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RESEARCH ARTICLE

ANALYSIS OF MAYFLIES (INSECTA: EPHEMEROPTERA) AND PHYSICO-CHEMICAL PROPERTIES OF RIVER NARMADA MADHYA PRADESH INDIA

*** Imtiyaz Tali, **Zahoor Pir, *Anis Siddiqui and Shailendra Sharma*****

*Department of Zoology, Govt. Holkar Science College Indore- 452017, India
**Department of Zoology, Govt. P.G. Girls College Motitabela Indore M. P
***Department of Biotechnology, Adarsh Institute of Management & Science, Dhamnod (M.P.)

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ABSTRACT

Limnological studies on various stations of river Narmada was carried out from August 2010 to July 2010.The present investigation was carried out to enumerate the biodiversity of ephemeroptera fauna and to analyze water qualities parameters throughout various stations of river Narmada. Water samples and insects were collected monthly. Mayflies were sampled using standard entomological methods, while water samples were analyzed using APHA methods to determine the Physico- chemical properties. The physico- chemical parameters showed wide variations throughout the study period. During present investigation, 17 species comprising of 6 families were recorded including Baetidae, Caenidae, Ephemeridae, Ephemerellidae, Heptageniidae and Leptophtebiidae. The dominant family was Baetidae of which Baetis simplex was the most common species. The value of Shannon and Weaver Index was found within the range between 0 and 2.597.

INTRODUCTION

Insects are the most diverse group of organisms in freshwater. Estimates on the global number of aquatic insect species derived from the fauna of North America, Australia and Europe is about 45,000, of this about 5,000 species are estimated to inhabit inland wetlands of India. Aquatic insects of inland wetlands comprise some well- known groups like mayflies (Ephemeroptera), dragonflies (Odonata) and caddiesflies (Trichoptera). Among the MacroinvertebratesEpemeroptera (Mayflies) are truly the 'ballerians' of the insect world. Mayflies are an ancient order of insects that are globally distributed in both northern and southern hemispheres. Mayfly is the common name for any of the insects that belong to the order Ephemeroptera. Other common names for Mayflies include 'day fly' ,'june bug' , 'shad fly', 'canandian solider' and 'fish fly' (Staneff-Cline and Neff 2007). Mayflies have a complex life cycle, involving both aquatic and terrestrial phases. Such life cycles create evolutionary dichotomy with selection pressures operating in two, more or less independent environments (Wilbur 1980). This dichotomy will lead to the reduction of one of these phases. This is clearly seen in the extremely short-lived adult stages of the Ephemeroptera whose sole, but crucial roles are reproduction and dispersal. They are the only insects to have two flying stages and can be recognized by their three caudal filaments (tails) at the tip of the abdomen, and a single claw on each leg. This differentiates them from the closely related stoneflies which have two tarsal claws. The flying stages are characterized by relatively large forewings, which are usually kept upright, and reduced or nonexistent hind wings. Ephemeroptera nymphs are usually microhabitat specialists. Each species survives best on a specific substrate at a certain depth under water with a certain amount of wave action. For example, Rithrogena generally live in medium to large trout streams. Ephemeridae burrow into soft areas where flow is slower, or in areas of lakes and rivers where deposits occur; the particular substrate and burrow depends on the genus. The primitive habitat of schistonate mayflies is still water even though most extant mayflies live in running water (Mccafferty 1990). In some areas, succession occurs by different species. For example, in Utah *Epeoruslongimanus* is followed by *E. deceptivus*. Some species dominate in the spring while others dominate in autumn (Edmunds *et al.*, 1976). Some mayfly nymphs are quite sensitive to pollution and are used to evaluate water pollution and stream health. A number of factors influence Ephemeroptera species distributions. It has been reported in a number of studies that environmental variables such as stream size, velocity, pH, conductivity, nutrients, amount of dissolved oxygen, riparian forest, and presence of impoundments are associated with Ephemeroptera distribution (Ogbogu and Akinya 2001, Ogbeibu and Oribhabor 2002, Rueda *et al*., 2002, Buss and Salles 2007). Deforestation is one of the primary threats to mayfly biodiversity and conservation in the tropics (Benstead*et al*., 2003, Benstead and Pringle 2004, Dudgeon 2000a, 2000b) whereas pollution (Rosenberg and Resh 1993) and building and reshaping of the banks leading to a lack of connectivity with the floodplain (Buijse e*t al.*, 2002) or habitat fragmentation (Zwick 1992) are the main causes in temperate areas. Mayflies are extremely important in the ecology of fresh water streams. Both immature and adult mayflies are an important part of the food web, particularly for carnivorous fish such as trout in cold water streams or bass and catfish in warm water streams. Their presence is an indication of good water quality given their sensitivity to pollution (PSERIE 2003). Mayflies are highly susceptible to pollution and thus are important indicators of water quality. Most mayfly species are known as sensitive to pollution (Bauernfeind and Moog 2000).

* *Corresponding author:* **Imtiyaz Tali**
Department of Zoology, Govt. Holkar Science College Indore- 452017, India

Mayflies requires high quality water for their existence, thus biologists have used their presence or absence, in conjunction with the numbers present at a particular location in a stream or river, to develop several indices of water quality.

MATERIALS AND METHODS

Study site

The Narmada, also called Rewa is a river in central India and the fifth largest river in the Indian subcontinent. It is the third largest river that completely flows within India after Ganges and Godavari. It forms the traditional boundary between North India and South India and flows westwards over a length of 1,312 km before draining through the Gulf of Cambey (Khambat) into the Arabian Sea, 30 km west of Bharuch city of Gujarat(NVDA). It is one of only three major rivers in peninsular India that runs from east to west (largest west flowing river) along with the Tapti River and the Mahi River. It is the only river in India that flows in a rift valley flowing west between the Satpura and Vindhya ranges although the Tapti River and Mahi River also flow through rift valleys but between different ranges. The Narmada basin, hemmed between Vindya and Satpuda ranges, extends over an area of 98,796 km^2 and lies between east longitudes 72 degrees 32' to 81 degrees 45' and north latitudes 21 degrees 20' to 23 degrees 45' lying on the northern extremity of the Deccan Plateau. The basin covers large areas in the states of Madhya Pradesh (86%), Gujarat (12%) and a comparatively smaller area (2%) in Maharashtra. The river Narmada receives 41 principal tributaries (Alvares and Ramesh 1988), each with a catchments area exceeding 500sq. kms. Out of these 22 (21 in MP and 1 in Gujarat) joins the river from left bank and 19 (18 in MP and 1 in Gujarat) from right bank (Ghosh*et al.*, 2004). The total length of these principal tributaries is 3387 Kms.

Sampling Stations

The present study was conducted for the period of one year from August 2010 to July 2011. The water and biological samples were collected from the various selected sampling stations in the river Narmada which are as under. A reconnaissance visit to the proposed study stations was made to select sampling locations, design sampling protocol and work out the logistics.

(A) Omkareshwar (S1)

Omkareshwar is a famous place of pilgrimage located in Khandwa District of Madhya Pradesh, on the **Mandhata** hill on the banks of the **Narmada river**. The river Narmada branches into two and forms an island **Mandhata** or **Shivapuri** in the center. The shape of the island resembles that of the visual representation of the Omkara sound, OM. There are two temples here, one to **Omkareshwar** and one to **Amareshwar**. Millions of pilgrims of both local and foreigners visit the place every year. There are steamboats across the Narmada river and also two connecting bridges to reach the temple. Its Latitude is 22º 15' 1" N and Longitude is 76º 8' 48"E.

(B) Khalghat (S2)

Khalghat is a small town and a Municipality in Dhar district in the state of Madhya Pradesh, India. It is located on the banks of Narmada River and national Highway 3 Agra- Indore – Dhule – Mumbai. It is 76 km away from Indore. Its latitude is 22º 10' O" N and longitude is 75º 27'O" E.

(C) Koteshwer (S3)

Koteshwer is a holy place in Barwani District Madhya Pradesh in Central India. It is located 17 km from Barwani District and 160 km from indore. Its latitude is 22º 1' 60''N and longitude is 75º 54' 0'' E.

Physico- Chemical analysis

The analysis of the Physico- chemical properties of water was performed by standard method prescribed in limnological literature. The Physico- Chemical parameters were determined by standard methods of APHA (2002).

Biological Analysis

Collection of Samples

Different methods were employed to sample aquatic insects from the target habitats. The samples were collected with various types of nets, surber sampler at shallow profundal zone, Ekman grab at deeper profundal zone and by random sampling. Supportive qualitative sampling was done by a hand net, D-net and by handpicking the zoo-benthos from different substrata in similar habitats. The substrate was disturbed in front of the D-net to collect the benthos. Artificial substrates, woods and other detritus were also looked upon for insects. The stones were also turned and observed.

Preservation and Further Investigation

The samples were preserved in 75% alcohol solution and transported to the laboratory for further investigation. In the laboratory, the samples were rinsed thoroughly with pure water to remove preservative through a sieve (100 µm mesh size). The samples were then poured in a white-bottomed tray of the appropriate size for good visualisation and the sorted mayflies were then identified.

Identification of Samples

Collected samples were examined under a standard microscope and identified using standard taxonomic literature. Samples were assigned to a family or genus using taxonomic keys like Dudgeon (1999), Soldan and Landa (1999), Barber-James and Lugoortiz (2003).

Diversity Index

The numerical relationship between the species population and whole communities often provides better reliable indications of pollution than single species (Datta and Datta 1995). These relationships are represented by "Diversity Indices". In the present study Shannon and Weaver diversity index (H) were used.

RESULTS

The result of the physico-chemical parameters of river Narmada water is presented in Table 1. The spatial trend in the pattern of each physical and chemical characteristic was similar along the river. During the present study, the physico- chemical parameters showed wide variations throughout the study period. The water temperature varied between 18- 35ºc (Fig. 1). The minimum water temperature was recorded in the month of January and the maximum water temperature was recorded in the month of May. The value of pH varied from 7.1 to 8.9 and the Dissolved oxygen fluctuated between 7.1 mg/l to 8.9 mg/l (Fig 2 & 3). The biological oxygen demand varied between 0.31 mg/l to 1.3 mg/l with minimum in January and maximum in the month of May (Fig 4). Alkanity of the river Narmada varied between 95- 235 (Fig 5). Minimum alkanity was recorded at Station I & III and maximum alkanity was recorded at Station I. The value of total hardness during the present study varied between 85 mg/l to 190 mg/l (Fig 6).

Table 1 Range of variation, mean and standard deviation of water quality parameters of river Narmada during August 2009to July 2010

Parameters	Station I	Station II	Station III
Temperature	27.08 ±0.707 (22- 33)	25.33 ±1.414 (18- 32)	28.25 ±1.414 (22- 35)
pH	8.6 ±0.919 (7.6- 9.3)	7.8 ±0.2828 (7.4- 8.5)	8.8 ±0.141 (7.3- 8.8)
Dissolved Oxygen	7.87 ±0.070 (7.2- 8.7)	8.1 ±0.070 (7.1- 8.9)	7.9 ±0.141 (7.2- 8.8)
Biochemical Oxygen Demand	0.66 ±0.098 (0.31- 1.05)	0.75 ±0.056 (0.37- 1.25)	0.72 ±0.084 (0.35- 1.30)
Alkanity	154.41 ±21.21 (95- 235)	169 ±10.60 (110- 222)	158.92 ±9.89 (95- 225)
Total Hardness	122.83 ±14.14 (85- 190)	132.25 ±14.14 (98- 170)	128.25 ±17.67 (90- 160)

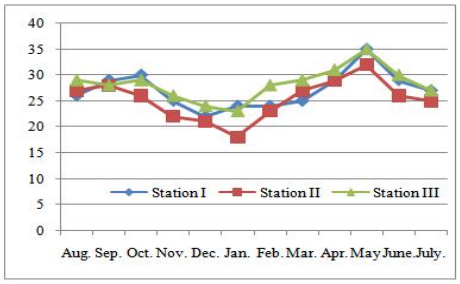

Fig 1 Monthly Flunctuation in Temperature (^{O}C) In River Narmada from August 2010 to July 2011

Minimum total hardness value was recorded in October and maximum total hardness was recorded in the month of June. Ephemeropterans were present at all sampling stations during the study period but at Station III (Koteshwer), the abundance of Ephemeroptera was low. A combined total of 17 taxa of Ephemeropterain six families were present along the whole system. The dominant family was Baetidae of which Baetis simplex was the most common species. Maximum biodiversity of ephemeroptera were noted in post monsoon and summer season.

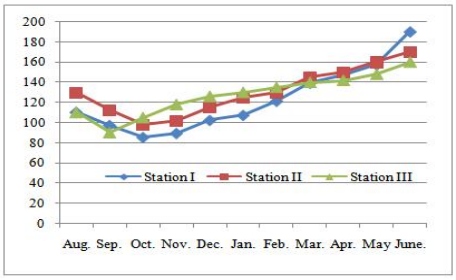

Fig 2 Monthly Flunctuation in Ph in River Narmada from August 2010 to July 2011

At Station I, seventeen species of Ephemeroptera (Mayflies) belonging to six families were recorded (Fig. 7). The dominant species recorded were *Baetiellaladakae*and *Baetis simplex* belonging to family Baetidae, while the species *Heptageniasolangensis* belonging to family Heptageniidae was less dominant throughout the study period. At station II, the most dominant species recorded were *Baetiellaladakae*, *Baetis simplex*, *Thraulusgopalani* belonging to family Baetidae and Leptophtebiidae and species *Heptagenianubila* belonging to family Heptageniidae was less dominant as compered to other species (Fig. 8). In the present study, sixteen species of Ephemeroptera (Mayflies) belonging to six families were recorded (Fig. 9).

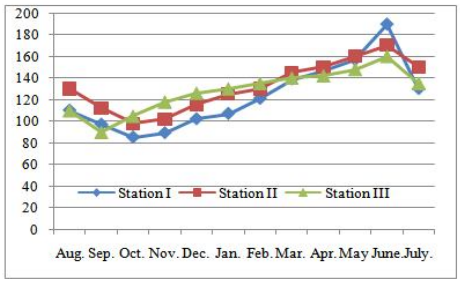

Fig. 3 Monthly Flunctuation in Dissolved Oxygen in Narmada River from August 2010 to July 2011

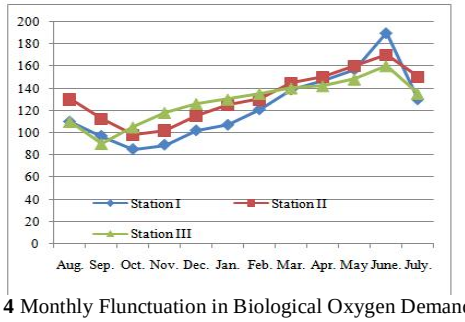

Fig. 4 Monthly Flunctuation in Biological Oxygen Demand in Narmada River from August 2010 to July 2011

The most dominant species recorded was *Baetis simplex* belonging to family Baetidae and *Heptagenianubila* belonging to family Heptageniidae was totally absent throughout the study period at this sampling station. The diversity and distribution of Ephemeroptera species at this station was very low as compared to other selected sampling stations.

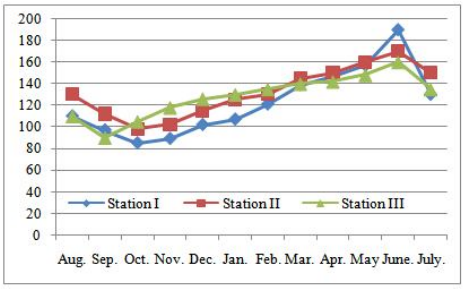

Fig.5 Monthly Flunctuation in Alkanity in Narmada River from August 2010 to July 2011

The value of Shannon and Weaver Index during the study period was found within the range between 0 to 2.597. This indicates that river Narmada has moderate water quality except during monsoon season in which water gets polluted due to heavy floods. The minimum value of Shannon and Weaver Index was recorded at Station III.

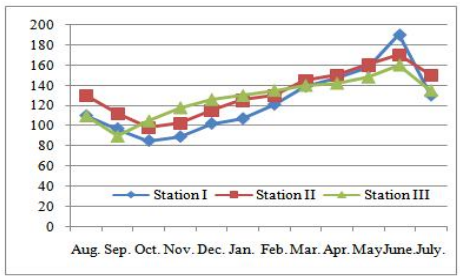

Fig.6 Monthly Flunctuation in Total Hardness in Narmada River from August 2010 to July 2011

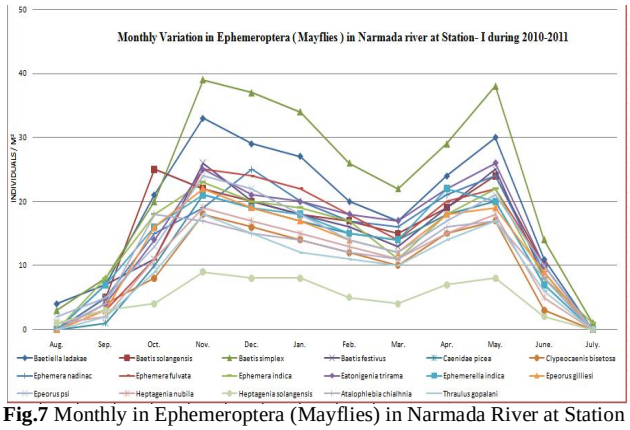

Fig.7 Monthly in Ephemeroptera (Mayflies) in Narmada River at Station I from August 2010 to July 2011

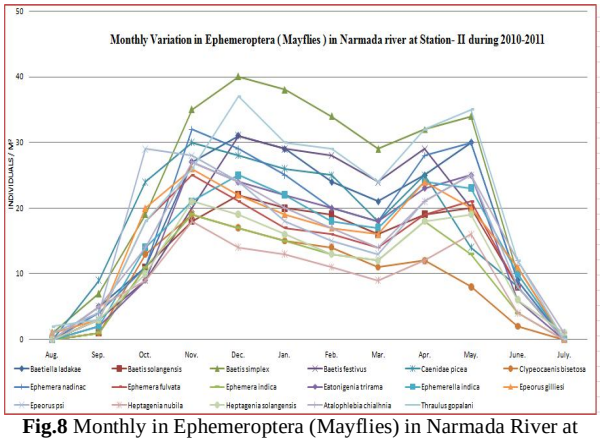

Fig.8 Monthly in Ephemeroptera (Mayflies) in Narmada River at Station Ii from August 2010 to July 2011

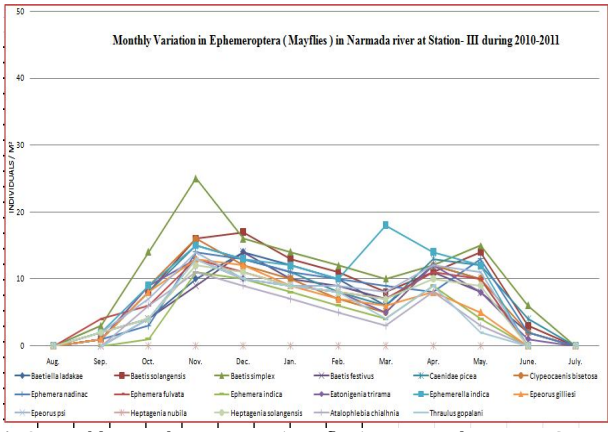

Fig.9 Monthly in Ephemeroptera (Mayflies) in Narmada River at Station Iii from August 2010 to July 2011

DISCUSSION

The physico- chemical parameters are important for assessing the water quality. Physico- chemical properties of a natural water body (like river), their spatial distribution and variation in time provide a lot of information about the ecosystem. The physico-chemical characteristics of the water body have direct influence over its flora and fauna. It is difficult to understand biological phenomena fully without the knowledge of water chemistry as the metabolism of the ecosystem and hydro biological interactions may be understood in relation to water chemistry (Kulahresth 2005). Study of physico- chemical characteristics of the river Narmada depict that the various physical and chemical characteristics show monthly and spatial changes. In present study the temperature of water ranged between 18^{o}c to 35^{o}c.These types of observations in river Narmada have also reported by Yodha (2004), Verma (2006), Bakawle (2008) and Sharma *et al*., (2011).Highest values of pH in summer may be due to the reduction in water volume and increase in photosynthetic activities and lower values of pH in rainy season may be attributed due to the dilution of water by rain. The present study records of DO values resemble the general trend as reported from other Indian rivers. As per the IST the minimum DO recommended is 3.00 mg/l. In the present study, the DO values were above 3.00 mg/l at all the study stations and hence river Narmada is not polluted respect to dissolved oxygen.During the present study the BOD values fluctuated between the ranges of 0.31 mg/l– 1.30mg/l at all sampling stations.Similar observations were confirmed by many other workers such as Pathak and Mudgal (2005), Mishra and Joshi (2003).In the present study total alkanity values resemble the general trend as reported by various workers from other Indian water bodies. Seasonal variation in total alkanity in the river Narmada seems to be controlled by several factors such as rain fall, sewage inputs and water temperature, but higher photosynthesis at the surface also has profound importance. The huge alkaline condition in river Narmada may be due to high photosynthesis activity of phytoplankton.In the present study the values of the total hardness varied between 85- 190 mg/l. These observations indicate that the Narmada water is neither hard nor very soft. The lower values of total hardness in post monsoon might be due to settlement of anions and cations.

Ephemeroptera is an important group of insects used in the bioassessment and monitoring of freshwater bodies worldwide because of their relative abundance in a wide variety of substrates and their increasing chances of detecting pollution impacts. They are often the most abundant and recognizable freshwater insects' especially in riffles, runs, and marginal vegetation and form an important component of fish diets (Miserendino and Pizzolon 2001, Barber-James *et al*., 2008). In the present study 17 species of Ephemeroptera (Mayflies) belonging to 6 families were recorded from river Narmada. The population of mayflies fluctuated from season to season. The mayfly diversity was maximum in post monsoon season and during summer and was very low in monsoon season. This is consistent with the observations made by Arimoro and Ikomi (2009) that numbers of taxa and the mean abundance of mayflies increased in the dry season and decreased in the wet season in the upper reaches of river Warri, Niger Delta. During the present study the diversity of mayfly nymphs was very low in monsoon season due to the heavy floods and poor water quality in the river. Pupilli and Puig(2003) also reported that floods especially those with a long return time can have a catastrophic effect on mayfly communities. Maldonado *et al*., (2001) while studying four non- Andean streams in central Venezuela reported that the rainfall to be a determining factor in the temporal fluctuation of density and composition of mayfly communities. In the present study the diversity of mayflies was very low in monsoon season due to pollution inputs by runoff waters, lower values of dissolved oxygen and disturbed ecological condition by high water current, which were directly responsible for reduction of mayfly species. Similar trend was observed by Kaushik*et al*., (1991) and Shukla and Shrivastava (2011),who showed the Ephemeroptera population was very low during rainy season due to high water discharge, which destroys habitats.

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