https://doi.org/10.33451/florafauna.v31i2pp187-198

FLORA AND FAUNA ISSN 2456 - 9364 (Online)

2025 Vol. 31 No.2 PP 187-198 ISSN 0971 - 6920 (Print)

Soil Nematode Assemblage and its Seasonal Dynamics in the Agro-ecosystems of East Kolkata Wetlands, (W.B.) India

***Olivia Das, Viswa Venkat Gantait and Swetapadma Dash**

Zoological Survey of India,
New Alipore, KOLKATA-700053 (W.B.) INDIA
*Corresponding Author
Email: oliviadas12@gmail.com

Received **:** 18.08.2025; ***Accepted*** : 25.09.2025

How to cite : Das O, Gantait VV, Dash S.. Soil Nematode Assemblage and its Seasonal Dynamics in the Agro-ecosystems of East Kolkata Wetlands, (W.B.) India. *Flora and Fauna* 2025. 31(2) : 187-198.

ABSTRACT

An year-long assessment was done, which aimed to investigate the changes in the diversity of soil-inhabiting nematodes during two different seasons, pre-monsoon and post-monsoon in agricultural fields of East Kolkata Wetlands at 17 fields and to determine the correlation of nematode abundance across both the seasons. A total of 120 soil samples were collected during the two seasons. Total 65 genera of soil nematodes were identified. A significant variation was exhibited among the nematode trophic groups. In particular the abundance of herbivores nematodes was 41.59% higher during the pre-monsoon season than post-monsoon. Other trophic groups such as bacteriovores, fungivores, omnivores and predatory were found to be higher during the post-monsoon season. Indicator species analysis (ISA) showed few genera such as *Cylindrolaimus* (IndVal=100%) followed by *Hirschmanniella* (IndVal=81%) and *Mesodorylaimus* (IndVal=84.8%) were significantly predominant during pre-monsoon. During post-monsoon however, *Trichotylenchus* (IndVal=98.7%) followed by *Pseudoacrobeles* (IndVal=95.3%) and *Discolaimus* (IndVal=82.4%) were dominant. Shannon-Weiner (3.34) and **Maturity Index (MI)** (**3.12**) were higher during the post-monsoon than pre-monsoon. While the **Plant Parasitic Index (PPI)** also rose from **2.98 to 3.19**, hinting at increasing plant-parasitic activity during post-monsoon. The **Nematode Channel Ratio (NCR)** showed only a marginal rise (0.73 to 0.74), indicating a consistently bacterial-dominated decomposition pathway.

Figures : 03 References : 50 Tables : 02

KEY WORDS : Abundance; Diversity indices; East Kolkata Wetlands; Indicator species; Nematodes; Seasonal variation

Introduction

Nematodes are minute vermiform organisms belonging to the phylum Nematoda. Although often overlooked, they are recognized as the most abundant animal on Earth[7]. These are usually microscopic organisms which are studied in different soil habitats[9,37,48] particularly as a crucial research tool which indicates soil quality[10,34,47]. Soil quality, on the other hand is very important for sustainable agriculture and also constitutes one of the main aims of an ecological study[41].

Soil nematodes, occupy an important part in the soil faunal community and play a vital role in soil ecosystem functions through decomposition and nutrient mineralisation[44]. As bioindicators, their community structure reflects ecosystem responses to environmental changes, including hydrological fluctuations, pollution, and land-use practices[27,38]. They are categorized according to their trophic habits into bacteriovores, fungivores, herbivores, predators and omnivores. Furthermore, their life strategies are classified on a colonizer-persister (c-p) scale, ranging from c-p 1 (nematodes with short life cycle and high disturbance sensitivity) to c-p 5 (nematodes with long life cycle and low disturbance sensitivity)[31]. Despite their ecological significance, nematode assemblages in tropical wetland agroecosystems, particularly those influenced by

ACKNOWLEDGEMENTS : The authors thank the Director, Zoological Survey of India, Kolkata, Dr. Dhriti Banerjee to provide necessary facilities to perform the experiments. No funding is involved in this research.

TABLE-1: Sample collection sites and vegetation

Sl. No	Collection sites	GPS Co-ordinates Latitude(°N) Longitude(°E)		Vegetation
1.	Dhapa	22°32'42"	88°24'33"	Maize, Red Spinach, Pomelo, Hibiscus, Ridge gourd, Cauliflower, Bottle gourd, Mustard, Brinjal
2.	Dhapa Manpur, Bantala	22°30'57"	88°26'33"	Zinnia, Garden cosmos, Common sunflower, Hibiscus
3.	Hatgacha	22°32'16"	88°28'24"	Palm tree
4.	Kheyadah, Bagdoba	22°30'21"	88°27'44"	Rice
5.	Khodhati	22°30'30"	88°28'12"	Banana, Lady's finger
6.	Nalban	22°40'25"	88°35'45"	Jackfruit
7.	Pratapnagar	22°26'39"	88°31'19"	Jute
8.	Samukpota	22°27'27"	88°30'19"	Banana
9.	Tardah	22°27'19"	88°31'12"	Rice
10.	Tardah kapashati	22°27'21"	88°31'31"	Rice

Nematode processing and identification

anthropogenic activities, remain understudied compared to temperate and terrestrial systems[46].

The wetlands in the eastern fringe of Kolkata, West Bengal, India popularly known as the East Kolkata Wetlands (EKW), work as absorber of sewage water and excess rainwater runoff from the city. The East Kolkata Wetlands (EKW), Ramsar site, represents a unique peri-urban ecosystem where traditional wastewater-fed agriculture and aquaculture coexist.

While EKW's role in nutrient recycling and water purification has been extensively documented[33], studies focusing on its soil microfauna—especially nematodes—are scarce. Given the increasing pressures of urbanization, pollution, and climate change on EKW[26], understanding the seasonal dynamics of nematode communities is essential for assessing ecosystem resilience and sustainable land-use management.

Around 2000 acres of vegetables[21] are grown on the agricultural fields of the wetland area, and nearly 40% vegetables produced from this "garbage farming" find its destination in the City Markets of Kolkata[23]. The paddy fields are also known to harvest good yield from this region. In West Bengal, most of the crops are grown in winter and summer seasons[32]. Thus, the seasonality and association of the nematodes with the different crops found here have been studied in these two seasons in the agro-ecosystems of EKW.

Globally, nematode populations exhibit strong seasonal variations driven by moisture, temperature, and resource availability[43]. In wetland agroecosystems, alternating flooded and dry conditions further influence nematode diversity and trophic structure. However, most existing studies focus on natural wetlands or upland agricultural systems, leaving a critical knowledge gap for tropical, waste water-impacted agro-wetlands like EKW.

TABLE-2 : Nematode genera identified from the present study

S. No.	Genera	Family	Order	Class	c-p value	Pre-monsoon	Post-monsoon
Bacteriovores							
1.	*Acrobeles*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
2.	*Acrobeloides*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
3.	*Alaimus*	Alaimidae	Enoplida	Enoplea	4	+	+
4.	*Alirhabditis*	Alirhabditidae	Rhabditida	Chromadorea	1	-	+
5.	*Amphidelus*	Alaimidae	Enoplida	Enoplea	4	+	+
6.	*Anaplectus*	Plectidae	Plectida	Chromadorea	2	+	-
7.	*Cephalobus*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
8.	*Cervidellus*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
9.	*Chiloplacus*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
10.	*Cruznema*	Rhabditidae	Rhabditida	Chromadorea	1	-	+
11.	*Cylindrolaimus*	Diplopeltidae	Araeolaimida	Chromadorea	3	+	-
12.	*Eucephalobus*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
13.	*Mesorhabditis*	Rhabditidae	Rhabditida	Chromadorea	1	+	+
14.	*Pseudoacrobeles*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
15.	*Plectus*	Plectidae	Plectida	Chromadorea	2	+	+
16.	*Prismatolaimus*	Prismatolaimidae	Triplonchida	Chromadorea	3	+	+
17.	*Rhabdolaimus*	Rhabdolaimidae	Plectida	Chromadorea	2	+	+
18.	*Stegelleta*	Cephalobidae	Rhabditida	Chromadorea	2	+	+
19.	*Zeldia*	Cephalobidae	Rhabditida	Chromadorea	2	-	+
20.	*Wilsonema*	Plectidae	Plectida	Chromadorea	2	+	-
Fungivores							
21.	*Aphelenchoides*	Aphelenchoididae	Rhabditidae	Chromadorea	2	+	+

22. *Aphelencus*	Aphelenchidae	Rhabditidae	Chromadorea	2	+	+
23. *Ditylenchus*	Anguinidae	Rhabditidae	Chromadorea	2	+	+
24. *Filenchus*	Tylenchidae	Rhabditidae	Chromadorea	2	+	+
25. *Tylencholaimus*	Tylencholaimidae	Dorylaimida	Enoplea	4	+	+
Plant parasitic/Herbivores						
26. *Axonchium*	Belondiridae	Dorylaimida	Enoplea	5	-	+
27. *Basiria*	Tylenchidae	Tylenchida	Chromadorea	2	+	+
28. *Bitylenchus*	Telotylenchidae	Tylenchida	Chromadorea	3	+	+
29. *Criconema*	Criconematidae	Tylenchida	Chromadorea	3	+	+
30. *Helicotylenchus*	Hoplolaimidae	Tylenchida	Chromadorea	3	+	+
31. *Hirschmaniella*	Pratylenchidae	Tylenchida	Chromadorea	3	+	+
32. *Histotylenchus*	Telotylenchidae	Tylenchida	Chromadorea	3	+	+
33. *Hoplolaimus*	Hoplolaimidae	Tylenchida	Chromadorea	3	+	+
34. *Paralongidorus*	Longidoridae	Tylenchida	Chromadorea	5	-	+
35. *Merlinius*	Merliniidae	Tylenchida	Chromadorea	3	+	+
36. *Pratylenchoides*	Merliniidae	Tylenchida	Chromadorea	3	+	+
37. *Pratylenchus*	Pratylenchidae	Tylenchida	Chromadorea	3	+	+
38. *Rotylenchulus*	Hoplolaimidae	Tylenchida	Chromadorea	3	+	+
39. *Rotylenchus*	Hoplolaimidae	Tylenchida	Chromadorea	3	+	+
40. *Telotylenchus*	Telotylenchidae	Tylenchida	Chromadorea	3	+	+
41. *Trichotylenchus*	Dolichodoridae	Tylenchida	Chromadorea	3	+	+
42. *Trichodorus*	Trichodoridae	Triplonchida	Enoplea	4	+	+
43. *Tylenchorhynchus*	Telotylenchidae	Tylenchida	Chromadorea	3	+	+
44. *Trophurus*	Telotylenchidae	Tylenchida	Chromadorea	3	-	+

Omnivores						
45. *Aporcelaimellus*	Aporcelaimidae	Dorylaimida	Enoplea	5	+	+
46. *Calodorylaimus*	Dorylaimidae	Dorylaimida	Enoplea	4	-	+
47. *Coomansinema*	Thornenematidae	Dorylaimida	Enoplea	5	+	+
48. *Crassolabium*	Dorylaimidae	Dorylaimida	Enoplea	4	+	+
49. *Enchodelus*	Nordiidae	Dorylaimida	Enoplea	4	+	+
50. *Kochinema*	Nordiidae	Dorylaimida	Enoplea	4	+	+
51. *Labronema*	Dorylaimidae	Dorylaimida	Enoplea	4	+	+
52. *Laimydorus*	Dorylaimidae	Dorylaimida	Enoplea	4	+	+
53. *Mesodorylaimus*	Dorylaimidae	Dorylaimida	Enoplea	5	+	+
54. *Neoactinolaimus*	Actinolaimidae	Dorylaimida	Enoplea	4	+	+
55. *Opisthodorylaimus*	Thornenematidae	Dorylaimida	Enoplea	5	+	-
56. *Oriverutus*	Nordiidae	Dorylaimida	Enoplea	4	+	+
57. *Thornia*	Thorniidae	Dorylaimida	Enoplea	4	+	+
58. *Thornenema*	Thornenematidae	Dorylaimida	Enoplea	5	+	+
59. *Pungentus*	Nordiidae	Dorylaimida	Enoplea	4	-	+
60. *Sicagutter*	Thornenematidae	Dorylaimida	Enoplea	5	-	+
Predators						
61. *Discolaimus*	Qudsianematidae	Dorylaimida	Enoplea	4	+	+
62. *Epidorylaimus*	Qudsianematidae	Dorylaimida	Enoplea	4	+	-
63. *Eudorylaimus*	Qudsianematidae	Dorylaimida	Enoplea	4	+	+
64. *Ironus*	Ironidae	Enoplida	Enoplea	4	+	+
65. *Mylonchulus*	Mylonchulidae	Mononchida	Enoplea	4	+	+

‘+’present; ‘–‘absent.

This study provides the first comprehensive assessment of soil nematode communities across seasons in EKW's agroecosystems. By integrating ecological indices, morphological identification, and multivariate statistics, we aim to establish baseline data on nematode diversity in EKW and develop nematode-based indicators for wetland soil health monitoring.

Materials and Methods

The study area, the East Kolkata Wetlands (Fig. 1) (longitude 22°322 193 N and latitude 88°252 73 E) is located in the eastern fringe of Kolkata, West Bengal. It is divided into 37 mouzas.

A total of 17 representative fields representing the mouzas at four different directions which are north, south, east and west were surveyed and sampled between two seasons around one year *i.e.,* during pre-monsoon season (March-May) and post-monsoon season (October-December) in the year 2022 (Table-1). A total of 5 subsamples were collected from the rhizospheric zone around the roots of the plants from a depth of 15-20 cm layer of soil. The top soil was removed and the soil samples were collected in a zig zag pattern from the agricultural fields using a hand shovel. The subsamples were then mixed thoroughly to form a composite sample. Samples were placed in polythene bags and labelled properly with hand written notes about locality, date of collection, name of the host, *etc.* GPS co-ordinates were also measured using recent mobile app (GPS map camera). Then immediately it was brought to the Nematology laboratory at the Zoological Survey of India, Kolkata for nematode extraction and identification.

Soil samples collected were thoroughly homogenized and processed for nematodes extraction within 48 hours after sampling time. In each sample, nematodes were extracted from 250g of soil of the composite sample prepared. Samples were extracted by using 'Cobb's sieving process and decantation technique'[15] which was followed by 'Modified Baermann's funnel-technique'[14]. After 24 hours of processing, nematode suspensions from both soil and roots were collected and examined under a stereo-microscope Olympus SZX16 (Model No. SX2-ILLTQ). The population number of each genus was expressed as the total number in 3ml aliquot of sample prepared after nematode extraction. The average number of nematodes present in each aliquot was multiplied by the final volume of nematode suspension to get the final population density of nematode genera present in each sample. The nematodes were then fixed using FAA fixative (4:1 formaldehyde and acetic acid). Nematodes were picked and transferred to glycerin-alcohol in cavity-blocks. These were then transferred to desiccators containing anhydrous calcium chloride for dehydration[39]. Nematodes were then mounted on a glass slide in anhydrous glycerin and sealed with wax following wax ring method[16] to prepare permanent slides. These were then studied taxonomically under microscope (Nikon Eclipse Ni-U Research Microscope). Nematodes in each sample were identified to genus level based on morphological features using dichotomous keys. For orders Dorylaimida[22], Tylenchida[42], Rhabditida[20], Enoplida and Mononchida[3]. Aid in the identification process was the Nematology Laboratory's interactive diagnostic key to plant parasitic, bacteriovorous, fungivorous, omnivorous and predatory nematodes, which is available online at (http:// nematode.unl.edu/knozlistbutt.htm).

Data Analysis

The diversity of soil nematode assemblage in EKW is shown by calculating nematode indices like; Shannon-Wiener Index (H´), which indicates the nematode genera diversity in a community. H´= P_i ln P_i, where P_i is the proportion of each taxon in the total population[40]. The genera evenness was determined by Pielou's evenness index (J') which is closely related to genera dominance. J' = H´/ln S, where S is the taxa number[36]. Genera richness was measured by Margalef Index (MgI) and was calculated as, MgI = (G-1)/ln (n), where G is the total genera number and n is the total number of individuals[29]. An environmental disturbance in soil was calculated by Maturity Index (MI). MI was calculated after allocating colonizer-persister (c–p) class values[10,11]. The c–p classes were specified based on characteristics ranging from colonizers (small life cycle with high reproduction rate & tolerate disturbances) to persisters (long life cycle with low reproduction rate and sensitive to disturbances) from 1 to 5 on a scale, meaning thereby that if a species is a strong colonizer, its c–p class would be 1 whereas strong persister has c–p class 5. MI value helps in calculating the ecological successional status of a soil community. High MI indicates persister nematode genera and stable soil conditions where a low MI shows a disturbed system or highly enriched soil due to fertilizers. It was calculated as; MI = v_i f_i/n, where v_i = c-p value of the family, f_i frequency of family i in sample and n is the total number of individuals in a sample. The plant parasitic index (PPI) which is a modified MI was calculated for plant parasitic taxa only which is cp=3. The functional structure of the community was measured by Wasilewska Index (WI)[45], Enrichment Index (EI), Channel Index (CI), Nematode Channel Ratio (NCR), and Structural Index (SI). The WI represents the ratio of bacterial feeders (BF) plus fungal feeders (FF) to plant-parasites (PP) as, WI = (BF + FF)/

PP[45]. The NCR is the ratio of the biomass of bacteriovorous to sum of fungivorous & bacteriovorous nematodes. Higher values designate more fungal decomposition than bacterial decomposition *i.e.,* NCR = B/ (B + F), where B % the abundance of bacterivorous nematodes and F- the abundance of fungivorous nematodes. The CI represents the fungal participation in decomposition channels of soil food webs. High value signifies dominated fungal feeding decomposition whereas, low values indicate dominated bacterial decomposition pathway. CI = 100 x (Fu_2 x 0.8/Ba_1 x 3.2 + Fu_2 x 0.8)[18]. Enrichment Index (EI) is calculated as the biomass of opportunistic bacterivorous (Ba_1 and Ba_2) and fungivorous (Fu_2) nematodes that rise from the decomposition of organic matter[18]and Structural Index (SI) indicates the state of the food web affected by disturbance or stress. High SI value indicates ecosystem stability, whereas low values represent environmental disturbances[18]. SI = 100* s/s + b where, s=Ba_n +Pr_n +Fu_n +Om_n, n=3–5 and b=Ba_2+ Fu_2 (Ba-bacteriovorous, Pr-Predatory, Fu-fungivorous & Om-omnivorous nematodes. The suffix represents the c-p values). EI=(e/ e+b)100 where, e=(Ba_1W_1) + Fu_2W_2) and b=(Ba_2+Fu_2) W_2; where W_1= 3.2 and W_2= 0.8.

Statistical Analysis

All statistical analyses were conducted to evaluate seasonal variations in the composition and ecological structure of soil nematode communities within the agroecosystem of the East Kolkata Wetlands (EKW). To assess the significance of seasonal differences among nematode community parameters, the **Mann-Whitney U test** was employed. The significant differences were detected at $p < 0.05$. Additionally, Dufrêne-Legendre Indicator Species Analysis **(ISA)** was carried out to determine the genera which were significantly associated with specific seasons, based on indicator values and their statistical significance was assessed[17]. To explore potential ecological relationships, **Spearman's rank correlation co-efficient** was calculated to examine associations among diversity indices across seasons. All statistical analyses were performed using **Microsoft Excel** for preliminary data handling. A significance threshold of $p < 0.05$ was applied throughout.

Results and Discussion

Results indicated that a total of 65 soil nematode genera belonging to 31 families, 9 orders and 2 classes were identified from the agro-ecosystem during the present investigation (Table-2). The diversity indices revealed moderate to high nematode diversity across both seasons. The **Shannon–Wiener diversity index (H2)** increased from **3.12** in the pre-monsoon to **3.34** in the post-monsoon season, indicating a slight rise in taxonomic diversity**. Pielou's evenness index** also rose from **0.78 to 0.82**, suggesting a more equitable distribution of nematode taxa post-monsoon. **Margalef's richness** remained relatively stable (7.44 vs. 7.57), confirming sustained taxonomic richness across seasons (Fig. 2). Functional diversity indicators showed notable shifts. The **Maturity Index (MI)** increased from **2.95 to 3.12**, while the **Plant Parasitic Index (PPI)** also rose from **2.98 to 3.19**, hinting at increasing plant-parasitic activity in post-monsoon. The **Nematode Channel Ratio (NCR)** showed only a marginal rise (0.73 to 0.74), indicating a consistently bacterial-dominated decomposition pathway.

The **Wasilewska Index (WI)** increased from **0.63 (pre-monsoon)** to **1.05 (post-monsoon),** and the **Channel Index (CI)** rose from **22.34 to 26.81**, supporting a transition toward a bacterial decomposition channel during the post-monsoon season. In contrast, the **Enrichment Index (EI)** declined from **69.91 to 53.53**, reflecting reduced resource enrichment or organic input availability in the later season. The **Structure Index (SI)** also decreased (81.609 to 69.859), suggesting a reduction in food web complexity. The Mann-Whitney U test revealed significant differences in nematode trophic group abundances between pre- and post-monsoon periods ($p = 0.05$). **Predators** showed a marked increase post-monsoon ($U = 81.5$, $p = 0.031$), indicating a strong seasonal response. In contrast, bacteriovores ($U= 119.5$, $p=0.340$), fungivores ($U=139.0$, $p=0.857$), herbivores ($U=154.0$, $p=0.756$) and omnivores ($U=128.5$, $p = 0.592$) exhibited no significant changes in abundance. The nematode abundance across the seasons (Fig. 2).

Indicator Species Analysis (ISA) has been assigned to genera to identify key genera associated with specific seasons. Exclusive pre**-monsoon indicators** were *Cylindrolaimus* (IndVal = 100%, p = 0.001) suggesting adaptation to drier soil followed by *Hirschmaniella* (IndVal = 81%, p = 0.002) which dominates in pre-monsoon but declines in post-monsoon, possibly due to sensitivity to water-logging. *Mesodorylaimus* (IndVal = 84.8%, p = 0.001) prefers stable less disturbed soil in pre-season. Post-monsoon indicators were ***Trichotylenchus* (IndVal=98.7%, p=0.001) followed by, *Pseudoacrobeles* (IndVal=95.3%, p=0.001) *Discolaimus* (IndVal=82.4%, p=0.002) and *Eudorylaimus* (IndVal=75.6%, p=0.004). *Aporcelaimellus* came up as a transitional-genera (IndVal=77.1%, p=0.003) showing post-monsoon seasonal preference. All the species showed significantly higher preferences in respective seasons.**

Spearman correlation analysis revealed strong internal consistency and ecological relationships. A **high positive correlation** between **H2 and MI (ñ = 0.85)** suggests that higher taxonomic diversity supports more mature and stable nematode communities. A strong correlation between **NCR and WI (ñ = 0.91)** indicates that post waterlogged, post-monsoon soils support bacterial decomposition, reflected in both indices (Fig. 3).

The results of this study elucidate seasonal differences in the composition and diversity of soil nematode communities in the agroecosystem of the East Kolkata Wetlands (EKW). The post-monsoon season exhibited a modest but consistent increase in the Shannon–Wiener index (H2 = 3.34) compared to the pre-monsoon (H2 = 3.12), signifying a shift toward greater taxonomic diversity. A similar rise in Pielou's evenness (from 0.78 to 0.82) indicated a more equitable distribution of individuals among taxa. These variations emphasize the strong influence of monsoonal dynamics and organic matter inputs on nematode diversity and trophic structure. The observed increase in the **Shannon–Wiener diversity index (H2)** and **evenness** post-monsoon suggests a more balanced and diverse nematode community following seasonal flooding. Similar trends have been reported in tropical wetland and rice agroeco systems where post-monsoon conditions enhance microbial activity and resource availability, leading to the proliferation of diverse nematode taxa[2,19]. These findings align with previous research highlighting the role of seasonal flooding in enhancing the habitat heterogeneity and resource base that supports higher nematode diversity in wetland agro-ecosystems[4,6]. Post-monsoonal soil conditions, enriched with decomposing organic residues and microbial blooms, likely facilitate niche expansion, enabling co-existence among diverse nematodes[13]. **Margalef's richness** remained stable, indicating that while taxonomic richness was unaffected by seasonal change, the **distribution and dominance** of taxa shifted notably reflected in higher **evenness**. This aligns with earlier findings which emphasized that changes in food web evenness often occur independently of richness in disturbed or enriched systems[19].

Ecological indices such as the **Maturity Index (MI)** and **Plant Parasitic Index (PPI)** increased post-monsoon, indicating both improved environmental stability and increased plant-parasitic nematode activity. The latter could result from elevated root biomass and nutrient influx in moist post-monsoon soils, a trend also documented in other Indian agro-wetland systems[28,12,25].

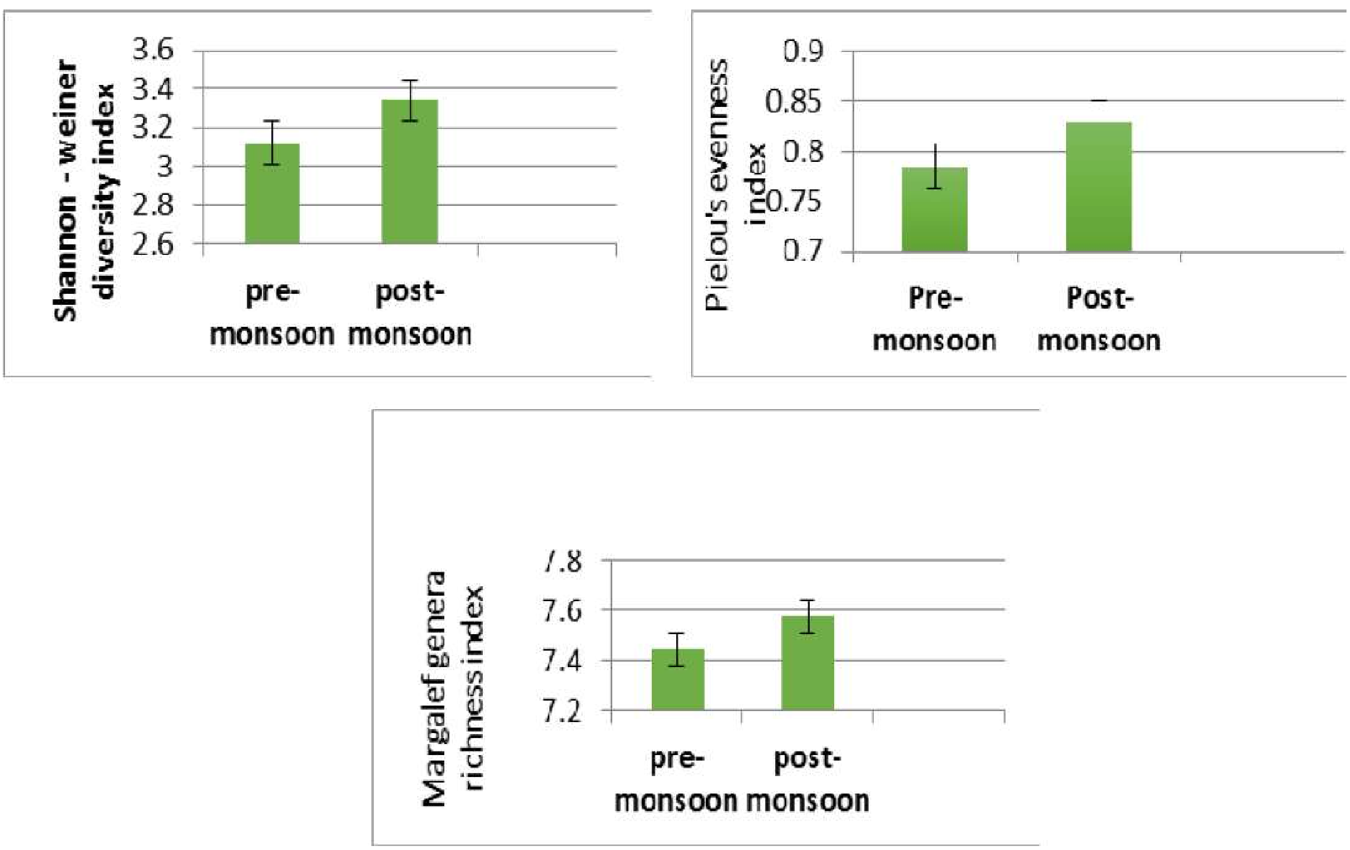

Fig. 1: Nematode diversity indices showing in pre-monsoon and post-monsoon seasons.

In contrast, the **Enrichment Index (EI)** decreased post-monsoon, possibly due to a **dilution effect** of resource input from runoff, leading to a **more stabilized system** with reduced bacterial bursts. This inverse EI–SI relationship is well-supported in nematode faunal analysis frameworks[18], where excessive enrichment can reduce trophic linkages and decrease structural complexity.

The observed post-monsoon increase in predator nematode abundance represents a significant seasonal shift in trophic structuring within the soil ecosystem. This response likely reflects enhanced prey availability or habitat changes such as improved soil moisture and organic matter inputs following rainfall events [1,30]. Predators are often regarded as indicators of a mature and stable soil food web due to their position at higher trophic levels and dependence on lower trophic groups for sustenance[24,30]. Their significant proliferation post-monsoon suggests a more active or complex nematode community, potentially contributing to greater ecological resilience and nutrient turnover during this phase[33]. Lack of significant variations in abundance of other trophic groups are consistent with previous findings suggesting that basal energy channels, particularly those involving microbial-feeding nematodes, are less responsive to short-term climatic fluctuations[34, 50].

Notably, the **Nematode Channel Ratio (NCR)** remained stable across seasons, but the **Wasilewska Index (WI)** increased post-monsoon, this pattern is previously reported in East Indian wetlands[8,12].

Indicator Species Analysis revealed distinct genera associated with each season. The application of Indicator Species Analysis (ISA) revealed distinct seasonal associations among nematode genera, highlighting the ecological specificity. *Cylindrolaimus*, emerged as a strong pre-monsoon indicator, likely reflecting its adaptation to drier, possibly oxygen-rich soil conditions that favor its colonization strategies[1]. *Hirschmaniella*, known for its plant-parasitic tendencies, showed a sharp decline in post-monsoon, supporting the hypothesis that water-logged conditions suppress its proliferation, possibly through increased microbial competition or root oxygen stress [30, 31]. Similarly, the dominance of *Mesodorylaimus* during the pre-monsoon suggests a preference for stable, less-disturbed edaphic environments often disrupted by monsoonal inputs.

In contrast, post-monsoon conditions supported a different assemblage of indicator genera. *Pseudoacrobeles* and *Trichotylenchus* were prominent, consistent with earlier studies linking opportunistic colonizers and herbivorous nematodes with pulses in microbial biomass and rhizosphere development following rainfall[35, 49]. *Discolaimus* and *Eudorylaimus*, with significant post-monsoon preference, further suggest that these genera thrive in enriched organic microhabitats formed post-precipitation. Notably,

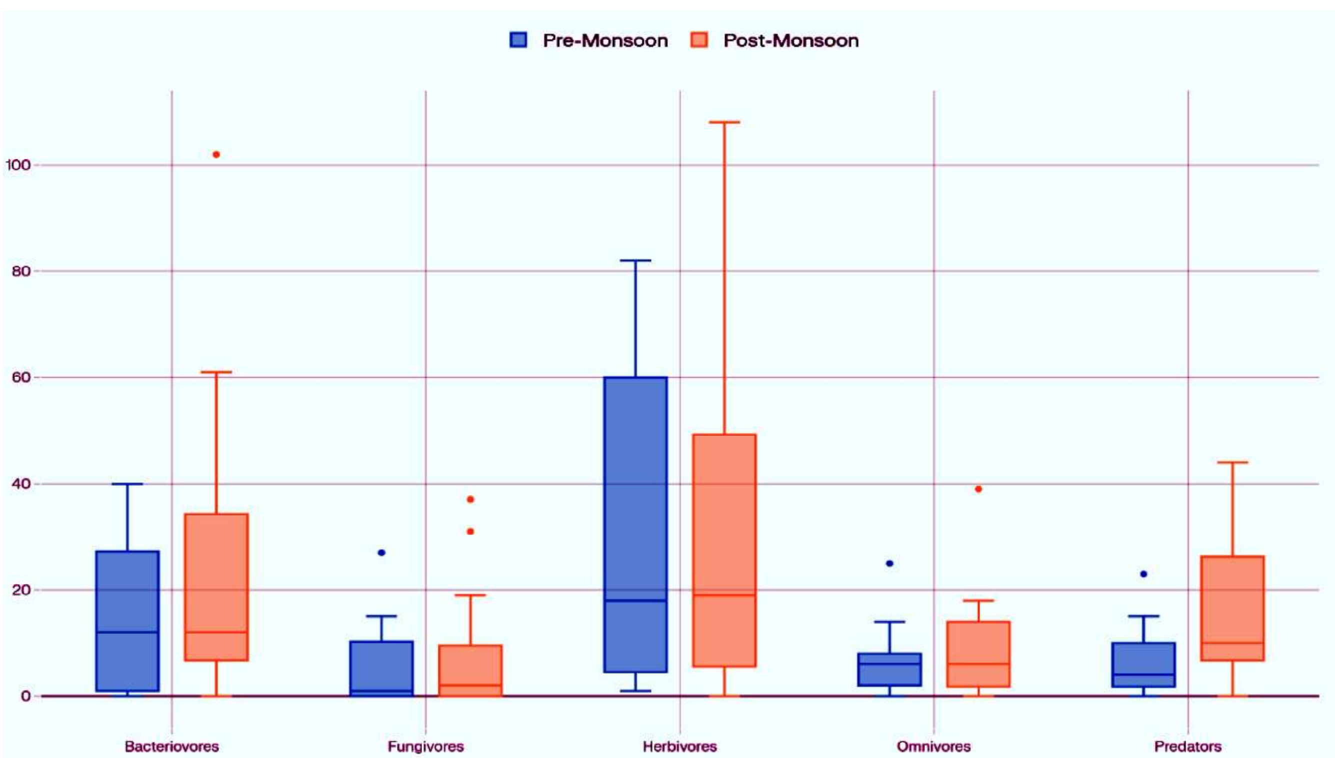

Fig. 2: Nematode abundance of different trophic groups under pre- and post-monsoon seasons

"Nematode abundance of different trophic groups under pre- and post-monsoon seasons"

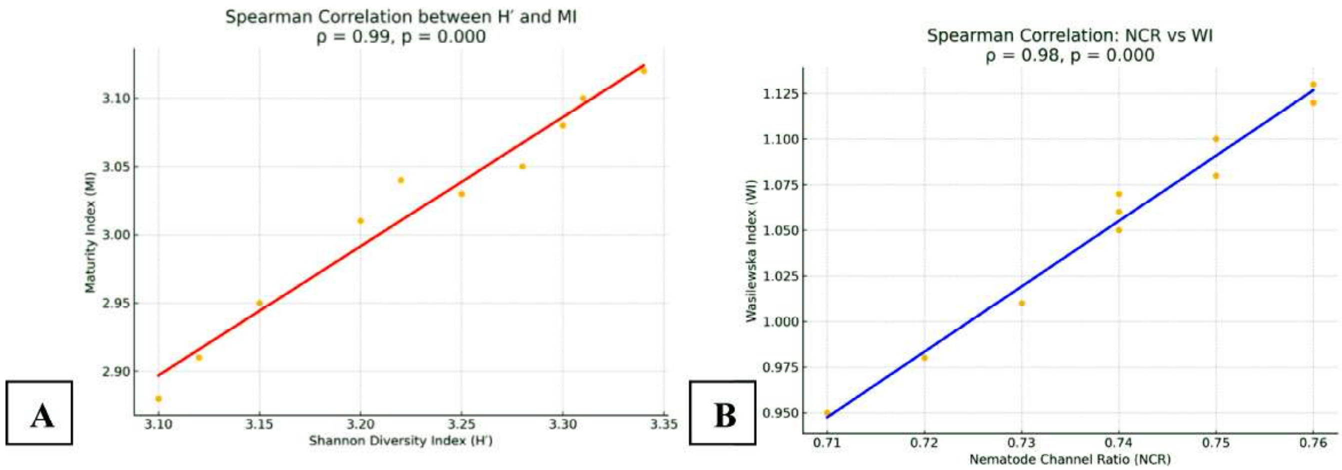

Fig. 3 : Spearman linear correlation graphs showing positive correlation between Shannon Diversity Index (H') and Maturity Index (MI) (A); positive correlation between Nematode Channel Ratio (NCR) and Wasilewska Index (WI) (B).

Aporcelaimellus emerged as a transitional genus, bridging both seasonal regimes, likely due to its ecological plasticity and ability to persist through variable moisture regimes[2].

Conclusion

This study demonstrates that seasonal hydrological shifts in the East Kolkata Wetlands drive substantial restructuring of nematode communities. Post-monsoon conditions favoured predator proliferation, indicative of microbial pathway enrichment and increased ecological maturity. These findings highlight the utility of nematode-based indices as early-warning indicators of soil health and emphasize the importance of integrating nematode ecology in wetland agroecosystem management frameworks.

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