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Comparative Assessment of the Hydro-Geochemical Characteristics of Mangrove and Non-Mangrove Regions with Special Reference to the Molluscan Fauna along the Ashtamudi and Vembanad Ramsar Sites – The Wetlands of International Significance, Southern Kerala, India

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Abstract

Mangrove ecosystems, the ecotones with high resilience power, are the most valuable and vulnerable natural resource that supports rich biological diversity. Various natural and anthropogenic interventions adversely affect the physico-chemical and biological characteristics of these valuable ecosystems. The present paper is focused to assess the hydro-geochemical characteristics and variation in molluscan fauna in mangrove and non-mangrove regions that supports fishery resources in Ashtamudi and Vembanad Ramsar sites- the wetlands of international significance in Southern Kerala, India. These wetlands are fringed with patchy mangrove ecosystems and are well-known for its fishery and clam resources, which form the livelihood of thousands of people residing near the banks and in turn supports the economy of the state. Samples were collected during pre monsoon from the six selected stations of Ashtamudi and Vembanad wetlands during February 2020. Hydrological parameters such as temperature, pH, salinity, carbon dioxide, dissolved oxygen and biological oxygen demand of surface waters, while geochemical parameters such as temperature and pH, and also Molluscan fauna were analyzed using standard methods. Primer Vs 6 and SPSS Vs 24.0 were used to analyse biological indices, PCA analysis, mean ± standard deviation and Pearson's product - moment correlation. In the present investigation, spatio-temporal variation in molluscan faunal composition included both gastropods and bivalves which represented ten species - *Cerithidea cingulate, Littoraria angulifera, Neritina violacea, Alcyna ocellata, Tibia insulaechorab*, *Marcia recens, Mytella strigata, Perna viridis, Villorita cyprinoides* and *Pinctada sp.* Species composition revealed higher species diversity and species richness in mangrove regions of both wetlands. *Mytella strigata* recorded high dominance at station I in Ashtamudi Ramsar Site whereas *Villorita cyprinoide*, a potential bio monitor, was the dominant species in Vembanad wetland. Station V at Vembanad Ramsar site revealed low pH, low dissolved oxygen and high salinity values, which indicates early warning sign of ecological degradation and the need for conserving these resources.

Keywords: Mangroves, Wetlands, Molluscs, Hydro-geochemistry, Invasive species

1. Introduction

Mangroves are one of the most biologically diverse ecosystems found in the tropical and subtropical regions of the world. Mangrove ecosystems are rich in organic matter, nutrients and support very large biomass of flora and fauna (Pawar, 2012). Estuarine mangroves are intertidal vegetation comprising of salt tolerant, fragile, complex and dynamic ecosystems which is a characteristic feature of near seashore region and protects the shoreline from the effect of harsh environmental conditions such as cyclones and tsunamis. They are highly productive ecosystems which forms the breeding and spawning ground for many commercially important fishes. The importance of mangroves is innumerable and the habitats formed in those areas are extremely isolated with a unique texture (Krishnan *et al.*, 2015).

Phylum Mollusca comprised of an ecologically diverse group of invertebrates that plays an important role in ecosystem function for forage of predators in their habitats. It has been shown that mollusc assemblages massively contribute to feeding resources of waders within the mangrove ecosystem (Al-Sayed *et al.*, 2008). Studies also have demonstrated the central ecological role of mangrove molluscs (Fratini *et al.*, 2008). Mangrove ecosystems are unique ecosystems which provide a large number of biological, ecological, economic, scientific, environmental, aesthetic, ethical values and so many other direct and indirect benefits (Gustavson *et al.* 2009). Molluscs economically support the fishery sector (Walters *et al.*, 2008). The use of molluscan populations as a source of food, ornamental purposes and commercial uses have made them endangered species (Shanmugam and Vairamani, 2005).

Ashtamudi and Vembanad Ramsar Sites- the wetlands of international significance, situated on the southwest coast of India, are enormously affected by various anthropogenic interventions. The resources from these wetlands form livelihood for thousands of people residing near the shore line, which are fringed with patchy mangrove ecosystems. Krishnan *et al.* (2015) studied the most abundant mangrove plants in the Ashtamudi wetland with reference to their niche specialties. Boominathan *et al.* (2012) studied mangrove associated fauna from Western Ghats. The present study was an attempt to evaluate the physico-chemical quality of water, sediment and molluscan diversity of selected mangrove and non-mangrove regions of the ramsar sites to elucidate its quality variations and to link the same with existing environmental scenario.

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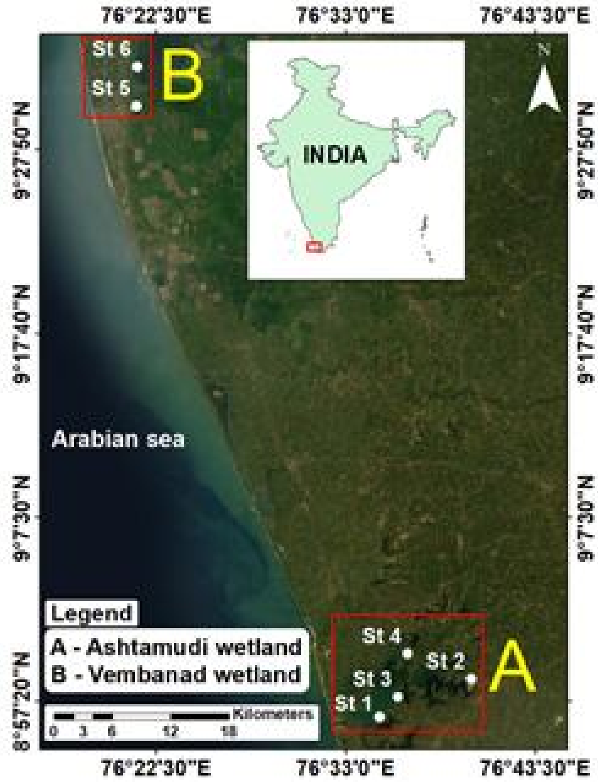
2. Materials and Methods

2.1. Study Area

The present study was carried out from the selected stations of Ashtamudi (8^0 532 -9^0 22 2 N and 76^0 312 -76^0 412 2 E) and Vembanad Ramsar Sites (9^0 302 -10^0 202 2 N and 76^0 132 -76^0 502 2 E.), the wetlands of international significance, Kerala, India, during the year 2020. Sample collection for water, sediment and molluscan fauna were taken from six stations (station I, II, III, IV, V and VI) viz; Prakulam (Station I), Kanjiracode (Station II), Ashtamudi Veerabhadra Temple (Station III), Munroe Island ((Station IV)), Punnamada (Station V), and Aryad Boat jetty region (Station VI) during pre monsoon, representing mangrove and non- mangrove areas (Fig. 1).

2.2. Sampling Methods

Sediment samples were collected in triplicate with a stainless-steel corer (8 cm diameter and 50 cm long). Samples were sieved through a 0.5 mm mesh and the fauna preserved in 70 % alcohol and identified using standard keys (Rao, 2017; Franklin and Laladhas, 2014 and WORMS database). The surface water was collected using a clean plastic bucket while the sediment samples were collected from the corer. Temperature of the both



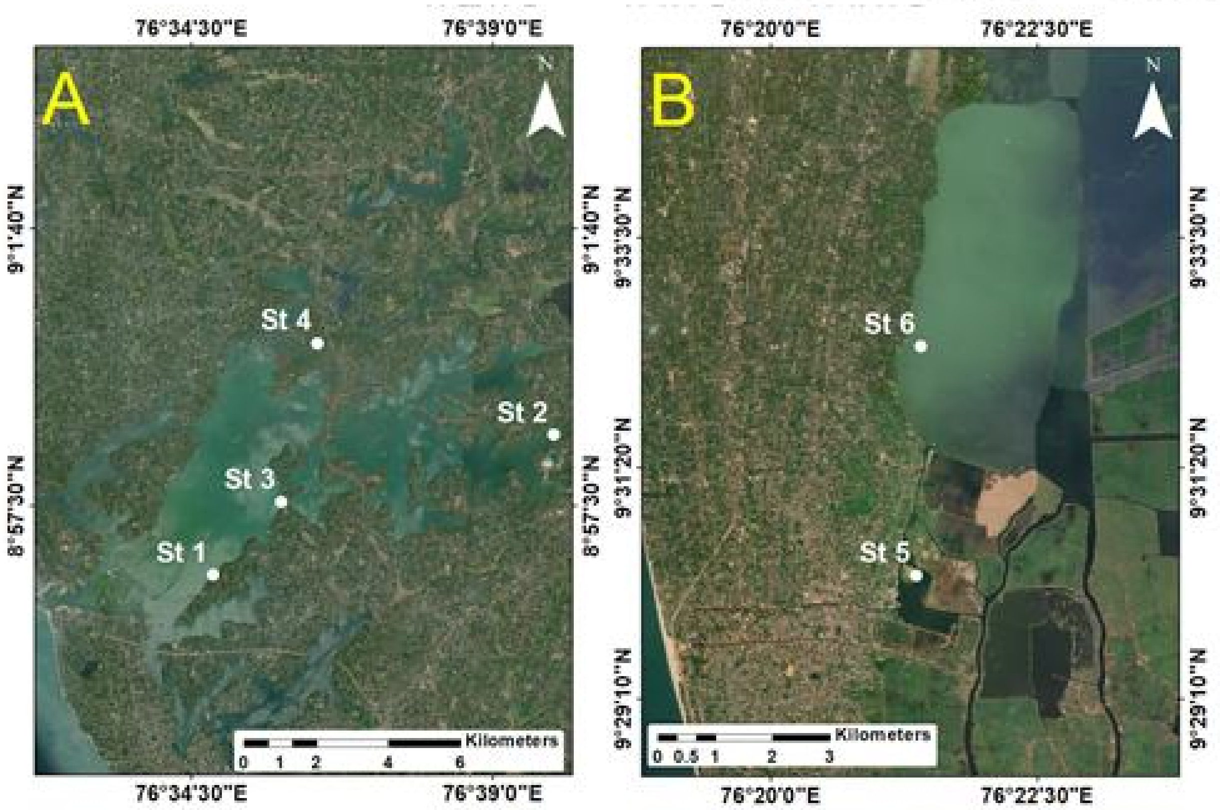


Fig. 1. Study area and Sampling sites (A - Ashtamudi wetland and B - Vembanad wetland)

water and sediment were analyzed using a thermometer with accuracy of 0.5^{0}C. pH was determined by a digital pH pen, dissolved oxygen by Winkler's method (Winkler, 1883), salinity by Mohr-Knudsen method (Grasshoff *et al.*, 1983), carbon dioxide by titrimetric method (APHA, 1992) and biological oxygen demand was determined by 5-day incubation by Winkler's method (APHA, 1992).

2.3. Statistical analysis

Primer Vs 6 was used to analyze biological indices such as Margalef's index (d), Shannon Weiner index (H'), Evenness (J') and Simpson's dominance index (λ) and also principal component analysis (PCA analysis). SPSS Vs 24.0 was used to analyse Pearson's product – moment correlation and also mean ± standard deviation.

3. Results and Discussion

3.1. Molluscan faunal composition and abundance

In the present investigation, molluscan faunal composition (Fig. 2) included both gastropods and bivalves which represent ten species - *Cerithidea cingulate, Littoraria angulifera, Neritina violacea, Alcyna* sp., *Tibia insulaechorab*, *Marcia recens, Mytella strigata, Perna viridis, Villorita cyprinoides* and *Pinctada* sp. Among the faunal population, Station I revealed the dominance of an invasive mussel *Mytella strigata* (51.9%), Station II revealed the dominance of micro molluscs, *Alcyna* sp. (61.6%), Station III, V and VI revealed the dominance of potential bio monitor, *Villorita cyprinoides* (78.4%), Station IV revealed the dominance of gastropod, *Cerithidia cingualta* (59.4%).

3.2. Diversity indices

The diversity indices for molluscan fauna are given in table 1. Shannon diversity (H') and species richness (d) showed maximum values in mangrove region at station I (H'=1.245 and d=1.284 respectively). Despite this, the station was dominated by an invasive mussel, *Mytella strigata*, which will outcompete many other bio-fouling native species in future, causing changes in the community structure and trophic relationships of the wetland. *M. strigata* will eventually cause considerable negative impact to the clam fishery and to the lake ecosystem (Biju Kumar *et al.*, 2019). In Ashtamudi wetland the newly invaded *M. strigata* has replaced the populations of Asian green mussel *Perna viridis* (Vallejo *et al.*, 2017). The success of establishment and rapid invasion potential of this species is attributed to their high fecundity, fast growth rate, tolerance to wide range of environmental thresholds, a short lifespan and good dispersal ability (Lim *et al.*, 2018). It was reported that previously *Marcia recens* is a dominant clam species in Ashtamudi wetland (Sujitha and Nasser, 2009). India supports extensive bivalve fisheries, notably for mussels, oysters, and clams, with an estimated annual production of 84,483 tons (CMFRI 2017).

Station V and VI in Vembanad wetland is dominated by *Villorita cyprinoide*, when compared to Ashtamudi wetland. Simpson dominance recorded maximum value at station V (λ= 1) while Pielous eveness (J') recorded maximum values in mangrove region at station VI (J'= 0.819). Station V revealed low pH, low dissolved oxygen and high salinity values which indicates early warning sign of ecological degradation and the need for conserving these resources. This station was dominated by *Villorita cyprinoide*, a potential bio-monitor which can bio accumulate high concentration of metals compared to water (Nair and Shivalingam, 2018).

3.3. PCA Analysis for physico- chemical parameters

PCA analysis for physico- chemical parameters (figure 3 and tables 2-3) with a total of three canonical axes explains a cumulative variance of 80.4 %. Of the total variables analyzed PC1 and PC2 explain about 61.5 % of the variance. Surface water temperature, water pH, carbon dioxide, biological oxygen demand and sediment pH have a greater contribution to PC1 which accounted for 36.7 % of the cumulative variance with an Eigen value of 3.31. Salinity, dissolved oxygen and sediment temperature have a greater contribution with PC2 with 61.5 % of the cumulative variance with an Eigen value of 2.22. Atmospheric temperature has a greater contribution with PC3 with 80.4 % of the cumulative variance with an Eigen value of 1.71. It was clear from the PCA plot that the distribution of atmospheric temperature, biological oxygen demand, water pH and dissolved oxygen ordinated to the left of station I. Whereas water temperature, sediment pH, sediment temperature, carbon dioxide and salinity ordinated to the right of station VI.

3.4. Pearson's product moment correlation

Station-wise variation in the physico- chemical parameters is given in table 4. Pearson's product moment correlation revealed that sediment temperature recorded a negative correlation with molluscan abundance ($P<0.05$). Surface water pH recorded negative correlation with salinity ($P<0.01$) and water temperature ($P<0.05$). *Villorita*

Table 1. Diversity indices of molluscs species

Stations	Margalef richness (d)	Pielous evenness (J')	Shannon diversity (H')	Simpson's dominance (λ)
Station I	1.284	0.599	1.245	0.381
Station II	1.097	0.518	1.008	0.457
Station III	0.958	0.425	0.684	0.645
Station IV	1.181	0.685	1.228	0.411
Station V	0	0	0	1
Station VI	0.542	0.819	0.9	0.469

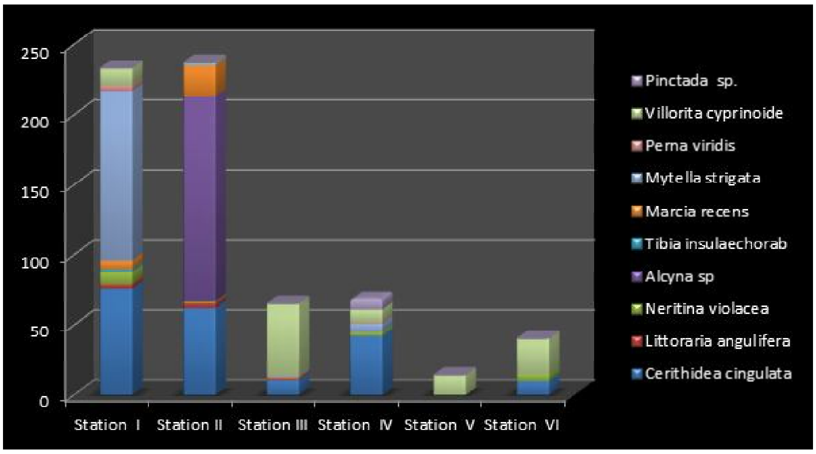


Fig. 2. Composition and abundance (No/m^2) of molluscs

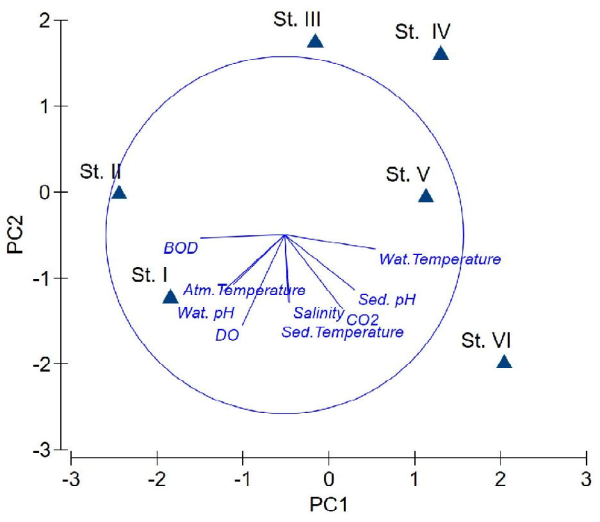


Fig. 3. Principal Component Analysis (PCA) ordinations for physico- chemical parameters

Table 2. PCA values for physico- chemical parameters

PC	Eigen values	% Variation	Cum. %Variation
1	3.31	36.7	36.7
2	2.22	24.7	61.5
3	1.71	19	80.4

Table 3. Pattern Matrix table for geo-chemical variables

Variable	PC1	PC2	PC3
Atmospheric Temperature	-0.288	-0.28	-0.508
water Temperature	0.51	-0.081	-0.145
water pH	0.344	-0.318	-0.337
Salinity	0.029	-0.381	0.594
Dissolved oxygen	0.235	-0.506	-0.01
Carbon dioxide	0.327	-0.419	-0.206
Biological oxygen demand	-0.47	-0.018	0.38
Sediment Temperature	0.02	-0.378	0.246
Sediment pH	0.392	-0.308	0.085

Table 4. Station-wise variation in the physico- chemical parameters

PARAMETERS	STATION I	STATION II	STATION III	STATION IV	STATION V	STATION VI
Atmospheric Temperature (^{0}C)	34 .09 ± 0.14	33 .11 ± 0.22	34 .36 ± 0.19	25. 34 ± 0.26	31.51 ± 0.22	32.57 ± 0.17
Surface water Temperature(^{0}C)	29 .36 ± 0.17	29.21 ± 0.14	30.41 ± 0.24	30. 16 ± 0.22	30.27 ± 0.19	31.36 ± 0.19
Surface water pH	7.05 ± 0.23	7.07 ± 0.20	7.09 ± 0.14	7.01 ± 0.16	6.85 ± 0.19	7.03 ± 0.23
Salinity (mg/l)	5.02 ± 0.18	5.02 ± 0.23	2.06 ± 0.17	5.02 ± 0.25	5.03 ± 0.24	5.02 ± 0.25
Dissolved oxygen (mg/l)	6.08 ± 0.20	6.13 ± 0.18	4.08 ± 0.18	4.08 ± 0.19	4.04 ± 0.22	6.04 ± 0.16
Carbon dioxide (mg/l)	13.05 ± 0.16	8.04 ± 0.10	11.02 ± 0.24	8.09 ± 0.17	25.03 ± 0.20	26,12 ± 0.14
Biological oxygen demand (mg/l)	4. 02 ± 0.18	8.06 ± 0.21	1.06 ± 0.17	2.04 ± 0.21	2.04 ± 0.16	1.02 ± 0.12
Sediment Temperature (^{0}C)	28 .12 ± 0.20	30.18 ± 0.18	28.39 ± 0.28	28.47 ± 0.16	29.46 ± 0.11	30.32 ± 0.23
Sediment pH	6.63 ± 0.24	6.01 ± 0.15	6.24 ± 0.22	6.72 ± 0.20	6.57 ± 0.21	6.89 ± 0.24

cyprinoide was found to be negatively correlated with dissolved oxygen, pH of water and sediment (P<0.01), whereas with salinity, biological oxygen demand and sediment temperature (P<0.05). *Mytella strigata* and *Perna viridis* were negatively correlated with carbon dioxide and sediment temperature (P<0.01).

4. Conclusion

The present study revealed that, the species diversity and richness of molluscs in mangrove regions were high when compared to non-mangrove regions, in both wetlands. Moreover, Ashtamudi ramsar site is subjected to adverse ecological impacts due to invasive alien species and revealed the need for its immediate conservation for the preservation of endemic species which supports the economy of the state. In the present scenario, depletion of mangrove ecosystems along with endemic molluscan resources with the abundance of invasive species which in turn upsets the ecological balance of the Ramsar Sites, warrants urgent need of conservative strategies and management plans for preserving these resources for future generations.

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