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# An Integrated Water Quality Assessment Of Parbati River Sehore, M.P India Using WQI, ASPT And Correlation.


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***Abstract***

The objectives of this study were to clarify and evaluate the water quality and macroinvertebrate density and diversity of Parbati river Sehore, M.P India.The present study successfully utilized the benthic macroinvertebrates diversity as well as physiochemical parameters of river water. Based on Average Score per Taxon (ASPT) and the (WQI) values, urban sites of the river Parbati were categorized as polluted with *Chironomus* sp., *Limmodrilus hoffmeisteri, Tubifex tubifex* and *Tubifex albicola* as codominant taxa and Rural sites of the River exhibited doubtful (ASPT) or good quality(WQI) containing Odonata and Ephemeroptera families as codominant taxa. Our results further demonstrated that the biotic indice (ASPT) were more sensitive towards organic pollution than the WQI. However, the sites p-1, p-2 and p-5 fall in good category as per WQI but biotic index confirm that these sites are fair instead of good due to limitation of Ephemeroptera only at the reference site and absence of Plecoptera and Trichoptera at all the sites. Macroinvertebrates such as Odonata, Diptera, Coleoptera, Hemiptera, and Planorbidae (Mollusca) decreased with relative nutrient load.





***Keywords: ASPT, BMWP , Correlation, WQI,***


## 1. Introduction

Rivers are important resources for human civilizations as they meet water demand for various uses apart from supporting flora and fauna. River being an open water ecosystems, get strongly influenced by the surrounding environment. Water quality of a river gets effected by parameters like land use, settlement patterns, farming, and industrial activities around that river( Patang *et al.*, 2018 ).The riverine resources of India contain 113 river basins out of which 14 are major, 44 medium and remaining 55 are minor rivers (Kumar, 2002) which are facing problems by urbanization and industrialization and significantly impacted freshwater biodiversity habitats, and ultimately disturbed the ecological balance and loss of aquatic biodiversity (Jewitt, 2002 and Hassan *et al.*, 2005). urban expansion and industrialization leads to the release of hazardous materials into natural fresh water bodies resulting in harmful effects not only on its biodiversity but also effects the terrestrial plants and animals, including human beings (Hassan *et al.*, 2005).

Macrozoobenthos are aquatic organisms that live in the bottom of any water body, having ability to respond environmental changes which is useful in assessing the quality of surface water **(**Hallawell,1986**)**. Release of hazardous materials and urban expansion activities deteriorate the water quality of rivers and accordingly lead to a change in the benthic macroinvertebrates community structure(Patang *et al*., 2018),hence study of biodiversity, species abundance, dominance, and distribution of macroinvertebrate fauna to determine the degree of changes in their structure and composition associated with water quality changes (Setiawan, 2009).Measuring the physicochemical properties of water utilized to estimate its quality cannot exactly represent the actual state of the waters to overcome this physical, chemical, and biological evaluation along with other monitoring methods are used to provide a comprehensive picture of ecological quality of the waters (Sciortino, 1999) ,so diversity of macroinvertebrate is one of the most effective and inexpensive ways to determine the ecological quality of the waters(Setiawan, 2009).Biological monitoring using macroinvertebrates has been found accurate and advantageous compared with using other organisms because macroinvertebrates are extremely sensitive to organic pollutants, widely distributed, and easy and economical to sample( Setiawan2009).The ASPT Score and Diversity indices Systems is easy to apply and has greatly reduced costs compared to physical and chemical analyses. Accordingly, the aptness of water for its usage is categorized in terms of water quality index (WQI),which is one of the most valuable ways to explain the status of water quality. WQI Being a single number and expressing water quality by aggregating the measurement of various water quality parameters reduces the bulk of information and express the data in a simplified and logical form (semiromi *et al.,* 2011).

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Parbati River originates from at a height of 610 m in the Vindhya Range at 76°35'40.75''E longitude and 22° 50'09.63''N latitude from Pithapura Lake near village Siddiqueganj in Sehore district, Madhya Pradesh. Being 471 km long it runs through various districts, of Madhya Pradesh and finally joins with Chambal River in Sawai Madhopur District of Rajasthan at District at 76° 33'58.86'' E longitude and 25° 50'56.86'' N latitude. It is one of the Chambal River's three main tributaries, along with the Banas River and the Kali Sindh River. Ramgarh crater is located on its eastern bank of the river

For the study, Samples were collected from 5 selected sites, Selection of the sampling stations was based on the possible pollutant loads and the magnitude of human activities along the rivers. Detailed location information of these sampling sites, and the latitude and longitude of all stations, are presented in Table 1.

**Table 1:** Characteristic features of the sampling station ,and their coordinates

| S. No | sampling station | station code | Characteristics of sampling stations | Longitude E | Latitude N |
|---|---|---|---|---|---|
| 1 | station 1 | P 1 | upstream forested area inhibated by some tribal families | $76^{0}$36'2.41''E | $22^{0}$50'13.96'' N |
| 2 | station 2 | P 2 | Rural area located arround the village siddiqganj | $76^{0}$37'0.41.53''E | $22^{0}$51'41.60''N |
| 3 | station 3 | P 3 | Shujalpur road borkheda(village) | $76^{0}$49'18.11'' E | $23^{0}$7'0.72'' N |
| 4 | station 4 | P 4 | urban site close to nationalhighway nh44 arround the vicinity klin -brick factory | $76^{0}$'47'42'' E | $23^{0}$3'35'' N |
| 5 | station 5 | P 5 | Forest area downstream close to the dam | $76^{0}$55'49''E | $23^{0}$13'55''N |

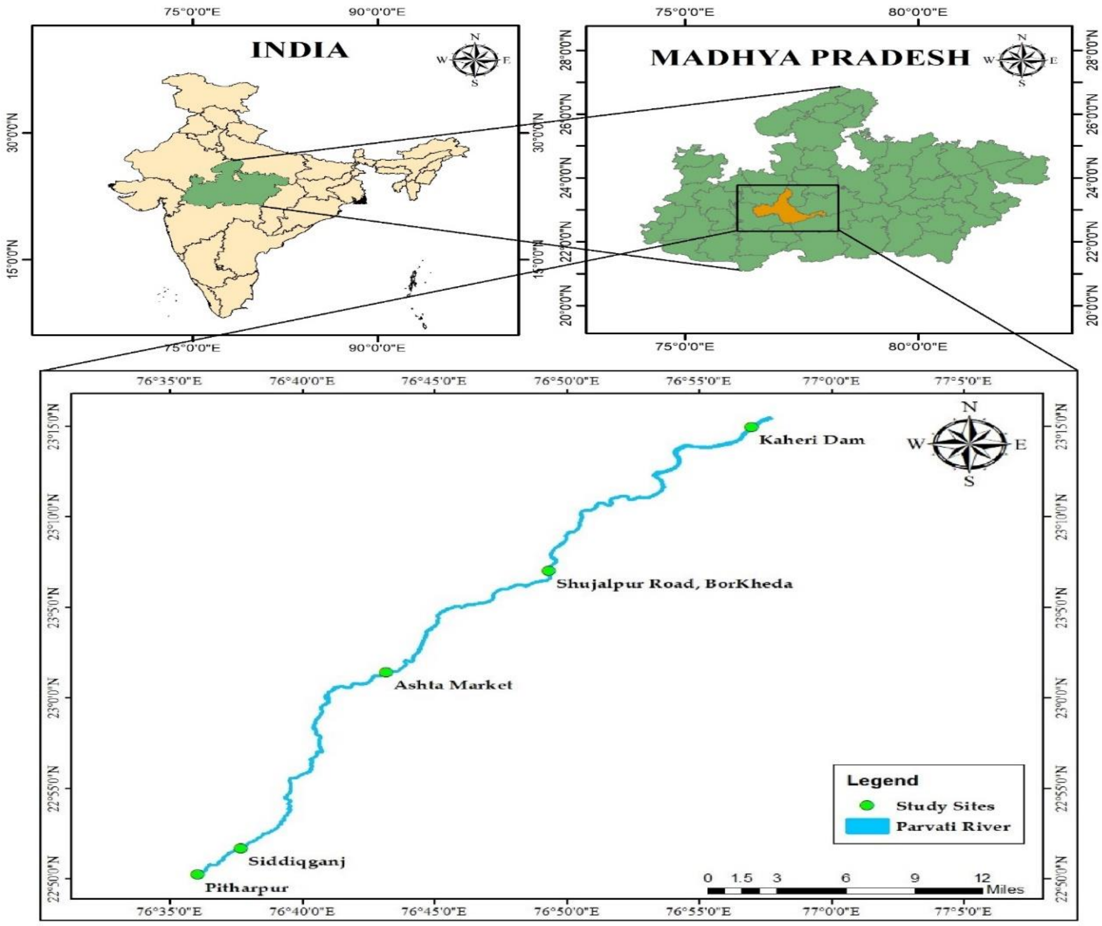


**Figure1 -**Map showing sampling stations.

## 2.2 Sample Collection

The various physico chemical parameters were assessed as per Adoni, *et al.*, (1985) and APHA (2005). The benthic macroinvertebrates were sampled from five stations of Parbati River using Surber net (30 × 30 $cm^2$ ) for rocky substrate, Ekman-grab (25 × 25 $cm^2$ ) for muddy substrate, and kick net for habitat containing dense aquatic plants. Organisms collected were rinsed with water, separated from debris and the organisms collected in sampler were spilled in labeled jars and fixed to 10% formalin and then sent to the laboratory for sorting under a binocular dissecting microscope. After sorting, they were grouped up to family level. A standard identification chart (Identification guide to freshwater macroinvertebrates) was used to classify the sample into various taxa and species (Gill 2011). Biological Monitoring Working Party (BMWP) score was allocated to each and every family of macroinvertebrates sampled at every station according to their sensitivity to physico-chemical parameters. Average Score per Taxon ASPT was calculated as the ratio of the score obtained in the BMWP index to the number of families scored in the sample.

**Table-2:** The BMWP and ASPT score table showing biological quality and water quality (Armitage et al., 1983; Hawkes, H. A. (1998).

| BMWP Score | Biological Quality | ASPT Score | Water Quality |
|---|---|---|---|
| Over 130 | A. Very good biological quality (natural) | Over 7 | Very good (natural) |
| 100 – 130 | B. Good biological quality | 6.0-6.9 | Good |
| 51 – 100 | C. Doubtful biological quality | 5.0-5.9 | Doubtful |
| 11 – 50 | D. Poor biological quality | 4.0-4.9 | Poor |
| 0 – 10 | E. Very poor biological quality | 3.9 or Less | Very Poor |

**2.3 Diversity indices**

The Shannon-Weaver diversity index is based on the type calculation and the percentage of each species within the given locality community. Integrates the wealth, number of taxa (species) and equilibrium or distribution of individuals and is calculated by the formula,

$$\mathrm{H} = \sum_{I=1}^{S} \mathrm{PixInPi}$$

H =Shannon index, pi – Relative abundance of $i^{th}$ taxon in the sample, s – total number of species in the sample.

The Evenness index (E) is computed from Pielou's index [36]:

$$E = \frac{\mathrm{H}}{\ln \mathrm{S}}$$

where H is Shannon–Weaner diversity index and lnS is natural log of the total number of species recorded.

The Simpson index measures the probability that two individuals randomly selected from a sample belong to the same species.

**1---ƛ=** $\sum_{I=LPI}^{S} 2$

1---ƛ =Simpson's index, pi – type participation in the sample, s – number of species in the sample.

**2.4 Water Quality Index**

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The method has been widely used by the various scientists ( Chauhan & Singh,2010, Chowdhury *et al* 2012, Rao, *et al* 2012 , Balan, *et al* 2012) and the calculation of WQI was made (Rown *et al* 1972) by using the following equation:

$$\mathrm{WQI} = \sum WIQI \,/\, \sum WIQI$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$\mathrm{Qi} = 100[(\mathrm{VI\text{-}VO} \,/\, SI - VO\,)]$$

Where,

Vi is estimated concentration of ith parameter in the analysed water

Vo is the ideal value of this parameter in pure water

Vo = 0 (except pH =7.0 and DO = 14.6 mg/l)

Si is recommended standard value of ith parameter the unit weight (Wi) for each water quality parameter is calculated by using the following formula:

The quality rating of the index was calculated by the formula

$$\mathrm{Wi} = \mathrm{K/Si}$$

Where,

K = proportionality constant and can also be calculated by using the following equation

$$\mathrm{K} = \frac{1}{\sum I/Si!}$$

**Table 3.** Water Quality Rating as per Weight Arithmetic Water Quality Index Method

| WQI Value | Rating of Water Quality | Grading |
|---|---|---|
| 0-25 | Excellent water quality | A |
| 26-50 | Good water quality | B |
| 51-75 | Poor water quality | C |
| 76-100 | Very Poor water quality | D |
| Above 100 | Unsuitable for drinking purpose | E |

## 3 Result and Discussion

### 3.1 Benthic Macroinvertebrates species reported in Parbati River during the study period.

50 taxa of macrobenthos were recorded from the parbati river which belongs to 3 phylum, 6 classes, 12 orders and 35 families. The phylum Arthropoda was dominant comprising 30 genera, 2 classes, 6 orders and 25 families as shown in Table -4. The results revealed that most taxa that dominate the community occur almost at all Stations are *Chironomus chironomus*, *Baetis* sp., *Anax* sp., *Palaemonete*s sp. *Dytiscus* sp. *Ranatra* sp. *Aphylla* sp. and *Gomphus* sp.were mostlty dominant throughout the study period. However,

some taxas like *Lamellidens marginalis*, *Pila globosa*, *Tubifex albicola*, *Rhagovelia* sp. *and Pelocoris* sp. were rare, they were reported from only one or two stations. In terms of percentage composition arthropoda holds dominant position 61%, followed by mollusca 29% and annelida 10% as shown in figure-2. The dominance of arthropoda was also documented by various authors from the different rivers. Kumar and Vyas, 2014 reported dominance of phylum arthropoda with 55% from river Narmada. Bashir *et al*., (2015) also reported phylum arthropoda dominant with 68% from the Bhanger stream which is the seasonal tributary of river Narmada. Nautiyal and Mishra, (2013) also found 48% to 93% of arthropoda richness from Ken river. From river Jhelum,( Abida *et al*., 2012) recorded 54.7% of arthropoda, followed by annelida 28.9% and mollusca 16.4% of total macrobenthos. From Ona River, South west Nigeria (Andem *et al*., 2012) also reported highest percentage of arthropoda 61%.

In mollusca, 16 taxa were reported which belongs to 4 orders, under 8 families, of which 11 species were represented by Gastropoda and 5 species from Bivilia. Among the Gastropoda species *Bellamya bengalensis*, *Lymnaea acuminate*, *Radiatula oocata and Pisidium nevillianum*, were the most dominant, followed by *Bellamya dissimilis*, *Thiara tuberculata and Gyraulus labiavvtus*, while as *Pila globosa and Lamellidens marginalis* were found in least number. Kumar and Vyas (2012) reported 19 species of mollusca, among them 13 species belongs to Gastropoda and 6 to Bivalvia from river Narmada. Similarly Roy and Gupta, (2010) reported 16 mollusca taxas which belongs to 2 Classes observed gastropda as dominant from the river Barak in Assam.

The annelida was least dominant and was represented by 2 Class oligocheta and clitellata. The class oligocheta was represented by *Limmodrilus hoffmeisteri*, *Tubifex tubifex and Tubifex albicola*. *Tubifex tubifex* was the most dominant species. Class Clitellata was represented by single species *Hirudiniaria* sp. least diversity and richness of Annelida was found from the study area. Sharma *et al*., 2013 reported only single genus of annelida from river Morand. Vyas *et al*. (2012) also reported least number of annelids from river Narmada. Abida *et al*., (2013) reported 3 species from river Jhelum. Bashir *et al*., (2015) also reported least diversity of annelids from river Bhagner a tributary of river Narmada.

**Table 4:** List of Benthic Macroinvertebrates species reported in Parbati River during the study period.

| Phyllum | Class | Order | Families | Species |
|---|---|---|---|---|
| Mollusca | Gastropoda | Megastropoda | Viviparidae | *Bellamya bengalensis* |
| | | | | *Bellamya dissimilis* |
| | | | Thiaridae | *Thiara scabra* |
| | | | | *Thiara tuberculata* |
| | | | | *Tarebia lineate* |
| | | | | *Tarebia graiffera* |
| | | | Ampullariidae | *Pila globosa* |
| | | Basommatophora | Lymnaeidae | *Lymnaea acuminate* |
| | | | Planorbidae | *Gyraulus convexiusculus* |
| | | | | *Indoplanorbis exustus* |
| | | | | *Gyraulus labiatus* |
| | Bivalvia | Trigoinoida | Unionidae | *Radiatula oocata* |
| | | | | *Corbicula striatella* |
| | | | | *Pisidium nevillianum* |
| | | Veneroida | Cyrenidae | *Lamellidens corrianus* |
| | | | Sphaeriidae | *Lamellidens marginalis* |
| Annelida | Oligocheta | Haplotaxida | Naididae | *Limmodrilus hoffmeisteri* |
| | | | | *Tubifex tubifex.* |
| | | | | *Tubifex albicola* |
| | Clitellata | Arhynchobdellida | Hirudinidae | *Hirudiniaria sp* |
| Arthopoda | Insecta | Diptera | Chironomidae | *Chironomus chironomus* |
| | | | Chaoboridae | *Chaoborus chaoborus* |
| | | | Culicidae | *Culex sp.* |
| | | | Simuliidae | *Simuluim sp.* |
| | | | Tabanidae | *Tabanus sp.* |
| | | Odonata | Gomphidae | *Aphylla sp.* |
| | | | | *Gomphus sp.* |
| | | | Cordulegastridae | *Cordulegaster sp.* |
| | | | Aeshnidae | *Anax sp.* |
| | | | Coenagrionidae | *Hagnius sp.* |

| | | | | |
|---|---|---|---|---|
| | | | | *Argia sp.* |
| | | | | *Enallagma sp.* |
| | | Hemiptera | Corixidae | . *Sigara sp* |
| | | | | *Notoneta sp.* |
| | | | Nepidae | *Ranatra sp.* |
| | | | | *Nepa sp.* |
| | | | Gerridae | *Gerris sp.* |
| | | | Veliidae | *Rhagovelia sp.* |
| | | | Naucoridae | *Pelocoris sp.* |
| | | Ephemeroptera | Caenidae | *Caenis sp.* |
| | | | Ephemerellidae | *Ephemerella sp.* |
| | | | Baetidae | *Baetis sp.* |
| | | Coleoptera | Crabronidae | *Dineutus sp.* |
| | | | Haliplidae | *Peltodytes sp.* |
| | | | Hydraenidae | *Hydraena sp.* |
| | | | Dytiscidae | *Dytiscus sp.* |
| | | | Carabidae | *Bembidium sp.* |
| | | | Elmidae | *Stenelmis sp.* |
| | | | Hydrophilidae | *Berosus sp.* |
| | Malacostraca | Decapoda | Palaemonidae | *Palaemonetes sp.* |

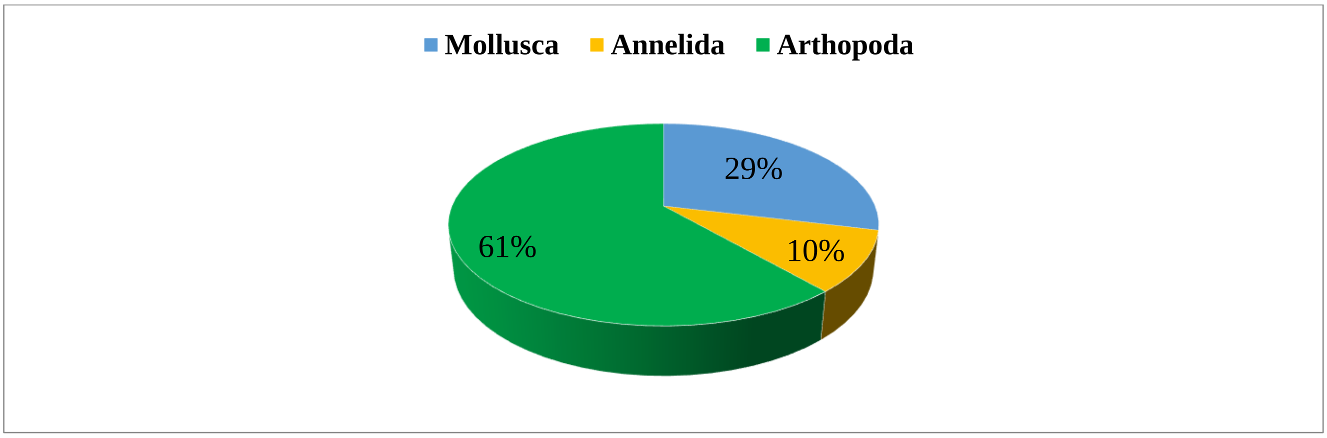


**Fig. 2:** Showing overall percentage composition of taxonomic groups at Parbati River.

### 3.2 Shannon-Wiener index

Shannon- wiener index varied from 1.93- 3.39 as shown in figure-3. The maximum value was recorded at Station P5 during winter 2021 and the minimum were observed at Station P4 during monsoon 2020. Similar results were recorded from the stream of national park in Turkey, value of Shannon diversity index was found between 1.48 and 3.21(Turkmen and Kazanci, 2010) which indicates diverse composition of organisms. Vyas *et al.* (2012) observed the value of Shannon diversity index was between 1.14 and 2.75 during their study of River Narmada and in Mouri river of Khulna, Bangladesh with the range of 1.20 to 1.49 (Khan *et al.*, 2007).The minimum value of Shannon-Wiener index was recorded at Station P3 and Station P4 which clearly reflected heavy pollution of river Parbati at these stations. Samweel and Nazir (2014) employed Shannon-Weiner diversity index (H') to study the diversity of aquatic insects in Song River of Rajaji National Park, India, and observed that Shannon index for aquatic insects remained above 3.0 throughout the study period indicating good quality of water.

Shannon's diversity index, Simpson's diversity index, Margalef richness and Evevnness values exhibited higher values at the Stations (P2 and P5) confirming that these stations possessed rich diversity whereas lower values were obtained from the stations (P3 and P4) predicting less diverse conditions. The maximum diversity at P2 and p5 is due to good riparian vegetation, which provide high nutrient sources for macroinvertebrates (Legendre, 1998) and well balanced habitate substratum because the distribution pattern of macrobenthos is related to the bottom substrate (Medupin, 2020) as these species showed their presence on habitats such as sand, gravel, cobble, boulders or moss while as the minimum richness and diversity was recorded at P3 and Station P4 low diversity of macroinvertebrates in these station is related to lack of riparian vegetation (Patang *et al.*, 2018). Further lower index value at these Stations is due to intense human activities (bathing, washing, urban location and highway road connectivity) which produce the high pollution load

(Setiawan, 2009). The dominances of Chironomus at Station P4 and P3 indicates the increase of nutrient enrichment such as nitrates and phosphate, because under such conditions only certain types of organism like Chironomus sp. can survive due to their ability to tolerate the high organic contamination (Mariantika and Retnaningdyah, 2014).The dominance of Chironomous at more polluted Stations is also in accordance with Ganie *et al.* (2018). Several authors also attributed increased diversity and species richness to habitat heterogeneity and downfall concerned with human impacted sections (Mendoza and Catalan, 2010; Cummins, 1973; Roy and Gupta, 2010 and Sharma *et al.*, 2013).

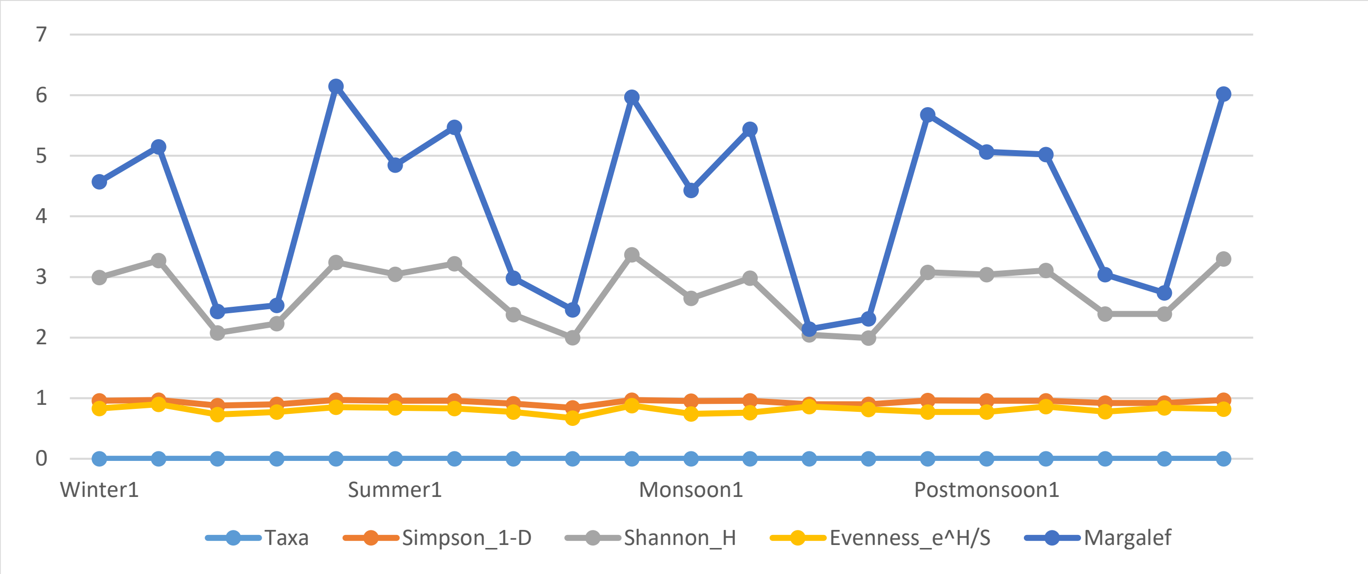


**Figure -3:** Showing Station wise diversity indices during different season

### 3.3 Biological Monitoring

### 3.3.1 Biological Monitoring Working Party (BMWP)

Biotic indices are numerical expressions combining a quantitative measure of species diversity with qualitative information on the ecological sensitivity of individual taxa, among others. They are based on two principles:

(1) Macroinvertebrates Plecoptera, Ephemeroptera and Trichoptera which are most sensitive orders disappear as the organic pollution level rises.

(2) The number of taxonomic groups is reduced as pollution increases (Hellawell, 1986).

BMWP score ranged from (24-112) as shown in figure 4,Station P1 (81), P2 (112) and P5 (99) possessed good water quality due to the presences of diverse species which contributes for BMWP score and conforms the good water quality at these stations. Guimaraes *et al*. (2009) also observed higher values of BMWP index in stream 1 which is located in natural reserve they suggested that BMWP better reflected environmental quality of streams, referring to the good quality of stream 1among other streams in the urban area of Uberlandia. Similar kind of study was also conducted by (Kazanci *et al.*, 2015) in Coruh River (Turkey) where the unimpacted Station was characterized with rich fauna and high BMWP score, while as stations P3 (26) and P4 (24) possessed poor water quality status. The mere possession of bad water quality status at Station p3 and p4 is attributed to the decline of benthic community due to decreased DO and increased relative nutrient load (Sultana & Seshi Kala, 2012). The human-induced changes in the river at these stations affect physical structure of the stream bed ,concentration of dissolved chemical in water, living organisms and ecosystem functioning (Pliuraite and Mickeniene, 2009).The similar type of study was carried on urban river of Sungal, Penchala, Malaysia where WQI and BMWP showed distorted water quality( Mahazar *et al.*, 2013).Further BMWP score was observed high in winter season and signifying presence of more number of species whereas, lowest in monsoon which shows lesser score signifying presence of less number of species (Mahazar *et al.*, 2013) recorded higher values of BMWP from the upstream section of Sungai Penchala in winter and minimum in monsoon.

### 3.3.2 ASPT (Average Species Per Taxa)

ASPT ranged from 2.75-5.8) as shown in figure 5 station P1 (5.8), P2 (5.4) and P5 (5.02) possessed good water quality this is due to the presences of dominance of macrobenthos species especially orders

(Ephemeroptera and Odonata) at these Stations which are sensitive and contributes more for ASPT (Kani and Murugesan, 2014) while as station P3 (3.18) and P4 (2.75) possessed poor water quality status. The decreased ASPT value is related to the increased pollution load at these stations which led to decline of sensitive species and in turn decrease the ASPT score (Hassan *et al.*, 2005). Solimini *et al.*, (2000) recorded decreased value of ASPT at urban rivers.

Stations P1, P2 and P5 fall in good quality as per ASPT and BMWP as shown in (Figures 4 & 5 ). The Co-dominance of orders (Ephemeroptera and Odonata) at these Stations confirms the findings ASPT and BMWP because these orders are intolerant to organic matter contamination Kazancı *et al*., (2013).Davis *et al*., (2003) also confirmed that ephemeroptera, plecoptera and trichoptera (EPT), crustacean and isopoda order were much higher at the reference Station or unpolluted area. While as Statioin P3 and P4 have dominance of species from phylum annelid (*Limmodrilus hoffmeisteri, Tubifex tubifex and Tubifex albicola)* and order diptera (*Chironomous* sp) hence these stations falls in poor quality as per the biotic index. The high dominance of these species is an indication of pollution as organism like *Chironomus* sp has ability to tolerate the high organic contamination (Mariantika & Retnaningdyah,2014).

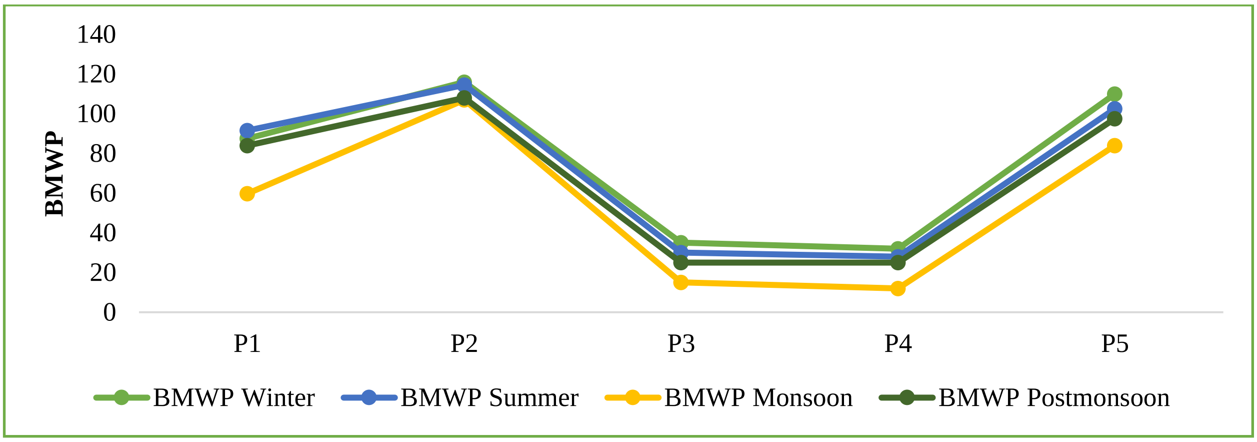


**Fig-4 :** Shows BMWP score during study

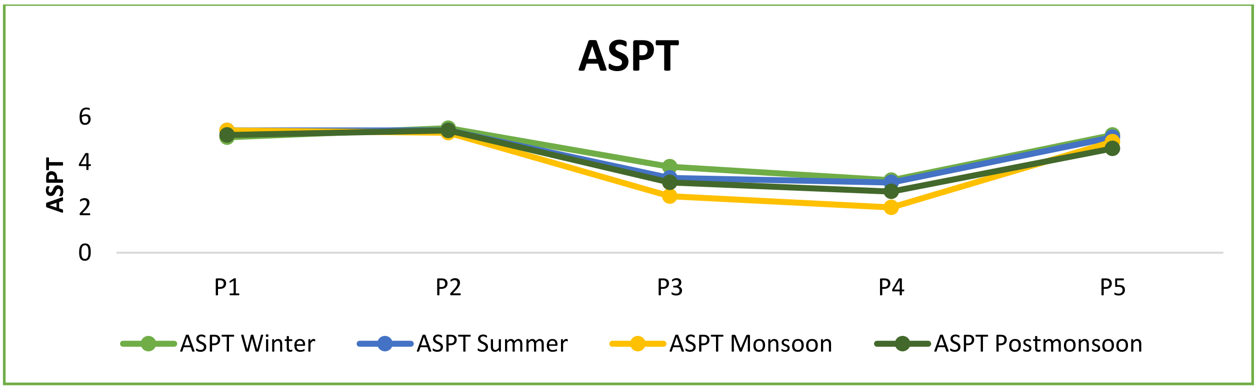


**Fig-5 :** Shows ASPT score during study

### 3.5 Water Quality Index

During the present investigation water quality index was applied at Parbati River. The overall water quality index value and water quality status of all sampling stations is given in (Table -5)

**Table-5: Showing WQI at Parbati River River in different seasons**

| Stations | Winter | | Summer | | Monsoon | | Post Monsoon | |
|---|---|---|---|---|---|---|---|---|
| | WQI | Status | WQI | Status | WQI | Status | WQI | Status |
| P1 | 35 | Good | 36.4 | Good | 30.8 | Good | 41.6 | Good |
| P2 | 39.5 | Good | 27.9 | Good | 28.8 | Good | 36.6 | Good |
| P3 | 44.7 | Good | 58.9 | Poor | 60.2 | Poor | 59.4 | Poor |
| P4 | 55.7 | Poor | 63.4 | Poor | 58.9 | Poor | 52.9 | Poor |
| P5 | 30.8 | Good | 33.5 | Good | 27.7 | Good | 32.3 | Good |

On overall basis it was found that station P1 (35.95), P2 (33.2) and P5 (31.07)(table 6) possessed good water quality this is due to the dense riparian vegetation, found on the banks of the river which provide high nutrient sources for macroinvertebrates and also play a prominent role in the remediation of contaminated water by pesticides and detergent active ingredients before entering the rivers (Legendre, 1998), while as station P3 (55.8) and P4 (57.72) possessed poor water quality status. The mere possession of bad water quality status at stations P3 and P4 is attributed to the anthropogenic activities in the vicinity of the river as several activities are being practiced at station P4 like Klin factory and cremating activities, while as at station P3 is area around the Astha main town were lot of anthropogenic activities are done.The anthropogenic activities including sewage disposal by the communities residing in the catchment area, agricultural runoff and unprotected river Stations has been found to deteriorate water quality status (Shah and Joshi, 2017).

WQI were observed to have a positive relationship with the seasonal changes. The maximum WQI values were recorded during summer from all the five stations followed by Monsoon, post monsoon and winter. The present investigation revealed that decrease in water level and increased accumulation of contaminants along the Parbati River is main cause of rise in WQI during summer and the minimum value during winter could be due to the absorption of contaminants by healthy riparian vegetation that is present along the river ,a similar finding has also been reported by researchers like (Bora and Goswami,2017) in their studies of assessment of surface water quality status of Kolong river and Nambul River.

### 3.4 Correlation Analysis

The various water quality parameters viz; temperature velocity, pH, Free CO2, DO, hardness alkalinity play a direct as well as indirect role in the distribution of macrobenthic diversity (Ishaq and Khan, 2014) thus supporting the resistant and sensitive species accordingly (Table 6).

During the study period various species recorded positive correlation while others recorded negative correlation with some of physicochemical parameters (Table 6). During the correlation analysis species viz., Culex, Gomphus, Anax, Notonecta, Gerris, Baetis, Palaemonetes, Ephemerella showed negative correlation with Cl, EC, TDS TH and TA but significant positive correlation with transparency the results are supported by (Jenila and Nair, 2012) reported negative correlation between insect population with nitrate and phosphate from kanyakumari. Hirudiniaria sp. and Chironomous sp. showed significant positive correlation with EC, TDS, pH, nitrate, Total hardness and Total alkalinity. Similar trends in the correlation between the physicochemical parameters and the distribution of organisms have been reported by many scientists such as (Baker *et al.*, 1979; Ogbeibu 2001). Further Lamellidens marginalis showed negative correlation with TDS and CL while positive with DO, Baetis sp.showed positive with pH and DO Lymnaea acuminate showed positive correlation with transparency, Radiatula oocata sp showed negative correlation with DO and TH. The results are supported by the work of Sharma and Chowdhary (2011) which also reported negative correlation of arthropoda with water temperature, mollusca with pH and Chloride. Likewise (Gupta and Narzary, 2013) also reported nitrates along with DO and CO2 to regulate the biodiversity of aquatic insects in phulbar lake Assam.

Table-6: Showing correlation between Taxa and physico-chemical parameters.

| | Ph | CL | TDS | COND | DO | TP | Pht | Nit | TH | TA | BA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lymnaea acuminate | | | | | | 0.747 | | | -0.603 | | |
| Radiatula oocata | | | | | | 0.817 | | | | | |
| Pisidium nevillianum | | | | | -0.624 | | | | -0.624 | | |
| Lamellidens marginalis | | -0.703 | | | 0.6418 | 0.765 | | | -0.722 | | |
| Hirudiniaria sp | | 0.791 | 0.7655 | 0.706 | | | 0.726 | 0.63 | 0.7405 | 0.6444 | 0.709 |
| Chironomus chironomus | | 0.853 | 0.7994 | 0.694 | | | | 0.83 | 0.8534 | | |
| Culex sps. | | -0.736 | -0.679 | -0.62 | | | -0.602 | | -0.814 | | |
| Gomphus sps. | | -0.697 | | -0.62 | | | | | -0.645 | | |
| Anax sps. | | -0.732 | -0.698 | -0.68 | | | | | -0.742 | -0.679 | -0.683 |
| Notoneta sps. | | -0.676 | | | | 0.785 | | | -0.618 | -0.601 | |
| Gerris sp. | | -0.68 | | | | 0.707 | | | -0.627 | | |
| Baetis sp. | 0.623 | | | | 0.6549 | 0.804 | | | -0.649 | | |
| Palaemonetes sps. | | -0.658 | | | | 0.655 | | | -0.701 | | |
| Cordulegaster sps. | | | | | | 0.655 | | | | | |
| Ephemerella sp. | | -0.688 | | | | | | | -0.677 | | |
| Thiara scabra | | | | | | 0.832 | | | | | |
| Sigara sp | | | | | | 0.789 | | | | | |
| Thiara tuberculata | | | | | | | | | | | -0.606 |

## 4. Conculsion

On the basis of obtained results, the present study revealed that the benthic fauna mainly dominates during winter in Parbati River due to the availability of phytoplankton density, low temperature and more dissolved oxygen. However, the least macroinvertebrates diversity during monsoon is due to surface run-off containing inadequately treated sewage and dilution of water which in turn affects the distribution of benthos due to increased load of suspended solids, reduced transparency and increased water flow. On the basis of diversity indices Stations P1, P2 and P5 of Parbati River revealed rich diversity while P3 and P4 showed least diversity. The low diversity of macroinvertebrates at Stations P3 and P4 is attributed to destruction of riparian zone due to intense human activities.

Based on WQI values of Parbati River generated from physicochemical parameters P1, P2 and P5 revealed good water quality status while stations P3 and P4 revealed poor water quality. On the other hand the good water quality status at Stations P1, P2 and P5 and poor water quality at Station P3 and P4 were also confirmed by Biotic indices (BMWP and ASPT) generated from macrozoobenthos. The dominance of Chironomus sp at station P3 and station P4 indicates the increase of nutrient enrichment (nitrates and phosphate), because under such conditions only certain pollution tolerant species can survive due to their increased ability to tolerate the high organic contamination, hence showed poor water quality at these stations. Although the Parbati River is rich in benthic diversity but due to increased human interventions the river health is proceeding towards deterioration, hence forth measures should be taken to prevent anthropogenic pressure nearby Parbati River to improve its water quality and biodiversity.

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