A Comparative analysis of physicochemical characteristics of a Tropical Kole wetland impacted by hydrological fluctuations

Vineetha S., Bijoy Nandan S., Rakhi Gopalan K.P.

Abstract— Wetland systems are characterized by dynamic hydrofluxes, correspondingly paddy fields (man managed temporary wetlands) are characterized by their dynamic, temporary and transitional nature. The response of environmental parameters to such changes is inquisitive which is vital in management and conservation aspects. In Maranchery Kole wetland, a part of Vembanad Kole wetland, a Ramsar site, the agricultural related activities and precipitation resulted in hydrological and land use pattern variability making the same area behave as different systems marked as Wet phase, Dry phase, Paddy phase, Channel phase and Stable phase within a short span. The variation in physico chemical parameters of water and sediment were analyzed during these different phases. Depth was the most variable parameter ranged from 0.36±0.14 m in the dry phase to 2.27±0.58 m in the stable phase (F17,172=110.64, p< 0.01). Though the variation seems less, it caused profound changes including drying up of the system as the water body was shallow. Water and sediment pH remained neutral or slightly acidic throughout the phases. The Redox potential (Eh) values showed a highly reducing trend throughout the study (average being -237.88±13.76 mV) the reason could be the increase in electron donor supply due to high organic matter irrespective of the phases. Due to the different phases, the moisture content was expected to differ, but it remained comparatively high (average being 28.82±2%), possibly due to high organic matter. No distinct distribution pattern was apparent in organic matter indicating a constant and eternal supply of detritus, irrespective of seasons and phases. In the wet and stable phases, decay of aquatic macrophytes and the influx of organic matter due to monsoon could be the reason for the high organic matter; in the dry and paddy phase, though macrophytes and monsoon inputs were not there, low water level decreased dilution effect resulting in higher organic matter. A significant variation in available phosphorus between phases was apparent (ANOVA F17,172=7.87, 1.94 p< 0.01). It was maximum in stable phase 1.49±0.86 ppm, dry phase also showed a similar value of 1.07±0.76 ppm, paddy and channel phases showed the minimum value of 0.33±0.11 ppm. Available nitrogen was lowest in the channel phase 0.016±0.005% and highest in the dry phase 0.021±0.006%. Apart from the general parameters affecting nutrient distribution, the cattle and bird excreta as well as macrophyte type and density were also suspected to impact nutrient levels. The sediments texture observed were clayey silt, sandy silt, clayey sand, sandy, silty clay and silty sandy. Principal component analysis clearly reflected the variation in environmental quality with respect to land use pattern by ordinating wet, stable phases together and dry, paddy phases together.

Key words— Kole wetland, paddy fields, sediment, Vembanad Kole wetland, water.

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1 INTRODUCTION

Wetlands are amongst the most productive, diverse and ecologically sensitive ecosystems on Earth [1], [2]. The functions of these complex ecosystems are driven by physical, chemical and biological processes. In contrast to upland systems, the biogeochemical characteristics of wetlands, including physical, chemical, and biological properties of soil and water quality is strongly governed by hydrology. As wetlands experience wide hydrological variations from drying to flooding, severe changes in its physico chemical character is expected. Previous studies showed that nutrient concentration in water and sediment may be related to flooding or confinement situations [3] and [4].

Similarly paddy fields (man managed temporary wetlands) comprise a mosaic of rapidly changing ecotones and are the most manipulated and frequently disturbed ecosystem. The alterations in hydrology and rice field ecology are suspected to reflect in its environmental parameters. This study is from Maranchery kole wetland, a part of Vembanad-Kol wetlands (Ramsar Site), the largest brackish, humid and tropical wetland system in the south west coastal state of Kerala, India. Kole wetlands are among the water-logged, paddy cultivating areas in Kerala and were under rice cultivation for the past 200 years since the erstwhile Maharaja permitted to convert this wetland into paddy fields in the early 18th century [5]. They are renowned for its high rice production, even the term Kole in Malayalam (the regional language in Kerala, India) means 'bumper yield of high returns in case flood does not damage the crops' [6]. The agricultural related activities and precipitation in the area resulted in extreme hydrological and land use pattern variability making the same area behave as four different systems during the study period such as normal water bodies (Wet phase), isolated water patches (Dry phase), paddy fields (Paddy phase) and narrow strips of water bodies (Channel phase). This study tried to explore the difference in sediment and water quality among the above phases and compared it to a part of the wetland, which remained inundated throughout the study period (Stable phase). These seasonal transformations has significant role in nutrient translocation and organic matter decomposition and hence a vital concern in management and conservation.

2 Materials and Methods

2.1. Study Area

The Kole land has an area of 13,632 ha. spreading over Thrissur and Malappuram districts of Kerala extending from northern bank of Chalakkudy river in the South to the southern bank of Bharathappuzha river in the North. The intrusion of salt water to the paddy fields is prevented by Viyyam dam situated at the downstream end of Kole lands. It is believed that Kole lands were lagoons formed by the recession of the seas centuries ago. A shallow portion of the sea along the western periphery of the main land was secluded and they were slowly silted up during rains making the lagoons shallow [7]. During summer months the farmers bunded the fields, dewatered and cultivated paddy. The main crop is *Punja* (Summer crop) raised between December/January and April/May. The study area (10^0 72′N 75^0 98′E), with an area of 100 acres, lies in between Maranchery and Veliyamkodu panchayats (a village council is called panchayat) in Malappuram district and forms a part of the Ponnani Kole. Eight stations were selected for monthly sampling (Fig. 1).

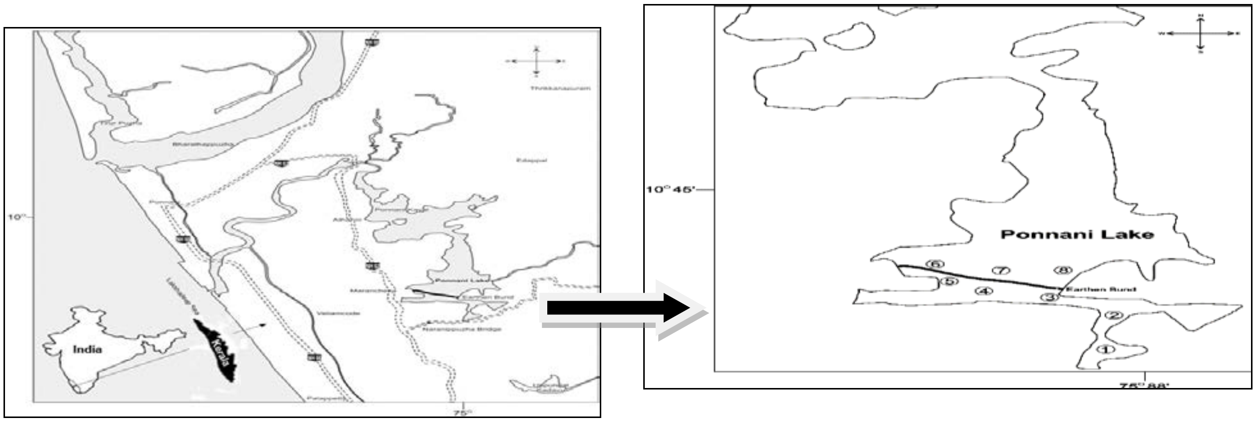

Fig. 1. Map showing Stations 1 to 8 in Maranchery Kole wetland.

2.2. The Hydrological regime and Phases

In January 2010, water was drained using the pumping device '*petti* and *para*' from sites 1 to 5 to sites 6 to 8 as the preparation for paddy cultivation. In February, these sites were again filled with water due to the accidental breaching of an adjacent earthen bund. March to June, there was no water in sites 1 to 5. Paddy cultivation was not done due to breech of the bund so the land was covered with grass. The stations 1 to 5, from January 2010 to June 2010 was considered as the dry phase since the area was dry with grasses and shrubs where cattle pastured. February 2010 was excluded because it was inundated due to the breach of a bund hence it could not be considered as dry phase. Stations 1,2,3,4,5 were inundated again by the end of June 2010 with the advent of South West monsoon. The period from July 2010 to December 2010 was considered as wet phase. During the similar period, the stations 6 to 8 were considered as stable phase for a comparison as it remained unaltered throughout the study period. In stations 6-8, paddy cultivation was practiced years back but since last few years it was kept fallow so the hydrological regime remained unaltered there. In January 2011, the dewatering for paddy cultivation started again, and during the year paddy cultivation was practiced in stations 1 to 3 so it was considered as paddy phase. Stations 4 and 5 were channels through the paddy fields. During the same period, the stations 4 to 5 were the narrow channels connecting the paddy fields so it was considered as channel phase (Fig.2).

2.3. Sampling and Analytical Methods

During wet months, samples were collected on a country boat (*Vallam*). As the water body was shallow, surface and bottom water was not taken separately. In wet months the water samples was collected using a Niskin water sampler (Hydrobios 5 L). In paddy and channel phases, the water samples were collected using a locally fabricated shallow water sampler of 1 L capacity. Due to low water level during the dry phase, water samples could not be taken in dry phase. The samples were stored in plastic containers and kept frozen for analysis. Samples for dissolved oxygen were collected in 125 mL Stoppard glass bottles taking care that no air bubbles were trapped in the samples. The samples were fixed immediately with manganous chloride solution (Winkler A) followed by alkaline potassium iodide (Winkler B) solution. Rain fall data was collected from the Indian Meteorological Department website (imd.gov.in). The sediment samples for the analysis of different parameters were collected using a Van Veen grab of size 45 cm^2

Temperature was determined using mercury thermometer in field. The samples were stored in plastic covers. Depth was measured by lowering a graduated weighted rope until it touched the bottom floor of the wetland. Temperature of the water and sediment samples were determined in the field using a standard degree centigrade thermometer of range 0°C to 50°C and 0.1°C accuracy. Water and sediment pHwere measured using Systronics water analyzer model 321 (accuracy ±0.01) [8]. Dissolved oxygen was analyzed by modified Winkler me

Wet Phase

Dry Phase

PaddyPhase

Channel Phase

Stable phase

Fig. 2. Different phases in Maranchery Kole wetland

thod [9], [10]. Sediment oxidation reduction potential (Eh) was measured in the laboratory using Systronics digital Eh meter (potentiometer) model 318 [8]. Moisture Content was determined by gravimetric analysis. Organic carbon was analyzed by Walkley Black method, it was then converted to organic matter by multiplying with Van Bemmelen factor of 1.742 [11]. Available nitrogen of sediment was analyzed by Kjeldhal method. Available phosphorus was determined by Olsen's method [12]. Particle size was analyzed using particle analyzer Sympatrec T 100 laser diffraction granulometer, made in Germany.

Data Analysis

The software programme SPSS 16 (Statistical Programme for Social Sciences, version 16) was used for statistical analyses and representation of data. Statistical analysis 2 Way ANOVA (Analysis of Variance), standard deviation and correlation was done based on SPSS 16.0 software packages for Windows for testing the presence of significant differences among the parameters between phases.

3. Results and Discussions

Water levels in wetlands are rarely stable; the main source of water in this wetland was rainfall. The maximum rainfall of 925.3 mm during the study period was observed in June 2011 and the minimum was 0.5 mm in March 2010. The South West monsoon contributed to the major share of rainfall (70%) accounting for the high water level in wet and stable phases. Depth was the most variable parameter in the study that ranged from 0.36±0.14 m in the dry phase to 2.27±0.58 m in the stable phase (Fig. 4.1). The results of ANOVA showed that there existed a significant difference in depth between phases ($F_{17,172}=110.64$, $p< 0.01$). The variation in depth in Maranchery kole wetlands was prominent between the various phases due to the agricultural related activities in the area. As the water body was very shallow, a drop in few centimeters of depth implied the absence of water in the area resulting in drying up of the wetland.

pH variations in water bodies are mainly due to the factors such as removal of carbon dioxide by photosynthesis through bicarbonate degradation, reduction in salinity and temperature, and decomposition of organic matter [13], [14]. The average values of water pH showed that the water in all stations were neutral or slightly acidic. The comparison in water pH between the five phases showed similar value for the wet (6.66) and stable phases (6.57). Paddy (5.97) and channel (5.84) phases were characterized by a slightly lower pH. Wet phase and channel phase showed the maximum and minimum water pH respectively (Fig. 4.3).

The comparison between the phases showed marginal variation in dissolved oxygen levels with highest value of 6.6±1.3 mg/L in wet phase and minimum of 5.16 ±1.3 mg/L in the paddy phase (Fig. 4.4). The results of ANOVA showed that there existed no significant variation in dissolved oxygen among the stations and phases. A comparison with the wetlands in Kerala also showed that dissolved oxygen was higher in Maranchery Kole wetlands. In Ashtamudi wetland dissolved oxygen ranged from was 1.9-5.46 mg/L and in Vembanadu lake the range was 2.02-4.89 mg/L [15].

There was a slight variation in sediment temperature between wet, dry, paddy and channel phases. Temperature was maximum in channel phase showing a mean value of 27.75±2.08 ºC and minimum in the stable phase 26.88±1ºC (Fig. 4.5). ANOVA of temperature in the sediment showed there was no significant difference between stations and phases. The variation in sediment temperature was closely in parallel to the water temperature which was implied by strong positive correlation between them. The phases also showed a trend similar to that of water temperature but the variation among the phases was less prominent. The channel phase showed the maximum temperature due to its existence in summer months. Shading by the paddy plants prevented the temperature to elevate in the paddy phase. The reduced water level and the summer heat elevated the temperature in the dry phase.

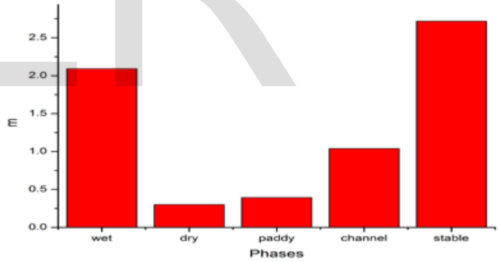

Fig.4. 1. Depth (m)

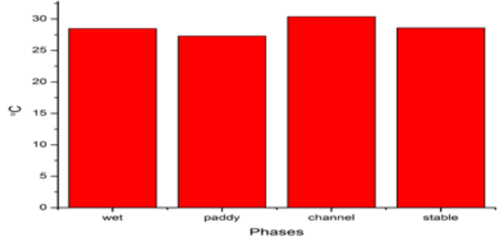

Fig.4. 2. Water temperature (°C)

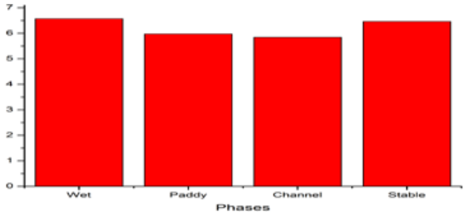

Fig.4.3 Water pH

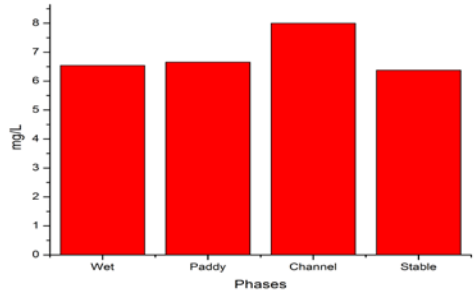

Fig.4.4 Dissolved oxygen (mg/m²)

Fig.4 (1-4). Phase wise variation in water parameters

The pH of sediment is influenced by several factors such as ionic composition of interstitial water, biochemical reactions, nutrients etc. Sediment pH showed no much variation among the phases. Paddy phase showed the lowest pH of 6.35±0.58 and the highest in the wet phase 6.73±0.33 (Fig. 4.6). Sediment pH remained neutral apart from a very few instances, where the pH levels changed from neutral to acidic. This result agrees with the findings of Reddy and Delaune [16], who summarized the pH range of freshwater sediments from various studies as 6.0 to 7.0. The reason stated was that high organic carbon in wetlands buffers the soil to neutrality [16]. In Maranchery Kole wetlands also the high organic carbon could be the reason for the neutrality of sediment pH. However previous studies from Kole wetlands revealed that the soils of Kole area in general are acidic with pH ranging from 4.9 to 6.1 due to the effect of underlying peat horizon [17]. The comparison between the wet, dry, paddy and stable phase showed that there was a slight increase in pH levels in the wet and the stable phase. The soil pH tends to increase when soils become more reduced due to water saturation because of the consumption of free protons with reduction processes [18], [19]. The slightly increased pH values in the wet and stable phase could be related to this observation.

The Redox potential (Eh) values showed a highly reducing trend in all stations throughout the study period. Wet phase showed the minimum value of -256±3.1 mV and paddy phase showed the maximum value of -225±4.6 mV (Fig. 4.7). Redox potentials in soils are affected by a number of factors including organic matter availability in the soil (electron donor). An increase in electron donor supply (organic matter) will decrease Eh values [16]. In this study also irrespective of the phases organic matter remained high in the wetland.

Moisture content is the water held in spaces between sediment particles, it is critical to the organisms, as they require water to maintain osmotic balance and to facilitate oxygen adsorption through the integument [20]. The comparison among the phases showed that the channel phase showed the lowest moisture content 20.66±2.71% and highest in the wet phase 37.59±6.09% (Fig. 4.8). Despite of the different phases in Maranchery wetlands, the moisture content remained comparatively high. High organic matter throughout the phases could be the reason as organic matter improves water holding capacity of sediments [16].

Organic matter is a key food source for benthic fauna though excess of it can have a negative effect by oxygen depletion and build up of toxic by-products [21], [22], [23]. Paddy phase showed the maximum value of 6.79±1.33% and the channel phase showed the minimum value of 5.57 ±1.17% (Fig. 4.9). In wetland ecosystems, the primary productivity often exceeds the rate of decomposition processes, resulting in net accumulation of organic matter. The decomposition process occurs significantly at slower rates due to the predominance of anaerobic conditions [16]. No distinct distribution pattern was apparent in organic matter, during the present study, indicating the constant and eternal supply of detritus, irrespective of seasons and phases, which give substantial flux of organic residues to the sediments by the decomposition process. The decay of aquatic macrophytes and the influx of organic matter due to monsoon could be the reason for the high organic matter in the wet and stable phase. Whereas in the dry and paddy phase, though macrophytes and monsoon inputs were not there, the reduced water level would have concentrated the organic matter hence resulted in a higher organic matter level [24], [25]. Ali et al. [26] and Walker et al. [27] observed that higher water levels may dilute the amount of organic matter. In trans-okpoka creek, Nigeria, Davies and Tawari [28] observed significant variations of organic carbon with a high organic carbon content in dry season and low in wet season, the suggested reason was high temperature and dilution effect (rains and runoff) in wet season. A significant positive correlation was observed between organic matter and moisture content. A significant positive correlation between organic matter and moisture content was reported from Yellow River Delta, China [29] where he found that high moisture conditions leads to exclusion of oxygen thus decreasing decomposition rates resulting in higher organic matter.

Though water level and their patterns of variation are the primary controlling factors in wetlands, when the basic nutrients are short in supply, growth and reproduction of organisms will be curtailed [30]. Phosphorus is an essential cellular component for many organisms. Although phosphorus is a limiting nutrient in fresh water ecosystems, in wetlands it is not limiting [16]. Available phosphorus showed considerable variation during the study period. The stable

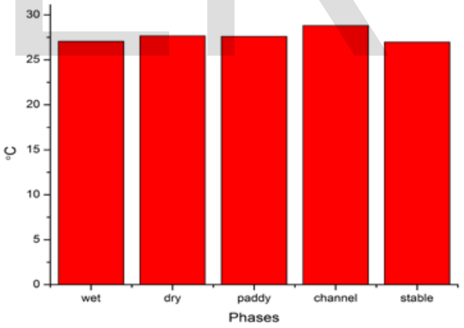

Fig.4.5 Sediment temparature (°C)

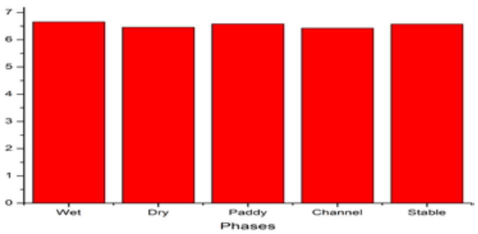

Fig.4.6 Sediment pH

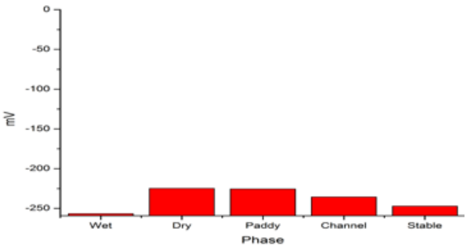

Fig.4. 7. Eh(mV)

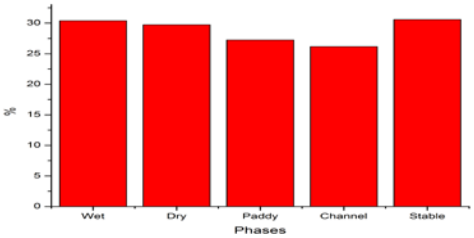

Fig.4.8.Moisturecontent(%)

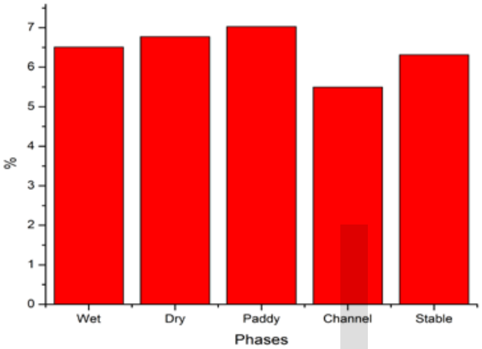

Fig.4.9. Organic matter (%)

Fig.4 (5-9). Phase wise variation in sediment parameters

phase showed the maximum value of 1.49±0.86 ppm, dry phase also showed a similar value of 1.07±0.76 ppm, and the paddy and channel phase showed the minimum value of 0.33±0.11ppm (Fig. 4.10). There existed a significant variation in available phosphorus between phases (ANOVA $F_{17,172}=7.87$, 1.94 $p< 0.01$). There are several abiotic and biotic processes involved in mobilizing phosphorus between soil and overlying water column. The stable phase showed the maximum available phosphorus levels, the comparison was made choosing the monsoon period, the runoff from the nearby areas could be one reason, agreeing with the findings of [29], that flooding increased soil nutrient concentration by sedimentation. In stations 6 to 8, the constituent stations of the stable phase, the macrophyte vegetation was less compared to that of others hence the removal of phosphorus from sediments through macrophytes might be less here compared to other sites. Macrophytes may be visualized as pumps that remove nutrients from sediments and return them to open water [31]. Wet phase also got the influence from monsoon, but the stations 1 to 5 which are the constituent stations of the wet phase were characterized by more number of aquatic macrophytes. The removal of phosphorus from the sediments through the macrophytes could have resulted in a lesser phosphorus levels than the stable phase. In the dry phase, the drying of anaerobic soils and sediments showed contradictory results with respect to phosphorus sorption characteristics. Phosphate buffering capacity of soils and sediments studies showed an increase in the degree of phosphate adsorption upon drying soils [31], [32]. In mineral wetland soils, drying potentially decreases the degree of hydration of iron hydroxide gels, hence increasing the surface area, resulting in increased phosphorus adsorption. However, McLaughlin et al. [33] observed that drying synthetic iron and aluminum oxyhydroxide increased crystallinity and decreased phosphorus sorption capacity. Under flooded-drained conditions, Sah et al. [34] showed an increase in concentration of amorphous iron at the expense of more crystalline forms, suggesting greater surface area and potential for higher phosphorus sorption. In floodplain-forested soils, Darke and Walbridge [35] reported a decrease in aluminium and iron oxide crystallinity during seasonal flooding. The observations from the present study showed that the available phosphorus level in the dry phase was comparable to the stable phase, which showed the maximum values among the five phases. The dry phase was characterized by the numerous avian fauna compared to the other phases, agreeing to the observations made on the avian fauna from Kole wetlands [36]. The bird faecal matter was observed throughout the stations. The input of nutrients (phosphorus and nitrogen) resulting from avian excrement could have contributed in the dry phase. In lake Grand-Lieu, France, the avian excrement contributed 95% of phosphorus annually [37]. The significant role played by the avian fauna in nutrient loading is already proved [38], [39]. Further during the dry phase, as the stations were like grassland, many cattle pastured there. The animal excreta could have also contributed to the phosphorus loading in the dry phase. The lowest available phosphorus level was observed in the paddy phase, the transfer of phosphorus through the plants could be the reason. Phosphorus assimilation and storage in plants depends on vegetative type and growth characteristics. Floating and submerged vegetation has limited potential for long-term phosphorus storage. Because of rapid turnover, phosphorus storage in biomass is short term, and much of the phosphorus is released back into water column upon vegetative decomposition. Emergent macrophytes have an extensive network of roots and rhizomes and have great potential for phosphorus storage. As paddy is an emergent plant it accumulated more phosphorus than the submerged plants. Channel phase also had a reduced available phosphorus level. Runoff through rains, resulting in loading phosphorus from the watershed was not there in the channel phase as it was not the monsoon season which could be the reason for less phosphorus level in channel.

Nitrogen is a key resource for animals, along with plants [40]. So nitrogen fixation, nitrogen absorption, and nitrogen reduction within plants may thus be the critical limiting steps in the production of the entire biota of wetlands [30]. Nitrogen is usually the limiting nutrient in wetlands. The bioavailability of nitrogen in a wetland is influenced by temperature, hydrologic fluctuations, water depth, electron acceptors availability and microbial activity. It is probably the major regulatory nutritional factor in most detritus based system [41]. The comparison between the wet, dry, paddy, channel and the stable phase showed that the lowest available nitrogen was in the channel phase showing 0.016±0.005% and highest in the dry phase 0.021±0.006% (Fig. 4.11). The present study showed significant variations in available nitrogen between different phases ANOVA $F_{17,172}=2.26$, 1.94 $p< 0.05$). The comparison between phases showed less available nitrogen in the paddy and channel phases. The absence of nutrient input through monsoon and excrements of avian fauna would have resulted in the low nitrogen levels in paddy and channel phase whereas the bird droppings and cattle excreta also might have resulted in the maximum available nitrogen in the dry phase. The input of nutrients from monsoon resulted in a high value in wet and stable phase. Flooding would have increased soil nutrient concentration by sedimentation [29]. This was contradictory to the results of similar study from Vellar estuary where low nitrogen values were recorded in monsoon [14].

The sediment of the Maranchery Kole wetland was composed of clayey silt, sandy silt, clayey sand, sandy, silty clay and silty sandy fractions during the study period. The substratum characteristics of the wet, dry, paddy, channel and stable phase showed that the wet, channel and stable phases were sandy silt in nature while the dry and paddy phases were clayey silt in character (Fig. 4.12). The substratum characteristics of the wet, dry, paddy, channel and stable phase showed that the wet, channel and stable phases were sandy silt in nature while the dry and paddy phases were clayey silt in character. The running water in the wet, channel and stable phases would have moved the finer particles resulting in more sand fractions in these phases. This could be viewed analogous to the winnowing activity of the monsoonal flood facilitating the dominance of sand. Similar observations were made from Vellar estuary [42] and Mandovi estuary [43]. In the dry and paddy phases the stagnant water would have resulted in deposition of finer clay fractions in these phases. A quite condition, conducive for flocculation and settling of finer fraction is necessary for the deposition of clay [44].

Principal Component Analysis (PCA)

Principal component analysis showed a total of 4 canonical axes, 3 of which explained 96.5% of the total variance between the phases (Table 1, Fig. 5). Water pH, sediment temperature, sediment pH and moisture content contributed significantly to the PC1, which accounted for 46.2% of the variance in the data (eigen value 6.47). PC2, which explained 31.8% of the total variance (eigen value 4.45), consisted primarily of silt, Eh, depth, organic matter content. Dissolved oxygen and clay content were the significant contributors of PC3. In this analysis, Principal axes 1 and 2 were found to be important as they explained 78% of the variance. The deepest phases (wet and stable phases) characterized by lowest sediment temperature, highest moisture content and highest phosphorus content were ordinated on the top left. Phase with medium depth, highest temperature and highest silt content (channel phase) was ordinated towards the top right of the PCA plot. The shallow phases (dry and paddy phases) with the highest organic matter were ordinated on the bottom right. Principal component analysis clearly reflected the variation in environmental quality with respect to the land use pattern by ordinating wet, stable phases together and dry, paddy phases together.

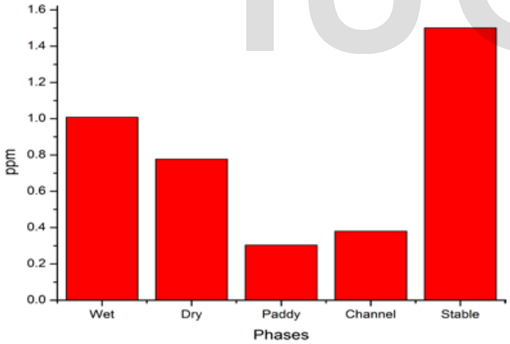

Fig.4. 10. Available phosphorus (ppm)

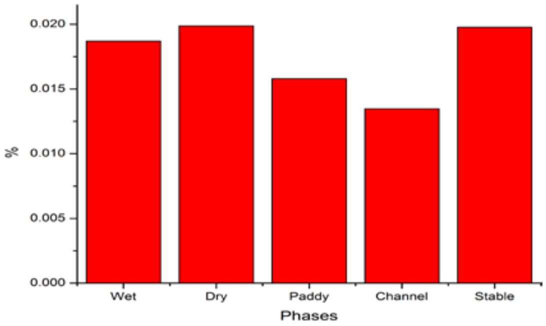

Fig.4.11. Available nitrogen (%)

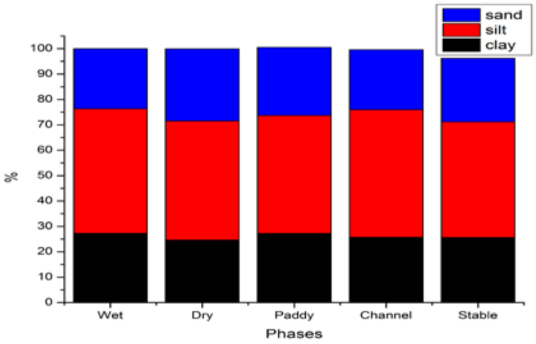

Fig.4.12. Sediment texture (%)

Fig.4 (10-12). Phase wise variation in sediment parameters

Hydrological alteration is a major disturbance affecting wetlands particularly when climate change characterized by higher temperature and reduced rainfall increase both spatial and temporal extends of drying events, together with the increased stress placed on wetlands. As most attention in aquatic studies has been directed to permanent waters (i.e., hydroperiod>1 year) [45], the basic ecological

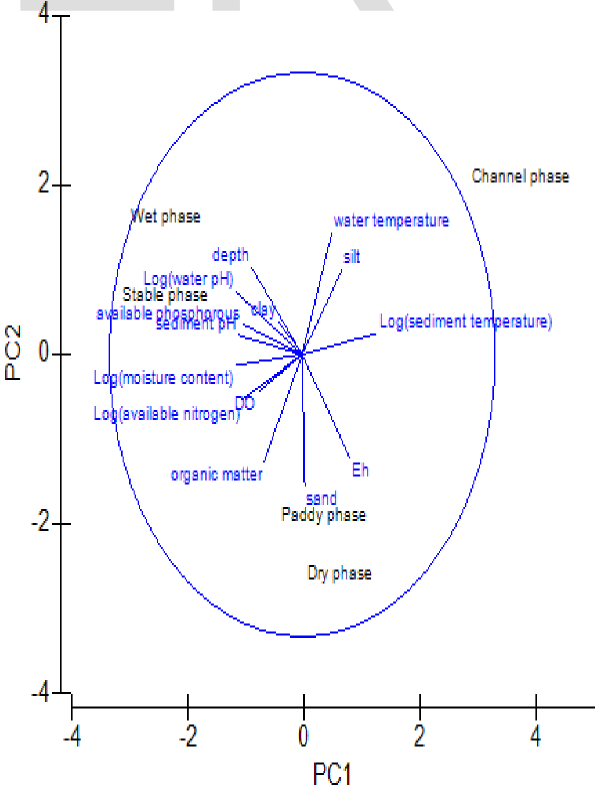

Fig. 5. Principal Component Analysis (PCA) ordination of environmental variables in different phases in Maranchery Kole wetland.

descriptions of temporary water including environmental characteristics remains scanty though such baseline information from the field it is vital for protecting these unique systems.

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Table 1. Results of Principal Component Analysis (PCA) of environmental parameters

Variable	PC1	PC2	PC3	PC4
Log (water pH)	-0.345	0.224	-0.042	-0.009
depth	-0.266	0.313	0.147	-0.317
Log (sediment temperature)	0.388	0.076	0.002	0.037
Eh	0.245	-0.363	-0.006	-0.218
Log (moisture content)	-0.346	-0.038	0.249	0.339
organic matter	-0.197	-0.378	-0.206	0.114
DO	-0.227	-0.132	-0.475	-0.118
Log (available nitrogen)	-0.317	-0.163	0.27	0.294
available phosphorous	-0.31	0.109	0.347	-0.158
sediment pH	-0.332	0.069	-0.318	0.049
clay	-0.124	0.121	-0.569	-0.027
silt	0.208	0.303	-0.123	0.74
sand	0.013	-0.467	0.108	0.017
water temperature	0.153	0.43	0.035	-0.213

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