first year of observations. However, the transparency was recorded to be maximum (0.60 m) at S3 during November and April and minimum transparency (0.00 m) at S1 and S2 in August during the successive year of observations.

Seasonally, transparency was found to be maximum (0.59±0.01) at S1 in autumn and minimum (0.02±0.03) in monsoon at S1 and S3 during the first year of observations. It was found to be highest (0.59±0.01m) during spring at S3 and lowest at S3 (0.02±0.02 m) during monsoon in the second year of observations (Fig. 4.1).

The annual mean values of transparency were recorded to be 0.47±0.21 m to 0.49± 0.22 m at all three sites (S1, S2 and S3) in the Manawar Tawi River.

9) **Turbidity**: The value of turbidity was recorded to be highest (189.00NTU) at S3 during the month of August, and minimum (6.45 NTU) at S3 in January during the first year of observations. The highest turbidity was (142 NTU) recorded at S1 in August and lowest (5.90 NTU) in January at S1 in the second year of observations.

Seasonally, turbidity was found to be minimum (10.97±6.17 NTU) in winter at S3 during the first year. It was maximum (139.00±1.41 NTU) in monsoon at S2 and minimum (11.97± 6.05 NTU) at S1 in winter season during the second year of observations.

The annual mean values of turbidity ranged from 38.64 ± 47 NTU to 43.60±60.63 NTU in the Manawar Tawi river.

10) **Conductivity**: The conductivity of Manawar Tawi River was recorded to be maximum (0.281 mS/cm) at S2 in June and minimum (0.166 mS/cm) at S1 in February during the first year of observations. It was recorded to be maximum (0.260 mS/cm) at S3 in May and minimum (0.150 mS/cm) at S1 in January during the second year of observations.

Seasonally, it was found to be maximum (0.245± 0.04 mS/cm) at S2 during summer, and minimum (0.178 ± 0.02 mS/cm) at S3 during monsoon in the first year of observations. However, it was found maximum (0.241 ± 0.02mS/cm) during summer at S3 and minimum (0.173±0.01 mS/cm) during the monsoon at S2 the successive year of observations.

The annual range of fluctuations of conductivity was found to be between 0.197 ± 0.0mS/cm at S1, 0.204 ± 0.0 mS/cm at S2, and 0.200± 0.03 at S3 during the first year of observations. It was 0.180± 0.02 mS/cm at S1, 0.193± 0.02 mS/cm at S2 and 0.200± 0.03 at S3 during the successive year of observations (Table 4.2-4.7).

11) **Total Dissolved Solids:** The total dissolved salts (TDS) was found to be maximum (162.0 mg/l) in July at S3 and minimum (56.0 mg/l) in February at S1 during the first year of observations. It was maximum (145.15 mg/l) in August at S3 and minimum (55.0 mg /l) at S1 in January during the second year of observations of Manawar Tawi.

The second values of TDS ranged from 148 ± 0.0mg/l to 60.33 ± 4.51 mg/l during the entire period of study.

Annually, it was found to be maximum (98.30± 24.0) and minimum (85.18±37.1) during the period of study.

12) **pH**: The hydrogen ion concentration (pH) in Manawar Tawi was found to be maximum (8.45) at S3 in the month of November and minimum (7.22) in August at S3 during the first year of observations. It was found to be maximum (8.45) in the month of May at S3 and minimum (7.31) was recorded in the month of August at S2 during the second year of observations.

The seasonal values of pH ranged from 7.32±0.13 to 8.29± 0.14 during the first year and

7.36± 0.07 to 8.41 ± 0.04 during the successive year of observations.

Annually the pH was found to be maximum (8.09± 0.30) at S3 and minimum (7. 49± 0.33) at S2 during the period of study on Manawar Tawi.

13) **Dissolved Oxygen**: the dissolved oxygen concentration of Manawar Tawi at all the three sites ranged from 10.0 mg/l to 16.30 mg/l being peak in January and minimum in July during the first year of observations. It ranged from 9.75 mg/l to 16.62 mg/l being peak in January and low in August during the second year of observations.

14) Seasonally, it was found to be maximum (15.70±0.88mg/l) in winter and minimum (10.02 ±0.03 mg/l) in monsoon. It was maximum (15.44±1.44 mg/l) at S1 in spring and minimum (9.88± 0.18 mg/l) in monsoon in the second year of study.

The annual mean values of dissolved oxygen were estimated to be maximum (13.02± 2.05-8 mg/l) and minimum (12.56±2.54 mg/l) at S2 during the period of study.

15) **Free Carbondioxide**: The free carbon dioxide concentration in Manawar Tawi River showed a maximum value (0.46 mg/l) in the month of August at S3 and minimum (0.02 mg/l) at S2 in January during the first year of study. It was maximum (0.49 mg/l) in the month of May and august at S3 and minimum (0.18 mg /l) in December and January at S2 in the successive year of study.

Seasonally, the free carbon dioxide was maximum (0.45± 0.01 mg/l) during monsoon at S1 and S3 and minimum (0.14±0.17 mg/l) during spring at S2 in the first year. However, it was maximum (0.45±0.04 mg/l) during monsoon at S1 and minimum (0.20±0.03 mg/l) in winter at S_2 during the second year of study.

Annually, it was maximum (0.34±0.10 mg/l) at S_3 and minimum (0.30±0.14 mg/l) at S_1 during the entire study period.

16) **Alkalinity**: The alkalinity was found to be maximum (48.0 $mg.l^{-1}$) at S_3 in November and minimum (32.0 $mg.l^{-1}$) at S_2 and S_3 in October and February during the first year of observations. During the second year it was found to be maximum (49.0 mg/l) at S_3 in the month of November and minimum (32.0g/l) in August at S_2 (4.6-4.7).

Seasonally, it was recorded to be maximum (43.0 ± 4.58 mg/l) at S_3 in winter and (33.50±0.71 mg/l) in autumn at S_1 in the first year. During the second year it was maximum (47.33±2.08 mg/l) in winter at S_3 and minimum (35.50 ± 0.71 mg/l) in autumn at S_1.

The annual values of alkalinity ranged from 38.38±4.32 mg/l to 44.25±3.25 mg/l during the period of study.

17) **Chlorides:** The chlorides were found maximum (11.98 mg/l) in the month of March and April at S2 and minimum (6.00 mg/l) at S1 in October during the first year of study. However, a maximum concentration of chlorides (18.02 mg/l) was found to be in July at S3 and minimum (6.24 mg/l) in November at S1 during the second year of observations.

18) Seasonally, it was recorded to be maximum (10.22±1.29 mg/l) during the summer and minimum (6.46 ±0.65 mg/l) during autumn at S1 in the first year of study. It was maximum (12.96±7.16 mg/l) at S3 in monsoon and minimum (7.26±0.19 mg/l) in monsoon at S1 in the successive year of observations.

19) The annual mean value of chlorides ranged from 7.72 ±1.71 to 9.27±3.05 mg/ l during the study period.

20) **Nitrates**: Nitrates were found to be maximum (0.238 mg/l) in the month of July at S1 and minimum (0.010 mg/l) in January at S2 during the first year of study. However, maximum concentration of nitrates (0.95 mg/l) was found in September at S1 and minimum (0.01 mg/l) in January at S1 during the second year of observations.

Seasonally, it was recorded to be maximum (0.202±0.05 mg/l) at S1 during monsoon and minimum (0.028±0.01 mg/l) during summer at S2 in the first year of study. It was maximum (0.50±0.64 mg/l) at S3 in autumn and minimum (0.03±0.01 mg/l) in winter at s2 in the successive year of observations.

The annual mean of nitrates ranged from 0.058±0.06 mg/l to 0.15±0.26 mg/l during the entire study period.

21) **Phosphates:** The concentration of phosphates in Manawar Tawi River was found to be maximum (0.079 mg/l) at S2 n August and minimum (0.012 mg/l) in March and April at S2 respectively during the first year of observations. However, it was found to be maximum (0.25 mg/l) in August at S2 and minimum (0.01 mg/l) in January at S1 during the second year of observations.

Seasonally, they showed maximum value (0.078±0.0 mg/l) at S2 in monsoon and minimum (0.015±0.0 mg/l) at S2 in spring during the first year of observations. However, the maximum concentration of phosphates ranged from (0.19±0.02 mg/l) in summer at S1 and minimum (0.03 ± 0.01 mg/l) at S2 during winter during the second year of observations.

The annual mean value of phosphates ranged from 0.041±0.01 mg/l to 0.09±0.06 mg/l during the study period.

22) **Sodium**: The sodium contents in the fluvial system of Manawar Tawi River showed the highest concentration (9.0 mg/l) in the month of July at S3 and minimum (5.90 mg/l) in the month of September

at S3 during the first year of study. The maximum concentration of sodium was (9.50 mg/l) in March at S3 and minimum (6.0 mg/l) in January and February at S1 during the second year of study.

23) Seasonally, sodium was found to be maximum (8.85±0.7 mg/l) at S1 in monsoon and minimum (6.00±0.14 mg/l) at S3 in the autumn season during the two-year study period.

The annual mean sodium contents fluctuated from (7.75 ±1.00 mg/l) to (7.36±1.11 mg/l) during the study period.

24) **Potassium**: The potassium contents in the River Manawar Tawi was found to be maximum (2.65 mg/l) in September at S3 and minimum (1.30 mg/l) in January at S1 and in April at S2 during the first year of observations. However, it was found maximum (2.60 mg/l) in October at S1 and in June and October at S3 and minimum (1.30 mg/l) in June at S2 during the second year of observations.

The seasonal fluctuation of potassium contents revealed that it was found to be maximum (2.53±0.18 mg/l) at S3 in autumn and minimum (1.53±0.25mg/l) in winter at S1 during the first year of study. However, it was found maximum (2.50±0.41 mg/l) in autumn at S1 and minimum (1.51±0.27 mg/l) at S2 in monsoon during the successive year of observations.

The annual mean range of potassium contents ranged from (2.06±0.30mg/l) to 1.89±0.38 mg/l) during the study period.

Statistical Treatment of Data:

Data on statistical correlation computed for various physico-chemical parameters on River Manawar Tawi for a two year illustrates that air temperature was found to be highly positively correlated with water temperature (r=0.92, P>70.01), water velocity (r= 0.70, P> 0.01), hydro median depth (r=0.70, P>0.01), nitrates (r=0.73, P>0.01) in Manawar Tawi River. However, It was negatively correlated with transparency (r= 0.55, P< 0.05) and dissolved oxygen (r=0.94, P>0.01).

Water temperature was found to be highly positively correlated with water velocity (r = 0.74, P> 0.01) and hydro median depth (r=0.71, P>0.01). However, it was negatively correlated with transparency (r = -0.59, P>0.05), dissolved oxygen (r=0.85, P>0.001) and pH (r = -0.79, P>0.01).

Water velocity was found to have significant positive correlation with hydro median depth (r=0.90, P> 0.001), total dissolved solids (r=0.87, P>0.01) and nitrates (r=0.59, P>0.05).It was negatively correlated with transparency (r=-0.95, P>0.001), pH (r =-0.82 P> 0.001), and dissolved oxygen (e=-0.73, P> 0.01).

Hydro median depth was positively correlated with nitrates (r=0.51, P < 0.05) and negatively correlated with transparency (r= -0.74, P > 0.01), pH (r= -0.68, P> 0.01) and dissolved oxygen (r= -0.75, P> 0.01).

Transparency was positively correlated with dissolved oxygen (r=0.55, P< 0.05) and negatively correlated with turbidity (r= -0.98, P> 0.001) and nitrates (r=-0.49, P< 0.05). Turbidity of Manawar Tawi River negatively correlated with dissolved oxygen (r=-0.63, P> 0.05).

Conductivity was found to be positively correlate with sodium (r= 0.65, P> 0.05). Total dissolved solids were positively correlated with phosphates (r= 0.42, P< 0.05). pH was negatively correlated with free carbon dioxide (r=-0.58, P> 0.05) and potassium contents (r=-0.66, P< 0.05).

Dissolved oxygen concentration had a significant negative correlation with nitrates (r= -0.72, P>0.01) and sodium (r=-0.66, P>0.01).

Free carbon dioxide has a positive correlation with phosphates(r=0.83, P>0.01), sodium (r= 0.58, P> 0.05) and Potassium (r= 0.55, P> 0.02).

Discussion

The physico-chemical environmental characteristics of water have a great role over the distribution over the distribution and abundance of living organisms. The physico-chemical environmental parameters of any aquatic ecosystem are of great importance in fresh water biological studies because they are very helpful in predicating type, composition and diversity of biological communities in the aquatic habitat. These parameters are more important in case of upland ecosystem of Himalayas. The changes in the physico-chemical parameters have substantial impact on the biotic communities living in that ecosystem. All conditions (physical, chemical and biological) of the river gradually change with distance along the main channel and in a definite direction (Welch 1952). The physical and biological conditions undergo pronounced alteration from time to time in a lotic ecosystem.

The nature of bottom substrates is one of the most significant environmental parameters in influencing the biodiversity in streams (Wisely, 1962: Hynes 1971: Hawkins, 1984 and Angradi, 1996). The riverine ecosystem of Manawar Tawi comprised of boulders, cobbles, pebbles, sand and silt. The complex structure of substratum supports rich biodiversity. Ward (1994) also pointed out that the boulders and cobbles are the dominant feature of headwater streams.

Temperature is an important factor and it regulates the composition of biotic profile as well as other characterizes of water. Temperature most certainly plays a significant role in delineating the biological communities. The temperature regime of

water body is a composite of the entire thermal pattern including absolute temperatures, amplitudes and rates of change, super imposed upon temporal and spatial vectors (Ward and Stanford, 1982). Every species is restricted in its distribution to a certain range of latitude and altitude, thus to a certain temperature range.

Natural streams of mid and high altitudes normally have temperatures which vary from 0-20ºC (Lekmkuhl, 1972). Ambient temperature is affected by the climatic conditions (Welch, 1952), solar radiation and topography of water system. The ambient temperature under the present study was found to be lowest during winter and spring and highest during monsoon season in Manawar Tawi River. The variations in air temperature in different seasons may be responsible for temperature fluctuations along the course of the stream situation.

The measurement of water temperature of a river is very useful for assessing the various trends of chemical, biological and bio-chemical activities of the aqueous medium. In running waters, temperature varies on seasonal and daily time scales. In streams, the seasonal changes in water temperature closely follow the trends in air temperature with two exceptions that during winter, the water temperature does not fall below 0ºC, while air warms more rapidly than water in the spring season and cool more rapidly in the autumn. The water temperature has direct or indirect bearing upon physico-chemical as well as biological activities in aquatic ecosystems (Barrett, 1957).

The water temperature of Manawar Tawi remained low during spring and summer season under the present study due to melting of snow at higher reaches. Badola and Singh (1981); Sharma (1984); and Gusain (1991) also found the same pattern of temperature variations in Alaknanda and Bhlanghana rivers of Garhwal Himalayas.

A close relationship between air temperature and water temperature has also been observed in Manawar Tawi during the study period (r=0.89, P>0.001, in the first year; r=0.92 P>0.001, in the second year. Sheridan (1961) also observed this relationship in the Pink Salmon stream of Alaska. Smith also found the same relationship between air and water temperature. Nautiyal (1990) and Pathak and Bhatt (1991) also found the same relationship between air and water temperature in upland rivers of Garhwal Himalayas. Yousuf et al (2006); Baba et al. (2006) also found the same relationship between air and water temperature in Jhelum and Chenab rivers of Jammu and Kashmir State.

Water velocity varies greatly in different sections of the same stream (boyh longitudinally and transversely to the axis of flow) and from one time to another (Odum, 1971). The mountain headwaters tend to have high gradients (slopes), hence current velocities are also high-water flow is turbulent and well oxygenated and substratum is predominantly bed rock, boulders and cobbles (Ward, 1994). The Manawar Tawi river has all the characteristics of head water stream of the hills. All the three sites of (S1, S2 and S3) Manawar Tawi River were represented by riffles. Seasonally, maximum water velocity was recorded in monsoon season (July-August) in Manawar Tawi due to frequent flash floods Nautiyal (1986), Gusain, 1991 and Kala, 2001 observed the similar results in the rivers of Garhwal Himalaya.

High or excessive flow may cause the destruction or washout of aquatic life (Cushma, 1985; Stevenson, 1996; and Biggs et al. 1998). Many aquatic populations living in the harsh environment of unpredictable suffer high mortality from physiological stress during high flow (Cushman, 1985). Increased water velocities flush and remove many aquatic populations. The water velocity in river Manawar Tawi has positive correlation (r=0.90, P>0.001) with the hydro median depth and with turbidity (r=0.94, P>0.001). While it was negatively correlated (r=-0.72, P> 0.001) with dissolved oxygen.

The hydro median depth in fluvial system of Manawar Tawi varied seasonally in accordance with the water discharge. It was recorded maximum during monsoon and minimum during winter months.

Most streams are transparent at times of low water discharge and they become turbid during floods, when great amount of suspended matter is carried. The transparency of Manawar Tawi river was found to be maximum in autumn and minimum in monsoon. Turbidity was observed to be maximum (171.50±24.75) during monsoon season, when transparency was minimum (0.02±0.02m) in Manawar Tawi River. Transparency in the river Manawar Tawi had a clear inverse relationship with turbidity (r=-0.98, P> 0.001). The sudden increase in the turbidity in monsoon season was mainly due to heavy rainfall in the catchment area which takes along with it soil, silt, sand and other inorganic and organic material to the river. Due to less light penetration capacity in Manawar Tawi the transparency is decreased. Schmitz (1961); Sunder (1988) have also drawn similar conclusions.

Conductivity n River Manawar Tawi was found to be highest in summer (April-june) and minimum during monsoon and autumn. The low values of conductivity in monsoon and autumn seasons may be due to high rainfall.

Total dissolved solids (TDS) were found to be maximum in monsoon and minimum during winter months. The increasing pattern in monsoon may be due to addition of inorganic salts and organic matter

carried along with rainwater and surface runoff during monsoon. The significant positive correlation of TDS with phosphates (r=0.42, P<0.05) also support this inference.

pH of water is principally governed by carbon dioxide-bicarbonate-carbonate system. Riverine ecosystem of Manawar Tawi was found to be alkaline throughout the study period. The pH range of Manawar Tawi ranged from 7.22-8.25 during the study period. In the first year of study, pH showed highest value during winter and spring and lowest during monsoon. But in the second year it showed highest value during summers (8.2±0.04) and minimum during monsoons (7.36±0.07).

The concentration of chlorides was found to be maximum in summer and monsoon months and minimum during autumn and winter seasons. The same trend was also found in the Chenab River by Baba *et al*. (2006).

Dissolved oxygen in water is essential for the most aquatic life forms and chemical reactions within streams such that minimum concentrations are necessary for any ecosystems functioning. Dissolved oxygen is an important factor associated with productivity and utility of an aquatic ecosystem. The level of dissolved oxygen in an aquatic ecosystem depends upon morphometery, climate and various biotic and a biotic component. Excessive amounts of oxygen and other supersaturated gasses can negatively affect aquatic life through the production of "gas bubble trauma" or the over. Dissolved oxygen concentration is a function of the temperature of the water, with increasing temperature, the solubility of oxygen decreases. At the same time, the respiratory requirements of aquatic organisms increase with increasing temperature, however, there is less oxygen in the water to meet these increased needs, and death can result.

Dissolved oxygen was recorded maximum (16.62 mg/l) during January and minimum (9.75 mg/l) during August under the present study. Seasonally, it showed greater values in winter and spring seasons and low during monsoon seasons. The increase in dissolved oxygen during winters is due to low water velocity and water temperature and high transparency. Decreased value of dissolved oxygen during summer and monsoon seasons can be attributed to increase in temperature and high metabolic rate of aquatic organisms (Slack 1955; and Elmoore 1961; Vass et al. (1977) recorded maximum values of dissolved oxygen during winter and minimum during summer season, while studying the hydrological patterns of river Jhelum in Kashmir. Dutta (1978) opined increased decomposition and water temperature responsible for the low dissolved oxygen contents.

In the present study on Manawar Tawi River, the dissolve oxygen concentration gradually increased as the temperature decreased in the River water. The correlation coefficient computed between water temperature and dissolved oxygen indicated the highly significant and a negative relationship in both the years in fluvial system of Manawar Tawi (r=-0.70 P> 0.01, in the first year, r = -.81, P > 0.01, in the second year).

Free carbon dioxide was recorded maximum (0.45±0.04 mg/l) during monsoon and minimum during (0.14±0.17 mg/l) winter and spring. The rise in monsoon may be attributed due to retarded photosynthetic activity or due to low oxygen consumption by the organic matter in turbid state of water or due to failure of carbon dioxide being poorly utilized during the state of low phytoplankton density. Free carbon dioxide was negatively correlated with dissolved oxygen (r=-0.94, P> 0.001) in the Manawar Tawi river. Similar results were obtained by Dobriyal and Singh (1988) and Nautiyal (1986) in Garhwal Himalayan Rivers.

The alkalinity of water is usually caused by the presence of carbonates, bicarbonates and hydrogen ions and less frequently by borates, silicates and phosphates. The Manawar Tawi River remained alkaline throughout the study period.

Nitrates and phosphates are the common forms of inorganic nitrogen and Phosphorus entering fresh water from anthropogenic sources. Like public use of water for bathing and washing which adds chemicals thus deteriorating the quality of water. Nitrates showed a maximum value of 0.95 mg/l and a minimum value of 0.010 mg/l. The concentrations of nitrates and phosphates were found to be low. It may be due to absorption of nitrates and phosphates by vegetation on stream side (Hynes, 1971). Nitrates showed an irregular trend in fluctuations. The nitrate concentration showed a positive correlation with water temperature (r=0.81, P > 0.001). Phosphates also showed a positive correlation with water temperature (r=0.66, P>0.01).

Sodium is generally found in association with chloride, indicating their common origin weathering of sodium chloride (NaCl) containing rocks, accounts foremost of the sodium ions found in the river water. However, potassium is the less abundant of the major cations. Roughly, 90% of it originates from the weathering of silicates material especially from potassium, Feldspar and Mica. Sodium showed a positive correlation with conductivity (r=65, P>0.01), Potassium showed positive correlation with T.D.S (r=0.35, P>0.05). In the fluvial system of Manawar Tawi, Sodium remained higher than potassium during the study period.

After a perusal of data on physico-chemical parameters and in depth discussion on their relationships, it was inferred that the high altitude fluvial system of Manawar Tawi is represented by extreme environmental conditions. Physico-chemical parameters like air temperature, water temperature, turbidity, hydro median depth and total dissolved solids remained low during winters. However, the free carbon dioxide and sodium showed higher values during monsoon. All these environmental variables have a direct bearing on the aquatic biodiversity of Manawar Tawi of Jammu region.

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