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Macrophytic diversity in lentic water being an indicator of water quality: A comparative study

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Abstract- Macrophytic diversity plays an important role in indicating the quality of water by their presence or absence. This study has been performed at Chotanagpur in Ranchi (Jharkhand) in two water bodies i.e. Kanke Dam and Ranchi Lake since 2022 to 2023 during all three season i.e. Pre-monsoon, Monsoon and Post-monsoon. It has been noted that richness of obligatory submerged and partially submerged (OSPS) macrophytes in Kanke Dam were highest during post monsoon while the richness of OSPS declined significantly by almost 50% in Ranch Lake at the same period. Data revealed the greater richness of family Cyperaceae, mainly constituted of *Fimbristylis dichotoma, Cyperus difformis,* and *Sacciolepsis interrupta* in Kanke Dam. Number of Cyperaceae family was extremely low in Ranchi Lake. Kanke Dam indicated highest population density and frequency for taxonomic species *Hydrilla verticillata* (L.f.) Royle followed by *Marsilea minuta*. A 15% increase in frequency of the macrophyte was noted during monsoon as it transited from pre-monsoon season. Likewise, in Ranchi Lake, its occurrences were only limited to monsoon season, that too was significantly lower (40%) than that of the Kanke Dam. In conclusion Kanke Dam indicated higher species diversity and species evenness comparing to Ranchi Lake, throughout the investigated period. These results indicate that quality of water, influence of season, area of lake and anthropogenic activities were mostly favourable to Kanke Dam, allowing higher diversity. Whereas, Ranchi Lake which is smaller in size and faces higher anthropogenic activities had relatively lower species diversity and lower species evenness.

Key words: Cyperaceae, *Fimbristylis dichotoma, Hydrilla verticillata,* Macrophytes, Obligatory submerged, *Sacciolepsis interrupta*, Species diversity.

INTRODUCTION

Freshwater resources are essential part of environment which provides healthy drinking water, water for farming, manufacturing, energy and transport. Not only these but it also plays important roles in recycle of nutrient, recharging of ground water, support to wildlife and recreation for people. Therefore, freshwater resources have greater contribution in various function of environment. Climate change and overexploitation of natural resources are also considered to be threat to the freshwater ecosystem. Slightest change in the aquatic ecosystem can have wider impact on assemblages that depends on food web provided by the system.

Therefore, these dependent assemblages are indicators of any physical and chemical change in aquatic ecosystem. Due to the interconnected dependences and mutual collaborations presence or disappearances of organisms from the ecosystem may act as biological indicator for exclusive changes in the characteristics of water.

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Lake ecosystems are unique in the sense that it contains relatively still freshwater (lentic ecosystem). Factors that modulate the ecosystem in lentic systems are limited, due to which overtime it becomes enriched by nutrients and organic sediments. Temperature, wind, oxygen, phosphorus etc. provide balances circulation of nutrients to microorganisms, primary producers, invertebrates, fish and other higher order consumers. Any change is ecosystem can reflect in overall abundance and richness of inhabited species. Thus, a regulated study of organisms during significant change in surrounding climate can elucidate species with exclusive toleration and sensitivity towards physical and chemical disturbances in quality of water. In the present study two water bodies (namely, Ranchi Lake and Kanke dam), located in district of Ranchi (23.36°N 85.33°E), Chotanagpur Plateau, distinctly different from each other based on location and encroachment area, were investigated. These two lakes located in urban and semi-urban locations were examined during pre-monsoon, monsoon, and post-monsoon seasons to observe change in quality of water and consequential disruption in macrophytic communities.

MATERIALS & METHODS

Collection of macrophytes were performed fortnightly along the littoral zones delimited by the aquatic vegetation. Qualitative sampling was carried out by handpicking, drag netting and sampler measuring ($20X20X40cm^3$)[1]. Separate depths were selected in each quadrant if the investigated lakes. For cross verification a total of 9 sampling attempts were made amounting 27 samples in each quadrant. Macrophytes were washed thoroughly and promptly in water and filtered subsequently. Macrophytes were collected manually and processed for identification. Identification of macrophytes were conducted through guidelines and taxonomical directories.[2] Species richness and abundance were recorded. Species diversity was measured by Shannon-Weiner Diversity Index (H). Species density and frequency was also measured in both lakes during each investigated season.

$$Density = \frac{number\ of\ organisms}{area\ of\ sampler \times number\ of\ replicates} \times 10000\ \text{ind/m}^2 \quad ....5$$

$$Frequency = \frac{number\ of\ quadrants\ where\ species\ found}{total\ number\ of\ quadrants} \times 100\ \% \quad ...6$$

Statistical analysis

Experiments done in multiple series were present in Mean±SD. All paired analyses were compared through Student-t test (MINITAB, US), for which any value below 95% CI was considered significant. Pearson's correlation test (r) (MS-EXCEL, US) was applied to enumerate cause and effect analysis between pre-monsoon, monsoon, and post-monsoon. The abundance was measured by calculating sampling area (0.05 m^2) at each site. Values were measured in Mean±SD, P variation lower than 0.05 was considered significant. Abundance was measured through taxa richness and overall abundance in each lake during period of investigation.

RESULTS

Number of species of macrophytes identified in Kanke Dam were 16, 44, and 34 during pre-monsoon, monsoon and post-monsoon. While lowest were found during pre-monsoon and maximum was observed during monsoon. Table-2 lists out respective species of macrophytes observed in Kanke Dam during period of investigation. During pre-monsoon season top five macroinvertebrates that indicated higher frequencies were *Polygonum barbatum* L., *Hydrilla verticillata* (L.f.) Royle, *Enhydra fluctuans* Loureiro, *Najas graminea* Del, and *Marsilea minuta* L. Whereas, during monsoon top five frequencies were observed for *Hydrilla verticillata* (L.f.) Royle, *Marsilea minuta* L., *Cyperus difformis* L., *Pistia stratiotes* L. and *Eichhornia crassipes* (Mart.) Salms. Likewise, during post-monsoon frequencies of top five macrophytes in Kanke Dam was *Hydrilla verticillata* (L.f.) Royle, *Fimbristylis dichotoma* (L.) Vahl., *Pistia stratioites* L., *Cyperus difformis* L., *Scirpus articubitu* (L.).

In Ranchi Lake density and frequency of macrophytes significantly altered during investigated seasons. Total number of species found during pre- monsoon, monsoon, and post-monsoon were 12, 19, and 15, respectively. Top five frequencies of macrophytes during pre-monsoon season in Ranchi Lake were *Pistia stratiotes* L., *Eichhornia crassipes* (Mart.) Salms., *Zostera marina, Salvinia molesta* Mitchell, and *Typha angustifolia*. Similarly, during monsoon top frequencies were measured for *Cyperus difformis* L., *Hydrilla verticillata* (L.f.) Royle, *Salvinia cuculata* Status, *Pistia stratiotes* L., and *Ludwigia hyssopifolia* (Don.) Excall. Top frequencies during post-monsoon season were recorded for *Hydrilla verticillata*

(L.f.) Royle, *Ceratophyllum demersum* L., *Sagittaria trifolia* L., *Cyperus difformis* L., and *Colocasia esculenta* (L.) (Table -3)

Shannon-Weiner Diversity Index (H') of macrophytes

Community diversity of macrophytes in both investigated lakes were evaluated through Shannon Diversity Index (H'). Observation predicted maximum diversity in Kanke Dam when compared with Ranchi Lake. The diversity index in Kanke Dam during pre-monsoon, monsoon and post- monsoon seasons were recorded as 2.32, 3.45, and 3.12, respectively. Diversity index during monsoon was higher comparing both pre- and post-monsoon. Community diversity of macrophytes during monsoon and post monsoon were close, thus post-monsoon lower precipitation could not make specific alterations in the community dynamics (Table-1). In Ranchi Lake significantly lower diversity was noted comparing to Kanke Dam. The H' value was noted as 2.19, 1.49, and 2.59, during pre-monsoon, monsoon, and post-monsoon seasons respectively. Unlike Kanke Dam, the Shannon Diversity Index in Ranchi Lake indicated significant stagnant response during investigated seasons. Interestingly, where during monsoon diversity of macrophytes increased in Kanke Dam, in Ranchi Lake it reduced substantially, and later reached to the level of pre-monsoon.

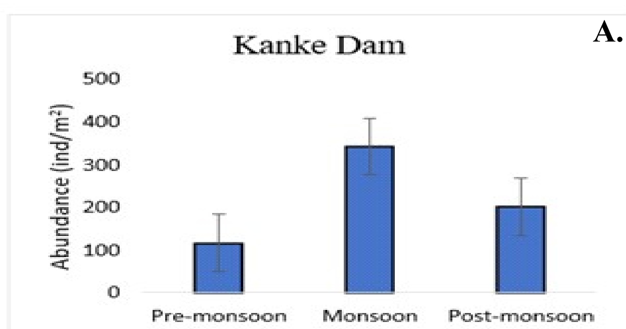
Likewise, Effective Number of macrophytes species (ENS) in both lakes showed major variations following each investigated season. In Kanke Dam ENS was noted as 10.21, 31.51, and 22.71 during pre-monsoon, monsoon, and post monsoon seasons, respectively. A three-fold increase in ENS during monsoon following pre-monsoon season indicate significant alterations in the ecosystem. Likewise, in Ranchi Lake ENS were recorded as 8.92, 4.47, and 13.39 during pre-monsoon, monsoon, and post monsoon, respectively. (Table-1). The diversity index in the lakes were distinctly different despite being apart from each other by 3-4 km. Regardless, both lakes seemed to have largely affected by monsoon and thus the effective n number of macrophytes was relative to resulting changes in the ecosystem.

Abundance and individual frequencies of macrophytes

Significant alterations in abundance (ind/m^2) of macrophytes were observed during period of investigation. An increasing trend was visible through transition from pre-monsoon to monsoon and from monsoon to post-monsoon in Ranchi Lake, overall abundance was noted as 73.75-118.13-126.25 ind/m^2. Whereas, macrophytes abundance in Kanke Dam increased significantly during monsoon and later during post-monsoon declined sharply. Regardless, abundance was still significantly higher than pre- monsoon; abundances were noted as, 116.25-342.50-200.63 ind/m^2. Comparatively, Kanke Dam indicated higher macrophytic abundance with respect to Ranchi Lake during all three seasons.

Individual frequency of families of macrophytes showed dominance of *Hydrilla verticillate* L. (18%), *Polygonum barbatum* L. (12%), and *Marsilea minuta* L. (13%) in Kanke Dam during pre-monsoon. Contrasting to this, significant diversity was evident during monsoon leading to undermined dominance of species existed during pre-monsoon. All families were within ranges of 0-4% regardless. Post-monsoon diversities of families of macrophytes rapidly began to show dominance over each other by re-emergence of *Hydrilla verticillate* L (6%), along with new emergence of *Marsilea quadrifolia* L. (5%), *Monochoria hastate* L. (5%), *Ludwigia adscendens* L. (5%), *Lemna acquinoctialis* Welwitsch (5%), *Pistia stratioites* L. (6%), *Fimbristylis dichotoma* L. (7%), *Cyperus difformis* L. (6%), *Scirpus articubitu* L. (5%), *Sacciolepsis interrupta* (Willd) (5%).

Likewise individual frequencies of macrophytes in Ranchi Lake indicated clear dominance of *Eichhornia crassipes* (14%), *Pistia stratioites* L. (17%), and *Salvinia molesta* (10%). During monsoon although extensive domination of these macrophyes were declined substantially to 5%, 9%, and 9% for *Eichhornia crassipes*, *Pistia stratioites* L., and *Salvinia molesta,* respectively. With this, emergence of other families was witnessed such as; *Hydrilla verticillate* L. (9%), *Ludwigia hyssopifolia* (Don.) (8%), *Cyperus difformis* L. (10%). Post-monsoon families of macrophytes showed mostly balanced frequencies around the families. Most of these [close to 11 out of 18 (i.e. 61%)] families were in range of 5-12%.



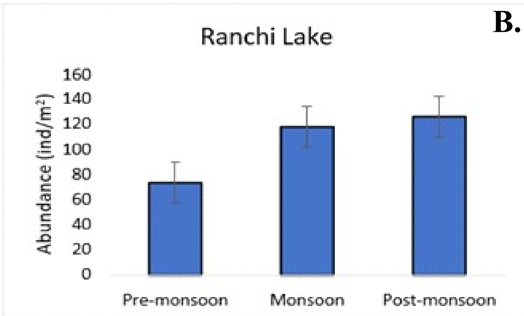
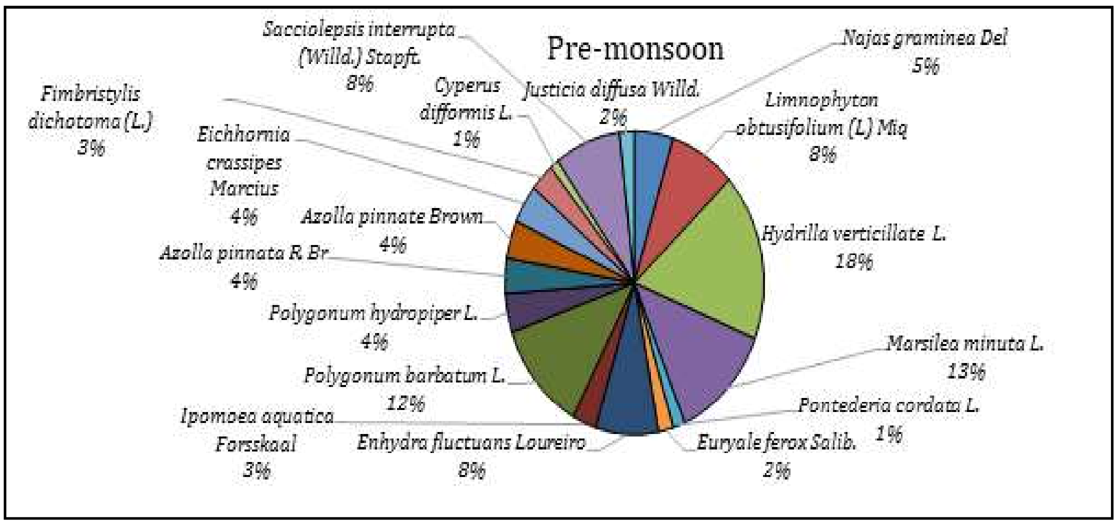
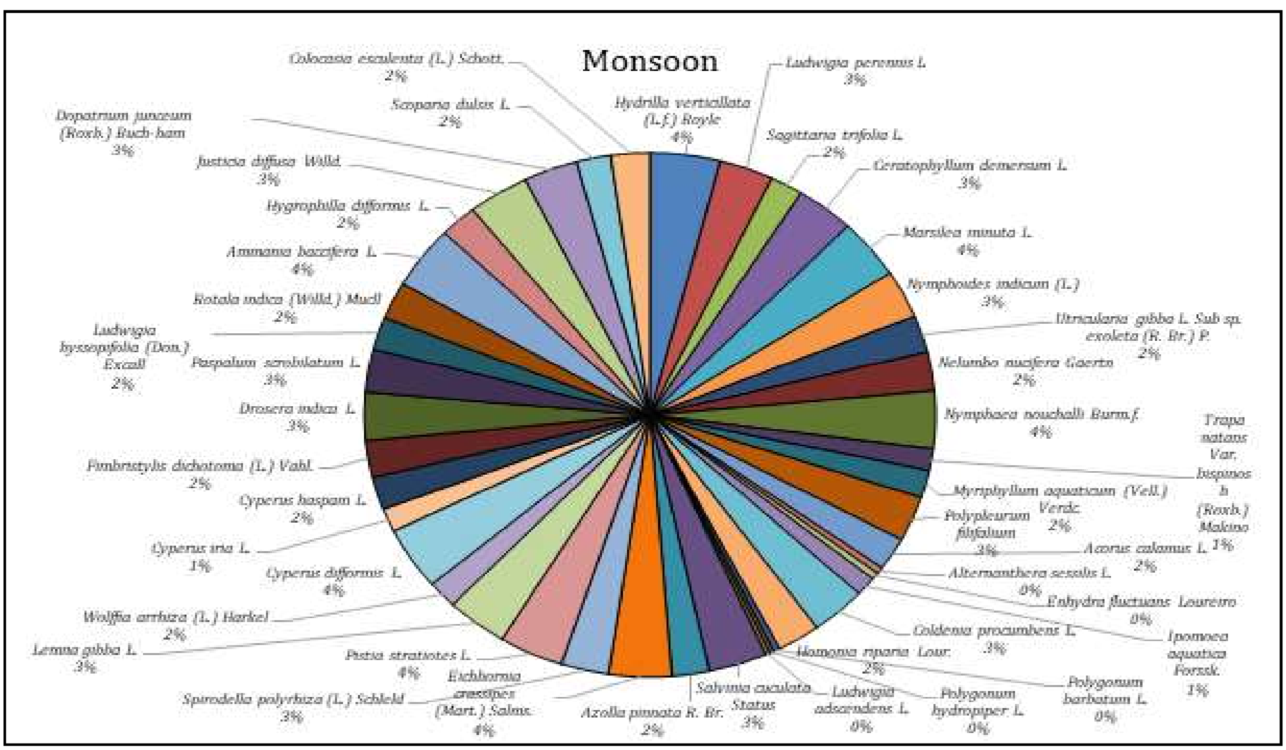


Figure-1 Abundance of macrophytes during investigated seasons in A. Kanke Dam and B. Ranchi Lake

Table 1: Shannon-Weiner Diversity Index (H') and Effective Number of Species (ENS) of macrophytes in the investigated lakes.

Site of investigation	Pre monsoon		Monsoon		Post monsoon	
	H'	ENS	H'	ENS	H'	ENS
Kanke Dam	2.32	10.21	3.45	31.51	3.12	22.71
Ranchi Lake	2.19	8.92	1.49	4.47	2.59	13.39





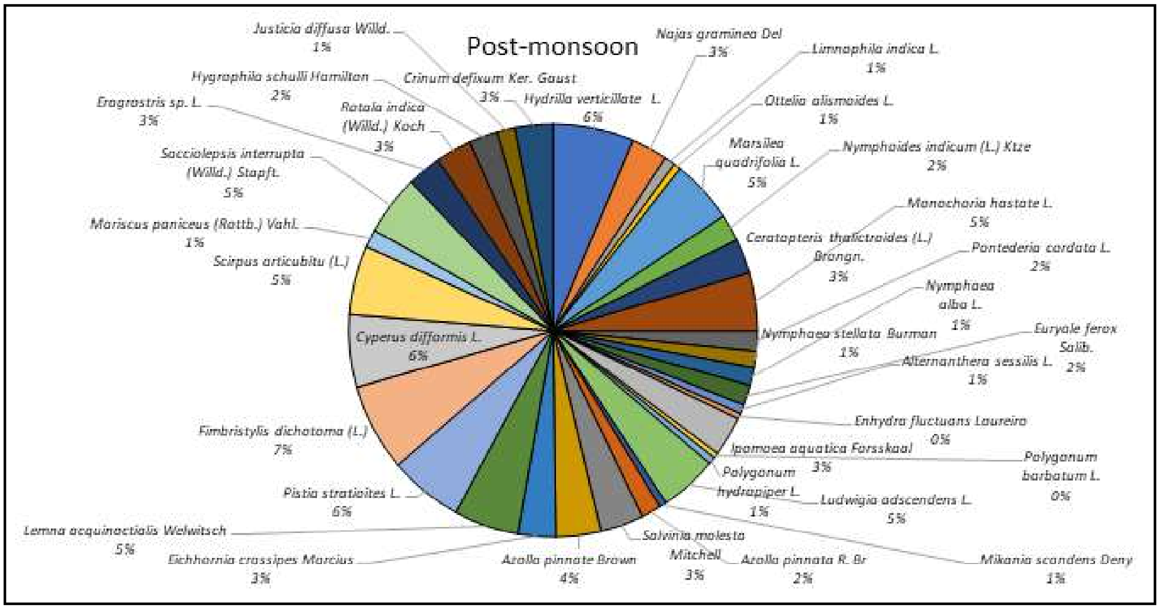
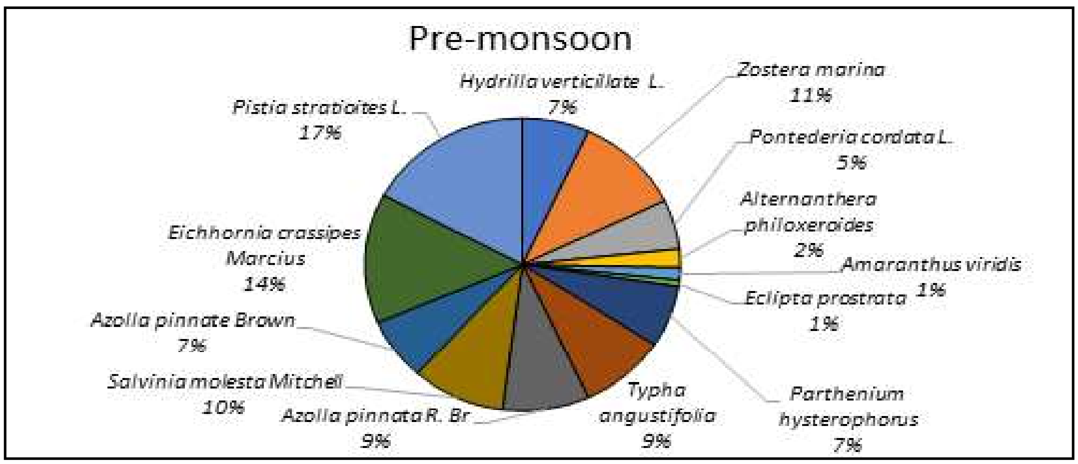
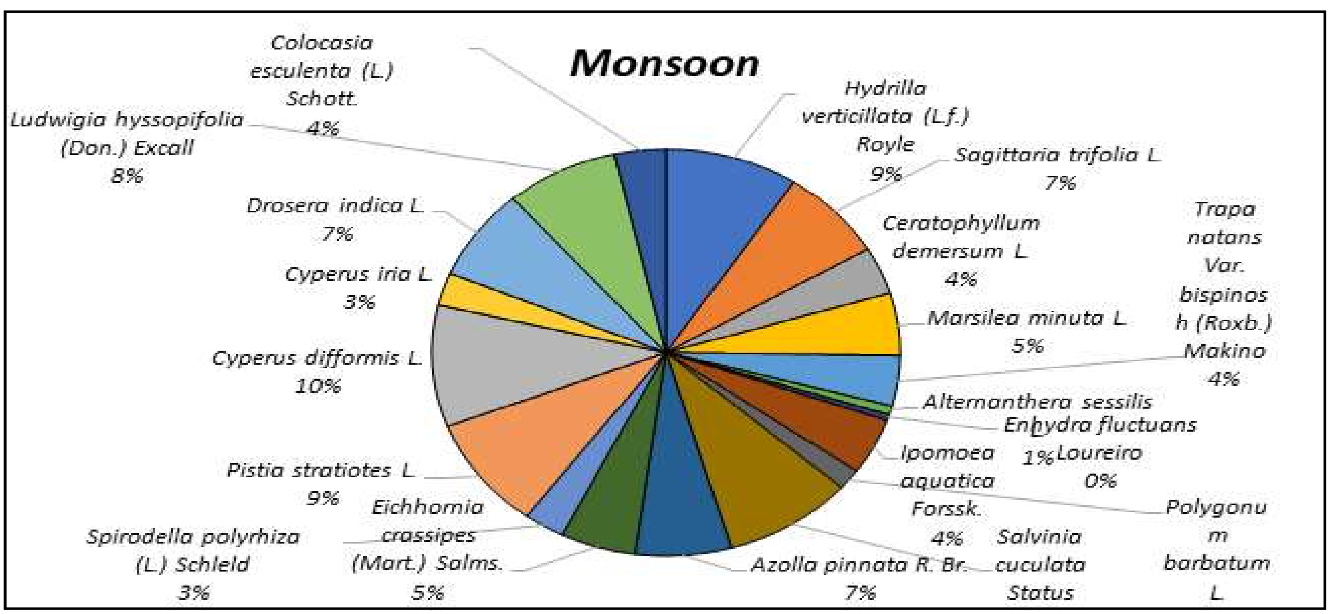


Figure-2: Frequency of macrophytes in Kanke Dam during pre-monsoon, monsoon & post-monsoon season





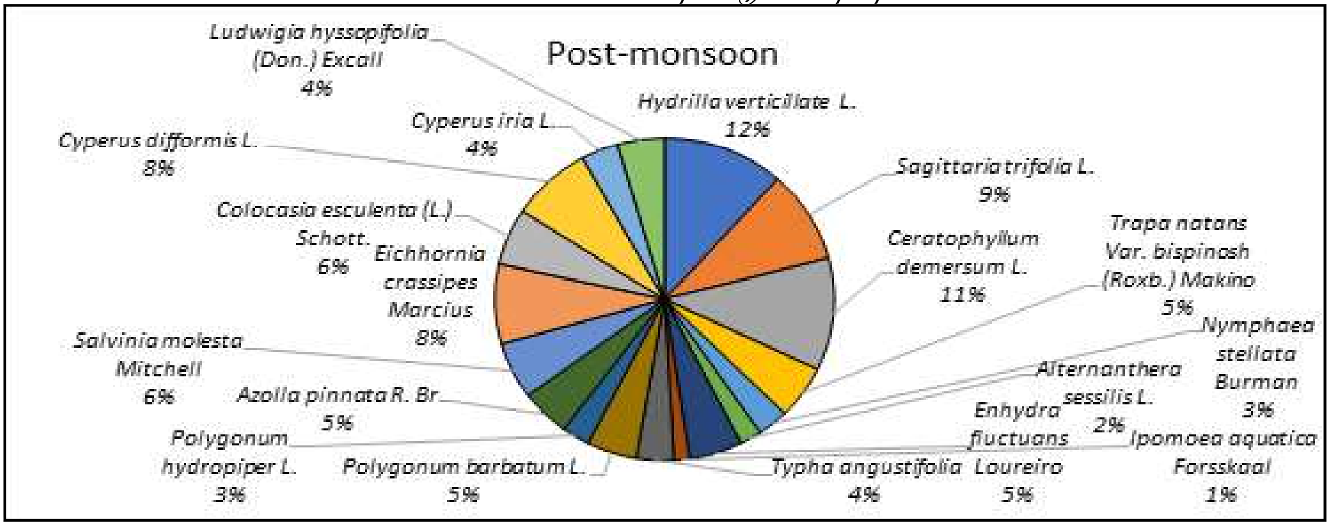


Figure-3: Frequency of macrophytes in Ranchi Lake during pre-monsoon, monsoon & post-monsoon season

Table- 2: Macrophytes diversity in Kanke Dam along with respective population densities and frequency during investigated seasons.

	Pre-monsoon		Monsoon		Post-monsoon	
Species	Population density	Frequency (%)	Population density	Frequency (%)	Population density	Frequency (%)
Hydrilla verticillata (L.f.) Royle	23.13	77.42	20.63	75.81	20.00	72.58
Ludwigia perennis L	-	-	9.38	58.06	-	-
Najas graminea Del	3.75	20.97	3.75	20.97	6.25	32.26
Sagittaria trifolia L.	-	-	8.13	35.48	-	-
Ceratophyllum demersum L.	-	-	15.00	62.90	-	-
Marsilea minuta L.	17.50	54.84	16.25	70.97	-	-
Nymphoides indicum (L.)	-	-	3.13	56.45	-	-
Utricularia gibba L. Sub sp. *exoleta* (R. Br.) P.	-	-	6.88	43.55	-	-
Nelumbo nucifera Gaertn	-	-	13.75	45.16	-	-
Nymphaea nouchalli Burm.f.	-	-	11.25	67.74	1.88	24.19
Trapa natans Var. bispinosh (Roxb.) Makino	-	-	5.00	25.81	-	-
Myriphyllum aquaticum (Vell.) Verdc.	-	-	1.25	32.26	-	-
Polypleurum filifalium	-	-	5.00	53.23	-	-
Acorus calamus L.	-	-	5.63	38.71	-	-
Alternanthera sessilis L.	-	-	1.25	8.06	0.63	8.06
Enhydra fluctuans Loureiro	5.63	33.87	2.50	8.06	0.63	4.84
Ipomoea aquatica Forssk.	1.88	12.90	1.88	22.58	3.13	35.48
Coldenia procumbens L.	-	-	11.88	59.68	-	-
Homonia riparia Lour.	-	-	4.38	46.77	-	-
Polygonum barbatum L.	25.00	51.61	0.63	6.45	0.63	4.84
Polygonum hydropiper L.	1.88	17.74	0.63	4.84	0.63	6.45
Azolla pinnata R. Br.	3.13	16.13	11.25	40.32	3.75	17.74
Eichhornia crassipes (Mart.) Salms.	1.88	17.74	13.13	67.74	8.13	33.87
Pistia stratiotes L.	-	-	14.38	69.35	-	-
Lemna gibba L.	-	-	11.88	66.13	-	-
Wolffia arrhiza (L.) Harkel	-	-	2.50	32.26	-	-
Cyperus difformis L.	1.25	4.84	20.63	74.19	14.38	64.52
Cyperus iria L.	-	-	5.00	27.42	-	-
Cyperus haspam L.	-	-	11.25	38.71	-	-
Fimbristylis dichotoma (L.) Vahl.	4.38	12.90	2.50	43.55	18.75	77.42
Drosera indica L.	-	-	7.50	56.45	-	-
Paspalum scrobilatum L.	-	-	3.75	50.00	-	-
Ludwigia hyssopifolia (Don.) Excall	-	-	6.25	38.71	-	-

Rotala indica (Willd.) Mucll	-	-	8.75	43.55	3.75	32.26
Ammania baccifera L.	-	-	33.75	74.19	-	-
Hygrophilla difformis L.	-	-	3.13	40.32	-	-
Justicia diffusa Willd.	1.88	8.06	6.25	66.13	2.50	16.13
Dopatrium junceum (Roxb.) Buch-ham	-	-	9.38	58.06	-	-
Scoparia dulsis L.	-	-	3.13	37.10	-	-
Colocasia esculenta (L.) Schott.	-	-	8.75	41.94	-	-
Limnophila indica L.	-	-	-	-	1.88	9.68
Ottelia alismoides L.	-	-	-	-	1.25	6.45
Marsilea quadrifolia L.	-	-	-	-	10.63	56.45
Ceratopteris thalictroides (L.) Brongn.	-	-	-	-	3.13	30.65
Monochoria hastate L.	-	-	-	-	25.00	51.61
Pontederia cordata L.	1.25	6.45	-	-	1.88	17.74
Euryale ferox Salib.	1.25	8.06	-	-	1.88	17.74
Mikania scandens Deny			-	-	1.25	6.45
Salvinia molesta Mitchell			-	-	8.75	38.71
Azolla pinnate Brown	5.63	17.74	-	-	5.63	40.32
Lemna acquinoctialis Welwitsch	-	-	-	-	6.88	58.06
Pistia stratioites L.	-	-	-	-	8.13	66.13
Scirpus articubitu (L.)	-	-	-	-	11.25	61.29
Mariscus paniceus (Rottb.) Vahl.	-	-	-	-	1.25	16.13
Sacciolepsis interrupta (Willd.) Stapft.	3.13	35.48	-	-	8.13	53.23
Eragrostris sp. L.	-	-	-	-	2.50	30.65

Table 3: Macrophytic distribution in Ranchi Lake during pre-monsoon, monsoon and post-monsoon seasons.

	Pre-monsoon		Monsoon		Post-monsoon	
Species	Population density	Frequency (%)	Population density	Frequency (%)	Population density	Frequency (%)
Hydrilla verticillata (L.f.) Royle	8.75	14.93	19.38	58.21	20.63	58.21
Sagittaria trifolia L.	-	-	5	46.27	3.75	46.27
Ceratophyllum demersum L.	-	-	4.38	23.88	11.25	56.72
Marsilea minuta L.	-	-	5.62	31.34		
Trapa natans Var. *bispinosh* (Roxb.) Makino	-	-	6.25	25.37	3.13	26.87
Alternanthera sessilis L.	-	-	0.63	4.48	0.63	10.45
Enhydra fluctuans Loureiro	-	-	0.63	2.99	9.38	25.37
Ipomoea aquatica Forssk.	-	-	1.88	28.36	0.63	7.46
Polygonum barbatum L.	-	-	5	10.45	6.25	23.88
Salvinia cuculata Status	-	-	6.88	56.72	11.25	28.36
Azolla pinnata R. Br.	6.88	19.40	9.38	41.79	6.88	23.88
Eichhornia crassipes (Mart.) Salms.	9.38	31.34	8.13	32.84	14.37	40.30
Spirodella polyrhiza (L.) Schleld	-	-	1.88	17.91	-	-
Pistia stratiotes L.	6.25	37.31	15.63	56.72	-	-
Cyperus difformis L.	-	-	17.5	61.19	16.25	38.81
Cyperus iria L.	-	-	1.88	16.42	0.63	17.91
Drosera indica L.	-	-	1.88	46.27	-	-
Ludwigia hyssopifolia (Don.) Excall	-	-	4.38	49.25	3.75	22.39
Colocasia esculenta (L.) Schott.	-	-	1.875	22.39	2.5	28.36
Zostera marina	15.63	23.88	-	-	-	-
Pontederia cordata L.	1.25	11.94	-	-	-	-
Alternanthera philoxeroides	1.25	4.48	-	-	-	-
Amaranthus viridis	0.63	2.99	-	-	-	-

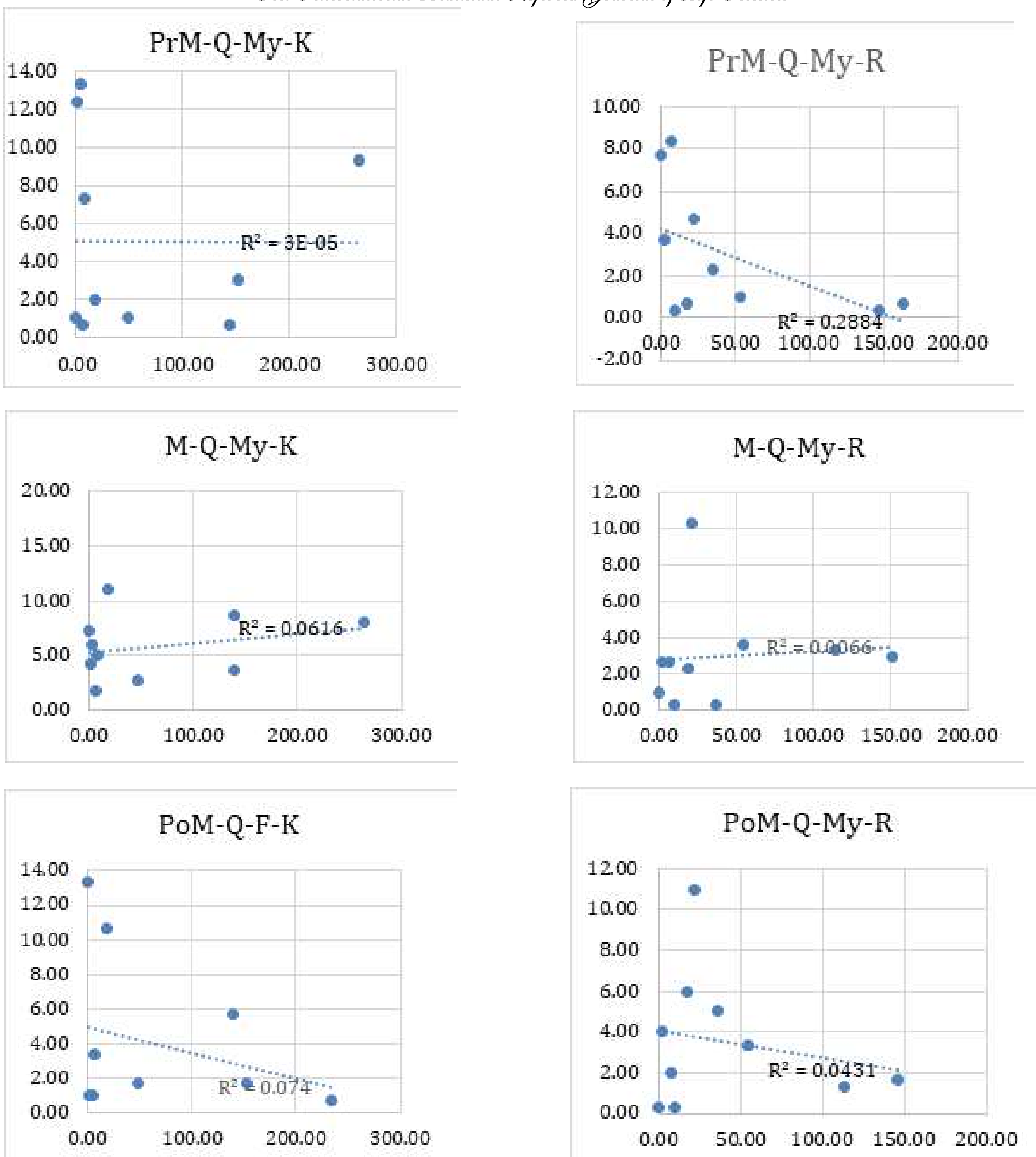


Figure-4:Relatedness between seasonal variation in macrophytes population and quality of water in the investigated lakes.

DISCUSSION

In most cases accumulation of nutrient at the sediment of aquatic ecosystem leads to growth of macrophytes and weeds. Eutrophication of freshwaters is considered one of the major reasons behind macrophytic vegetation. Regardless, existence of macrophytes in freshwater resources plays important role in maintenance of freshwater resources. Macrophytes such as; emergent, free floating, submerged etc are types those have specific contributions to that water quality it inhabited. For instance, submerged macrophytes maintain quality of water along with biodiversity in shallow lakes.[3] Previous studies claimed that presence of submerged macrophytes inhibit algal bloom by reducing level of nutrient, allelopathy and shading.[4-6] This study noted presence of second largest groups of submerged and partially submerged macrophytes in Kanke Dam second only to the emergent. This study revealed that during post-monsoon richness of Obligatory Submerged and Partially Submerged (OSPS) macrophytes were highest followed by monsoon and pre-monsoon, respectively. Visual inspection of lake also reflected most algal bloom during pre-monsoon and least during post-monsoon. The above assumptions were in accordance to the earlier claim that presence of OSPS in freshwater causes improvement in quality of water by sucking up excessive nutrients. At the same time in Ranchi Lake, richness of OSPS significantly declined by almost 50% during each investigated season in comparison to Kanke Dam. This study already mentioned that Kanke Dam was more often infested by algal bloom than Kanke Dam. A report published in The Telegraph[7] states that Ranchi Lake water is heavily infested by the blue-green algae bloom.

Sedge vegetation in freshwater has important role in maintenance of physiochemical properties of water. It belongs to the family *Cyperaceae* which is consisted of an estimated 5000 species.[8] Its presence is diverse with particular exception of desert, marine and deep water. These sledges support the food-web by recycling nutrients in the freshwater. Previous studies explained that compared other macrophytes, sledges recycle excess nutrients faster than any other. Sledges also serve as bioindicator for pH and salinity in freshwater ecosystem. The present study indicated greater richness of family Cyperaceae, mainly constituted of *Fimbristylis dichotoma*, *Cyperus difformis*, and *Sacciolepsis interrupta*. These three species were present during all three seasons examined. Among these *Fimbristylis dichotoma*[9] and *Sacciolepsis interrupta*[10] were exclusively affected by the pH and salinity of the water. Its presence in the Kanke Dam reflected interference in pH of water which was significantly altered during post-monsoon and pre- monsoon seasons when compared with monsoon. Richness of Cyperaceae were varied accordingly during pre-monsoon, monsoon, and post monsoon seasons, explaining exclusive alteration in Kanke Dam. It also reflected why lower deviation in pH was recorded in Ranchi Lake, as richness and identification of species under Cyperaceae family was extremely low comparing to Kanke Dam.

Kanke Dam indicated highest population density and frequency for taxonomic species *Hydrilla verticillata* (L.f.) Royle followed by *Marsilea minuta* L. A study by Srivastava and Srivastava[11] reported that *Hydrilla verticillata* (L.f.) Royle can grow in contaminated water providing high biomass and its unique ability to remove metal contaminants from water can be utilized as primary and secondary detoxification mechanism. It can tolerate various unfavourable factors and stressors, causing it to grow in most pollutant and eutrophic freshwater due to wide-range physicochemical properties of water.[12] Its presence in such frequency was therefore justified. However, in Ranchi Lake its population density and frequency significantly lower (close to 80%] than that of Kanke Dam. Despite having unique feature to grow in adverse conditions its inefficiency in Ranchi Lake indicate exclusive pattern. A study by Gao *et al*.(2015)[13] reported that coexistence of *Hydrilla verticillate* and algae bloom is inhibitory to each other. There could be possibility for relatively lower frequency of *Hydrilla verticillate* due to extensive algal bloom in Ranchi Lake.

Likewise, *Marsilea minuta*, a dwarf water clover, widely distributed in African and South Asian countries. It is a creeping, rooted branched rhizomes. It can grow well in freshwater, mostly in clay and sandy soil. Previous studies have noted many species of this genus are extremely vulnerable to anthropogenic activities. In some European countries it has been considered as endangered species and/or extremely rare species. Based on earlier studies it is sensitive to the eutrophication of lakes and quality of water. The present study noted second maximum frequency of *Marsilea minuta* in Kanke Dam, however, its population was only evident during pre-monsoon and monsoon, its occurrences during post-monsoon was low. A 15% increase in frequency of the macrophyte was noted during monsoon as it transited from pre- monsoon season. Likewise, in Ranchi Lake, it occurrences was only limited to monsoon season, that too was significantly lower (40%) than that of the Kanke Dam. No evidences of *Marsilea minuta*, was observed during pre- monsoon and post-monsoon seasons. It explained that Kanke Dam sustained more anthropogenic contaminants during post-monsoon season, whereas, Ranchi Lake faced higher down gradation in water quality during pre- monsoon and post-monsoon seasons comparing to monsoon. It can be concluded that monsoon precipitations have unique role in growth of

Marsilea minuta, nevertheless, more studies are required to ascertain as to why both lakes recorded higher frequency of *Marsilea minuta*, during monsoon in the region.

The present study showed clear distinction between abundances of macrophytes in Kanke Dam. Where, most these were more abundant during monsoon season. However, in Ranchi Lake abundance of macrophytic groups were similar during monsoon and post-monsoon. A study by Qadri *et al*. (2021)[14] revealed that selected macrophytes can depend on existing COD, nitrogen, phosphorus, and total suspended solids. Therefore, its abundance is more likely dependent on the quality of water having higher COD, phosphate and nitrate. It justifies why followed by an increase in abundance of macrophytes in Ranchi Lake, abundances of these remained intact during post-monsoon season.

The diversity of macrophytes in freshwater is declining at very rapid rate.[15] Since lakes play major role in biodiversity of freshwater ecosystem. The Diversity Index (SWDI] of macrophytes in Kanke Dam indicated higher diversity comparing to Ranchi Lake, throughout the investigated period. Whereas, evenness of species was also better distributed in Kanke Dam in comparison to Ranchi Lake. These results indicate that quality of water (conductivity, and transparency), area of lake and anthropogenic activities were mostly favourable to Kanke Dam, allowing higher diversity. Whereas, Ranchi Lake which is smaller in size and faces higher anthropogenic activities had relatively lower species diversity.

CONCLUSION

The present study indicated greater richness of family *Cyperaceae*, mainly constituted of *Fimbristylis dichotoma*, *Cyperus difformis*, and *Sacciolepsis interrupta*. These three species were present during all three seasons examined. Kanke Dam indicated highest population density and frequency for taxonomic species *Hydrilla verticillata* (L.f.) Royle followed by *Marsilea minuta* L. However, in Ranchi Lake its population density and frequency significantly lower (close to 80%) than that of Kanke Dam. Evenness of macrophyte species was better distributed in Kanke Dam in comparison to Ranchi Lake. Results indicated that quality of water (conductivity, and transparency), area of lake and anthropogenic activities were mostly favourable to Kanke Dam, allowing higher diversity.

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