International Journal of Advanced Research in Biological Sciences
www.ijarbs.com

Research Article

Biomonitoring status and contribution to the knowledge of benthic macro invertebrates for river Meenachil, Southern Kerala, India: A First case approach

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Abstract

The diversity patterns and occurrence of benthic macro invertebrate families encountered in river Meenachil, originating from the Western Ghats, Kerala was a first approach conceded based on the knowledge of benthic macro invertebrates, since there is no available research done in this area. The primary objective of this study was to identify the fresh water benthic macro invertebrates and to find out the biological water quality using BWQC developed by Central Pollution Control Board (New Delhi). The study also emphasizes the anthropogenic influences especially of pollution-sensitive organisms belonging to the order Ephemeroptera, Plecoptera and Tricoptera. A total of 134 individuals of aquatic insects belonging to 36 genera, 31 families and 9 orders were collected from the six stations of the River Meenachil during pre monsoon and monsoon (2010) period. The highest species richness and abundance was observed in Poonjar (Station 2) followed by Erattupettah (Station 3) during monsoon and pre monsoon respectively. The most dominant taxa found in this river were Ephemeroptera. The sampling stations showed less taxonomical diversity than expected. The rivers in Kerala is undergoing serious anthropogenic effects, the need to conserve the pollution sensitive organisms bears prime significance. Temporal/biological factors could have conceivably diminished the density of benthic communities, however the ever increasing population load, wetland filling, sand mining, encroachment of river banks have adversely affected the diversity of life forms.
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Keywords: River Meenachil, Benthic macro invertebrates, Saprobic and diversity score, Sand mining, Wetland filling, Encroachment, BWQC.

Introduction

Biomonitoring is generally used to examine existing stream condition and instant insights into changes in stream water and habitat quality (Rosenberg and Resh, 1993). Historically, invertebrates have received considerable attention in the study of running water ecosystems, in particular relationships between macro invertebrate community structures and environmental variables have been the subject of numerous investigations (Cummins, 1992; Thorner, 1997; Kazancig, 1998; Metcalfe, 1998; Bunns, 1999). Biological assessments are being developed worldwide evaluating changes in genetic composition of specific populations, bioaccumulation of toxins and related occurrence of morphological deformities, changes in community composition and ecosystem functioning (Marques and Barbosa, 2001). Water pollution is a serious problem in India and many other parts of the world. Modern techniques for monitoring pollution involve the use of pollution-sensitive insects, especially benthic macro invertebrates as biological indicators or “sentinels” has become wide spread only over the last two decades (Morse et al., 1994). Since benthic aquatic insects are sensitive indicators of environmental changes they can be employed to express long-term changes in water and habitat quality rather than instantaneous conditions (Johnson et al., 1993).

The Kerala state has an area of 38,863 km^2 and is bordered by Karnataka to the north and northeast, Tamil Nadu to the south and southeast and the Arabian Sea towards the west. This land is blessed with 44 Rivers, however many of these are under the threat due to anthropological activities like Wet land filling, sand mining, deepening of lands along the river banks, construction of large dams across the rivers, encroachment of river banks and pollution. Sand mining which is a major threat for rivers in Kerala, has ultimately pushed the water table down, reduced the water holding capacity and adversely affected the diversity of life forms. Construction of large dams across the rivers has adversely affected the flow pattern, extent and nature of sediment formation and deposition, riverine biodiversity and the quality of water.

The river Meenachil is formed by several streams originating from the Western Ghats. The river flows through the Kottayam district of Kerala state, India. The river, 78 km long, flows through Poonjar, Teekoy, Erattupetta, Palai, Ettumanoor and Kottayam before discharging itself into the Vembanad Lake at Kumarakom, the famous tourist place of Kerala. A total of six stations were selected for the present study during pre-monsoon and monsoon (2010) period. Major objective of the study was to identify the fresh water Benthic Macro invertebrates including aquatic insects, crustaceans, molluscs, platy helminthes etc and to find out the biological water quality using BWQC developed by Central Pollution Control Board (New Delhi), India. In this study, the biomonitoring of water quality using the benthic macro invertebrates of river Meenachil is the first attempt carried out, since there is no available research done in this area.

Study area

The Station 1 (Adivaram) was taken as the origin for the river Meenachil. Station 1 is a riffle/run with a substrate of boulders, cobbles, gravel and clay. Station 2 (Poonjar) has an average width of 8-10 mts and the water use status was limited to bathing and drinking. The substrate composition remained similar to Station 1. Average main stream flow was 0.75 and 0.50 m/s for monsoon and pre monsoon (Table 2). Erattupettah, taken as Station 3 was disturbed to some extend by the influence of human settlements and the water use pattern was destined to washing, bathing and urban waste discharge. Station 4 (Kadapattur) was also found to be disturbed by various anthropogenic activities and the substrate composition was mainly gravel, sand and clay. Paeroor considered as station 5 was being used for religious ceremony with a substrate of gravel, sand and clay. The river discharges at Kanjiram Jetty (Station 6), which empties into Vembanad Lake, the largest lake in Kerala (Table 1). Location map of river Meenachil showing the six sampling site is depicted in Figure 1.

Materials and Methods

Benthic Sampling

The Procedures employed for sampling of biological parameters were developed by Central pollution Control Board (CPCB, New Delhi, India). Sampling was made from six stations of the river Meenachil. Various measurements such as latitude, longitude, altitude, temperature, average depth, approximate width and main stream flow of sampling sites were congregated during the collection. Sampling should be conducted during availability of ample amount of sunlight in the field. Benthic (bottom dwelling) larvae were collected and identified from the origin of the river to the discharge site. Sampling was made from tributaries and from a variety of upland headwaters as well as lowland rivers. Collection methods include the use of benthic nets (D net) and kick screens. The stream current was used to wash the specimens physically from substrates, and the aquatic insects were surveyed on cobbles, rock, large woody debris, decaying leaves and dislodgable boulders to find the attached larvae and pupae. Identification of specimens to the most refined taxonomic level possible will commence immediately after the collection with the help of keys for identification.

To assess the actual health of water bodies, CPCB has derived a Biological Water Quality Criteria (BWQC) for water quality evaluation (Table 3). This system is based on the range of saprobic values and diversity of the benthic macro invertebrate families with respect to water quality. Saprobic score method involves a quantitative inventory of the presence of Macro-Invertebrate benthic fauna up to family level of taxonomic precision**.** All possible families having saprobic indicator value are classified on a score scale of 1 to 10 according to the preference for saprobic water quality. The families which are more sensitive to pollution are getting a score of 10 while the most pollution tolerant families are getting a score of 1 and 2.

Fig. 1. Map showing location of sampling

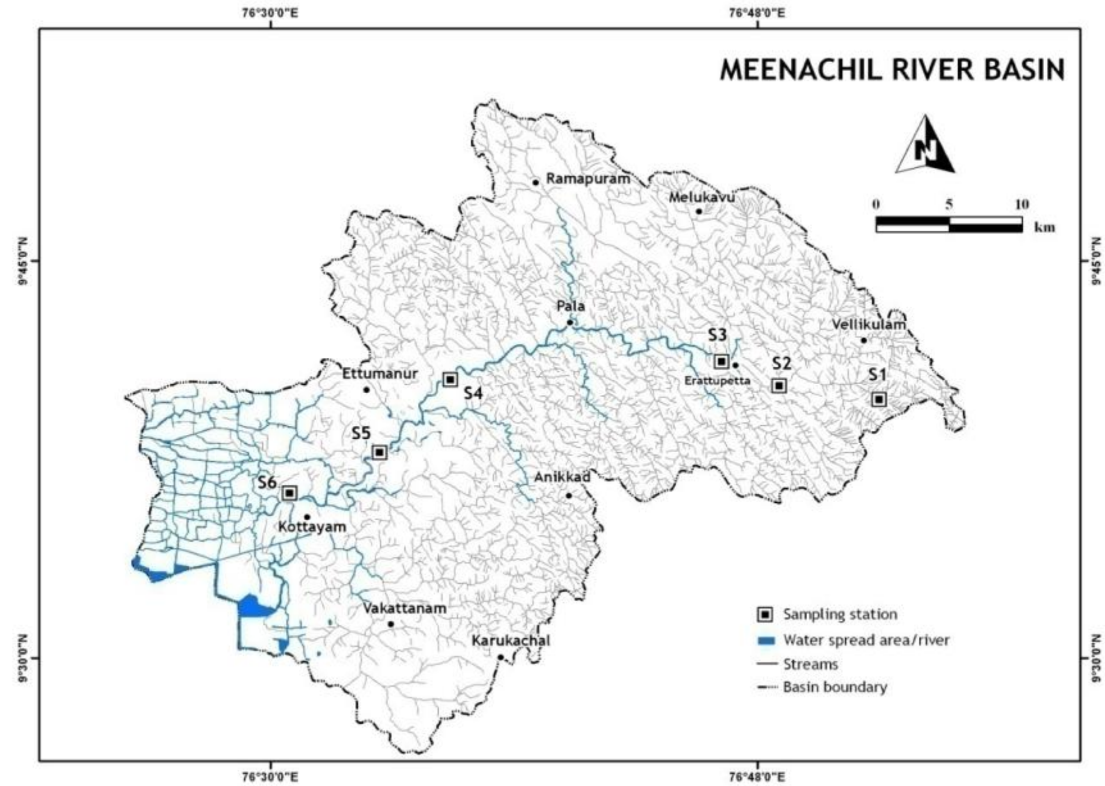

Table 1. Showing geological position of stations for river Meenachil

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Stations	Latitude	Longitude	Altitude (Ft)
Adivaram	$09^{0}40.478'$	$76^{0}51.318'$	780
Poonjar	$09^{0}40.317'$	$76^{0}48.922'$	175
Erattupettah	$09^{0}41.596'$	$76^{0}48.357'$	145
Kadappattur	$09^{0}42.441'$	$76^{0}40.387'$	61
Paeroor	$09^{0}37.880'$	$76^{0}33.967'$	140
Kanjiram jetty	$09^{0}34.097'$	$76^{0}29.139'$	38

Table 2. Physical characteristics of river Meenachil during pre monsoon and monsoon.

Stations	River Flow (m/sec)		River Width (m)		Water temperature (°C)	
	Monsoon	Premonsoon	Monsoon	Premonsoon	Monsoon	Premonsoon
Adivaram	0.75	0.50	10	9	20	24
Poonjar	0.50	0.35	10	8	26	30
Erattupettah	0.70	0.60	15	13	25	27
Kadappattur	0.89	0.60	25	15	28	33
Paeroor	0.80	0.50	15	14	26	33
Kanjiram jetty	0.75	0.50	12	10	25	27

Table 3. Biological Water Quality Criteria (BWQC).

Range of Saprobic Score	Range of Diversity Score	Water Quality	Water Quality Class	Indicator Colour
7 and more	0.2 - 1.0	Clean	A	Blue
6 - 7	0.5 - 1.0	Slight pollution	B	Light Blue
3 - 6	0.3 - 0.9	Moderate Pollution	C	Green
2 - 5	0.4 - less	Heavy Pollution	D	Orange
0 - 2	0 - 0.2	Severe Pollution	E	Red

Abundance scale:-

A = single (one individual)
B = scarce (2-10 individuals)
C = common (10-50 individuals)
D = abundant (50-100 individuals)
E = excessive (more than 100 individuals or only one species)

Diversity score method involves a pair-wise comparison of sequentially encountered individuals, and the differences of two specimens can easily be observed up to species level, no taxonomic skill is required. First observed animal is always different and scored as 1 run. When the next observed is different from the last, a new run starts. The encounter of an individual which cannot be discerned from the last does not increment the number of runs.

To indicate changes in water quality to different grades of pollution level, the entire taxonomic groups with their range of saprobic score from 1 to 10, in combination with the range of diversity score from 0 to 1 has been classified into five different classes of water quality. The abnormal combination of saprobic score and diversity score indicates sudden change in environment conditions.

Results

A total of 134 individuals of aquatic insects belonging to 36 genera, 31 families and 9 orders were collected from the six stations of the river Meenachil during pre monsoon and monsoon period. The highest diversity of benthic macro invertebrates were noticed in station 1 and station 3 (Adivaram and Erattupettah) and the lowest diversity were collected from the station 5 (Paeroor). A total of 31 families of macro invertebrates belonging to orders Ephemeroptera, Coleoptera, Mollusca, Crustacea, Odonata, Hemiptera, Tricoptera, Plecoptera and Lepidoptera were encountered. During the present study, Ephemeroptera were the most diverse with 9 families, Coleoptera and Mollusca had 5 and 4 families. The numbers of families for the other orders were: Crustacea (4), Odonata (3), Hemiptera (2), Tricoptera (2), Plecoptera and Lepidoptera (1) (Table 4).The most dominant genera of Ephemeroptera were *Campsoneuria*, *Thalerosphyrus and Cinygmina.* For Mollusca, *Wattebledia and Bithynia* were the most numerous. The dominant genera of Odonata were *Heliogomphus* and *Megalogomphus.* (Table 4).

Biological Water Quality Criteria (BWQC), based on the range of saprobic and diversity values of the benthic macro-invertebrate families were displayed for the six sampling stations. Station I (Adivaram), showed a saprobic score (8.66) and a diversity score (0.65) during pre monsoon and monsoon showed a saprobic score of 6.30 and a diversity score of 0.44 respectively. Station II (Poonjar), showed a lower saprobic value (5.50) during pre monsoon, when compared to the value procured (7.25) during Monsoon. Diversity score was higher during the pre monsoon (0.66), with respect to monsoon (0.60) suggesting a higher flow rate and flooding nature of the riverine system. Station III (Erattupetta) displaying a saprobic score of 7.36 and a diversity value of 0.85. Monsoon was characterized by an increase in the water level and flow rate illustrating an intricate collection procedure and exhibiting a saprobic score (3.0) and diversity score (1.0). Station 5 was exemplified by a saprobic score of 6.0/6.30 and a diversity score of 1.0/0.74 during pre monsoon and monsoon respectively. Station 6 (Kanjiram Jetty) showed a little contrast in the values, displaying a slight pollution during pre monsoon and clean during monsoon, thereby exhibiting a saprobic score of 6.25 and a diversity score of 0.55 during pre monsoon and 7.50/0.40 during monsoon. This suggests the exposure of the river water to various anthropogenic activities at the discharge site (Table 5).

Table 4. Taxonomical distribution of benthic macro invertebrates during pre monsoon and monsoon.

Sl.No	Order	Family	Genus
1	Ephemeroptera	Leptophlebiidae	*Habrophlebiodes Thraulus*
		Baetidae	*Chloeon Baetis*
		Heptageniidae	*Campsoneuria Thalerosphyrus Cinygmina*
		Ephemerellidae	*Ephemerella Teloganodes*
		Siphlonuridae	*Ameletus*
		Tricorythidae	*Tricorythus*
		Ephemeridae	*Ephemera*
		Caenidae	*Caenis*
		Neoephemeridae	-
2	Coleoptera	Hydrophilidae	*Amphiops*
		Psephenidae	*Psephenoidinae*
		Dytiscidae	*Hyphydrus*
		Scirtidae	*Cyphon sp*
		Elmididae	*Stenelmis*
3	Mollusca	Thiaridae	*Melanoides pyramis*
		Bithyniidae	*Wattebledia, Bithynia*
		Hydrobiidae	*Clenchiella*
		Planorbidae	*Indoplanorbis Amerianna*
4	Crustacea	Parathelphusidae	*Parathelphusa*
		Cirolanidae	*Corallana grandiventra*
		Atyidae	*Caridina gracilipes*
		Palaemonidae	-
5	Odonata	Chlorolestidae	-
		Libellulidae	-
		Gomphidae	*Heliogomphus Megalogomphus*
6	Hemiptera	Corixidae	*Corixa Morphocorixa*
		Naucoridae	*Ctenipocoris asiaticus*
7	Tricoptera	Philopotamidae	-
		Hydropsychidae	*Cheumatopsyche Macrostemum*
8	Plecoptera	Perlidae	*Phanoperla*
9	Lepidoptera	Pyrulidae	*Eoophyla*

Table 5. Biological Water Quality of river Meenachil during pre monsoon and monsoon.

Location	Period	Saprobic Score	Diversity Score	Water Quality	Water Quality Class
Adivaram	Premonsoon	8.66	0.65	Clean	A
	Monsoon	6.30	0.44	Slight Pollution	B
Poonjar	Premonsoon	5.50	0.66	Moderate pollution	C
	Monsoon	7.25	0.60	Clean	A
Erattupettah	Premonsoon	7.36	0.85	Clean	A
	Monsoon	3.00	1.00	Moderate Pollution	C
Kadapattoor	Premonsoon	7.60	0.85	Clean	A
	Monsoon	6.50	0.50	Slight Pollution	B
Paeroor	Premonsoon	6.00	1.00	Slight Pollution	B
	Monsoon	6.30	0.70	Slight Pollution	B
Kanjiram Jetty	Premonsoon	6.25	0.55	Slight Pollution	B
	Monsoon	7.50	0.40	Clean	A

Discussion

The river Meenachil is formed by several streams originating from the Western Ghats of India. One of the tributary originates from the southern valley of the Kurishumala hills and flows through Adivaram, Peringalam and Poonjar. Another tributary is formed by the stream originating at Illikkal kallu near Thalanadu and flowing through Mankombu and Vakakkadu. These two streams join together and flows south-eastwards and joins with Teekoy river which further flows southward to enter the northern side of Erattupettah. Since the river originates from the Western Ghats, considered to be a protected region under the Reserve Forest Area, the quality of water implies to be pristine in nature.

The presence of *Thalerosphyrus, Teloganodes, Ephemerella and Thraulus* (Ephemeroptera), *Macrostemum* (Tricoptera) and *Amphiops, Cyphon* sp (Coleoptera) were quite predominant, since many species of Ephemeroptera, Tricoptera and Coleoptera find it vital to cling to coarse substrate/ or behavioral adaptation for attachment to surfaces of stones or other substrates between short bursts of swimming (Merritt and Cummins, 1996). The river was characterized by profound water discharges and flooding during monsoon directing to an increase in the water level, illustrating an intricate collection procedure. This nature of the river may sometimes topple the substrates, remove the organisms and, increase levels of nutrients and organic matter in the streams and rivers (Barbosa et al., 2004, Petrucio and Barbosa, 2004). This may lead to gathering of benthic organisms further downstream to the station 1 (Adivaram) and furthermore the reason for slight pollution revealed. Station 2 (Poonjar) displayed high values of taxonomic richness, when compared with the other studied systems. Stations 2 suffer lower intensity of human impacts and are sufficiently stable to maintain a well utilization of their resources by natural biota (Barbosa et al., 1997). Station 1 (Adivaram) was found to be clean during the period of pre monsoon and a slight disparity was exposed by station 2, deflecting to moderate pollution (Table 5). Pre monsoon exhibited a decreased flow rate and the total dissolved solids become high thereby physico chemical variables influences community structure and function of aquatic insects (Resh and Rosenberg, 1984; Ward, 1992).

The differences found on the density values between monsoon and pre monsoon can be explained by temporal changes that occur on the water level and flux affecting some abiotic parameters such as temperature, dissolved oxygen and nutrients availability/ biological factors like predation risk, temporal changes on macrophytes community during growth period and trophic resources availability that vary along the year (De Paula et al., 1997; Barbosa et al., 1997).

The discharge of municipal waste from the nearest town, effects of agricultural activities in the river basin and the practice of fertilizers and associated chemicals (Lin and Chang, 1990) being drained into the river jointly with sand mining, encroachment of river banks and wetland filling has ultimately placed Station 3 and 4 to be moderately polluted and slightly polluted during monsoon. The input of organic matter into rivers modifies the bottom substrate characteristics. Roy et al. (2003) and Brabec et al. (2004) pointed out that effects of organic pollution and eutrophication on stream benthic fauna are linked to each other by organic matter and nutrients transformation processes. Beisel et al. (2000) pointed out intense relationships between macro invertebrate assemblages and substrate heterogeneity.

Human impacts, can determine a shift in the benthic organisms and a gradual replacement of species. Changes in species composition and dominance of pollution tolerant species are some of the scenarios commonly observed (Marques et al., 1999, 2003). *Elmidae* (Coleoptera) and *Baetidae* (Ephemeroptera) being present in some of the sampling stations suggested these taxa as tolerant to some level of environmental contamination, caused by inputs of domestic untreated sewage (Goulart and Callisto, 2003). *Perlidae* (Plecoptera) suggests that these organisms are indicators of good water quality. Moreover, the low diversity of habitats affected the distribution of this taxon (Galdean et al., 2000; Goulart and Callisto, 2003; Callisto and Goulart, 2005). Presence of *Macrostemum* (Hydropsychidae) reveals the fact that the water is polluted, since the tolerant species of Tricoptera are mostly associated with the animals of highly polluted waters. They are besides the most commonly encountered family of Tricoptera in Asian streams (Morse et al., 1994). Caddisfly occur in most type of fresh water habitats: spring streams and seepage areas, rivers, lakes, marshes and temporary pools (Betten, 1934). The Tricoptera and Diptera have the capability to adapt to varied aquatic habitats due to their extra ordinary structural organization (Tyagi, 2006; Needham and Needham, 1969; Tonapi, 1980). Lenat and Barbour (1994) reported that Ephemeroptera, Plecoptera and Tricoptera taxa (EPT taxa) are a reliable index sensitive to changes in stream water and/ or substrate quality.

In conclusion biomonitoring is used to document the condition of the aquatic resource and detecting subtle problems. It is a key companion for water quality standards and criteria. Since the river water in Kerala is undergoing serious anthropogenic effects, the need to conserve the pollution sensitive organisms bears prime significance. Temporal/biological factors could have conceivably diminished the density of benthic communities, however the ever increasing population load, wetland filling, sand mining, encroachment of river banks have adversely affected the diversity of life forms.

Acknowledgment

The authors are thankful to Central Pollution Control Board (CPCB, New Delhi) for financial assistance to carry out the work.

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