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Research Article

BIOMONITORING STUDY OF RIVER NARMADA IN JABALPUR REGION WITH SPECIAL REFERENCE TO BENTHIC MACROINVERTEBRATES

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ABSTRACT

Water pollution is essentially a biological problem. Physico-chemical monitoring and biological parameter indicates the health of river. The present research has been focused on Narmada river in Jabalpur region in three selected sampling sites in Jabalpur region: Bargi Dam, Gwarighat and Bhedaghat. In the present study many of the physico-chemical parameters were showing highest value in Gwarighat while minimum in other stations. WQI value was decreased in IInd. It may be due to start of "Clean Narmada Abhiyan" and "Swachchhta Abhiyan" in Jabalpur as well as throughout the India. A total of 758 individuals of 55 families belong to 18 orders and 4 phylum. Further abundance status of identified families was categorized under four categories, very rare, rare, common and very common and those were 20%, 20%, 47% and 13% respectively. To compared 4 biotic indices used to evaluate water quality via benthic macro-invertebrates in order to determine health of river Narmada. The saprobic index, B-IBI and EPT% revealed the fair water quality. The calculation results for Hilsenhoff biotic index revealed very poor to good biological condition of water, in all the study Sites, slightly divergent from least disturbed condition.

INTRODUCTION

Water is one among the prime necessities of life required for growth and activity of all living beings on globe. It is also known as 'blue gold'. About 98% of planet's water is salt water which is unusable for drinking, only 0.036% freshwater that is found in rivers and lakes. Colorless, tasteless, and odorless water is always pure. Most living organisms have 60% water in their body. Evolution of life on Earth was impossible without presence of water. The river Narmada is the third holy and seventh longest river of India among the fourteen major river basins. It originates from Amarkantak hills in the Mekhala range of Shahdol district, Madhya Pradesh. It lies between east longitude $72^0$32' and $81^0$45' and north latitude $21^0$20' and $23^0$45'.

In central India, Jabalpur is a major city, also known as 'Sanskardhani'. It is situated in the 'Mahakaushal' region of Madhya Pradesh. The city is located between 23°10' North latitude and 79°59' East longitude. River Narmada flows and passes from through the whole Jabalpur city as well nearby area of district and hence used in municipal supply as major drinking water source for the city people. According to CPCB (2007) census statistics, Jabalpur city ranks as third largest urban agglomeration in Madhya Pradesh and the 38th largest in India.

River restoration can be only done by using its natural structure and parameters such as the physico-chemical parameter or the composition of biological assemblages. In this context, change in several physicochemical features of River water has been ascertained. The physical and chemical characteristics of ecosystem have significant impact and influence on aquatic life (Agarwal *et al.,* 1976). Traditionally physico chemical analysis of water will help to know the water quality at the time of sample collection.

Biomonitoring of River Using Benthic Macroinvertebrate

Water pollution is essentially a biological problem. In order to achieve and maintain the highest water quality in lakes, rivers and streams, environmental advocating are using the resident organisms living in these waters as sensitive indicators of change. For river systems, the biomonitoring of aquatic invertebrates, such as insects, is recognized as an important tool for determining a rivers health and, with proper background data, identifying changes in that health. The benthic macroinvertebrates fauna of river is most suitable biological parameter of water quality evaluation in relation to

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biotic indices and diversity of species richness. Physico-chemical monitoring and biological parameter indicates the health of river. Benthic macro invertebrates are larger aquatic animals, bottom dwelling invertebrates which associate with bottom or any solid liquid interface retained by a sieve or mesh with pore size of 0.2mm to 0.5mm included Arthropoda, Annelida, Mollusca and others. Macroinvertebrates being a biological indicator are used to assess the water pollution. Although a large number of biological indicators are reported (Chessman *et al.,* 1999; Harris and Silveira, 1999; Kingsford, 1999), but benthic macroinvertebrates are most commonly used as biological indicator (Resh and Jackson, 1993; Smith *et al.,* 1999 and Kay *et al.,* 1999).

Plecoptera and Ephemeroptera animals are very sensitive to pollution. Odonata indicate input of little organic pollution in the slow moving or standing clean waters. Crustacea are moderately intolerant of pollution. Adult beetles are tolerant of a wide variety of pollutants. Some types of Mollusca are quite intolerant to pollution, while other is tolerant. Chironomous larvae or Red worms are very common indicator of highly polluted waters among the Diptera group. These species are tolerant to the organic pollution and found in high abundance in sedimentation area. Red tailed maggots are typical indicators of severely polluted waters their presence indicates very low oxygen contents of water.

Water Quality Indices

The water quality information should be accurate and fetch on time because it is necessary to improve water quality management programs for the environmental and public welfare to the concerned citizens and policy makers. Indices are broadly classified in two parts, first biological indices and second physicochemical indices. Various biological indices are derived from biological information to calculate the effect of aquatic ecosystem using taxa composition of the sample, diversity of various taxa, their distribution pattern and presence or absence indicator species or group while for physicochemical analysis water quality index is applied.

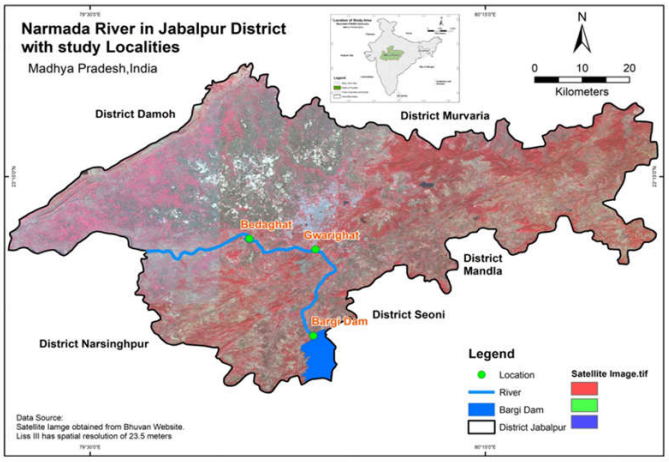
MATERIAL AND METHODS

The present research has been focused on Narmada river basin and specifically in three selected sampling sites in Jabalpur region: Bargi Dam, Gwarighat and Bhedaghat. The study sites are ideal for river water quality study as it covers various gradients in substrate composition, high biotic pressure on the study sites and surrounded by hilly topography with natural vegetation as well as unmanaged tourism which increases pollution load.

Bargi dam is the first sampling site, situated at South East of Jabalpur at a distance of about 40 km from Jabalpur city. It is located between 22°56'30.12'N Latitude and 79°55'30'E Longitude. Topo-sheet no. 55N/4, UTM Zone 44.

Gwarighat is situated at the bank of river Narmada on Narmada road. Geographically it is located between 23°6'29'N Latitude and 79°55'42'E Longitude. It is 7 km from Jabalpur railway station. Topo-sheet no. 55M/16, UTM Zone 44.

Bhedaghat is situated by the side of River Narmada at 23° 7' 55.2' N at Latitude and 79°48'3.6'E Longitude and 408m from the sea level, approximately 21 km away from Jabalpur city. Topo-sheet no. 55M/4, UTM Zone 44.



Map 1 Showing study sites in Narmada river at Jabalpur district

Water samples were collected and analyzed from the three sampling sites from November 2015 through October 2017 at least once a month under condition in about 56 Km stretch right from Bargi dam to Bhedaghat for physicochemical as well as biochemical component. Length of Narmada river has been divided into two sampling segments which were upstream and downstream named as station 1 and station 2 respectively for each site that were finally made into one composite sample. November 2015 to February 2016 were considered as Winter Season I, where total four sampling have been done for every season namely, Summer Season I (March-June 2016), Rainy Season I (August-October 2016), Winter Season II (November 2016-February 2017), Summer Season II (March-June 2017) and Rainy Season II (August-October 2017). Thus total 24 sampling have been done in the duration of two years. Water samples and biological samples were collected as per standard sampling technique during morning time between 8-9 am and evening time 5-6 pm. Random sampling was done on the selected stations of imaginary quadrate in the river. In order to maintain consistency, the method of sample collection at every sampling station has remained essentially the same throughout work duration from year by year. Samples were collected from different methods for physico-chemical analysis as well as biological monitoring.

Table 1 Water Quality Parameter Guideline Value

S.No	Physico Chemical Parameter	Volume required (in ml)	Technique/Apparatus Used	Unit	Indian Standard
1	Temperature	Not required to collect (Into stream)	Thermometer	^{0}C	15°C maximum (fresh water aquatic life)
2	Turbidity	100	Turbidity meter	NTU	01
3	pH	20	pH meter	-	6.5-8.5
4	Conductivity	100	Conductivity meter	mg/L	300 µS/cm
5	Total Dissolved Solid	200	Filtration method	mg/L	500mg/L
6	Dissolved Oxygen	300	Winkler's method	mg/L	05 mg/L
7	Biochemical Oxygen Demand	1000	Winkler's method	mg/L	5mg/L

8	Chemical Oxygen Demand	50	Potassium dichromate reflux method	mg/ L	10mg/L
9	Chloride	50	Silver nitrate titration	mg/ L	250 mg/L
10	Total Hardness	100	EDTA titration	mg/ L	300 mg/L

Computation of Water Quality Index (Wqi)

In the present of research eight water quality parameters were chosen for calculating water quality index which were pH, turbidity, conductivity, Dissolved oxygen, total dissolved solids, chloride, BOD, COD and total hardness.The WQI was calculated by applying the standard of drinking water quality recommended by WHO, Bureau of Indian standards (BIS) and Indian Council of Medical Research (ICMR) (Yogendra and Puttaiah, 2008). The approach of Brown *et al.,* (1975) was rather used to calculate the WQI of river Narmada which has been named as Weighted Arithmetic Index Method. WQI was calculated by aggregating the quality rating with unit weight linearly in a equation which is given below:

$$\mathbf{WQI} = \sum \mathbf{Q_n} \times \mathbf{W_n} / \sum \mathbf{W_n}$$

Applying above equation seasonal Water Quality Index for each site which is shown as $WQI_{Sw}$for winter season, WQI_{Ss} for summer season, and $WQI_{Sr}$for rainy season as well as annual Water Quality Index for each site isshown by WQI_{Y1} and WQI_{Y2} for first year and for second year was calculated to compare the water quality status of various sites. Generally, Water Quality Index was examined for a particular and planned utilization of water. According to Chaterjee & Raziuddin (2002), the considerable and permissible WQI as well as WQI showing status of water qualityfor human consumption.

Benthic Macroinvertebrates Monitoring

Benthicmacroinvertebrates are bottom dwelling organisms that inhabit the sediments or other substrates of aquatic ecosystem. According to Hynes (1963) these are visible to the unaided eyes while in actual some are difficult to see without magnification. The samples were collected in the morning 8-9 am and evening 5-6 pm once in a month from each sampling station.

The samples with screened material were washed into a container and fixed the material in a solution of FAA (Formaldehyde, Acetic acid, 70% Alcohol 5:5:90) by Pennak (1989). The collected samples were transferred to be laboratory for identification. Identification of macroinvertebrates was done up to family level by using available keys a Fauna of British India and 'A guide to the study of Freshwater Biology' by Needhem and Needhem (1962); Aquatic Entomology: The Fishermen's and Ecologist Illustrated Guide to insects and their relatives by Patrick and Cafferty (1981); Fresh water molluscs of India by Rao (1993). The identification of the organisms was also carried out by taking the help of Zoological survey of India Jabalpur and Kolakata.

Biotic Indices

Biotic Index is utilized to screen the pollution sensitive taxa. A few organisms are more pollution tolerant than others where stoneflies, mayflies and caddis flies also referred as the "River Canaries" as they are so sensitive to pollution that means indicates great water quality.

Saprobic Index

Saprobic Index is a quantitative method which was based on presence of benthic Macroinvertebrate up to family level of taxonomic precision by utilizing information from their individuals were encountered. Saprobic Index was calculated as per the following formula given by Biological Monitoring Working Party (BMWP, 1978).

Hilsenhoff Biotic Index (HBI) for Arthropods on Family Level

Hilsenhoff (1988) was proposed a biotic index specially for some indicator taxa where the organisms were assigned a "quality" value which was ranging from 0 to 5 (Hilsenhoff, 1988).

Benthic Index of Biological Integrity (B-IBI) on Family Level

5 metric indexes were used for variety of estimations to survey the biological condition, or health of river. The 5-metric Benthic Index of Biological Integrity (B-IBI) is one such benthic macroinvertebrate multimetric index after identifying all taxa upto family-level has been provided a relative integrity score. The 5 metrics are given are total taxa richness, Ephemeroptera taxa richness, Plecoptera taxa richness, Trichoptera taxa richness and percent dominance.

EPT Percent

The EPT Richness Index assess the water quality by relative abundance of three noteworthy orders of river insect that have low tolerance to water contamination or pollution CPCB (2007).

RESULT

Water quality can be assessed by analysis of its physical chemical and biological parameters. In the present investigation water quality of river Narmada has been assessed in Jabalpur region during two years (November 2015 to October 2017) of study using its all three physical, chemical and biological component.

Water Quality Study using Physico-Chemical Parameters

This chapter explains and discusses results of all three sampling sites that spanned almost two years for analysis for water quality parameters. Sampling and study of river Narmada was begins in November 2015 and end in October 2017. Water sampling was done two times every month, where consecutive four months reading together form average seasonal reading of each water quality parameter. Water quality status was determined in six stations of three study sites by assessment of following ten physico-chemical parameters discussed below in Table 2:

Table 2 Physico-chemical Parameters mean values in all three sites

S.N.	Physico-chemical Parameter	Ist year Mean	IInd year Mean
1.	Temperature	25˚C	24.1˚C
2.	Turbidity	5.9 NTU	5.9 NTU
3.	pH	7	6.9
4.	Conductivity	631.3 µS/cm	632.1µS/cm
5.	Total Dissolve Solids (TDS)	751.6 mg/l	733.4 mg/l
6.	Dissolved Oxygen (DO)	6.2 mg/l	6.1 mg/l
7.	Biological Oxygen	4.2 mg/l	4.1 mg/l

	Demand (BOD)		
8.	Chemical Oxygen Demand (COD)	5.9 mg/l	5.9 mg/l
9.	Total Hardness	145.4 mg/l	146.1 mg/l
10.	Chloride	30.7 mg/l	31.1 mg/l

Temperature

The annual mean temperature was 25˚C and 24.1˚C for Ist and IInd year respectively for all three sites. Throughout the year maximum temperature was 35.4˚C reported in Bhedaghat during June while minimum was 14.3˚C again in Bargi dam during March in both the year.

Turbidity

The annual mean turbidity was 5.9 NTU for both the year in all three sites. Throughout the year maximum seasonal mean Turbidity was reported in Gwarighat during rainy season while minimum in Bhedaghat during winter season.

pH

The annual mean pH was 7 and 6.9 for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean pH was reported in Bargi dam during rainy season while same minimum value in all the station during all season.

Conductivity

The annual mean temperature was 631.3 µS/cm and 632.1µS/cm for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean Conductivity was reported maximum in Gwarighat during rainy season while minimum Bargi dam value in all the station during all season.

Total Dissolved Solids (TDS)

The annual mean TDS was 751.6 mg/l and 733.4 mg/l for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean TDS was reported in Gwarighat during rainy season while minimum in Bargi dam during winter season.

Dissolved Oxygen

The annual mean DO was 6.2 mg/l and 6.1 mg/l for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean DO was reported in Bargi dam for Ist year and Bhedaghat fro IInd year during all seasons while minimum in Gwarighat in all seasons.

Biological Oxygen Demand

The annual mean BOD was 4.2 mg/l and 4.1 mg/l for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean BOD was reported in Gwarighat during all season while minimum in Bargi dam in all season.

Chemical Oxygen Demand

The annual mean COD was 5.9 mg/l for both the year in all three sites. Throughout the year maximum seasonal mean COD was reported in Bargi dam while minimum in Gwarighat during winter season.

Chloride

The annual mean Chloride was 30.7 mg/l and 31.1 mg/l for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean chloride was reported in Gwarighat while minimum in Bargi dam.

Total Hardness

The annual mean Total hardness was 145.4 mg/l and 146.1 mg/l for Ist and IInd year respectively for all three sites. Throughout the year maximum seasonal mean chloride was reported in Gwarighat while minimum in Bargi dam.

Water Quality Index (Wqi)

Water quality index represent the integrated effects of the relevant water quality variables in different study sites. WQI value was found to be 64.106 and 59.674 in Ist and II nd year respectively in all seasons at all sampling sites. WQI value was decreased in IInd year which shows water in 1st year was of poor quality than IInd year study. It may be due to start of "Clean Narmada Abhiyan" and "Swachchhta Abhiyan" in Jabalpur as well as throughout the India.

Thus the previous study of WQI in Narmada River showed significant difference and overall indicate fair water quality than those of other research.

Benthic Macroinvertebrates

Aquatic macroinvertebrates, among other groups, have been used to develop biotic water quality indices based on sensitive taxa, tolerant taxa or other metrics that represent macroinvertebrates assemblages (Hering *et al.,* 2006 and Stoddard *et al.,* 2008). A total of 758 individuals of 55 families belong to 18 orders and 4 phylum's were identified and illustrated in Table 3 with their common name, and relative abundance in Narmada river at Jabalpur region during 2015 to 2017. Further abundance status of identified families was categorized under four categories, very rare, rare, common and very common and those were 20%, 20%, 47% and 13% respectively.

Table 3 Family Level Distribution, Diversity and Abundance of Benthic Macroinvertebrates in Narmada River

S.n	Name of family	Common name	Total no. Of individual	Abundance status
	PHYLUM : PLATYHELMINTHES			
	CLASS : TURBELLARIA			
	ORDER : TRICLADIDA			
1.	Family : Planariidae (Stimpson, 1857)	Planaria, Flat worm	1	Very Rare
	PHYLUM : ANNELIDA			
	CLASS : CLITELLATA			
	ORDER : HAPLOTAXIDA			
2.	Family : Tubificidae (Naididae) Ehrenberg, 1828	Clitellate oligochaete worms	25	Very Common
	PHYLUM : ARTHOPODA			
	CLASS : INSECTA			
	ORDER : HEMIPTERA (True Bugs)			
3.	Family : Nepidae (Latreille, 1802)	Water scorpions	8	Rare
4.	Family : Notonectidae (Latreille, 1802)	Backswimmers	5	Rare
5.	Family : Corixidae	Water	13	Common

	(Leach, 1815)	Boatmen		
6.	Family : Mesovellidae (Douglas & Scott, 1867)	Water Teaders or pondweed bugs	5	Rare
7.	Family : Vellidae (Amyot & Serville, 1843)	Riffle bugs, small water striders	7	Rare
8.	Family : Gerridae (Leach, 1815)	Water striders,	24	Common
9.	Family : Pliedae (Fieber, 1817)	Pygmy backswimmers	4	Very Rare
10.	Family : Belostomatidae (Leach, 1815)	Giant water bugs	17	Common
	ORDER : DIPTERA (True Flies)			
11.	Family : Simulidae (Newman, 1834)	Black fly	9	Rare
12.	Family : Chironomidae (Macquart 1838)	Non-biting midges, or lake flies	19	Common
13.	Family : Tipulidae (Latreille, 1802)	Crane fly	17	Common
14.	Family : Tabanidae (Latreille, 1802)	Horse fly	4	Very Rare
15.	Family : Culicidae (Meigen, 1818)	Mosquitoes	19	Common
	ORDER : COLEOPTERA (Beetles)			
16.	Family : Psepheniidae (Lacordaire, 1854)	Water-penny beetles	4	Very Rare
17.	Family : Dytiscidae (Leach, 1815)	Predaceous diving beetles	4	Very Rare
18.	Family : Elmidae (Curtis, 1830)	Riffle beetle	13	Common
19.	Family : Dryopidae (Billberg, 1820)	Long-toed water beetles	1	Very Rare
20.	Family : Gyrinidae (Latreille, 1802)	Whirligig Beetles	13	Common
21.	Family : Hydrophilidae (Latreille, 1802)	Water Scavenger Beetle	13	Common
	ORDER : ODONATA			
	SUB ORDER : ZYGOPTERA (Damselflies)			
22.	Family : Lestidae (Calvert, 1901)	Spread-winged damselflies	19	Common
23.	Family : Platycnemididae (Jacobson and Bianchi, 1905)	White-legged damselflies	16	Common
24.	Family : Coenagrionidae (Kirby, 1890)	Narroww-winged damselflies	23	Common
	SUB ORDER : ANISOPTERA (Dragonflies)			
25.	Family : Gomphidae (Rambur, 1842)	Clubtail dragonflies	16	Common
26.	Family : Aeschnidae (Rambur, 1842)	Darner	5	Rare
27.	Family : Cordulegasteridae (Calvert, 1893)	Spiketail dragonflies	18	Common
28.	Family : Cordulidae (Selys, 1871)	Emerald Dragonfly	13	Common
29.	Family : Libellulidae (Rambur, 1842)	Skimmers or perchers	14	Common
	ORDER: PLECOPTERA (Stoneflies)			
30.	Family : Perlidae (Latreille, 1802)	Stoneflies	12	Common
	ORDER: EPHEMEROPTERA (Mayflies)			
31.	Family : Ephemeridae (Linnaeus, 1758)	Burrowing Mayflies	4	Very Rare
32.	Family : Baetidae (Leach, 1815)	Small minnow mayflies	4	Very Rare
33.	Family : Heptageniidae (Needham, 1901)	Flat-headed mayflies	22	Common
34.	Family : Leptophlebiidae (Peters & Edmunds 1970)	Prong-gilled mayflies	15	Common
	ORDER: TRICHOPTERA (Caddisflies)			
35.	Family : Hydropsychidae (Curtis, 1835)	Net-spinning caddisflies	11	Common
36.	Family : Hydroptilidae (Stephens, 1836)	Microcaddisflies or purse-case caddisflies	5	Rare
37.	Family : Leptoceridae (Leach, 1815)	Long-horned caddisfly	14	Common
	ORDER: LEPIDOPTERA			
38.	Family : Pyralidae (Latreille, 1809)	Water Moth	25	Very Common
	ORDER: MEGALOPTERA			
39.	Family : Sialidae (Leach, 1815)	Alder fly	1	Very Rare
40.	Family : Corydalidae (Leach, 1815)	Dobsonfly	5	Rare
	CLASS: MALACOSTRACA			
	ORDER: DECAPODA			
41.	Family : Atyidae (De Haan, 1849)	Shrimp	10	Rare
42.	Family : Palaemonidae (Rafinesque 1815)	Prawn	23	Common
	ORDER: AMPHIPODA			
43.	Family : Gammaridae (Leach, 1813)	Gammarids	10	Rare
	CLASS: ARCHNIDA			
	ORDER: ARANEAE			
44.	Family : Pisauridae (Simon, 1890)	Nursery web spiders	4	Very Rare
45.	Family : Tetranychidae (Donnadieu, 1875)	Spider mite	8	Rare
	PHYLUM: MOLLUSCA			
	CLASS: GASTROPODA			
	ORDER: MESOGASTROPODA			
46.	Family : Viviparidae (J. E. Gray, 1847)	River snails or Mystery snails	30	Very Common
47.	Family : Thiaridae (Troschel, 1857)	Thiarids	39	Very Common
48.	Family : Bithyniidae (Gray 1857)	Mud snails	32	Very Common
49.	Family : Ampullariidae (J. E. Gray, 1824)	Apple snails	34	Very Common
	ORDER: BASOMMATOPHORA			
50.	Family : Lymnaeidae (Rafinesque, 1815)	Pond snails	14	Common
51.	Family : Planorbidae (Rafinesque, 1815)	Ramshorn snails or Orb snail	15	Common
	CLASS: BIVALVIA			
	ORDER: UNIONIDA			
52.	Family : Unionidae (Fleming, 1828)	River mussel	38	Very Common
53.	Family : Amblemidae (Rafinesque, 1815)	Freshwater mussels	16	Common
	ORDER: VENEROIDA			

54.	Family : Corbiculidae (Gray, 1847)	Basket clams	14	Common
55.	Family : Sphaeriidae (Deshayes 1855)	Pea clams or Fingernail clams	4	Very Rare
TOTAL NUMBER OF FAMILIES			55	
TOTAL NUMBER OF INDIVIDUALS			758	

In the present study total 9 species belongs to 7 families found under IUCN red data list record. These specimens identified during the two year study and these species were very common or common in Narmada river, Jabalpur. Out of 9 species 4 belongs to Arthropoda while other 5 belongs to Mollusca enlisted in Table 4.

Table 4 IUCN : RED DATA RECORD LISTThe IUCN Red List of Threatened Species 2010 Species and their Family recorded in Narmada River Jabalpur (M.P.) (IUCN, Red Data List, 2010) (Plate 1 & 2)

S.n.	Name of species	Taxonomy Phylum-animalia Class-order-family	Red list assessment by	Year	Status In jabalpur
1.	Agriocnemis pygmaea (Rambur, 1842)	Arthropoda -Insecta-Odonata - *Coenagrionidae*	Subramanian, K.A.	February 25, 2010	Common
2.	*Trithemis aurora* (Burmeister,1839)	Arthropoda-Insecta-Odonata-*Libellulidae*	Subramanian, K.A. & Dow, R.A.	February 20, 2010	Common
3.	*Trithemis festiva* (Rambur, 1842)	Arthropoda-Insecta-Odonata-*Libellulidae*	Dow, R.A.	June 29, 2007	Common
4.	Orthetrum sabina (Drury, 1773)	Arthropoda-Insecta-Odonata-*Libellulidae*	Mitra, A.	October 11, 2009	Common
5.	*Lymnaea luteola* Lamarck, 1822	Mollusca-Gastropoda-Hygrophila-*Lymnaeidae*	Madhyastha, A., Dutta, J. & Daniel, B.A.	March 3, 2010	Common
6.	*Bellamya bengalensis* (Lamarck, 1882)	Mollusca-Gastropoda-Architaenioglossa - *Viviparidae*	Budha, P.B., Dutta, J. & Daniel, B.A.	January 9, 2010	Very Common
7.	Tarebia lineata (Gray, 1828)	Mollusca- Gastropoda-Sorbeoconcha-*Thiaridae*	Budha, P.B.	January 9, 2010	Very Common
8.	*Parreysia caerulea* (Lea, 1831)	Mollusca-Bivalvia-Unionoida-*Unionidae*	Budha, P.B. & Daniel, B.A.	January 7, 2010	Very Common
9.	*Pila globosa* (Swainson, 1822)	Mollusca-Gastropoda-Architaenioglossa-*Ampullariidae*	Budha, P.B., Madhyastha, A. & Dutta, J.	March 3, 2010	Very Common

Interpretation of Water Quality

Water Quality Index (WQI) serves as single index that describes water quality of certain location at certain time using abiotic factors which provide the snapshot of water but several Biotic index can describe the water quality as a videography because organism can only survive in their favourable environment. In Ist year, according to the WQI values, river Narmada was in poor water quality but IInd year it was improved to moderate quality. Similar results were found through biotic indices which showed improved water quality in IInd year study.

The present study compared four biotic indices commonly used to evaluate water quality via benthic macro-invertebrates in order to determine health of river Narmada. The saprobic index, B-IBI and EPT% revealed the fair water quality. The calculation results for Hilsenhoff biotic index revealed very poor to good biological condition of water, in all the study Sites, slightly divergent from least disturbed condition. Comparative average values of indices revealed that the overall condition of river Narmada was improved from Ist to IInd year provided in the Table 5.

Table 5 Overall Health of River Narmada

S.N.	Biotic Index	November 2015- October 2016			November 2016- October 2017			River Health
		Bargi dam	Gwarighat	Bhedaghat	Bargi dam	Gwarighat	Bhedaghat	
1.	WQI	55.089	76.124	60.641	64.106	51.593	71.066	Moderately Polluted
2.	Saprobic Score	5.492	5.507	5.524	5.389	5.402	5.542	Moderately Polluted
3.	HBI	4.835	5.933	5.069	4.444	4.13	4.636	Fair - Good
4.	B-IBI	16	17	15	12	19	17	Poor - Good
5.	EPT%	8%	9.09%	10.98%	12.19%	14.45%	13.16%	Fair - Good
OVER ALL WATER QUALITY								FAIR

DISCUSSION

Many researchers have studied the ecology of polluted river. A detailed account of water pollution and its effect on soil environment have been presented in Pollution and Biomonitoring of Indian Rivers (Trivedy, 2000). Water Pollution, Laws and Remedies presented by Sahay and Avgerou (2002) deals with various types of water pollution and major sources of pollution of Indian rivers. Similarly, a detailed account of river pollution has been given in Ecology of Polluted Water by (Kumar, 2002).

Imtiyaz *et al.,* (2012) in a study on River Narmada evaluated various physico-chemical parameters characteristics and analyzed them as per standard method. Minimum value of total solids, BOD and Chloride were recorded in January month and maximum value in June-July months. The results further indicated that physico-chemical parameters of Narmada River are within WHO limits. From the data obtained from physico-chemical analysis Water Quality Index (WQI) is being calculated which is defined by Bordalo *et al.,* (2006) as a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality. Bharti and Katyal (2011) stated that WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for public policy makers to manage the water bodies.

Benthic macroinvertebrates are most preferable used in biomonitoring studies and is an important ecological tools to describe spatial and temporal changes in an aquatic ecosystem (Vyas *et al.,* 2010). The benthic community shows a range of taxa-specific responses to environmental stressor; these may be with respect to alteration in the food webs (Stockley *et al.,* 1998) or due to floods or drought (Covich, 1993 and Johnson *et al.,* 1998) that after the species composition of the benthic macro fauna.

Chandra *et al.,* (2010) A compendium on the Faunal resource of Narmada River Basin in Madhya Pradesh the present study embodies the enumeration together with distribution of 2422 species (665 are vertebrates and 1757 invertebrates) belonging to 40 different faunal groups so far known from the Narmada river basin covering 23 district of the Madhya Pradesh. While in present study 55 families were recorded.

CONCLUSION

On the basis of the present research, it can be concluded that the deterioration in the water quality was observed at Narmada river, Jabalpur region. WQI was somehow similar to the biotic indices which shows deteriorate river condition in Ist year of study while in IInd year water quality was improved may be due to various strict action has been taken by government and people.

Benthic macroinvertebrates community as a whole in the river has been found to have significant positive correlation with the physicochemical parameters. The results show that all the locations assessed for quality using macroinvertebrates and physicochemical analysis were in the range of water quality class III (Moderately Polluted) and the water cannot be used for direct drinking purposes as Narmada River water is a chief source for drinking and irrigation, hence it should be free from the impurities.

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