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Research Article

Contribution to the knowledge of taxonomic and functional structure of benthic macroinvertebrate communities of River Neyyar, Southern Kerala, India: A First approach

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Abstract

The diversity patterns and occurrence of benthic macro invertebrate families encountered in river Neyyar, originating from the Agastyar Koodam hills (Western Ghats), Kerala was a first attempt study carried out, since there is no available research work done in this area. The primary objective of this 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). A total of 229 individuals of aquatic insects belonging to 31 genera, 31 families and 10 orders were collected from the five stations of the River Neyyar during pre monsoon and monsoon period. The results showed that un-disturbed river has complete sensitive taxa namely Ephemeroptera, Plecoptera and Trichoptera (EPT). Mean while, there were only one sensitive taxa namely Plecoptera were found in the river which flows through the station Mandapathinkadavu. The most dominant taxa found in this river were Trichoptera. In addition, the results obtained from the last station during pre-monsoon where there was three sensitive taxa (EPT) and all other pollution resistant taxa comprised Coleoptera, Diptera, Odonata, Mesogastropoda, Basommatophora, Hirudinea and Haplotaxida absent in the river which flows through discharge area. The results can be use as a biological indicator for river water quality assessment.

Keywords: River Neyyar, Benthic macro invertebrates, Saprobic and diversity score, BWQC.

Introduction

Biomonitoring is the use of biological variables to survey the environment (Gerhardt, 2000). The primary task in biomonitoring is the search for the ideal indicator (or bioindicator) whose presence, abundance, and/or behavior reflects a stressor's effect on biota (Nuria et al. 2006). Historically, invertebrates have received considerable attention in the study of running water ecosystems, in particular relationships between macroinvertebrate community structures and environmental variables have been the subject of numerous investigations (Thorne and Williams, 1997; Resh, 1995; Kazancing and Girgins, 1999; Metcalf, 1998; Hickeys and Dugel, 2000; Whiles et al. 2000; Zweigs and Rabenic, 2001). Benthic macroinvertebrates are the animals that lack a back bone and generally are visible with the naked eye, and are sensitive indicators of environmental changes in streams because they express long term changes in water and habitat quality rather than instantaneous condition (Johnson et al. 1993). Anthropogenic activities, such as habitat modification, pollution and the over exploitation of living resources, continue to have a detrimental effect on global biodiversity levels and the subsequent provision of ecosystem services (Loreau et al. 2001; Jackson et al. 2001). Biological monitoring is generally used to examine existing stream conditions. The biological

approach for assessing streams and rivers is the use of benthic macroinvertebrates, especially aquatic insects, as indicators of pollution (Dudgeon, 1999) The use of benthic macroinvertebrates is wide spread and constitutes the basis for most aquatic biomonitoring programs currently in use (Metcalf. 1989; Rosenberg and Resh, 1993). The State Kerala has an area of 38,863 km^2 (15,005 sq mi) and consist of 14 districts, this land is blessed with 44 Rivers, however many of these are under the threat due to anthropological activities. Wetland filling and sand mining are the prime problems of the rivers of the State. The main objective of the study was to evaluate the water quality of the river Neyyar, a major river in southern Kerala using benthic macroinvertebrates. In this study, the biomonitoring of water quality using the benthic macro invertebrates of river Neyyar is the first attempt carried out, since there is no available research work done in this area.

Materials and Methods

Study area

The Neyyar River is a river of south-western India in the Western Ghats. It flows from the Agastya Mala (also known as Agastyarkoodam) hills of Thiruvananthapuram District of Kerala state. The river passes through Neyyattinkara taluk and finally meander its way to the Arabian Sea near Poovar. It has a total length of 56 km. Tributaries include the Kallar River, Mullayar River, and the Karavaliyar River. It has several small canals along the river and the Neyyar Irrigation Project is situated in this river. The sampling site are previously fixed, a total of five sites are taken from origin to discharge. Station 1 was present downstream to the Dam site and the water use status is mainly for the hydro electric power and irrigation purpose of Thiruvananthapuram District, Kerala. Station 2 (Veeranakavu) has an average width of 10 mts, surrounded by sand, gravel, macrophytes, detritus matter and clay. Average main stream flow was 0.75m/sec. The station 3, Mandapathinkadavu, a pig farm has been spotted at its bank and all the waste product from the farm was found to be released to the river and the substrates consist mainly of sand, clay and with a few cobbles. Station 4 (Erattinpuram) has an average width of 25 mts, surrounded by boulders, cobbles, pebbles, gravel, clay and macrophytes and an average flow rate of 0.87m/sec. Poovar is the last site or the discharge site where the Neyyar River joins the Arabian sea (Estuary). The water was found to be salty, the substrate consist of sand and clay (Table 1, 2).

Benthic Sampling

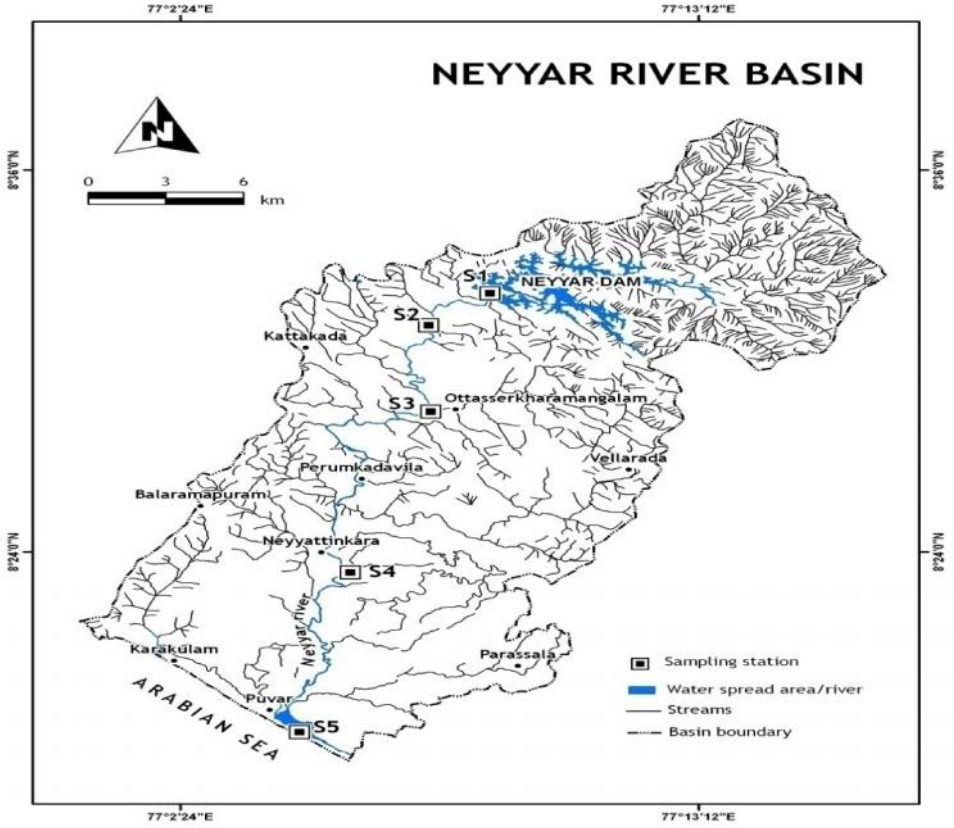
The Procedures employed for sampling of biological parameters were developed by Central pollution Control Board (CPCB, New Delhi.). Sampling was made from five stations of the Neyyar River. Various measurements such as latitude, longitude, altitude, temperature, average depth, approximate width and main stream flow of sampling sites were done 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.

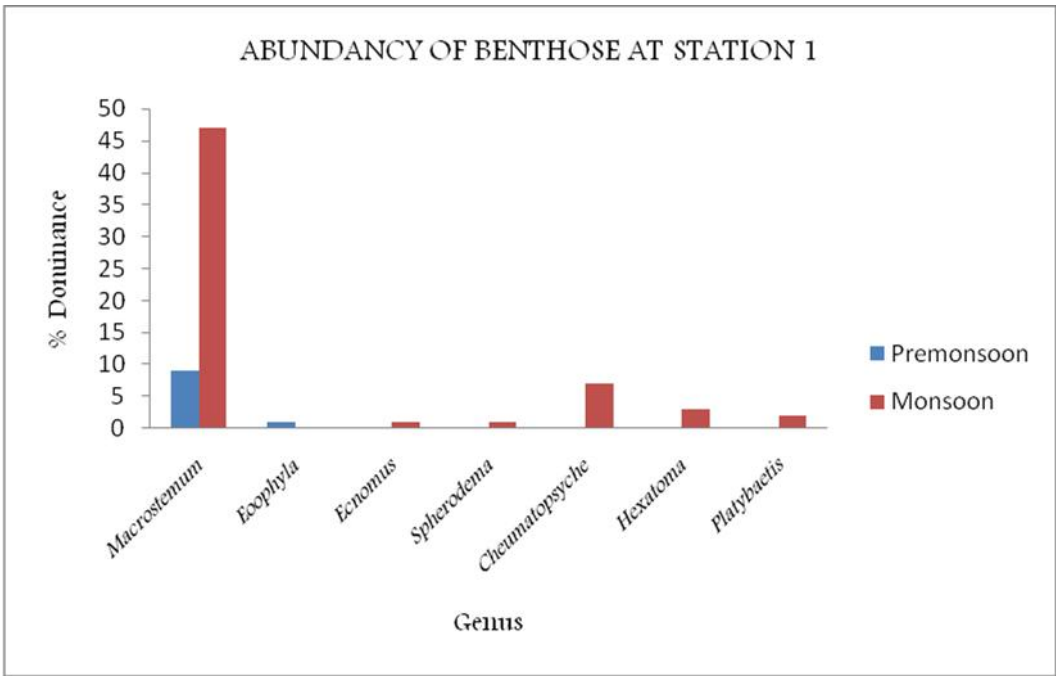
To assess the actual health of water bodies, CPCB has derived a Biological Water Quality Criteria (BWQC) for water quality evaluation (Table 3). This system is based on the range of saprobic values and diversity of the benthic macro-invertebrate families with respect to water quality. Saprobic score 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. Abundance scale:-

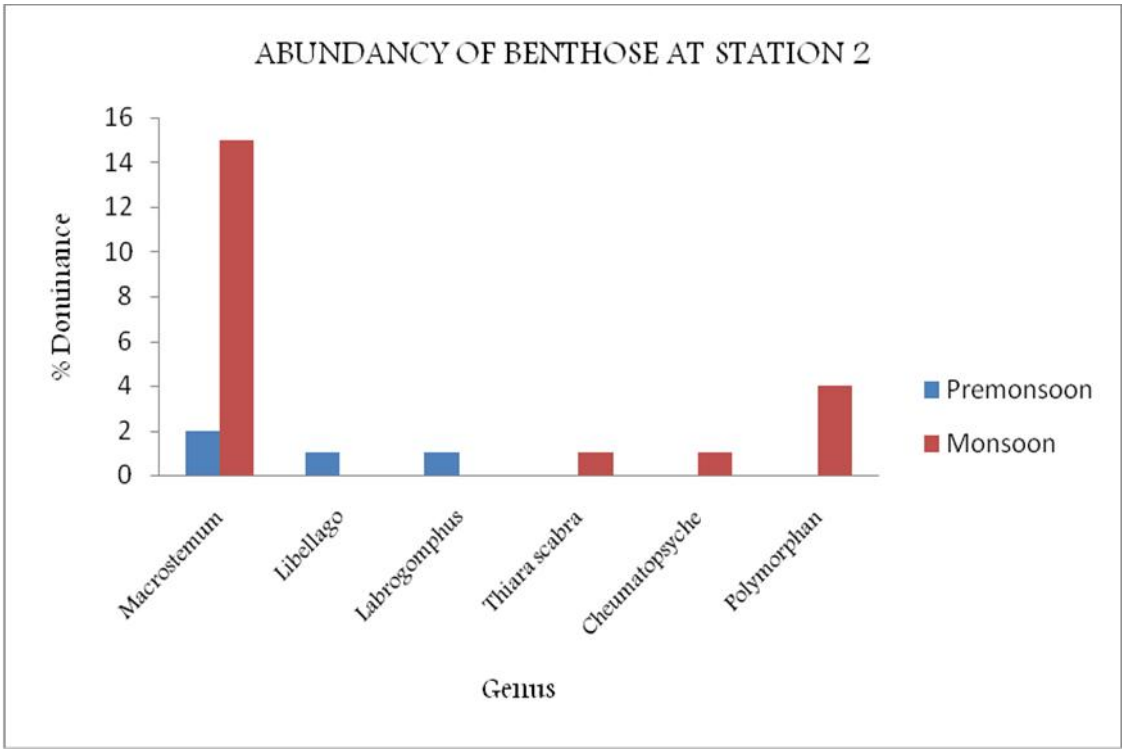
A = single (one individual)
B = scarce (2-10 individuals)
C = common (10-50 individuals)
D = abundant (50-100 individuals)
E = excessive (more than 100 individuals or only one species)

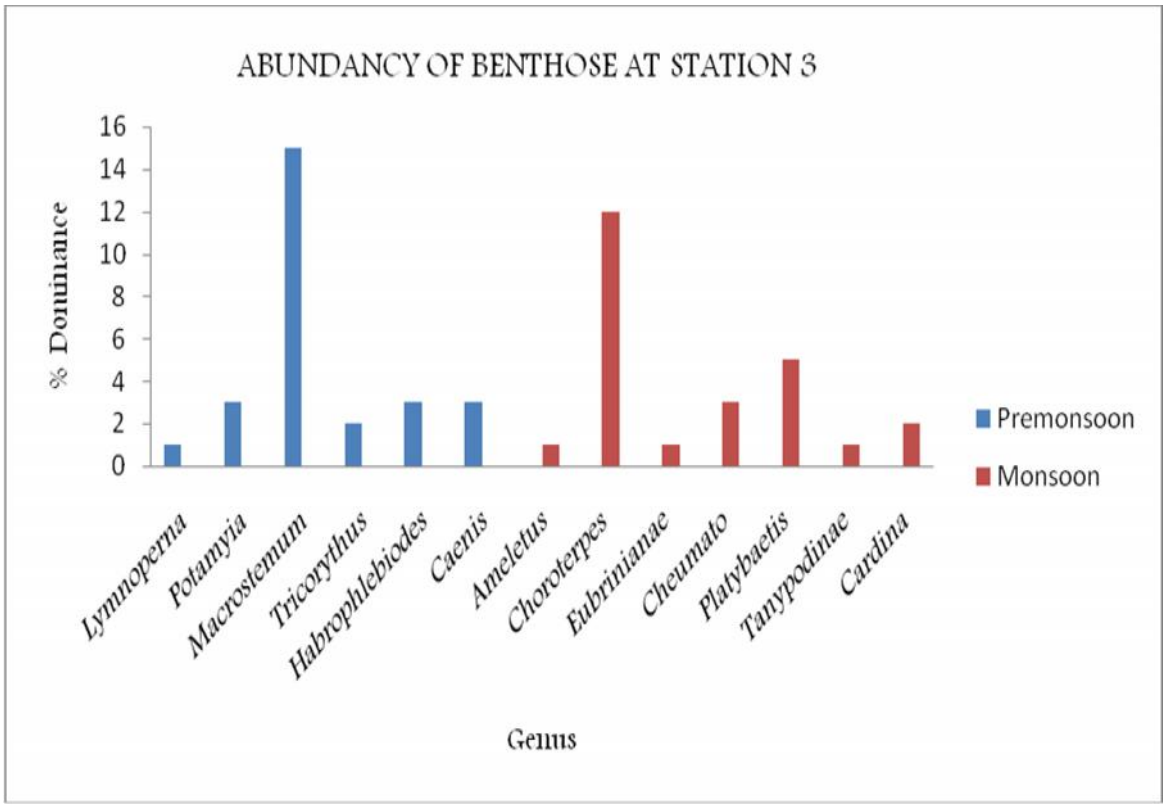
Diversity score method involves a pair-wise comparison of sequentially encountered individuals, and the differences of two specimens can easily be observed up to species level, no taxonomic skill is required. First observed animal is always different and scored as 1 run. When the next observed is different from the last, a new

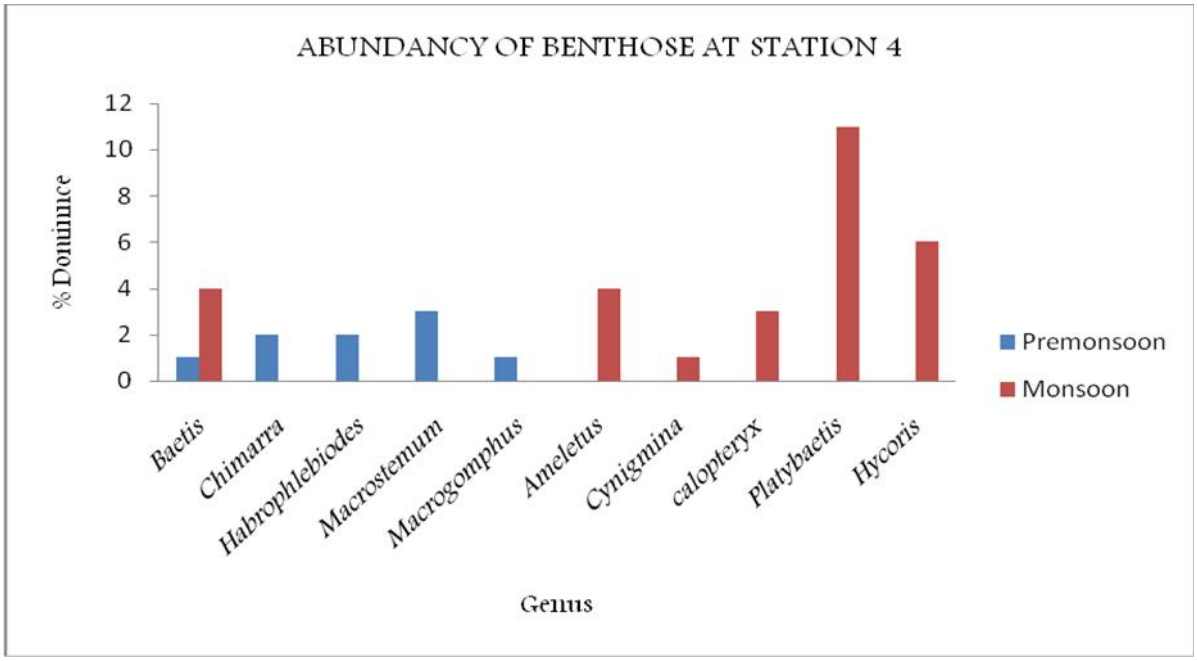
Fig: 1. Map showing the sampling location of Neyyar






ABUNDANCY OF BENTHOSE AT STATION 2
% Dominance
16
14
12
10
8
6
4
2
0
Premonsoon
Monsoon
Macrostemum
Libellago
Labrogomphus
Thiara scabra
Cheumatopsyche
Polymorphan
Genus


ABUNDANCY OF BENTHOSE AT STATION 3
% Dominance
16
14
12
10
8
6
4
2
0
Premonsoon
Monsoon
Lymnoperna
Potamyia
Macrostemum
Tricorythus
Habrophlebiodes
Caenis
Ameletus
Chorotepes
Eubrinianae
Cheumato
Platybaetis
Tanypodinae
Cardina
Genus



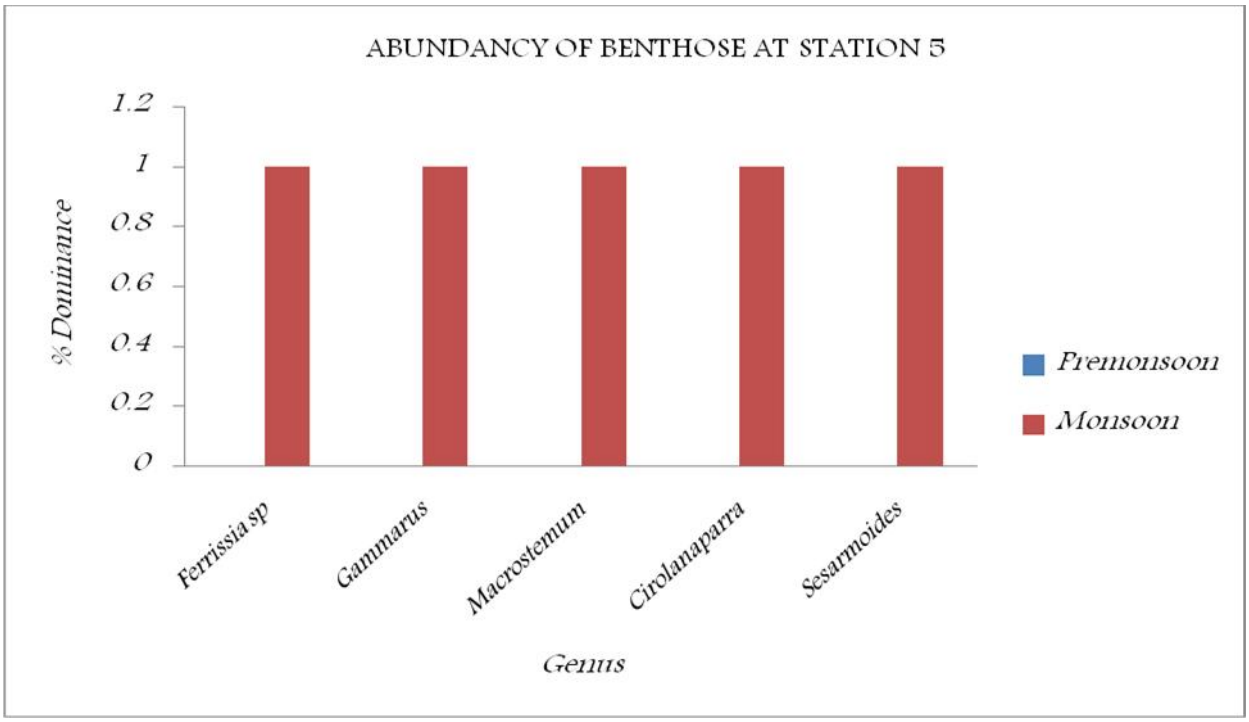


Table 1. Showing geological position of sampling stations of Neyyar

Sl.No	Stations	Latitude	Longitude	Altitude (Ft)
1	Neyyar Dam	$08^0$31.980’	$077^0$8.779’	179
2	Veeranavu	$08^0$31.061’	$077^0$07.34’	160
3	Mandapathin kadavavu	$08^0$28.485’	$077^0$06.810’	138
4	Erattinpuram	$08^0$27.338’	$77^0$05.833’	115
5	Poovar.	$08^0$31.004’	$71^0$07.042’	63

Table 2. Physical characteristics of River Neyyar during pre monsoon and monsoon.

Sl. No	Stations	Depth (Meter)		Width (Meter)		Flow rate (Meter/sec)		Water Temperature(°C)	
		Monsoon	Pre monsoon	Monsoon	Pre monsoon	Monsoon	Pre monsoon	Monsoon	Pre monsoon
1	Neyyar Dam	5	1	100	90	0.75	0.50	26	27
2	Veeranakaavu	3	2	10	8	0.50	0.35	27	27
3	Mandapathinkadavu	8	5	15	13	0.70	0.25	28	27
4	Erattinpuram	5	3	25	15	0.89	0.60	28	30
5	Poovar	5	4	15	15	0.08	0.05	28	28

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 229 individuals of aquatic insects belonging to 10 orders, 31 families and 31 genus were collected from the five stations of the River Neyyar during Pre monsoon and Monsoon period. The highest diversity of benthic macro invertebrates were noticed in Station 3 (Mandapathinkadavu) during premonsoon and the lowest diversity were collected from the last Station (Poovar), during premonsoon. A total of 31 families of macro invertebrates belonging to orders Ephemeroptera, Odonata, Tricoptera, Coleoptera, Diptera, Hemiptera, Plecoptera, Lepidoptera, Crustacean and Mollusca were encountered. During the present study, Ephemeroptera were the most diverse with 8 families and 8 genus, Mollusca had 5 families with 4 genus the number of families for the other orders were: Tricoptera (4), Odonata and Crustacean (4), Diptera and Hemiptera (2), Coleoptera, Plecoptera and Lepidoptera (1) (Table 6).

The dominant genera of Ephemeroptera were *Choroterpes and Platybaetis.* In Tricoptera *Macrostemum* (Hydropsychidae) showed the maximum diversity. *Bithyniidae* was the dominant family in the order Mollusca. The generic diversity of Odonata was higher in almost all stations and C*alopteryx* (Calopterygiidae) showed the dominancy. *Cardina* (Atydae) showed the dominancy in the crustacean order. In the river Neyyar the order Hemiptera, Lepidoptera and Plecoptera showed less diversity and the genus *Hycoris* (Naucoridae) which appear in the order Hemiptera was the most dominant (Table 6).

Biological Water Quality Criteria (BWQC), based on the range of Saprobic and diversity values of the benthic macro-invertebrate families were displayed for the five sampling stations. Station I (Neyyar Dam), showed a saprobic score (8.1), diversity score (0.670) during monsoon and Pre Monsoon showed a saprobic score of 6.0 and a diversity score of 0.93. Station II (Veeranakavu), showed a saprobic value (7.0) and diversity score (0.91) during pre monsoon. In monsoon the saprobic score become less (5.2) and diversity score was 0.581 when compared to pre monsoon. Station III (Mandapathinkadavu) revealed a diversity score (0.607), and displayed a saprobic score of 6.0 during the period of monsoon and a diversity value of 0.84 and saprobic score of 6.91 during premonsoon. Station IV (Erattinpuram) showed a little contrast in the values, displaying a moderate pollution during pre monsoon and slight pollution during monsoon, thereby exhibiting a saprobic score of 6.5 and a diversity score of 0.428 during monsoon. Pre monsoon showed a saprobic score of 5.7 and diversity score of 0.4 when compared to monsoon. Discharge site of the river Neyyar (Poovar estuary), station V, showed a saprobic score (5.2) and diversity score of 0.714 during pre monsoon were the presence of saline intrusion and discharge of municipal waste was in elevated level (Table 7).

Table 3. Biological Water Quality Criteria

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

Table 4. Abundancy of benthic macro invertebrates during Monsoon

Sl No	Station Name	Taxonomical families	Genus	Number of organism	Abundance
1	Near Neyyar Dam	Ecnomidae	*Ecnomus*	1	A
		Naucoridae	-	1	A
		Belastomatidae	*Spherodema*	1	A
		Hydropsychidae	*Macrostemum* *Cheumatopsyche*	47 7	C B
		Tipulidae	*Hexatoma*	3	B
		Baetidae	*Platybaetis*	2	B
2	Veeranakavu	Thiaridae	*Thiara scabra*	1	A
		Hydropsychidae	*Macrostemum* *Cheumatopsyche* *Polymorphan*	15 1 4	C A B
3	Mandapathinkadavu	Siphonuridae	*Ameletus*	1	A
		Leptophlebiidae	*Choroterpes*	12	B
		Hydroptillidae	-		B
		Psephenidae	*Eubrinianae*	1	A
		Hydropsychidae	*Cheumatopsyche*	3	B
		Baetidae	*Platybaetis*	5	B
		Chironomidae	*Tanypodinae*	1	A
		Atydae	*Cardina*	2	B
4	Erattinpuram	Siphonuridae	*Ameletus*	4	B
		Heptageniidae	*Cynigmina*	1	A
		Calopterygidae	*Calopteryx*	3	B
		Baetidae	*Platybaetis* *Baetis*	11 4	C B
		Naucoridae	*Hycoris*	6	B
5	Poovar	Ancylidae	*Ferrissia sp.*	1	A
		Gammaridae	*Gammarus*	1	A
		Hydropsychidae	*Macrostemum*	1	A
		Cirollanidae	*Cirolanaparva*	1	A
		Sesarmidae	*Sesarmoides*	1	A

Table 5. Abundancy of benthic macro invertebrates during Pre monsoon.

Sl No	Station Name	Taxonomical families	Genus	No of organism	Abundance
1	Near Neyyar Dam	Hydropsychidae	*Macrostemum*	9	B
		Naucoridae	-	7	B
		Nymphulinae	*Eoophyla*	1	A
2	Veeranakavu	Hydropsychidae	*Macrostemum*	2	B
		Leptohyphidae	-	3	B
		Cordullidae	-	2	B
		Chlorocyphidae	*Libellago*	1	A
		Gomphidae	*Labrogomphus*	1	A
3	Mandapathinkadavu	Palaemonidae	-	1	A
		Mytilidae	*Lymnoperna*	1	A
		Tipulidae	-	2	B
		Perlidae	-	1	A
		Hydropsychidae	*Potamyia*	3	B
		Hydropsychidae	*Macrostemum*	15	C
		Euthyplocidae	-	4	B
		Tricorythidae	*Tricorythus*	2	B
		Leptophlebiidae	*Habrophlebiodes*	3	B
		Caenidae	*Caenis*	3	B
		Naucoridae	-	1	A
4	Erattinpuram	Baetidae	*Baetis*	1	A
		Philopotamidae	*Chimarra*	2	B
		Leptophlebiidae	*Habrophlebiodes*	2	B
		Hydropsychidae	*Macrostemum*	3	B
		Gomphidae	*Macrogomphus*	1	A
		Naucoridae	-	3	B
		Bithyniidae	-	15	C
5	Poovar	-	-	-	-
		-	-	-	-

Discussion

Water quality of Neyyar river becomes polluted due to the various anthropogenic activities. In the present study Station1 (Neyyar Dam) was the only sight found to be clean during the period of monsoon and in pre monsoon it divert to second category, slightly polluted. Since the dam opens only during Monsoon, Premonsoon 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 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 has ultimately placed Station 2 to be moderately polluted during monsoon. The discharge site of the river Neyyar (Poovar) was also found to be moderately polluted during monsoon due to the discharge of the municipal waste from the nearest town. The site was severely polluted during premonsoon leading to absence of insects. The station being an estuary, influx of salinity is one of the major reason for the absence of fresh water macro benthos. Apart from this Automobile wash down and bathing, may also increase the pH of the water resulting in the absence of the benthic community.

Table 6. Taxonomical distribution of benthic macro invertebrates during pre monsoon and monsoon.

Sl. No	Order	Taxonomical families	Genus
1	Ephemeroptera	Leptophlebiidae	*Choroterpes*
			Habrophlebiodes
		Siphonuridae	*Ameletus*
		Heptageniidae	*Cynigmina*
		Baetidae	*Platybaetis*
			Baetis
		Euthyplocidae	-
		Tricorythidae	*Tricorythus*
		Caenidae	*Caenis*
2	Mollusca	Thiaridae	*Thiara scabra*
		Ancylidae	*Ferrissia sp.*
		Gammaridae	*Gammarus*
		Bithyniidae	-
		Mytilidae	*Lymnoperna*
3	Tricoptera	Hydropsychidae	*Macrostemum*
			Cheumatopsyche
			Polymorphan
			Potamyia
		Hydroptillidae	-
		Ecnomidae	*Ecnomus*
		Philopotamidae	*Chimarra*
4	Odonata	Calopterygiidae	*Calopteryx*
		Cordullidae	-
		Chlorocyphidae	*Libellago*
		Gomphidae	*Labrogomphus*
			Macrogomphus
5	Crustacean	Atydae	*Cardina*
		Cirollanidae	*Cirolanaparva*
		Palaemonidae	-
		Sesarmidae	*Sesarmoides*
6	Diptera	Tipulidae	*Hexatoma*
		Chironomidae	*Tanypodinae*
7	Hemiptera	Belastomatidae	*Spherodema*
		Naucoridae	*Hycoris*
8	Lepidoptera	Nymphulinae	*Eoophyla*
9	Coleoptera	Psephenidae	*Eubrinianae*
10	Plecoptera	Perlidae	-

Table 7. Biological Water Quality of river Karamana during pre monsoon and monsoon

Location	Period	Saprobic Score	Diversity Score	Water Quality	Water Quality Class
Neyyar dam	Premonsoon	6.0	0.93	B	Slight pollution
	Monsoon	8.1	0.670	A	Clean
Veeranakavu	Premonsoon	7.0	0.91	B	Slight pollution
	Monsoon	5.2	0.58	C	Moderate Pollution
Mandapathinkadavu	Premonsoon	6.91	0.84	B	Slight pollution
	Monsoon	6.0	0.607	B	Slight pollution
Erattinpuram	Premonsoon	5.7	0.5	C	Moderate Pollution
	Monsoon	6.5	0.428	B	Slight Pollution
Poovar	Premonsoon	0.0	0.0	D	Severe pollution
	Monsoon	5.2	0.714	C	Moderate Pollution

Comparison of taxonomic composition and abundance of the aquatic insects of the river Neyyar indicated major differences in community structure between the stations. A total of 10 order of insect include, order Ephemeroptera, Odonata, Tricoptera, Coleoptera, Diptera, Hemiptera, Plecoptera, Lepidoptera, Crustacean and Mollusca. The maximum abundance of insect was found in the station 1 during monsoon. The most abundant insect order belongs to Tricoptera taxa, Ephemeroptera, Mollusca, Odonata, Hemiptera and Crustacean in descending order. The order Coleoptera, Plecoptera and Lepidoptera was found to be very less in number. In all stations *Macrostemum* (Hydropsychidae) was dominating since this is the most commonly encountered family of Tricoptera in Asian streams (Morse et al. 1994). The second primitive family in the river was found to be *Corydalus* (Corydallidae). The larvae of this genus consume fallen leaves on the stream beds, and function as chief decomposers in forested stream ecosystem (Hayashi, 1995). The family Plecoptera was found only in station 3 (Mandapathinkadavu). 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. The number of EPT taxa decreases with increasing human impacts. The presence of Baetidae (*Platybaeties* and *Baetis*), Gomphidae (*Melligomphus ardens), Macrostemum, Hydropsychae, Stenopsychae* (Tricoptera) and the Coleopteran family (*Eubriniane*) were also quite predominant, since many species of Ephemeroptera, Odonata, Tricoptera and Coleoptera showed morphological and/ or behavioral adaptation for attachment to surfaces of stones or other substrates between short bursts of swimming (Merritt and Cummins, 1996) The Molluscs family (*Bithyniidae*) were also found to be most abundant in station 4 (Erattinpuram), further the area being surrounded by substrate of boulders, cobbles and high deposition of organic wastes, the station was found to be moderately polluted in Premonsoon season. The abundance of molluscs indicates the high deposition of organic matters and the influences of human activities (Table 4, 5).

The purpose of our study was simply to detect the impact of a perturbation on macro invertebrate communities, and thus we assumed that determination to family level was useful. The use of benthic macroinvertebrate communities is a useful tool in the assessment of water quality and freshwater ecosystem health. According to Barbosa et al (2001) and Galdean et al. (2003) the taxonomic composition and community structure also offer important information for these assessments, starting from the biological knowledge of nutritional requirements, utilization of available trophic resources and relationships with the diversity of available habitats. If the goal is going to be the assessment of community and population changes (and it is probably desirable), lower taxonomic determinations will be imperatively needed. On the other hand, a benefit-cost balance must be consider, due to the increasing need for rapid and low-cost methods to assess water quality and the necessity of much time for the determination to low taxonomic levels by (rare) specialists.

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