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STUDIES ON THE SEASONAL VARIABILITY IN THE SEDIMENT CHARACTERISTICS OF SELECTED PERENNIAL PONDS IN KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

This study investigates seasonal fluctuations in sediment properties, specifically temperature, pH, EC, organic carbon, nitrogen, phosphorous, magnesium, calcium and potassium, across five perennial ponds in Kanyakumari district from February 2022 to January 2023. The findings demonstrated considerable seasonal variations in sediment characteristics caused by climate and human activity. During the pre-monsoon season, high concentrations of EC, Mg and Ca, were reported, owing to evaporation and nutrient concentration in the sediment. The monsoon season saw increasing pH, N, P, and K levels due to agricultural runoff and leaching from nearby fields, but dilution effects reduced other parameters such as EC and Ca. After the monsoon, water levels stabilized and runoff was reduced, resulting in moderate concentrations of most parameters, while K, Mg, N, and Ca were found slightly higher. Pond-specific differences revealed the impact of land-use practices, with Pond II accumulating the most nutrients due to agricultural runoff. These findings highlight the necessity of knowing seasonal dynamics and land-use influences in order to create effective solutions for sustainable pond management and sediment quality enhancement.

Keywords: Monsoon, Physico-Chemical, Pond Water, Pollution, Pre-Monsoon, Wastes

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1. INTRODUCTION

Ponds, though small freshwater ecosystems, are vital for supporting biodiversity, regulating water quality, and providing resources for agriculture and aquaculture. Sediments in ponds play a key ecological role, acting as reservoirs of nutrients like nitrogen and phosphorus, facilitating nutrient cycling, and influencing water quality[1]. They also serve as substrates for aquatic plants, supporting primary productivity and sustaining ecosystem functions. Seasonal variations, driven by rainfall, runoff, and sedimentation rates, affect sediment composition in ponds[2]. In tropical regions like Kanyakumari, where monsoon rainfall dominates, these seasonal dynamics influence nutrient and heavy metal concentrations. Excessive nutrients, particularly nitrogen and phosphorus, can lead to algal blooms, while heavy metals from natural and anthropogenic sources accumulate in sediments, posing ecological and health risks. This study

investigates the seasonal variability in sediment characteristics of five perennial ponds in Kanyakumari over one year (February 2022 to January 2023) (Fig 1). By analyzing sediment texture, nutrient content, organic matter, and heavy metals, the study aims to provide insights into sediment dynamics and inform sustainable management of ponds [3].

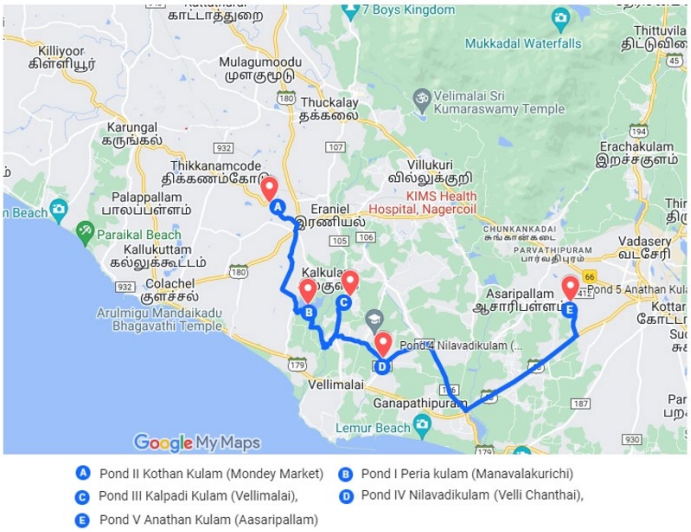

Figure 1 Location Map of the Study Area Showing Sampling Ponds

2. MATERIALS AND METHODS

Sediment samples, each weighing 1 kg, were collected from five perennial ponds located in the study area: Pond I (Peria Kulam, Manavalakurichi), Pond II (Kothan Kulam, Monday Market), Pond III (Kalpadi Kulam, Vellimalai), Pond IV (Nilavadi Kulam, Velli Chanthai), and Pond V (Anathan Kulam, Aasaripallam). Sampling was conducted over a one-year period from June 2022 to May 2023. The collected samples were sealed in plastic bags and transported to the laboratory for further processing. In the laboratory, the samples were air-dried at 60°C, manually crushed, and sieved through a 2 mm mesh to obtain uniform particle sizes for analysis.

The physico-chemical properties of the sediment samples were analyzed using standard methods. The pH and electrical conductivity (EC) were measured using the electrometric method. Total phosphorus (TP) content was analyzed in ppm using Bray's No. 1 method. Total nitrogen (TN) was measured in ppm using the Kjeldahl method. Organic carbon (OC) content was analyzed as a percentage using the Walkley and Black method. The concentrations of potassium (K), calcium (Ca), and magnesium (Mg) were measured in ppm using flame photometry.

3. RESULTS AND DISCUSSION

3.1. SEASONAL VARIATION IN TEMPERATURE, PH, AND ELECTRICAL CONDUCTIVITY (EC).

The data collected from the pre-monsoon, monsoon, and post-monsoon periods across the five ponds reveal significant seasonal variations in temperature, pH, and electrical conductivity (EC) (Table 1). During the pre-monsoon period, temperatures ranged from 26.55°C to 28.2°C, with Pond V being the warmest and Pond IV the coolest. The pH levels varied from 6.3 to 7.2, indicating slightly acidic to neutral conditions, while EC values ranged from 0.06 dS/m to 0.21 dS/m, with Pond IV showing the highest EC, suggesting an accumulation of nutrients and minerals. In the monsoon season, temperatures slightly decreased to between 25.77°C and 27.5°C, primarily due to cloud cover and rainfall. During this period, Pond 1 was the coolest, and Pond IV was the warmest.

The pH levels moved towards neutrality, ranging from 6.4 to 7.25, as rainwater diluted organic acids and runoff introduced fresh nutrients. EC values also fell, ranging from 0.07 dS/m to 0.2 dS/m, reflecting the dilution effect from rain. In the post-monsoon period, temperatures increased slightly to between 26.12°C and 28.3°C, with Pond III being the warmest and Pond II the coolest. The pH stabilized around neutral, ranging from 6.45 to 6.97, as the effects of runoff diminished. EC values rose slightly to between 0.08 dS/m and 0.17 dS/m, indicating an ion concentration increase due to evaporation and the stabilization of water levels.

Table 1: Seasonal Variation in Temperature, pH, and Electrical Conductivity (EC)

Ponds	Pre-Monsoon			Monsoon			Post-Monsoon		
	Temp (°C)	pH	EC (dS/m)	Temp (°C)	pH	EC (dS/m)	Temp (°C)	pH	EC (dS/m)
Pond1	26.95	6.97	0.14	25.77	6.52	0.08	26.6	6.6	0.13
Pond2	27.35	7.2	0.11	27.02	7.25	0.1	26.12	6.97	0.08
Pond3	27.32	6.3	0.06	27	6.72	0.1	28.3	6.45	0.08
Pond4	26.55	6.65	0.21	27.5	6.4	0.2	26.85	6.5	0.12
Pond5	28.2	7.07	0.09	26.32	6.87	0.07	26.67	6.92	0.17

In terms of pH variations, the highest values were observed during the monsoon season, while the lowest (most acidic) pH values were recorded in the post-monsoon season. This marked increase in pH during the monsoon can be attributed to the rapid rate of organic matter decomposition, which releases alkaline compounds into the water, thereby raising the pH [4]. Additionally, the higher pH values during the monsoon are consistent with increased microbial activity, which is most active within this pH range [5]. Variations in pH can also be influenced by redox changes in the sediments and the water column, as well as the influx of fresh water during the monsoon season[6].

In the current study, the highest electrical conductivity (EC) values were recorded during the pre-monsoon period in Pond IV. These elevated EC values can be attributed to water evaporation and subsequent concentration of pond water, leading to the accumulation of minerals in the sediments. Higher EC values are generally associated with increased total dissolved solids (TDS) and elevated water temperature, reflecting a higher concentration of soluble salts within the sediments [7]. In contrast, lower EC values were observed during the monsoon, likely due to the dilution effects of rainfall and the movement of water, which resulted in the dissolution and mixing of minerals from the sediments into the water column.

3.2. SEASONAL VARIATION IN ORGANIC CARBON (% OC), NITROGEN (N), AND PHOSPHORUS (P) CONCENTRATIONS.

The organic carbon (OC), nitrogen (N), and phosphorus (P) levels were compared across five ponds during pre-monsoon, monsoon, and post-monsoon seasons (Table 2). OC levels were highest during the monsoon season, with values ranging from 1.553% to 1.568%, peaking in Pond IV (1.568%). Pre-monsoon OC levels were relatively lower, ranging from 1.019% to 1.033%, with Pond V having the highest content (1.033%) and Pond II the lowest (1.019%). Post-monsoon OC values were slightly reduced but remained elevated compared to pre-monsoon, varying from 1.32% to 1.43%, with Pond II showing the highest (1.43%) and Pond III the lowest (1.32%).

Nitrogen concentrations peaked during the monsoon, ranging from 52.5 ppm in Pond II to 94.75 ppm in Pond III, due to agricultural runoff and plantations. Pre-monsoon values ranged from 39.17 ppm in Pond I to 71.25 ppm in Pond II, with Pond II being the highest. Post-monsoon levels remained high, between 51.25 ppm and 97 ppm, with Pond III at 97 ppm and Pond IV at 70.5 ppm, showing a decrease from the monsoon but still higher than pre-monsoon levels.

Phosphorus concentrations were highest during the monsoon, ranging from 6.5 ppm in Pond I to 12.25 ppm in Pond II, with Pond II consistently showing the highest levels due to increased nutrient runoff and reduced sediment release. Pre-monsoon phosphorus levels varied from 3.81 ppm in Pond IV to 11.28 ppm in Pond II, with Pond II again having the highest content. Post-monsoon concentrations were lower, ranging from 1.4 ppm in Pond II to 9.55 ppm in Pond III, likely due to sedimentation and nutrient uptake by aquatic organisms.

Table 2 Seasonal Variation in OC, N, and P Concentrations

Ponds	Pre-Monsoon			Monsoon			Post-Monsoon		
	OC %	N (ppm)	P (ppm)	OC %	N (ppm)	P (ppm)	OC %	N (ppm)	P (ppm)
Pond1	1.026	39.17	5.71	1.558	62.3	6.5	1.34	51.25	2.17

Pond2	1.019	71.25	11.28	1.567	52.5	12.25	1.43	53.25	1.4
Pond3	1.02	49.5	5.01	1.553	94.75	11.5	1.32	97	9.55
Pond4	1.03	51.75	3.81	1.568	65.25	10.5	1.36	70.5	7.45
Pond5	1.033	52	4.31	1.567	63.05	8.5	1.37	63.75	2.02

In the present investigation, the highest organic carbon levels were recorded during the monsoon season in Pond IV and pond II, likely due to rainwater leaching organic carbon from surrounding agricultural fields, as well as sewage and decomposing plant and animal matter. The highest total nitrogen values were observed during the monsoon in Pond III, attributed to nitrogen inputs from nearby rubber plantations and paddy fields. Rainfall enhances nitrogen runoff, which is used by plants and organisms, with excess organic matter depositing in sediments. This increased nitrogen uptake by algae and biological activity may lead to lower nitrogen levels in the pre-monsoon period. Total phosphorus was highest in Pond II during the monsoon, possibly due to reduced phosphorus release from sediments. The distribution of phosphorus in sediments depends on particulate matter addition, decomposition, and recycling, and is influenced by environmental factors like oxygen levels, pH, and temperature [8,9]. Phosphorus enrichment due to agricultural runoff and domestic effluents can increase phosphorus levels in the water [10]. Lower phosphorus levels may result from oxygen deficiency in the water.

3.3. SEASONAL VARIATION IN MAGNESIUM (MG), POTASSIUM (K), AND CALCIUM (CA) CONCENTRATIONS

The magnesium (Mg), calcium (Ca), and potassium (K) levels were compared across five ponds during pre-monsoon, monsoon, and post-monsoon seasons (Table 3). In the pre-monsoon season, magnesium values ranged from 47 ppm in Pond I to 53.75 ppm in Pond II. During the monsoon, magnesium concentrations dropped significantly, ranging from 29 ppm in Pond V to 36.6 ppm in Pond I. In the post-monsoon season, magnesium concentrations ranged from 44 ppm in Pond I to 47.75 ppm in Pond III, indicating a slight recovery compared to the pre-monsoon.

Calcium levels in the pre-monsoon ranged from 44.25 ppm in Pond IV to 49.5 ppm in Pond II. During the monsoon, calcium levels decreased, ranging from 20.25 ppm in Pond III to 25.25 ppm in Pond V. Post-monsoon calcium levels rose slightly compared to the monsoon, showing partial recovery from pre-monsoon levels, ranging from 32.25 ppm in Pond V to 36.75 ppm in Pond III.

In the pre-monsoon, potassium concentrations ranged from 34.25 ppm in Pond IV to 119.5 ppm in Pond II. During the monsoon, potassium concentrations remained higher than magnesium and calcium, ranging from 43.5 ppm in Pond V to 140.5 ppm in Pond II. However, in the post-monsoon season, potassium concentrations dropped, ranging from 26.25 ppm in Pond V to 80.75 ppm in Pond III, reflecting reduced dilution and a return to pre-monsoon levels.

Higher magnesium concentrations observed during the pre-monsoon season can be attributed to the evaporation and concentration of magnesium-containing salts in sediments. Anthropogenic activities, such as the use of magnesium-containing fertilizers and medicinal applications, also contribute to its accumulation. The pre-monsoon season showed increased calcium concentrations due to the stagnation and evaporation of water, leading to the accumulation of calcium salts. In contrast, monsoon levels were lower due to the dilution and leaching effects caused by rainfall. Agricultural use of calcium-containing fertilizers, liming, and effluents from cement factories are significant contributors. Calcium, found in various forms like calcite, dolomite, and gypsum, enters aquatic systems through natural sources and human activities. Potassium concentrations peaked during the monsoon season, particularly in Pond II. This can be linked to runoff from surrounding paddy fields, coconut plantations, and banana farms that use potassium-rich fertilizers. Potassium ions from sedimentary minerals are released and adsorbed at cation exchange sites, contributing to the higher levels. Additionally, fertilizers and agricultural runoff from nearby farming areas significantly enhance potassium content in the sediments.

Table 3: Seasonal Variation in Mg, K, and Ca Concentrations

Ponds	Pre-Monsoon			Monsoon			Post-Monsoon		
	Mg (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Ca (ppm)
Pond1	47	63	47.75	36.6	98	23.7	44	39.25	35.25

Pond2	53.75	119.5	49.5	32.5	140.5	24.5	44.25	76.5	38
Pond3	51.5	105.75	46.25	31.75	91.5	20.25	47.75	80.75	36.75
Pond4	52	34.25	44.25	30	51.75	23.25	45.25	51.45	34.6
Pond5	47.75	64.5	48.25	29	43.5	25.25	51.5	26.25	32.25

4. CONCLUSION

This study highlights the significant seasonal variations in sediment characteristics of perennial ponds in Kanyakumari district, influenced by climate and human activities. Pre-monsoon periods showed high EC, Mg, and Ca levels due to evaporation and nutrient concentration, while the monsoon season saw increased pH, N, P, and K from agricultural runoff and leaching. Post-monsoon stabilization resulted in moderate nutrient levels with slight elevations in K, Mg, N, and Ca. Pond-specific differences, particularly nutrient accumulation in Pond II, underscore the role of land-use practices. These findings stress the need for targeted strategies to manage nutrient loading and ensure sustainable pond management.

CONFLICT OF INTERESTS

None.

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