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RESEARCH ARTICLE

# Rotifer community in relation to limnological characteristics of Wular lake in Kashmir Himalaya

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**Abstract:** The present study was aimed to assess the impact of physico-chemical parameters of water on the rotifer community in Wular Lake, the largest freshwater lake in the Indian subcontinent. Water samples were collected between September, 2012 to August, 2014 from nine study sites. Rotifers were collected by filtering 100 liters of water through a nylon silk net having 75 meshes/ linear cm and preserved in 5% formalin. Rotifers were abundant during summer and lower diversity was observed during the winter. Kaiser-Meyer-Olkin (KMO) and Bartlett's test was also performed to check the significance of the all the variables with the rotifer species. KMO test reflects that the data can be preceded for PCA as the data reflects significant values. The physico-chemical parameters such as water temperature (19.3±8C°to 23.3 ± 9.9 C°), depth (1.7±0.8m to 4±1.7 m), pH (7.1±0.2 to 7.8±0.4) and total phosphate phosphorus (201±86.4 to 257.3±119.4 µg/l) strongly influenced the rotifer community in the lake.

***Keywords:*** Rotifera, Brachionidae, eutrophication, Wular lake, Principal component analysis.

## INTRODUCTION

Rotifers in aquatic ecosystems are exposed to many changes in their physical, chemical and biological processes (rate of reproduction, survival etc.) deciding their survival in aquatic ecosystems (King and Serra, 1998). Some of these changes may be comparatively trifling and organisms can acclimatize, or modify their position in the water column, or sometimes alter their behavior as well. Some environmental confrontations are at times so harsh that the individuals or even community get completely distressed. Populations respond both spatially and temporarily when confronted with environmental changes result in variation in number or frequency. Rotifers, act as important food source for large zooplankton and also for higher trophic levels. Some of the wheel animalcule (Rotifers) species involve in the decomposition of soil organic matter and are considered to be an important food link of water ecosystems (Arora and Mehra, 2003). Further, environmental variations are the most crucial factors for any organism living in temperate lakes. Temperature and chemistry of the water are the most outstanding contributors that affect the qualitative and quantitative composition of plankters in aquatic ecosystems. Most of these parameters show seasonal patterns of change within an annual cycle. Any population must adopt broad range of environmental variations to survive.Usually it is found that populations with a generation time of one year or longer either remain or pass through part of the year in a relatively inactive state. Therefore, the lacustrine population confronting several short-lived generations each year are quite different and vary from one system to the other (King, 1972). In such cases, each generation follow a particular succession pattern existing in different environments (Sommer *et al.,* 1986). Across the globe, number of researchers have conducted studies on determining the impacts of physico-chemical parameters of water on rotifer communities (May, 1983; Berzins, and Pejler, 1987; Stemberger,1995; Devetter, 1998; Lougheed and Fraser, 1998; Arora and Mehra, 2003; Dias *et al*., 2014). However, no published work is available on Wular Lake till date. In this backdrop, the present study was undertaken to study to identify environmental factors that affect the rotifer community in Wular Lake, a Ramsar Site of International Importance in Kashmir Himalaya.

## MATERIALS AND METHODS

Water samples were collected between September, 2012 and August, 2014 from nine study sites into clean polyethylene bottles to measure various physico-chemical as well as

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biological parameters. Among the physico-chemical parameters, temperature, pH, depth and transparency were determined *in situ*. The remaining parameters were analyzed following the standards of APHA (1998) and Wetzel and Lichen (2000). For rotifer analysis, samples were collected by filtering 100 liters of water through a net with 75 meshes/ linear cm and preserved in 5% formalin. Identification of the taxa were made by using different keys (e.g. Koste, 1978; Edmondson; 1992; Segers, 1995; Sharma and Sharma, 2008). All Statistical analysis like range, standard deviation (SD), Pearson correlation and Principle component analysis) were performed by SPSS version 16.

## STUDY AREA

Wular Lake is the largest freshwater lake in the Indian sub-continent located in the flood plains of river Jhelum. It is situated towards north -west of Kashmir about 55 km from Srinagar city.Geographically the lake is situated at an altitude of 1,580 m (asl) lying between 34°16´-34°20´N latitudes and 74°33´-74°44´E longitudes. (Figure 1). The oxbow type lake (with a maximum length of 16 km and breadth of 7.6 km.) is of fluviatile origin, formed by the meandering of river Jhelum, which brings huge quantities of alluvial deposits. The lake has regular inlets and outlet. River Jhelum is the main feeding channel entering the lake basin, through its bifurcation, near Baniyar and Makhdoomyari in the southeast. It is further drained at Ningli (Sopore) in the north-east by the only single outlet in the form of river Jhelum.

The macrophyte dominant lake has a well developed littoral zone while as limnetic zone is poorly developed. Extended littorals, in general, are dominated by reeds like *Phragmites australis* and *Spargamium ramosum* besides rooted floating-leaf types *Nymphoides peltatum* and *Trapa natans*. The slightly deeper zones has abundant growth of submerged palnts like *Ceratophyllum demersum*, *Myriophyllum spicatum* and *Potomogeton* spp. forming meadows at various places while the littorals towards the northeastern side are densely populated with *Salix* plantation which is eating the vitals of the lake.

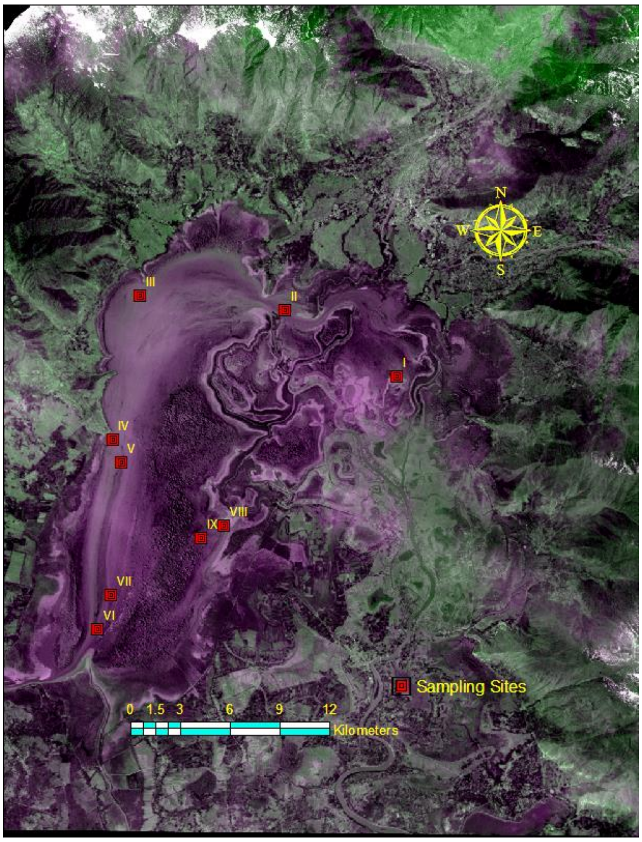


**Figure 1:** Map of Wular lake highlighting the nine study sites.

## RESULTS AND DISCUSSION

### Physico-chemical parameters of water

During the study period, water temperature varies from 19.3±8 C° to 23.3 ± 9.9 C°among sampling sites. Water depth ranges from a minimum of 1.7±0.8 m to a maximum of 4±1.7 m in sites II and VI, respectively (Table 1). Being a shallow lake, the process of continuous siltation brought from the feeding channels not only leads to shrinkage of the wetlands but also damages the littoral zones there in (Pandit, 1999, 2002; Shah *et al.,* 2013). Further, on the basis of the lowest mean depth ranges, a warning sign of an evolutionary progression, corresponded with higher trophic status as also opined by Rawson (1955) and Hayes (1957) and Pandit (2002). Transparency of water fluctuates spatially and temporarily and recorded lower values at site VIII (41.4±17.9) and higher at site I (67.4±31.7). Dissolved oxygen predicted a definite trend registering lower values in summer and higher in winter and ranges from a minimum of 4.64.6±1.9 mg/l at site I to a maximum of 7.1±3 mg/l/ at site IX. During the entire study, dissolved oxygen concentration recorded higher values in winter and lower in summer, thereby reflecting an inverse relation with temperature (Gurumayum *et al*., 2000; Naz and Turkmen, 2005; Idowu, 2013).Total alkalinity ranged from111±50.2 mg/l to167.6±79.7 mg/l at sites III and I respectively. Lower alkalinity values at site III can be attributed to the copious growth of macrophytes (Duggan *et al.,* 1998; 2001) Ammonium- nitrogen and nitrate-nitrogen were lowest at site V (180.4±84.3 µg/l) and at site VII (281.6±130 µg/l) respectively. Orthophosphate phosphorus and total phosphorus registered highest values at site IX (129.4±57.5µg/l) and at site II (279±12 (µg/l) respectively.

### Biological features

The unpredictability of environmental parameters in terms of spatial and temporalis the main cause for species distribution and their coexistance. Dynamic conditions in the aquatic ecosystems are said to be double edged sword for diversity, either endorsing coexistence via temporal positioning or a parting the species by stochastic extinctions (Shurin *et al.,* 2010). Zooplankton communities respond strongly to any change in the aquatic ecosystem (Gannon and Stemberger, 1978). Jeppesen *et al*., (2002) opined that the distribution pattern of zooplankton community vary according to physico- chemical parameters of water. There can be a biological equilibrium in aquatic ecosystems with the surrounding medium. However, any environmental factor exceeds species tolerance rangeswill result in the change in community structure (Finlayson and Moser, 1992).

During the entire study period, 26 rotifers represented by 11 families were recorded. Highest number (23) of species were recorded at site II, followed by 18 at site VII, 17 at VI, 15 at IV and VIII, 14 from sites V and VIII and recording the lowest (13) at site III (Table 2). Among the reported families, Brachionidae and Lecanidae were the most dominant, perhaps due to their adaptability to diverse and harsh environmental conditions (Pejler 1977; Shiel *et al.* 1998; Nandini *et al.* 2007; George *et al.* 2011). Segers, (1995) opined that Lecanidae is the second largest family among rotifers with about 160 valid species. Further, Rotifers showed a prominent growth peak in summer in terms of population density in par with high abundance of macrophytes (Ferreiro *et al*., 2011; Sousa *et al*., 2011,). Similar summer peaks in terms of density were observed by many workers (Sharma and Srivastav; 1986; Duggen *et al.,* 1998; Bruno *et al.,* 2005; School and Kiss, 2008; Ezhili*et al.,* 2013). However, some workers have reported population peaks in late summer and early autumn (Whitman *et al.,* 2004; Castro *et al.,* 2005; Paulose and Meheshwari, 2007). Further, Shyeshefer *et al.,* (2008) attributed high rotifer peak in summer to high temperature, long photo period and higher intensity of light.

Principal Component Analysis (PCA) is considered to be an appropriate way to perform data reduction (Fabrigar *et al.,* 1999). This widely-used method reduces a large number of variables to a much smaller number of uncorrelated linear combinations of variables, called principal components that represent the observed data as closely as possible. Generally, the components on steep slope (03) contribute highly while the remaining variables contribute very little for the component analysis (Figure 2). Further, Kaiser (1970) suggested that KMO value should be 0.60 or higher in order to proceed with a factor analysis (Table 3). He further opined 0.50 as a cut-off value, and considered desirable of value as 0.8 or higher. In the ordination of physico- chemical variables through PCA, water temperature, depth, pH and total phosphate phosphorus are strongly and positively associated with component 3 confirming their significant impacts on the rotifer community. The remaining parameters (free carbon dioxide, total hardness, magnesium, total alkalinity nitrate nitrogen) showed some impacts but not so strongly as above parameters (Figure 3).Thus, it appears that temporal changes in the rotifer community were greatly influenced by the variables which lie in component 3. It is important to note that dissolved oxygen, transparency, ammonical nitrogen and nitrate nitrogen did not appear to affect the sapatial or temporal distribution of rotifer community. The species which were abundant in summer and autumn were positively associated with pH, water temperature, depth and total phosphate phosphorus and vice versa for winter- spring species (Berzins and Pejler, 1987; Shiel and Koste, 1993). Herrmann (1999) opined that the lakes under eutrophication due to anthropogenic pressures favour higher diversity of rotifers, similar to the observations in the present study during the summer. Pearson correlation matrix predicts that Wheel animalcules maintained significant positive correlation with water temperature ($r=0.740$; $P < 0.01$), pH ($r=0.626$; $P < 0.01$), Chloride ($r=0.610$; $P < 0.01$), orthophosphate-phosphorus ($r= 0.804$; $P < 0.01$) and total phosphorus ($r=0.775$; $P < 0.01$) while the remaining parameters showed negative correlations (Table 1). Among various parameters, temperature seems to be the foremost important factor that influences the rotifers (Edmondson, 1965). Castro *et al.,* (2005) and Buyurgam *et al.,* (2010) opined that increase in temperature is always associated with high abundance and diversity of rotifers in aquatic ecosystems (Hensen *et al.,* 2007; Shah and Pandit, 2013a). Positive correlation between temperature and the abundance of rotifers was also observed by many workers across the globe (Schöll and Kiss, 2008; Sulehria *et al*., 2009a; 2009b; Sulehria and Malik, 2012). Wheal animalcules showed a negative correlation with dissolved oxygen in the study. Rutner- Kolisko (1974) stated that rotifers thrive well in low oxygen conditions as majority of them are detritus feeders. Further, Chittapun *et al.,* (2007) found that rotifers maintained negative correlation with dissolved oxygen and total hardness. Our results are in line with Martaugh (1985) who opined that water flies tolerate low dissolved oxygen content (Chittapun *et al*., 2007; Saler and Sen, 2002; Sulehria and Malik; 2012).Tamas and Horvarth (1978) are in the opinion that there is no influence of chemical ions such as calcium and magnesium on the rotifer density, which is confirmed in the present study.

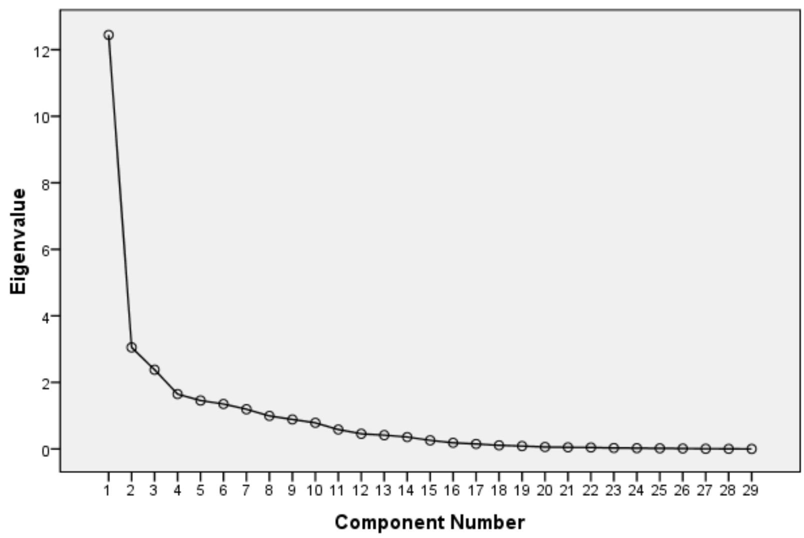


**Figure 2:** Screen plot of eigenvalues of initial component.

**Table 1**: Physico-chemical parameters of water (Range ± SD) at different sites with Pearson correlation values.

| Sites | I | II | III | IV | V | VI | VII | VIII | IX | Correlation |
|---|---|---|---|---|---|---|---|---|---|---|
| WT (C°) | 19.3±8 | 20.7±8.5 | 21.3±9.1 | 22.3±9.5 | 22.3±9.5 | 22.3±9.4 | 23.3±9.9 | 21.7±9 | 20.7±8.7 | 0.740** |
| Depth (m) | 2.2±1 | 1.7±0.8 | 2±0.8 | 3.1±1.3 | 3±1.3 | 4±1.7 | 3.7±1.7 | 2.7±1.2 | 3±1.3 | 0.075 |
| Transp (%) | 67.4±31.7 | 57.4±25.5 | 51.4±23.9 | 49±23 | 49±22.6 | 46±20 | 47.4±23.2 | 41.4±17.9 | 45.3±20.3 | -0.526** |
| pH | 7.1±0.4 | 7.6±0.3 | 7.2±0.4 | 7.1±0.2 | 7.8±0.4 | 7.4±0.4 | 7.5±0.4 | 7.8±0.3 | 7.4±0.2 | 0.626** |
| DO(mg/l) | 4.6±1.9 | 4.9±2 | 6±2.5 | 6.6±2.8 | 6.4±2.7 | 6.2±2.5 | 4.8±2 | 7.2±3.1 | 7.1±3 | -0.786** |
| $FCO_2$ (mg/l) | 19.6±8.2 | 15.7±6.7 | 16.5±6.8 | 16.8±6.9 | 19.7±8.1 | 25.3±10.6 | 24±10.6 | 20.9±9.6 | 14.3±6.5 | -0.710** |
| TA (mg/l) | 167.6±79.7 | 159±74.4 | 111±50.2 | 151.6±73 | 150±66.7 | 150.3±67.8 | 160.6±71.7 | 150.7±75.1 | 154.6±75.7 | -0.579** |
| TH (mg/l) | 97±40.7 | 139±58.3 | 92±37.7 | 117.3±50.8 | 124.3±53.3 | 114.7±48.7 | 125.7±55.6 | 111±48.2 | 103.7±42.4 | -0.677** |
| Ca (mg/l) | 54.4±22.2 | 36.6±15.1 | 35.3±15.4 | 40.4±20.3 | 45±20.6 | 27.7±13.6 | 38.3±18.2 | 50.6±21.4 | 40±18.3 | -0.513** |
| Mg (mg/l) | 10.4±4.9 | 24.8±10.7 | 13.7±5.7 | 19.3±9.1 | 20.7±9.1 | 21.2±9 | 21.5±10.3 | 14.7±6.6 | 15.5±6.8 | -0.699** |
| Cl (mg/l) | 17.7±7.4 | 14.3±6.7 | 20±8.9 | 19±8.6 | 17.3±7.1 | 18±7.5 | 18.4±7.8 | 16±7 | 12.4±5.8 | 0.610** |
| $NH_4$-N (µg/l) | 214±93.3 | 203.7±90.3 | 183±80 | 197.7±90.3 | 180.4±84.3 | 210.6±94.6 | 202.7±92.1 | 257±113.2 | 223.7±98.8 | -0.630** |
| $NO_3$-N (µg/l) | 420.3±207.1 | 428.3±210.2 | 358.7±191.7 | 374.7±166.5 | 387.7±182.9 | 346.6±165.7 | 281.6±130 | 454.7±222.8 | 453.7±199.5 | -0.737** |
| OPP (µg/l) | 101.7±45.9 | 124.7±55.3 | 131.4±55.9 | 98.3±43.4 | 82±35.6 | 92.4±40.6 | 125.7±53.4 | 129.4±57.5 | 101.4±43.8 | 0.804** |
| TPP (µg/l) | 252.7±110.6 | 279±125 | 212.7±93.6 | 201±86.4 | 238±102.3 | 212.3±94.9 | 178.7±80 | 257.3±119.4 | 240.6±113.2 | 0.775** |

WT= water temperature; DO=dissolved oxygen; $FCO_2$= free carbon dioxide; TA= total alkalinity; TH= total hardness; Ca= calcium content; Mg=magnesium content; Cl= chloride, $NH_4$-N= ammonical nitrogen; $NO_3$-N= nitrate nitrogen; OPP= orthophosphate phosphorus TPP= total phosphorus and correl= Pearson correlation coefficient
**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

**Table 2**: Distribution of rotifers among different sites of Wular lake.

| S. No | Rotifera | Abrr. | I | II | III | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Family Brachionidae** | | | | | | | | | | |
| 1 | *Anuraeopsis* sp. | Anu.sp | + | + | - | + | - | + | + | - | + |
| 2 | *Brachionus bidentata*(Anderson, 1889) | B.bid | - | + | + | + | + | + | + | + | + |
| 3 | *B. calyciflorus* (Ehrenberg, 1838) | B.cal | + | + | + | + | + | + | + | + | - |
| 4 | *B. quadridentata* (Hermann, 1783) | B.quad | + | + | - | + | - | - | + | - | - |
| 5 | *Brachionus* sp. | Br. sp | + | + | + | + | + | + | + | + | + |
| 6 | *Keratella cochlearis* (Gosse, 1851) | K.coc | + | + | - | - | + | + | + | - | + |
| 7 | *Keratella hiemalis* (Carlin, 1943) | K.hie | + | + | - | - | - | + | + | + | - |
| 8 | *Platyias quadricornis* (Ehrenberg, 1834) | P. quad | + | + | + | - | - | - | - | + | - |
| 9 | *Platyias patulus* ( O. F. Muller, 1786) | P.pat | + | + | + | + | + | + | + | + | + |
| | **Family Lecanidae** | | | | | | | | | | |
| 10 | *Lecene* sp. | Lec.sp | + | + | + | + | + | + | + | + | + |
| 11 | *Monostyla bulla* (Gosse, 1867) | M.b | + | - | - | + | - | - | - | - | + |
| 12 | *Monostyla depressa* (Bryce,1891) | M.dep | + | + | + | + | - | - | - | - | + |
| 13 | *Monostyla* sp. | M.sp | + | + | + | + | + | + | + | + | + |
| | **Family Lepadellidae** | | | | | | | | | | |
| 14 | *Lepadella patella* (O. F. Muller, 1786) | Lep.pat | + | + | - | - | - | - | + | - | - |
| 15 | *Squatinella* sp. | Squ.sp | - | - | + | - | + | - | - | - | + |
| 16 | *Colurella obtusa* (Gosse, 1886) | cl.sp | + | + | + | + | + | + | + | + | + |
| 17 | *Paracolurella* (Myers, 1936) | P.sp | - | + | - | - | - | - | + | + | - |
| | **Family Filiniidae** | | | | | | | | | | |
| 18 | *Filinia terminalis*(Plate, 1886) | F.ter | + | + | - | + | + | + | + | + | + |
| 19 | *Filinia*sp. | F.sp | + | + | - | - | - | + | + | + | + |
| | **Family Mytilinidae** | | | | | | | | | | |
| 20 | *Mytilina* sp. | My.sp | - | + | + | - | + | + | + | + | - |
| | **Family Synchaetidae** | | | | | | | | | | |
| 21 | *Polyarthra vulgaris* (Carlin, 1943) | Pol.vul | + | + | - | - | + | + | - | - | - |
| | **Family Asplanchnidae** | | | | | | | | | | |
| 22 | *Asplanchna priodonta* (Gosse, 1850) | As.sp | + | + | + | + | + | + | + | + | - |
| | **Family Notommatidae** | | | | | | | | | | |
| 23 | *Cephalodella* sp. | Cep.sp | - | + | - | - | + | + | - | - | - |
| | **Family Hexarthridae** | | | | | | | | | | |
| 24 | *Hexarthra mira* (Hudson, 1871) | H.mr | - | + | + | - | - | + | + | + | + |
| | **Family Scaridiidae** | | | | | | | | | | |
| 25 | *Scardium longicaudum* (O. F.Muller, 1786) | S.lo | + | - | - | + | - | - | - | - | - |
| | **Family Trichocercidae** | | | | | | | | | | |
| 26 | *Trichocerca* sp. | Tr.sp | - | + | - | + | - | - | - | - | - |
| | **Grand Total** | | **19** | **23** | **13** | **15** | **14** | **17** | **18** | **15** | **14** |

**Table 3:** KMO and Bartlett's Test.

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .649 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1.405E3 |
| | df | 406 |
| | Sig. | .000 |

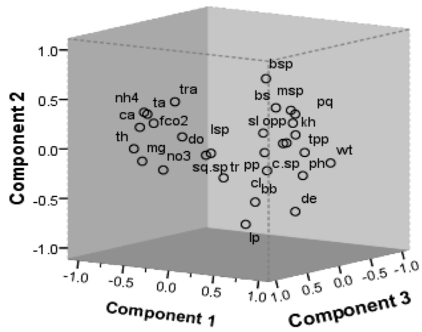


**Figure 3:** Principal Component analysis ordination plot for rotifer abundance and score of environment variables.

## CONCLUSION

The results can conclude that the rotifers were abundant during warm environmental conditions and lower in colder conditions. Also, the rotifers were abundant in sites having high anthropogenic pressures suggesting that these animalcules act as bioindicators to assess the trophic status of wetlands. Further, the distribution and diversity of rotifers arecontrolled by combination of both physical as well as biological factors.

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## COMPETING INTERESTS

The authors declare that there is no competing interests.

## AUTHORS' CONTRIBUTIONS

AKP and GMS authors are the research guides of the first author JAS. They have also drafted the sampling design and critically evaluated, coordinated and helped in draft the manuscript. Without their support it was impossible to perform the research. The first author has made collection, identification, analysis and interpretation of the whole data. All authors read and approved the final manuscript.

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