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Seasonal Effects of Physicochemical Parameters on Fish diversity, Population Dynamics, Species Index, and IUCN Status in the Kalpakkam Coastal Waters, Bay of Bengal, India

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Abstract

Seasonal variations in physicochemical parameters and fish diversity, population dynamics, species index, and IUSN status were investigated in this study; quantitative samples were collected monthly from January 2019 to December 2020 around the Kalpakkam coastal water in the Bay of Bengal (BOB). Water and sediment parameters are compared to fish diversity. The Zoological Survey of India confirmed the existence of 102 fish species collected along the coast, divided into two groups, 22 orders, and 56 families. Fish diversity was calculated in five villages using the species index, species richness, and Shannon-Weiner index, with Sadras kuppam having the highest and Mahabalipuram beach having the lowest. When the collected fish species were compared to the International Union for Conservation of Nature (IUCN) threatened lists, 46.08 % were determined to be the least concerned. When compared to physicochemical parameters and fish diversity, principal component analysis, and cluster analysis were found to be statistically significant. According to the study, strict conservation measures should be implemented to ensure the conservation and sustainability of fish diversity.

Keywords: Marine fish diversity; Species index; IUCN status; Coastal zone

Abbreviations: BOB: Bay of Bengal; EC: Electrical Conductivity; LC: Least Concern; NE: Not Evaluated; DD: Data Deficient; PC: Principle Components; PCA: Principle Component Analysis

Introduction

Fish make up roughly half of all known vertebrate species (approximately 54,711). Nelson [1] defines the formalized world, approximately 33,059 legitimate fish species have been described by Eschmeyer et al. [2]. Marine fish spend nearly all of their lives in the ocean. The diversity of India's marine and freshwater fish varied according to the country's biodiversity. Fish diversity is directly related to the variety exemplified by ecosystems/habitat assemblages in inland and marine waters. India has over 8000 kilometers of coastline, a 2.02 million square-kilometer Exclusive Economic Zone (EEZ) that includes its continental shelves and coastal areas, and a diverse range of coastal habitats such as estuaries, lagoons, mangrove swamps, backwaters, marshlands, rocky coasts, sandy stretches, and reefs [3].

Only commercially important groups, such as fishes and mollusks, have a complete species inventory, whereas other associations, tiny phyla, and microbes have only a hazy one. In terms of spatial coverage, only about two-thirds of all coastal environments have been studied, leaving isolated islands and other small estuaries largely unexplored. The diversity of life in coastal areas is most likely much greater than is currently recognized [4]. The global marine fish inventory is estimated to be approximately 79% complete, with the remaining 21% yet to be identified and named.

Later, the Zoological Survey of India published the State Fauna Series, which listed the fishes found in the marine and estuarine waters of all Indian maritime states, including Lakshadweep [5], West Bengal [6], Gujarat [7], Pondicherry [8], and Andhra Pradesh [9]. India still requires a comprehensive scientific record of its marine fish diversity. Even a complete list of marine fishes in India has yet to be compiled. The authors attempted to study and appraise the marine fish variety known from Indian marine waters while developing such a checklist.

This chapter summarizes the most important aspects of the fish diversity known from Indian maritime waters based on our research. Subspecies are not considered species because they are a valid classification and a taxon with their evolutionary history. The authors looked into all relevant literature, including web-based sources when updating the species counts [2]. As a result, the current study sought to compare the physicochemical parameters of water and sediment with statistical significance in marine fish diversity and make recommendations to fisheries managers to improve sustainability.

Material and Methods

Study area

Five stations in Kalpakkam were used to collect data on the diversity of marine fish. The following stations have been selected: Sadras kuppam is north of Madras Atomic Power Station (MAPS), Meyyar kuppam and Wyalli kuppam are south of MAPS, and Mahabalipuram Beach and Kokkilamedu kuppam are north of MAPS (Figure 1). Edaiyur and Sadras' backwater systems are one-of-a-kind properties connected to the Buckingham estuary, which runs parallel to the shore. Based on the accuracy of rainfall and accompanying variations in hydrogeological properties at the Kalpakkam coast, the entire year has been separated into three seasons

a) Summer

b) Southeastern

c) Northern west [10]

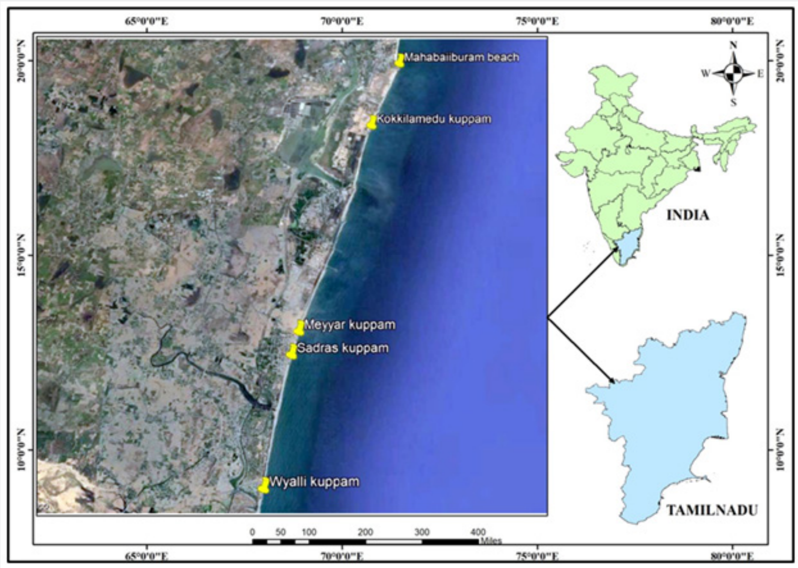

Figure 1: Shows the study area.

The two backwaters flood onto the shoreline during the NE monsoon season, dumping massive amounts of fresh water into the coastal environment for 2 to 3 months. The NE monsoon is responsible for 60% of the rainfall in this Indian region. Kalpakkam gets about 1250mm of rain each year. Coastal drift, on the other hand, causes a sandy beach to form between the swamplands and the sea during the post-monsoon period, preventing low-saline water influx from the swamplands to the sea. In comparison to the Edaiyur backwater, which receives Buckingham canal discharge and drainage from neighboring agricultural areas, the Sadras backwater is relatively filthy due to both domestic waste discharge and Buckingham canal discharge. A slew of aquaculture farms has sprouted along the Buckingham canal, significantly worsening the situation of this brackish water canal. In addition, a slew of small businesses has sprouted up throughout the belt, increasing the amount of human input into this body of water. Aside from the municipality's estimated 50,000 residents, two fishing villages on either side of the municipality have sizable populations.

Collection of water samples

The seawater samples were collected using a Niskin water sampler and stored in pre-cleared polypropylene containers in an icebox (4°C) until transmitted to the laboratory. Water temp, pH, salinity, oxygen concentration (DO), and turbidity were all measured on-site using a multi-parameter probe. Furthermore, collected samples are transported to the laboratory and stored in a freezer at 4°C until analyzed.

Collection of bottom sediment samples

The Van Veen Grab equipment was used for sediment sample collection. In each location, approximately 2.5kg sediment samples were collected and put in polyethylene bags after being preserved in a -20°C deep freezer. Further analysis of physicochemical parameters the sediment sample were put it in hot air oven-dry 105°C completely moisture are removed then samples were analysis

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Collection of fish samples

The fish are caught along the Kalpakkam coast, iced, and delivered to the SRM Institute of Science and Technology for processing. When the fish samples arrived at SRM Institute of Science and Technology, they were stored in 10% formalin, and the species identification was done at the Zoological Survey of India Laboratory (ZSI) in Chennai, F. No 4-492015tech.988.

Analysis of physico-chemical parameters in water

To prevent microbial growth, the water samples were filtered through Whatman No. 42 filter paper and acidified with 3ml/l Conc. HNO_3 and 0.5 ml/l chloroform. A multi-parameter probe was used to measure temperature, pH, salinity, dissolved oxygen (DO), and turbidity on-site. In addition, collected samples are transported to the laboratory and kept in a freezer at 4°C until they are analyzed.

The dissolved micronutrients nitrate, ammonia, silicate, phosphate, as well as TN and TP, were measured after filtering the water samples with 0.45m of Millipore filter paper using the conventional procedures described below [11]. The chlorophyll content was determined using a pigment extraction procedure with 90% acetone. The pigment concentration was determined using a UV-VIS spectrophotometer (Shimadzu-UV) with 5cm cells at 630nm, 645nm, and 665nm [12].

Analysis of Physico-chemical parameters in sediment

The sediment measurements were dried in a hot air oven for 2-3 days at 105°C until they reached a steady weight, then homogenized with a mixing console blender, mesh sieve to a uniform size, and stored in pre-cleaned polythene zip lock bag bags. A digital pH meters model (LI 120) was used to measure sediment characteristics such as pH, and a conductivity meter model (CM 183) equipment was used to test electrical conductivity (EC) (Elico).

The Walkley-Black (1947, 1934) [13,14] titration method was used to estimate total organic carbon. Alkaline-permanganate methods were used to estimate nitrogen [15] and to estimate phosphorus using the UV-Visible Spectrophotometer model (SL 244), estimate potassium in flame photometer using the calibration curve method model (CL-361 ELICO), the fine aggregation approach, estimate the sediment particle size distribution (Associated Scientific and Engineering Works, New Delhi, Delhi - 110 055, India).

Population structure

For the past two years, sampling has taken place within 30 kilometers of MAPS. From January 2019 to December 2020, fish samples were collected along the Kalpakkam coast at various sampling locations, landing centers, and the fish market. Several morphological characteristics of the specimens were examined. Standard manuals were used to identify fish species [1,16]. Estimates were made for the number of fish families, orders, IUCN status, and fish diversity.

Species indexes based on diversity

Species richness, Simpson's index (D), Simpson's diversity index (1 - D), The Shannon-Weiner index (H), and Evenness (E) are estimated based on the species index calculation.

IUCN status

Fish diversity status was estimated by the IUCN status based on the fish base website.

Statistical analyses

The data from the analytical procedures were statistically handled with the origin 2018. To determine the association between the physicochemical parameters of water, sediment, and fish diversity in the environment, a multivariate analysis approach comprising the Pearson correlation matrix, principal component analysis, and cluster analysis was used.

Result and Discussion

Physiochemical parameters of water

The physical and chemical properties of coastline water and sediment are important in terms of ecological significance, particularly in aquatic ecosystems. It reflects pollution's history. The effluent contains all organic and inorganic solids and liquid matter, and it is discharged into the river water. In the aquatic environment, water and sediments serve as both carriers and sinks for contaminants. These sediments are a source of food for living organisms [17].

The water temperature was higher (30.1 C) in summer 2019 and lower (26.20 C) in the northeast monsoon in 2019. As a result of very heavy rain, cloud cover, and a strong air storm [18]. The maximum pH was 9.38 in the southeast monsoon of 2020, and the lowest pH was 7.18 in the northeast monsoon. The water salinity was higher (48.11 PSU) in 2020 and lower (25.02 PSU) in the southeast monsoon of 2019. This range coincided with a previous report published in the same area by a few scientists [19] as well as reports from all over the world [20].

Oxygen concentration is an important factor for determining water quality because it indicates whether the environment is oxidizing or reducing. Natural systems such as photosynthesis, organic matter degradation, and re-aeration from the atmosphere all have a significant impact on oxygen distribution in aquatic systems [21]. In 2019, the lowest concentration of dissolved oxygen was found in the southeast monsoon (5.40 mg/L). In 2020, the highest concentration was found in the southeast monsoon (6.78 mg/L).

The maximum SPM water valuation was 22.48 mg/L in the northeast monsoon of 2019, and the lowest SPM water valuation was 12.5 mg/L in the summer of 2019. In the Bay of Bengal,

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there were noticeable seasonal and spatial differences in the distribution of SPM. The influence of freshwater input is greatest in the northeast and gradually decreases towards the bay's southern stations [22].

Silicate is an essential component that regulates the distribution of primary producers in the coastal ecosystem [23]. The silicate valuation was highest in summer 2019 (6.7mol/l) and lowest in the southeast monsoon of 2020 (0.53mol/l). The ammonia valuation was highest (18.13 mol/l) during the southeast monsoon in 2019 and lowest (1.5613 mol/l) during the northeast monsoon in 2020. The physical and chemical factors of water from different seasons are shown in table 1.

Table 1: Shows physiochemical parameters of water in different seasons.

Parameters	Summer		Southeast Monsoon		Northeast Monsoon	
	2019	2020	2019	2020	2019	2020
Temp (°C)	30.1±0.7	29.45±1.76	28.20±1.20	29.45±1.76	26.20±0.38	26.45±1.90
pH	8±0.28	7.38±0.134	7.19±0.21	9.38±0.13	8.19±0.04	7.18±0.14
Salinity (PSU)	33.2±0.91	46.11±3.39	25.02±2.12	48.11±3.39	26.02±3.39	27.91±2.25
DO (mg/L)	4.6±0.42	4.78±0.53	5.40±0.63	6.78±0.53	6.40±0.24	5.49±0.23
SPM (mg/l)	12.5±6.85	12.39±5.38	21.48±7.00	14.39±5.38	22.48±22.99	14.24±13.50
Turbidity (NTU)	4.1±1.41	0.78±4.32	0.99±10.39	0.45±4.05	0.91±1.73	0.95±3.06
Silicate (μmol/l)	6.7±1.76	0.98±0.66	3.39±8.83	0.53±0.66	2.39±1.60	1.15±2.82
Ammonia (μmol/l)	8.1±22.48	16.93±7.28	18.13±12.02	15.93±7.28	17.13±15.06	1.56±2.51
Phosphate (μmol/l)	0.8±0.42	0.45±0.12	0.84±0.77	0.75±0.12	0.24±0.23	0.56±0.13
Nitrate (μmol/l)	2.8±0.98	2.98±2.24	0.76±2.12	2.48±2.24	0.46±0.87	2.06±42.15
Total Nitrogen (μmol/l)	41.4±3.74	20.90±10.71	48.89±2.89	25.90±10.71	36.19±6.75	11.99±23.51
Total Phosphate (μmol/l)	2.1±2.47	0.59±0.41	0.788±0.63	0.56±0.41	0.75±0.37	0.76±0.91
Chlorophyll a (mg/m^3)	2.6±0.84	0.47±0.32	2.19±1.69	0.39±0.32	1.16±3.88	0.74±1.29

In 2019, the southeast monsoon (0.84mol/l) had a higher phosphate value than the northeast monsoon (0.24mol/l). The dynamics of this nutrient in the marine environment are controlled by a variety of factors and processes such as freshwater influx, biological uptake, localized upwelling, organic matter decomposition, and benthic-pelagic coupling [24]. The nitrate value was highest in the summer (2.98mol/l) in 2019 and lowest in the northeast monsoon (0.46mol/l) in 2019. Lower nitrate concentrations observed during the northeast monsoon season may be due to high nitrate uptake by autotrophic bloom biomass [25].

In 2019, the total nitrogen value was higher in the southeast monsoon (48.89mol/l) than in the northeast monsoon (11.99mol/l) 2020. A high concentration of TN can cause significant changes in water quality due to algal growth and dense growth of aquatic plants, affecting aquatic life in the long run [26]. Total phosphate levels were highest in the summer (2.1mol/l) in 2019 and lowest in the southeast monsoon (0.56mol/l) in 2020. According to Mohanty et al. (2014), [27] high TP values in the summer suggested that this place was near the sea.

Chlorophyll levels were higher in the summer of 2019 (2.6 mg/m^3) and decreased in the southeast monsoon of 2020 (0.39 mg/m^3). The relatively high chl-a values observed during the summer corresponded with the higher phytoplankton density observed during this season due to a mixed bloom formed by the flagellate community. The high chlorophyll-a concentration could be because there is enough UV radiation, clean water, and nutrients available [28].

Physiochemical parameters of sediment

The majority of micronutrients and macronutrients are readily available in sediment, which has a pH range of 6.9 to 7.8, with an average of 7.5 [29]. Sediment pH was higher in the southeast monsoon (9.17) in 2019 and lower in the northeast monsoon (7.19) in 2020. Table 2 displays the physical and chemical variables of sediment in various seasons.

The northeast monsoon had the highest EC value (4.44) is 2020, while the southeast monsoon had the lowest value (3.46) in 2019. Nitrogen levels were higher in the southeast monsoon (45.25mg/kg) in 2019 than in the summer (36.58mg/kg). On numerous occasions, the entire possible nitrogen in marine ecosystems has been suggested as a conservative estimate [30]. The phosphorus value was highest during the southeast monsoon (10mg/kg) in 2019 and lowest during the summer (7.96mg/kg). Phosphorus is weakly adsorbed onto the outside of tiny particles like clay, allowing it to migrate freely into the aquatic due to the fragile cohesive force [31].

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Table 2: Shows physiochemical parameters of sediment in different seasons.

Parameters	Summer		Southeast Monsoon		Northeast Monsoon	
	2019	2020	2019	2020	2019	2020
pH	7.42±0.33	8.56±0.35	9.17±0.79	8.85±0.50	8.98±0.85	7.19±0.36
EC	3.79±1.45	3.94±0.72	3.46±1.47	3.53±0.67	3.98±2.23	4.44±0.49
Nitrogen	36.58±23.06	41.09±17.41	45.25±23.25	42.50±13.63	39.12±21.99	37.99±13.44
Phosphorus	7.96±1.90	8.52±1.06	10 ±3.53	9.76±1.46	8.93±2.36	8.92±1.53
Potassium	257.16±80.61	243.91±40.95	392.5±107.48	358.25±44.72	300.75±94.04	306.08±47.43
Total organic carbon	0.23±0.54	0.49±0.06	0.98±0.37	0.73±0.28	0.25±0.39	0.75±0.11
≥4.75mm	31.33±12.71	29.08±11.39	32.25±14.81	36±16.94	23.33±17.64	24.33±16.97
≥2.36mm	52.33±20.50	53.75±2474	60.41±31.81	52.33±28.28	51.83±33.94	60.83±33.23
≥1.18mm	165.58±43.84	151±43.13	171.75±42.39	160.91±35.34	158.58±74.21	154.66±74.97
≥600μ	180.75±89.09	187.5±91.91	198.5±89.09	195.33±88.38	169.91±21.21	164.16±41.01
≥300μ	355.08±78.48	374.91±79.90	390.58±71.49	351.41±67.84	364.25±36.74	344.58±35.34
≥150μ	123.25±30.40	120.58±28.75	114.83±27.54	112.75±26.14	105.16±45.27	110.16±51.61
Pan	86.58±20.50	92.16±24.04	95.25±19.79	89.25±19.79	79.5±12.72	86.25±13.45
Cumulative % Retained	9.92±0.18	9.98±0.26	9.78±0.24	9.19±0.20	9.21±0.19	9.22±0.14

In 2019, the potassium value was higher in the southeast monsoon (392 mg/kg) than in the summer (243.91mg/kg) in 2020. The application of normalized K concentration levels in fine siliciclastic sediments may pave the way for the more widespread implementation of continental sediments in the long term. The minerals that carry K have the greatest influence on the effect of particle size on K concentrations [32]. Total organic carbon was highest in the eastern monsoon (0.98 mg/kg) in 2019 and lowest in the summer (0.23mg/kg).

The distribution of fine-grain sediments reflects the physical transport of sediments and associated trace metals in the water column, which is influenced by current velocity, salinity, and suspended particulate matter [33]. The particle size (4.75mm) was greatest in the southeast monsoon (36mm) in 2020 and lowest in the northeast monsoon (23.33mm) in 2019. The particle size (2.36mm) was greatest in the northeast monsoon (60.83mm) in 2020 and the lowest in the northeast monsoon (51.83mm) in 2019. The particle size (1.18) was greatest in the southeast monsoon (171.75mm) in 2019 and lowest in the summer (151mm) in 2020.

The particle size (600) was greatest in the southeast monsoon (198.5) in 2019 and lowest in the northeast monsoon (164.16) in 2020. The particle size (300) was highest in the southeast monsoon (390.58) in 2019 and lowest in the northeast monsoon (344.58) in 2020. The particle size (150) was highest in the warmer months (123.25) and lowest in the northeast monsoon (105.16) in 2019. Particle size (pan) was highest in the southeast monsoon (95.25) in 2019 and lowest in the northeast monsoon (79.5) in 2020. In 2020, the cumulative percent retention of particles of different sizes was higher in the summer (9.98 percent) and lower in the southeast monsoon (9.19 percent) 2020. Grain size analysis is the most basic attribute used by geologists to investigate transportation phenomena such as sediment movement and deposit. This feature is also useful to ecologists conducting habitat research and engineers conducting permeability research. This feature is used by both geochemists and hydrologists to analyze kinetic mechanisms and subsurface liquid flow [34]. The physicochemical parameters are also influenced based on fish diversity [35,36].

Fish diversity around the Kalpakkam coastal zone

First and foremost, 'biodiversity' is such a broad concept that it can and has been defined in a variety of ways, depending on the needs and interests of researchers [37]. Some 102 fish species were reported from the Kalpakkam around the coast, divided into two groups, 22 orders, and 56 families. These are caught from various landing sites, including the Wyalli kuppam, Meyyar kuppam, Kokkilamedu kuppam, Sadras kuppam, and Mahabalipuram beach.

The distribution of fish families ranged between different families. Leiognathidae, and Portunidae family was highest moved by Carangidae, Engraulidae, Lutjanidae, and Penaeidae. More than 49 % of the major contributory species are Perciformes were the highest moved by Decapoda, and Acanthuriformes (Figure 2). It has been stated that, apart from its commercial importance, fish as a group have the greatest species diversity of all vertebrate taxes, from a biodiversity point of view [38]. Analysis of current literature on coastal and aquatic biodiversity found that, relative to other fauna, only fish is well cataloged in the Indian Ocean countries [39].

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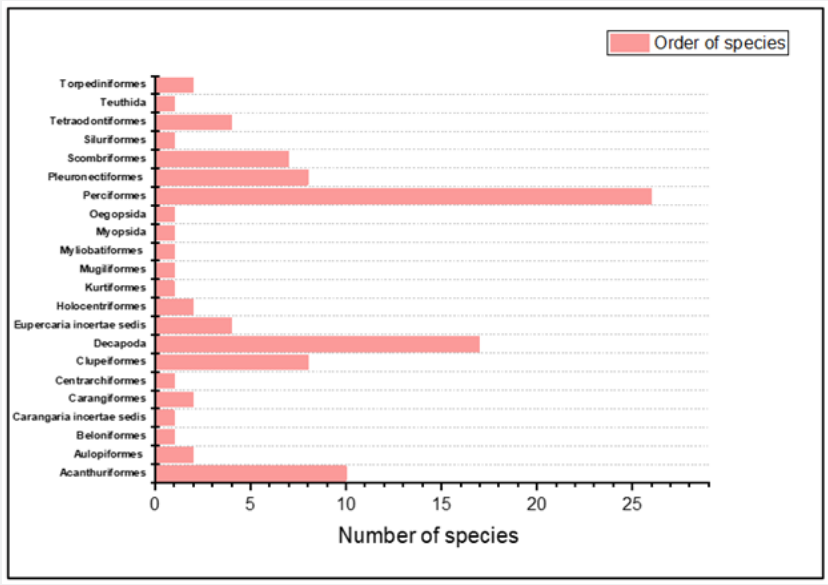

Figure 2: Shows the number of the fish order.

IUCN status fish diversity

Marine conservation area brings several advantages and benefits for fishermen, local communities, and biodiversity such as

a) empowering local people with alternate sources of income and helping them get out of poverty

b) enhancing the number of fish caught in nearby fishing grounds

c) Protect vulnerable environments from fishing gear, such as bottom trawls, that can cause disturbances and damage

d) improving fish catches by encouraging natural age patterns in fish populations

e) act as benchmarks for what constitutes a pristine, natural ecosystem that can be used to assess the effects of fishing in other places, so assisting in the improvement of fisheries management [40].

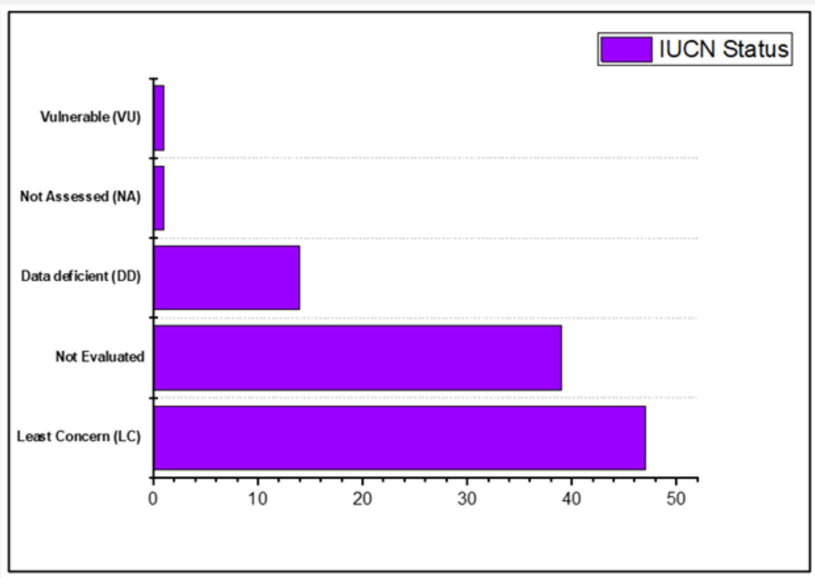

Figure 3: Shows an IUCN status of fish diversity.

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The IUCN status of fish diversity has been categorized into 5 categories for the Kalpakkam coast vulnerable (VU), least concern (LC), not evaluated (NE), data deficient (DD), and not assumed (NA) (Figure 3). The threat level of the fish biota near the Kalpakkam coast, are VU- 0.98 %, DD- 13.73 %, LC- 46.08 %, NE -38.24%, and NA -0.98 %. The FAO Code of Conduct for Responsible Fisheries, along with its Technical Guidelines, lays the groundwork for governments to develop appropriate management practices for future sustainable fisheries [41]. In fisheries, sustainability refers to the ability to produce the benefits to society that natural systems bring over time [42].

Fish diversity index

The diversity of animals in a specific environment is referred to as biodiversity. Fish diversity calculations species richness (S), Simpson index (D), index of similarity (1 - D), reciprocal index (1/D), Shannon-wiener index (H), and evenness (E) were performed in five villages from 2019 to 2020 based on the diversity distribution. Table 3 shows the distribution of fish diversity index in a different village. The Species Richness (S) was higher (100) in the Meyyer kuppam and lower (71) on the Mahabalipuram beach. The Simpson diversity index represents the probability that two individuals have taken at random from the community of interest (with replacement) represent the same species, and thus takes values in the unit interval [43]. The Simpson's Index (D) was higher (0.04) in the Meyyer kuppam and lower (0.022) in the Wyallikuppam. The Index of Similarity (1 - D) was higher (0.978) in the Wyallikuppam and lower (0.96) in the Meyyer kuppam. The Reciprocal Index (1/D) was higher (45.455) in the Wyallikuppam and lower (25) in the Meyyer kuppam.

Table 3: Shows in the distribution of fish diversity index in a different village.

Fish Species Diversity	Mahabalipuram Beach	Kokkilamedu Kuppam	Meyyer Kuppam	Sadras Kuppam	Wyalli Kuppam
Species Richness (S)	71	74	100	99	81
Simpson's Index (D)	0.034	0.024	0.04	0.023	0.022
Index Of Similarity (1 - D)	0.966	0.976	0.96	0.977	0.978
Reciprocal Index (1/D)	29.412	41.667	25	43.478	45.455
Shannon-Wiener Index (H)	3.742	3.94	3.923	4.109	4.018
Evenness (E)	0.878	0.915	0.85	0.894	0.91

The Shannon-Wiener index (H) was higher (4.109) in the Sadras kuppam and lower (3.742) on the Mahabalipuram beach. The high and low diversity values, uniformity, and dominance in waters show an influence on physical-chemical factors and the availability of fish feed. It is revealed that other things that affect the Diversity index (H'), be affected in the data collection process [44]. The Evenness (E) was higher (0.915) in Kokkilamedu kuppam and lower (0.85) in the Meyyer kuppam. Evenness is a key factor in preserving the functional stability of ecosystems [45]. Haque [46] and Kumar [47] also discussed about fish species composition and diversity around the Bay of Bengal.

Statistically Analysis

Pearson correlation analysis

The high correlation coefficient between water physicochemical parameters and fish diversity demonstrates their common nature, mutual dependence, and identical behavior during transport. Correlation analysis was performed as a bivariate statistic to evaluate the relations and strength of the association between pairs of variables using the linear Pearson correlation. Table 4 shows Pearson correlation matrices for physicochemical parameters and fish diversity in water samples from the Kalpakkam coastal zone. These matrices are used to show how the variables are linked.

A Pearson correlation analysis is estimated using a two-tailed test of significance. The established silicate concentration (mol/l) had a strong correlation with the total phosphate concentration (mol/l) and chlorophyll-a concentration (mg/m^3). Phosphate (mol/l) has a positive correlation with the number of fish. Table 5 shows the Pearson correlation matrices for physicochemical parameters and fish diversity in sediment samples from the Kalpakkam coastal zone to establish relationships between the variables. A Pearson correlation analysis is estimated using a two-tailed test of significance. Potassium and total organic carbon have a strong relationship with phosphorus. All of the parameters of the coastal sediment around Kalpakkam were negatively correlated with the number of fishes.

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Table 4: Shows the persons correlation between fish diversity and physicochemical parameters of water.

	Temp	pH	Salinity	DO	SPM	Turbidity	$[SiO_4]4-$	NH_3	PO_4^{3-}	NO_3-	TN	TP	Chlorophyll a	No of fishes
Temp	1													
pH	0.46	1												
Salinity	0.75	0.52	1											
DO	-0.2	0.68	0.08	1										
SPM	-0.6	-0.08	-0.66	0.45	1									
Turbidity	0.27	-0.01	-0.25	-0.52	-0.26	1								
$[SiO_4]4-$	0.19	-0.14	-0.41	-0.54	0	0.93	1							
NH_3	0.18	0.27	0.21	0.32	0.51	-0.41	-0.16	1						
PO_4^{3-}	0.04	-0.68	-0.49	-0.77	-0.03	0.58	0.69	-0.3	1					
NO^{3-}	0.7	0.14	0.75	-0.44	-0.98	0.24	0	-0.37	0	1				
TN	0.14	0.021	-0.4	-0.09	0.55	0.44	0.69	0.49	0.46	-0.48	1			
TP	0.3	-0.03	-0.21	-0.56	-0.29	0.99	0.93	-0.39	0.58	0.27	0.42	1		
Chlorophyll a	0.08	-0.26	-0.57	-0.47	0.23	0.79	0.94	-0.06	0.8	-0.23	0.81	0.78	1	
No. of fishes	-0.38	-0.97	-0.43	-0.61	0.07	-0.13	0	-0.21	0.65	-0.13	-0.05	-0.11	0.17	1

Table 5: Shows persons correlation between fish diversity and physicochemical parameters of sediment.

	PH	EC	Nitrogen	Phosphorus	Potassium	TOC	≥4.75	≥2.36	≥1.18	≥600	≥300	≥150	Pan	Cumulative % Retained o	No of Fishes
PH	1														
EC	-0.67	1													
Nitrogen	0.79	-0.68	1												
Phosphorus	0.65	-0.49	0.85	1											
Potassium	0.51	-0.52	0.74	0.94	1										
TOC	0.24	-0.25	0.74	0.81	0.78	1									
≥4.75	0.33	-0.85	0.52	0.38	0.4	0.33	1								
≥2.36	-0.19	0.24	0.29	0.4	0.45	0.76	-0.21	1							
≥1.18	0.26	-0.7	0.38	0.4	0.62	0.29	0.5	0.19	1						
≥600	0.61	-0.91	0.8	0.52	0.48	0.46	0.88	-0.05	0.5	1					
≥300	0.68	-0.53	0.7	0.35	0.29	0.29	0.17	0.2	0.4	0.59	1				
≥150	-0.29	-0.28	-0.08	-0.47	-0.42	-0.13	0.47	-0.14	0.13	0.42	0.17	1			
Pan	0.23	-0.5	0.7	0.4	0.34	0.69	0.6	0.44	0.3	0.78	0.57	0.55	1		
Cumulative % Retained	-0.04	-0.29	0.07	-0.4	-0.38	-0.12	0.25	-0.02	0.19	0.41	0.56	0.87	0.57	1	
No. of fishes	-0.17	0.31	0.17	0.01	0	0.42	-0.38	0.8	-0.01	-0.08	0.48	0.16	0.47	0.43	1

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Principle component analysis (PCA)

The first principle component accounts for as much variability in the data as possible, while the second is orthogonal to the first. The PCA calculates communalities, eigenvalues, or eigenvectors, and explains total variance. Principle components (PC) would then be created for any given data structure. These components would show linear relationships between two variables that were taken into account for the highest variance in the data set by trying to describe vectors that fit n observations in p-dimensional space, subject to being orthogonal to each other. Two-tailed test of significance is used to estimate Pearson correlation analysis

According to the findings, the physicochemical parameters of water and fish diversity distribution could be grouped into a six-component model that accounted for 100% of the data variation. These findings were consistent with the findings of the Eigenvalue correlation test. With an eigenvalue of 5.22, the first component (PC1) explained 87.16 percent of the total variance. This component could be labeled "summer 2019 seasons." The second component (PC2) explained 8.35 percent of the variance using an eigenvalue of 0.50, the third component (PC3) clarified 2.71 percent of the variance using an eigenvalue of 0.16, the fourth component (PC4) explained 1.33 percent of the total variance using an eigenvalue of 0.07, the fifth component (PC5) explained 0.43 percent of the total variance using an eigenvalue of 0.02, and the sixth component (PC6) explained 0.02 This component could be labeled "South-West Monsoon 2019, 2020, and North-East Monsoon seasons 2019, 2020." As shown in figure 4, the first and second principal components typically accounted for a large proportion of the total variance; thus, the first six principal components were plotted against each other, and sample clustering was conceivable in the effects of all factors within the three-dimensional planes. According to the findings, the number of fish was related to the South-West and North-East monsoon seasons.

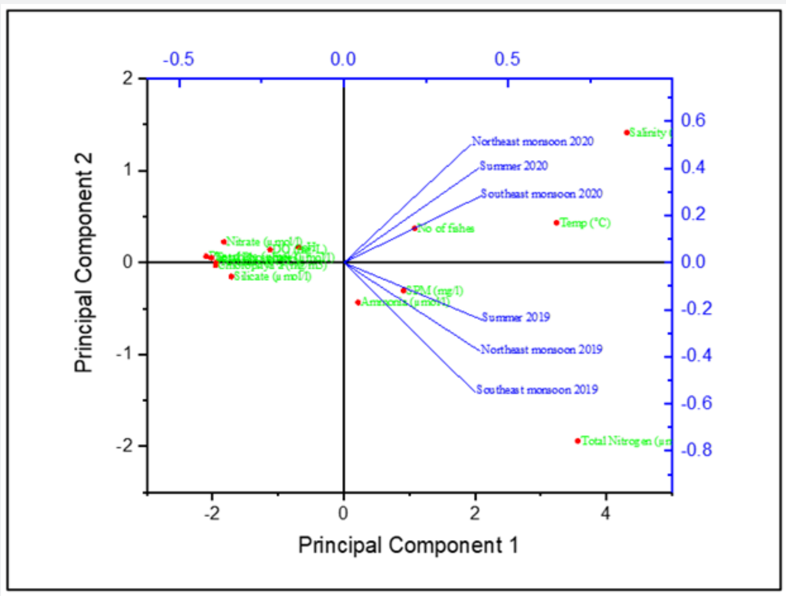

Figure 4: Shows the principle component analysis (PCA) of water parameters.

The component matrices of physicochemical parameters, and fish diversity distribution in sediment samples. The interrelationship between fish diversity and the physicochemical characteristics of sediment provided data on sources of contamination and pathways. The primary components with eigenvalues greater than one were retrieved. According to these findings, there were two eigenvalues greater than one. This result corresponded to the end of the Pearson correlation.

With an eigenvalue of 5.94, the first component (PC1) explained 99.02 percent of the total variance. This portion could be labeled "summer seasons 2019." The second component (PC2), with an eigenvalue of 0.05, explained 0.88 percent of the total variance and could be identified as "summer seasons 2020." Because of its high level of presence in sediment, (PC3, PC4, PC5, and PC6) explained 0.05 percent, 0.03 percent, 0.01 percent, and 0.00 percent of the total variance with eigenvalues of 0.00, 0.00, 8.55E-04, and 8.80E-05. "South-West Monsoon 2019, 2020 and North-East Monsoon seasons 2019, 2020." Because the first and second principal components typically accounted for a large proportion of total variance, the first five principal components were plotted against each other, and sample clustering was possible in the impacts of all variables within the 3-dimensional planes, as shown in figure 5. According to the component plot in rotated space for physical-chemical parameters and fish diversification distributed in sediment samples, potassium is now mostly associated with all seasons.

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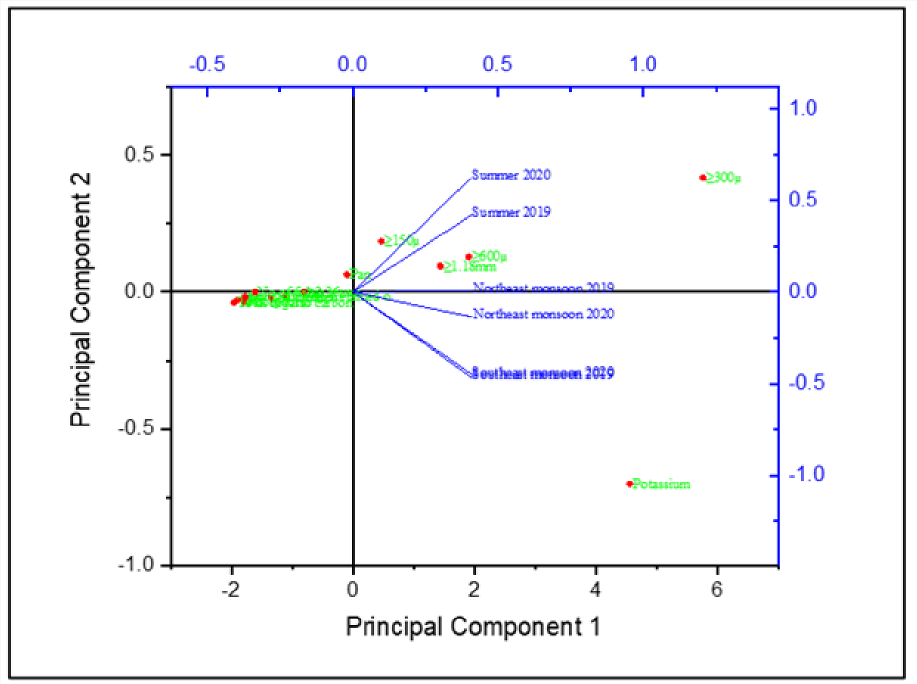

Figure 5: Shows the principle component analysis (PCA) of sediment parameters.

Cluster Analysis

The primary statistical method for identifying relatively homogeneous clusters of cases based on measured characteristics is hierarchical cluster analysis. It starts with each case as a separate cluster and then sequentially combines the clusters, reducing the number of clusters at each stage until only one remains. When forming clusters, the clustering method makes use of the dissimilarities or distances between objects. Each year, the physicochemical parameters of the water and the distribution of fish diversity were grouped. The abundance data were clustered using the complete linkage method (log 1 transformed) based on Bray-Curtis similarities. Figure 6 depicts the results of cluster analysis for matrices of physicochemical parameters of water and fish diversity distribution in water samples. Based on cluster results, it was possible to identify significant groups with the greatest similarity. Cluster analysis yielded 13 distinct clusters as a result of correlation coefficients and distances between the parameters under consideration.

Cluster group 1 is found at a distance of more than 60 m and is linked to all variables (Cluster Dendrogram analysis of physicochemical parameters and fish diversity delivery through water), but it isn't the only one. 1. Temperature, 2. pH3, and 3. Salinity, 4. DO, 5. SPM, 6. Turbidity 7. $[SiO_4]$4. NH_3, 9. $PO_4$3, 10.NO_3^- , 11. TN(S), 12. TP, 13. Chlorophyll a, and 14. Fish number. This relationship is most likely influenced by the diurnal fluctuation pattern of these parameters, with the intensity suggesting pollution from both natural and anthropogenic activities. Cluster group 2 appears at a distance of fewer than 40m and is associated with the parameters (temperature and total nitrogen (mol/l). This association is most likely because the temperature has a direct influence on the distribution of fish diversity in the Kalpakkam coastal zone. Cluster group 3 appears at a distance of fewer than 20m and is related to the parameters of Ph and NH_3. This association is most likely caused by ammonia, which has a direct impact on the distribution of fish diversity in the Kalpakkam coastal zone.

Cluster group 4 appears at a distance level greater than 10m, and the parameters are associated with 7 major groups. This association is most likely due to wastewater discharges, which are another potential source of nitrites in the water. Meanwhile, a high level of ammonium is a good indicator of the distribution of sewage discharges and livestock liquid wastes around the Kalpakkam coastal zone. This is most likely because of how far away the parameters are from the fish that are being studied, and it is possible to figure out which ones are bad for the pollution level in the Kalpakkam coastal zone.

Figure 7 depicts the results of cluster analysis for matrices of physicochemical parameters of sediment and fish diversity distribution in sediment samples. It was possible to form significant groups based on cluster results that showed the

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greatest similarity depending on the distance. Cluster analysis yielded ten distinct clusters based on the correlation coefficient and distances between the parameters under consideration. Cluster group 1 appears at a distance of more than 700 m and is connected with the variables (1. pH and particle size 300). This association is most likely influenced by the discharges of increased aquaculture activity near the drainage channels. Cluster group 2 appears at a distance level greater than 300 m and is related to the variables of pH and particle size. This association is most likely because particle size has a direct influence on the distribution of fish diversity around the Kalpakkam coastal zone, with cluster group 3 involving the majority of the parameters.

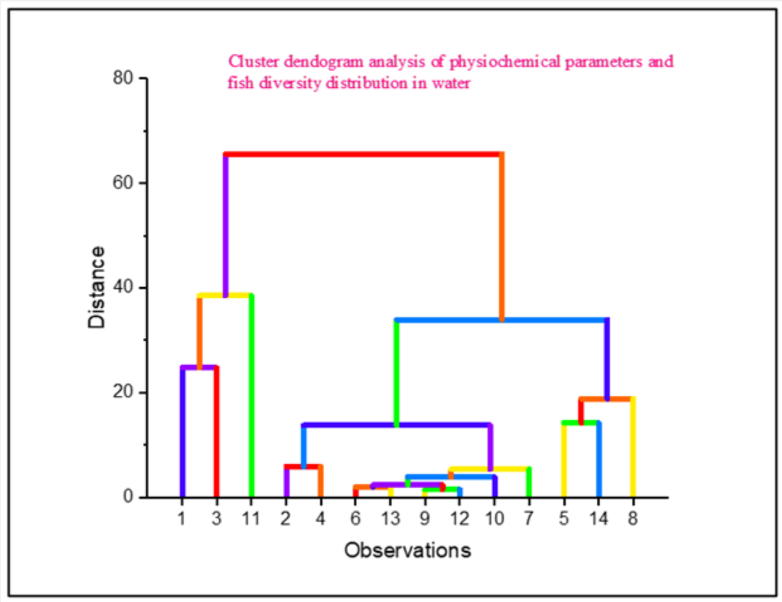

Figure 6: Shows the hierarchical cluster analysis (a) physiochemical parameter of water (1. PH, 2. EC, 3. Nitrogen, 4. Phosphorus, 5. Potassium, 6. TOC, 7. ≥ 4.75, 8. ≥ 2.36, 9. ≥ 1.18, 10. ≥ 600, 11. ≥ 300, 12. ≥ 150, 13. Pan, 14. Cumulative % Retained and15. No of fishes) with fish diversity.

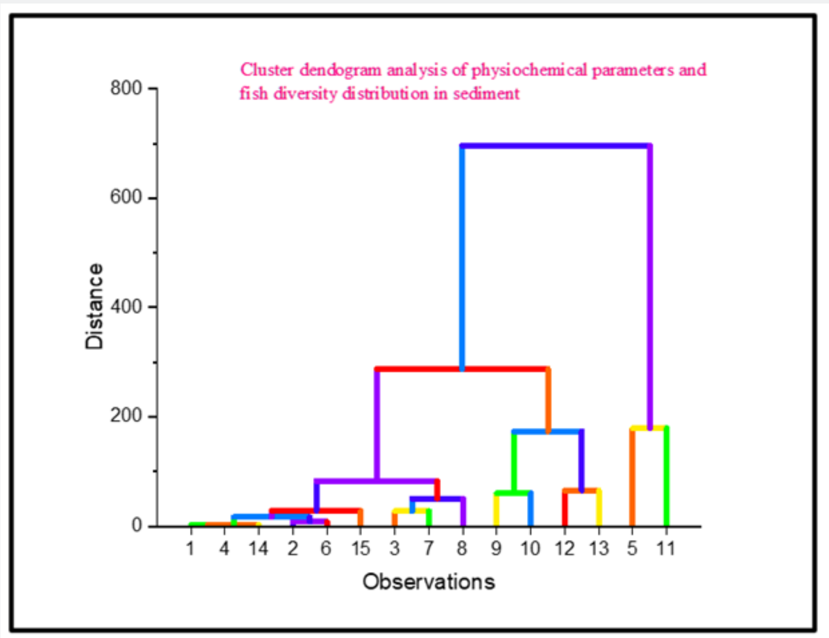

Figure 7: Physiochemical parameter of sediment (1. PH, 2. EC, 3. Nitrogen, 4. Phosphorus, 5. Potassium, 6. TOC, 7. ≥4.75, 8. ≥2.36, 9. ≥1.18, 10. ≥600, 11. ≥300, 12. ≥150, 13. Pan, 14. Cumulative % Retained and15. No of fishes) with fish diversity.

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Conclusion

The current study summarizes seasonal variations in physicochemical characteristics and fish diversity along the Kalpakkam coast. The Kalpakkam waters are highly susceptible to riverine freshwater influence because the Edaiyur and Sadras backwater estuaries discharge into the Bay of Bengal. During the monsoon season, substances such as nitrate and silicate are primarily added to coastal waters. The beginning of an elevated organic load usually contains phosphate, silicate, and nitrate during the southeast monsoon season has a significant impact on fish distribution in subsequent seasons, allowing fish to connect nutrients and proliferate. The individual correlation demonstrates that nutrients vary massively between periods and have a major impact on fisheries resources and population dynamics. The current study's Principle component analysis (PCA) and cluster analysis show that fish diversity is highly dynamic, depending on nutrient availability. Temperature, salinity, ammonia, TN, and particle size all play an important role in the distribution of marine biodiversity and population structure, as shown by the CA biplot. Overall, this research provides a detailed understanding of the strong relationship between fishery resources and environmental parameters throughout the seasons.

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References

1. Nelson JS (2006) Fishes of the World. In: (4th edn.), John Wiley and Sons, Inc, p. 3.
2. Eschmeyer WN (2014) Catalog of Fishes: Genera, Species.
3. Venkataraman K, Wafar M (2005) Coastal and marine biodiversity of India. Indian J Mar Sci 34(1): 57-75.
4. Mora C, Tittensor DP, Myers RA (2008) The completeness of taxonomic inventories for describing the global diversity and distribution of marine fishes. Proc Royal Soc (B) 275(1631): 149-155.
5. Rao GC (1991) Lakshadweep: General features, Fauna of Lakshadweep, State Fauna Series. Zool Surv India 2: 5-40.
6. Talwar PK, Mukherjee P, Saha D, Paul SN, Kar S (1992) Marine and estuarine fishes, Fauna of West Bengal, State Fauna Series. Zoological Survey of India, Kolkata, India 3(2): 243-342.
7. Barman RP, Mukherjee P, Kar S (2000) Marine and Estuarine Fishes, Fauna of Gujarat, State Fauna Series. Zoological Survey of India, Kolkata, India 8 (1): 311-411.
8. Mishra SS, Krishnan S (2003) Fish fauna of Pondicherry and Karaikal, Rec. Zool Surv India Occ Paper 216: 53.
9. Barman RP, Kar S, Mukherjee P (2004) Marine and Estuarine Fishes, Fauna of Andhra Pradesh, State Fauna Series. Zoological Survey of India, Kolkata 5(2): 97-311.
10. Nair KVK, Ganapathy S (1983) Baseline ecology of Edaiyur-Sadras estuarine system at Kalpakkam. I: General hydrographic and chemical features, Mahasagar 16(2): 143-151.
11. Parson TR, Maita Y, Lalli CM (1984) A Manual of Chemical and Biological Methods for Seawater Analysis.
12. Strickland JDH, Parsons TR (1972) A Practical Handbook of Seawater Analysis. In: (2nd edn.), Fish Res Board Canada, Ottawa, pp. 310.
13. Walkley A, Black IA (1934) An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci 37(1): 29-38.
14. Walkley A (1947) A critical examination of a rapid method for determination of organic carbon in soils - effect of variations in digestion conditions and inorganic soil constituents. Soil Sci 63(4): 251-264.
15. Sahrawat KL, Burford JR (1982) Modification of the alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. Soil Sci 133(1): 53-57.
16. Nelson JS (1994) Fishes of the world. In: (3rd edn.). John Wiley and Sons, Inc, New York, USA, pp. 600.
17. Ayoko GA, Singh KS, Balerea S, Kokot S (2007) Exploratory multivariate modeling and prediction of the physicochemical properties of surface water and groundwater. J Hydrol 336(1-2): 115-124.
18. Akhil VP, Durand F, Lengaigne M, Vialard J, Keerthi MG, et al. (2014) A modeling study of the processes of surface salinity seasonal cycle in the Bay of Bengal. Journal of Geophysical Research: Oceans 119(6): 3926-3947.
19. Hagens M, Middelburg JJ (2016) Attributing seasonal pH variability in surface ocean waters to governing factors. Geophysical Research Letters 43(24): 12528-12537.
20. Kumar SB, Mohanty AK, Padhi RK, Selvanayagam M, Satpathy KK (2018) Coastal water characteristics along Tamil Nadu, east coast of India during the pre-northeast monsoon period. Indian Journal of GeoMarine Sciences 47(2): 308-318.
21. Granier C, Pétron G, Müller JF, Brasseur G (2000) The impact of natural and anthropogenic hydrocarbons on the tropospheric budget of carbon monoxide. Atmospheric Environment 34(29-30): 5255-5270.
22. Gopalakrishna VV, Murty VSN, Sengupta D, Shenoy S, Araligidad N (2002) Upper ocean stratification and circulation in the northern Bay of Bengal during the southwest monsoon of 1991. Cont Shelf Res 22(5): 791-802.
23. Sospedra J, Felipe L, Niencheski H, Falco S, Andrade CFF, et al. (2018) Identifying the main sources of silicate in coastal waters of the Southern Gulf of Valencia (Western Mediterranean Sea). Oceanologia 60(1): 52-64.
24. Satpathy KK, Mohanty AK, Sahu G, Sarguru S, Sarkar SK, et al. (2011) Spatio-temporal variation in physicochemical properties of coastal waters of Kalpakkam, southeast coast of India, during summer, pre-monsoon, and post-monsoon period. Environmental Monitoring and Assessment 180(1-4): 41-62.
25. Shivanna AM, Nagendrappa G (2014) Chemical analysis of soil samples to evaluate the soil fertility status of selected command areas of three tanks in Tiptur Taluk of Karnataka, India. IOSR J Appl Chem 7(11): 1-5.
26. Saito M, Onodera Si, Jin G, Shimizu Y, Taniguchi M (2018) Nitrogen dynamics in a highly urbanized coastal area of western Japan: impact of sewage-derived loads. Progress in Earth and Planetary Science 5(17).
27. Mohanty AK, Sahu G, Bramha SN, Samantara MK, Satpathy KK (2014) Assessment of temporal variation in coastal water characteristics through multivariate statistics- A case study at southwestern Bay of Bengal, India. Indian Journal of Geo-Marine Science 3(9): 1718-1731.

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28. Sardessai S, Ramaiah N, Prasanna KS, De Sousa SN (2007) Influence of environmental forcing on the seasonality of dissolved oxygen and nutrients in the Bay of Bengal. Journal of Marine Research 65(2): 301-316.

29. Donahue RL, Miller RW, Schickluna JC (1983) An introduction to soils and plant growth. In: Miller J (5th edn.), Prentice-Hall Inc, USA, pp. 667.

30. Richardson AM (1997) Development of an estuarine water quality index (eWQI) for New South Wales. University of Sydney, Sydney, Australia.

31. Babu KN, Ouseph PP, Padmalal D (1999) Interstitial water-sediment geochemistry of N, P and Fe and its response to overlying waters of tropical estuaries: a case from the southwest coast of India. Environmental Geology 39: 633-640.

32. Grygar TM, Mach K, Martinez M (2019) Checklist for the use of potassium concentrations in siliciclastic sediments as paleo environmental archives. Sedimentary Geology 382: 75-84.

33. Csiki SJC, Rhoads BL (2014) Influence of four run-of-river dams on channel morphology and sediment characteristics in Illinois, USA. Geomorphology 206: 215-229.

34. McCave IN, Syvitski JPM (1991) Principles and methods of particle size analysis. In: Syvitski JPM (Edt.), Principles, methods, and applications of particle size analysis. Cambridge University Press, New York, USA pp: 3-21.

35. Kumar P, Mohamed KSB, Balasubramani R, Murugesan C, Rajakrishnan RA, et al. (2022) Potential health risk caused by heavy metal associated with seafood consumption around the coastal area. Environmental Pollution 294: 118553.

36. Kumar P, Sivaperumal P, Manigandan V, Rajaram R, Hussain M (2020) Assessment of potential human health risks due to heavy metal contamination in edible finfish and shellfish collected around Ennore coast, India. Environmental Science and Pollution Research.

37. De Long D (1996) Defining biodiversity. Wildl Soc Bull 24: 738-749.

38. Sarkar UK, Jena JK, Singh SP, Singh AK, Rebello SC (2012) Documenting Coastal Fish Biodiversity of India: Status, Issues, and Challenges. (International Day for Biological Diversity Marine Biodiversity) Uttar Pradesh State Biodiversity Board, India, p. 22-28.

39. Wafar M, Venkataraman K, Ingole B, Khan SA, Lokabharti P (2011) State of knowledge of coastal and marine biodiversity of Indian Ocean countries. PLoS One 6(1): 1-12.

40. World Wild Fund (WWF) (2008) Marine Protected Areas Providing a Future for Fish and People. Gland, Switzerland.

41. FAO (2011) Fisheries management, Marine protected areas and fisheries, FAO technical guidelines for responsible fisheries, 4 Suppl. 4. Rome, Italy.

42. FAO (2016b) Marine spatial planning for enhanced fisheries and aquaculture sustainability, its application in the Near East. FAO Fisheries and Aquaculture Technical Paper No. 604. Rome, Italy.

43. Keylock CJ (2005) Simpson diversity and the Shannon-Wiener index as special cases of a generalized entropy. Oikos 109: 203-207.

44. Marshall PA, Baird AH (2000) Bleaching of corals on the Great Barrier Reef: differential susceptibilities among taxa. Coral Reef 19: 155-163.

45. Wilsey B, Potvin C (2000) Biodiversity and ecosystem functioning: Importance of species evenness in an old field. Ecology 81(4): 887-892.

46. Haque AB, Cavanagh RD, Seddon N (2021) Evaluating artisanal fishing of globally threatened sharks and rays in the Bay of Bengal, Bangladesh. PLoS ONE 16(9): e0256146.

47. Pandion K, Arunachalam KD, Ayyamperumal R, Chang SW, Chung WJ, et al. (2022) Environmental and anthropogenic impact on conservation and sustainability of marine fish diversity. Environ Sci Pollut Res.

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