

ORIGINAL ARTICLE

Assessment of Physico-Chemical Parameters in the River
Cauvery, Tamil Nadu, India.

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ABSTRACT

The world's largest variety of ecosystem is the aquatic one. Water was the primary both internal and external environment for creatures when life first began, and early organisms were also aquatic. One of the most prevalent and valuable resources in the planet is water. Organic, inorganic, and biological pollutants are polluting ground water supplies. Thus, in recent years, managing aquatic ecosystems in particular has become a top priority. From January 2022 to December 2022, the current study on the hydrobiological and seasonal pattern of nutrients in the Grand Anaicut reservoir of the River Cauvery was conducted in detail. The physico-chemical parameters, including temperature of the air and water, pH, DO, total dissolved solids, ammonia, phosphate, silicate, sand, silt, nitrite, nitrate, and total organic carbon. There was a notable seasonal change in the freshwater mollusca density, population density, and percentage composition. During the study period, the pH ranged slightly alkaline, and there was a little seasonal variation in the temperature of the water and atmosphere. There was notable variance in DO, total dissolved solid, ammonia, nitrite, nitrate, phosphate, and silicate. Mollusca species were identified in two groups for the current study. Bivalves and gastropods, in this investigation, a total of 19 species were identified. Four of these species were bivalves, and the other fifteen were gastropods. Ampullariidae, Viviparidae, Bithniidae, Thiaridae, and Planorbidae were the families to which gastropods belonged. There were five species from the family Bithyniidae, three from the Ampullariidae and Thiaridae, and two from the Viviparidae and Planorbidae. In gastropods, *Bellamyia bengalensis*, *Pila globosa*, and *Pila virens* were found to be the prevalent species. There are four species of bivalves in the Unionidae family. The study's leading species were found to be *Lamellidens marginalis*.

Keywords: River Cauvery hydrobiology, Nutrients, Temperature, mollusca, *Lamellidens marginalis*

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INTRODUCTION

Estuaries represent dynamic ecosystems which consist of some of the highest levels of biodiversity and biological activity found globally. They have become progressively susceptible to human-induced factors in the past few decades, experiencing intricate biogeochemical and hydrological phenomena. These ecosystems of water exhibit a notable susceptibility to external pressures, primarily stemming from the persistent introduction of pollutants, predominantly resulting from terrestrial runoff, as well as agricultural as well industrial wastewater. Indian estuaries are characterized as monsoonal estuaries due to their distinctive features, which arise from the influence of the rainy Indian Summer Monsoon. High runoff during the wet season and low runoff during the eight-month dry season cause significant temporal fluctuations in the brackish and velocity systems in these estuaries. The estuaries exhibit a diverse array of habitats which have adapted to these transformations.

The effects of environmental issues would be detrimental to the habitats [1]. Ecotoxicology is an investigation of how dangerous physical and chemical substances may be to living organisms, especially to individuals and groups that are a member of a given ecosystem. Industrialization and residential development present significant threats to coastal ecosystems, especially estuaries. Estuaries are recognized for their significant ecological productivity, allowing them to sustain a diverse array of organisms all through their entire life cycle or solely during the stage of larval development. A variety of

pollutants, such as metals, chemical herbicides, hydrocarbons, and recurrent compounds of chemicals, consistently exert pressure on these fragile ecosystems. While heavy metals belong to naturally occurring elements in the surroundings, there is substantial scientific proof indicating a rise in their levels in numerous coastal regions [2]. Water resources' quality is determined by a wide range of physicochemical factors, including the level and source of any contamination load. Assessing these factors is crucial to determining their quality.

Among these are seasonal fluctuations in the physico-chemical properties and nutritional dynamics of the nation's numerous water bodies. One trait that all three distinct kinds of estuaries have in common is seasonality in the salinity of their water. It is caused by seasonal fluctuations in the volume of freshwater that rivers are supplying to the estuaries. India's monsoonal environmental condition, which has two different seasons—a rainy period and a dry period—is the reason for this seasonality. The Indian Summer Monsoon, which normally lasts between June to September, provides about 80% of India's annual rainfall. It is around the period of year when river runoff peaks. There are no rainy months left in the year. River discharge quickly decreases after the rains [3]. There is usually little to no discharge into the estuaries throughout the eight months of the dry season. Indian estuaries are usually referred to as the monsoonal because of their seasonality [4], according to Vijith et al., [5]. Numerous fish species can be found in Tamil Nadu's diverse estuarine and marine habitats [6-8].

Overall, 1656 fish species have been identified in Tamil Nadu's coastal and estuary waters, categorized into two categories, 40 orders, 191 families, and 683 genera. According to the assessment, 1075 species of fish were identified in basic marine water, whereas 581 fish species showed *diadromus*. It comprises an aggregate of 128 species (11 orders, 36 families, along with 70 genera) and 1528 species (29 orders, 155 families, along with 613 genera) within the groupings *Elasmobranchii* and *Actinopterygii*. The most diverse order of animals in terms of species composition was *Perciformes*, which comprised 932 species (56.29% of the total fauna); *Tetraodontiformes* included 99 species, *Pleuronectiformes* included 77 species, *Clupeiformes* included 72 species, and *Scorpaeniformes* included 69 species. The *Gobiidae* family has the most variety of organisms in the family, at 86. Featuring 65, 64, and 63 different species, accordingly, the *Carangidae*, *Labridae*, and *Serranidae* are the next greatest. A fishery assessment indicates that there are 1029 species of fish for capture, 425 species for aquarium fisheries, 84 species for culture, 242 kinds for sport, and sixty kinds for bait. The danger status assessment of the IUCN Red List comprises 46.01% of species of fish for which the IUCN has not yet established their conservation status, 50.25% of non-threatened fishes, and 3.75% of sensitive fish organisms [9, 10]. In this study, a physico-chemical investigation of Grand Anicut, also known as Kallanai, Tiruchirapalli, Tamilnadu, India, has been conducted.

MATERIAL AND METHODS

Laboratory analysis

Kallanai is located on the left bank tributaries of the Cauvery River, sixteen kilometers east of Tiruchirapalli, with 209 km beyond Mettur Dam. It is located at 78°49'E longitude and 10°50'N latitude. With the Cauvery, Vennar, and Grand Anicut canals as its three head regulators and a surplus regulator on the Northern Bank of the Cauvery, which releases water from spilling into Coleroon (Kollidam), the complete Grand Anicut complex—also referred to as Grand Anicut or Kallanai—is created. After several centuries, Grand Anicut, also known as Kallanai, is more efficient beyond any other recent dam, demonstrating the extraordinary engineering talent that underpins it. It's also noteworthy that, in contrast to the current building's flawlessly planned and expertly produced fully fledged stepped apron, this structure has a very basic sloping apron on the side facing downwards (Figure 1).

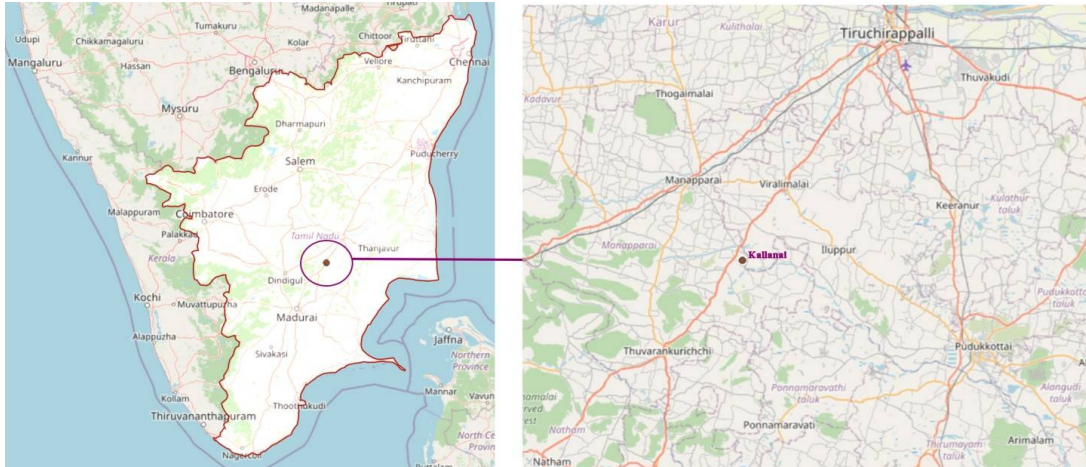


Figure 1: Study site - Grand Anicut

The River Cauvery, also called "Akanda Cauvery," or "Broad Cauvery," splits into the Cauvery and Vennar, two equally-sized branch rivers, at this point. A man-made canal known as the "Grand Anicut" (GA) canal was excavated in 1934, with its head situated next to the heads of these two branches. Grand Anicut or Kallanai is the collective name for Cauvery's head works. Thus, the Cauvery Delta begins in Kallanai. Over a distance of 160 km, the relatively flat fan-shaped Cauvery delta gently dips eastward till it meets the Bay of Bengal's coastline. Following the steps described by Strickland and Parsons [11], Winkler's method was used to determine the bottom water's dissolved oxygen content. A digital pH meter was used to determine the water sample's pH. Water samples were taken every two weeks throughout this investigation period (January 2022 to December 2022); data gathered were compiled seasonally to comprehend the seasonal effect.

Sediment analysis

For the purpose of examining the soil texture, total organic carbon, and trace metals, we removed a small portion of soil from each grab haul. Samples were collected, placed in sanitized polythene bags, and allowed to air dry. Sieved these specimens using a mechanical shaker to study soil texture after air drying. The volume of silt that passed through the 62-mm sieve was used to calculate the sand fraction. El-Wakeel and Riley's approach was used to determine the amount of organic carbon in sample sediments [12].

Mollusca samples

Making use of a Peterson grab, mollusca forms have been removed from the bottom silt. Additionally, we collected them from floating objects and aquatic vegetation. We used a scoop net for this collection, which included a 30 cm x 30 cm steel frame bar, wire nets, a 10 cm deep scoop with an eight-centimeter-wide blade, and a wooden grip. We handpicked the samples from arid areas with shallow water levels, using a scoop net. Wide plastic bottles have been utilized to take each sample to the lab. They underwent washing, counting, photographing, taxonomy, and documentation [13]. Mollusca specimens have been gathered and divided, and the dead and living specimens were taken to the lab for additional identification after 13 (1 x 1 x 1) foot quadrates were placed at the study area. And randomly position small, uniformly sized quadrats in specific foraging locations to gather samples. The number of quadrates depended on the size of the foraging habitat. Shells from mollusks were gathered by hand-picking and scraping. After being gently cleaned with water to get rid of any stuck material, the shells were allowed to dry. We used morphological characteristics to identify the gathered mollusca species [13, 14]. We represented the macrofaunal density as the number of individuals per square meter. The samples were gathered between January 2022 and December 2022, which is a one-year timeframe.

Diversity measures

PRIMER Ver. 6, a statistical tool, was used to apply a variety of univariate, graphical, and multivariate techniques to the acquired data.

Shannon-Wiener index (H')

The data were analyzed using the Shannon and Wiener [15] derived a formula which is known as the Shannon index of diversity (H').

$$H' = \sum_{i=1}^s P_i \log_2 P_i$$

Here $P_i = n_i / N$ for the i^{th} species, S = total number of species, (n_i) = number of individuals of a species in sample, N = total number of individuals of all species in sample. Here the value of H' is dependent upon the number of species present, their relative proportions, sample size (N), and the logarithm base.

Margalef index (d): Margalef index is denoted by 'd' and was used to calculate species richness using the following formula: $d = (S-1) / \log N$, Where, S = total number of species and N = total number of individuals

PIELOU'S EVENNESS INDEX (J'): THE EQUITABILITY (J') WAS COMPUTED USING THE FOLLOWING FORMULA OF PIELOU [165]: $J' = H' / H'_{\text{MAX}}$, WHERE, H' IS THE OBSERVED SPECIES DIVERSITY AND H'_{MAX} IS THE LOGARITHM OF THE TOTAL NUMBER OF SPECIES (S) IN THE SAMPLE.

Graphical/distributional techniques: These techniques form as an intermediate between univariate summaries and full multivariate analysis of the species/samples matrix.

K-dominance curve: Developed by Lamshead *et al.*, [17], result from plotting percentage cumulative abundance against species rank k on a logarithmic scale.

Multivariate methods: Cluster analysis: The purpose of the cluster study was to identify similarities among stations. The hierarchical agglomerative method is the most frequently employed clustering technique. A dendrogram is utilized to illustrate the results, with the x-axis showing the entire set of specimens and the y-axis indicating the degree of resemblance once the individual specimens or groups are combined. To create the dendrogram, the Bray-Curtis coefficient [18] was employed. The equation that follows was used to determine the coefficient:

$$S_{jk} = 100 \left\{ 1 - \frac{\sum_{i=1}^p |y_{ij} - y_{ik}|}{\sum_{i=1}^p (y_{ij} + y_{ik})} \right\}$$

$$= 100 \frac{\sum_{i=1}^p 2 \min(y_{ij}, y_{ik})}{\sum_{i=1}^p (y_{ij} + y_{ik})}$$

where, y_{ij} represents the entry in the i^{th} row and j^{th} column of the data matrix i.e. the abundance or biomass for the i^{th} species in the j^{th} sample; y_{ik} is the count for the i^{th} species in the k^{th} sample; $| \dots |$ represents the absolute value of the difference; 'min' stands for, the minimum of the two counts and \sum represents the overall rows in the matrix.

MDS (NON - METRIC MULTI DIMENSIONAL SCALING)

Kruskal [19] proposed this technique, which was employed to determine the similarities (or variations) between every pair of items in order to create a "map" that might ideally illustrate how everything is related to everything else. Samples positioned closer together have a more comparable species composition and abundance, while samples positioned farther apart exhibit significant differences.

PAST statistical tool for analysis for mollusca and environmental parameters

We used the PAST upgraded version of the free program to evaluate environmental characteristics and mollusca diversity. It was carried out to assess potential relationships among freshwater mollusca, environmental characteristics, and variation in the research location.

RESULT AND DISCUSSION

Estuaries play a pivotal role in ecological diversity including hydrological systems; they are also an important part of marine ecosystems. Estuaries are created by the flow of weathering particles from the ground to the ocean, which changes the physico-chemical properties of water. Seasonal variations in the meteorological and physico-chemical parameters of pH, DO, ammonium, nitrate, nitrite, phosphate, sulfate concentration were observed in the Cauvery estuary waters over a year, from January 2022 to December 2022. The estuary is formed by the Cauvery River, which empties into Tamil Nadu's Bay of Bengal. The Cauvery River divides into the Coleroon in the north and the Cauvery proper in the south in Tamilnadu's deltaic area. Little is known about the fishing potential of the Cauvery Estuary. This estuary is often home to *Mulletts*, *Clupeids*, *Perches*, *Lates*, *Polynemus*, *prawns*, *crabs*, and other species. Seasonal variations in all physico-chemical component characteristics, as well as alterations in primary producers along with nutrient distribution, had an impact on the research areas' spectacular area. From January 2022 to December 2022, the station's hydrobiological characteristics were monitored for a full year. The temperature of the atmosphere varied from 27.11°C to 39.13°C. The lowest recorded temperatures in October, November, and December of 2022 were 27±0.121°C, 28±0.121°C, and 29±0.121°C, respectively, while the highest measured temperature in May of 2022 was 39±0.154°C.

Figure 2a displays the measured water and air temperatures. In the research region, the water temperature ranged from 27.11 to 37.21°C, reaching its lowest points in October and November 2022 ($22\pm 0.014^\circ\text{C}$, $23\pm 0.045^\circ\text{C}$) and its highest points in April, May, and August 2022 ($33\pm 0.417^\circ\text{C}$, $33\pm 0.330^\circ\text{C}$, and $33\pm 0.132^\circ\text{C}$).

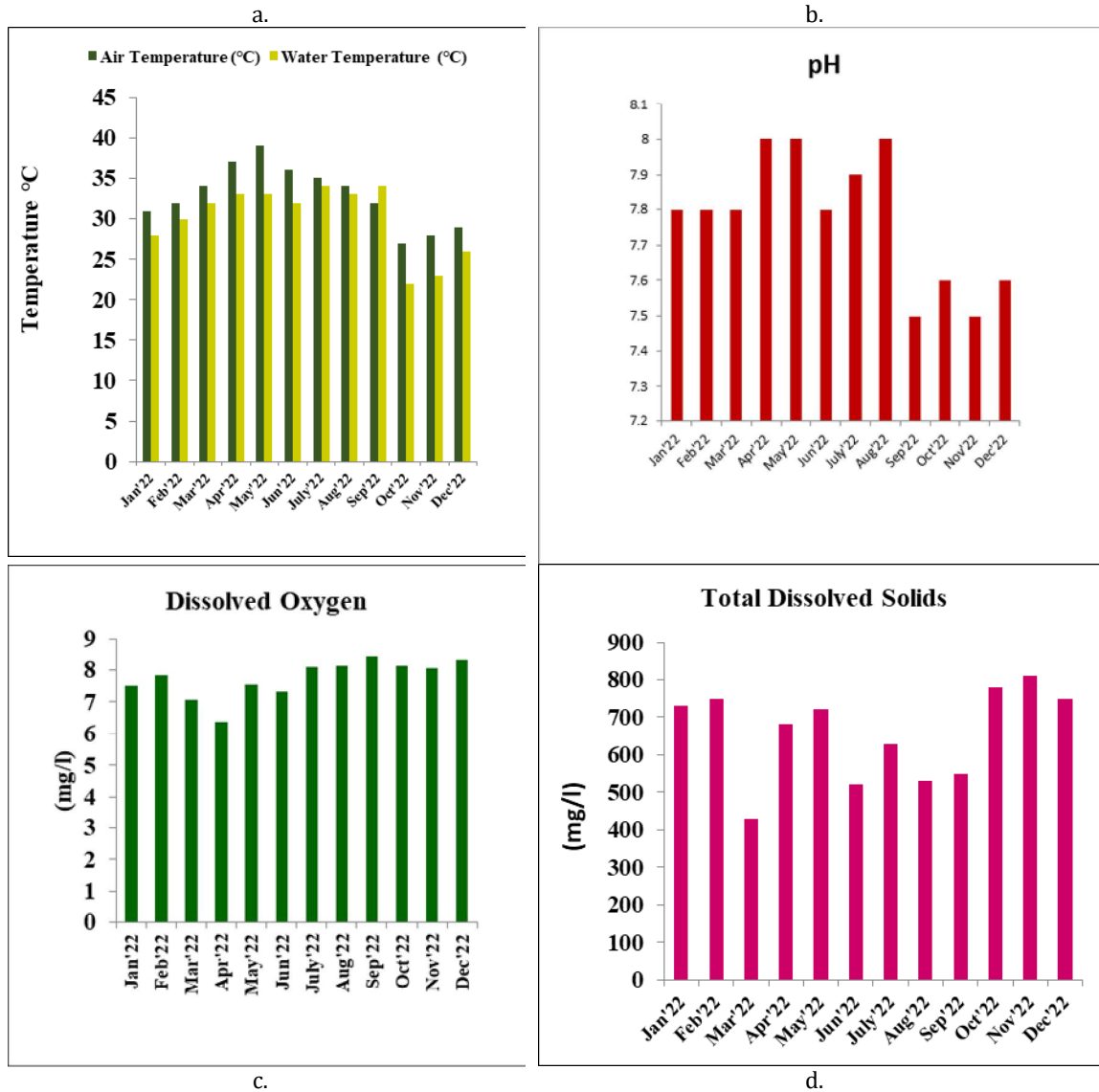


Figure 2: Seasonal variation in Temperature, pH, Dissolved oxygen and total dissolved solids levels of water at the river.

The pH of the water's environment plays a crucial role in maintaining all aquatic creatures, especially animals and plants. The pH measures the quantity of hydrogen ions (H^+) in a solution. By analyzing all the biochemical processes and physico-chemical characteristics, the pH preserves the acidic or basic property and is a crucial aspect of all aquatic ecosystems. When the pH is measured at 6.5, the body stops producing vitamins. The water pH is presented in Figure 2b. The water pH value was varied from 7.51 to 8.12. The minimum value was recorded during September and November 2022 it was 7.51, 7.53 and the maximum during April, May and August 2022, it was 8.12, 8.01, 8.02. The pH of the Cauvery Estuary ranged from 7.51 to 8.12, suggesting that the water was somewhat alkaline. The cold temperatures of the water slow down all living things' metabolisms, lowering the river's oxygen content throughout the winter. Nearby villages and irrigation fields may generate sewage that complements the alkaline character of river water. The taste of water turns salty and might lead to skin and eye discomfort when

the pH of the water exceeds 8.5. Sewage and agricultural discharges contain numerous fertilizers, metals, sediments, pesticides, nutrients, salts, and other materials. Most organisms can grow in water with a pH between 6 and 9. The results show that the pH levels are within the acceptable range. pH alters the solubility of toxic metals in aquatic environments, which can have detrimental effects on how organisms use water and on human health. Monthly variations of dissolved oxygen recorded in the study area are given in Figure 2c The dissolved oxygen content varied between 6.36 ± 0.01 and 8.41 ± 0.03 mg/l; the lowest value was recorded in April 2022, while the highest was recorded in September 2022. Figure. 1d displays the results of the analysis of total dissolved solids. There was a range of results from 430 ± 0.021 mg/l to 810 ± 0.034 mg/l. March 2022 was the month with the lowest value, and November 2022 was the month with the highest.



Figure 3: Seasonal variation in a. Ammonia, b. Nitrite, c. Nitrate and d. Phosphate levels of water at the river.

Water Nutrients

Water nutrients like Ammonia, Nitrite, Nitrate, Phosphate, and Silicate were analyzed and the values were presented in Figures 3 (a, b, c, d) and 4. Ammonia values was ranged between 0.08 to 0.43 mg/l, maximum ammonia observed in the month of March 2022, minimum ammonia observed in the month of September. Nitrite was ranged between 0.18 ± 0.1 and 2.84 ± 0.11 mg/l, maximum nitrite observed in the month of September 2022, minimum nitrite observed in the month of June. Nitrate values varied from 1.63 ± 0.04 to 4.33 ± 0.031 mg/l, maximum nitrate observed in the month of September 2022, minimum nitrate observed in the month of February. Phosphate was varied from 0.08 ± 0.11 to 0.32 ± 0.20 mg/l, maximum phosphate observed in the month of June 2022, minimum phosphate observed in the month of

February and the Silicate was ranged between 2.26 ± 0.010 and 5.68 ± 0.024 mg/l, maximum silicate observed in the month of June 2022, minimum silicate observed in the month of February (Figure 4a).

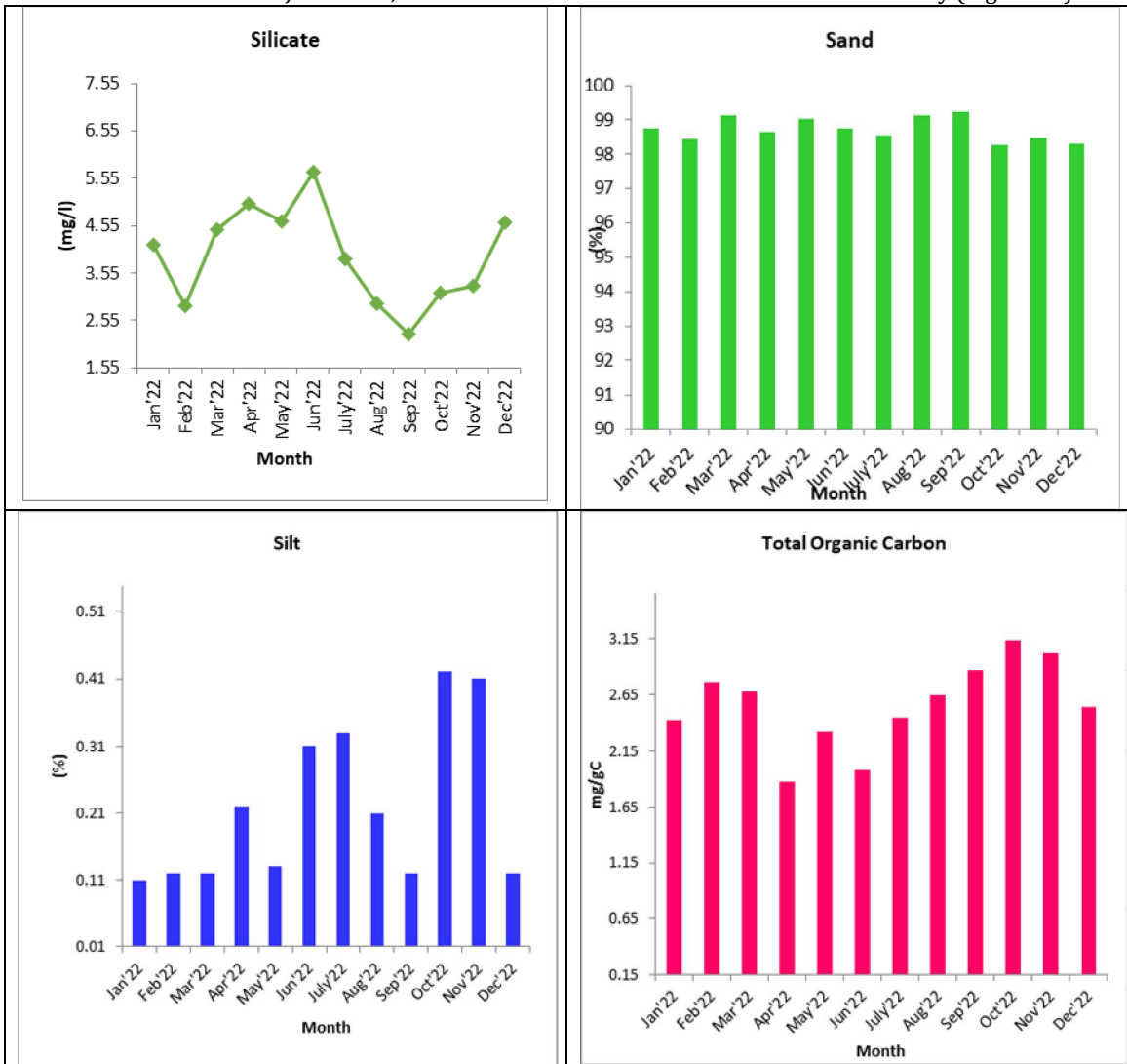


Figure 4: Seasonal variation in a. Silicate, b. Sand, c. Silt and d. Total organic carbon levels of water at the river.

Sediment texture

Monthly variations of sediment characteristics for the study area are given in Figure 4b. The sand percentage was varied between 98.26 ± 0.021 to $99.12 \pm 0.10\%$ and the maximum percentage showed in September 2022 and the minimum was showed in March 2022. The Silt percentage was varied between 0.11 ± 0.01 to 0.42 ± 0.012 % and the lowest value was noted during January 2022 and the highest value was noted during October 2022 (Figure 4c). Figure 4d shows the total organic carbon values. The TOC level ranged from 1.87 ± 0.04 to 3.14 ± 0.012 mg C/g with minimum during April 2022 and maximum during October 2022.

Density of Fresh water mollusca

The seasonal variations of *mollusca* population density are plotted in Figure 5a. The monsoon season had the lowest molluscan population density, whereas the post-monsoon season had the highest density. The range of the population concentration was 294 ± 0.12 to 451 ± 0.11 persons/m².

a.

b.

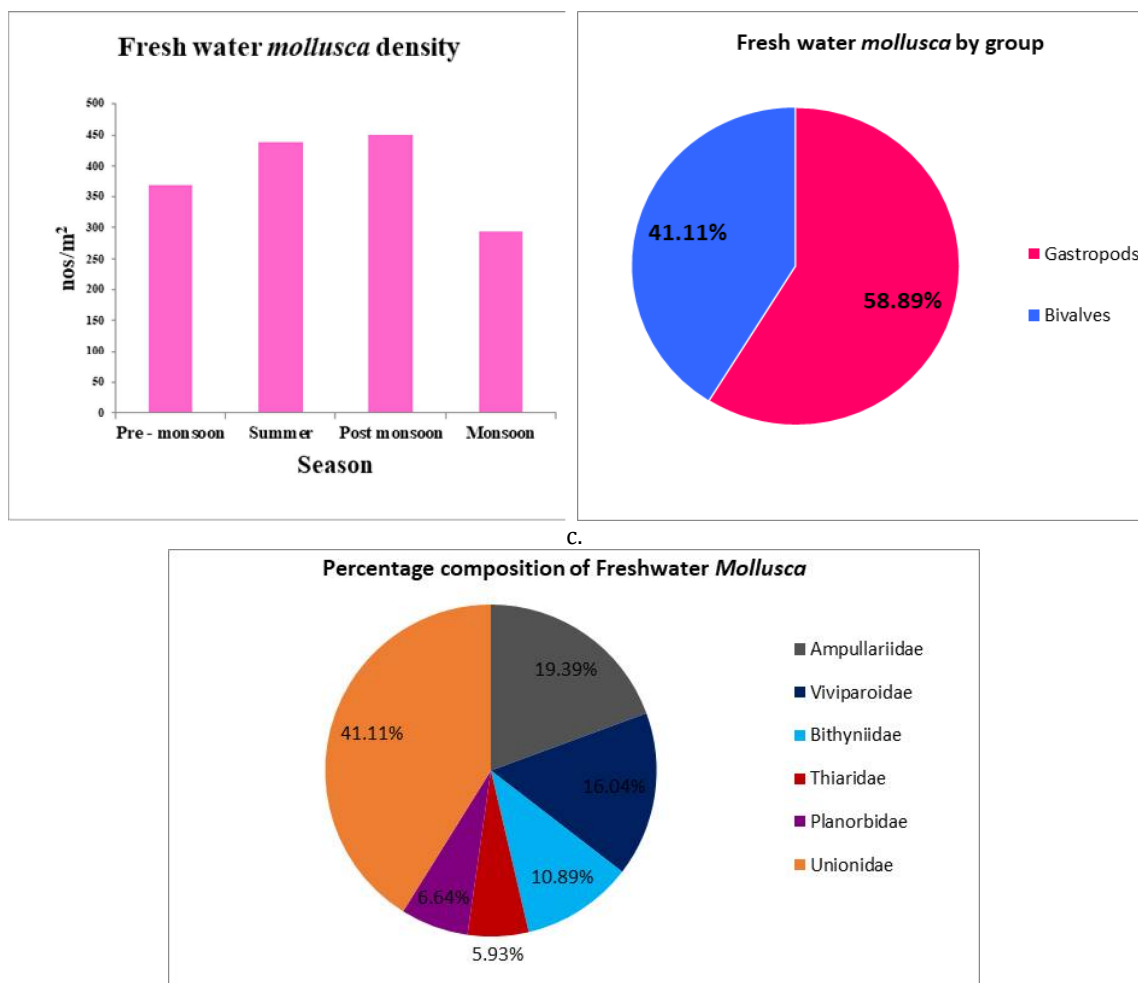


Figure 5: seasonal variations a. mollusca population density b. fresh water mollusca groups, c. percentage compositions of fresh water mollusca

Species composition of fresh water mollusca

This investigation has identified Mollusca species in two categories (Figure 5b). This study identified nineteen species of gastropods and bivalves. Of these 15 species were gastropods and 4 species were bivalves. *Gastropods* were belonging to families viz, *Ampullariidae*, *Viviparoidae*, *Bithyniidae*, *Thiaridae* and *Planorbidae*. Family *Bithyniidae* was represented by five species; *Ampullariidae* and *Thiaridae* were represented by three species, *Viviparoidae* and *Planorbidae* by two species. *Pila globosa*, *Pila virens* and *Bellamyia bengalensis* were showed the dominant species in gastropods. Bivalves consist of four species under the single family *Unionidae*. *Lamellidens marginalis* and *Lamellidens corrianus* were showed the dominant species in this study. Overall, investigation showed the bivalve more abundantly than the *gastropods*. The percentage compositions of fresh water mollusca in family wise are represented in Figure. 5c. In the present study there are six families under the two groups of freshwater mollusca were observed. Family *Ampullariidae* contains $19.39 \pm 0.22\%$, *Viviparoidae* contains $16.04 \pm 0.21\%$, *Bithyniidae* contains $10.89 \pm 0.17\%$, *Thiaridae* contains $5.93 \pm 0.14\%$, *Planorbidae* contains $6.64 \pm 0.11\%$ and *Unionidae* contains $41.11 \pm 0.01\%$.

Diversity measures

The diversity indices calculated in the study for comparison of fresh water mollusca abundance in various seasons are given in Table 1.

Table 1: Cluster analysis / MDS (non - metric Multi Dimensional Scaling)

Mollusca Diversity	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
Pre-monsoon	2.813	4.511	0.9929
Summer	2.807	4.463	0.9908
Post monsoon	2.849	4.724	0.9856
Monsoon	2.868	4.816	0.9921

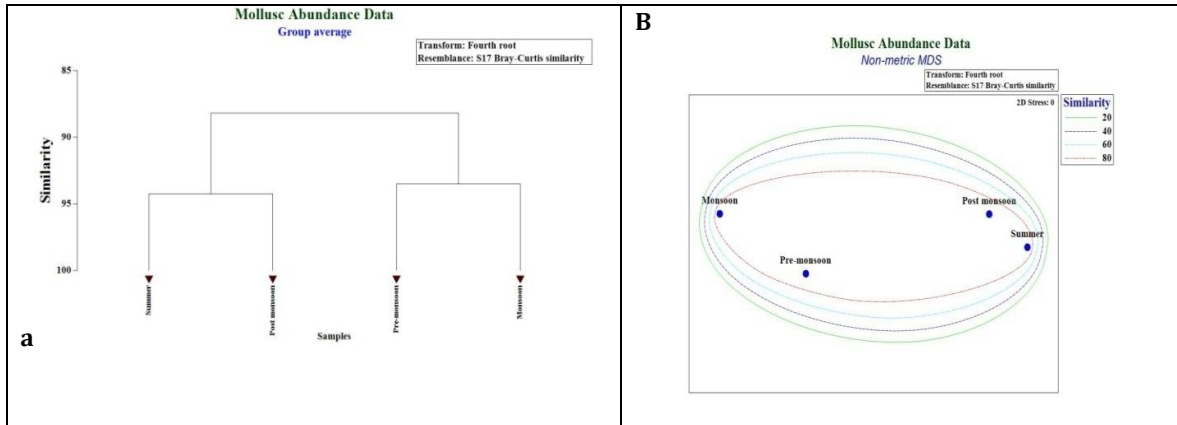


Figure 6: a. Cluster analysis, b. Mollusca Abundance Data

Cluster analysis is a method that creates a two-dimensional hierarchical structure (dendrogram) by successively connecting things based on the extent to which (or dissimilar) they are. The results of the clustering method used in the present research to determine the similarity of the seasons are displayed in Figures 6a and 6b. From the clustering and MDS result showed that, summer and post monsoon seasons were grouped together and monsoon and pre - monsoon seasons grouped together with above 90% similarity.

Figure 7 to confirm the pattern recognized in the diversity indices, the data were also approached to k-dominance curve for the study. The plots clearly demonstrated the trend as obtained through various diversity indices. Monsoon season showed lowest curve indicate the maximum dominance.

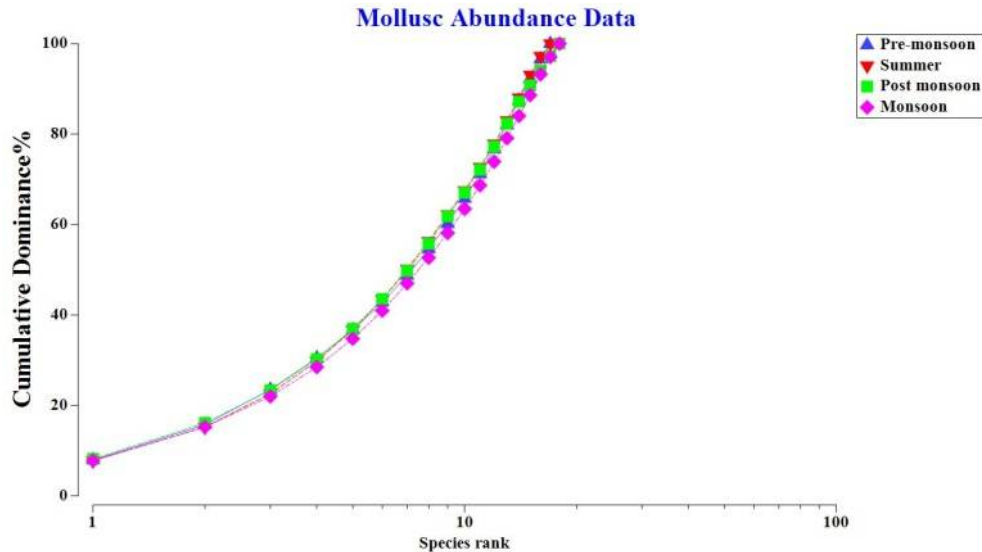


Figure 7: Pattern recognized in the diversity indices

The monsoon season had the largest rainfall maxima, while the summer months had the lowest, according to reports by Pazhanisamy *et al.*, [20] and Umamaheswari *et al.*, [21]. Temperature and humidity were found to be indirectly related [22] (Jeralad, 1994;). Another significant abiotic component that affects the biota is temperature. Temperatures at the study sites in this analysis were greatest in summertime and smallest in the time of the monsoons [23–25]. According to reports by Begum [26], the

water temperature in certain Cauvery River tributaries ranges from 24 to 28°C. Several researchers noted that the temperature of the Cauvery River was at its lowest in the monsoon season and at its highest in the summer [27, 28]. One crucial hydrobiological factor that affects aquatic creatures' eating, development, and nutritional value is the amount of hydrogen ions [29]. Since earlier researchers found a modest seasonal change in pH, the water's pH change is less noticeable during the investigation period [30-32].

The current study also found that dissolved oxygen (DO) had been at its lowest level in summertime and at its greatest in the winter, indicating another important finding. This could be because of natural disturbance with autotrophic producers from photosynthesis [33]. The concentration range of dissolved oxygen at Lower Anaicut Reservoir was 6.0 mg/l to 10.89 mg/l. Moreover, the dissolved oxygen level in the Cauvery varies between 4.3 and 7.8 mg/l, based on Annalakshmi and Amsath [28].

The salts of strong bases or weak acids are primarily responsible for the alkalinity of river water. Together with hydroxide alkalinity, bicarbonates along with carbonates are the main forms of alkalinity. In Lower Anaicut near the Cauvery River, the premonsoon had the highest overall alkaline value, accompanied by the postmonsoon and monsoon [22]. Kalavathy *et al.*, [34] showed that the alkalinity in the Cauvery River varied seasonally, ranging from 190 to 260 mg/l. The incorporation of nitrogenous chemicals and degraded biological components is the primary cause of the river's nitrate level. The biological oxidation of organic nitrogenous compounds is the primary source of nitrate.

While Pazhanisamy and Ebanasar [20] noted fluctuations in nitrate concentration (0.1 – 0.23 mg/l) in Lower Anaicut reservoir, Mangayarkarasi [31] claimed that seasonal fluctuations in the amount of nitrate were not very significant. Pure water contains phosphate in the form of organic as well as soluble phosphates. Runoff and human feces can cause it to get into surface water. Bagiola from Calcutta stated that an untreated water canal had a high level of total organic phosphate [35]. Phosphate levels in the Cauvery River in Thanjavur district ranged from 0.22 to 1.82 mg/l, with minor seasonal variations, according to Baskar *et al.*, [36]. In Lower Anaicut Reservoir, a seasonal decline in turbidity was observed between monsoon to postmonsoon and to premonsoon [22]. According to Amanullah [37], suspended substances in different industrial effluents and sewage washes are primarily responsible for the highest levels of contaminants during the premonsoon times and the least amount through the postmonsoon duration. The river Cauvery recorded a lesser level over the monsoon period [21]. Large volumes of silt, microbes, plant fibers, sawdust, wood ashes, chemical, and dust from coal can all result from the turbidity [27].

CONCLUSION

Findings from this study support the use of the Cauvery River for aquaculture and irrigation because they show that the river's hydrobiological characteristics and distribution of nutrients are within acceptable limits.

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