RESEARCH ARTICLE

Eco-floristic Survey on Aquatic Macrophytes from Three Mouzas of East Kolkata Wetland, West Bengal, India

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Abstract

The East Kolkata Wetland, a Ramsar site of West Bengal, harbors a rich source of biodiversity. It is a vital natural resource that plays a crucial role in environmental protection. The objective of the survey is to explore the seasonal changes in the floristic composition of three mouzas (Nonadanga, Chalk Kalarkhal, and Patuli) of the East Kolkata Wetland. The survey provides a detailed quantitative analysis of phytosociological parameters, including frequency, density, abundance, and diversity of aquatic macrophytes in three mouzas. The survey revealed a diverse group of aquatic macrophytes, comprising 51 species and 41 genera, under 27 vascular plant families. The highest plant diversity was recorded in Patuli during winter, and the lowest diversity was found in Nonadanga during summer. *Alternanthera philoxeroides* is the most widely distributed species among all mouzas, having the highest mean frequency, followed by *Colocasia esculenta*, *Eichhornia crassipes, Commelina diffusa, Typha angustifolia*, *Myriophyllum* sp., *Ipomoea aquatica and Pistia stratiotes.* The Amaranthaceae family exhibited the highest range of frequency, followed by Araceae, Pontederiaceae and Typhaceae. Lemnaceae exhibited the highest density and abundance. Aquatic macrophyte diversity has a significant positive correlation ($p < 0.01$) with frequency, density, and abundance, whereas density shows the highest degree of positive correlation with aquatic macrophyte diversity. This study will be beneficial for biodiversity conservation and the development of a mouza-wise database on the aquatic macrophyte diversity and floristic composition of the entire East Kolkata Wetland in the future.

Highlights

- The study has explored 51 species of aquatic macrophytes that belong to 41 genera and 27 families.
- The present study reveals the floristic composition and aquatic macrophyte diversity of three mouzas in different seasons from January 2023 to January 2025.
- The study also explores the quantitative analysis of phytosociological parameters of aquatic macrophytes of the three mouzas.

Keywords: East Kolkata Wetland, aquatic macrophytes, frequency, diversity, floristic composition.

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Introduction

East Kolkata Wetland (EKW) was first introduced by Dr. Dhrubajyoti Ghosh (Ghosh *et al.,* 2018; Mandal, 2021). It achieved global importance status since the First International Convention on Wetlands was held in Ramsar, Iran (1971) (Roy *et al.,* 2013; Dutta and Chakraborty, 2017). It was designated as a 'Wetland of International Importance' under the 'Ramsar Convention' on August 19, 2002, and received the designation of 'Ramsar site' in November 2002 (Ahmad and Kalam, 2017). It is the largest wastewater wetland among 37 Ramsar Sites in India (Chandra *et al.,* 2020). It bears both man-made and natural wetlands, agricultural lands, solid waste farms, and some built-up areas (Chaudhuri *et al.,* 2008; Ghosh *et al.,* 2018). EKW has a rich source of floral diversity. Almost 381 taxa are documented by the Botanical Survey of India, which belong to 92 families and 282 genera (Chandra *et al.,* 2020). The primary objective of this survey is to determine the seasonal floristic composition and quantitative analysis of phytosociological parameters of aquatic macrophytes in the three mouzas (Nonadanga, Chalk Kalarkhal, and Patuli). Further research on remaining mouzas is necessary to determine the floristic composition of the entire East Kolkata Wetland. The survey aims to address the research gap on seasonal variation in floristic composition, aquatic macrophyte diversity, and phytosociological parameters, such as the frequency, density, and abundance of aquatic macrophytes in the study area, which have remained unexplored in all previous works.

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Materials And Methods

Study Area

East Kolkata Wetland is situated at 22° 25′ to 22° 40′ N and 88° 20′ to 88° 35′E, located at the eastern part of Kolkata, West Bengal (Chaudhuri *et al.,* 2012). EKW has multiple water bodies (almost 11085) distributed across the districts of South and North 24 Parganas (Sanyal *et al.,* 2015). It spreads over 12,500 hectares, containing 37 mouzas (Dasgupta and Panigrahi, 2014; Mandal and Bandyopadhyay, 2018). The present survey was conducted in the wetlands of three mouzas of EKW, namely Nonadanga, Chalk Kalarkhal, and Patuli, from January 2023 to January 2025.

Species collection, identification and preservation

Fifteen quadrats of 1 square meter were randomly laid down on different wetlands in each mouza from January 2023 to January 2025 during summer, monsoon, and winter seasons. Aquatic macrophytes were collected from the studied quadrats. Aquatic macrophytes were identified using standard literature Naskar (1990), Cook (1996) and Fassett (2006) and with the help of taxonomic expertise. Herbarium specimens of the collected macrophytes were prepared.

Data analysis

The number of individuals of each species was counted from each quadrat to determine phytosociological parameters (Mishra, 1968). Several phytosociological parameters, like frequency, density, abundance, and diversity, were calculated and analyzed. Statistical analysis had been carried out for data analysis with the SPSS software.

Results And Discussion

Aquatic macrophytic diversity

Aquatic macrophytic diversity is calculated for these three mouzas from, January 2023 to January 2025 during the summer, monsoon and winter seasons. Both the Shannon-Weiner Index, and the Simpson's Index of Diversity are used to compare aquatic macrophytic diversity. The highest plant diversity has been recorded from Patuli in winter (Shannon-Weiner Index: 2.6, Simpson's Index of Diversity: 0.84), and the lowest diversity is found in Nonadanga in summer (Shannon-Weiner Index: 0.99, Simpson's Index of Diversity: 0.45) (Figure 1 &Table 1). Rapid urbanization, an increase in built-up areas and anthropogenic pollution are the serious threats to the biodiversity of EKW (Dasgupta and Panigrahi, 2014). Declining floral diversity has deleterious effects on the entire food chain of the wetland (Bhanja *et al.,* 2023). Aquatic macrophytes can be used to reduce water pollution because many aquatic macrophytes can absorb contaminants from water (rhizofiltration) and play a vital role in phytoremediation (Galal and Farahat, 2015). The government should take necessary management plans to monitor and mitigate the stress on the EKW.

Table 1: Aquatic macrophyte diversity of the mouzas in different seasons

Mouza name	*Season*	*Shannon-Weiner index*	*Simpson's index of diversity*
Kolarkhal	Summer	1.84	0.75
	Monsoon	1.83	0.75
	Winter	2.37	0.86
Nonadanga	Summer	0.99	0.45
	Monsoon	2	0.83
	Winter	1.45	0.66
Patuli	Summer	1.78	0.77
	Monsoon	2.22	0.75
	Winter	2.6	0.84

Floristic composition and quantitative analysis of phytosociological parameters

The survey shows the presence of 51 species of aquatic macrophytes, which belong to 41 genera and 27 families. Dicotyledon plants have 23 genera and 29 species that belong to 18 families, whereas monocotyledon plants belong to 7 families, having 16 genera and 20 species. Pteridophytic plants have 2 genera and 2 species that belong to 2 families (Figure 2 and Table 2).

Alternanthera philoxeroides (Mart.) Griseb. is the most widely distributed species among all mouzas, having the highest mean frequency (65.92%), followed by *Colocasia esculenta* (L.) Schott (39.81%), *Eichhornia crassipes* (Mart.) Solms (37.22%), *Typha angustifolia* L. (26.66%), *Myriophyllum sp (20%), Ipomoea aquatica* Forssk. *(19.58%),* and *Pistia stratiotes* L. (19.17%) (Figure 3 and Table 2). *A. philoxeroides* (Mart.) Griseb. (60%) also has the highest range of frequency, followed by *E. crassipes* (Mart.) Solms (40%), *C. esculenta* (L.) Schott (35%), *T. angustifolia* L (33.33%), and *P. stratiotes* L. (26.67%) (Table 2). The remaining plants fall within the 20% frequency ranges (Table 2). *Lemna perpusilla* Torr. has the highest mean density and abundance, followed by *Spirodela polyrhiza* (L.) Schleid. (Figure 4 and Table 2).

Members of *the* Amaranthaceae family exhibit the highest range of frequency (86.67%) across all mouzas, followed by

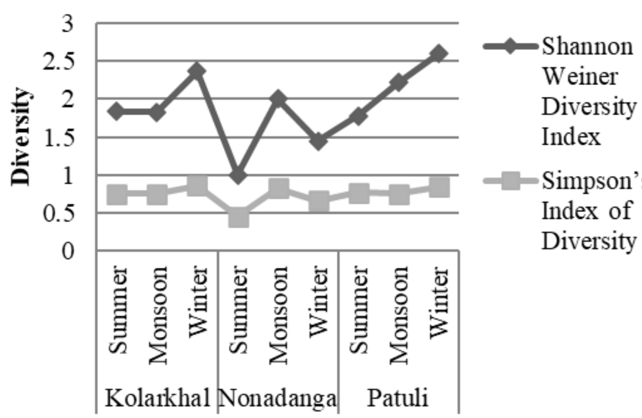

Fig. 1: Comparison of aquatic macrophyte diversity

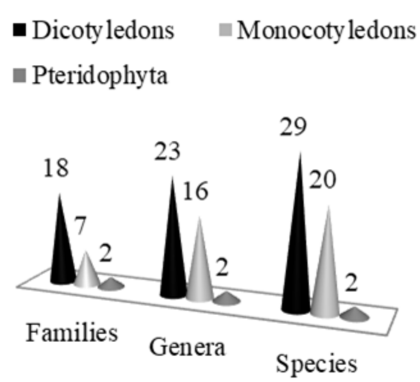

Fig. 2: Floristic composition of three mouzas

Table 2: Frequency, density and abundance of aquatic macrophytes and respective families

Plant	*Family*		*Frequency*	*Density*	*Abundance*
Abuliton sp.	Malvaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.07	1.00
		Standard Error	0.00	0.00	0.00
Alternanthera philoxeroides (Mart.) Griseb.	Amaranthaceae	Range	60.00	15.88	20.18
		Mean	65.93	9.94	14.70
		Standard Error	7.15304	1.64942	2.11368
A. sessilis (L.) R.Br. ex DC.	Amaranthaceae	Range	20.00	6.05	30.50
		Mean	14.29	2.13	14.02
		Standard Error	3.06148	0.77306	3.81646
Bacopa monnieri (L.) Wettst.	Plantaginaceae	Range	0.00	0.00	0.00
		Mean	6.67	1.13	17.00
		Standard Error	0.00	0.00	0.00
Brachiaria sp.	Poaceae	Range	0.00	0.00	0.00
		Mean	13.33	1.87	14.00
		Standard Error	0.00	0.00	0.00
Ceratophyllum demersum L.	Ceratophyllaceae	Range	20.00	11.13	38.00
		Mean	15.56	4.22	18.17
		Standard Error	5.87945	3.62549	12.42421
Colocasia esculenta (L.) Schott	Araceae	Range	35.00	2.20	5.56
		Mean	39.81	1.15	3.12
		Standard Error	4.65180	.21252	.60827
Colocasia sp.	Araceae	Range	0.00	0.00	0.00
		Mean	6.67	0.20	3.00
		Standard Error	0.00	0.00	0.00
Commelina benghalensis L.	Commelinaceae	Range	13.33	2.35	19.46
		Mean	13.67	1.58	13.37
		Standard Error	2.80872	.43327	3.57049
Commelina diffusa Burm.f.	Commelinaceae	Range	0.00	0.00	0.00
		Mean	26.67	3.73	14.00
		Standard Error	0.00	0.00	0.00
Cooccinia grandis (L.) Voigt	Cucurbitaceae	Range	1.67	0.00	0.00
		Mean	7.50	0.08	1.00
		Standard Error	0.83	0.00	0.00
Cynodon dactylon (L.) Pers.	Poaceae	Range	5.00	2.50	31.97
		Mean	11.67	1.79	17.01
		Standard Error	1.67	0.81	9.28
Cyperus articulates L.	Cyperaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.27	4.00
		Standard Error	0.00	0.00	0.00
Cyperus sp.	Cyperaceae	Range	13.33	1.33	20.73
		Mean	12.92	0.46	4.26
		Standard Error	2.04	0.18	2.45

Echinochloa sp.	Poaceae	Range	0.00	0.00	0.00
		Mean	6.67	5.00	75.00
		Standard Error	0.00	0.00	0.00
Eclipta prostrata (L.) L.	Asteraceae	Range	6.67	0.13	2.50
		Mean	8.89	0.13	1.83
		Standard Error	2.22	0.04	0.73
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Range	40.00	9.65	17.94
		Mean	37.22	4.33	10.56
		Standard Error	4.34	1.08	2.04
Enhydra fluctuans Lour	Asteraceae	Range	0.00	0.00	0.00
		Mean	6.67	0.47	7.00
		Standard Error	0.00	0.00	0.00
Hydrilla verticillata (L.f.) Royle	Hydrocharitaceae	Range	0.00	0.00	0.00
		Mean	20.00	1.93	9.67
		Standard Error	0.00	0.00	0.00
Ipomoea fistulosa Mart. ex-Choisy	Convolvulaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.08	1.00
		Standard Error	0.00	0.00	0.00
Ipomoea aquatica Forssk.	Convolvulaceae	Range	20.00	0.52	2.50
		Mean	19.58	0.46	2.18
		Standard Error	2.55	0.07	0.29
Kyllinga brevifolia Rottb.	Cyperaceae	Range	13.33	0.92	4.75
		Mean	11.11	0.47	3.42
		Standard Error	4.44	0.27	1.58
Leersia hexandra Sw.	Poaceae	Range	5.00	5.33	40.00
		Mean	12.08	3.95	32.88
		Standard Error	1.25	1.29	9.34
Lemna perpusilla Torr.	Lemnaceae	Range	0.00	38.30	288.50
		Mean	13.33	19.32	144.25
		Standard Error	0.00	19.15	144.25
Lippia alba (Mill.) N.E.Br. ex-Britton & P. Wilson	Verbenaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.08	0.50
		Standard Error	1.49	0.17	2.63
Ludwigia adscendens (L.) H.Hara	Onagraceae	Range	6.67	1.12	17.67
		Mean	10.00	0.47	5.22
		Standard Error	1.49	0.17	2.63
Ludwigia sp.	Onagraceae	Range	0.00	0.00	0.00
		Mean	6.67	0.33	5.00
		Standard Error	0.00	0.00	0.00
Marsilea quadrifolia L.	Marsileaceae	Range	0.00	3.47	52.00
		Mean	6.67	2.07	31.00
		Standard Error	0.00	1.73	26.00
Mikania micrantha Kunth	Asteraceae	Range	20.00	0.67	3.75
		Mean	17.22	0.46	2.53
		Standard Error	2.78	0.10	0.59

Myriophyllum sp.	Haloragaceae	Range	13.33	1.27	4.00
		Mean	20.00	0.83	3.50
		Standard Error	6.67	0.63	2.00
Nymphaea nouchali Burm. f.	Nymphaeaceae	Range	6.67	0.20	0.00
		Mean	10.00	0.30	3.00
		Standard Error	3.33	0.10	0.00
Nymphaea sp.	Nymphaeaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.07	1.00
		Standard Error	0.00	0.00	0.00
Nymphoides cristata (Roxb.) Kuntze	Menyanthaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.27	4.00
		Standard Error	0.00	0.00	0.00
Nymphoides sp.	Menyanthaceae	Range	13.33	1.13	9.00
		Mean	17.78	1.04	6.67
		Standard Error	4.44	0.33	2.92
Oxalis corniculata L.	Oxalidaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.47	7.00
		Standard Error	0.00	0.00	0.00
Passiflora sp.	Passifloraceae	Range	0.00	0.00	0.00
		Mean	16.67	0.17	1.00
		Standard Error	0.00	0.00	0.00
Persicaria hydropiper (L.) Delarbre	Polygonaceae	Range	13.33	0.33	2.50
		Mean	13.33	0.43	3.38
		Standard Error	2.72	0.10	0.55
Persicaria sp.	Polygonaceae	Range	3.33	0.25	2.40
		Mean	18.33	0.38	1.80
		Standard Error	1.67	0.13	1.20
Phragmaites karka Adans.	Poaceae	Range	20.00	0.67	6.69
		Mean	13.57	0.51	4.40
		Standard Error	2.42	0.08	1.03
Phyla nodiflora (L.)	Verbenaceae	Range	6.67	0.80	6.50
		Mean	11.00	0.39	3.30
		Standard Error	1.45	0.14	1.09
Pistia stratiotes L.	Araceae	Range	26.67	16.35	248.96
		Mean	19.17	5.96	50.37
		Standard Error	4.07	2.01	28.72
Ricinus communis L.	Cucurbitaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.08	1.00
		Standard Error	0.00	0.00	0.00
Salvinia sp	Salviniaceae	Range	0.00	0.00	0.00
		Mean	6.67	0.08	0.02
		Standard Error	0.00	0.00	0.00

Schoenoplectus sp.	Cyperaceae	Range	0.00	1.20	18.00
		Mean	6.67	1.80	27.00
		Standard Error	0.00	0.00	0.00
Senna sophera (L.) Roxb.	Fabaceae	Range	5.00	0.17	1.83
		Mean	11.67	0.22	1.72
		Standard Error	1.66667	.05556	.54716
Solanum sisymbriifolium Lam.	Solanaceae	Range	1.67	0.08	1.00
		Mean	7.50	0.13	1.50
		Standard Error	0.83	0.04	0.50
Spirodela polyrhiza (L.) Schleid.	Araceae	Range	11.67	23.83	180.00
		Mean	15.62	13.17	86.42
		Standard Error	1.57	3.19	22.92
Synedrella nodiflora (L.) Gaertn.	Asteraceae	Range	0.00	0.00	0.00
		Mean	6.67	0.08	0.50
		Standard Error	0.00	0.00	0.00
Typha angustifolia L.	Typhaceae	Range	33.33	2.15	8.31
		Mean	26.67	1.19	4.52
		Standard Error	5.04	0.25	0.81
Typha elephantine Roxb.	Typhaceae	Range	10.00	0.72	6.00
		Mean	10.00	0.57	5.83
		Standard Error	3.33	0.21	1.74
Vallisneria spiralis L.	Hydrocharitaceae	Range	6.67	1.93	17.50
		Mean	15.56	2.38	16.83
		Standard Error	2.22	0.60	5.46
	Amaranthaceae	Range	86.67	16.38	30.59
		Mean	43.33	6.52	14.40
		Standard Error	7.79	1.39	1.97
	Araceae	Range	53.33	23.93	249.00
		Mean	24.74	6.29	43.28
		Standard Error	3.02	1.50	12.83
	Asteraceae	Range	20.00	0.67	6.50
		Mean	13.03	0.34	2.56
		Standard Error	2.13	0.08	0.60
	Ceratophyllaceae	Range	20.00	11.13	38.00
		Mean	15.56	4.22	18.17
		Standard Error	5.88	3.63	12.42
	Commelinaceae	Range	20.00	3.48	19.46
		Mean	15.83	1.94	13.48
		Standard Error	3.15	0.50	2.92
	Convolvulaceae	Range	20.00	0.52	2.50
		Mean	18.15	0.41	2.05
		Standard Error	2.67	0.07	0.29
	Cucurbitaceae	Range	1.67	0.00	0.00
		Mean	7.22	0.08	1.00
		Standard Error	0.56	0.00	0.00

Cyperaceae	Range	13.33	2.33	35.88
	Mean	10.89	0.60	6.83
	Standard Error	1.47	0.17	2.64
Fabaceae	Range	5.00	0.17	1.83
	Mean	11.67	0.22	1.72
	Standard Error	1.67	0.06	0.55
Haloragaceae	Range	13.33	1.27	4.00
	Mean	20.00	0.83	3.50
	Standard Error	6.67	0.63	2.00
Hydrocharitaceae	Range	6.67	1.93	17.50
	Mean	16.67	2.27	15.04
	Standard Error	1.92	0.44	4.26
Lemnaceae	Range	0.00	38.30	288.50
	Mean	13.33	19.32	144.25
	Standard Error	0.00	19.15	144.25
Malvaceae	Range	0.00	0.00	0.00
	Mean	6.67	0.07	1.00
	Standard Error	0.00	0.00	0.00
Marsileaceae	Range	0.00	3.47	52.00
	Mean	6.67	2.07	31.00
	Standard Error	0.00	1.73	26.00
Menyanthaceae	Range	20.00	1.40	9.00
	Mean	15.00	0.85	6.00
	Standard Error	4.19	0.30	2.17
Nymphaeaceae	Range	6.67	0.33	2.00
	Mean	8.89	0.22	2.33
	Standard Error	2.22	0.10	0.67
Onagraceae	Range	6.67	1.12	17.67
	Mean	9.52	0.45	5.19
	Standard Error	1.35	0.14	2.22
Oxalidaceae	Range	0.00	0.00	0.00
	Mean	6.67	0.47	7.00
	Standard Error	0.00	0.00	0.00
Passifloraceae	Range	0.00	0.00	0.00
	Mean	16.67	0.17	1.00
	Standard Error	0.00	0.00	0.00
Plantaginaceae	Range	0.00	0.00	0.00
	Mean	6.67	1.13	17.00
	Standard Error	0.00	0.00	0.00
Poaceae	Range	20.00	7.63	74.97
	Mean	12.40	1.98	18.90
	Standard Error	1.17	0.52	5.42
Polygonaceae	Range	13.33	0.35	3.90
	Mean	15.00	0.41	2.85
	Standard Error	2.06	0.07	0.57

Pontederiaceae	Range	40.00	9.65	17.94
	Mean	37.22	4.33	10.56
	Standard Error	4.34	1.08	2.04
Salviniaceae	Range	0.00	0.00	0.00
	Mean	6.67	0.08	0.02
	Standard Error	0.00	0.00	0.00
Solanaceae	Range	1.67	0.08	1.00
	Mean	7.50	0.13	1.50
	Standard Error	0.83	0.04	0.50
Typhaceae	Range	40.00	2.20	8.81
	Mean	22.12	1.02	4.88
	Standard Error	4.36	0.21	0.73
Verbenaceae	Range	6.67	0.85	6.50
	Mean	10.28	0.34	2.83
	Standard Error	1.39	0.13	1.01

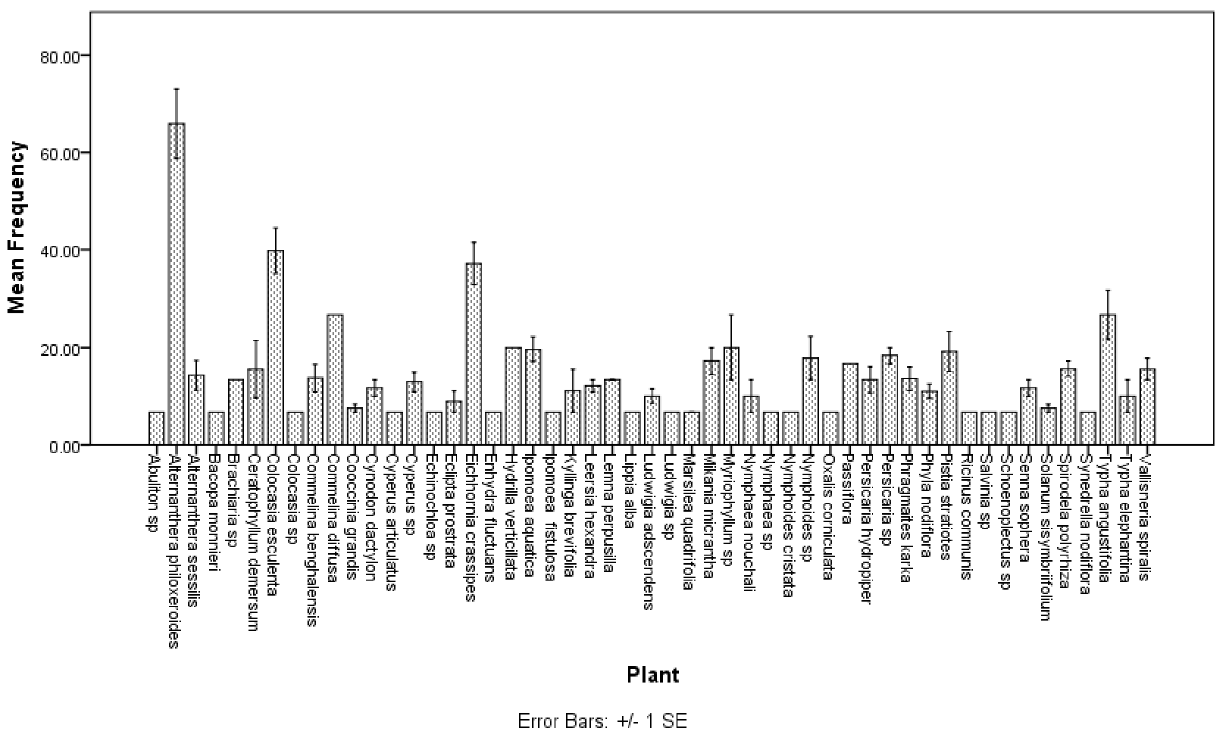

Fig. 3: Frequency of aquatic macrophytes

Araceae (53.33%), Pontederiaceae (40%), and Typhaceae (40%); whereas Amaranthaceae also shows the highest mean frequency (43.33%) across all mouzas, followed by Pontederiaceae (37.22%), Araceae (24.74%), Typhaceae (22.12%), Haloragaceae (20%), and Convolvulaceae (18.15%) (Figure 5 and Table 2). Lemnaceae (19.32/m^2) exhibits the highest mean density across all mouzas, followed by Amaranthaceae (6.52/m^2), Araceae (6.23/m^2), Pontederiaceae (4.33/m^2) and Ceratophyllaceae (4.22/m^2) (Figure 5 and Table 2). Very low density is detected in Hydrocharitaceae (2.27/m^2), Marsileaceae (2.07/m^2), Poaceae (1.97/m^2), Commelinaceae (1.94/m^2), Plantaginaceae (1.13/m^2) and Typhaceae (1.02/m^2) (Figure 5 and Table 2). A relatively high

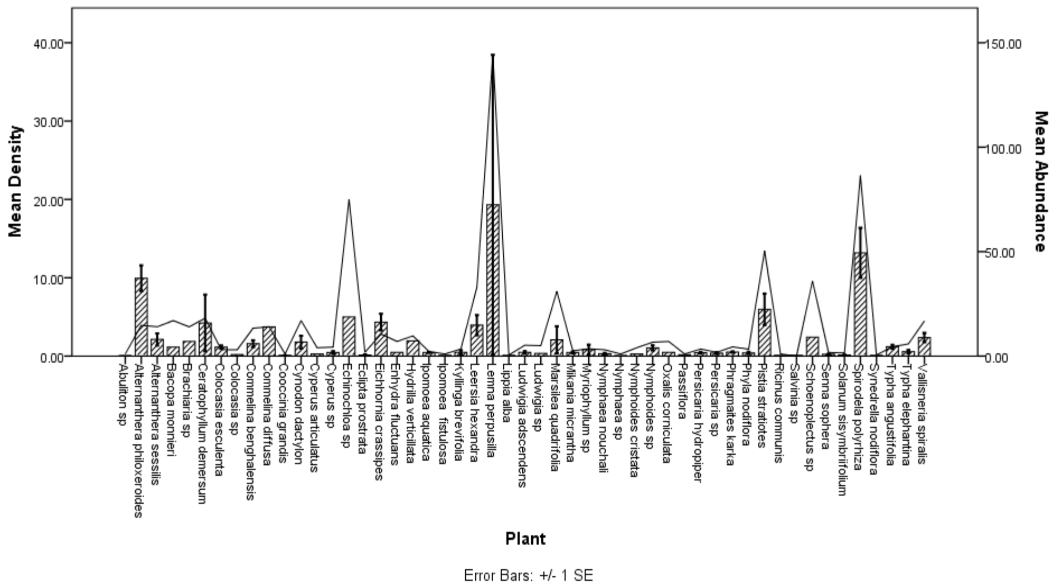

Fig. 4: Density and abundance of aquatic macrophytes (bars indicate mean density & line indicates mean abundance)

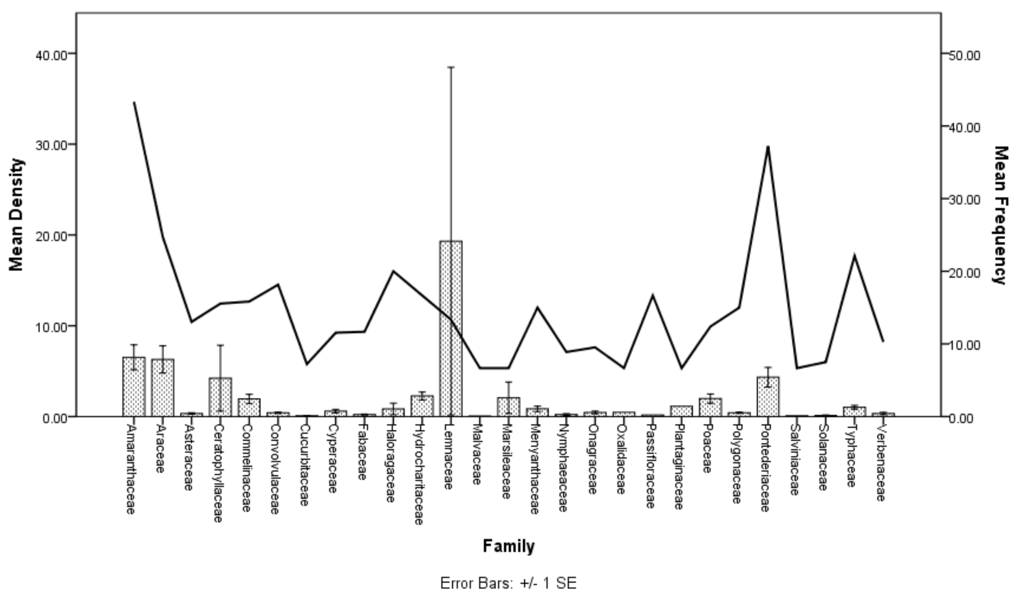

Fig. 5: Mean density and mean frequency of different families of aquatic macrophytes (bars indicate mean density & line indicates mean frequency)

range of density is found in Lemnaceae (38.30/m^2), Araceae (23.93/m^2), Amaranthaceae (16.38/m^2), Ceratophyllaceae (11.13/m^2), Pontederiaceae (9.65/m^2) and Poaceae (7.63/m^2) (Table 2). Lemnaceae (144.25) shows the highest mean abundance, followed by Araceae (43.28), Marsileaceae (31) & Ceratophyllaceae (18.17) (Figure 6 and Table 2). Lemnaceae has the highest range of abundance (288.50), followed by Araceae (249), Poaceae (74.97), Marsileaceae (52), Ceratophyllaceae (38), Cyperaceae (35.88), and Amaranthaceae (30.59) whereas Commelinaceae (19.46), Pontederiaceae (17.94), Onagraceae (17.67), Hydrocharitaceae (17.50), Menyanthaceae (9) and Typhaceae (8.81) have very low range of abundance (Table 2).

Mouza-wise comparison of the frequency of aquatic macrophytes reveals that *A. philoxeroides* (Mart.) Griseb., *C. esculenta* (L.) Schott, *E. crassipes* (Mart.) Solms, *Typha angustifolia* L., *Ipomoea aquatica* Forssk., *and Pistia stratiotes* L. are the most dominant macrophytes in all mouzas due to their invasive nature, rapid reproduction, extensive growth and tolerance to pollution. *A. philoxeroides* (Mart.) Griseb. has the highest frequency across all mouzas, whereas *C. esculenta* (L.) Schott

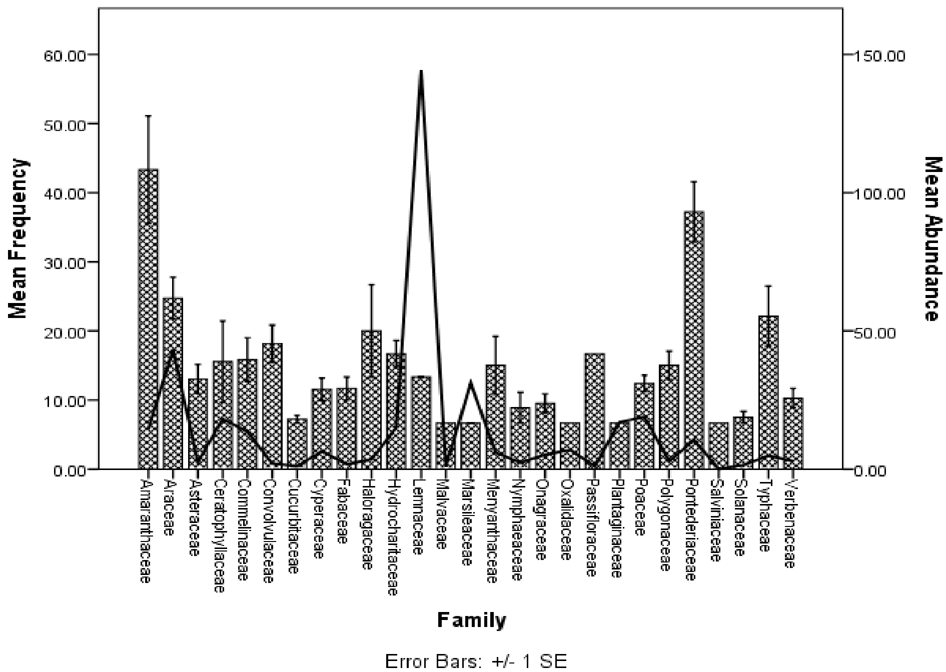

Fig. 6: Mean frequency and mean abundance of different families of aquatic macrophytes (Bars indicate mean frequency & line indicates mean abundance)

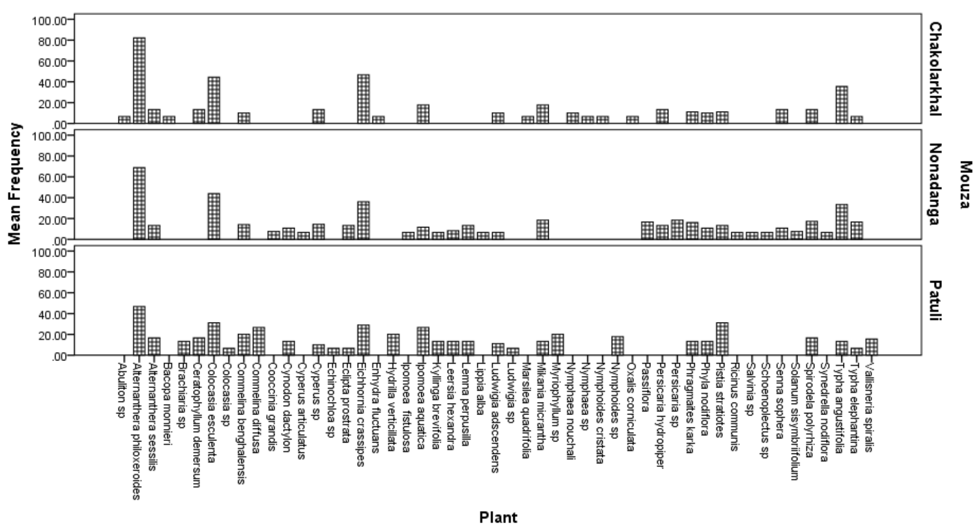

Fig. 7: Comparison of frequency of aquatic macrophytes at different mouzas

exhibits a relatively lower frequency in Patuli in comparison to other mouzas (Figure 7). *P. stratiotes* L. shows the highest frequency in Patuli (Figure 7). *E. crassipes* (Mart.) Solms show the highest frequency in Chak Kolarkhal, followed by Nonadanga and Patuli (Figure 7). Submerged macrophytes, namely *Hydrilla* sp., *Myriophyllum* sp., *Nymphoides* sp., *and Vallisneria spiralis* L. are only reported from Patuli. The presence of submerged macrophyte vegetation indicates a good quality of water

Table 3: Test of normality

	Shapiro-Wilk		
	Statistic	*Degree of freedom*	*Significance*
Frequency	0.729	171	.000
Density	0.536	171	.000
Abundance	0.399	171	.000

Table 4: Result of Independent samples Kruskal-Wallis test

Test	*Null hypothesis*	*Significance*	*Decision*
Independent samples Kruskal-Wallis' test	The aquatic macrophytes exhibit a similar pattern of distribution in terms of frequency across different mouzas.	0.307	The Null hypothesis is accepted
	The aquatic macrophytes exhibit a similar pattern of distribution of density across different mouzas.	0.000	The Null hypothesis is rejected
	The aquatic macrophytes of different mouzas exibit a similar pattern of distribution of abundance.	0.000	The Null hypothesis is rejected
	The aquatic macrophytes exhibit a similar pattern of distribution of diversity in different mouzas.	0.077	The Null hypothesis is accepted.
	The aquatic macrophytes reveal a similar pattern of distribution of frequency during different seasons.	0.815	The Null hypothesis is accepted
	The aquatic macrophytes show a similar pattern of distribution of density during different seasons.	0.026	The Null hypothesis is rejected
	The aquatic macrophytes show a similar pattern of distribution of abundance during different seasons.	0.001	The Null hypothesis is rejected
	The aquatic macrophytes show a similar pattern of distribution of diversity during different seasons.	0.267	The Null hypothesis is accepted

The test shows asymptotic significance. Alpha level is 0.05

Table 5: Result of Spearman's rho correlation

		Frequency	*Density*	*Abundance*	*Diversity*
Frequency	Correlation coefficient (r_s)	1	0.494**	0.094	0.493**
	Significance (Two-tailed)		0.000	0.221	0.000
	Total number of observations (N)	171	171	171	171
Density	Correlation coefficient (r_s)	0.494**	1.0	0.890**	0.879**
	Significance (Two-tailed)	0.000		0.000	0.000
	Total number of observations (N)	171	171	171	171
Abundance	Correlation coefficient (r_s)	0.094	0.890**	1	0.713**
	Significance (Two-tailed)	0.221	0.000		0.000
	Total number of observations (N)	171	171	171	171
Diversity	Correlation coefficient (r_s)	0.493**	0.879**	0.713**	1.0
	Significance (Two-tailed)	0.000	0.000	0.000	
	Total number of observations (N)	171	171	0.171	171

** Significant correlation at 0.01 level (two-tailed).

(Rameshkumar *et al.*, 2019). These submerged macrophytes are only reported from those wetlands, where the density of invasive macrophytes like *E. crassipes* (Mart.) Solms is very low. Thick mat of *E. crassipes* (Mart.) Solms prevent the growth of submerged plants (Bayu Zeleke *et al.*, 2024). The frequency, density and abundance of *E. crassipes* (Mart.) Solms in Patuli are relatively lower than the other two mouzas. *Ipomoea aquatica* Forssk. shows the highest frequency in Patuli, followed by Chak Kolarkhal and Nonadanga (Figure 7). *T. angustifolia* L. shows the highest frequency in Chak Kolarkhal, followed by Nonadanga and Patuli (Fig. 7).

Statistical analysis

Shapiro-Wilk test for normality indicates that all independent variables (frequency, density and abundance) do not follow normal distribution (Table 3). As the data do not follow normal distribution, the nonparametric test (Independent-Samples Kruskal-Wallis Test) is conducted for the analysis of floristic composition and phytosociological parameters.

Three mouzas show a similar type of distribution of frequency of plants, but the distribution of density and abundance significantly differs across the mouzas (Table 4). The distribution of frequency and diversity is the same in all seasons, but the distribution of density and abundance significantly differs across the seasons (Table 4). Spearman's rho correlation test shows that aquatic macrophyte diversity is significantly positively correlated to frequency, density and abundance (p <0.01) (Table 5), where density shows the highest positive correlation with diversity (r_s=0.879) (Table 5). Density is also significantly positively correlated to frequency and abundance, but there is no significant correlation between frequency and abundance (Table 5).

Conclusion

This is the first study to explore the mouza-wise and season-wise aquatic macrophyte diversity and floristic composition of the East Kolkata Wetland. The present survey reveals a diverse range of aquatic macrophyte species, comprising 51 plant species that belong to 41 genera and 27 families. The highest plant diversity is recorded from Patuli during the winter season, whereas the lowest diversity is found in Nonadanga during the summer. *A. philoxeroides* exhibits the highest mean frequency in all mouzas. Lemnaceae has the highest mean density among all families. Aquatic macrophyte diversity exhibits a significant positive correlation with frequency, density, and abundance, whereas density has the highest correlation with plant diversity. Independent-Samples Kruskal-Wallis test indicates that aquatic macrophyte diversity does not significantly differ among the mouzas.

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Authors Contribution

Debasis Mandal designed the study and drafted the manuscript. He collected, analyzed, and interpreted the data. Dr. Debnath Palit supervised the entire work and made necessary corrections in the manuscript.

Conflict of Interest

Nothing.

References

Ahmad, S.R., & Kalam, A. (2017). Study of diversity in East Kolkata Wetland including Gosaba Island with special reference to fungi. *Biosciences Biotechnology Research Asia,* 14(2), 805-816. DOI:10.13005/bbra/2512

Bhanja, A., Sinha, N., Mandal, B., & Payra, P. (2023). Diversity of Aquatic Macrophytes in Four Blocks of Purba Medinipur District, West Bengal, India. *Indian Journal of Pure Applied and Biosciences* 11(1), 1-8. DOI:10.18782/2582-2845.8974

Bayu Zeleke, T., Soeprobowati, T. R., Adissu, S., & Warsito, B. (2024). Analysing the effect of water hyacinth (*Eichhornia crassipes*) invasion on water quality and trophic state of Lake Tana. *Chemistry and Ecology*, 41(3), 297–313. DOI:10.1080/02757540.2024.2432886

Chaudhuri, S.R., Salodkar S., Sudarshan, M., Mukherjee, I., & Thakur, A.R. (2008). Role of water hyacinth mediated phytoremediation in waste water purification at east Calcutta wetland. *Environmental Sciences,* 5(1), 53–62. DOI:10.1080/15693430701833427

Chaudhuri, S. R., Mukherjee, I., Ghosh, D., & Thakur A. R. (2012). East Kolkata Wetland: A multifunctional niche of international importance. *Online Journal of Biological Sciences,* 12 (2), 80-88. DOI:10.3844/ojbsci.2012.80.88

Chandra, K., Raghanathan, C., & Mao, A.A. (2020). Biodiversity Profile of East Kolkata Wetlands,. Jointly published by the Director, Zoological Survey of India, Kolkata and East Kolkata Wetlands Management Authority, Department of Environment, Govt. of West Bengal, pp.1-326.

Cook, C. D. K. (1996). Aquatic and wetland plants of India. Oxford University Press, London.

Dasgupta, S., & Panigrahi, A.K. (2014). Studies on the effect of aquatic pollution on ichthyofaunal diversity of the East Kolkata Wetland. *International Journal of Research in Applied, Natural and Social Sciences*. 2(4), 145-152.

Dutta, S., & Chakraborty, S. (2017). The effect of pollution on hydrological parameters analysis of East Kolkata Wetland Area. *International Journal of Development Research,* 7(9), 15452-15458. DOI:10.13140/RG.2.2.17494.29767

Fassett, N. C. (2006). A manual of aquatic plants. Agrobios (India), Jodhpur

Galal, T. M., & Farahat, E. A. (2015). The invasive macrophyte Pistia stratiotes L. as a bioindicator for water pollution in Lake Mariut, Egypt. *Environmental monitoring and assessment*. 187. 701. DOI:10.1007/s10661-015-4941-4.

Ghosh, A.R., Mondal, S., & Kole, D. (2018). Environmental Impact Assessment: A Case Study on East Kolkata Wetlands. In: Jana B., Mandal R., Jayasankar P. (eds) *Wastewater Management Through Aquaculture*. Springer, Singapore. DOI:10.1007/978-981-10-7248-2_15

Mandal, D., & Bandyopadhyay, M. (2018). On the biology of some aquatic monocotyledons occurring in East Kolkata Wetland. *Journal of the Botanical Society of Bengal*, 72 (1&2): 95-100.

Mandal, D. (2021). A review on the significance of East Kolkata Wetland: A Ramsar Site with integrated resource recovery activities. *Ecology, Environment and Conservation,* 27 (October Suppl. Issue), 244-247

Mishra, R. (1968). Ecology Workbook. Oxford and IBH Publishing Company, Calcutta.

Naskar, K. (1990). Aquatic and semi-aquatic plants of the lower Ganga delta: its taxonomy, ecology and economic importance. Daya Publishing House, New Delhi.

Rameshkumar, S., Radhakrishnan, K., Anand, S., & Rajaram, R. (2019). Influence of physicochemical water quality on aquatic macrophyte diversity in seasonal wetlands. *Applied Water Science,* 9, (12). DOI:10.1007/s13201-018-0888-2

Roy, U.S., Goswami, A.R., Aich, A., Chattopadhyay, B., Datta, S., & Mukhopadhyay, S.K. (2013). Changes in physico-chemical characteristics of wastewater carrying canals after relocation of Calcutta tannery agglomerates within the East Calcutta Wetland ecosystem (a Ramsar site). *International Journal of Environmental Studies,* 70(2), 203– 221. DOI:10.1080/00207233.2013.774810

Sanyal, P., Chakraborty, S.K., & Ghosh, P. B. (2015). Phytoremediation of Sewage-Fed Wetlands of East- Kolkata, India - A Case Study. *International Research Journal of Environmental Sciences*, 4(1), 80-89.