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Inventory of the aquatic macrophytes in Govindgarh Lake, Rewa (M.P.) India

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Abstract
The present study has been undertaken in Govindgarh lake situated in Rewa district (M.P.), India. The focal objective of the study is to evaluate the quantitative characters of the aquatic macrophytes *viz*., frequency, density, dominance and importance value index (IVI). During the whole study period, a total of 28 macrophytic plant species belonging to 28 species station A, 22 species station B, 19 species station C and 15 species station D were found distributed in the Govindgarh lake. Dominating species with IVI value *Lagenandra ovata* (120.27), *Saccharum bengalense* (111.27), *Lemna trisulca* (92.83) at station A, *Vallisneria spiralis* (71.34), *Monochoria vaginalis* (60.98), *Ceratophyllum demersum* (56.78) at station B, *Ranunculus aquatalis* (53.85), *Vallisneria spiralis* (31.12), *Nymphaea stellate* (30.75) at station C and *Hydrilla verticillate* (139.27), *Ceratophyllum demersum* (64.11), *Cryptocryne retrospiralis* (44.74) at station D. The analysis of variance (ANOVA) for all the aquatic macrophytes reported from the lake indicates that there is no significant variation within the four study sites in terms of distribution. However, F-test result indicates significant variation in the quantitative characters between the different macrophytic plant species of the lake.

Keywords: Inventory, aquatic macrophytes, quantitative, govindgarh lake, India

Introductions
India has large diversity of aquatic habitats due to geomorphological, climatic, biotic and cultural diversities. Investigation on community structure and function is an important attribute in the management of aquatic bodies (George, 1997) [1]. Recently attention has been given on species diversities as measure of pollution or eutrophication based on the principle that in clean water, community diversity is high, while in polluted water the diversity is low (Wilhm, and Dorris, 1968 and Unni, 1985) [2-3]. Studies not only on the microphyte diversity, but on the macrophyte diversity also are useful in evaluating water quality (RIIS and Hawes, 2002) [4]. Several workers (Kaul & Handu, 1989, Kaul, 1977, Kaul *et al.* 1978, Gopal *et al.* 1978, Singhal & Singh, 1978, Unni *et al.* 1998 and Unni & Fole, 1997) [5-11] have studied the structural and functional aspects of macrophytic vegetation in fresh water ponds and lakes of India. However the information related to community organization of macrophytic vegetation of a tropical shallow fresh water habitat in different seasons and to focus its data towards pollution and eutrophication.
Species composition is one of the major characteristics of a plant community. Simpson (1949) [12] discussed the significance of plant communities as indicator to provide a rough estimate of controlling factors present in the habitat. The vegetation is also greatly influenced by attitudinal differences. Polunin and Stainton (1999) [13] are of the view that climate is a master factor determining vegetation of an area. Beadle (1934) [14] gave the opinion that the development of vegetation within same climate also depend largely on the availability of plant species and their adaptation cannot be ignored.
In consonance with the efforts taken up by the International Biological Programme (IBP) and Man and the Biosphere Programme (MAB), Convention on Biological Diversity (CBD), Ramsar Convention, National Programme for Wetland Conservation (NPWC) of the Ministry of Environment and Forest (MoEF), Government of India (GoI), Inventory of the aquatic macrophytes in Govindgarh lake has been undertaken. This study would serve as an important prerequisite for assessment of the distribution of the aquatic macrophytes of the lake. In the light of the above reasons, the present study has been carried out with the main objectives to evaluate the quantitative characters like frequency, density, dominance and importance value index (IVI) of the aquatic macrophytes found in the lake at regular intervals during the study periods.

2. Materials and Methods

For the present investigation, the Govindgarh lake was divided into four study sites representing as Station A, B, C, and D respectively. The aquatic macrophytic plant samples were collected at regular monthly intervals during the period January, 2018 to December, 2019 from the different study sites. The sampling technique used for inventory of the aquatic macrophytes was the standard method as described by Curtis (1959) [15] and Misra (1968) [16]. The quantitative analysis comprises frequency, density, dominance and importance value index (IVI). Assessing of the different quantitative characters were done by using a square quadrat of 25 cm × 25 cm in dimension and in each study site not less than 20 quadrats were sampled randomly (Ambasht, 1970) [17].

Description of the Study Sites

The Govindgarh lake is one of the unique water body in M.P. and located in south of Rewa district at a distance of 20 km. with a longitude 81°15'0" and latitude 24°20'25". It comes under the Rewa district and in Huzur tehsil. The lake is connected with all-weather Rewa-Shahdol and Satna-Sidhi road. The lake was formed by impounding of small nalla originating from Kaimore hill. With a view to storing rain water the Maharaja of Rewa at that time built a bandh across the nalla to form a tank in 1958.

In Govindgarh lake the study sites are:

1. Station A (Fort at East of the lake)
2. Station B (Khakhari Kothi South)
3. Station C (Gopal Bag at Centre)
4. Station D (Anandgarh Ghat at Centre)

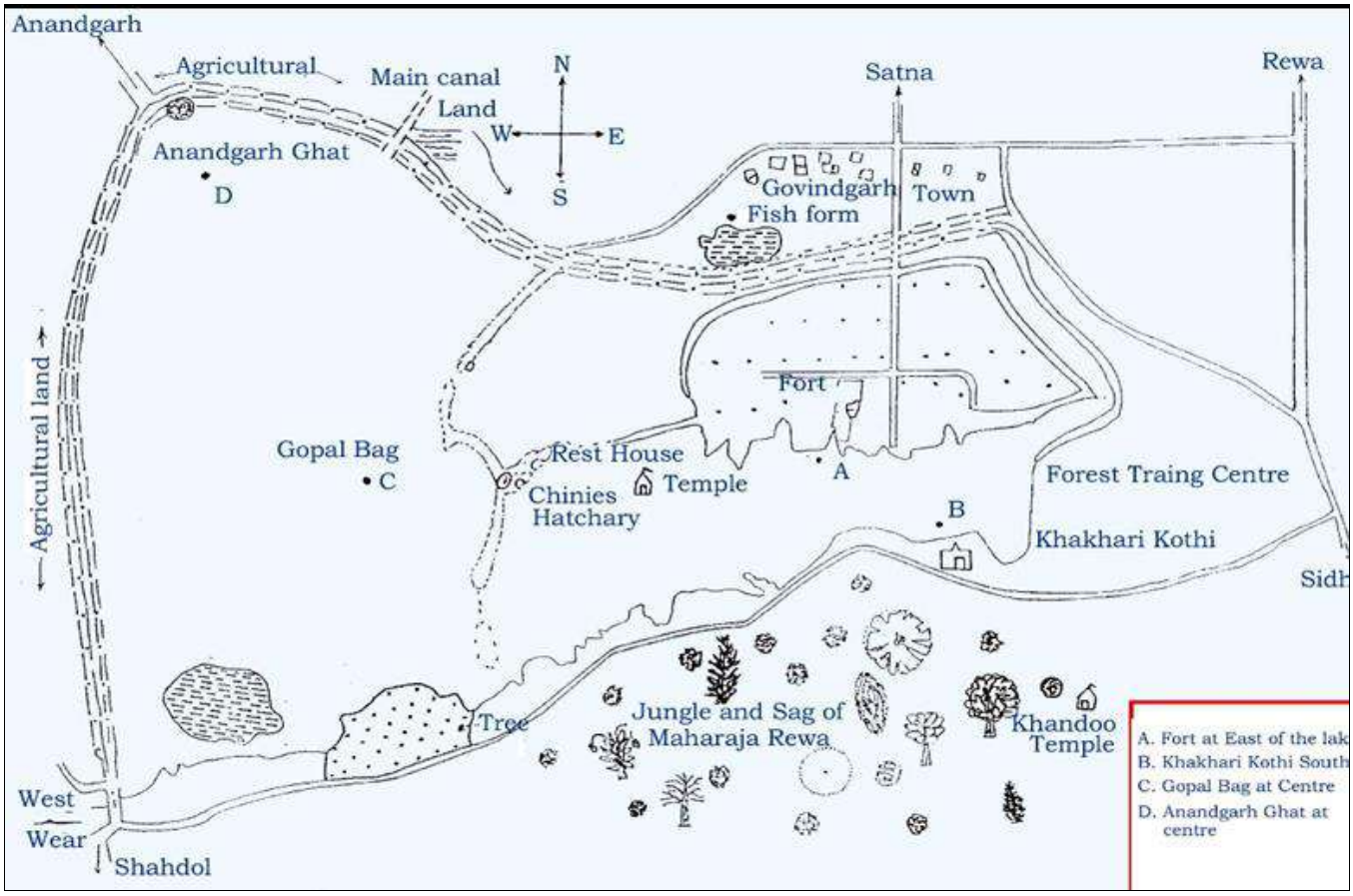

Fig 1: Map of Govindgarh Lake, Rewa (M.P.) showing the different study sites

Calculation of Quantitative Characters

$$\text{Relative Frequence} = \frac{\text{Number of quadrats of occurance of the plant}}{\text{Number of quadrats of occurance of all the plants species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100$$

Importance Value Index

Importance Value Index were calculated by adding the value of Relative density, Relative frequency and Relative dominance for each species (Cain and Castro 1959) [18].

Statistical and Data Analysis

The statistical analysis is carried out by using SPSS Ver-20 and the statistical tools like ANOVA (Analysis of Variance) and Box Plot techniques are used for interpretation of the findings. ANOVA is done for quantitative characters *viz.*, frequency, density, dominance and IVI of the aquatic macrophytes between different study sites of the lake and also within different species of the lake. Box Plot is used to represent the distribution of the different macrophytic species recorded from the lake.

3. Results and Discussion

List of Aquatic Macrophytes in Govindgarh Lake

S. No.	Station A	Station B	Station C	Station D
1	*Lagenandra ovata*	*Vallisneria spiralis*	*Ranunculus aquatalis*	*Hydrilla verticillata*
2	*Saccharum bengalense*	*Monochoria vaginalis*	*Vallisneria spiralis*	*Ceratophyllum demersum*
3	*Lemna trisulca*	*Ceratophyllum demersum*	*Nymphaea stellata*	*Cryptocryne retrospiralis*
4	*Echinochloa spp.*	*Echinochloa spp.*	*Hydrilla verticillata*	*Lamna perpusilla*
5	*Potamogeton crispus*	*Potamogeton perfoliatus*	*Cryptocryne retrospiralis*	*Cabomba aquatica*
6	*Potamogeton perfoliatus*	*Cryptocryne retrospiralis*	*Jussiea repens*	*Echinochloa spp.*
7	*Eleocharis equisetoides*	*Colocasia antiquorum*	*Colocasia antiquorum*	*Scirpus spp.*
8	*Najas minor*	*Jussiea repens*	*Lemna minor*	*Phragmites karka*
9	*Eichhornia crassipes*	*Ipomoea aquatica*	*Ceratophyllum demersum*	*Fimbristylis miliacea*
10	*Lemna minor*	*Hydrilla verticillata*	*Potamogeton perfoliatus*	*Colocasia antiquorum*
11	*Spirodela polyrhiza*	*Saccharum bengalense*	*Echinochloa spp.*	*Najas minor*
12	*Cryptocryne retrospiralis*	*Lemna minor*	*Aponogeton crispus*	*Limnophylla heterophylla*
13	*Wolffia arrhiza*	*Phragmites karka*	*Typha elephantina*	*Potamogeton perfoliatus*
14	*Hydrilla verticillata*	*Nechamandra alternifolia*	*Potamogeton crispus*	*Monochoria vaginalis*
15	*Typha elephantina*	*Lagenandra ovata*	*Cyperus iria*	*Potamogeton crispus*
16	*Jussiea repens*	*Potamogeton crispus*	*Nechamandra alternifolia*	
17	*Cyperus iria*	*Najas minor*	*Limnophylla heterophylla*	
18	*Lamna perpusilla*	*Cyperus iria*	*Ipomoea aquatica*	
19	*Limnophylla heterophylla*	*Lamna perpusilla*	*Sagittaria sagittifolia*	
20	*Fimbristylis miliacea*	*Scirpus spp.*		
21	*Monochoria vaginalis*	*Limnophylla heterophylla*		
22	*Ceratophyllum demersum*	*Alisma plantago-aguatica*		
23	*Colocasia antiquorum*			
24	*Nymphaea stellata*			
25	*Alisma plantago-aguatica*			
26	*Utricularia vulgaris*			
27	*Lemna gibba*			
28	*Ipomoea aquatica*			

The quadrates laid down in various point of dam and occurred 28 species. The *Lagendra ovata* had the highest IVI (120.27) and lowest IVI *Ipomoea aquatic* (2.26). The other dominant macrophytes are *Saccharum bengalense* (111.27), *Lemna trisulca* (92.83), *Echinochloa spp*. (86.93), *Potamogeton crispus* (85.53), *Potamogeton perfoliatus* (79.51), *Eleocharis equisetoides* (73.37), *Najas minor* (58.54), *Eichhornia crassipes* (57.83) and *Lemna minor* (53.79). The macrophytic species varied on the basis of topography and other physiognomic characteristics of Govindgarh Lake in station A (Fig. 2)

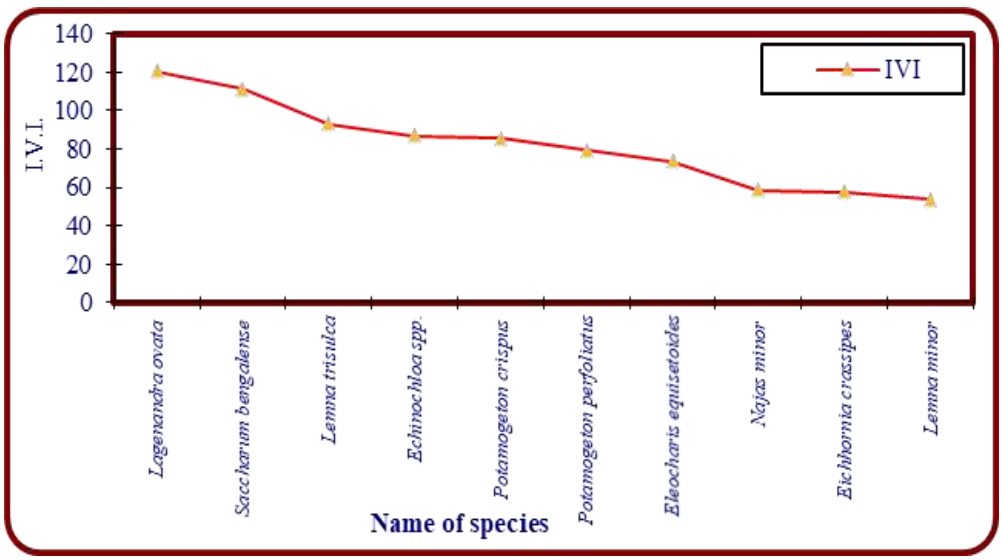

Fig 2: Ten dominating species in Station A at Govindgarh lake

Ten most dominant macrophytes their identified on the basis of the descending values of IVI. The most dominant macrophytes was *Vallisneria spiralis* (71.34), *Monochoria vaginalis* (60.98), *Ceratophyllum demersum* (56.78), *Echinochloa spp.* (55.80), *Potamogeton perfoliatus* (42.35), *Cryptocryne retrospiralis* (32.67), *Colocasia antiquorum* (31.66), *Jussiea repens* (30.72), *Ipomoea aquatic* (30.01) and *Hydrilla verticillata* (18.87). The lowest IVI of *Alisma plantago aquatic* (3.10) were noted in station B (Fig. 3).

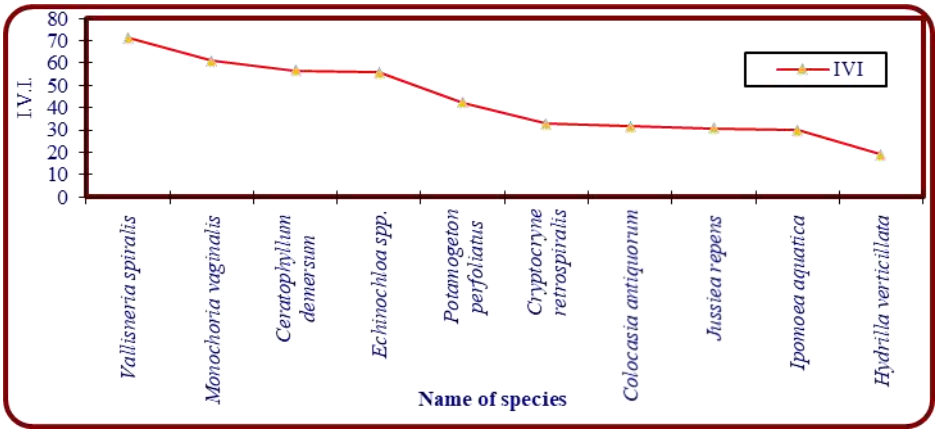

Fig 3: Ten dominating species in Station B at Govindgarh lake

During present study nineteen macrophytes were observed Govindgarh lake in station C (Fig. 3). The highest IVI of ten macrophytes *viz. Ranunculus aquatalis* (53.85), *Vallisneria spiralis* (31.12), *Nymphaea stellata* (30.75), *Hydrilla verticillata* (30.04), *Cryptocryne retrospiralis* (29.07), *Jussiea repens* (28.15), *Colocasia antiquorum* (24.50), *Lemna minor* (22.51), *Ceratophyllum demersum* (13.53) and *Potamogeton perfoliatus* (12.05) was noted. The *Sagittaria antiquorum* having lowest (1.49) IVI.

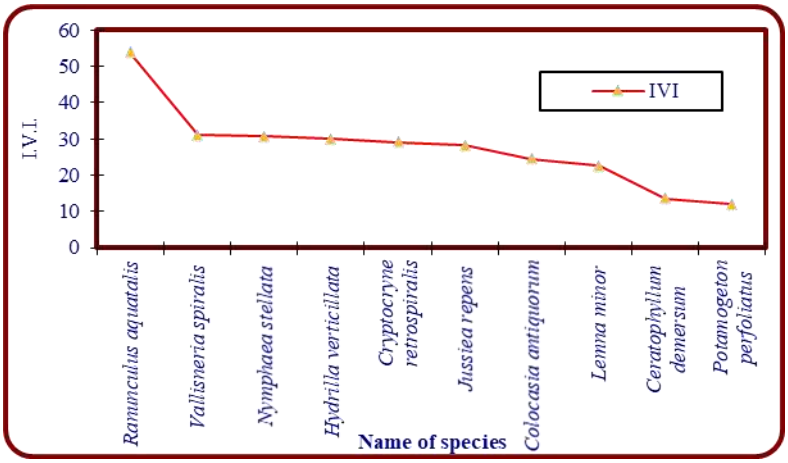

Fig 4: Ten dominating species in Station C at Govindgarh lake

During investigation only fourteen macrophytes were observed by quadrate methods. The ten macrophytes *viz. Hydrilla verticillata* (139.27), *Ceratophyllum demersum* (64.11), *Cryptocryne retrospiralis* (44.74), *Lamna perpusilla* (31.26), *Cabomba aquatic* (29.13), *Echinochloa spp.* (28.15), *Scirpus spp.* (21.47), *Phragmites karka* (12.05), *Fimbristylis miliacea* (9.74) and *Colocasia antiquorum* (8.57) shows highest IVI value among others. The lowest IVI of *Potamogeton crispus* (3.53) was noted in Govindgarh lake at station D (Fig. 4)

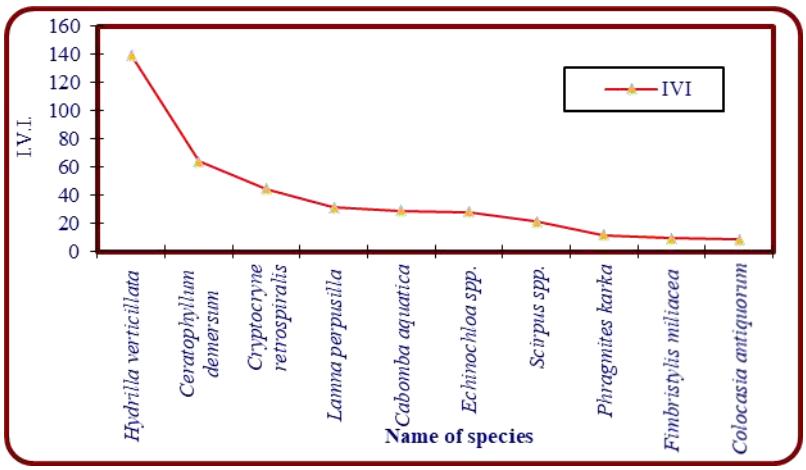

Fig 5: Ten dominating species in Station D at Govindgarh lake

Table 1: Ten dominating species with IVI value in each study sites

S. No.	Station A		Station B		Station C		Station D	
	Name of species	IVI	Name of species	IVI	Name of species	IVI	Name of species	IVI
1	*Lagenandra ovata*	120.27	*Vallisneria spiralis*	71.34	*Ranunculus aquatalis*	53.85	*Hydrilla verticillata*	139.27
2	*Saccharum bengalense*	111.27	*Monochoria vaginalis*	60.98	*Vallisneria spiralis*	31.12	*Ceratophyllum demersum*	64.11
3	*Lemna trisulca*	92.83	*Ceratophyllum demersum*	56.78	*Nymphaea stellata*	30.75	*Cryptocryne retrospiralis*	44.74
4	*Echinochloa spp.*	86.96	*Echinochloa spp.*	55.80	*Hydrilla verticillata*	30.04	*Lamna perpusilla*	31.26
5	*Potamogeton crispus*	85.53	*Potamogeton perfoliatus*	42.35	*Cryptocryne retrospiralis*	29.07	*Cabomba aquatica*	29.13
6	*Potamogeton perfoliatus*	79.51	*Cryptocryne retrospiralis*	32.67	*Jussiea repens*	28.15	*Echinochloa spp.*	28.15
7	*Eleocharis equisetoides*	73.37	*Colocasia antiquorum*	31.66	*Colocasia antiquorum*	24.50	*Scirpus spp.*	21.47
8	*Najas minor*	58.54	*Jussiea repens*	30.72	*Lemna minor*	22.51	*Phragmites karka*	12.05
9	*Eichhornia crassipes*	57.83	*Ipomoea aquatica*	30.01	*Ceratophyllum demersum*	13.53	*Fimbristylis miliacea*	9.74
10	*Lemna minor*	53.79	*Hydrilla verticillata*	18.87	*Potamogeton perfoliatus*	12.05	*Colocasia antiquorum*	8.57

Table 2: ANOVA of Aquatic Macrophytes in the different study sites of Govindgarh Lake, Rewa

Parameters	Study sites	N	Mean ±SE	Lower bound	Upper bound	Min.	Max.	F	P-value
Frequency	A	28	12.46±1.45	11.9	13	1.38	24.56	2.0627	0.1117
	B	22	9.36±1.29	8.8	9.9	1.65	23.55		
	C	19	8.27±1.21	7.7	8.8	0.69	20.39		
	D	15	9.01±1.26	8.4	9.7	1.30	22.80		
	Total	84	9.78±1.28	9.5	10.1	0.69	24.56		
Density	A	28	12.96±1.75	12.3	13.6	0.42	25.91	1.6372	0.1873
	B	22	9.23±1.22	8.7	9.7	0.77	25.90		
	C	19	7.38±1.17	6.9	7.9	0.22	22.16		
	D	15	8.75±1.19	8.2	9.4	1.24	21.51		
	Total	84	9.58±1.28	9.3	9.9	0.22	25.91		
Dominance	A	28	17.47±4.68	15.7	19.2	0.01	78.54	2.7876*	0.046
	B	22	6.24±3.09	5.0	7.5	0.06	58.87		
	C	19	1.65±0.64	1.4	1.9	0.04	11.30		
	D	15	10.01±6.68	6.6	13.4	0.03	97.35		
	Total	84	8.84±5.01	7.8	9.9	0.04	97.35		
IVI	A	28	42.89±6.59	40.5	45.3	2.26	120.27	3.5529*	0.018
	B	22	24.83±4.39	23.0	26.7	3.10	71.34		
	C	19	17.3±3.21	15.9	18.7	1.49	53.85		
	D	15	27.78±9.13	23.2	32.4	3.53	139.27		
	Total	84	25.7±5.24	24.6	26.8	1.49	139.27		

Note: S.E. = standard error; C.I. = Confidence Interval; <0.01 = * = Significant

The mean frequency of any one of the species found in one quadrat is 9.78 with standard deviation 1.28 and 95% C.I. (9.5, 10.1). The density of a particular species concentrated in one quadrat is found to be 9.58 plants with standard error (S.E.) 1.28 and 95% C.I. (9.3, 9.9). Further, it is found that the mean dominance of any species in a study area is 8.84 plants with standard error of 5.01 and 95% C.I. (7.8, 9.9). The mean IVI of the study area for all species is 25.7 with S.E. 5.24 and 95% C.I. (24.6, 26.8). The analysis of variance for all the aquatic macrophytic plant species reported from the different study sites of the Govindgarh lake are presented in Table 2. The F-test result indicates that the variation of among species with respect to these measures *viz.*, frequency & density not significant, dominance and IVI are significant of the different aquatic macrophytes in the four study sites.

Table 3: ANOVA for the different Aquatic Macrophytes of Govindgarh lake, Rewa

Parameters	Source of variations	d.f.	Sum of Squares	Mean Sum Squares	F	P- values	Significant level
Frequency	Between species	3	411.2092	137.0697	2.0627	0.1117	NS
	Within species	80	5316.2154	66.4527			
	Total	83	5727.4246				
Density	Between species	3	249.9963	83.3321	1.6372	0.1873	NS
	Within species	80	4071.8747	50.8984			
	Total	83	4321.871				
Dominance	Between species	3	3185.8772	1061.9591	2.7866	0.046	*
	Within species	80	30487.803	381.0975			
	Total	83	33673.6802				
IVI	Between species	3	8369.2198	2789.7399	3.5529	0.018	*
	Within species	80	62815.2074	785.1901			
	Total	83	71184.4272				

Note: NS = Not significant, <0.01 = * = Significant

The analyses of variance between species available in whole study site are presented in Table 3. The variability of species available with respect to frequency, density, dominance and IVI is tested by applying statistical tools. It is observed that the variation of among species with respect to these measures *viz.*, frequency & density not significant,

dominance and IVI are significant as evident by F-test result. This finding reveals that the inventory of species within the study area is also significantly different in terms of quantitative parameters due to heterogeneities of basic features like temperature, pH etc.

The quantitative characters which comprises the estimation of frequency, density, dominance, and importance value index (IVI) of the different macrophytic species in the different study sites of the lake, recorded higher values during rainy season which influenced the growth of the macrophytes and favouring good climatic conditions.

It was observed that the maximum numbers of aquatic macrophytic plant species were recorded at the onset of the summer season and the rainy season due to the favourable warm temperature while the lowest numbers of species were recorded during the winter season. Hogeweg & Brenkert (1969) [19] and Verma *et al.*, (1982) [20] earlier recorded luxuriant growth of the aquatic macrophytes, in the tropics during the rainy season. It is evident from the survey of the aquatic macrophytes distributions in the different lakes and wetlands in record that the Govindgarh lake is comparatively richer in Macrophytic species as compared to the other lakes of the state and other regions of India.

The statistical analysis reveals that there is no significant variation with respect to frequency, density and significant Dominance and IVI of the different aquatic macrophytes recorded in the four study sites of the lake. The analysis of variance within the different species of the aquatic macrophytes indicated significant variation with respect to the quantitative characters. Comparable findings were reported from Manasbal Lake, Kashmir Himalaya, India (Rather & Pandit, 2006) [21], Itaipu reservoir, Brazil (Mormul, *et al.*, 2010) [22], Lake Kharungpat, India (Singh, *et al.* 2013) [23] and Govindgarh lake, Rewa (Patel and Dubey, 2019b) [24].

4. Conclusion

Aquatic macrophytes in different growth forms represent the most important biotic elements in a aquatic ecosystem. Macrophytes are excellent indicators of the ecological state of water bodies, mainly because they integrate environmental changes over periods of several years, and reflect the cumulative effects of successive disturbances.

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