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# Rotifer diversity in most polluted areas (Mandideep and Nayapura) of river Betwa, Madhya Pradesh, India

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## Abstract

The aim of the study was to find out rotifers diversity in most polluted areas (Mandideep and Nayapura) of river Betwa. Survey and sampling took place between October-2011 to September- 2012, and two major stations and ten sampling sites were selected for the study. Thirty-four rotifers taxa were identified (34 species, 11 genera). In all members of rotifer most dominant species were *Brachionus* (18 species) and *Keratella* (06 species). Rotifers reached peak in density in the summer season, while minimum were in winter season. Physico-chemical parameters of river water Temperature, pH, Dissolve oxygen, Biological oxygen demand and Chemical oxygen demand were also measured and the correlation coefficient of physic-chemical parameter with rotifers were established, The rotifer significant relation with pH (0.810), inverse relation with dissolve oxygen (-0.314) while significant relation with BOD (0.430) and COD (0.220). The abundance of rotifers with various physico-chemical indicate that the selected sites station I and II is polluted from various industrial, domestic and municipal waste and the present of rotifers species at this sites shows indicator of pollution.

Key-Words: Rotifera, zooplankton, Mandideep, Biomonitoring, Betwa

## Introduction

Aquatic pollution in India has now reached at a critical point. Almost every river system in India is now polluted to a considerable extent. In developing countries 1.8 million people, mostly children, die every year as a result of water-related diseases (WHO, 2004).According to an estimate; about 80% of the total population in India is deprived of pure and safe drinking water. A recent study revealed that there were 1, 53,000 village in India, which had infected water supply. 90% of total drinking water is severally polluted. Ganga is the most polluted river in the world. Other Indian rivers include Damoder, Hoogly, kulu, which have almost the same story to reveal.

The word plankton is derived from the Greek *planktos*, meaning wandering. It is used to describe the small, usually immotile, freely floating organisms living in aquatic habitats (Powell *et al.* 1975). Plankton drives energy cycling in aquatic ecosystems as they are the productive base of food webs, converting basic forms of energy into forms usable by higher trophic levels (Vilar *et. al.*, 2003). Plankton growth and dynamics depends on the characteristics of their environment – light and nutrient availability, temperature, salinity, pH, currents, turbulence, and predation intensity.

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**Rotifers (Rotatoria)** are the microscopic pelagic living mostly in fresh water, and characterized by the presence of an anterior wheel like rotating structure called corona. Rotifers are important zooplankton and biotic component in fresh water ecosystem, comprising integral links of aquatic food-webs (primary as fish food) and contributing significantly to secondary productivity. The cosmopolitan distribution and occurrence in relation to water quality have been the attention of many planktologists (Cajander, 1983; Edmondson, 1959; Pennack, 1953; Sladecek, 1983). Rotifers are considered as most sensitive indicator of water quality (Ali *et al.* 1990).

As a group, the rotifers display an amazing range of morphological variation and adaptation. Among the zooplankton, rotifers respond quickly to the environmental stress so they can be used as a bioindicators of pollution, Bahura *et. al.*, (1993) reported that *Brachionus* and *Keratella* were indicators of eutrophication. There have been only limited investigations on the rotifer fauna of the Indian reservoirs and lakes which confined mainly on the systematic, seasonal occurrence and the spatiotemporal variations (C. George, 1961; Singhal *et al.*, 1989). Only a few Indian workers have reported the seasonal abundance of rotifers.

The river Betwa plays a significant role in the human life of the villages located in Mandideep, Nayapura and Bhojpur areas. It has become polluted at some places of Mandideep due to industrial activities and the confluence of sewage, domestic wastes and industrial effluents of many big and small enterprises with various types of organic compounds and heavy metals deterioted to human health and aquatic organisms. Urban areas, farms, factories and individual households – all contribute to the contamination of this river. The water quality in the stretch of the river Betwa extending from its origin near Mandideep industrial area up to Bhojpur remains poor because of the regular inflow of domestic waste of the Bhopal city through the Kaliyasot river and industrial/domestic waters from Mandideep (Kori *et. al*., 2006).

The present work is aim to understanding various types of pollution in River Betwa at selected sites, and observes the impact of pollution on different sites of River Betwa, both biologically as well as chemically; bio-assessment will be done by using zooplankton as bio-indicator of pollution.

## Material and Methods

**Study area (sampling sites):**

The Betwa is a river Northern India, and tributary of the Yamuna originating in the Kumra (Jhirri) village in Raisen district of Madhya Pradesh, India, the river basin lies between the latitudes of 22º 54' N and 26º00, N and the longitudes of 77º10' E and 80º20' E. The total length of the river from its origin to confluence with the Yamuna is 590 km. out of which 232 km. in Madhya Pradesh and the rest 358 km. in Uttar Pradesh (fig. no.1).

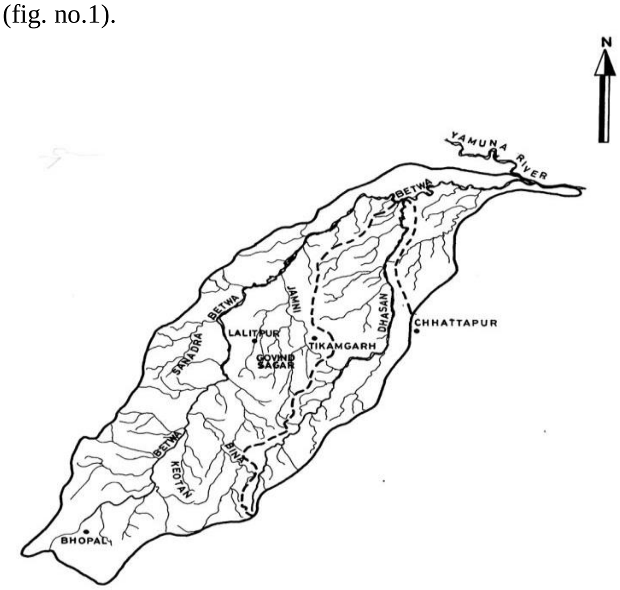



**Fig. 1: Index map of Betwa basin**

After the intensive survey of river Betwa ten sites were selected. The selected sites (Mandideep and nayapura) were affected with anthropogenic and industrial activities.

**Major Station I Nayapura (1 to 5 sampling sites):**

It is a village near Mandideep, the Betwa touches the boundary of this village near Road Bridge where it confluences with the Kaliyasot tributaries.

**Major Station II Mandideep (6 to 10 sampling sites):**

Mandideep is the municipality in Goharganj district Raisen in MP. Mandideep is 20 km away from Bhopal and popular as Industrial Township which came in to existence in late 1970s. It has an industrial area, the major industries that are closer are Hindustan Electro Graphite (HEG), Procter & Gamble, Eicher tractors Ltd, Lupin laboratories, and national and international level companies have their manufacturing units at Mandideep. It is located near River Betwa. River Betwa encircle this industrial area, thus, Mandideep was also selected as a study site in the present research work.

**Measurement of physico-chemical parameters:** The physico-chemical parameters temperature, pH, dissolved oxygen, Biological oxygen demand and Chemical oxygen demand were measured as per detail follows (APHA 1995).

**Temperature** :Systronic Labtronics laboratory digital thermometer (An iso 9001:2008 certified)

**pH** :Systronic Labtronics laboratory digital pH meter (An iso 9001:2008 certified)

**Dissolved oxygen**: Winklar`s method (Titrometric method)

**Biological oxygen demand** : 5 days incubation method

**Chemical oxygen demand** : Reflux index method (Titrometric method)

**Biodiversity of rotifers (Analysis of zooplankton):**

**Collection of zooplankton:** Plankton samples were collected from the surface water of the river. Each sample was collected by filtering 50 liters of water through mesh size 60-65µm plankton net.

**Preservation**: Plankton preserved in 5% formaline. Slide was prepared by using stain with fuschin acid.

**Quantitative analysis (counting):** The quantitative enumeration of the zooplankton was carried out with the help of a Sedgwick-Rafter (S-R) counting cell which is 50 mm long, 20 mm wide and 1 mm deep. Before filling the SR cell with sample, the cover glasses were diagonally placed across the cell and then samples were transferred with a large bore pipette so that no air bubbles in the cell covers were formed. The S-R cell was let stunned for at least 15 minutes to settle zooplankton. Then plankton on the bottom of the S-R cell was enumerated by compound microscope. By moving the mechanical stage, the entire bottom of the slide area was examined carefully. To achieve a random sampling, each time 3 fields were examined for each sample and an average of the counts had been recorded. The organisms thus counted, were expressed as cells per liter (cells) of the sample. From each sample 20 cells counts in 3 slides have been made to achieve random counts and an average of the counts has been recorded. Number of plankton (Zooplankton) in the S-R cell was derived from the following formula (Gosh, *et.al*., 2011).

$$No./ml = \frac{C \times 1000\ mm^3}{L \times D \times W \times S}$$

Where, C = Number of Organisms Counted; L = length of each strip (S-R cell length) in mm; D = depth of a strip (whipped grid image width) in mm; S = number of strips counted. The number of cells per mm was multiplied by a correction factor to adjust the number of organisms per liter (APHA 1976).

**Identification**: The zooplanktons were identified with the help of standard books and monographs as follows:

**Needham, J G. Needham, P. R. (1962):** A guide to the study of freshwater biology.

**Pennak, W. R. (1953):** Freshwater Invertebrates of the United States.

**Edmonson, W. T. (1965)**: Fresh water biology.United State of America.

**Ward, H. B. and Whipple, G. C. (1959)**: Freshwater biology, New York

**Altaff, K. (2003)**: A manual of zooplankton.

**Battish, S.K. (1992)**: Fresh water zooplankton of India.

**Dhanapathi, M.V.S.S.S (2000)**: Taxonomic notes on the Rotifers from India.

**Digital documentation:** Images of zooplankton or digital documentation were prepared by the Magnus (mips) live 2.0 usb camera attached with computer with 10X and 100Xmagnification.

**Statically analysis:** The correlation between rotifers and abiotic (physico-chemical) parameters was done by using coefficient of correlation Karl Pearson`s formula

$$r = \frac{\sum d_x d_y}{\sqrt{\sum d_{x^2} \sum d_{y^2}}}$$

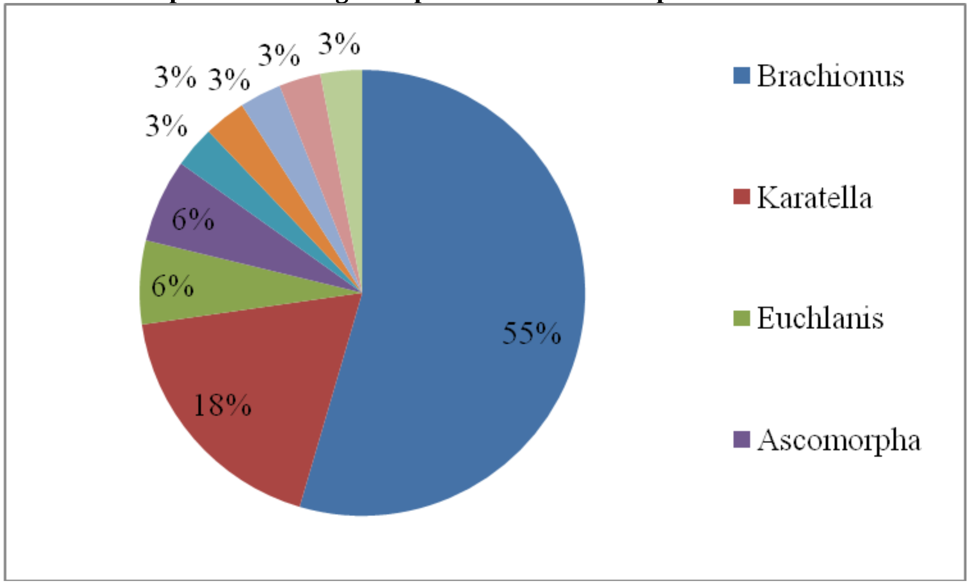
## Results and Discussion

Rotifers are economically and ecologically important group, they occupy a wide range of habitat existing in aquatic ecosystem. Recently it has shown that diversity abundance of rotifers is sensitive to change in water variables. During the period of study, Thirty-four rotifers taxa were identified (34 species, 11 genera). In all members of rotifer most dominant species was *Brachionus* (18 species) and *Keratella* (06 species). Thirty four species of Rotifers which is includes 18 species of *Brachionus*, 06 species of *Keratella*, 02 species each of *Euchionus* and *Ascomorpha* and 01 species of *Chromogaster* , *Harringia*, *Mikrocodides*, *Tetramastix*, *Notholca* (Graph.No.1& Table.No 1).

**Table 1: List of Rotifers at station-1 Nayapura and station-2 Mandideep**

| | | |
|---|---|---|
| *Brachionus bidentata* | *Brachionus murrayi* | *Keratella serrulata* |
| *Brachionus Rotundiformis* | *Brachionus plicatilis* | *Keratella tropica* |
| *Brachionus calyciflorus* | *Brachionus quadridentata* | *Keratella valga tropica* |
| *Brachionus caudatus* | *Brachionus rubens* | *Euchlanis dialatata* |
| *Brachionus diversicornis* | *Brachionus variabilis* | *Euchlanis deflexa* |
| *Brachionus calyciflorus f* | *Branchionus urceolaris* | *Asplanchna priodonta* |
| *Brachionus durgae* | *B. dichotomus reductus* | *Ascomorpha ecaudis* |
| *Brachionus falcatus* | *Keratella hiemalis* | *Ascomorpha saltans* |
| *Brachionus forficula* | *Keratella cochlearis* | *Chromogaster* |
| *Brachionus havanaensis* | *Keratella quadrata* | *Harringia eupoda* |
| *Mikrocodides chlaena* | *Tetramastix opoliensis* | *Notholca acuminate* |

**Graph 1: Percentage composition of different species of rotifers**




In addition the influence of biotic on abiotic parameters is correlated in order to understand ecological relationship. During the study period, minimum temperature $17^0$ C was measured in the month of February and the maximum temperature was $31^0$ C in the month of June, the hydrogen ion concentration (pH) value was ranged 5.3 to 6 at Nayapura and Mandideep . Dissolved oxygen mean value was maximum 3.1 mg/L. in winter season, while the lowest mean value of dissolved oxygen as 1.7. BOD value ranges between 12.2 mg/L. to 15.5 mg/l. at Nayapura and Mandideep. In Betwa river maximum value of COD (62 mg/L.), and minimum value of COD (55.5 mg/L.), have been recorded Highest value of COD indicates that most of pollution in study zone in Betwa river in caused by industrial effluents discharged by industrial units (Table No.2). In this study, pH ranged 5.3 to 6. The pH showed positive correlation (0.810) in relation to the population of rotifers in all ten study area. The population density and biodiversity of most rotifers genera showed inverse relation (-0.314) with DO of water in all the study areas. BOD ranged were 12.2 to 15.5 mg/L in the present study, the population of rotifers showed significantly positive correlation (0.430) with BOD of water in all the study area. In the present study minimum COD 55.5 mg/L. and maximum COD value 62mg/L. the rotifers population of rotifers showed positive correlation (0.220) with COD of river water (Table No.3).

**Table 2: Values of physico-chemical parameter at different sites of river**

| Months | Sites | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | M |
| | | | | | Temperature | | | | | | |
| Oct. | 21 | 20 | 20.5 | 21 | 21.4 | 22 | 20 | 21.1 | 22 | 22.4 | 21 |
| Dec. | 19 | 18 | 19.4 | 19 | 17.3 | 18.3 | 19.2 | 20 | 20.5 | 17.7 | 18.6 |
| Feb. | 16.3 | 17.5 | 17.2 | 18 | 16.5 | 18.5 | 19.2 | 17 | 19 | 18.5 | 17.5 |
| Apri. | 23 | 23.5 | 24.3 | 22 | 23 | 24 | 21 | 23 | 23.2 | 23.5 | 23 |
| Jun. | 30 | 30.2 | 31.3 | 29.5 | 32 | 31 | 31.6 | 30.2 | 32.2 | 31.2 | 31 |
| Aug. | 24 | 24.3 | 23 | 22 | 24 | 23 | 21 | 23.2 | 23 | 24.3 | 23.1 |
| | | | | | | pH | | | | | |
| Oct. | 6.3 | 6.1 | 6.2 | 6.4 | 6 | 5.8 | 5.5 | 5.7 | 5.9 | 6 | 5.8 |
| Dec. | 6.4 | 5.8 | 5.5 | 6 | 6.2 | 6.3 | 5.4 | 5.3 | 5.8 | 5.5 | 5.5 |
| Feb. | 6.2 | 6 | 6.3 | 6.5 | 5.7 | 5.3 | 5.2 | 5 | 5.8 | 5.1 | 5.3 |
| Apri. | 6.1 | 6.4 | 6.2 | 6.1 | 6 | 5.5 | 5.6 | 5.7 | 5.3 | 5.2 | 5.7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun. | 6 | 6.2 | 6.4 | 6.3 | 6.1 | 6 | 5.7 | 5.4 | 5.2 | 5.5 | 6 |
| Aug. | 5.8 | 5.4 | 5.6 | 5 | 5.3 | 5.5 | 5.1 | 5.4 | 5.8 | 5.2 | 5.7 |
| Dissolved oxygen | | | | | | | | | | | |
| Oct. | 2.4 | 2.2 | 2.6 | 2.8 | 2 | 1.8 | 1.6 | 2 | 2.2 | 1.5 | 2.1 |
| Dec. | 2.2 | 2.3 | 2.4 | 2 | 2.1 | 2.5 | 2 | 2.7 | 1.8 | 1.7 | 1.9 |
| Feb. | 2.8 | 2.9 | 2.6 | 2.5 | 3 | 3.1 | 3.2 | 2.2 | 2 | 2.4 | 2.7 |
| Apri. | 2.1 | 2.2 | 2.4 | 2.3 | 2.4 | 2.1 | 2.8 | 2.3 | 2.5 | 2.1 | 2.2 |
| Jun. | 1.8 | 1.9 | 1.5 | 1.3 | 1.6 | 1.3 | 1.2 | 1.9 | 1.5 | 2.1 | 1.7 |
| Aug. | 2.8 | 2.5 | 2.8 | 2.9 | 3.2 | 3.4 | 2.6 | 2.8 | 2.6 | 3.5 | 3.1 |
| Biological oxygen demand | | | | | | | | | | | |
| Oct. | 6.4 | 6.5 | 7.4 | 7.5 | 6.3 | 18.6 | 16.5 | 16.4 | 16.2 | 18.4 | 15.5 |
| Dec. | 8.4 | 8.2 | 8 | 8.5 | 8.2 | 16.3 | 16.7 | 17.4 | 16.8 | 16.5 | 12.2 |
| Feb. | 8.5 | 9.9 | 8.5 | 8 | 9 | 18.5 | 18 | 18.3 | 18.4 | 17.5 | 13.5 |
| Apri. | 10.2 | 10.4 | 10.5 | 10.2 | 9.8 | 19.4 | 19.5 | 19.8 | 19 | 19.2 | 14.5 |
| Jun. | 10.4 | 10.2 | 11 | 10.5 | 10.6 | 19.8 | 20.1 | 18.8 | 19.5 | 18.5 | 15 |
| Aug. | 9.5 | 9.8 | 9.4 | 9.2 | 9.1 | 18.6 | 18.5 | 19.5 | 18.4 | 18.2 | 14 |
| Chemical oxygen demand | | | | | | | | | | | |
| Oct. | 41.1 | 40.4 | 42.3 | 42.2 | 40.5 | 71.2 | 70.5 | 72.2 | 70.6 | 71.5 | 56.2 |
| Dec. | 38.4 | 38.5 | 38.6 | 38.2 | 38.9 | 72.5 | 71.3 | 73.5 | 72.2 | 73.8 | 55.5 |
| Feb. | 39.5 | 39.8 | 39.2 | 40 | 40.6 | 74.2 | 75.6 | 73.5 | 75.8 | 76.4 | 57.5 |
| Apri. | 41.5 | 40.5 | 42.5 | 40.3 | 40.2 | 78.5 | 76.4 | 72.3 | 78.5 | 72.2 | 58.2 |
| Jun. | 42.5 | 41.2 | 43.3 | 41.4 | 42.5 | 82.2 | 80 | 81.4 | 80.5 | 82.4 | 62 |
| Aug. | 41.5 | 40.3 | 42.8 | 40.6 | 40.8 | 81.8 | 82.5 | 80.4 | 83.2 | 80.6 | 61.4 |

**Table 3: correlation of rotifers with abiotic parameters**

| Parameters | Rotifera | Co-efficient of Corre. | Comments |
|---|---|---|---|
| Temperature | Rotifera | 0.110 | Significant |
| pH | Rotifera | 0.810 | Significant |
| DO | Rotifera | -0.314 | Inverse relation |
| BOD | Rotifera | 0.430 | Significant |
| COD | Rotifera | 0.220 | significant |

Zooplankton organisms occupy central position in the food webs of aquatic ecosystem. They do not only form an integral part of the lentic community but also contribute the biological productivity of the fresh water ecosystem (Wetzel, 2001). Due to short life cycle, zooplankton communities often respond quickly to environmental changes Sharma *et. al*., (2007). Rotifera are the most important soft bodied metazoans among the zooplankton. Species diversity was highest at station – II and III in river Betwa at Nayapura and Mandideep (graph no.2 & table no.1).

*Brachionus* and *Keratella* genus was abundant at station- II and III. The genus *Brachionus* is considered as a biological indicator for the eutrophication, and *Keratella* species has been indicated as an indicator of pollution Nogueira,2001; Sampath *et. al.*, 1978; Bahura *et. al*.,1993). Similar observation was also noticed by various workers Arora ,(1996) and Patil *et. al*., (2006). *Brachionus angularis, B. calyciflorus* and *B. diversicornis* are indicative of the mesosaprobic condition and *B. angularis* and *B. calyciflorus* are also having strong affinity to alkaline waters (Sladecek, 1983). The dominance of *Brachionus* and *Keratella* is the general trend in freshwater bodies in India (Singhal *et al.,* 1989; Sharma, 1988, Sukumaran and Das, 2003).

Temperature is very important in controlling the population density and diversity of rotifers. The surface of water directly receives solar radiation, suitable for the growth of plankton. The seasonal variation in the temperature of river water were observation all sampling stations. The seasonal variation showed a similar trend at all the stations. The temperature at station No.I & II was slightly higher because of mixing of sewage and industrial effluents. During the study period of investigation, due to shallowness of river Betwa at Mandideep, the water temperature has show a tendency to follow closely the atmospheric temperature. The findings were common with the observations of Malhotra *et. al.,* 1986; and Das *et. el.*,(2003).

The pH of a solution refers to its hydrogen ion activity and is expressed as the logarithm of the reciprocal of the hydrogen activity in moles per liter at a given temperature (APHA.1992). The pH expresses the intensity of acidity or alkalinity of an aquatic environment. The present finding reveal that in river Betwa pH fluctuate in station I Nayapura and station II Mandideep, In the present study low pH value were found may be due to industrial effluent of nearby industries. Effect of low pH on zooplankton was studied by Zhaung Dehvi (1995).

Dissolved oxygen (DO) levels in natural and waste water are dependent on the physical, chemical and biochemical activities prevailing in the water body. Running water contain relatively high concentration of dissolved oxygen. In the present finding, the volume as well as rate of flow of water decreases, while the disposal of waste water, industrial effluents and sewage remain virtually the same at station- II Nayapura and station- III Mandideep showed lowest value of dissolved oxygen. The same results were reported by Verma and Mathur (1971), Baruah *et.al.*, 1996. Minimum dissolved oxygen due to effluents discharge, Emongor *et. al.*, 2005.

Biological oxygen demand (BOD) is an important parameter which is widely used to determine the pollution load of waste water. Biological oxygen demand is the amount of oxygen required by microorganism for stabilizing biologically decomposable organic matter (carbonaceous) in water under aerobic condition. In the present finding the highest BOD value was recorded station I, and station –III Mandideep. Seasonal fluctuations in the hydro biological factors revealed higher value of BOD were observed during late summer (May-June). These were due to higher rate of decomposition of organic matter at higher temperature, turbidity and less water current (Sanap *et.al.*, 2006) . Similar observation recorded Sachidanandamurthy and Yajurvedi, (2004), and Pratima (2008).

Chemical oxygen demand is a test which is used to measure pollution of domestic and industrial waste. COD gives us reliable parameter for judging the extent of pollution in water (Shrivastava and Patil 2002). This makes COD useful as indicators of organic pollution in surface water (King *et. al.*, 2003). The chemical oxygen demand (COD) was higher than the NESREA (2011) and WHO (1993) values recommended for good water quality. High COD value at the discharge point could be due to high organic load of total solid and total suspended solid from industries. This could probably explain the linear relationship between solid and COD (Osibanjo and Adie, 2007). Highest value of COD indicates that most of pollution in study zone in Betwa river in caused by industrial effluents discharged by industrial units. Similar results were also reported by Pande and Sharma (1998). The population of rotifers seemed to be positive correlation (0.110) with temperature. The rotifer significant relation with pH (0.810), inverse relation with dissolve oxygen (-0.314) while significant relation with BOD (0.430) and COD (0.220) (Table No.3), These findings similar to various investigators (Das *et. al.*, 2003; Rim- Rukeh *et.al.*, 2006; Arimoro *et al*., 2007; Pratima 2008; Osibanjo and Adie, 2007).

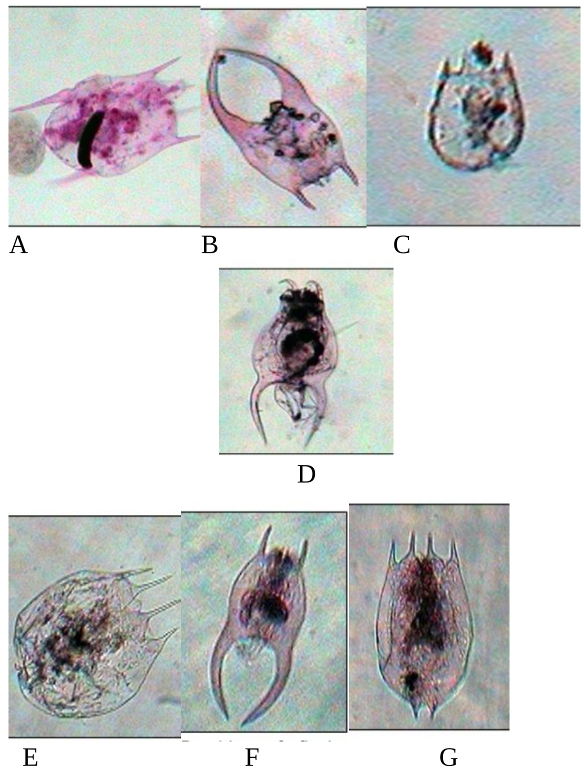



**Fig. (A-G): Different species of rotifers *Brachionus bidentata*, B-*Brachionus diversicornis* C-*Keratella cochlearis*, D-*Brachionus falcatus*, E-*Brachionus murrayi*, F-*Brachionus forficula*, G-*Brachionus plicatilis***

| Species composition | (S-1) | (S-2) |
|---|---|---|
| *Rotifera (34species)* | | |
| *Brachionus bidentata* | + | - |
| *Brachionus Rotundiformis* | - | + + |
| *Brachionus calyciflorus* | + | + |
| *Brachionus caudatus* | + | + |
| *Brachionus diversicornis* | - | + |
| *Brachionus quadridentatus var*. | + | - |
| *Brachionus calyciflorus f.* | - | + + |
| *Brachionus durgae* | + | - |
| *Brachionus falcatus* | - | + |
| *Brachionus forficula* | - | + |

| | | |
|---|---|---|
| *Brachionus havanaensis* | + | + |
| *Brachionus murrayi* | - | + |
| *Brachionus plicatilis* | + + | - |
| *Brachionus quadridentata* | + | - |
| *Brachionus rubens* | - | + |
| *Brachionus variabilis* | - | + |
| *Branchionus urceolaris* | + | - |
| *B. dichotomus reductus* | - | + + |
| *Keratella hiemalis* | - | + |
| *Keratella cochlearis* | + + | - |
| *Keratella quadrata* | + | + |
| *Keratella serrulata* | - | + |
| *Keratella tropica* | - | + |
| *Keratella valga tropica* | - | + |
| *Euchlanis dialatata* | + | - |
| *Euchlanis deflexa* | + | - |
| *Asplanchna priodonta* | + | - |
| *Ascomorpha ecaudis* | - | + |
| *Ascomorpha saltans* | - | + |
| *Chromogaster* | + | - |
| *Harringia eupoda* | - | + |
| *Mikrocodides chlaena* | + | + |
| *Tetramastix opoliensis* | - | + |
| *Notholca acuminate* | + | - |

-= Absent; + = Common; ++ = Abundant

**(S-1 Nayapura) (S-2 Mandideep)**

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