STUDIES ON MACRO-INVERTEBRATE POPULATION AND THEIR RELATIONSHIPS WITH ENVIRONMENTAL FACTORS IN DAROJI LAKE, BALLARI, KARANATAKA

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Abstract

An investigation was made on the study of macro invertebrate communities in Daroji Lake from July 2018-to December 2018. In the present study, it was found that the order Odonata comprises five species viz., Lestes, Aeshna, Epitheca, Sympetrum and Cordulegaster followed by Hemiptera (5 species) Buenoa, Notonecta, Nepa, Lethocerus and Gerris. Ephemeroptera and Plecoptera comprise *Epeorus* sp, *Leptophlebia* sp. and Pteronorsis, Capnia respectively. Whereas, Megaloptera and Trichoptera showed single species *Dysmicohermes disjusctus* and Chimarra each. The percentage composition indicated that Odonata showed maximum 33 % followed by Epimeroptera (25 %), Hemiptera (19 %), Megaloptera (10 %), Plecoptera (10 %) and Tricoptera (3 %). The predicted Shannon-Wiener diversity index was found to be (SW=1.59) and Family Biotic Index (FBI) ranged between 1 and 2 (with fair 11 points), indicated the fair representation of benthic organisms. The analysis of physicochemical parameters indicated fluctuation from July to December. These changes were attributed to the drastic water level fluctuation of the Daroji Lake. However, physicochemical and biological data showed they were within the standards.

Keywords: Benthic fauna, Daroji Lake, Family Biotic Index, Shannon-Wiener diversity index

Introduction

The benthic zone is the bottom region of water bodies such as a lake, pond, or stream. In freshwater systems, organisms that are larger than 250-500 microns are called macro invertebrates. Generally the presence of a diverse assemblage of long-lived taxa such as the larvae of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddis flies) indicates a relatively healthy water body that is not subject to high degrees of pollution (Ferro, and Sites, 2007). These insect groups (the "EPT") are thus considered indicators of relatively healthy water bodies (Ghani *et al.*, 2016). On the other hand, proliferation of oligochaetes and some members of the family Chrionomidae may be indicative of organic pollution or stagnant water (Philips, 1980).

Small invertebrates are functionally important in many terrestrial and aquatic ecosystems (Freckman *et al.*, 1997). In freshwater sediments, benthic invertebrates are diverse and abundant, but they are often patchily distributed and relatively difficult to sample, especially when they live in deep subsurface sediments. Thus, the species richness and functional importance of freshwater benthic invertebrates generally go unnoticed until unexpected changes occur in ecosystems. Unanticipated changes in freshwater ecosystems are often due to alterations in the complex connections among sediment-dwelling species and associated food webs (Goedkoop and Johnson 1996) or to disturbances, such as floods or drought (Johnson and Covich 1997), that alter the species composition of the benthos. Hutchinson (1993) concluded that "the Diptera are by far the most diverse order of insects, approximately four times the number of Coleoptera in fresh water. Others estimate that there are large numbers of benthic species of protozoa, Crustacea, and other groups (Palmer *et al*. 1997). The role of benthic organisms in the ecosystem is significance; however, loss of some species will likely alter or degrade critical ecosystem processes because of the unavailability of replacement species (Wilson 1992; Sreenivasa *et al.*, 2017).

The benthic environment of any lake is related to combinations of water column productivity (tropic status) and circulation (mixis) and sediment deposition patterns (Wetzel 2001, Miller and White 2007). The distribution of benthic invertebrates generally follows the littoral to profundal patterns described above (White *et al.*, 1986, Wetzel 2001). Maximum benthos density and diversity usually occur in the sub littoral zone in what has been termed the 'concentration zone' (Mackie 2001). Invertebrates like Chironomidae and Oligochaeta are usually successful aquatic macro invertebrate inhabit in freshwater bodies, including eutrophic waters (van der Berg 1999; Mackie 2001). The littoral areas of lakes and ponds are ideal breeding places for chironomids, nematodes, rotifers, annelids, protozoa, other biting midges etc. (Szadziewski *et al.*, in Nilsson 1997) as there are plenty of vegetation covers. According to Jackson (1997) and Cheruvelil et al. (2002) the architecture of macrophytes itself may significantly affect the colonisation by phytophilous invertebrates.

Studies on water quality management have dealt with the use of benthic macro invertebrates in evaluating the level of environmental degradation (Edopkayi and Eikhalo, 2001). Some abiotic factors such as temperature, pH, electrical conductivity, dissolved oxygen in water column, determine the distribution of benthic macro invertebrate communities (Allan, 1995). Hence the present study was undertaken to evaluate the influence of benthic organisms on Daroji lake water quality.

Materials and Methods

Daroji Lake is geographically located at latitude 15°15´0´´ and longitude 15°15´0´´. It is named after the village Daroji, located in the Sandur taluk of Bellary district in Karnataka (Fig.1).

Fig.1. Study area; Location of Daroji Lake

The lake is regarded as the second largest water bodies in Karnataka, which can irrigate a total of 4,700 acres of land. Other than its agricultural importance, it is also serving as comfortable habitat for many numbers of flora and fauna. The water samples were collected from two sources for different physico-chemical parameter analysis. Water temperature and pH were measured in the field by using digital probes after making standard calibrations. The dissolved oxygen, carbon dioxide, chloride and total hardness of the water samples were estimated by following the methods as mentioned in Strickland and Parsons (1972). Nitrate and phosphate were estimated as described by EPA (1993) and Olsen *et al*. (1954). Benthic sediment samples were collected different areas form the lake using a modified Van Veen grab sampler and taken to the laboratory for sorting and analysis. All benthic samples were sieved through 200-500 μm mesh net and fixed in 5% formaldehyde for further identification. The qualitative and quantitative analyses were done as described by Arbačiauskas *et al.* (2008). Thereafter, the organisms were grouped into different taxa in each sample.

Results and Discussion

The physico-chemical parameters and list of benthic animals in the water and sediments at all the sampling stations are shown in Table 1, 2 and 3 and illustrated in the figure 2 and 3.

Physico-chemical parameters

Table 1. Physico-chemical parameters of water collected from Station 1 of Daroji Lake (Mean ± SE)

Parameters	Jul	Aug	Sep	Oct	Nov	Dec
pH	5.7± 0.12	5.77±0.03	5.87±0.03	6.13±0.03	6.13±0.03	6.17C0.03
Temp ºC	22.17±0.6	20.45±0.02	22.93±0.32	21.6±0.31	21.37±0.23	20.51±0.26
DO mg/l,	6.96±0.75	7.52±0.49	5.67±0.09	6.1±0.29	6.47±0.28	5.37±0.29
CO2 mg/l	7.39±0.95	8.23±1.39	9.86±1.74	8.8±2.2	8.8±2.2	8.8±2.2
Nitrate-nitrogen mg/l	0.76±0.04	0.51±0.04	2.12±1.64	0.46±0.28	0.49±0.03	0.5±0.01
P mg/l	2.17±0.61	4.46±1.28	3.08±0.8	1.93±0.25	1.93±0.25	1.93±0.25
Hard mg/l $CaCO_3$	119.67±5.04	142.67±22.98	122.67±2.67	111.33±6.2	131.67±1.76	106.67±1.86
Chl mg/l	24±2.52	28.33±1.45	19.9±0.61	22±1.53	21.3±0.91	29.11±5.04

Table 2. Physico-chemical parameters of water collected from Station 2 of Daroji Lake (Mean ± SE)

Parameters	Jul	Aug	Sep	Oct	Nov	Dec
pH	5.9± 0.12	5.67±0.03	6.17±0.03	6.15±0.03	6.53±0.03	6.77±0.03
Temp ºC	21.13±0.6	20.45±0.02	21.93±0.32	21.9±0.31	23.17±0.23	24.11±0.26
DO mg/l,	5.9 ±0.75	6.1 ±0.49	6.7 ±0.09	6.1±0.29	6.57±0.28	5.37±0.29
CO2 mg/l $CaCO_3$	5.23±1.39	5.39±0.95	5.86±1.74	6.8±2.2	5.8±2.2	5.8±2.2
Nitrate-nitrogen mg/l	0.96±0.04	0.31±0.04	1.9±1.64	0.66±0.28	0.56±0.03	0.5±0.01
P mg/l	3.17±0.61	3.46±1.28	3.18±0.8	3.03±0.25	2.53±0.25	2.73±0.25
Hard mg/l $CaCO_3$	121.67±5.04	132.67±22.9	142.67±2.67	121.33±6.2	165.67±1.76	131.67±1.86
Chl mg/l	34±2.52	38.33±1.45	29.9±0.61	21±1.53	22.3±0.91	27.11±5.04

pH of the water showed variations from 5.7± 0.12 (Jul) to 6.17±0.03 (Dec) in station 1 and 5.67±0.03 (Aug) to 6.77±0.03 (Dec) in station 2. The surface water temperature in the station 1 varied between 20.45±0.02 (Aug) and 22.93±0.32 (Sep) and in station 2 the values varied between 20.45±0.02 (Aug) and 24.11±0.26 (Dec).Total dissolved oxygen in station 1 showed variation. Much fluctuation was observed in the water, initially the value was found to be 6.96±0.75 mg/l and increased to 7.52±0.49 mg/l in August month. Further it was observed that sudden fall in the value in September (5.67±0.09 mg/l) and increased progressively to 6.47±0.28 mg/l in November followed by further depletion in December. In Station 2 the values found to be increased from 5.9 ±0.75 mg/l (Jul) to 6.7 ±0.09 mg/l (Sep), further value decreased (6.1±0.29 mg/l) in October followed by increment (6.57±0.28 mg/l) in November. Te value further decreased to 5.37±0.29 mg/l in December. The values of total dissolved carbon dioxide in the station 1 showed increment in the initial period from July (7.39±0.95 mg/l $CaCO_3$) to September (9.86±1.74 mg/l $CaCO_3$) followed by constant values 8.8±2.2 mg/l $CaCO_3$ from October to December. In the station 2 the values increased form 5.23±1.39 mg/l $CaCO_3$ in July to 6.8±2.2 mg/l $CaCO_3$ in October, followed by constant values 5.8±2.2 in November and December. The nitrate (NO3-N) noticeable variations between the sampling months the lowest and highest values (0.46±0.28mg/l and 2.12±1.64mg/l respectively) were observed during different months in station 1 and 0.31±0.04 mg/l in and highest 1.9±1.64 mg/l in station 2 respectively. The total phosphorus (TP) concentration in water samples showed increasing trend in the initial period from July to August. Further decreased from4.46±1.28 mg/l to 1.93±0.25 mg/l and remained constant till December. Whereas, in the station 2 also showed similar trends. The values varied between 2.53±0.25 mg/l in November and 3.46±1.28 mg/l in Augusthe total hardness showed fluctuation in both the station. The minimum values were noticed in December (106.67±1.86 mg/l) and highest value was 142.67±22.98 mg/l in the month of August from the station 1. Whereas, in the station 2 the minimum value was noticed in 121.67±5.04 mg/l in July and 165.67±1.76 mg /l in November. Minimum chloride levels were found to be 19.9±0.61 mg/l in September and 21±1.53 mg/l in October and higher values 29.11±5.04 mg/l in December and 38.33±1.45 mg/l in August in station 1 and 2 respectively (Table 1 &2).

Benthic fauna

There were 16 representative species identified in the sediments comprising six orders. Ephemeroptera (mayflies larvae) comprised *Epeorus* sp. and *Leptophlebia* sp., Odonata included Leste, Aeshna, Epitheca Sympetrum and Cordulegaster. Plecoptera (larvae of stoneflies) included Pteronorsis and Capnia. Hemiptera (true bugs) included Buenoa, Notonecta, Nepa, Lethocerus and Gerris. Megaloptera (Dobson flies and Alder flies) included *Dysmicohermes disjusctus* and Trichoptera (caddis flies) included Chimarra.

Table 3. Mean Value of Individuals, Percentage composition and Hilsenhoff Family Biotic Index (FBI) of benthic organisms

Benthic Fauna	Jul	Aug	Sep	Oct	Nov	Dec	Avg. %	FBI	$(P_i * \ln P_i)$
Ephemeroptera	17.6	19.9	22.6	23.8	33.5	34.7	25.35	2	-0.35
Odonata	44.9	40.2	32.9	27.5	28.0	25.6	33.18	2	-0.37
Plecoptera	4.8	9.1	7.9	12.2	9.5	13.0	9.41	2	-0.22
Hemiptera	18.7	15.8	18.9	19.1	21.9	17.9	18.71	2	-0.31
Megaloptera	11.8	11.6	13.1	12.5	4.7	6.4	10.01	2	-0.23
Trichoptera	2.1	3.3	4.6	4.9	2.4	2.4	3.28	1	-0.11
								11 Fair	H= 1.59

Shannon-Weiner Diversity **H= < 1.5 low diversity; 1.5< X<2.5 Medium diversity; >2.5 More diversity**

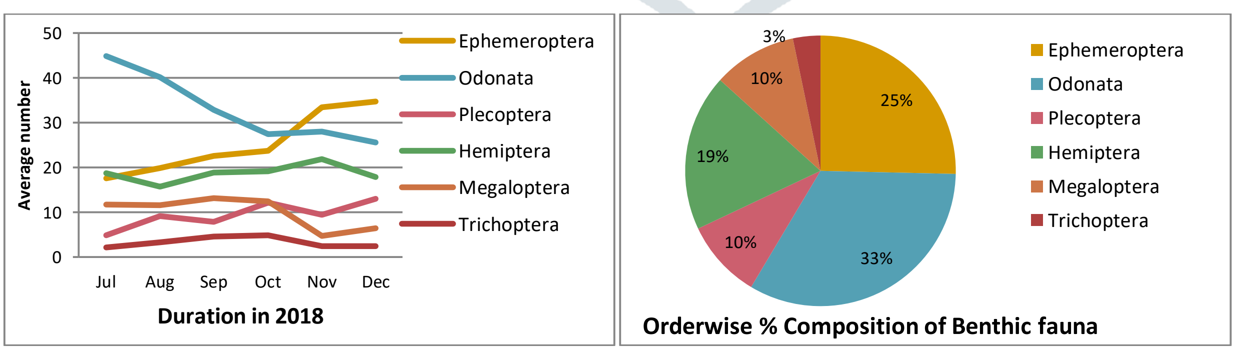

Fig. 2. Order wise distribution (Left) and percentage composition (right) of benthic invertebrates.

Order Odonata showed decreased trends from 44.9 (July) to 25.6 (Dec) and exhibit highest percentage (33.18%) among the individuals. Ephemeroptera showed increased trend from July (17.6) to December (34.7) with 25.35 %. Hemiptera composed of 5 species with 18.71 %. Megaloptera composed of 10.01 % with single individual. Plecoptera showed increased trends in number with two individuals and showed 9.41 %. Trichoptera showed 3.28 % with single individual (Fig. 2 & 3). Hilsenhoff Family Biotic Index (FBI) of benthic organisms showed 11 points and indicated the Daroji lake water at sampled area was considered as Fair water. The Shannon wiener diversity index indicated that the species diversity falls in medium diversity category (H=1.59) (Table 3).

In the present study the pH and Temperature has always been the most important water quality parameter which has direct influence on the growth and metabolism of fauna. Fluctuation in both parameters might be due to higher solar radiation, low water level, and higher atmospheric temperature. However both the parameters are in favorable limit (Kunda *et al.*, 2008). Dissolved oxygen in fresh water should be 5 mg/l or more which is favorable for organisms. DO of the lake was found fluctuated between 5.37±0.29 and 7.52±0.49 in station 1 indicated the presence of more number of benthic organisms in the shallow water and constant fluctuation in dissolution of atmospheric oxygen in the water (Wahizatul *et al.*, 2011). The oxygen and carbon dioxide level in the study lake favors good growth of flora and fauna (Tewari and Mishra 2005; Garg et al.2006; Suresh *et al.*, 2019). The nitrate content related to the disposal of agricultural wastes containing fertilizers around the lake (Ewers 1999). The phosphate values at site 2 is slighter higher than site 1. This could be collective mineralization of organic matter at the bottom. However, total phosphorous and nitrate values were within the WHO standards (Ayers and Westcot 1994; WHO 2008). In the present study the total hardness of the water showed fluctuation throughout the study period. This might be due to the influence of natural weathering of Ca^+ and Mg^+ ions (Murhekar 2011; Zeitoun and Mehana 2014). Based on hardness standard, the Daroji Lake water can be categorized into soft water to moderately hard water (Soni et al. 2013; Suresh *et al.*, 2019). Chloride in fresh water generally remains quite low and increases by the contribution of agriculture runoff, sewage and industrial effluent. Besides, human beings and other animals exert high quantities of chlorides together with nitrogenous compounds. The chloride concentration is harmless up to 1500 mg/l though it produces salty taste at 200-250mg/l (Trivedy and Goel, 1984).

Basically polluted water contains Oligochaetes, Dipterans and Gastropods and pure water contains Ephemeropterons, Trichopterons, Plecopterons and Odonates and they are very sensitive to pollution. Ephemeropterans are sensitive to environmental perturbations and usually live in clean and well oxygenated waters (Oliveira and Nessimian 2010) and their species diversity is influenced by substratum type, riparian vegetation, catchment land use and human activities (Bispo 2006). Among benthos Caddis fly (Trichoptera) and May fly are less abundant in the river water –soil interface because they tend to prefer specific substratum type in the streams (Selvakumar 2014).In this study pollutant tolerant organisms were found to be less dominant since species of Oligochaetes, Dipterans and Gastropods have less density. Presence of Odonata shows less pollution in the water. The present study it is therefore can be concluding that the Daroji Lake is slightly mesotrophic with minimum amount of nutrients. This might be due inflow of water from agricultural surrounding areas during rainy season. This is also having conformity with that of the studies carried out by Spence (1964), Vollenwelder (1968). The present results also indicated that the varied physico-chemical characteristics of water, diversity of benthos, water body which might turn towards eutrophication in the later summer. Further, the trophic condition clearly demands a proper conservation and management strategies.

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