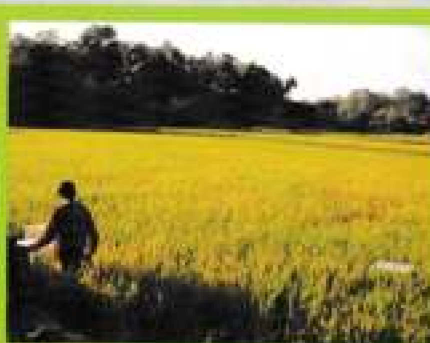
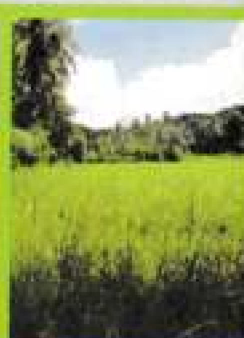



FINAL PROJECT REPORT

AGROBIODIVERSITY ENHANCEMENT PROGRAMME-STUDY ON BENTHIC FAUNA AND SOIL CHEMISTRY OF SELECTED WETLANDS IN PALAKKAD, KERALA

February 2009 to February 2011



SUBMITTED TO
KERALA STATE BIODIVERSITY BOARD
THIRUVANANTHAPUARAM

Dept. of Marine Biology, Microbiology & Biochemistry
School of Marine Sciences
Cochin University of Science and Technology
cochin - 16

Final Project Report

AGROBIODIVERSITY ENHANCEMENT PROGRAMME- STUDY ON BENTHIC FAUNA AND SOIL CHEMISTRY OF SELECTED WETLANDS IN PALAKKAD, KERALA

February 2009 to February 2011

Principal Investigator

Dr. S. Bijoy Nandan

Associate Professor in Marine Biology
Dept. of Marine Biology, Microbiology & Biochemistry
Cochin University of Science and Technology

Submitted to

KERALA STATE BIODIVERSITY BOARD, THIRUVANANTHAPUARAM

GOVERNMENT OF KERALA

GOVERNMENT OF KERALA

KERALA STATE BIODIVERSITY BOARD, THIRUVANANTHAPURAM

Final Project Report
(February 2009 to February 2011)

1. Title of the project	:	AGROBIODIVERSITY ENHANCEMENT PROGRAMME- STUDY ON BENTHIC FAUNA AND SOIL CHEMISTRY OF SELECTED WETLANDS IN PALAKKAD, KERALA
2. Period	:	February 2009 to February 2011
3. Name and address of PI With Phone no	: :	Dr. S. Bijoy Nandan Associate Professor in Marine Biology Dept. of Marine Biology, Microbiology & Biochemistry School of Marine Science, Lake Side Campus, Cochin University of Science & Technology (CUSAT) Fine Arts Avenue, Cochin -6820 16 91-484- 2368120, Fax: 91-484- 2374164 & 2532495, Mob. 9446022880, Grams: CUSAT
4. Name of Project Fellows	:	Akhilesh Vijay
5. Date of commencement	:	20-02-2009
6. Date of Termination	:	20-02-2011
7. Total fund allotted for the period (2009-2011)	:	Rs. 6,47,400/-

TABLE OF CONTENTS

1. General Introduction

Wetlands and agriculture are closely linked together, dating back to the prehistoric period. Both these systems are greatly influenced by mankind because of its high biodiversity and special environments, which human being relay on. Available evidence suggests that human settlements started in and around the wetlands, long before humans learned to grow food and they depended, at least partly on wetlands for their sustenance. Globally wetlands cover an area of about 530 million hectares, of which 78% are in tropical countries and in India it constitute to about 58.2 million hectares (Prasad *et al.*, 2002). Of this, rice cultivation accounts for about 15% and provides staple food for about 40% of the world's human population. The concern for wetlands is rather recent only about three decades old. Until recently, wetlands were treated with contempt as wastelands, worthy of drainage and reclamation for agriculture and other land uses. Natural wetland, which lies at the interface between agricultural uplands and the deep open waters, act as recipients of sediments and agrochemicals and are known to regulate their flux to the lakes and rivers. The cycling of organic matter between the water and sediment phase is an important part of the productivity of the wetland at different levels. The paddy wetlands are man powered temporary wetlands which are subject to various disturbances. There is a continuous nutrient exchange in soil subsystem involving a number of organisms ranging from microbes (bacteria and fungi) to an array of macro invertebrates.

The Erumayur panchayat in Palakkad district has 400 acres micro-watershed wetland ecosystem, having hills on three sides with various agriculture and vegetation types. Hundred acres in the plains are used for paddy cultivation. It was proposed to convert 100 acres of the paddy wetlands in the area to organic farming type. So improving and restoring the biodiversity, through suitable practices would be ideal for improving the productivity of the system. Organic farming helps to improve the physical, chemical and biological properties of the soil and maintain the ecological balance as well as productivity of life supporting systems for future generations (Raja Gopal and Sree Ramulu, 1999). Soil management practices that do not impair health and structure are pre requisites for achieving higher productivity and reduced cost of cultivation in agriculture. Dimitrov (1997) suggested that organic farming could be easily applied during transition period taking into account the limited resources of the country. The opinion varies greatly about the organic farming as part of sustainable agriculture. It has been called, organic farming which is a system of production that largely organic farming strategies would depend on long term whole farm systems involving all aspects of crop production that will maintain soil productivity and reduce dependence on chemical inputs. By definition organic farming is a production system which avoids or largely excludes the use of synthetically compounded, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible organic farming system rely upon crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral bearing rocks, and aspects of biological pest control to maintain soil productivity, to supply plant nutrients, and to control insects, weeds and other pests.

The ever increasing attention is being paid to the environmental impact of intensive agricultural practices, and in this context organic farming is gaining recognition as a relatively friendly production system. In general, the risk of harmful environmental effects is lower with organic than with conventional farming methods, though not necessarily so. In this context the present study was undertaken in 100 acres of Padayati wetland in Palakkad to study the soil chemistry, benthic fauna as well as microfloral changes for a period of two years in the fertilizer as well as organic amended zones.

2. Importance of the proposal in the National and International context – A review

The "Convention on Biological Diversity" encourages the development of technologies and farming practices that not only increase productivity, but also arrest degradation as well as reclaim, rehabilitate, restore and enhance biological diversity and monitor adverse effects on sustainable agricultural diversity. These include, *inter alia*, organic farming, integrated pest management, biological control, no-till agriculture, multi-cropping, intercropping, crop rotation and agricultural forestry"

The most common form of agriculture in wetlands is, however, paddy cultivation. Evidence of rice culture dates back to the earliest age of humans. Domestication of rice started in shallow swamps, and probably independently in China, Thailand, and India. With the growing demand for food, seasonal marshes throughout South and Southeast Asia and in China were modified into paddy fields as man-managed wetlands. The conversion of extensive mangroves (Sunderbans) in the Ganga-Brahmaputra Delta started at the end of the 18th century by then the East India Company, which required the private landowners to clear mangroves had been converted to rice fields. The pace of conversion got further accelerated, and though enormous deposits of sediments transported by the two rivers had resulted in the expansion of Sunderbans, 2,750 km^2 of Sunderbans were reclaimed between 1880 and 1940 and another 5,230 km^2 in the next 40 years (Reeve, 1997).

The changes in agricultural wetlands, such as paddy fields, depend upon the agricultural practices involving removal of plants other than the crop, water management, and the use of agrochemicals. In less intensive paddy cultivation, the paddy fields support large biodiversity and their productivity, taking into account that the production of all consumable biota is substantially high (Dimitrov 1997). Under intensive cultivation, the biodiversity is greatly reduced. Numerous studies have provided evidence of the positive role organic farming in both above and below-ground biodiversity, reduction of agricultural pollutants and the preservation and restoration of onfarm biodiversity. Long-term comparison with conventional agriculture systems demonstrated that organically farmed soils showed higher biological activity (30-100 %) and higher total mass of soil micro-organisms (30-40 %). Nitrate leaching rates on organic farms were shown to be significantly lower (40-64 %) and energy use to be more efficient (30-50 %) on a per hectare basis (FAO, 2002). Studies taking place between 1988-2001, comparing conventional and organic agricultural practices in both the US and UK have repeatedly shown higher levels of wild biological diversity (e.g. birds, arthropods, weedy vegetation and soil organisms) in organically managed farms (FAO 2002). The influence of organic agriculture and landscape diversity was further illustrated in over 30 separate studies contrasting organic and conventional farms in the UK between 1983 and 2000. The findings showed that organic systems consistently had higher levels of wild plants (5 times more biomass and 57 % more species); arthropods, non-pest lepidoptera and spiders; and birds. In particular, 25 % more birds were found at field edges, with 44 % more in-field birds in the fall-winter, and higher numbers of breeding pairs of rare bird species

In an agricultural ecosystem, soil organic matter (SOM) and soil total nitrogen (STN) are the major determinants and indicators of soil fertility and quality, and are closely related to soil productivity (Reeves, 1997; Susanne and Michelle, 1998). The reduction of soil organic matter and soil total nitrogen levels results in a decrease of soil fertility, soil nutrient supply, porosity, penetrability and thus soil productivity (Gray and Morant, 2003). From a global perspective, soils represent an important terrestrial stock of carbon, holding approximately 3 and 2 times as much as terrestrial vegetation and atmosphere, respectively stocks (Janzen *et al.*, 1997). The dynamics of organic C in soils as affected by farming practices, to a great extent, affects the CO_2 concentration in the atmosphere as well as even the global climate change (Knorr *et al.*, 2005; Tan and Lal, 2005).A better understanding on temporal and spatial variability of SOM and STN and related factors is important for improving sustainable land use management (McGrath and Zhang, 2003) and providing a valuable base against which subsequent and future measurements can be evaluated. In this context the breakdown of organic matter by soil microbial community and benthic organisms with its further recycling in the wetland soil is a crucial aspect of the soil productivity. The soil chemical characteristics also play an important factor that determines as well as that contributes to the abundance of organisms and productivity of the system. Therefore this study is unique in the Indian context where the benthic productivity in relation to its chemistry would be assessed in the context of different stages of the organic farming in a wetlands ecosystem. This study can be considered a model for other wetlands which are to take up organic farming practices.

3. Objectives of the project

1) To study the soil chemical parameters in relation to different farming practices.
2) To assess the composition, distribution and abundance of macro benthic fauna in soil samples.
3) To assess the microbial biomass (heterotrophic count) in relation to farming practice.

4. Field visit and sampling

Monthly field sampling for the collection and analysis of soil chemical parameters, macro fauna and bacterial biomass (Total plate count) from selected stations were undertaken from July 2009 to October 2010 in Padayatti paddy wetlands of Palakkad formed the basis of the study.

5. Materials and Methods

5. a Study Area

The area selected for the study was Padayatti in Erumayur panchayat, Palakkad, having 400 acres of micro-watershed ecosystem with mostly paddy cultivation and also some vegetable cultivation in the peripheral zone. From the 400 acre area a zone of 100 acres was parameters, macrofauna and microbial heterotrophic biomass (Fig.1). St.1 to 3 was under organic paddy cultivation, whereas St.4 was under cultivation using chemical fertilizers. All study stations were typical paddy wetland systems. The details on the latitude, longitude and area of the stations are given in Table1. Traditionally the farmers in Padayatti area were cultivating paddy and vegetables using chemical fertilizers since the last two decades. But in early 2009, the Kerala State Biodiversity Board lead an initiative to introduce organic farming practices in 100 acres of paddy cultivated area. It was in this context that, the present study was entrusted with CUSAT to monitor the soil quality and faunal characteristics in the fertilizer as well as organic amended zones as indicated in Table 1.

The organic farming within the selected hundred acres of paddy fields was based on vermicomposting, leaf decoctions, and "*Panchagavaya*. The *Panchagavya* was locally prepared by farmers of Padayetti with the technical support of the State Agriculture Department. The constituents of the *Panchagavya* assortment were milk (2 litre), curd (2 litre), ground nut cake (1 kg), tender coconut water (3 litre), banana (12 nos.), toddy (2 litre), cow dung (7 kg), and urine (5 litre). The constituents were mixed and 1 litre of it was diluted to 10 litre and applied in the organic farming areas. The period of application of *Panchagavya* was for 25 days, 45 days, and 60 days, interval from the date of sowing paddy and its further growth.

The vermicompost was applied at rate of 1tonne/ acre, indigenously developed by the farmers of Padayatti, Palakkad. The leaf decoctions were made from locally available 5 varieties of plants and were applied, when there was any threat of pest attack on the cultivation.

The annual farming system consisted of early rice (July to September), late rice (November to January) and followed by summer fallow. The seeds commonly employed for cultivation were Navara, Aishwarya, Jothi, JST, 1001. The technical support regarding the application of organic manure, its periodicity and related aspects were provided to the farmer by the State Agriculture Deptmeant, Allathur as well "Thanal", a non-governmental oraganisation approved by the Kerala State Biodiversity Board.

The soil for the analysis of benthos was collected using a standard corer, based on the procedure of Holme and Mc Intyre (1971) and APHA (2005). The soil samples were collected using a standard corer of 5 cm diameter and 40 cm in length, for macrofauna. Suitable quadrate of 25 cm ×25 cm × 45cm size were also used to collect the benthic fauna from the study areas depending on the seasonal changes. The benthic samples were preserved using 4 % formalin. The preserved samples were washed through suitable sieves of mesh size 500μm for macro fauna and those that are retained in the sieve were collected and preserved in formalin and stained in Rose Bengal for identification (APHA, 2005, Holme and Mc Intyre, 1971).

The sediment pH was measured using a Systronics make pH meter, NO.MK VI, whereas Eh was measured using Systronics make Eh meter, No.318. Calcium, sodium and potassium in the sediment were estimated using Flame Photometer (Systronics make No 128). Total and available nitrogen, available phosphorus, and organic carbon were analyzed based on standard procedures (APHA, 2005, Jackson 1973).

The organic matter was derived from organic carbon values (El-Wakeel and Riley, 1957), whereas the energy content was obtained from organic matter using an equivalent of 21.6 J/mg dry weights (Barnes, 1959). The microbial biomass, mainly the heterotrophic and total counts were also determined (Alfred E Brown- Bensons manual 2001, APHA, 2005).

Location Map Showing Study Area in Padayatti, Palakkad Dist. Kerala

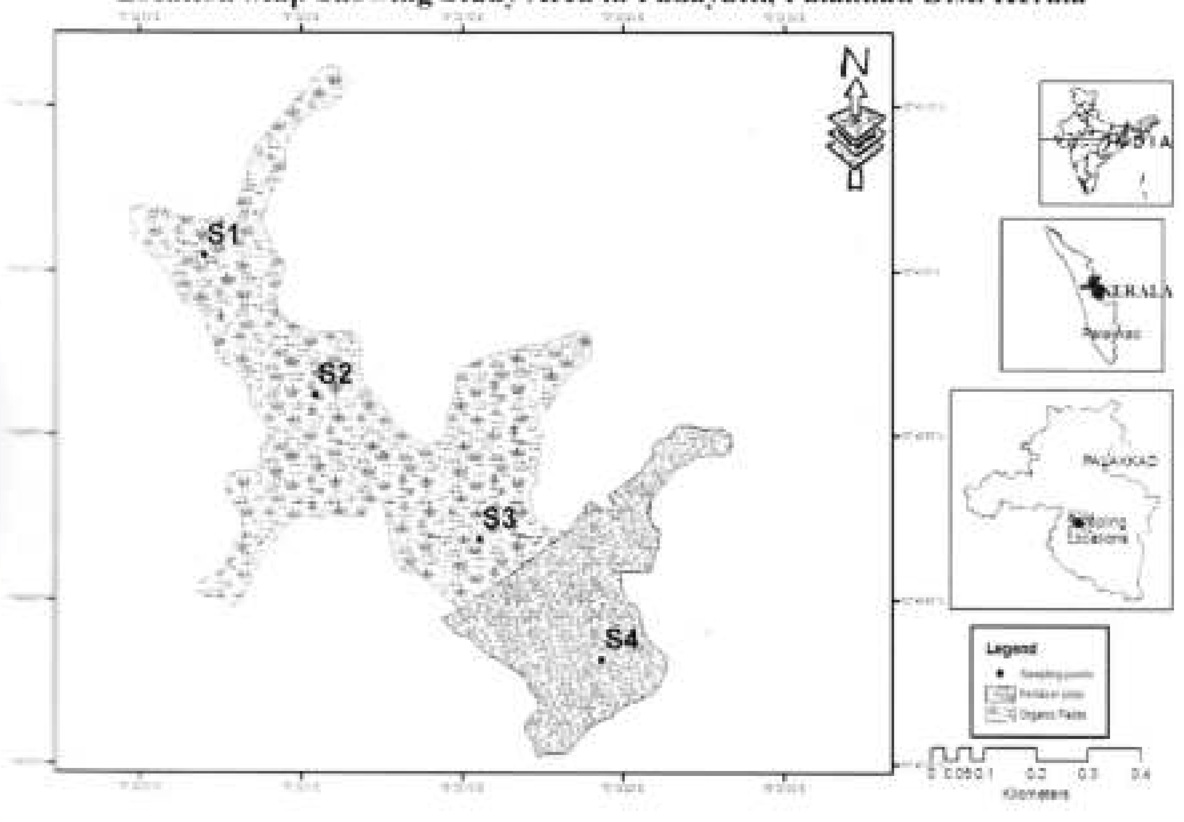


Fig. 1 Location map showing wetlands of Padayatti, Palakkad.

The benthic macrofauna were analyzed by hand picking and microscopic analysis. The standard as well as published references were employed for identification of the different fauna up to their generic or species level. (Holme and Mc Intyre, 2003, Fauvel, 1953 and other published works).

The univariate & multivariate analysis were done by statistical software's SPSS version 6. Primer v6.1 was employed for Bray-Curtis and non-metric multidimensional scaling to evaluate the variations in the parameters (Plymouth Routines in Multivariate Ecological Research).

Table 1 Details on study stations in Padayatti wetland, Palakkad .

Station	Coordinates	Manure applications	Area (in acres)
1. Organic	10° 41" 057' N 76° 32" 829' E	Vermicompost, *Panchagavaya*, Organic pest repellents etc	0.60
2. Organic	10° 41" 085' N 76° 32" 856' E	Vermicompost, *Panchagavaya*, Organic pest repellents etc.	1.30
3. Organic	10° 41" 127' N 76° 32" 882' E	Vermicompost, *Panchagavaya*, Organic pest repellents etc	1.30
4.Chemical fertilizer	10° 40" 902' N 76° 32" 777' E	Chemical manures like factomphose,Urea, ammonium sulphate, sulphur-phosphate & Chemical pesticides	0.40

Plate 1 Sampling and study stations of Padayatti wetland, Palakkad.

6 Results and Discussion

6. a Soil temperature and pH

The soil temperature varied from an average of 28.00^{0}C in the organic farming stations, to 28.4° C in the chemical application zone (St 4). The highest temperature was observed in March 2010 with a mean value of 34°C and lowest temperature of 21.6°C was observed in December 2009 (Fig.2). Soil pH is one of the most indicative measurements of the chemical properties of soil. The nutrient availability to plants and major chemical reactions as well as microbial activity was influenced by soil pH. In the present study, the average pH values were found marginally higher in organic amended stations as compared to fertilizer zones. Station wise analysis of the pH showed average values of 6.22 in st.1, 5.95 in st.2, 6.11 in st.3 and 6.03 in st.4 respectively (Fig.3).

In St.1 an average pH value of 6.22 ± 0.55 was observed. pH showed a lowest value of 5.25 in March 2010 and a highest value of 7.1 in February 2010, with a coefficient of variation (CV %) of 8.67%. The characteristic pH values showed that, pH was acidic to neutral in St.1. In St.2 soil pH showed an acidic nature, with an average value of 5.94 ± 0.61 with a highest value of 6.8 in February 2010 and a lowest value of 3.81 in September 2009, having a coefficient of variation of 7.84%. In St. 3, pH values showed an average value of 6.11 ± 0.59, with a lowest value of 5.29 in November 2009 and a highest value of 7.3 in February 2010, with a coefficient of variation of 8.13%. St.4 showed an average value of 6.02 ± 0.38 with highest value of 6.9 in February 2010 and an acidic value of 5.51 in March 2010 (CV = 8.84%).

Seasonally, wide variation in pH was observed in the four stations. An average value of 5.91 ± 0.51 was observed in monsoon 2009, 6.44 ± 0.51 in pre monsoon, 6.036 ± 0.49 during post monsoon 2009 and 6.12 ± 0.54 in monsoon 2010 respectively (Fig.4). The ANOVA of soil pH showed an overall significance at 1% level (F = 9.873) (Table 2). Duncan post hoc test also revealed that the variations were significant, where three seasons were grouped into 2 subsets, having stations 1 and 3 in subset1 and 2 in subset 2. The groupings were significant at 1% in subset 2 (Table 3). The nature of soil was mostly acidic during the monsoon in the years 2009 and 2010. pH values were almost neutral in post monsoon and slightly acidic in pre monsoon during both the years. Mean station wise analysis of dendrogram depicted that the pH was grouped in to 3 clusters with the highest similarity in organic St.3 and fertilizer St.4 (99.75%) whereas a least similarity was shown in organic station 1 (98.8%) (Fig.5). Station wise non-metric multidimensional scaling (MDS) ordination of pH concentration showed a clear distinction in the distribution of pH between organic and chemical fertilizer stations (Fig.6). All the four stations showed a similarity of 80% whereas highest similarity in pH variation was found between St.3 and St.4. Season wise, Bray- Curtis similarity profile indicated that, pH gave three clusters (Fig.7). The similarity in pH was highest in second cluster represented by St.3-monsoon 2009, St.4 monsoon 2010, St.2 post monsoon 2009 and St.4 monsoon 2009 (99.8 %), followed by cluster 1 represented by St.2 pre monsoon 2009, St.1 Monsoon 2009, St.3 Pre monsoon 2009, and St.4 monsoon 2009 (99.5%) and least in cluster 3 represented by St.1 monsoon 2009, St.1 monsoon 2010, St.4 Post Monsoon 2009, St.1 post monsoon 2009, St.2 Monsoon 2010, St.3 Monsoon 2009 and Post Monsoon 2009 (99.3%). Seasonally non-metric multidimensional scaling (MDS) ordination of pH concentration showed a similar trend in all seasons except in monsoon 2009. An overall similarity of 20% was shown in all seasons with a stress factor of 0.01 which is an excellent representation. (Fig.8). Pearson correlation analysis of pH showed a negative correlation with Eh having a significance of 0.05%.

In the present study, soil pH values were found marginally higher in the organic amended stations as compared to fertilizer zones. The pH values were mostly acidic in nature during March, May, July and August 2010 in both organic as well as fertilizer farming stations. Studies conducted in California's Sacramento Valley reported that pH values in organic farming systems experienced a rise in soil pH (Sean Clark *et al.*, 1998). This agrees with the present study where a marginal increase in values was observed in organic zones (6.091) as compared to the fertilizer zone (6.028). The rise in pH could be attributed to long-term changes in soil pH that occur as a result of displacing cations or adding sources of acidity such as H^{+} and Al^{3+} on the cation exchange complex of soils as reported by Tisdale *et al.*, (1993).

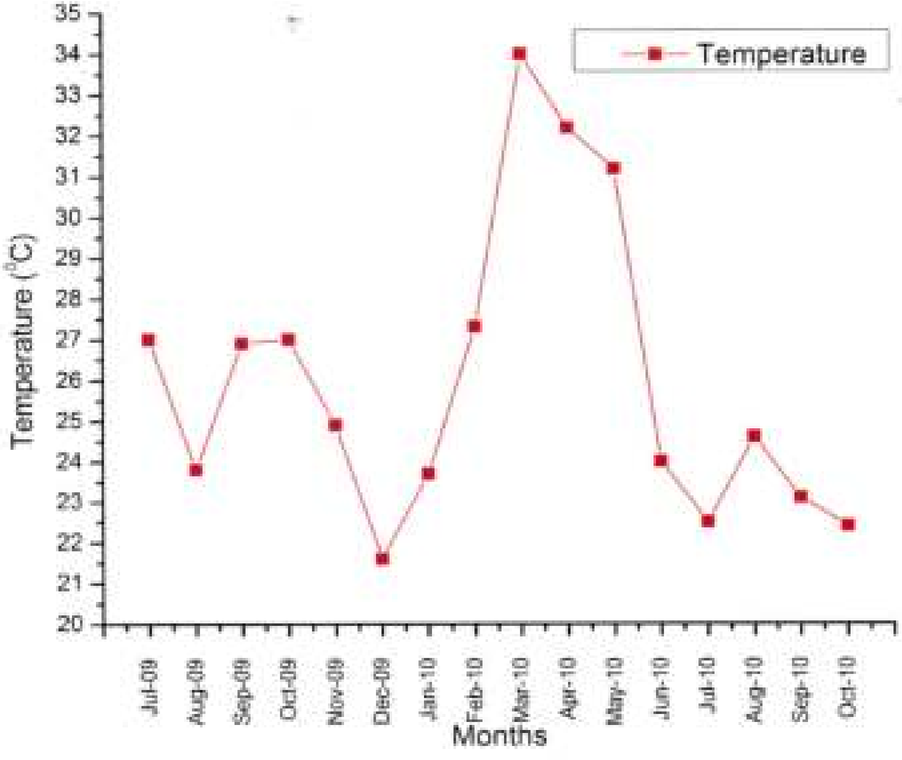


Fig.2 Monthly variation of temperature (°c) in selected stations of Padayatti wetland, Palakkad 2009-2010.

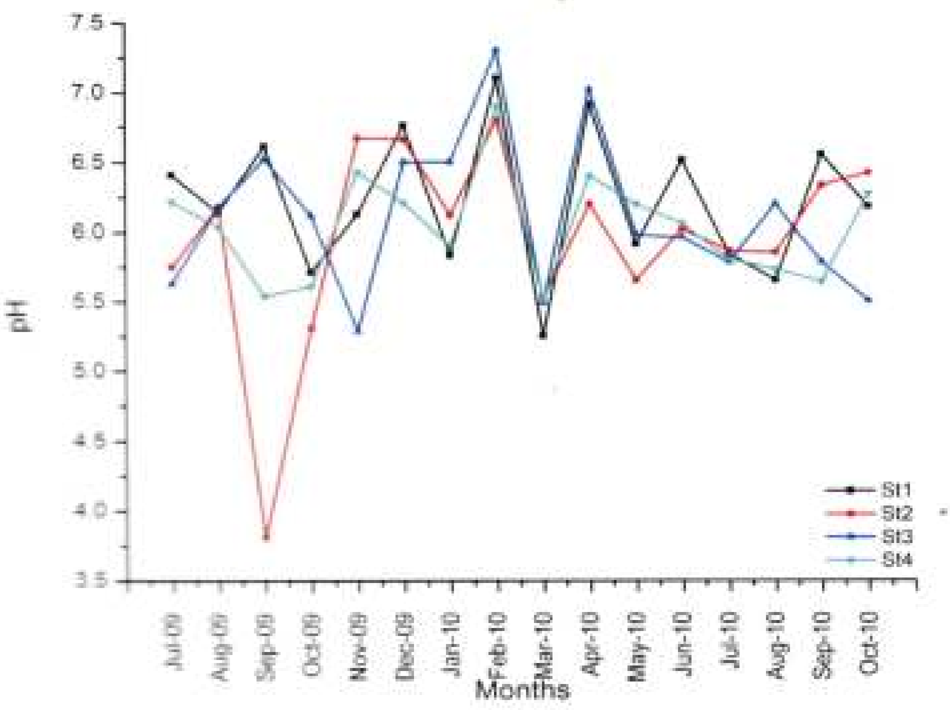


Fig.3 Monthly variation of pH in selected stations of Padayatti wetland, Palakkad during 2009-2010.

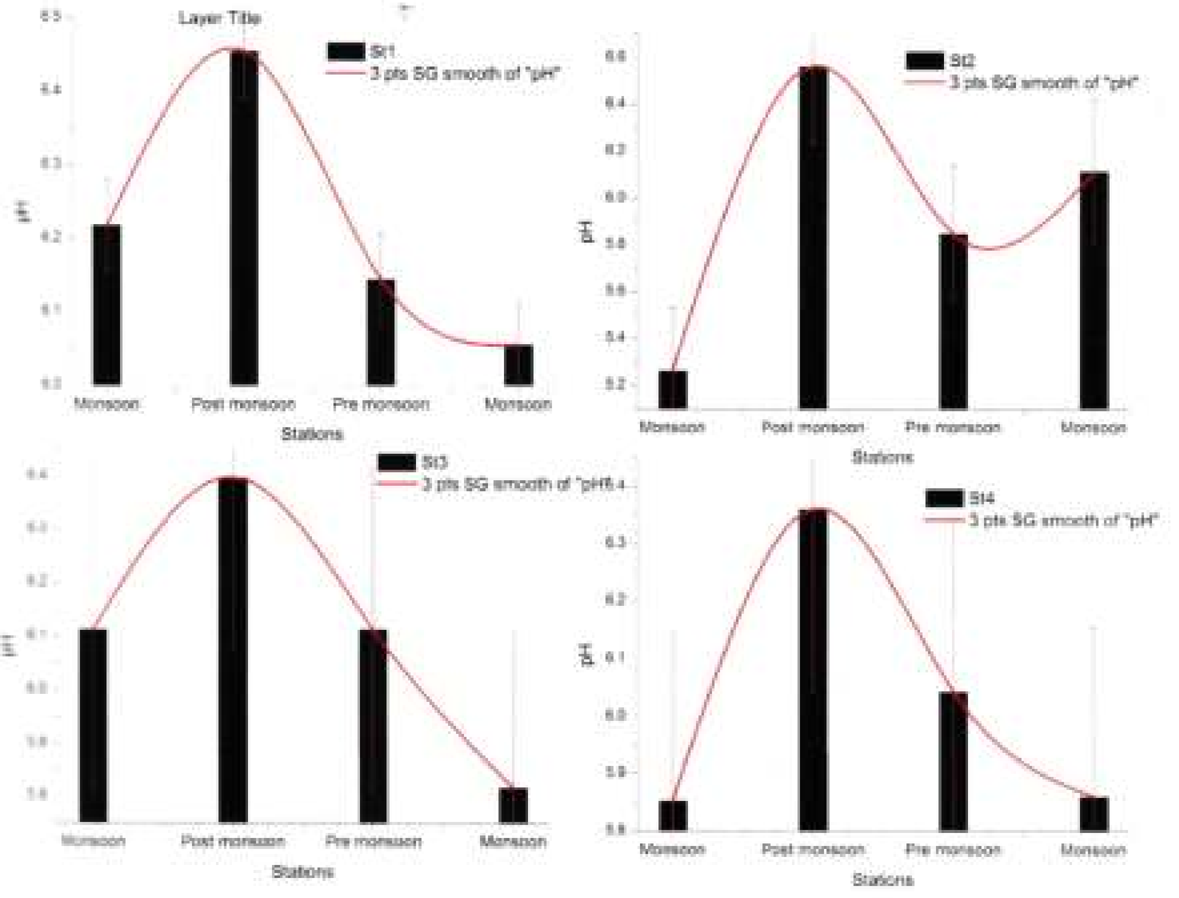


Fig.4 Seasonal variation of pH in selected stations of Padayatti wetland, Palakkad during 2009 - 2010.

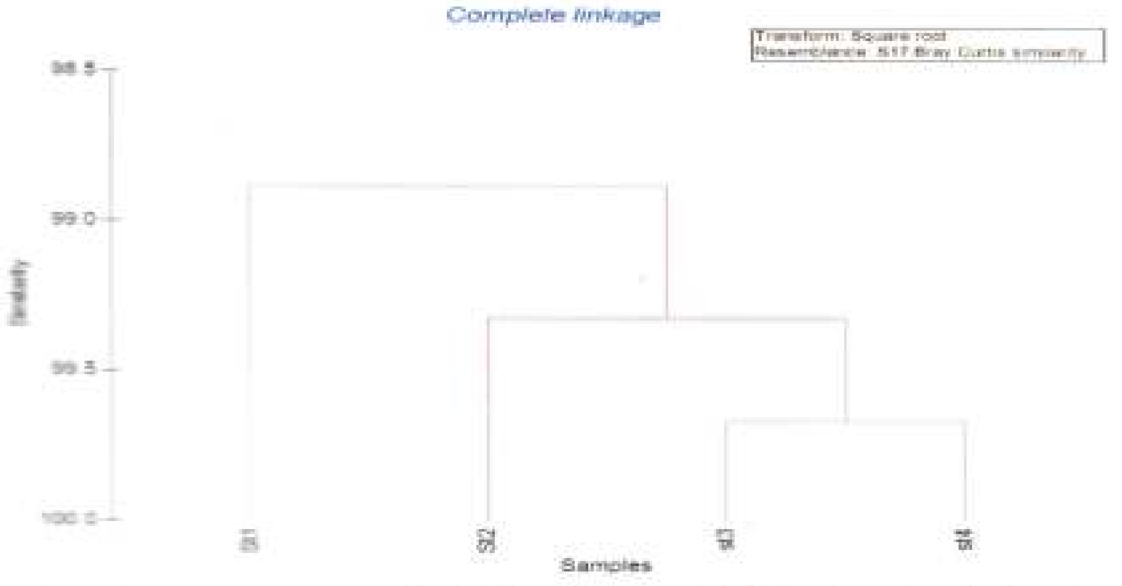


Fig.5 Station wise Bray-Curtis similarity plot of soil pH in selected wetlands of Padayatti, Palakkad 2009 - 2010.

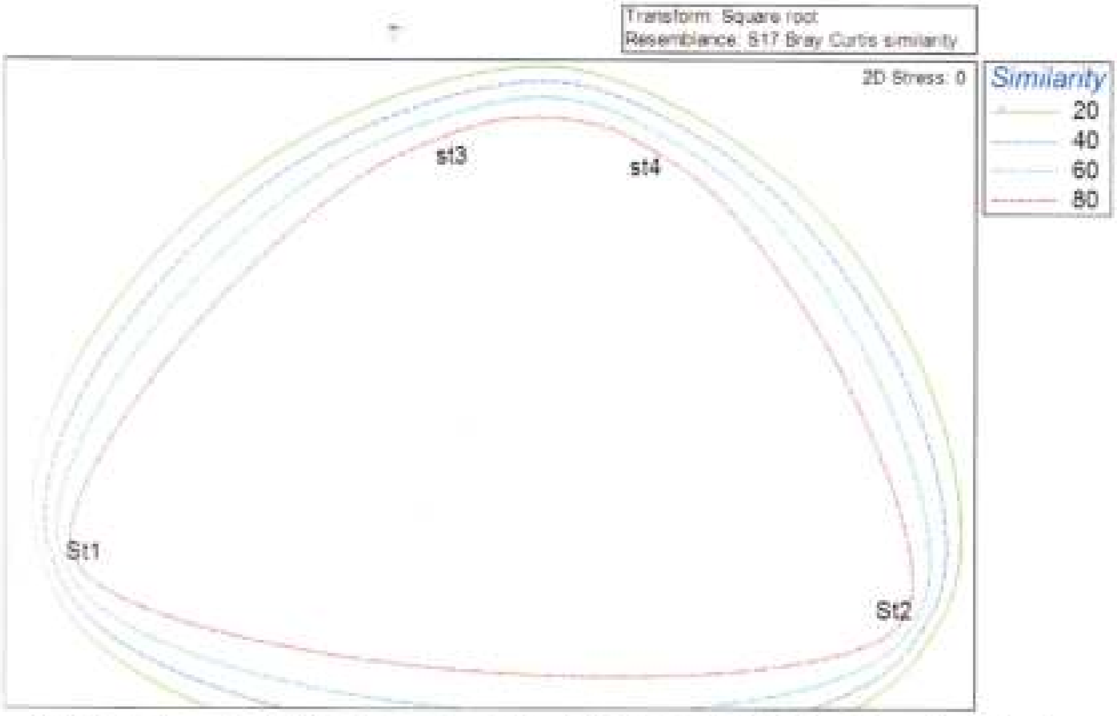


Fig.6 Station wise Multi dimensional plot (MDS) of soil pH in selected wetlands of Padayatti, Palakkad 2009 - 2010.

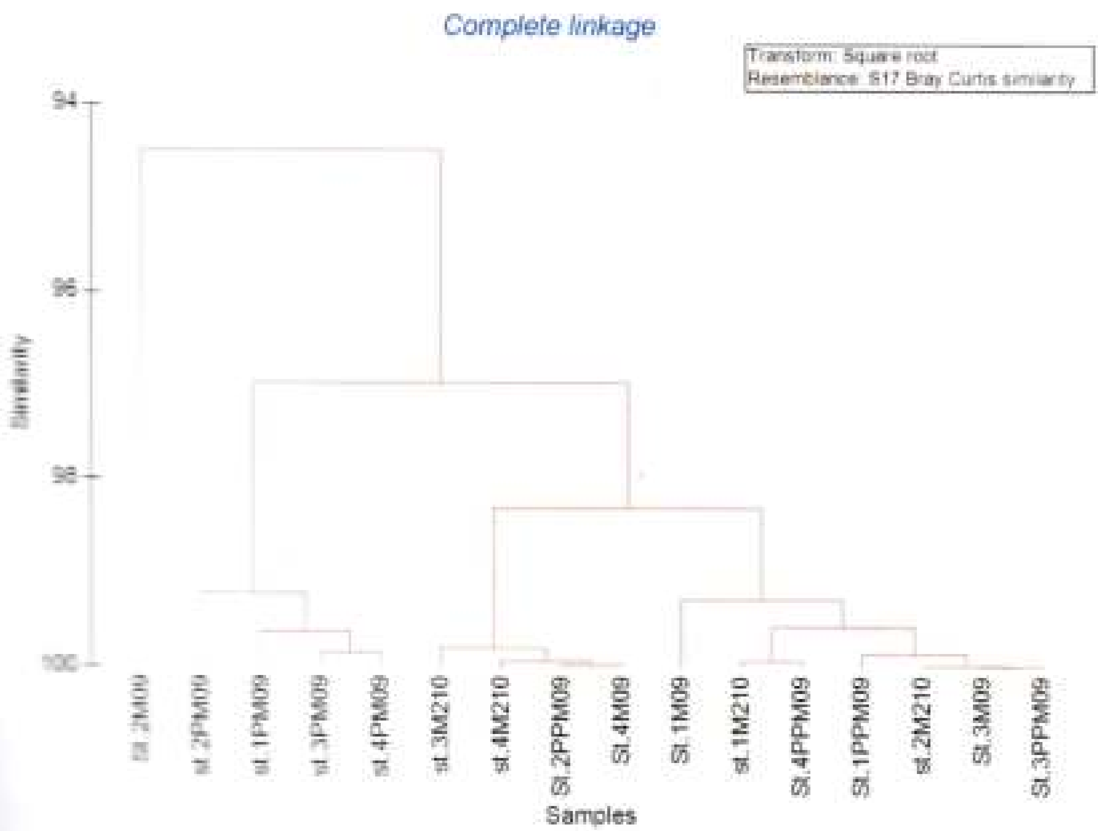


Fig. 7 Season wise Bray-Curtis similarity plot of soil ph in selected wetlands of Padayatti, Palakkad 2009 - 2010.

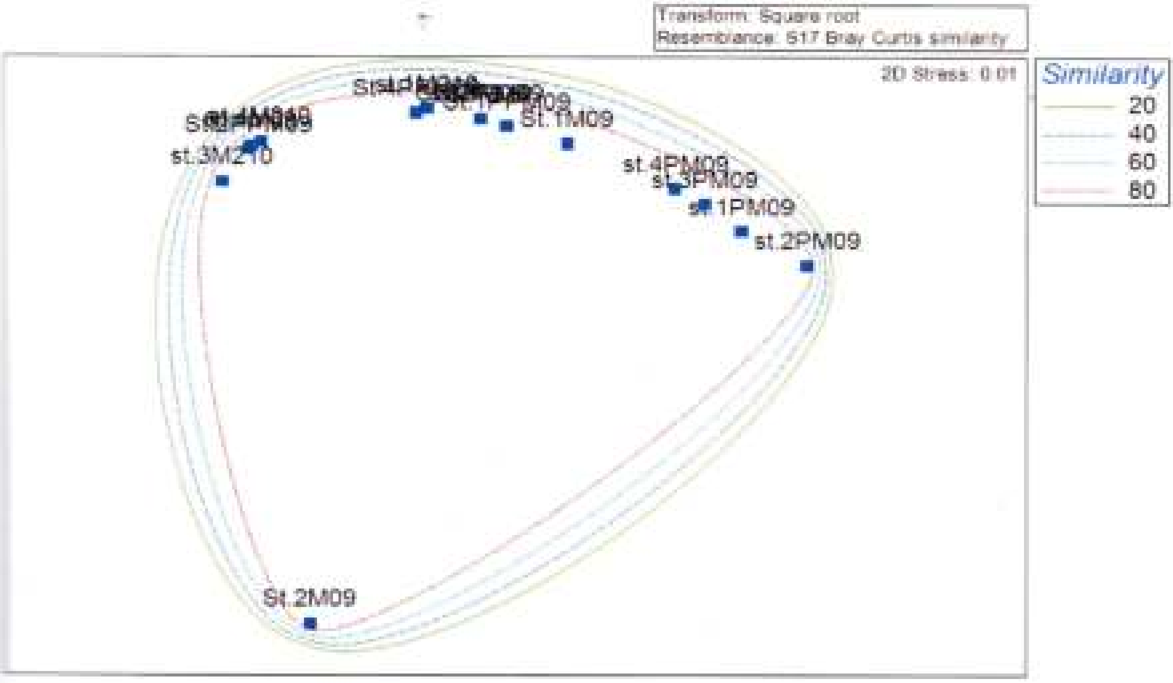


Fig. 8 Season wise Multi dimensional plot (MDS) of soil pH in selected wetlands of Padayatti, Palakkad 2009 - 2010.

Table 2 ANOVA table of pH in Padayetti wetland, Palakkad during 2009 – 2010

Source	df	Mean Square	F
Corrected Model	11	.614	2.387
Intercept	1	4059.133	15779.233
Season	2	2.540	9.873**
Station	3	.229	.890
Season * station	6	.149	.580
Error	100	.257	
Total	112		
Corrected Total	111		

R Squared = .208

**- significant at 1% level.
* - significant at 5% level.

Table 3 Post Hoc table of pH in Padayetti wetland, Palakkad during 2009-2010

pH				
	Season	**N**	**Subset**	
			1	**2**
Duncan	1	32	5.9112	
	3	48	6.0369	
	2	32		6.4438
	Sig.		.296	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square (Error) = .257.

a. Uses Harmonic Mean Sample Size =36.000.

6.2 Oxidation Reduction Potential (Eh)

Oxidation-reduction potential is the measure of electron activity of the soil and is one of the most important electrochemical properties of the soil affected by the dynamic changes, when wetlands are subjected to hydrological fluctuations. Station wise analysis of Eh showed a similar trend in all stations depending on the hydrological pattern. During the study a reducing trend was observed during the water logged months in July, August, September, and October 2010 whereas an oxidative nature was observed during the dry months of November, December, January, and February 2010 (Fig.9).

The oxidation reduction potential showed a negative trend in station1 having an average of -92.46 ± 129 mv with a lowest value of -336 mv in September 2010 and -102 mv in April 2010. Station 2 also showed an average value of -92.62 ± 148 mv with the lowest value of -339 in the month of September 2010 and a highest value of 105 in May 2010. Average Eh value of -59.9 ± 123.9 mv was observed in st.3 with a minimum value of -298 mv in August 2010 and maximum value of 126 in May 2010. Station 4 also showed a negative trend in Eh with an average value of -85 ± 101.3 mv, having a lowest value of -227mv and a highest value of 64 mv in April 2010.

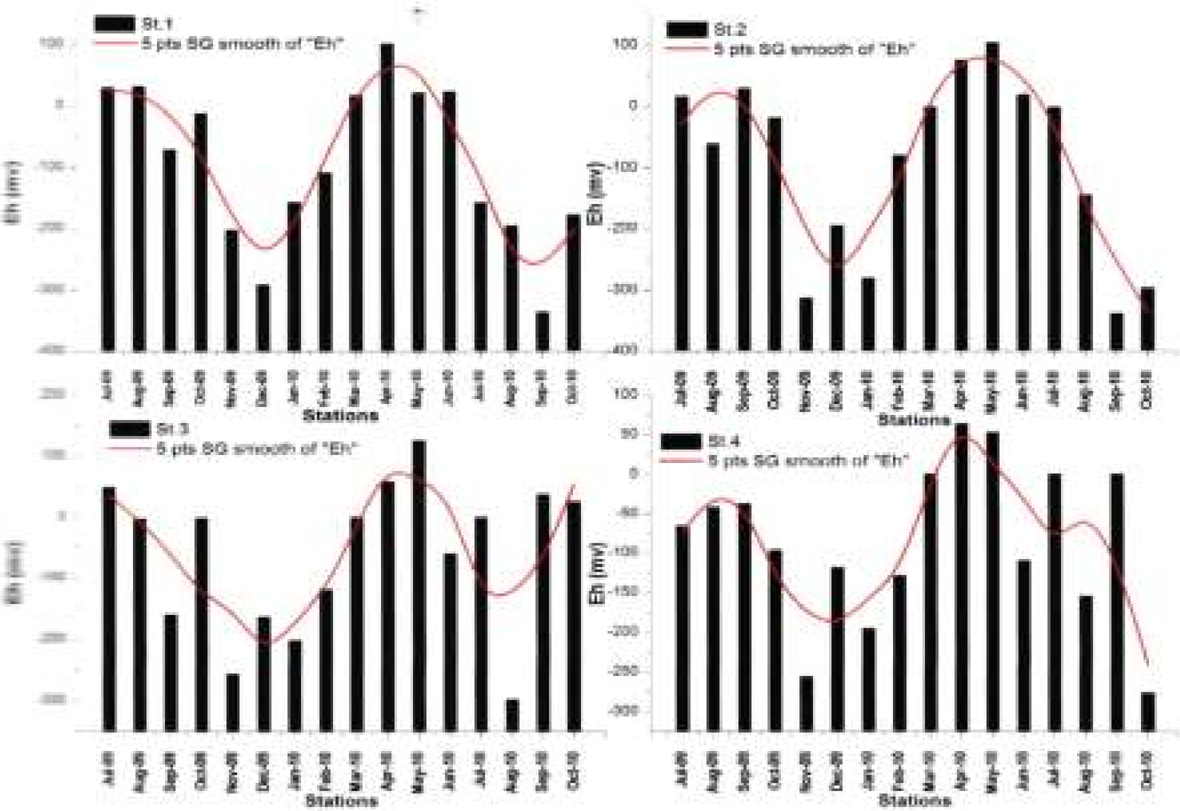


Fig. 9 Monthly distribution of Eh (MV) in selected stations of Padayatti wetland, Palakkad, during 2009- 2010

Seasonally the Eh values showed a similar trend in all stations. During the study period (2009-2010) a reducing trend in Eh was observed in all seasons except pre monsoon (Fig.10). Dynamic changes in hydrological pattern greatly influenced the oxidation reduction conditions of the system. The average values of Eh in different seasons were given in Table 3. The correlation analysis of Eh showed a positive correlation coefficient of 1% significance between Sodium, potassium and calcium concentrations. The ANOVA of pH was significant at 1% level (F = 66.855) seasonally (Table 5). The Duncan post hoc test revealed that the three seasons were grouped into 3 subsets with a significance of 1% (Table 6).

Table 4 Average seasonal variation in Eh (mv) in different stations of Padayati wetland, Palakkad during 2009-2010

Season/ Eh(mv)	St1	St2	St3	St4
Monsoon	-5.575	-5.575	-28.125	-60
Post monsoon	-189.25	-189.25	-184.5	-174.25
Pre monsoon	41.25	41.25	31.50625	2.00
Monsoon	-216.25	-216.25	-58.5173	-107.76

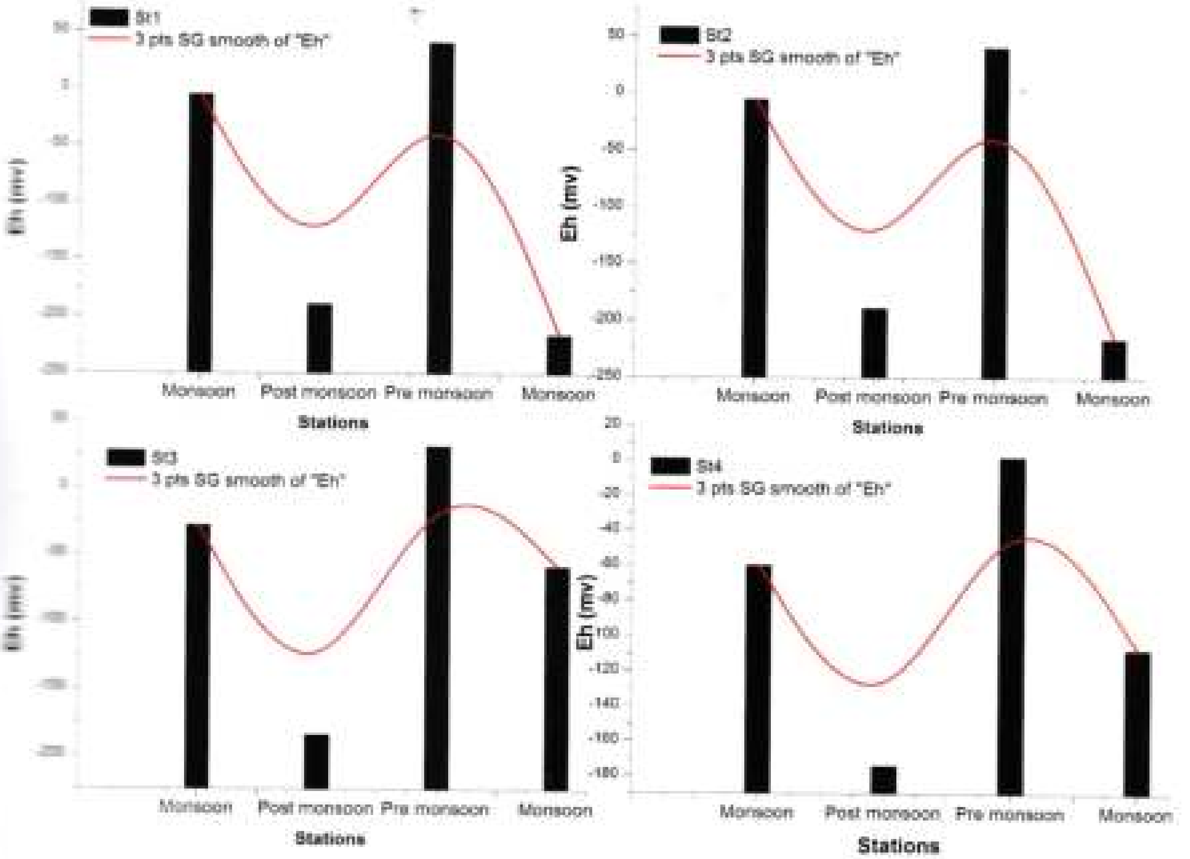


Fig.10 Seasonal distribution of Eh in selected stations of Padayatti wetland, Palakkad

Table 5 ANOVA table of Eh in Padayetti wetland, Palakkad

Source	df	Mean Square	F
Corrected Model	11	91964.049	12.723
Season	2	483225.224	66.855
station	3	3245.851	.449
Season * station	6	6257.799	.866
Error	100	7227.919	
Total	112		
Corrected Total	111		
R Squared = .583 **- significant at 1% level. * - significant at 5% level.			

Table 6 Post Hoc table of pH in Padayetti wetland, Palakkad during 2009-2010

Eh					
	Season	N	Subset		
			1	2	3
Duncan	2	32	-191.1875		
	1	32		-84.9997	
	3	48			31.1919
	Sig.		1.000	1.000	1.000
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = 7227.919.					
a. Uses Harmonic Mean Sample Size = 36.000.					

6.3 Soil Total Nitrogen (STN)

In an agricultural ecosystems soil total nitrogen (STN) is a major determinant and indicators of soil fertility (Reeves, 1997). Thus a reduction in total nitrogen levels will result in decrease in soil fertility, soil nutrient supply, and thus soil productivity (Gray and Morant, 2003). The station wise analysis of total nitrogen in the paddy wetlands of Padayatti depicted an average value of 0.739% in st.1, 0.768% in st.2, 0.85% in st.3 and 0.769% in st.4 respectively (Fig. 11).

In St.1 an average value of 0.739±0.508% was observed. Total Nitrogen showed a lowest value of 0.265% in the month of January 2010 and a highest value of 1.825% in December 2009, with a coefficient of variation (CV %) of 68.3%. In station 2 variations in soil total nitrogen showed an average value of 0.768 ± 0.779 %, with a lowest value of 0.096% in the month September 2010 and a highest value of 2.934% in November 2009, having a coefficient of variation of 101.41%. An average percentage value of 0.849 ± 0.779 in total nitrogen were observed in St.3, with a lowest reported value of 0.222% in January 2010 and a highest observed value of 2.78% in November 2009 (CV=91.38). St.4 the chemical fertilizer zone, showed an average value of 0.77 ± 0.556 % in STN, with a lowest observed value of 0.236% in the month May 2010 and a highest value of 2.01% in November 2009, with a coefficient of variation of 72.24%.

Seasonally wide variation in total nitrogen was observed in the four stations (Fig. 12). A mean total nitrogen value of 1.02% was observed in monsoon 2009, 1.2% in pre monsoon

St. 1to 3. Whereas an average value of 0.895% in monsoon 2009, 1.15 in post monsoon 2009, 0.44 during post monsoon 2009 and 0.59 in monsoon 2010 was observed in chemical fertilizer applied St.4. During the monsoon, St.1 showed a highest average value of 1.0569 % in 2009, whereas highest value of 1.4% was observed in St.2 during post monsoon. In the pre monsoon highest mean value of 0.503% was reported in St.3 and 0.59% in St.4 during monsoon. In all the stations the percentage variation of STN was low in both pre monsoon and monsoon whereas elevated concentrations were observed during post monsoon period. The ANOVA of soil total nitrogen showed an overall significance at 1% level (F = 14.182) (Table 7). In Duncan post hoc analysis, the 3 seasons were grouped into 3 subsets and were significance at 1% level. The correlation coefficient analysis of soil total nitrogen showed a positive correlation between organic carbon, organic matter significant at 1% level (Table 8).

Mean station wise analysis of dendrogram depicted highest similarity in organic (St.2) and fertilizer St.4 (99%), whereas a least similarity was shown in organic st.3 (97.5%) (Fig.13). Station wise non-metric multidimensional scaling (MDS) ordination of total nitrogen concentration showed a clear distinction in variation of total nitrogen between organic and chemical fertilizer stations (Fig.14). All the four stations showed a similarity of 80% whereas highest similarity in total nitrogen variation was found between St.2 and St.4. Season wise Bray-Curtis similarity profile for total nitrogen showed four clusters (Fig.15). The similarity in total nitrogen was highest in third cluster (98%) represented by St.1 post monsoon 2009, St.2 monsoon 2009 and St.4 monsoon 2009. Cluster 1 showed 96% similarity in seasonal distribution of total nitrogen represented by St.4 monsoon 2010, St.1 post monsoon 2009 and monsoon 2010. Followed by cluster 2 with a similarity of 96% represented by St 2 post monsoon 2009, St 2 monsoon 2010, and St.4 post monsoon 2009, St.3 post monsoon 2009 and St.3 monsoon 2010. Least similarity was found in cluster 4 having a similarity of 91% represented by St.2 monsoon 2009, St.3 monsoon 2009, st.4 monsoon 2009, St.1 monsoon 2009 and St.3 monsoon 2009. Seasonally non-metric multidimensional scaling (MDS) ordination showed that of total nitrogen concentration were similar in all seasons with an overall similarity of 20% (Fig.16) whereas it was highly similar at about 80% between St.1, St.2, St.3, and St.4 during post monsoon 2009 and St.1 and St.2 in Monsoon 2009. Seasonally, in all the four stations monsoon and pre monsoon, periods showed highest concentrations of total nitrogen. The organic farming zones represented by St.1 to St.3 showed comparatively higher total nitrogen values as compared to the fertilizer amended zone St.4. However the overall examination of the data could not evolve any remarkable variability among the fertilizer or organic amended zones. Studies conducted by Gosling and

Shepherd (2004) observed that the higher nitrogen content was related to organic fertilizer application. Total nitrogen has a significant correlation with soil organic matter and an enhancement in the total nitrogen content under organic fertilizer application were reported by Saeid Hojati and farshid Nourbakhsh (2006) due to high loading of organic C and N in the organic materials.

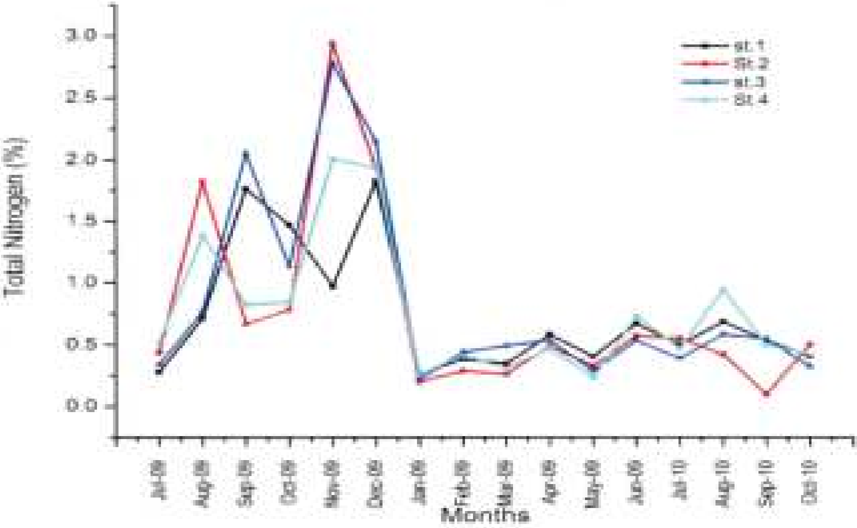


Fig.11 Monthly variation of soil total nitrogen(%) in selected stations of Padayatti wetland, Palakkad during 2009-2010.

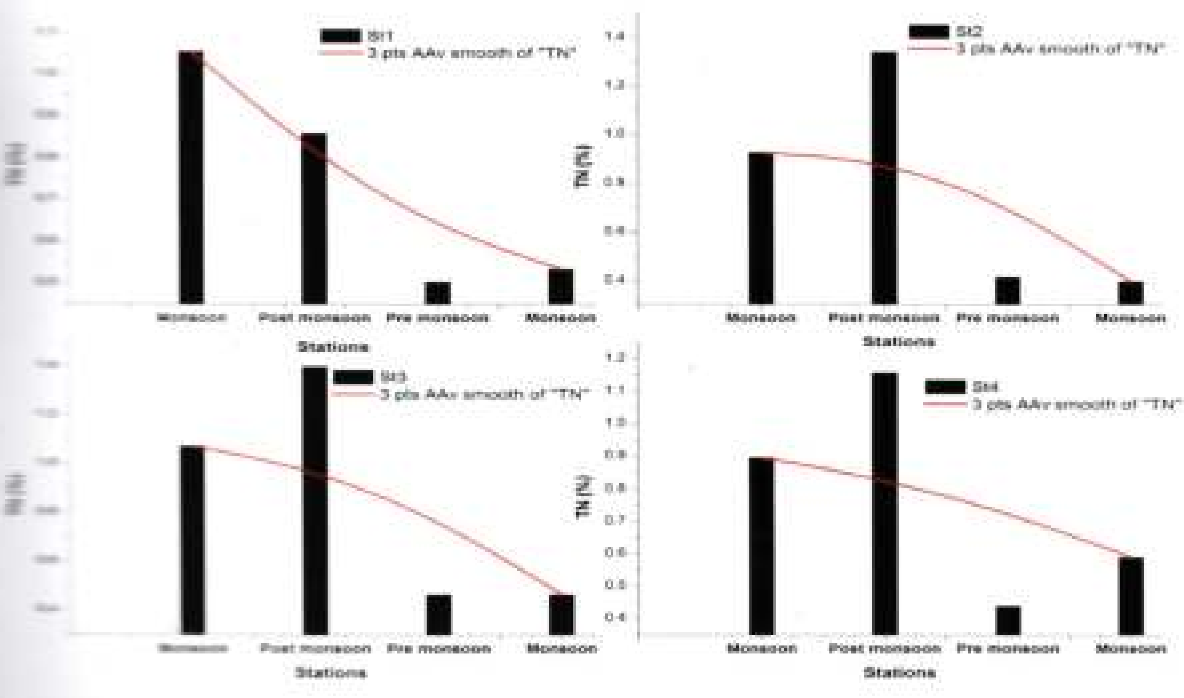


Fig.12 Seasonal variation of Total Nitrogen (%) in selected stations of Padayetti wetland, Palakkad during 2009-2010.

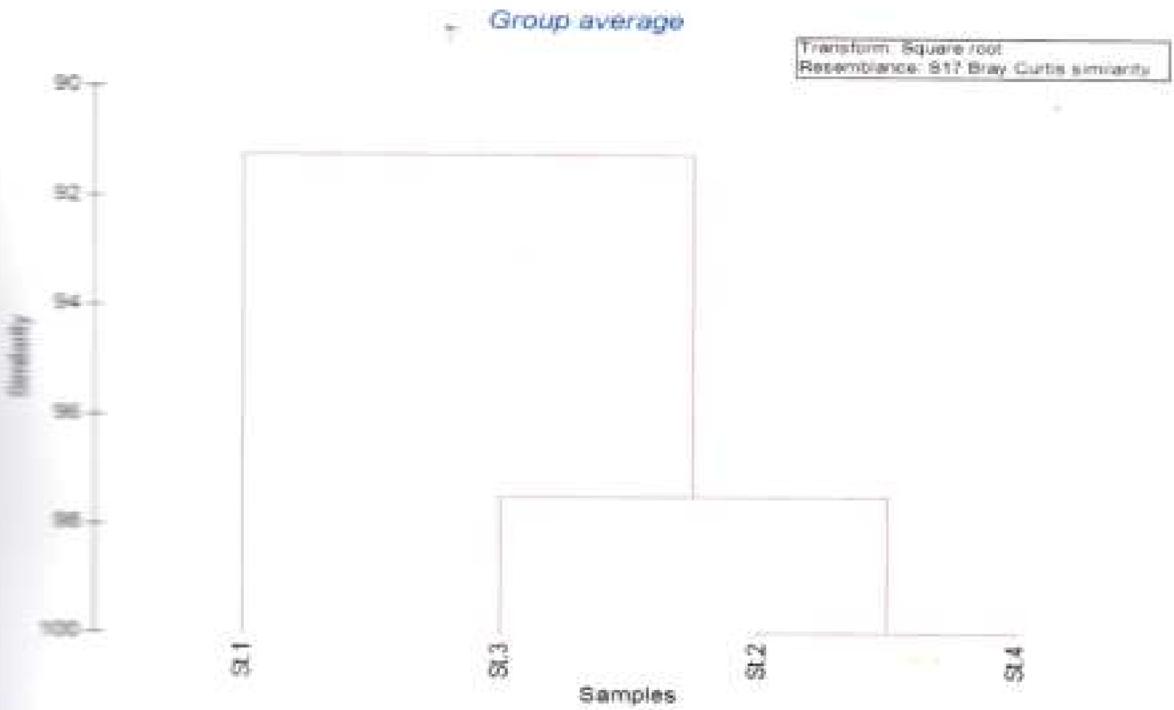


Fig.13 Station wise Bray-Curtis similarity plot of soil Total Nitrogen (%) in selected wetlands of Padatati, Palakkad during 2009-2010.

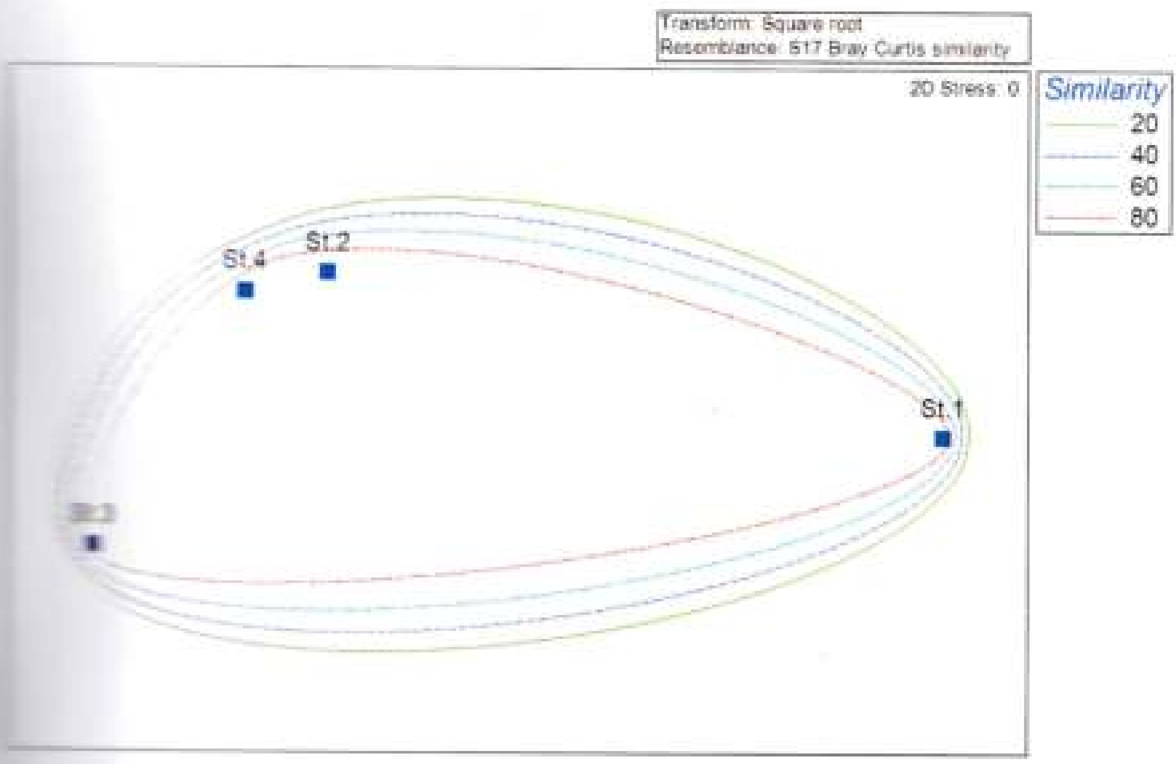


Fig.14 Station wise Multi dimensional plot (MDS) of Total Nitrogen (%) in selected wetlands of Padayatti, Palakkad during 2009-2010.

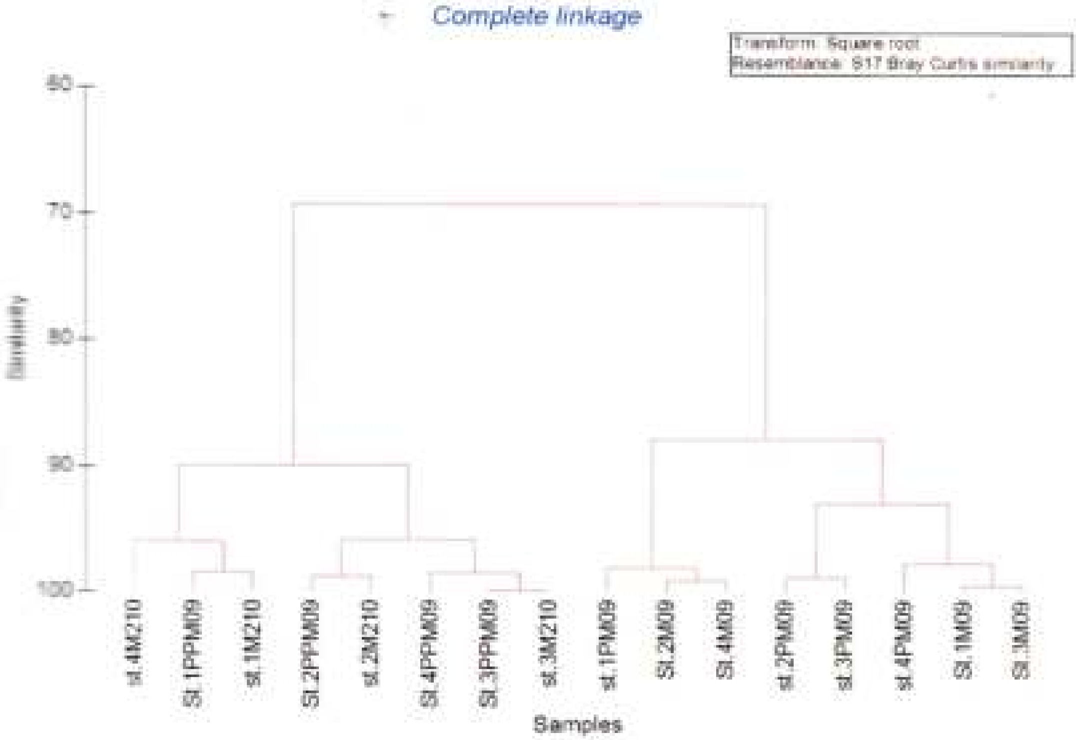


Fig.15 Season wise Bray-Curtis similarity index of Soil Total Nitrogen (%) in selected wetlands of padayati, Palakkad during 2009-2010.

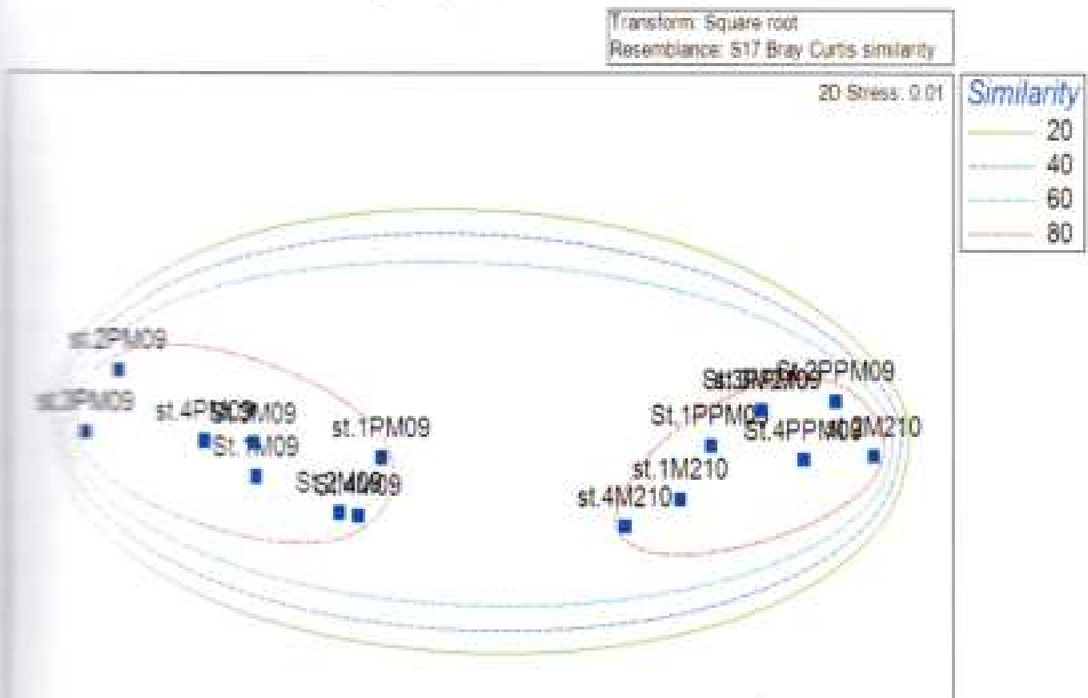


Fig.16 Multi dimensional plot (MDS) of Soil Total Nitrogen (%) in selected wetlands of Padayati, Palakkad during 2009-2010.

Table 7 ANOVA table of Total Nitrogen (%) in Padayati wetland, Palakkad

Source	df	Mean Square	F
Corrected Model	11	1.080	2.961**
Intercept	1	68.195	186.989**
Season	2	5.172	14.182**
station	3	.114	.314
Season * station	6	.215	.590
Error	100	.365	
Total	112		
Corrected Total	111		
R Squared = .246,	* 5 % level of significance ** 1% level of significance		

Table 8 Post Hoc table of pH in Padayetti wetland, Palakkad during 2009-2010

TN					
	Season	N	Subset		
			1	2	3
Duncan	3	48	.4542		
	1	32		.7415	
	2	32			1.1882
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = .365.
Uses Harmonic Mean Sample Size = 36.000.

6.4 Available Nitrogen

In the present study station wise analysis of the soil available nitrogen depicted no profound variations between the organic amended and chemical fertilizer stations. A mean value of 0.047% was observed in the four stations. Station wise analysis showed an average value of 0.0592 ± 0.079 % in st.1 with a lowest reported value of 0.0064% in the month of April 2010 and a highest value of 0.355% in October 2010. St.2 showed an average value of 0.399 ± 0.0095 % with a lowest value of 0.0131 % in April 2010 and a highest value of 0.054% in September 2010. An average value of 0.0448 ± 0.0096 % was observed in st.3 with a highest value of 0.071% in September 2009 and lowest value of 0.0321% in September 2010. St.4 showed an average value of 0.0449 ± 0.0060 % with lowest reported value of 0.0327% in September 2010 and highest value of 0.0556% in June 2010 (Fig.17).

Seasonally wide variation in available nitrogen was observed in the four stations (Fig.18). An average value of 0.522 ±0.056 % was observed in monsoon 2009, 0.438 ± 0.055% in post monsoon, 0.405± 0.013% in pre monsoon 2009 and 0.448± 0.032 % monsoon 2010 respectively. The average percentage composition of available nitrogen in St.1 in monsoon 2009, Post monsoon 2009, pre monsoon 2010 and monsoon 2010 was 0.115, 0.0425, 0.036 and 0.431 respectively. In St.2 it was 0.037 % in monsoon 2009, 0.043% in post monsoon, 0.036 in pre monsoon and 0.042% in monsoon 2010. In St.3 the average percentage composition of available nitrogen varied from 0.0386 in monsoon 2009, 0.044% in post monsoon 2009, 0.043% in pre monsoon 2010 and 0.053 % in monsoon 2010. In St.4 concentrations varied from 0.046 % in monsoon 2009, 0.045% in post monsoon 2009, 0.0465% in pre monsoon 2010 and 0.0414 % in monsoon 2010.

Mean station wise analysis of dendrogram depicted highest similarity in organic St.3 and fertilizer Zone St.4 (100%) whereas a least similarity was in organic zone st.2 (95%) (Fig. 19). Station seen wise non-metric multidimensional scaling (MDS) ordination of total nitrogen concentration showed a clear distinction in variation of available nitrogen between organic and chemical fertilizer stations (Fig.20). All the four stations showed a similarity of 80% whereas highest similarity in total nitrogen variation was found between St.3 and St.4. Season wise Bray-Curtis similarity profile for total nitrogen showed four clusters (Fig.21). The similarity in total nitrogen was highest in third cluster (98%) represented by St.1 post monsoon 2009, St.2 monsoon 2009 and St.4 monsoon 2009. Cluster 1 showed 96% similarity in seasonal distribution of total nitrogen represented by St.4, monsoon 2010, St.1 post monsoon 2009 and monsoon 2010. In cluster 2 a similarity profile of 96%, were represented by St 2 post monsoon 2009, St 2 monsoon 2010, and St.4 post monsoon 2009, St.3 post monsoon 2009 and St.3 monsoon 2010. Least similarity was found in cluster 4 having a similarity of 91% represented by St.2 monsoon 2009, St.3 monsoon 2009, st.4 monsoon 2009, St.1 monsoon 2009 and St.3 monsoon 2009. Seasonally non-metric multidimensional scaling (MDS) ordination showed that of total nitrogen concentration were similar in all seasons with an overall similarity of 20% whereas it was highly similar at 80% between St.1, St.2, St.3, and St.4 during post monsoon 2009 and St.1 and St.2 in monsoon 2009 (Fig.22).

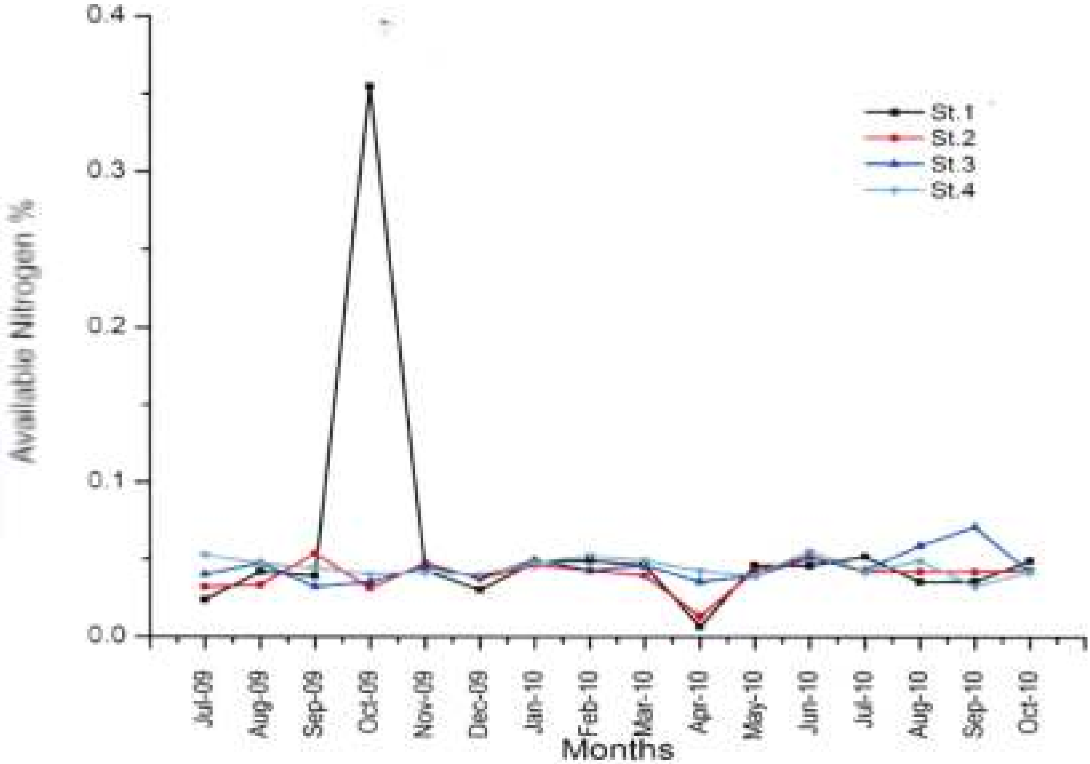


Fig.17 Variation of available nitrogen (%) in selected stations of Padayati wetland, Palakkad during 2009-2010

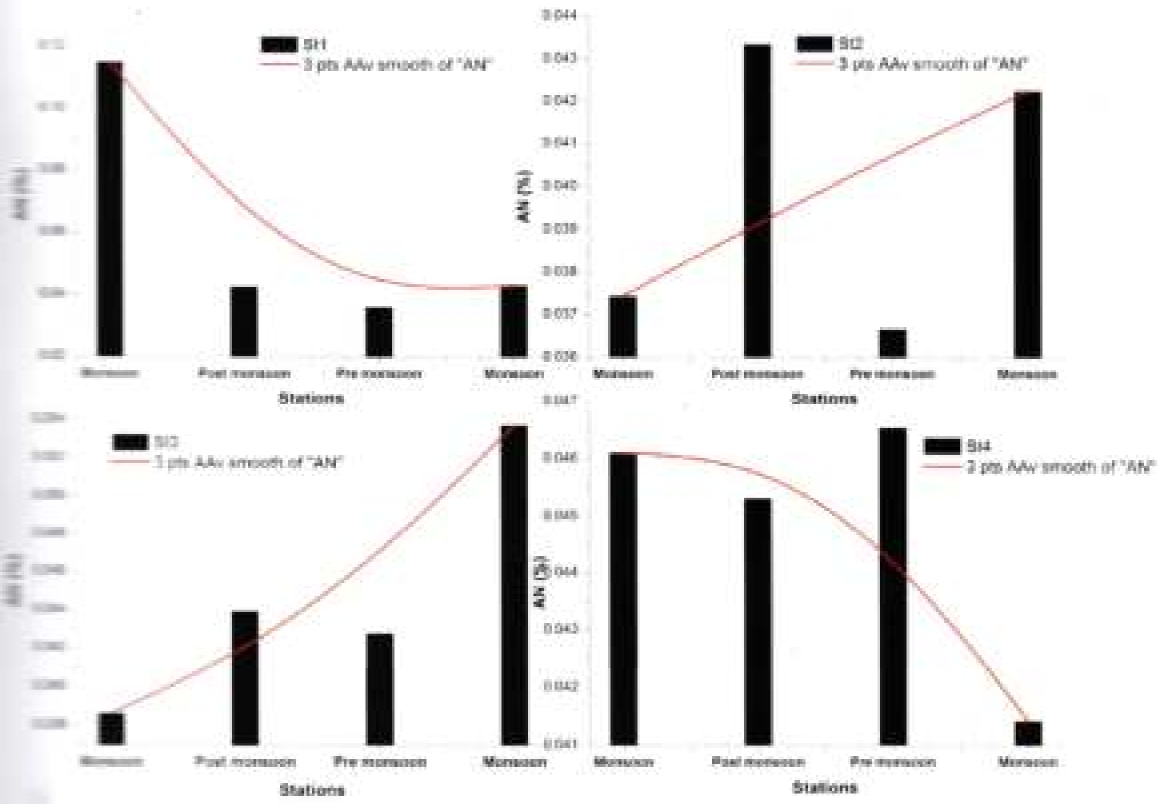


Fig.18 Seasonal variation of available nitrogen % in selected stations of Padayati

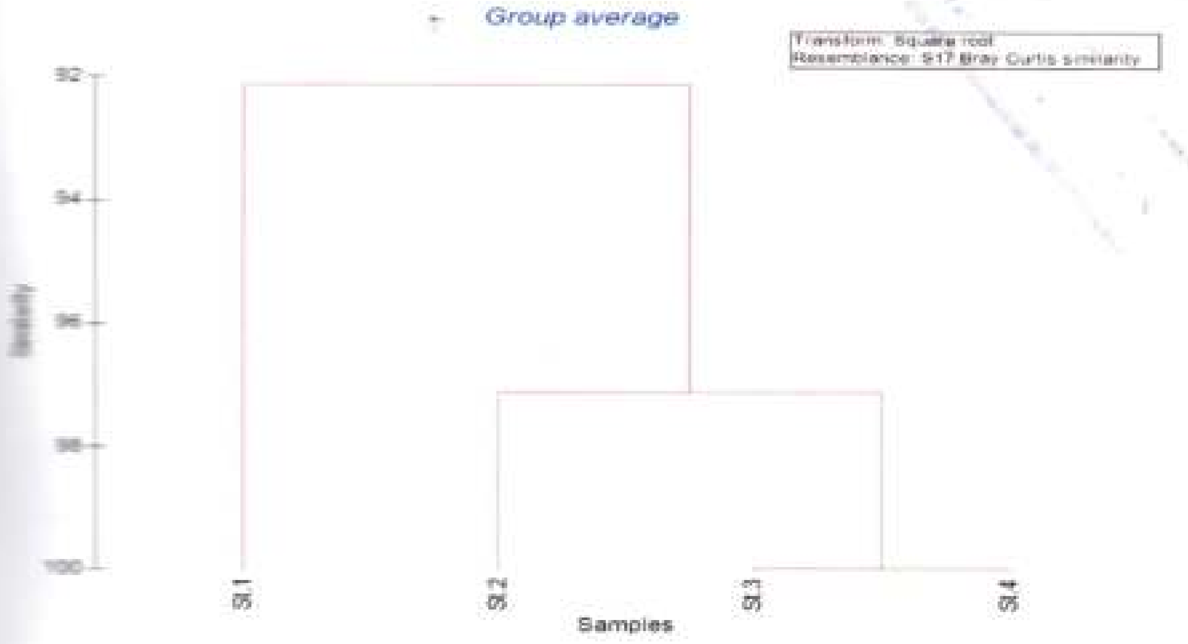


Fig. 19 Station wise Bray-Curtis similarity plot of Available Nitrogen (%) in selected wetlands of Padatati, Palakkad during 2009-2010.

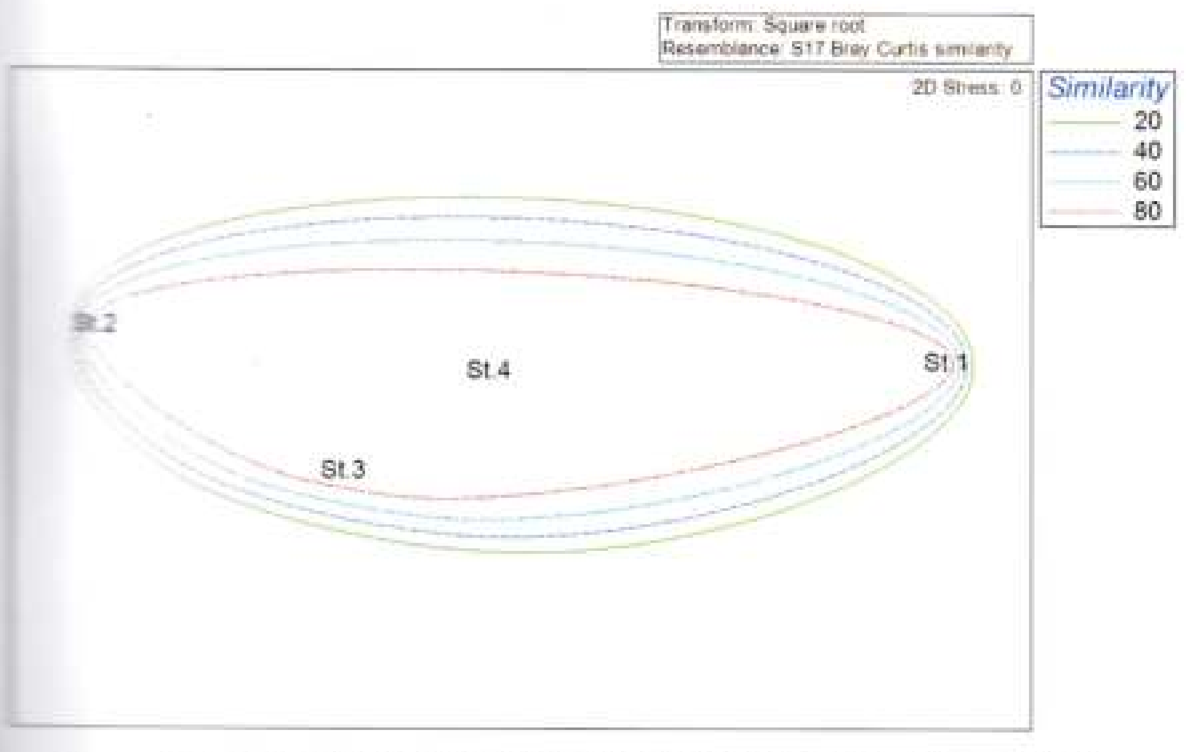


Fig.20 Station wise Multi dimensional plot (MDS) of Available Nitrogen (%) in selected wetlands of Padayatti, Palakkad during 2009-2010.

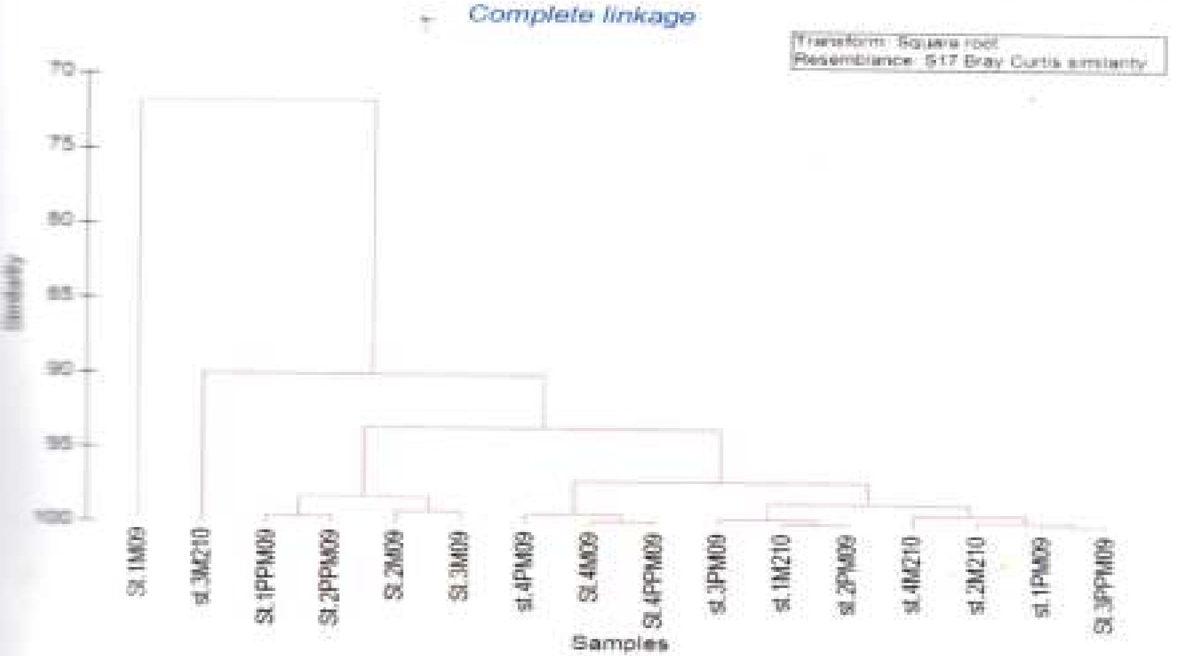


Fig.21 Season wise Bray- Curtis similarity of soil available nitrogen (%) in selected wetlands of Padayatti, Palakkad during 2009-2010.

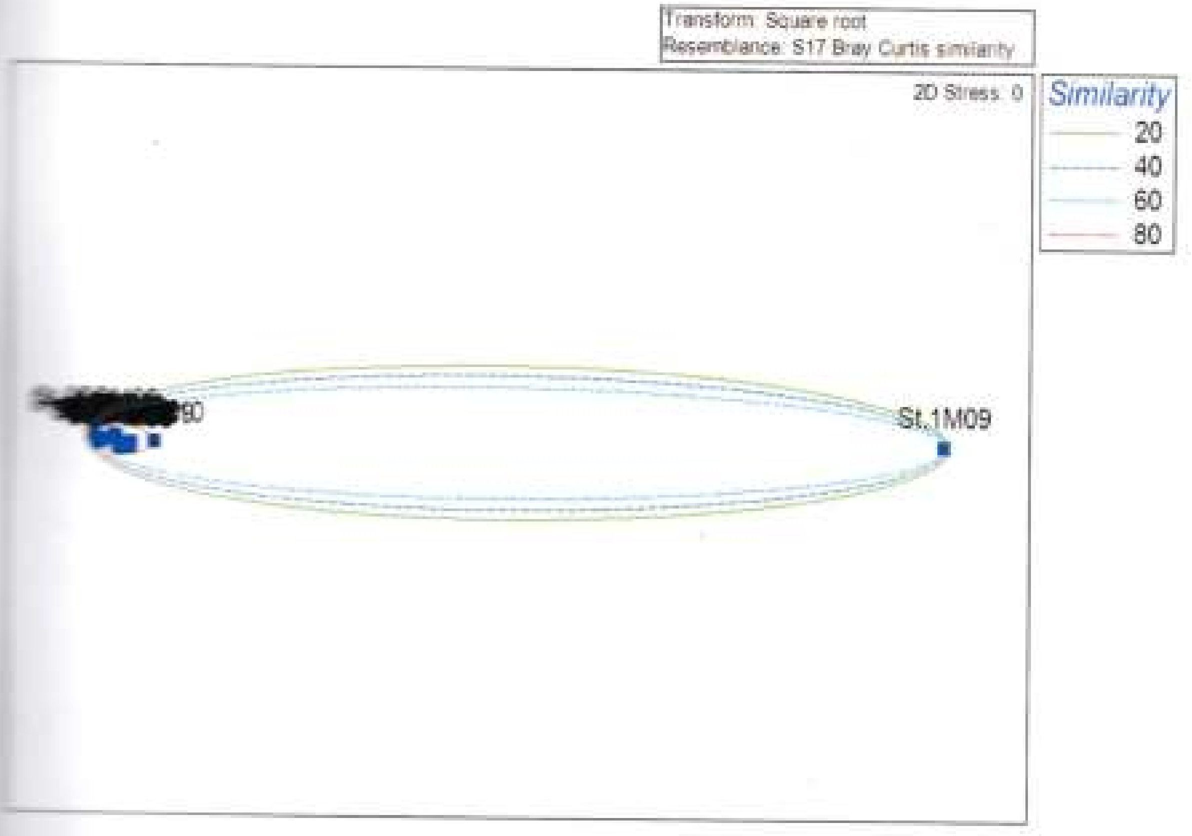


Fig.22 Season wise multi dimensional plot (MDS) of soil available nitrogen (%) in selected wetlands of Padayatti, Palakkad during 2009-2010.

Table 9 ANOVA table of Available Nitrogen in Padayati wetland, Palakkad during 2009-2010

Source	df	Mean Square	F
Corrected Model	11	.001	1.074
Intercept	1	.224	230.113**
Season	2	.001	1.378
station	3	.001	.755
Season * station	6	.001	1.231
Error	100	.001	
Total	112		
Corrected Total	111		

R Squared = .106

* 5 % level of significance
** 1% level of significance

Table 10 Post Hoc table of pH in Padayetti wetland, Palakkad during 2009-2010

An			
	Season	N	Subset
			1
Duncan	3	48	.0405
	2	32	.0438
	1	32	.0522
	Sig.		.136

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .001.
a. Uses Harmonic Mean Sample Size = 36.000.

6.5 Available Phosphorus

Phosphorus is one of the limiting essential element classified as a macronutrient because of the relatively large requirement by plants. Station wise analysis of available phosphorus showed an average value of 76.89 ± 67.14 mg/g in St.1, with a lowest value of [illegible] mg/g in August 2009 and a highest value of 209.62 mg/g in June 2010. In St.2 the [illegible]

152.74 mg/g in July 2010 and minimum value of 1.05 mg/g in July 2009. In St.3 the average value of phosphorus was 61.76 ± 49.13 mg/g with the value of 0.129 mg/g in the month September 2009 and a highest value of 129.09 mg/g in September 2010. In St.4 Phosphorus showed a mean value of 67.44 ± 58.12 mg/g with a lowest value of 0.034 mg/g in September 2010 and a highest value of 67.436 mg/g August 2010 (Fig.23).

Seasonally wide variation in phosphorus concentrations was observed in the four stations (Fig.24). ANOVA of soil phosphorus showed an overall significance at 1% level (F =21.263) (Table 11). Duncan Post hoc analysis showed that seasons were grouped in to 3 subsets, where stations 1, 2 and 3 are in subsets 1, 2 and 3 respectively and the groupings are significant at 1% level (Table 12). An increasing trend in phosphorous concentration was observed in all stations during the study period 2009 – 2010. Seasonally, in St.1 phosphorus showed the highest average value of 130.82 mg/g during monsoon 2010. In St.2 highest value of 109.5 mg/g was observed during pre monsoon 2009. An average highest value of 113.94 mg/g was observed in monsoon 2010 in St.3 and in St.4 the highest concentration of 131.41phosphorus was observed during monsoon 2010.

Mean station wise analysis of dendrogram depicted that the phosphorus was grouped in to 2 clusters with the highest similarity in organic zone St.1 and St.3 (98%) whereas a least similarity was shown in st.2 and St.4 (96%) (Fig.25). Station wise non-metric multidimensional scaling (MDS) ordination of phosphorus showed a clear distinction in the distribution between organic and chemical fertilizer stations. All the four stations showed a similarity of 80% whereas highest similarity in pH variation was found between St.1 and St.2 (Fig.26). Season wise, Bray- Curtis similarity profile indicated that, pH gave three clusters (Fig.27). The similarity in pH was highest in second cluster represented by St.1- pre monsoon 2009, St.5 monsoon 2009, St.3 post monsoon 2009 and St.2 pre monsoon 2009 (95 %), followed by cluster 1 represented by St.2 pre monsoon 2009, St.1 Monsoon 2009, St.3 Pre monsoon 2009, and St.4 monsoon 2009 (99.5%) and least in cluster 3 represented by St.1 monsoon 2009, St.1 monsoon 2010, St.4 Post monsoon 2009, St.1 post monsoon 2009, St.2 monsoon 2010, St.3 monsoon 2009 and Post monsoon 2009 (99.3%). Seasonally non-metric multidimensional scaling (MDS) ordination of pH concentration showed a similar trend in all seasons except in monsoon 2009. An overall similarity of 20% was shown in all seasons with a stress factor of 0.01 which is an excellent representation with no prospect of misrepresentation (Fig.28).

The correlation coefficient analysis of phosphorous showed a positive correlation between Eh, energy content, sodium, potassium and calcium significant at 1% level. The average available phosphorous concentration showed only marginal variation among the organic and fertilizer amended zones. During the study period available phosphorous were observed with its highest concentration in organic zone, St.1 and St.2, whereas the concentrations were lowest in station St.3. Studies show that concentrations of extractable P after conversion to organic management were considerably low in organic managed areas than conventionally managed fields. However, the results do offer support to the argument that organic farming is mining reserves of phosphorus built up by conventional management (Gosling and Shepherd 2005). However studies conducted in more than 30 farms in England under conventional and organic management zones reported that no significant difference in available P concentrations were found between organic and fertilizer amended zones (Sean Clark *et al* 1998).

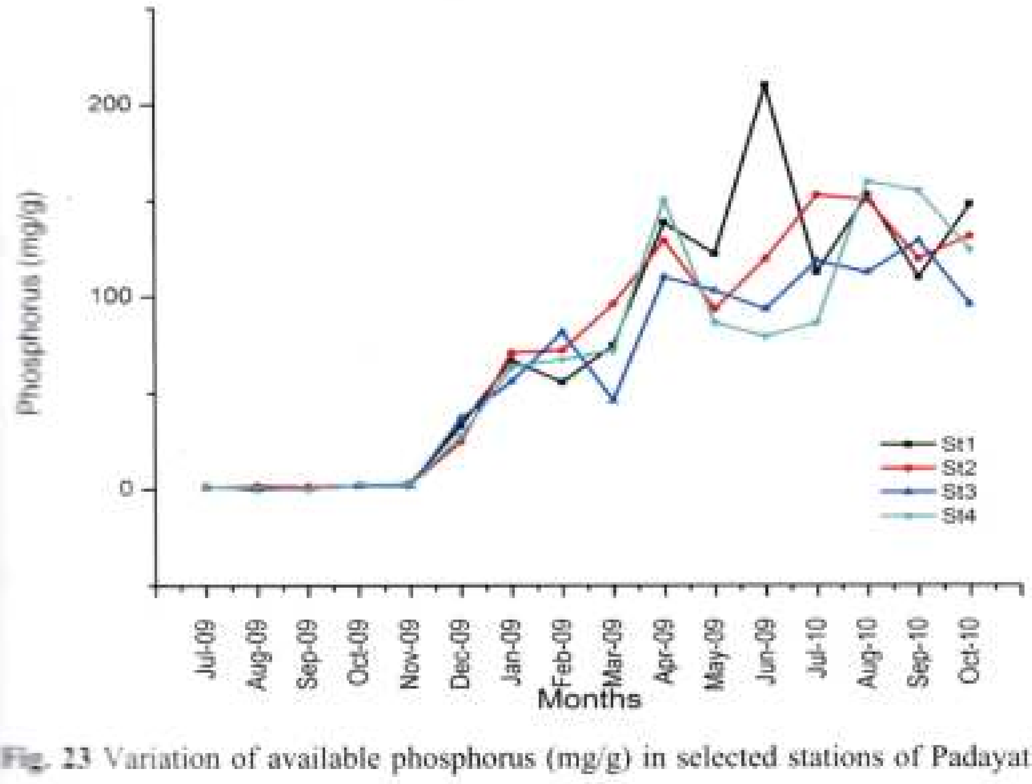


Fig. 23 Variation of available phosphorus (mg/g) in selected stations of Padayati wetland, Palakkad.

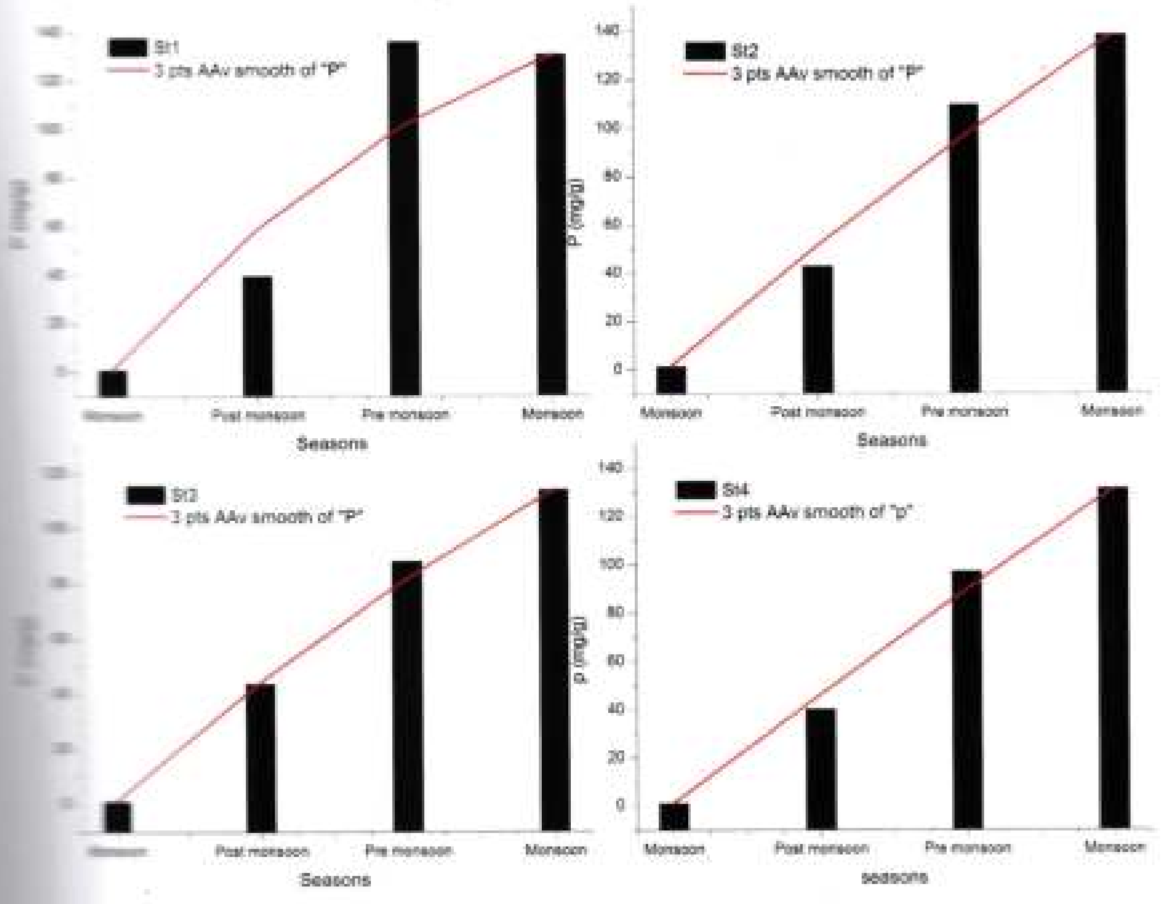


Fig. 24 Seasonal variation of Phosphorus (mg/g) in selected stations of Padayati wetland, Palakkad during 2009-2010

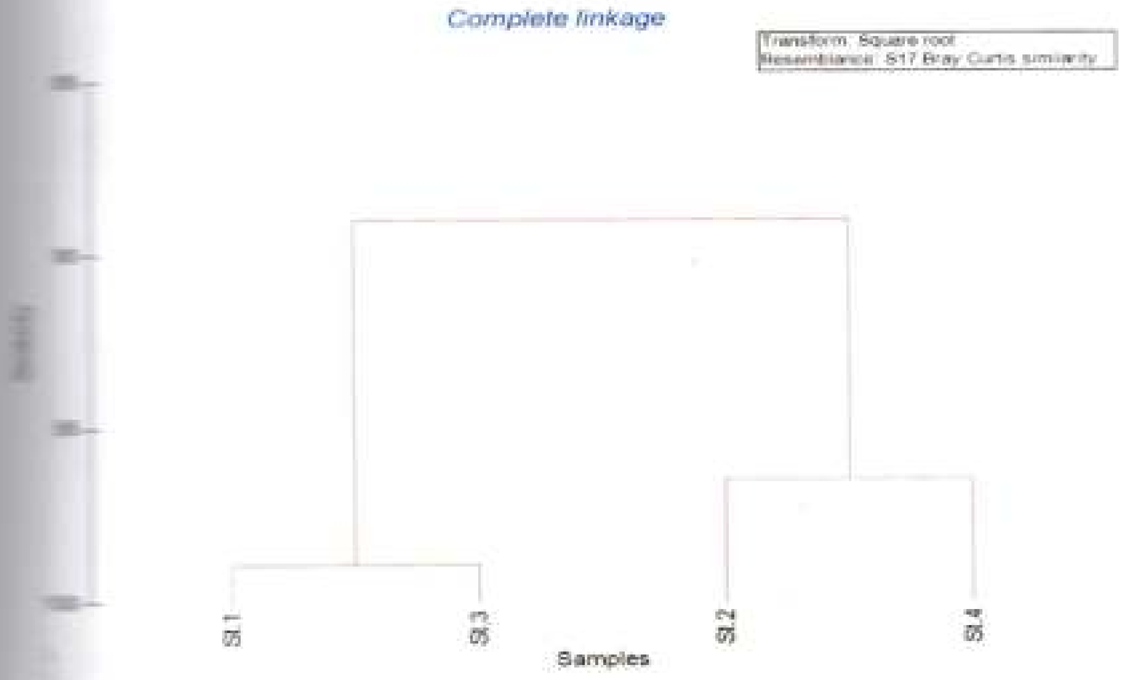


Fig.25 Station wise Bray-Curtis similarity plot of phosphorus (mg/g) in selected

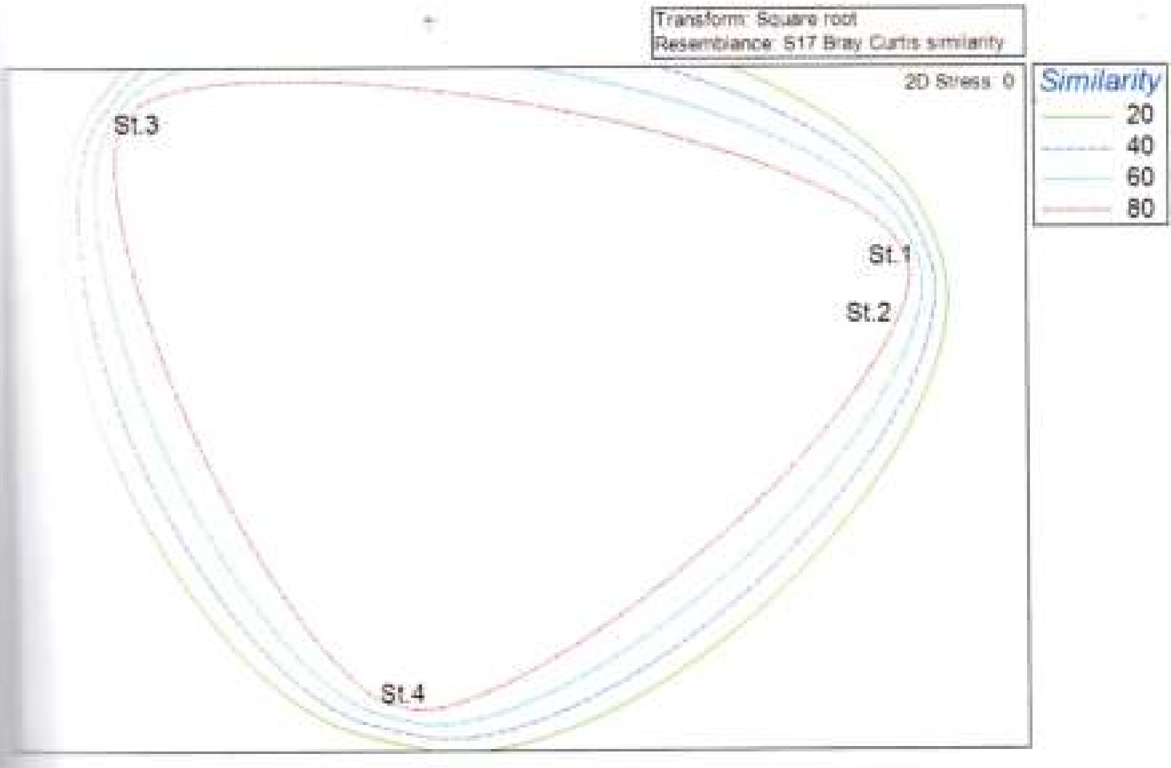


Fig.26 Station wise Multi dimensional plot (MDS) of soil Available Nitrogen in selected wetlands of Padayatti, Palakkad during 2009-2010.

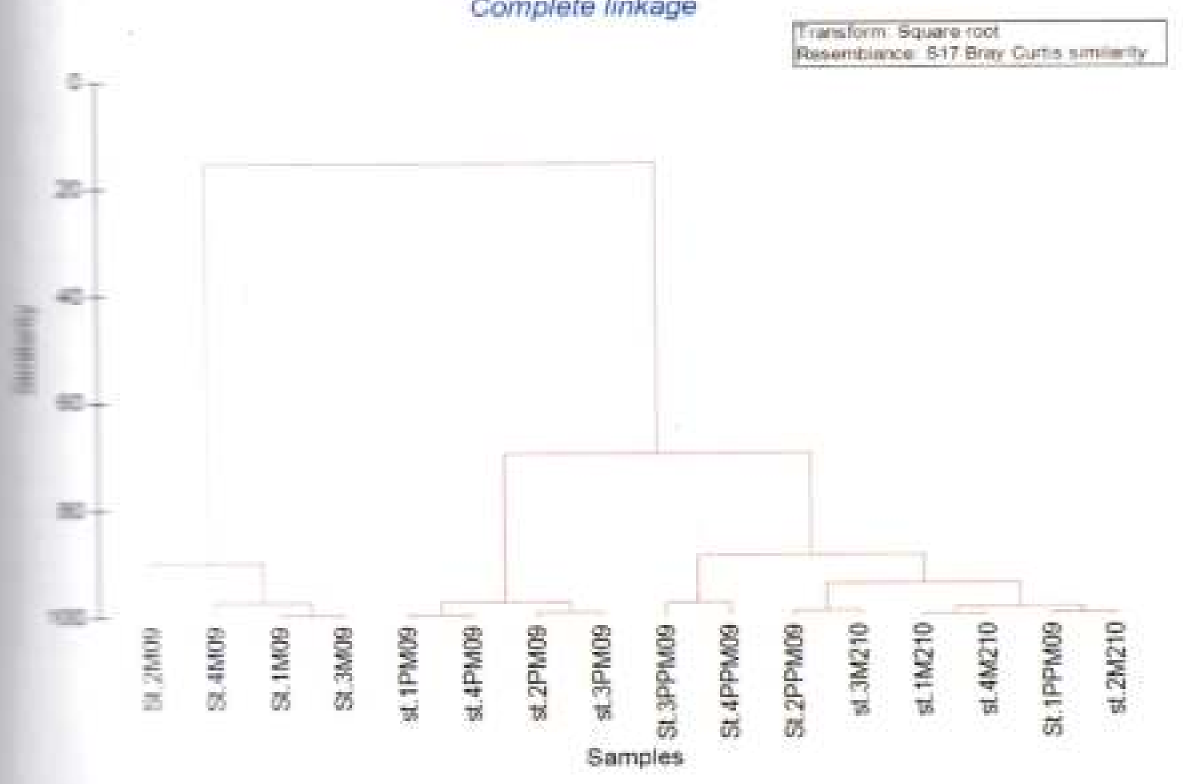


Fig.27 Season wise Bray- Curtis similarity of soil phosphorous in selected wetlands of Padayatti, Palakkad during 2009-2010.

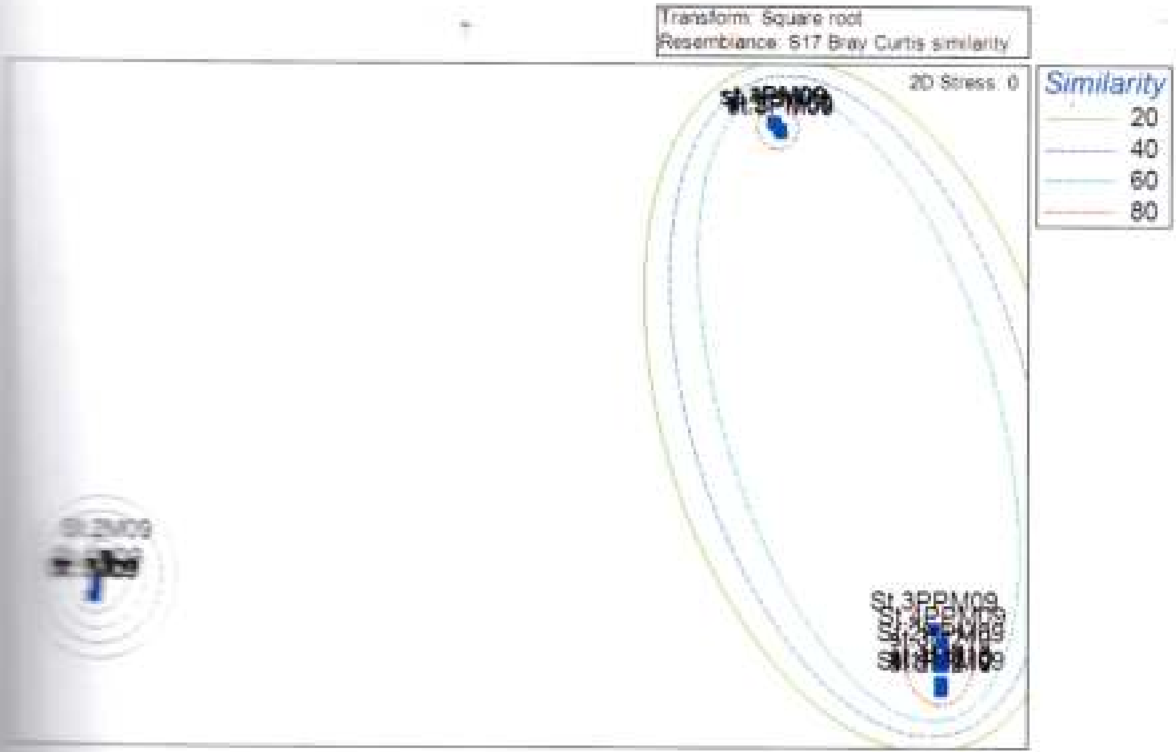


Fig.28 Seasonal Multi dimensional plot (MDS) of soil phosphorus in selected wetlands of Padayatti, Palakkad during 2009-2010

Table 11 ANOVA table of phosphorous in Padayati wetland, Palakkad during 2009-2010.

Phosphorous			
Source	df	Mean Square	F
Corrected Model	11	9683.236	4.573
Intercept	1	550637.837	260.053
Season	2	45022.375	21.263**
station	3	1536.185	.726
Season * station	6	1505.793	.711
Error	100	2117.410	
Total	112		
Corrected Total	111		
R Squared = .335	**- significant at 1% level. * - significant at 5% level.		

Table 12 Post Hoc table of phosphorus in Padayetti wetland, Palakkad during 2009-2010

P					
	Season	N	Subset		
			1	2	3
Duncan[a]	2	32	41.5938		
	1	32		64.9076	
	3	48			107.7100
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = 2117.410.
a. Uses Harmonic Mean Sample Size = 36.000.

[illegible] Sodium

The mean sodium concentration in the soils of Padayatti wetland during the present study was 0.442 mg/g. The station wise analysis of the data showed an average of 0.484 ± [illegible] mg/g in St.1 with a highest value of 0.735mg/g in the month of July 2009 and a lowest value of 0.331 mg/g in November 2009. In St.2, sodium showed an average value of 0.438 ± [illegible] mg/g, with a highest value of 0.767 mg/g in July 2009 and a minimum reported value of [illegible] in September 2010. An average value of 0.447 ± 0.115 mg/g was observed in St.3 with a maximum value of 0.706 in July 2010 and a minimum value of 0.221 mg/g in October 2010 (Fig.29). In St.4 an average value of 0.45 ± 0.136 mg/gwas observed with a highest value of [illegible] mg/g in July 2009 and 0.038 in March 2009 (Fig.29).

Seasonally wide variations in concentrations were observed in the three seasons. All the stations showed lowest concentration of sodium during post monsoon. Highest concentrations were observed in pre monsoon and moderate valued were shown in 2009 and 2010 monsoon season (Fig. 30). The ANOVA of soil sodium showed an overall significance at [illegible]% level (F = 9.910) (Table 13). Duncan post hoc test showed that sodium was grouped into 2 subsets, where station 2 and 1 were in subset1 and 2 in subset2. The grouping was significant at 1% in subset 2 (Table 14). Elevated concentrations of sodium were observed in pre monsoon in all stations.

Mean station wise analysis of Bray- Curtis similarity showed, that sodium was grouped into two clusters with highest similarity in organic St.2 and St.3 (99.5%) whereas a multidimensional scaling (MDS) ordination of total nitrogen concentration showed a clear distinction in variation in sodium between organic and chemical fertilizer stations (Fig.32). All the four stations showed a similarity of 80% whereas highest similarity in total nitrogen variation was found between St.1, 2 and 3. Season wise Bray-Curtis similarity profile for sodium showed three clusters (Fig.33.). The similarity in sodium concentration was highest in third cluster (98%) represented by St.1 post monsoon 2009, St.2 monsoon 2009 and St.4 monsoon 2009. Cluster 1 showed 96% similarity in seasonal distribution of total nitrogen represented by St.4 monsoon 2010, St.1 post monsoon 2009 and monsoon 2010. Followed by cluster 2 with a similarity of 96% represented by St 2 post monsoon 2009, St 2 monsoon 2010, and St.4 post monsoon 2009, St.3 post monsoon 2009 and St.3 monsoon 2010. Least similarity was fond in cluster 4 having a similarity of 91% represented by St.2 monsoon 2009, St.3 monsoon 2009, st.4 monsoon 2009, St.1 monsoon 2009 and St.3 monsoon 2009. Seasonally non-metric multidimensional scaling (MDS) ordination showed that of sodium concentration were similar in all seasons with an overall similarity of 20% (Fig.34) whereas it was highly similar at about 80% between St.1, St.2, St.3, and St.4 during post monsoon 2009 and St.1 and St.2 in Monsoon 2009.

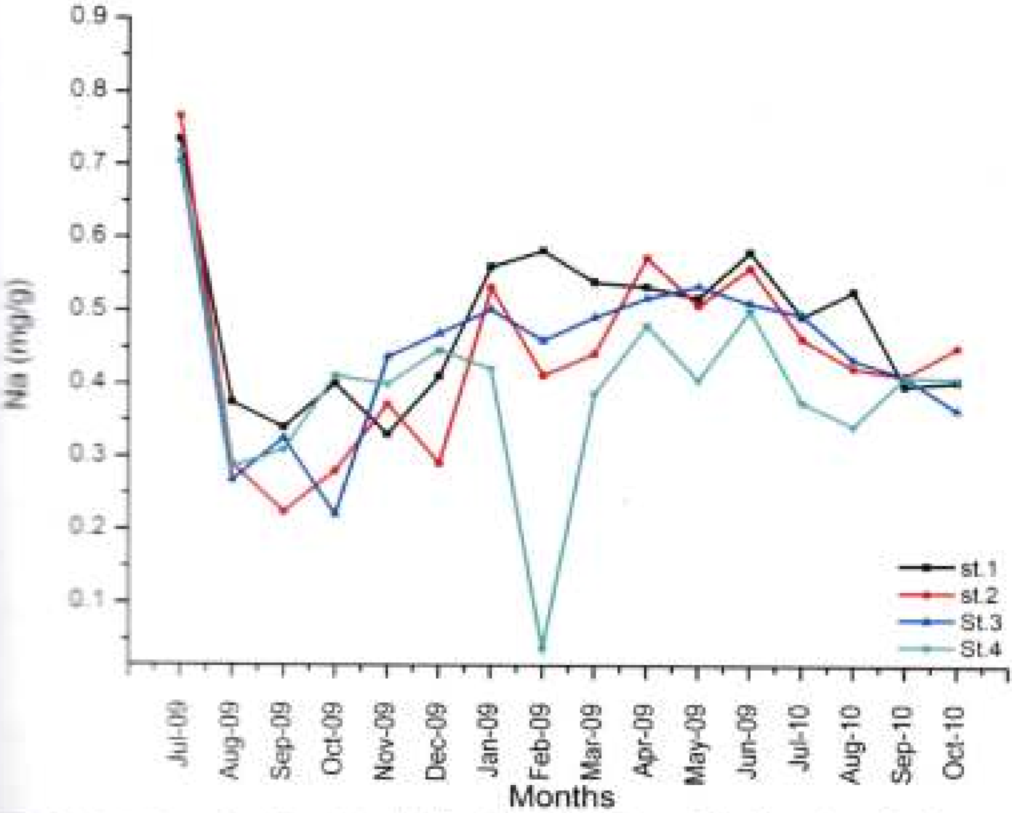


Fig.29 Variation of sodium (mg/g) in selected stations of Padayatti wetland, Palakkad during 2009-2010

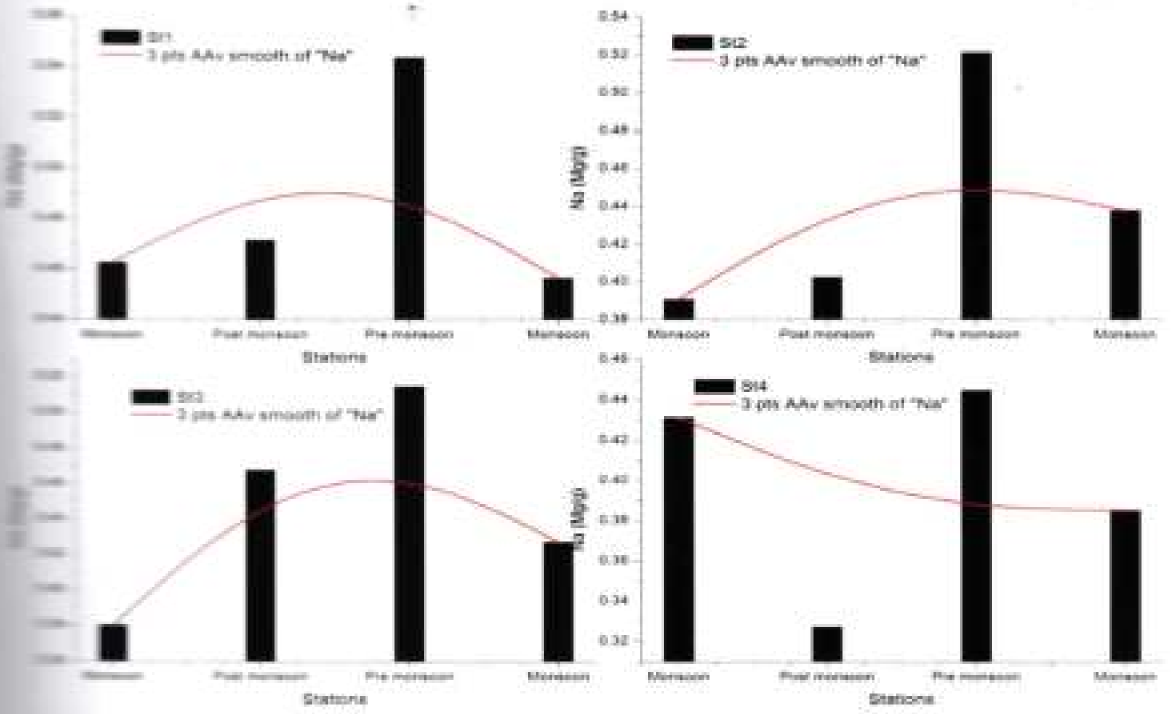


Fig.30 Seasonal variation of Sodium (mg/g) in selected stations of Padayatti wetland, Palakkad during 2009-2010.

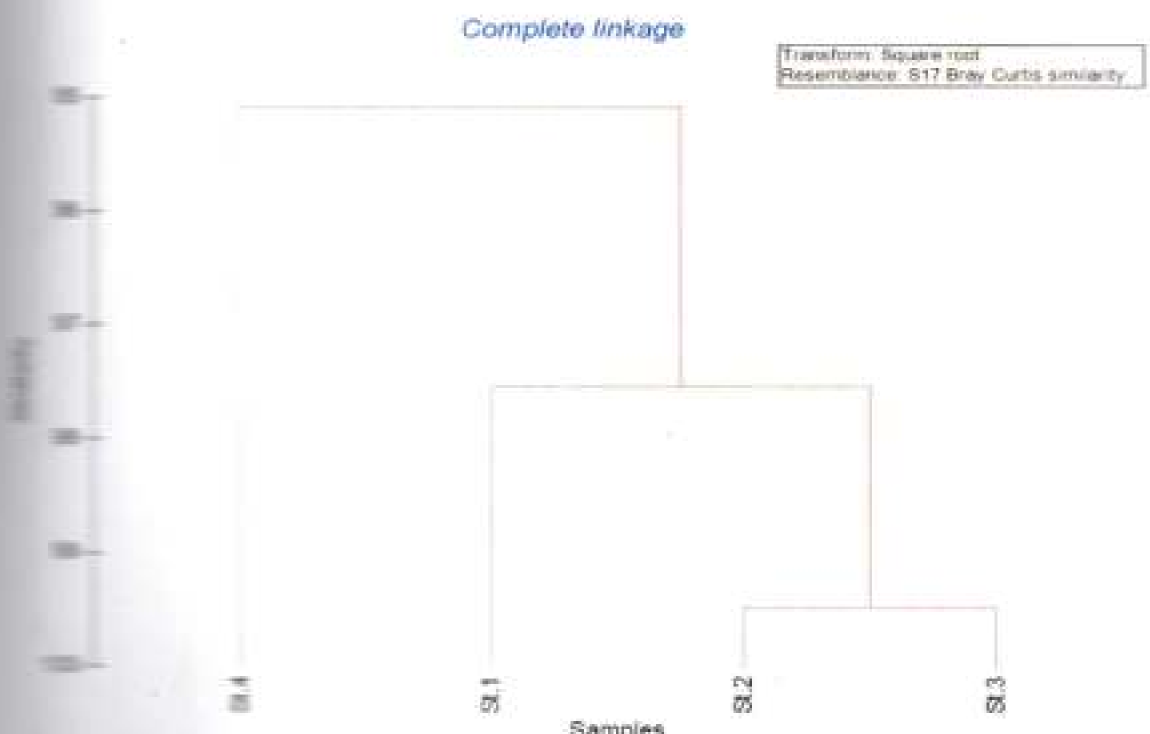


Fig.31 Station wise Bray- Curtis similarity of sodium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

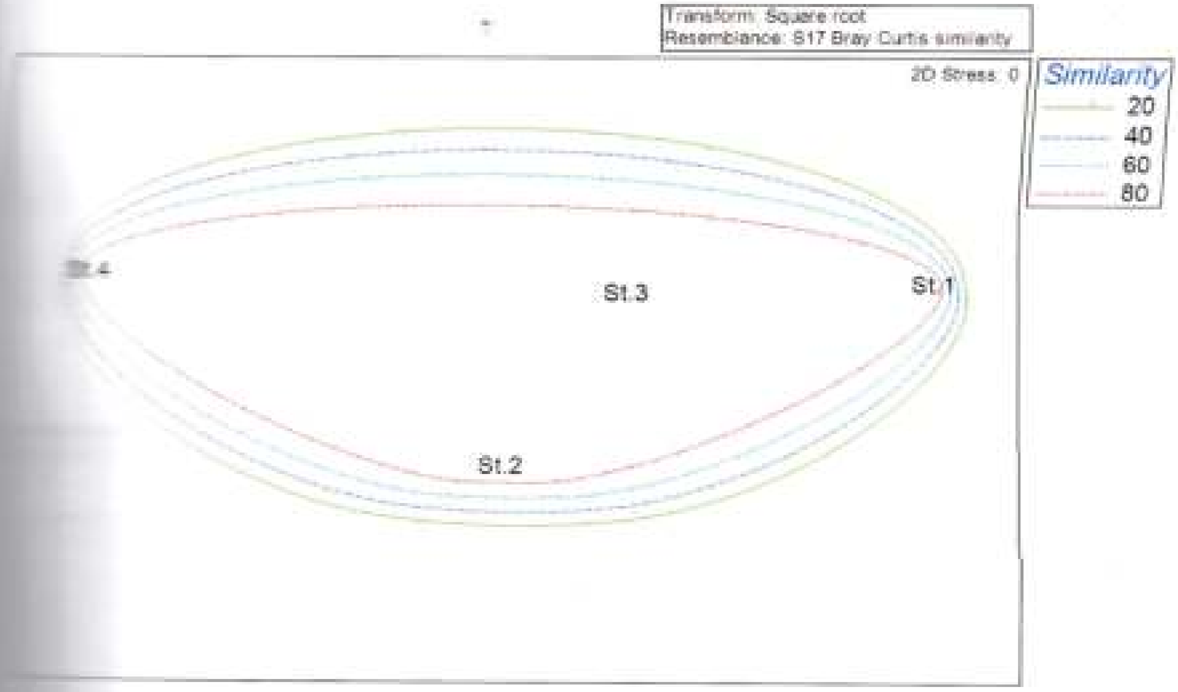


Fig.32 Station wise multi dimensional plot (MDS) sodium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

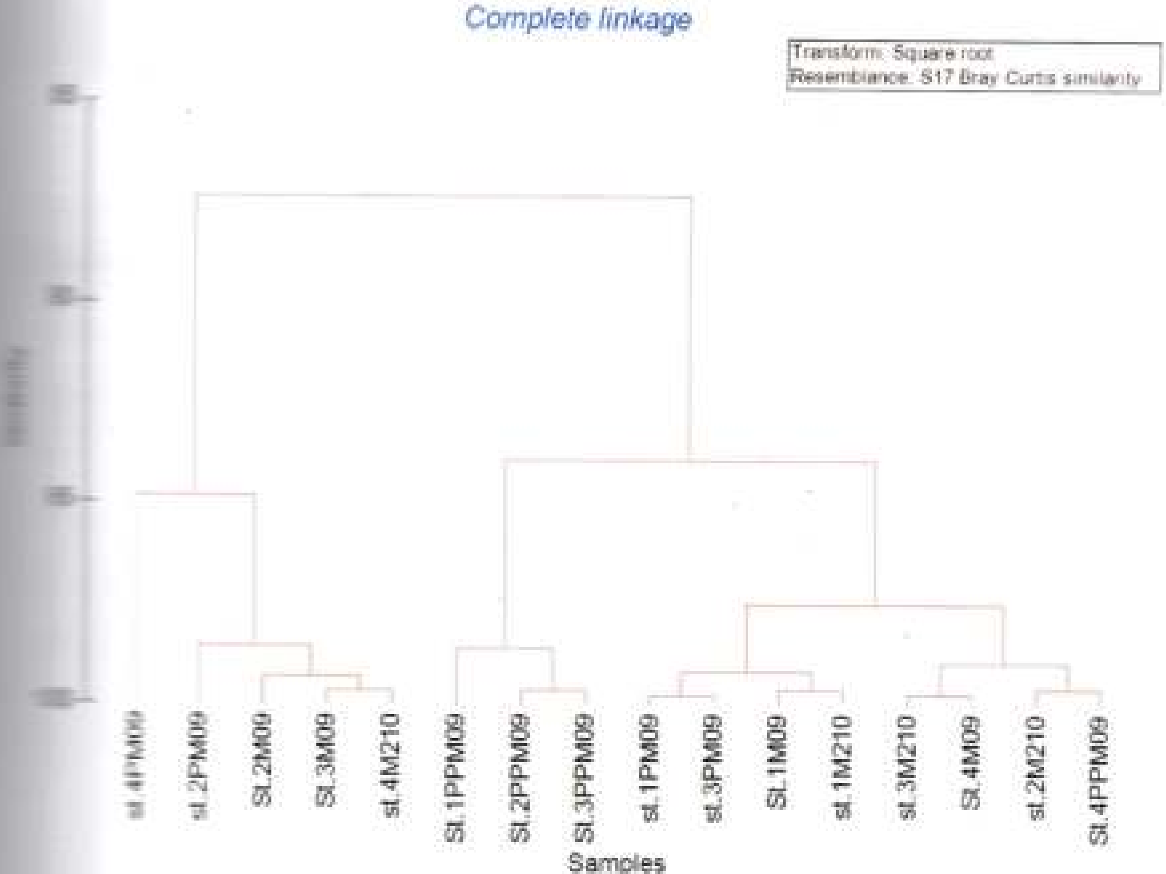


Fig.33 Season wise Bray- Curtis similarity of soil sodium in selected wetlands of Padayatti, Palakkad during 2009-2010.

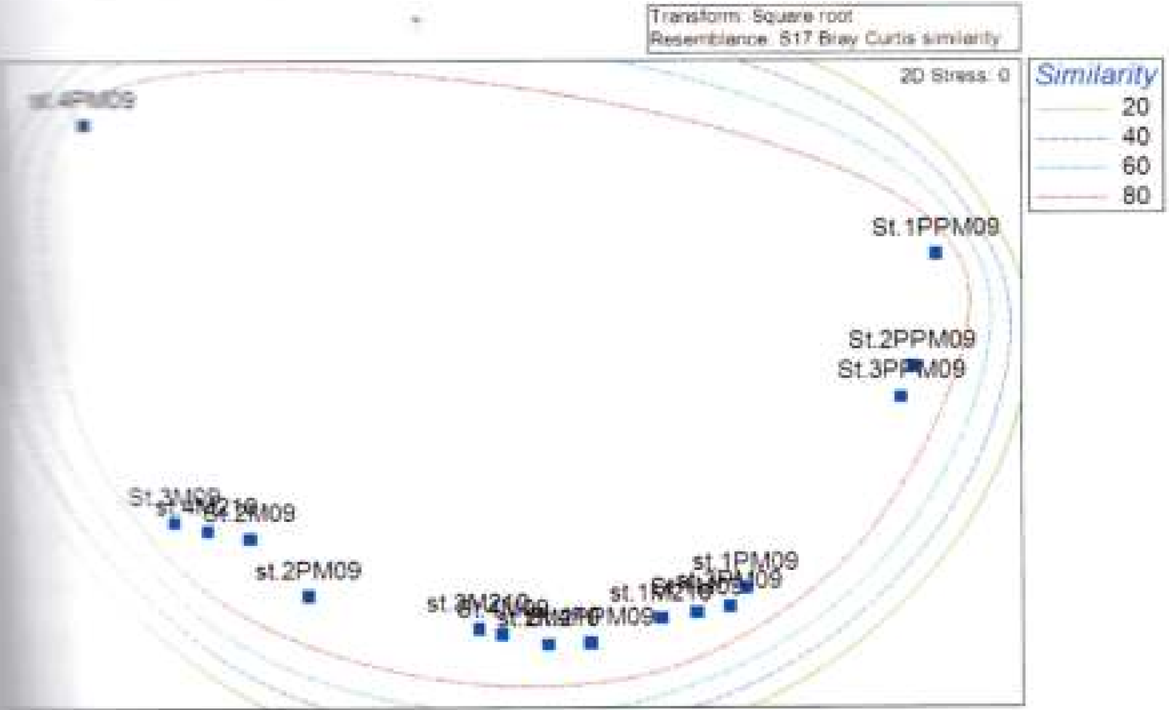


Fig.34. Seasonal multi dimensional plot (MDS) of soil Sodium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

Table: 13 ANOVA table of Sodium in Padayetti wetland, Palakkad

Source	df	Mean Square	F
Corrected Model	11	.036	3.480
Season	2	.103	9.910**
station	3	.046	4.388**
Season * station	6	.008	.798
Error	100	.010	
Total	112		
Corrected Total	111		

R Squared = .277

**- significant at 1% level.

* - significant at 5% level.

Table 14 Post Hoc table of-sodium in Padayetti wetland, Palakkad during 2009-2010

Na				
	Season	N	Subset	
			1	2
Duncan	2	32	.4173	
	1	32	.4215	
	3	48		.5062
	Sig.		.861	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = .010.

Uses Harmonic Mean Sample Size = 36.000.

6.7 Potassium

The average concentration of available potassium in the soil of Padayatti wetland was [illegible] mg/g during the study period. In St.1 the average potassium concentration was 0.843 ±[illegible] mg/g with highest value of 2.17 mg/g in July 2009 and lowest of 0.106 mg/g in August 2010. St.2 showed a mean value of 0.747 ± 0.489 mg/g during the entire study with a highest value of 1.89 mg/g in the July 2010 and lowest value of 0.206 mg/g in August 2010. St.3 also showed an average value of 0.599 ± 0.35 mg/g during the entire study, with a maximum value of 1.214 mg/g in July 2009 and a lowest value of 0.235 in August 2009. The St.4 also reported an average value of 0.503 ± 0.42 mg/g potassium with highest value of 1.45 mg/g in July 2010 and 0.061 mg/g in February 2010 (Fig.24). The monthly station wise analysis showed that potassium concentration ranged from 0.258 mg/g in September 2010 to [illegible] in June 2010 in St.1; that from 0.206 in September 2010 and 1.676 in June 2010 in St.2; that from 0.267 in September 2010 to 1.169 in June 2010 in St.3 and 0.061 in February 2010 to 1.445 in July 2010 in St.4. Organic farming practices in California sacramento valley over the 8 year have found higher K levels especially the plant available potassium in organic systems as compared to conventional management (Sean Clark et al 1998, Reganold, 1988; Garcia et al., 1989; Drinkwater et al., 1995) (Fig.35).

Seasonal analysis of potassium during the study period showed highest concentration during pre monsoon in all station except in St.4. In St.4, practiced by chemical fertilizers all elevated potassium concentration was observed except in post monsoon season (Fig.36). Station wise ANOVA of soil potassium showed an overall significant at 1% level (F = 5.762) (Table 15). A Duncan post hoc test revealed that potassium is grouped in to 3 subsets (Table 16). The ANOVA of seasons showed a statistical difference of 1%. Seasonally post hoc analysis are grouped in to 2 subsets, where stations 2 and 1 was in subset1 and 3 in subset 2. The groupings are significant at 1% level in subset 2.

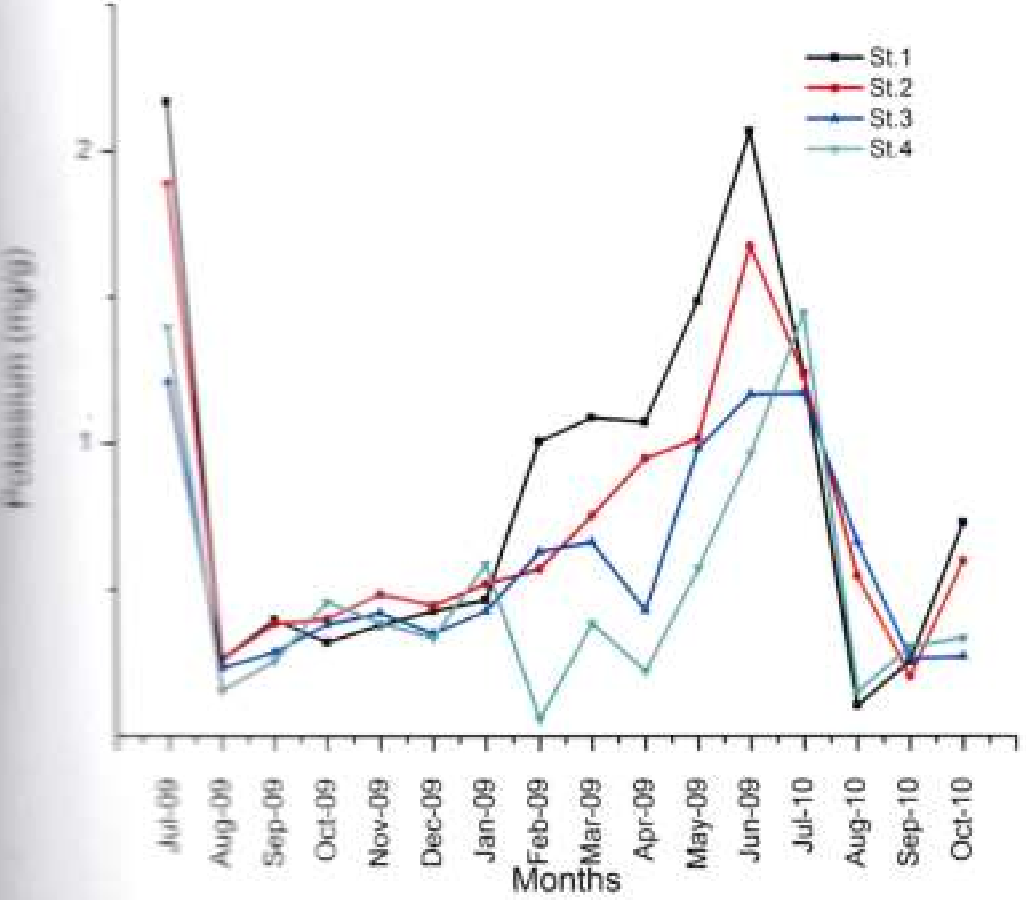


Fig.36. Monthly variation potassium (mg/g) in selected stations of Padayatti wetland, Palakkad during 2009-2010

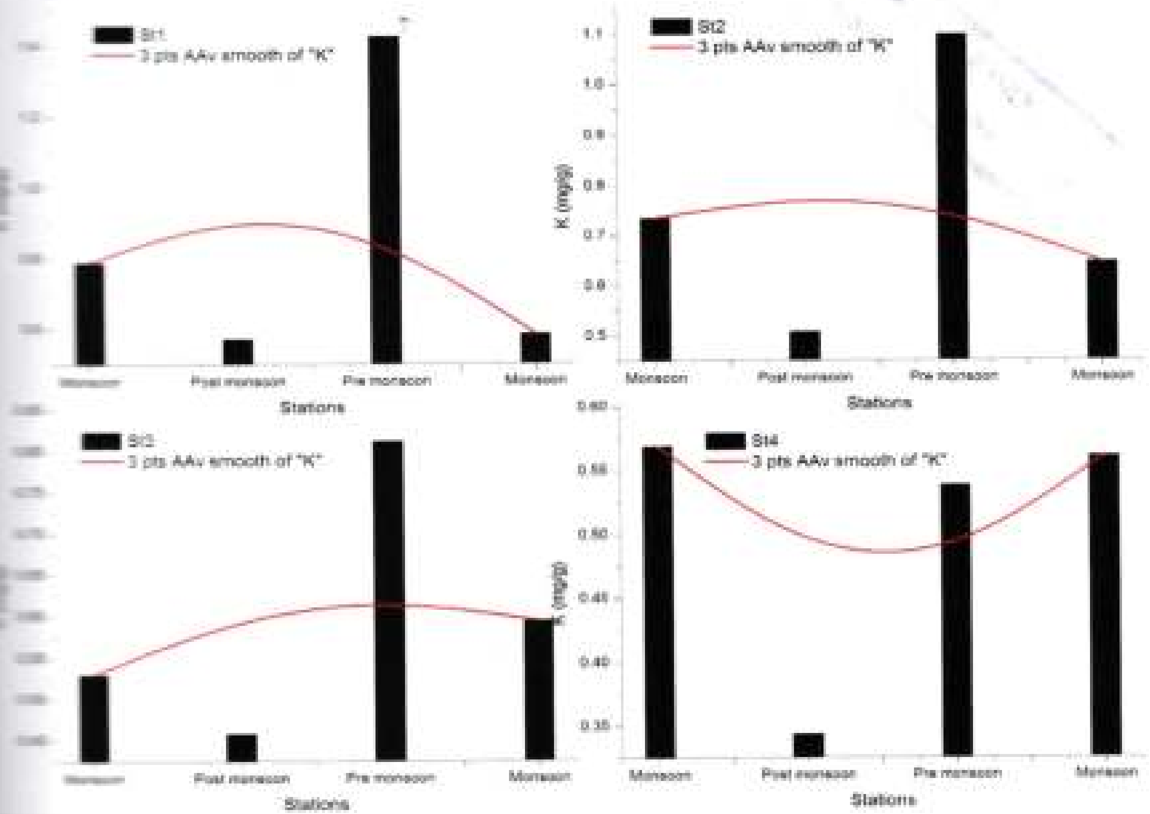


Fig.36 Seasonal variation of Potassium (mg/g) in selected stations of Padayetti wetland, Palakkad during 2009-2010.

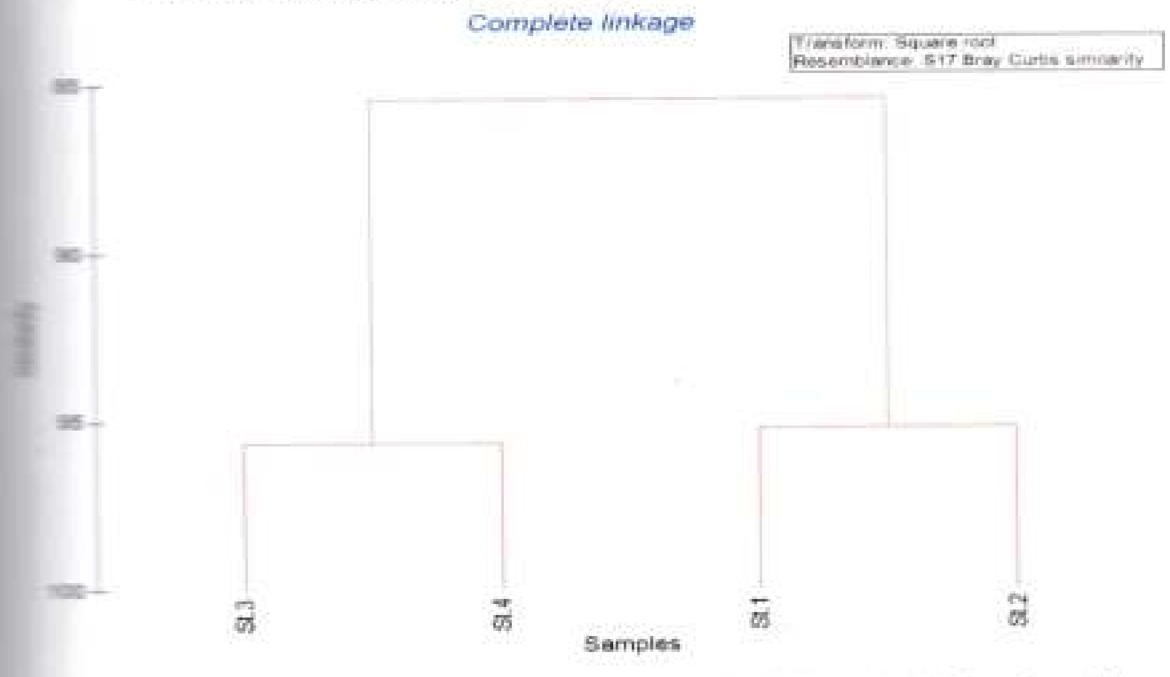


Fig.37 Station wise Bray- Curtis similarity of soil Sodium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

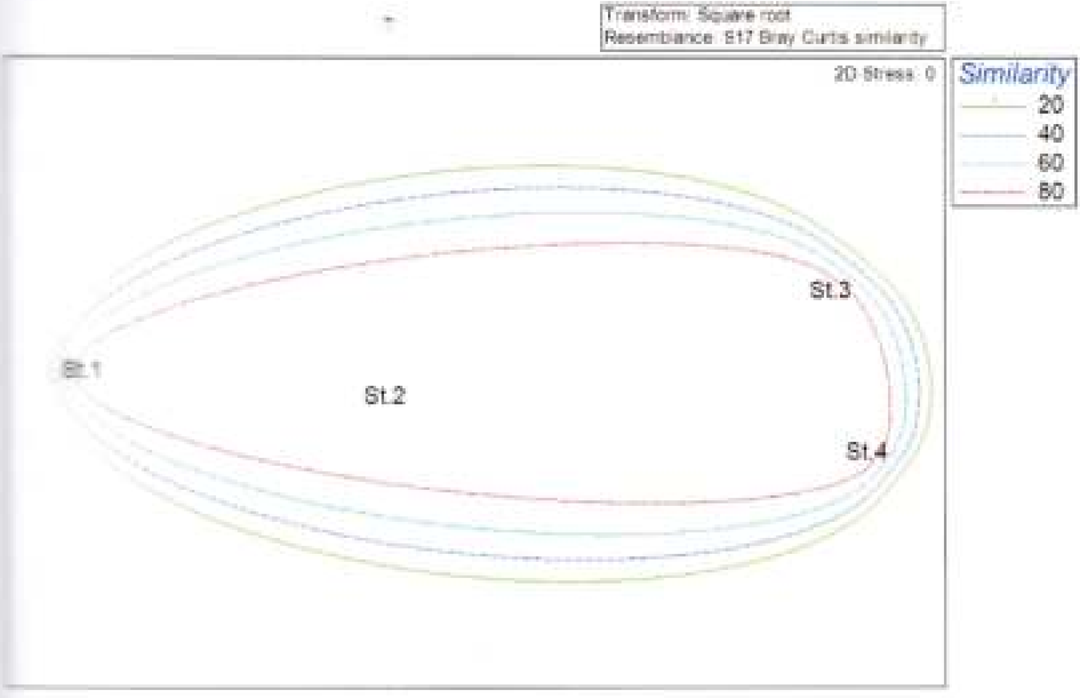


Fig.38 Station wiseMulti dimensional plot (MDS) of soil Sodium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010

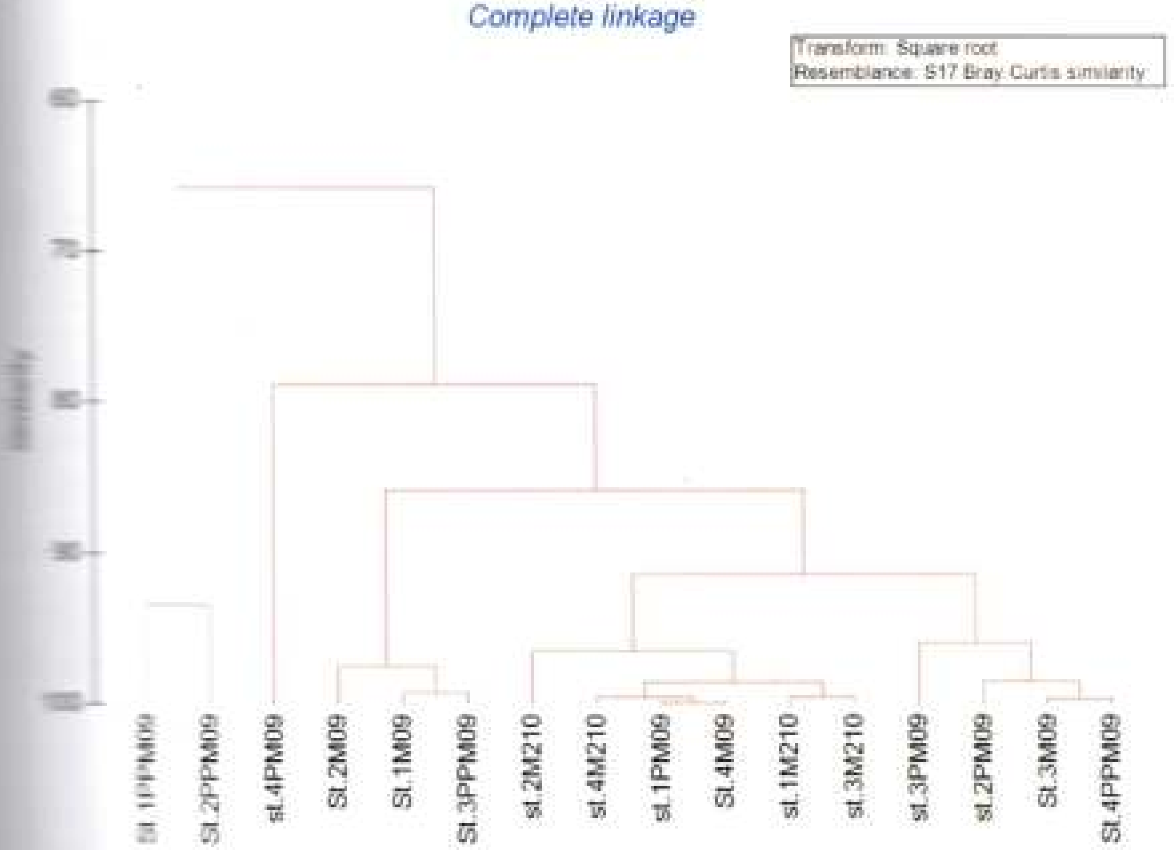


Fig.39 Season wise Bray- Curtis similarity of soil Sodium (mg/g) in selected

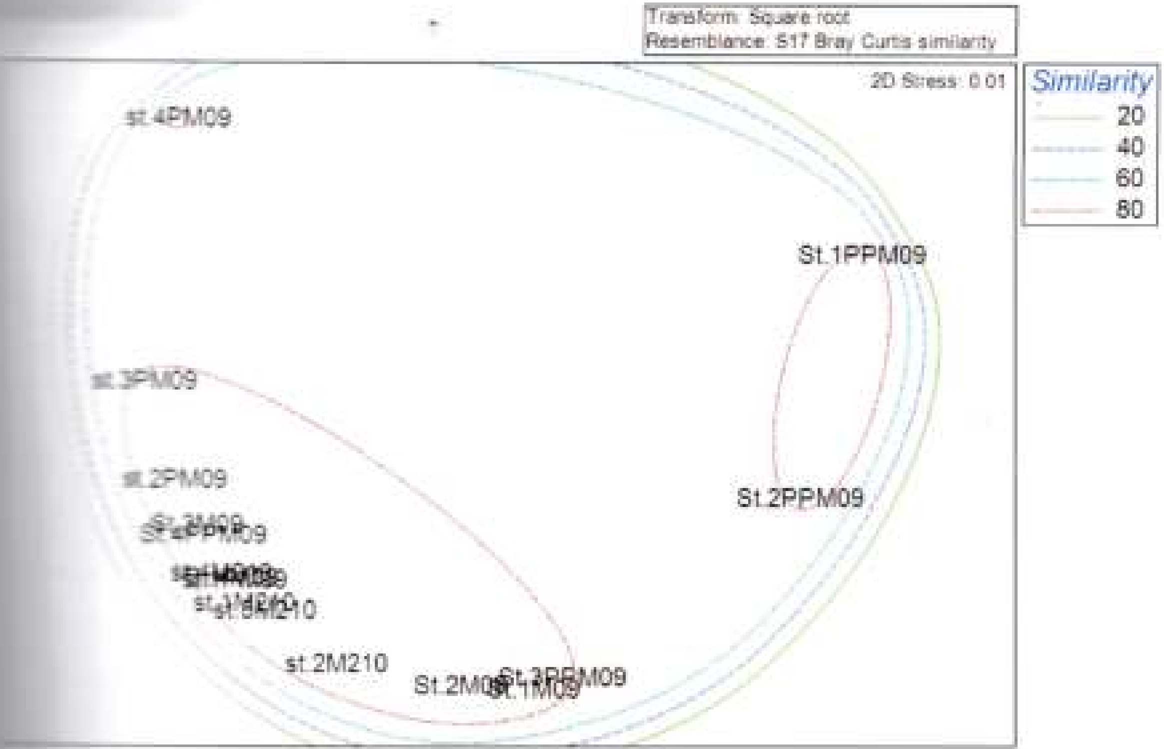


Fig.40 Multi dimensional plot (MDS) of soil Sodium in selected wetlands of Padayatti, Palakkad during 2009-2010

Table: 15 ANOVA table of potassium in Padayati wetland, Palakkad during 2009-2010

Source	df	Mean Square	F
Corrected Model	11	990	6.510
Season	2	2.635	17.332
Station	3	.876	5.762
Season * station	6	.325	2.136
Error	100	.152	
Total	112		
Corrected Total	111		

R Squared = .417 **- significant at 1% level.

* - significant at 5% level.

Table 16 Post Hoc table of sodium in Padayetti wetland, Palakkad during 2009-2010

K				
	Season	N	Subset	
			1	2
Duncan[a]	2	32	.4697	
	1	32	.6260	
	3	48		.9696
	Sig.		.092	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .152.
a. Uses Harmonic Mean Sample Size = 36.000.

6.8 Calcium

The average concentration of calcium during the study period in Padayatti wetland was 2.987 mg/g. The station wise analysis of the data showed an average value of 3.114 ± 1.08 mg/g in St.1 with a highest value of 5.631 mg/g in July 2009 and a lowest value of 1.08 mg/g in January 2010. In station 2 calcium concentration showed an average value of 2.825 ± 0.83 mg/g with a highest value of 4.417mg/g in February 2010 and 1.483 mg/g in September 2009 as the lowest. An average value of 3.1 ± 0.95 was in St.3, with a highest concentration in the month of March 2010 (4.59 mg/g) and lowest concentration of Ca in June 2009 (1.024 mg/g). In St.4 calcium showed an average concentration of 2.513 ± 0.84 mg/g with a highest reported value of 3.57 mg/g in the month of October 2010 and lowest value of .148 in February 2010 (Fig.41). The average concentrations of calcium during the study period ranged from 2.22 mg/g in St.4 to 3.015 mg/g in St.3. The monthly station wise analysis of the data showed that calcium concentration varied marginally among stations and it varied from 0.271mg/g in December 2010 to 5.009 mg/g in June 2010 in St.1; that from 0.305 mg/g in December 2010 to 3.85 mg/g in July 2010 in St.2; that from 4.588 mg/g in March 2010 to 0.255 mg/g in January 2011in St.3 and 0.148 mg/g in October 2010 to 3.568 mg/g in October 2010 in St.4.

Seasonally calcium showed highest concentration during pre monsson in all the four stations. Lowest concentrations were reported during monsoon (2009) in organic stations 2 and 3. (Fig.42). ANOVA of calcium showed an overall significance at 1% level (F = 12.187) (Table 11). Duncan post hoc test revealed that the three stations were grouped into 3 subsets with a significant at of 1% level.

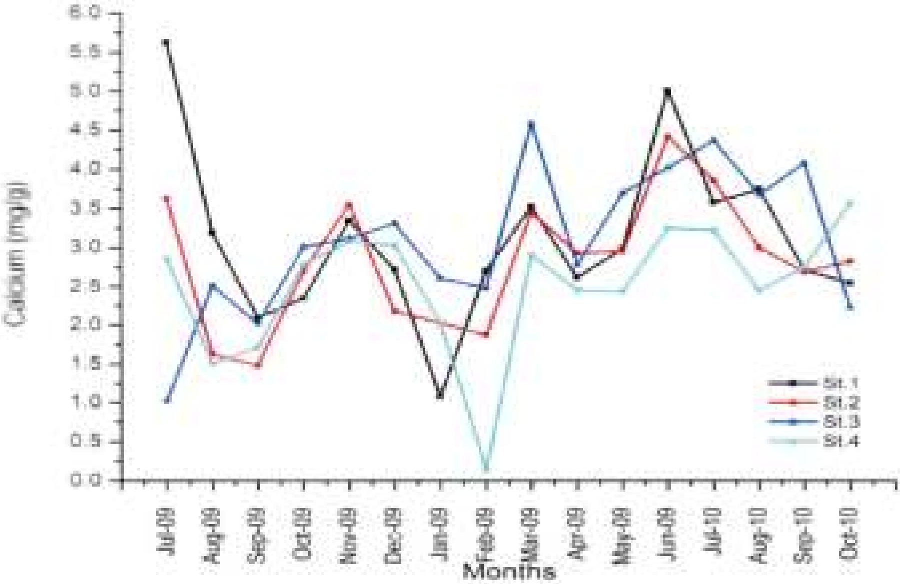


Fig.41 Variation of calcium (mg/g) in selected stations of Padayatti wetland, Palakkad during 2009-2010

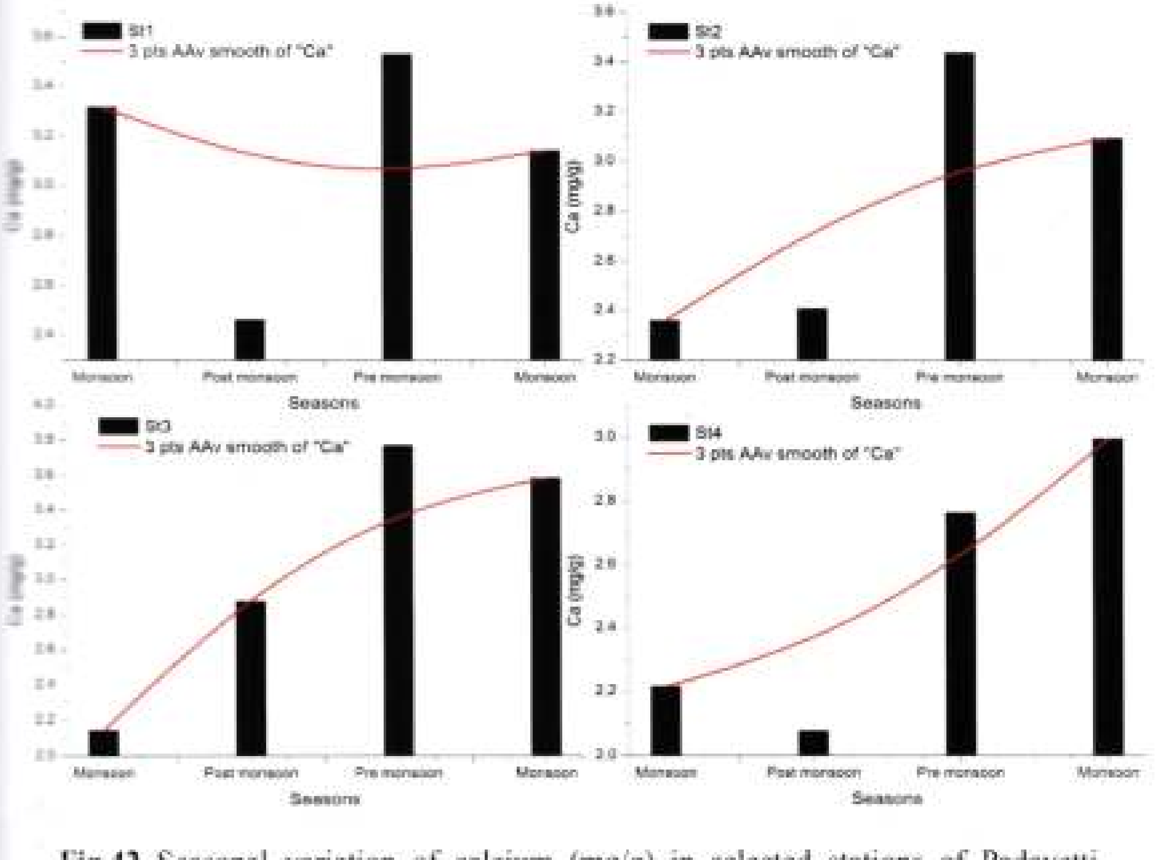


Fig.42 Seasonal variation of calcium (mg/g) in selected stations of Padayetti

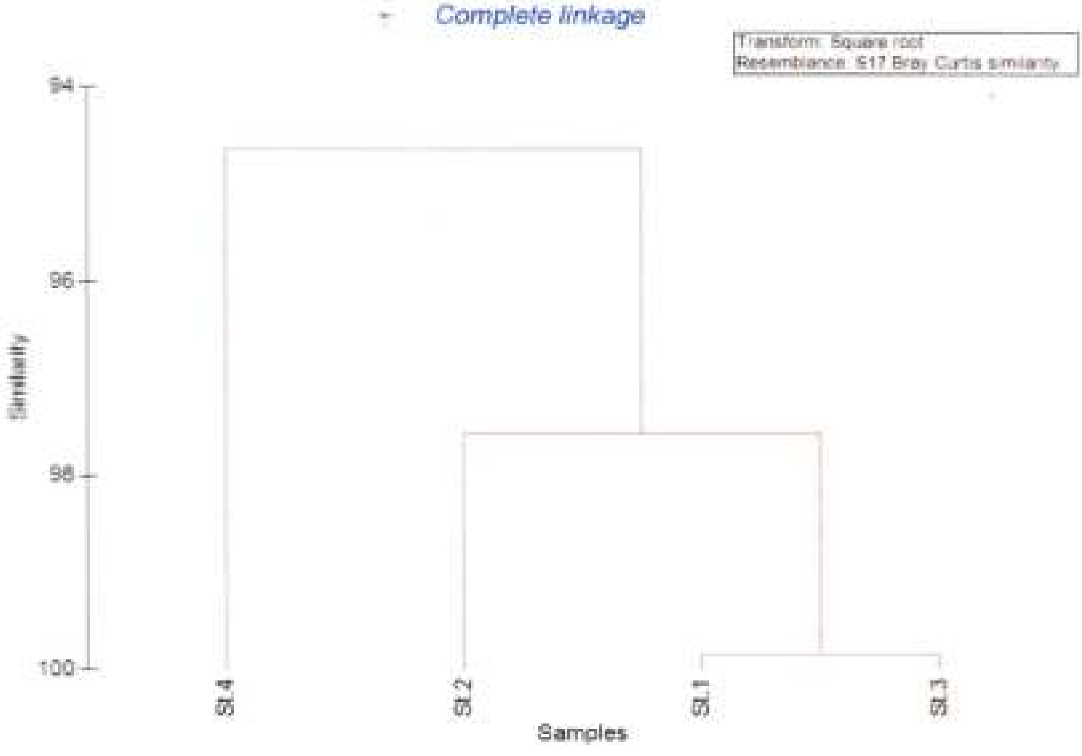


Fig.43 Station wise Bray- Curtis similarity of soil Calcium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

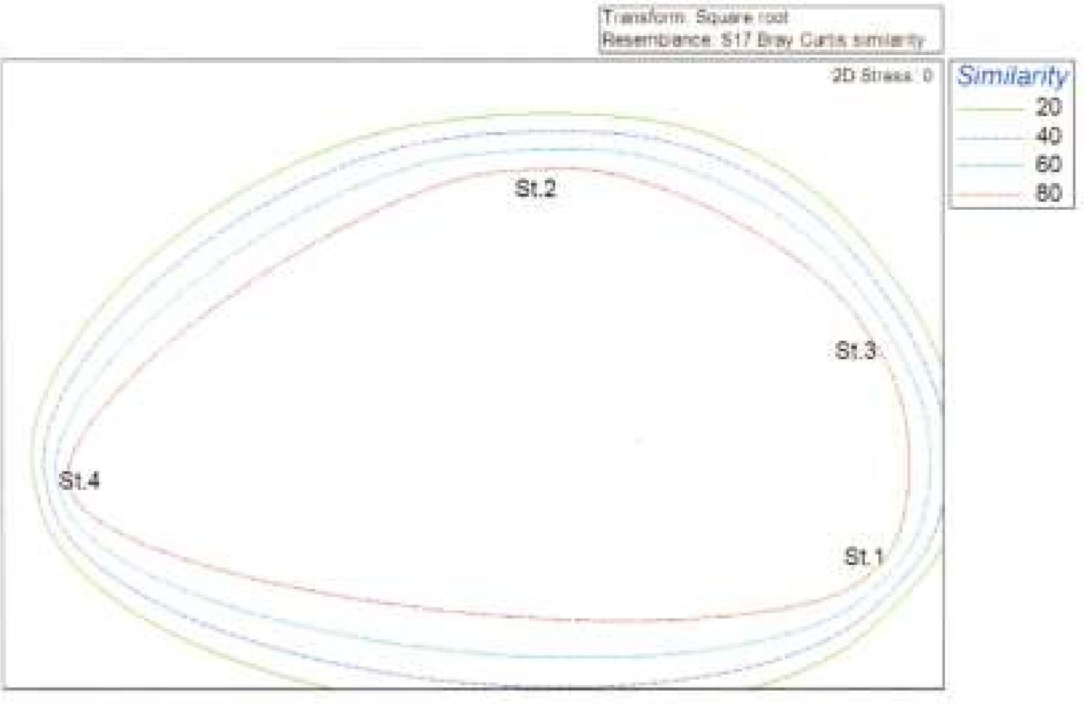


Fig.44 Station wise multi dimensional plot (MDS) of soil Calcium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

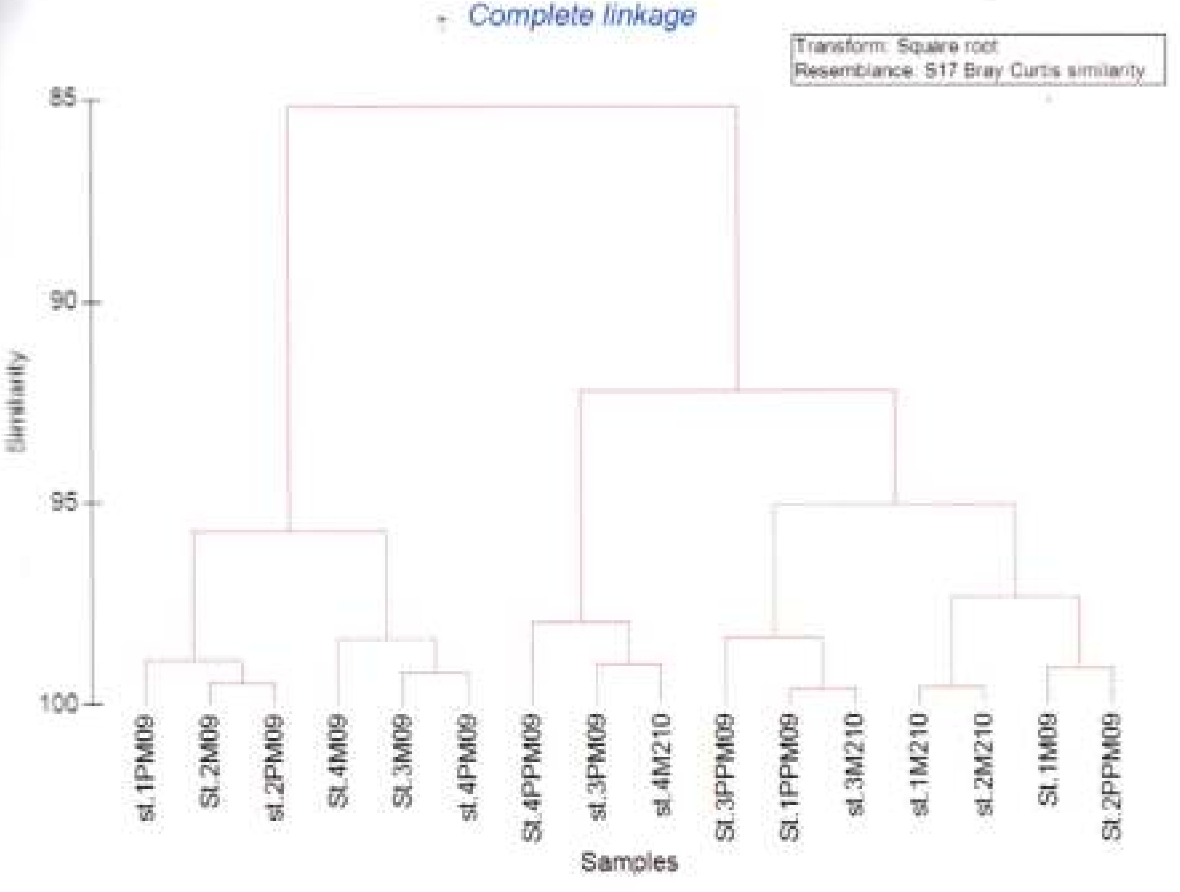


Fig.45 Season wise Bray- Curtis similarity of soil Calcium (mg/g) in selected wetlands of Padayatti, Palakkad during 2009-2010.

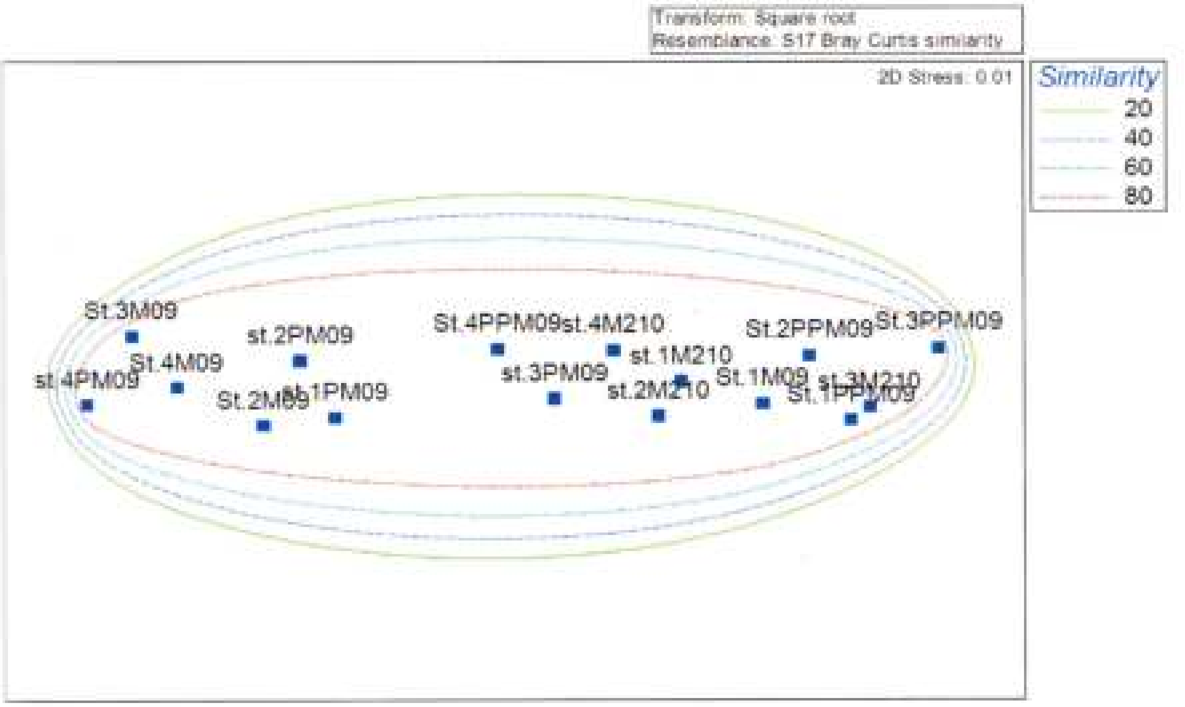


Fig.46 Multi dimensional plot (MDS) of soil Calcium 9mg/g) in selected wetlands

Table 17 ANOVA table of Calcium in Padayati wetland, Palakkad during 2009-2010

Source	df	Mean Square	F
Corrected Model	11	2.528	3.683
Season	2	8.364	12.187**
Station	3	2.531	3.688
Season * station	6	.385	.561
Error	100	.686	
Total	112		
Corrected Total	111		
R Squared = .288	**- significant at 1% level. * - significant at 5% level.		

6.9 Soil Organic Carbon, Organic Matter and Energy Content

Soil organic carbon (SOC) is one of the most important terrestrial pools for carbon storage. It is estimated that the paddy wetland ecosystems on the earth have a total carbon stock of about 20–25% of the total stock in terrestrial soils, and are considered to play an important role in global carbon cycling. During the present study organic carbon showed an average of 0.714 % in the four stations. Station wise analysis showed an average value of 0.7196% in St.1 having a CV value of 34.04%, with a maximum value of 1.1% in June 2010 and a lowest value of 0.379% in February 2010. In St.2, organic carbon showed an average value of 0.786% with a maximum value of 1.26% in December 2010 and a lowest value of 0.408 % in January 2010 having a CV value of 34.1%. In St.3 organic carbon depicted an average value of 0.69 % (CV = 44.22%) with a peak value of 1.2% in November 2010 and a lowest of 0.83% in January 2010. St. 4 showed an average value of 0.663 % with a maximum value of 1.29% in January 2009 and 0.419 % in April 2010 (CV = 31.84%) (Fig.47). Soil organic carbon showed an increased availability in soil during the months of April 2010 to August 2010. Mean results showed that St.3 had the highest organic matter with 0.769%. Studies comparing soils of organic and conventionally managed farming systems it was reported that, higher soil organic matter was reported in organic farming regions as compared to conventional methods (Lockeretz et al 1981; Alvarez et al., 1988; Reganold et al., 1993; Drinkwater et al 1995). This agreed with the present study.

Seasonally the ANOVA of-soil organic carbon showed that it was significant at 1% level (F = 12.187) (Table 18). Season wise, Duncan test was grouped into 3 subsets with a significant level of 1%. Seasonally wide variation in organic carbon was observed in the four stations. An annual increasing trend in organic carbon (%) was observed in St.1 and 3 where as St.2 and St.4 showed a decline in its concentration. In St.1 and station 3 maximum concentration of organic carbon were observed during the monsoon 2010, station 2 its highest concentration in pre monsoon whereas station 4 it was highest concentration in monsoon 2009. During the present study organic carbon showed significant positive correlation with total nitrogen, potassium and calcium. Pearson correlation coefficient results between organic carbon and total nitrogen showed a coefficient value of 0.350, is significant at 1 % level, whereas potassium and calcium showed significance at 5% level. Mean station wise analysis of Bray Curtis analysis showed highest similarity in organic zone St.3 and fertilizer zone St.4 (99%) whereas a least similarity was shown in organic St.1 (98.5%) (Fig.49). Station wise, non-metric multidimensional scaling (MDS) ordination of organic carbon showed an overall similarity of 80% whereas highest similarity in total nitrogen variation was found between St.3 and St.4 (Fig.50). Season wise Bray-Curtis similarity profile for organic carbon showed four clusters (Fig.51). The similarity in organic carbon was highest in third cluster (98%) represented by St.1 in post monsoon 2009, St.1 monsoon 2010, St.3 post monsoon 2009 and St.2 monsoon 2010. Cluster 4 showed a similarity of 98% represented by St.3 in pre monsoon 2009, St.4 pre monsoon 2009, St.1 monsoon 2009, and St.2 monsoon 2009. Followed by this Cluster 2 showed 97% similarity in seasonal distribution of organic carbon represented by St.4 post monsoon 2009, St.3 monsoon 2009, and St.4 monsoon 2010. Seasonally non-metric multidimensional scaling (MDS) ordination showed that of organic carbon concentration were similar in all seasons with an overall similarity of 20% whereas it was highly similar at about 80% (Fig.52).

Organic matter and energy content are reflective of organic carbon present in the system. During the study organic matter showed an average value of 1.613 ± 0.52% in St.1, 1.76 ± 0.62% in St.2, 0.688 ± 0.67% in St.3 and 1.486 ± 0.49 % in St.4 respectively. Seasonally wide variation in organic carbon was observed in the four stations (Fig.53).The ANOVA of soil organic matter showed a seasonal significance of 1% level (F = 0.871) (Table 19). Season wise Duncan test, was grouped into 3 subsets with a significant level of 1%. Energy content also varied from 17.36 ± 13.19 j/g in St.1, 18.16 ± 11.25j/g in St.2, 19.77 ± 12.78j/g in St.3 and 16.25 ± 9.82 j/g in St.4.

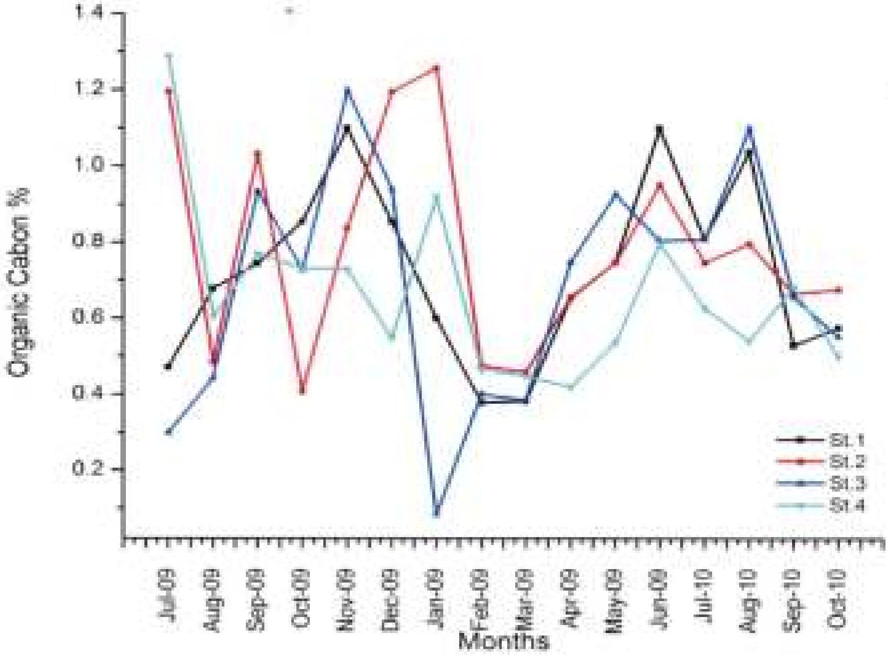


Fig.47 Monthly variation Soil organic carbon (%) among four stations in selected wetlands in Padayati, Palakkad during 2009-2010

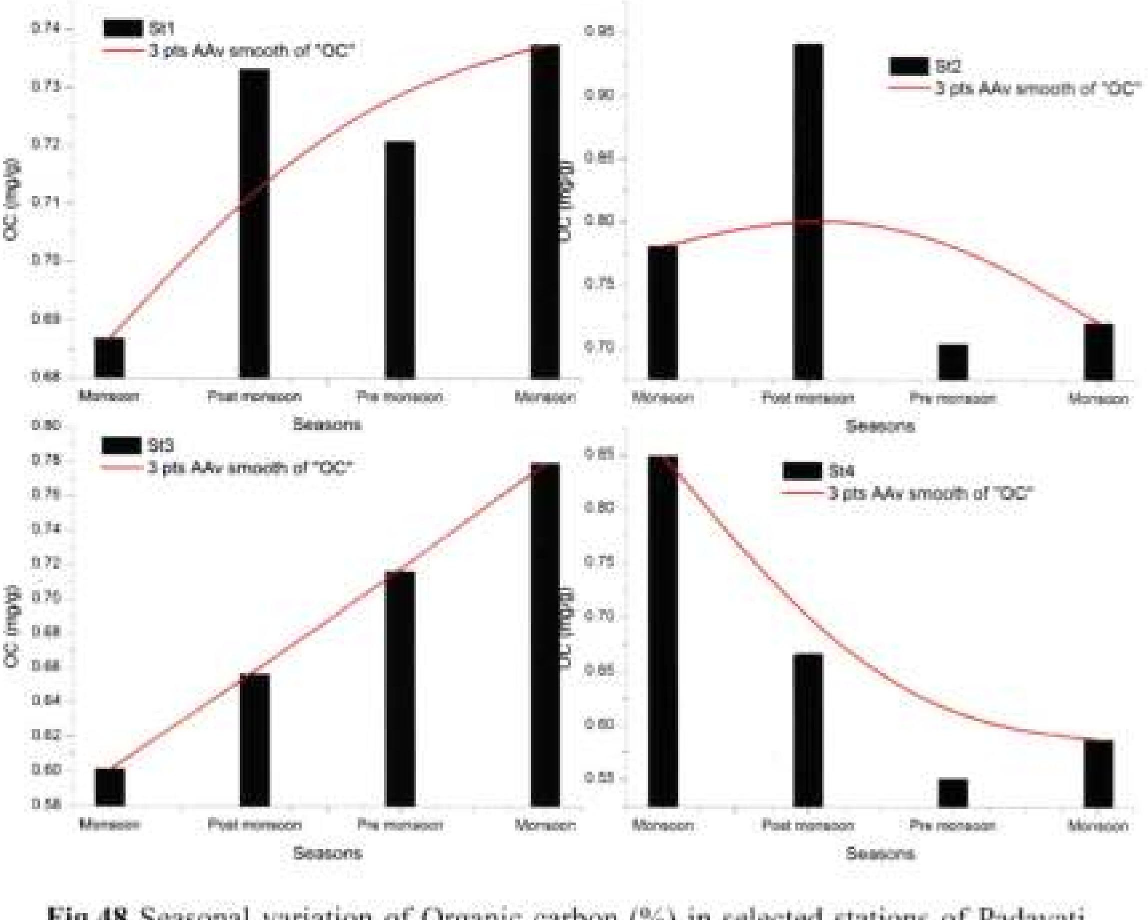


Fig.48 Seasonal variation of Organic carbon (%) in selected stations of Padayati wetland, Palakkad during 2009-2010

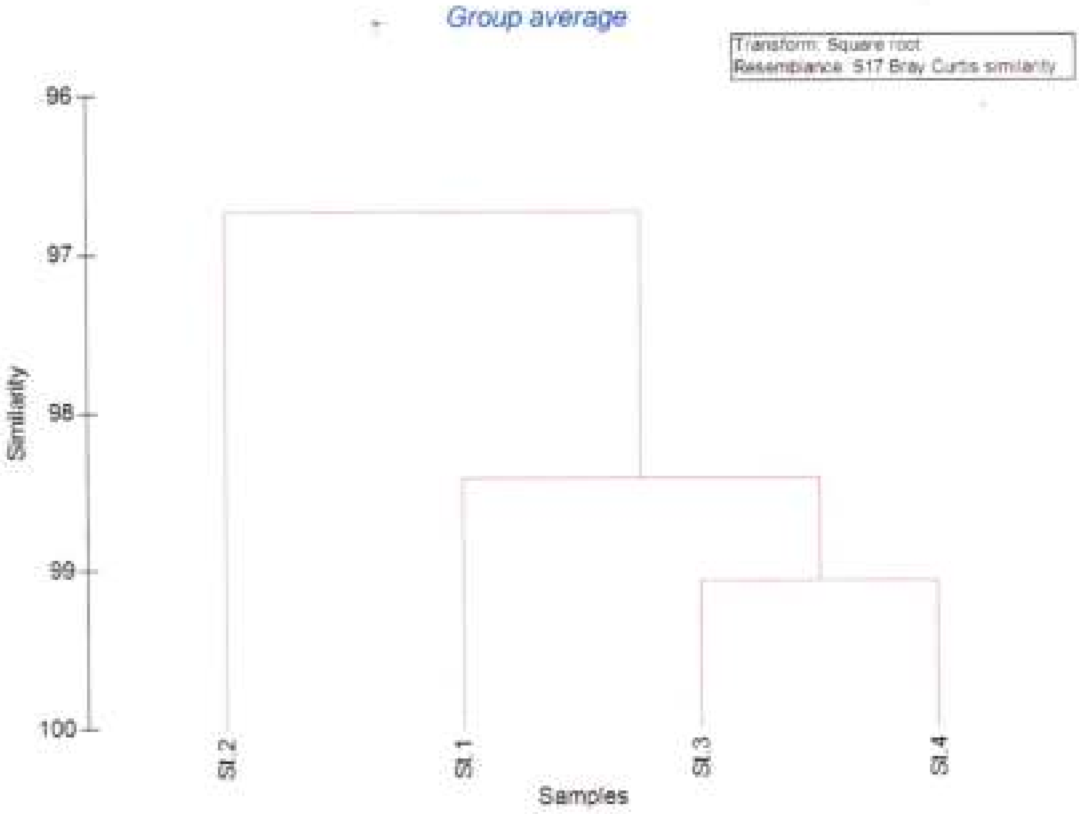


Fig.49 Station wise Bray- Curtis similarity of soil Organic Carbon in selected wetlands of Padayatti, Palakkad during 2009-2010.

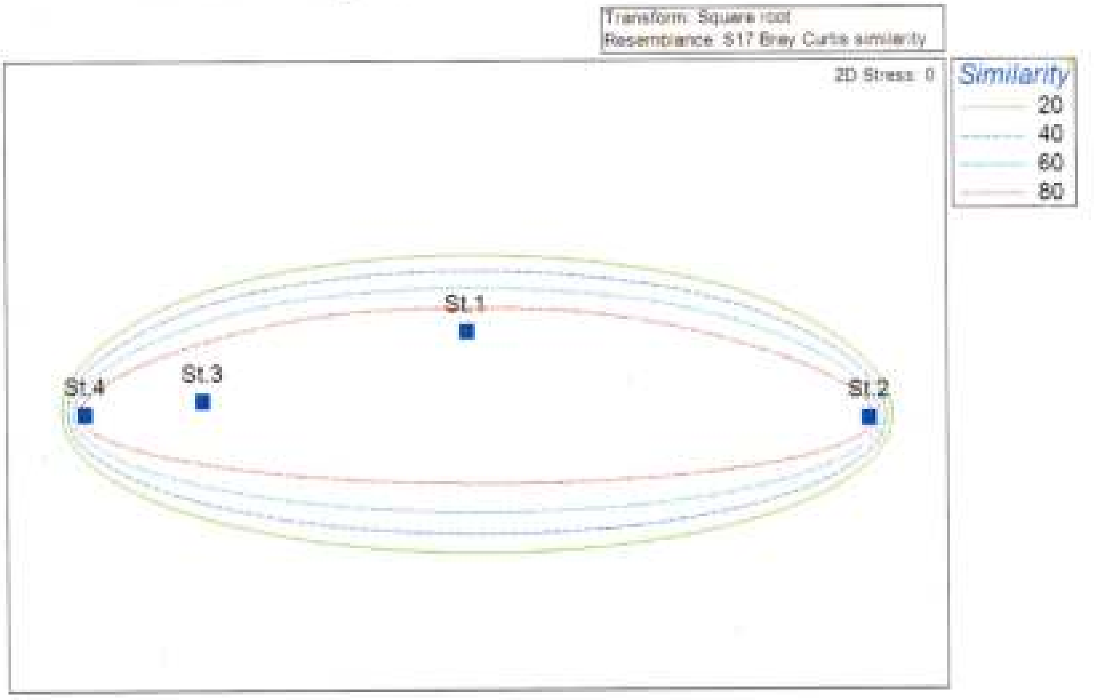


Fig.50 Station wise Multi dimensional plot (MDS) of soil organic carbon in selected wetlands of Padayatti, Palakkad during 2009-2010.

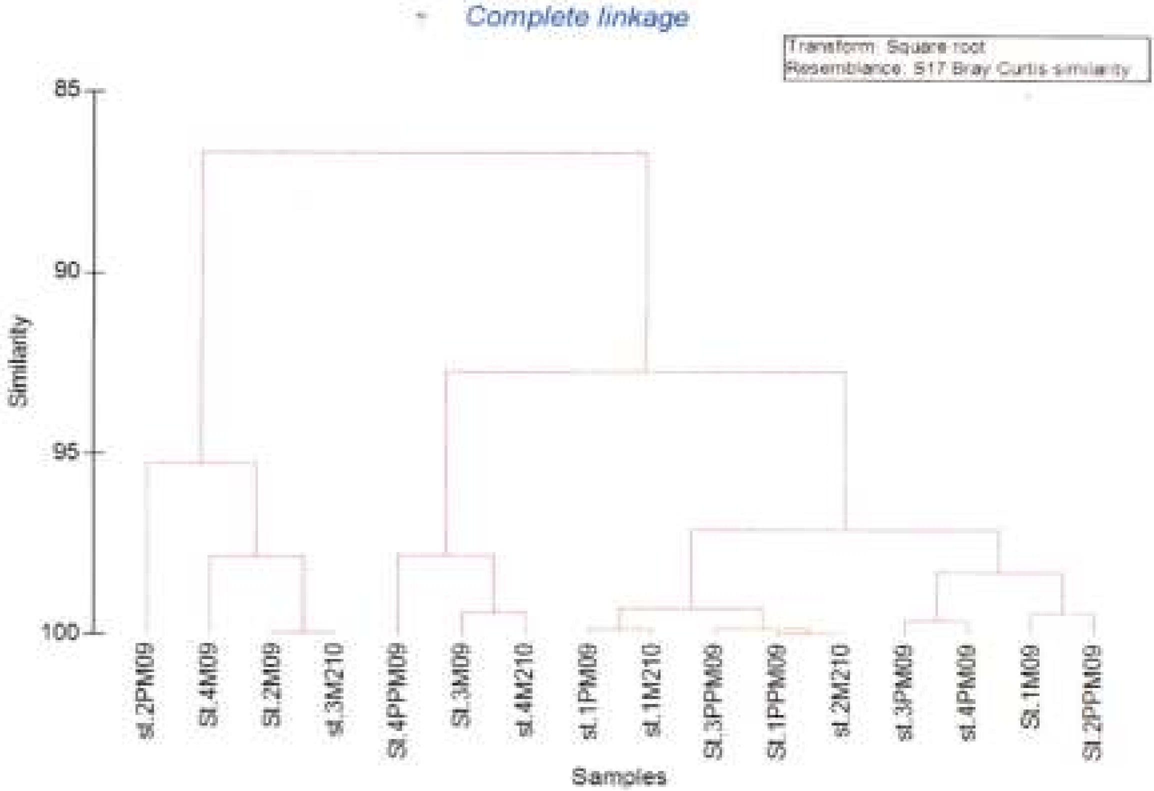


Fig.51 Season wise Bray- Curtis similarity of soil Organic Carbon in selected wetlands of Padayatti, Palakkad during 2009-2010.

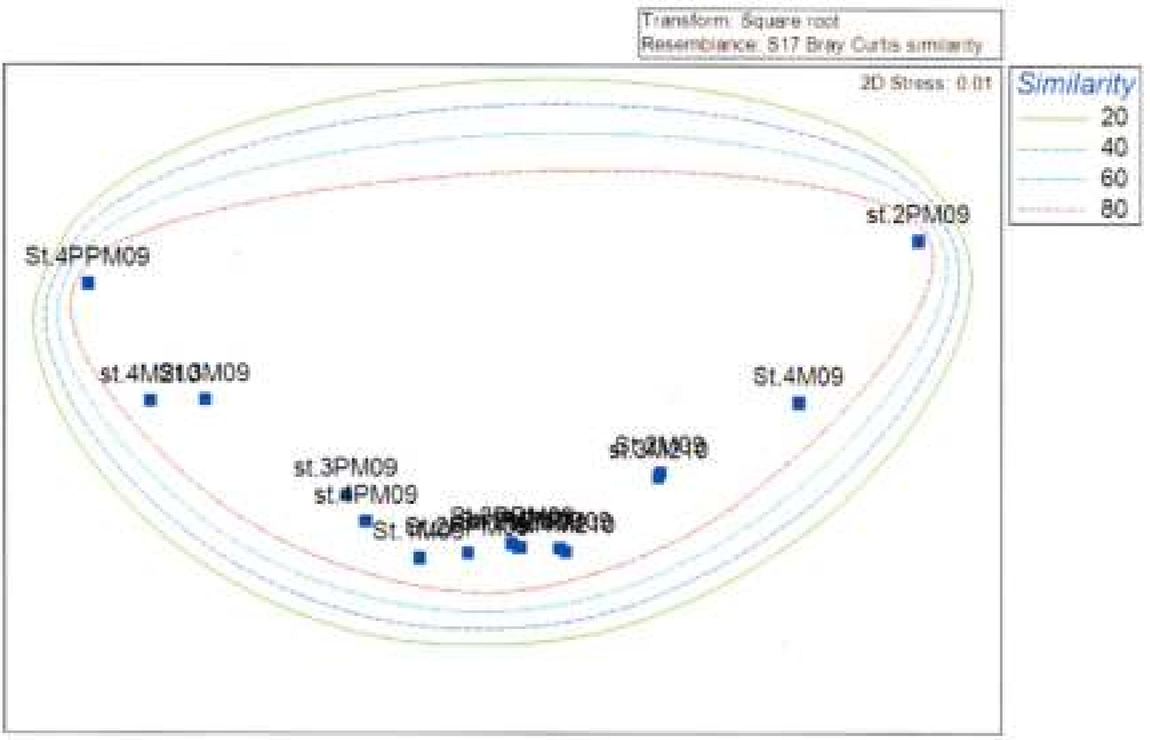


Fig.52 Season wise Multi dimensional plot (MDS) of Soil Organic Carbon in selected wetlands of Padayatti, Palakkad during 2009-2010.

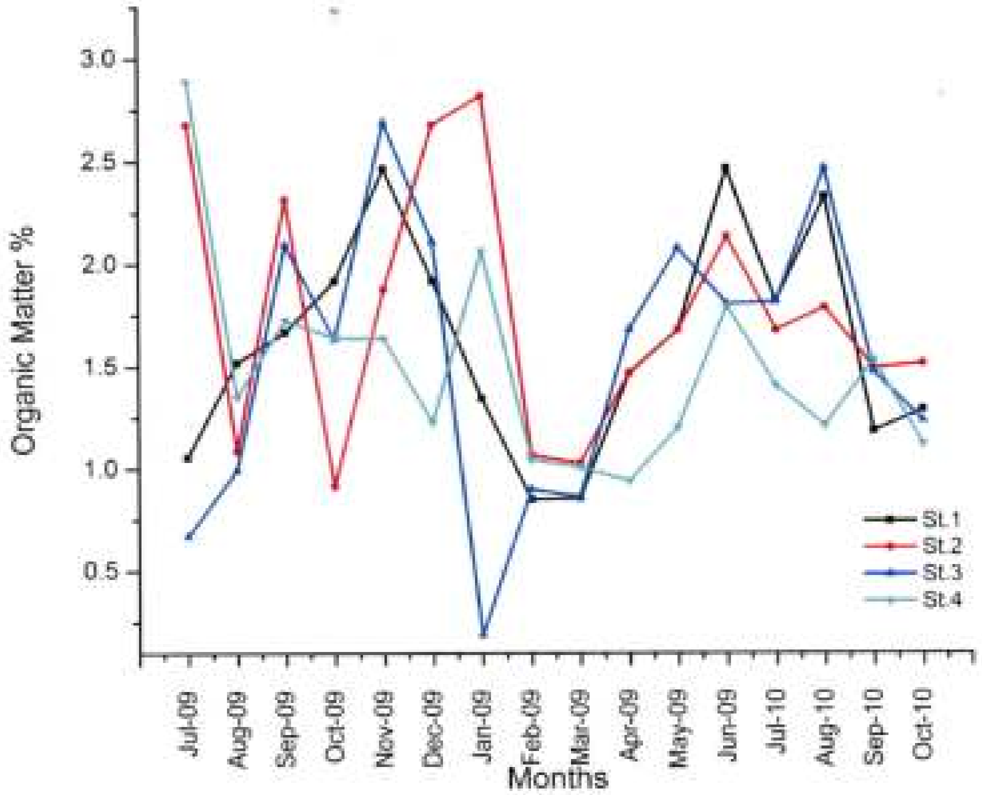


Fig .53 Variations of organic matter % in selected stations of padayati wetland Palakkad.

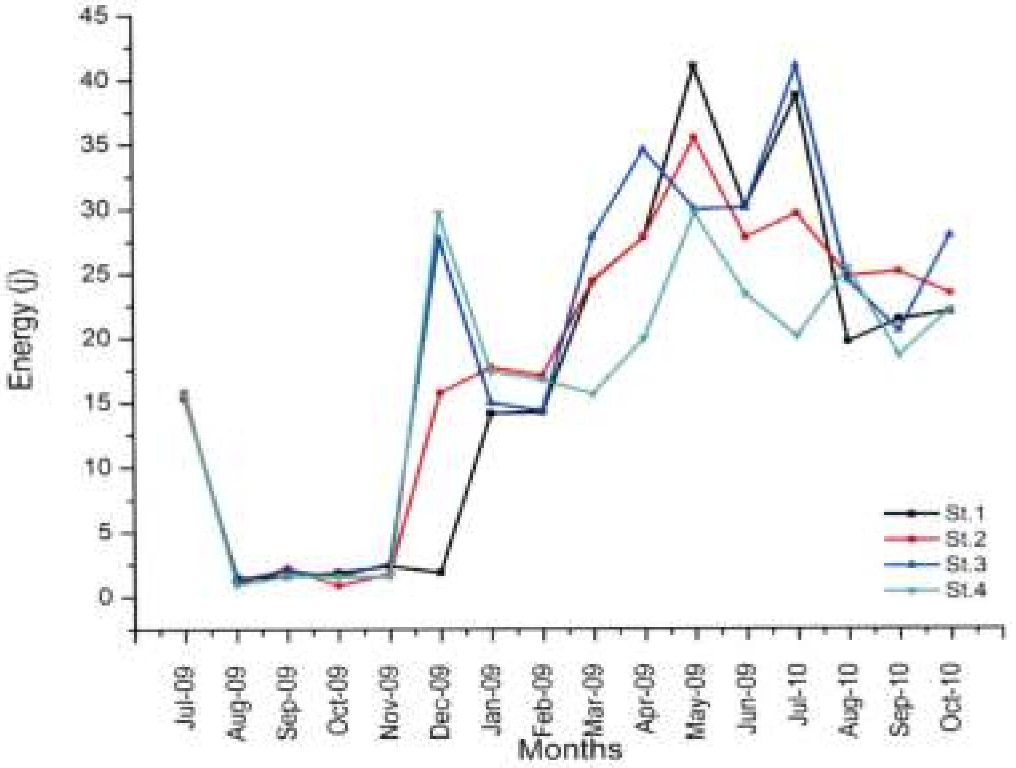


Fig.54 Distribution of energy content (J/g) in selected stations of Padayati

Table 18 ANOVA table of Organic Carbon in Padayati wetland, Palakkad during 2009-2010

Organic Carbon			
Source	**df**	**Mean Square**	**F**
Corrected Model	11	.072	1.072
Season	2	.059	.871
station	3	.114	1.689
Season * station	6	.056	.830
Error	100	.067	
Total	112		
Corrected Total	111		
R Squared = .105 **- significant at 1% level. * - significant at 5% level.			

Table 19 ANOVA table of Organic Matter in Padayati wetland, Palakkad during 2009-2010

Organic Matter			
Source	**df**	**Mean Square**	**F**
Intercept	1	275.994	816.480
Season	2	.294	.871
station	3	.571	1.689
Season * station	6	.281	.830
Error	100	.338	
Total	112		
Corrected Total	111		
R Squared = .105 **- significant at 1% level. * - significant at 5% level.			

Table 20 ANOVA table of Energy content in Padayati wetland, Palakkad during 2009-2010

Energy			
Source	**df**	**Mean Square**	**F**
Corrected Model	11	579.991	7.666
Intercept	1	38156.593	504.341
Season	2	2714.166	35.875
station	3	61.880	.818
Season * station	6	116.196	1.536
Error	100	75.656	
Total	112		
Corrected Total	111		
R Squared = .457 **- significant at 1% level. * - significant at 5% level.			

6.10 Methane Flux

Agricultural wetlands play an important role in the global flux of green house gases especially methane. Since agro ecosystems are usually intensively managed, agricultural practices may offer a way to curb agricultural emission, in turn partially mitigating the enhanced greenhouse effect. Agricultural soils can constitute either a net source or sink of greenhouse gases. The ways that these soils are managed can influence the flux of greenhouse gases by changing one or more of the following: the soil climate (i.e., temperature and water content), the physical/chemical environment of the soil, and the amount and chemical composition of organic residues applied to soil. Changes in these variables control the rate and extent of microbial processes, which in turn control the stabilization of C in soil and affect the production of greenhouse gases.

The preliminary analysis of the potential green house gas – methane flux from the organic and conventional fertilizer plots in padayatti were done on a monthly basis from july 2011 to November 2011. The analysis has showed that the emission rates of methane were higher in the organic stations as compared to fertilizer stations (Fig.44). The gaseous methane efflux from soil is initially dependent on the rate of production of carbon dioxide (or CH_4) within the soil–plant root system, and subsequently on the rate of gaseous diffusion and mass flow from soil pore waters to the atmosphere; a function of soil moisture and textural

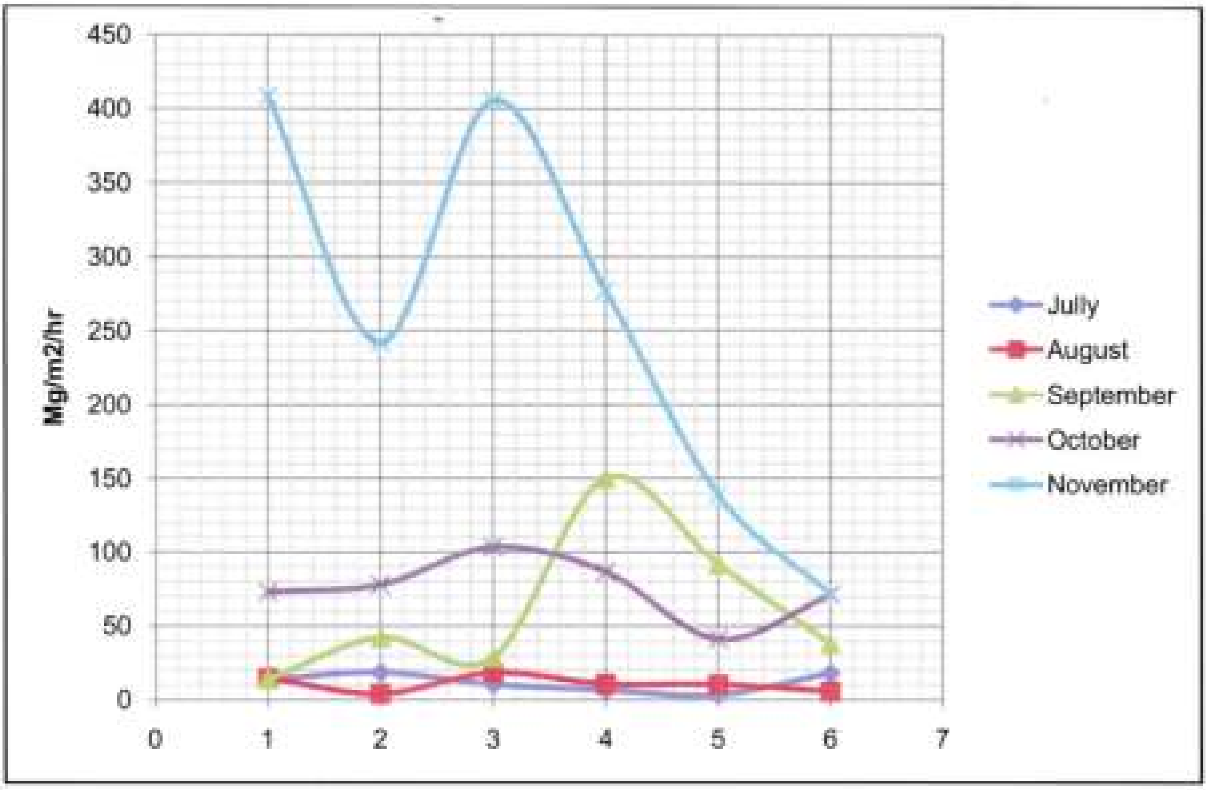


Fig.55 Methane emission flux from selected zones of Padayatti, Palakkad during 2010-2011

6.11Microbial Biomass (Total Plate Count)

Soil micro organisms constitute a source and sink for nutrients and are involved in numerous activities, such as transformation of C, N, P and S, degradation of xenobiotic organic compounds, formation of soil physical structure and enhancement of plants' nutrient uptake (Gregorich *et al.*,1994; Seklemova *et al.*, 2001). For these reasons, the importance of microorganisms in the maintenance of quality and productivity of agricultural soils is unquestionable. The responsiveness of microorganisms to environmental factors implies that disturbances imposed by agricultural treatments may lead to alterations in the composition and activity of soilmicrobiota and, therefore, may affect soil quality (Gregorich et al., 1994; Shibahara and Inubushi, 1997).

Soil microorganisms play a major role not only in decomposing organic matter, but also as a sink for plant nutrients. They represent a small fraction (1-3%) of the total soil organic matter, it has relatively rapid turnover and it exerts an important influence on soil carbon and nutrient cycling, both through the oxidation of soil organic matter and a labile reservoir of nutrient elements such as carbon, nitrogen, phosphorus and sulfur (Anderson and health which forms the living component of organic matter decomposing it into humus. A comparative analysis of heterotrophic bacterial counts in organic and fertilizer fields revealed that heterotrophic count was significantly low in fertilizer stations as compared to the organic stations.

During the present study, station wise analysis of microbial biomass showed an average value of 17.52 x 10^5 in St.1, 12.95 x 10^5 in St.2, 16.76 x 10^5 in St.3 and 11.25 x 10^5 in St.4 respectively. Variations in the heterotrophic counts of bacteria in different stations are given in Fig.56. In 2010 average highest value of 2413636 cfu/g soil was observed in St.1 whereas colony forming units of 1602727 cfu/g soil was observed in fertilizer stations (Fig.13). Monthly observation of the data showed that microbial count varied from 50000 cfu/g in March 2010 to 5350000 cfu/g in St.1; that from 9700 cfu/g in February 2010 to 6310000 cfu/g in September 2010 in St.2; that from 12000 cfu/g in February 2010 to 7410000 in St.3 and 0 in February 2010 to 2010000 in November 2010 in St.4.

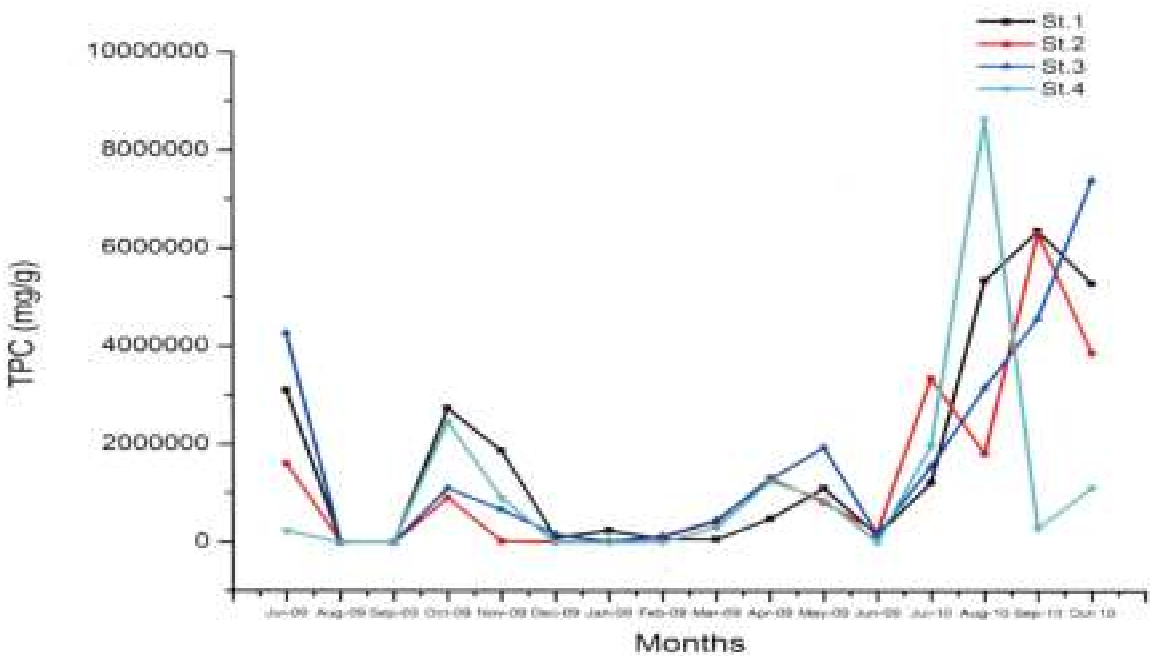


Fig.56 Monthly Variation heterotrophic bacterial count (cfu/g) among four stations in selected wetlands in Padayetti, Palakkad during 2009-2010.

Determination of soil microbial biomass is generally used as a rapid indicator of change in soil management which in turn affects the turnover of organic matter (Nannipieri et *al* 1990). A relatively rapid response to organic amendments has been reported for microbial biomass carbon by several workers which suggest it could be a useful indicator in identifying positive effects of soil management (Fauci and Dick, 1994). Reports of Danish Biobal

Committee, Axelsen and Elmholt (1998) reported that a transition to 100% organic farming in Denmark has increased the microbial biomass by 77%, with rise the concentration of springtails by 37%, that augment the density of earthworms by 154% as a national average. Conversion to organic farming therefore provides opportunities for significantly increase the biological activity of the soil.

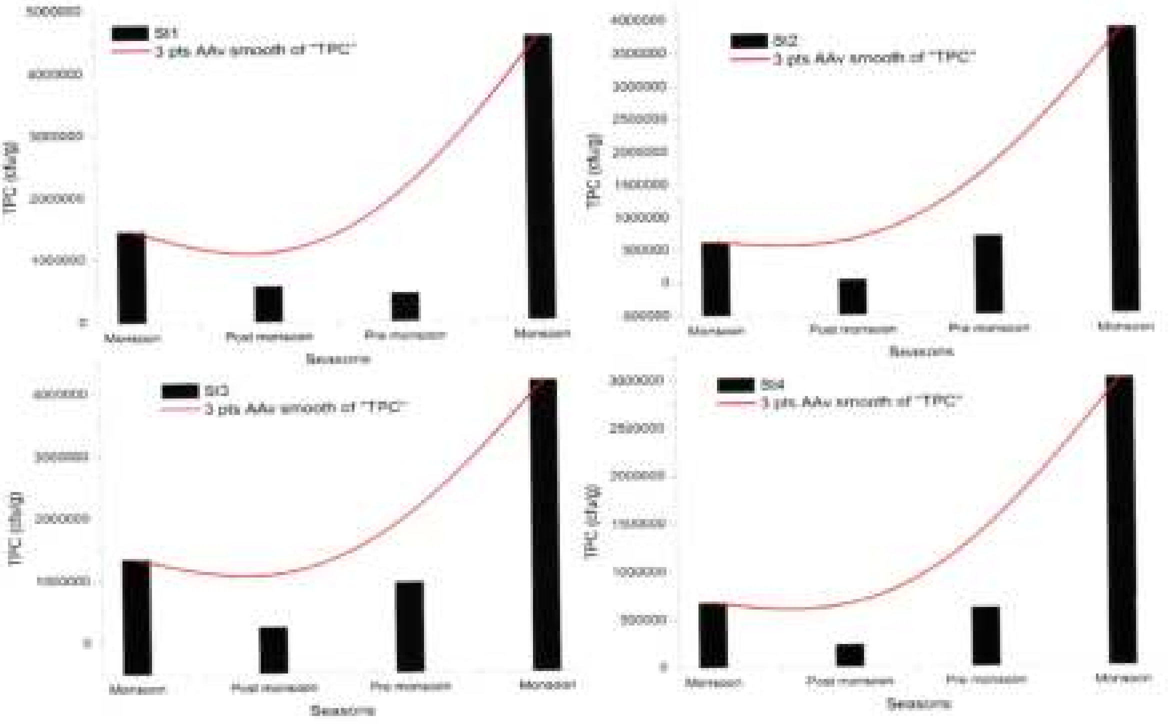


Fig.57 Seasonal variation of microbial biomass in selected stations of Padayati wetland, Palakkad during 2009-2010

From the ANOVA table it was evident that, the variation of microbial biomass were seasonally significant at 1% level (F=22.412) (Table 21). Seasonally biomass was high during Monsoon season in both 2009 and 2010 (Fig. 22). In season wise Duncan test showed that microbial biomass was grouped in to 2 subsets seasonally and all the subsets were significant at 1% level, indicating that the grouping was prominent as compared to the season where only 2 groups were observed.

Mean station wise dendrogram depicted highest similarity in Microbial biomass in St.1 and St.3 (98%) whereas a least similarity was seen in organic st.2 and St.4 (97.5%). Station wise non-metric multidimensional scaling (MDS) ordination of microbial biomass showed a similarity of 80%. Season wise Bray-Curtis similarity profile for microbial biomass showed four clusters (Fig.58). The similarity in microbial biomass was highest in first cluster (99%) represented by St.3 post monsoon 2009, St.4 post monsoon 2009. Cluster 3 showed, 92% similarity in seasonal distribution of total nitrogen represented by St.4 monsoon 2010, St.2 monsoon 2010 and St.2 monsoon 2010 and St.3 monsoon 2009. Followed by cluster 4 with a similarity of 91% represented by St 3 post monsoon 2009, St 1 monsoon 2010 and St.3 monsoon 2009. Least similarity was fond in cluster 2 having a similarity of 90% represented by St.1 monsoon 2009, St.2 post monsoon 2009, st.4 monsoon 2009, St.1 post monsoon 2009 and St.3 monsoon 2009, St.2 monsoon 2009, St.4 monsoon 2009 and St.4 post monsoon 2009. Seasonally non-metric multidimensional scaling (MDS) ordination showed that microbial biomass was generally similar in all seasons except St.2 during post monsoon 2009 with a similarity of 20%.

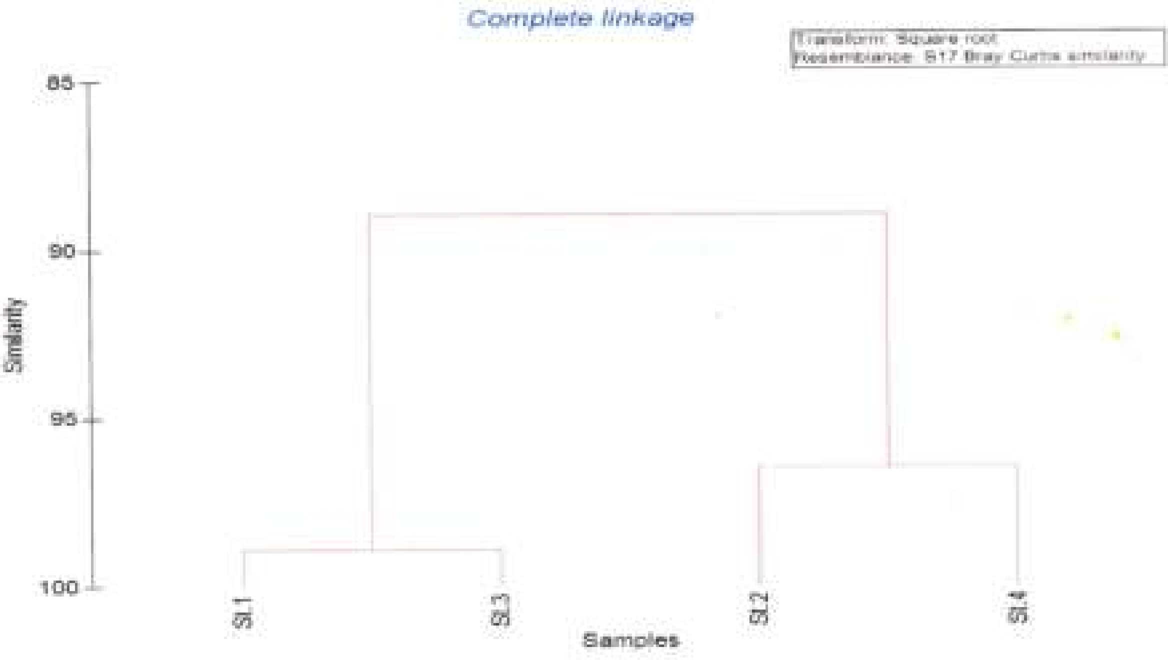


Fig.58 Station wise Bray- Curtis similarity of microbial biomass in selected wetlands of Padayatti, Palakkad during 2009-2010.

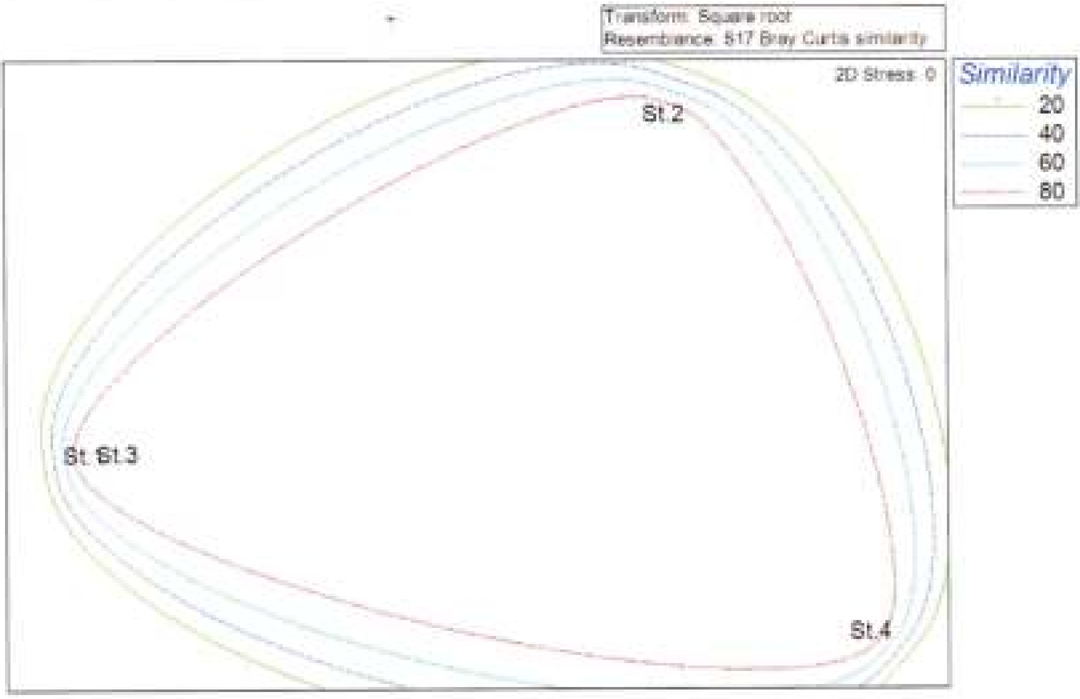


Fig.59 Station wise Multi dimensional plot (MDS) of Soil Organic Carbon in selected wetlands of Padayatti, Palakkad during 2009-2010.

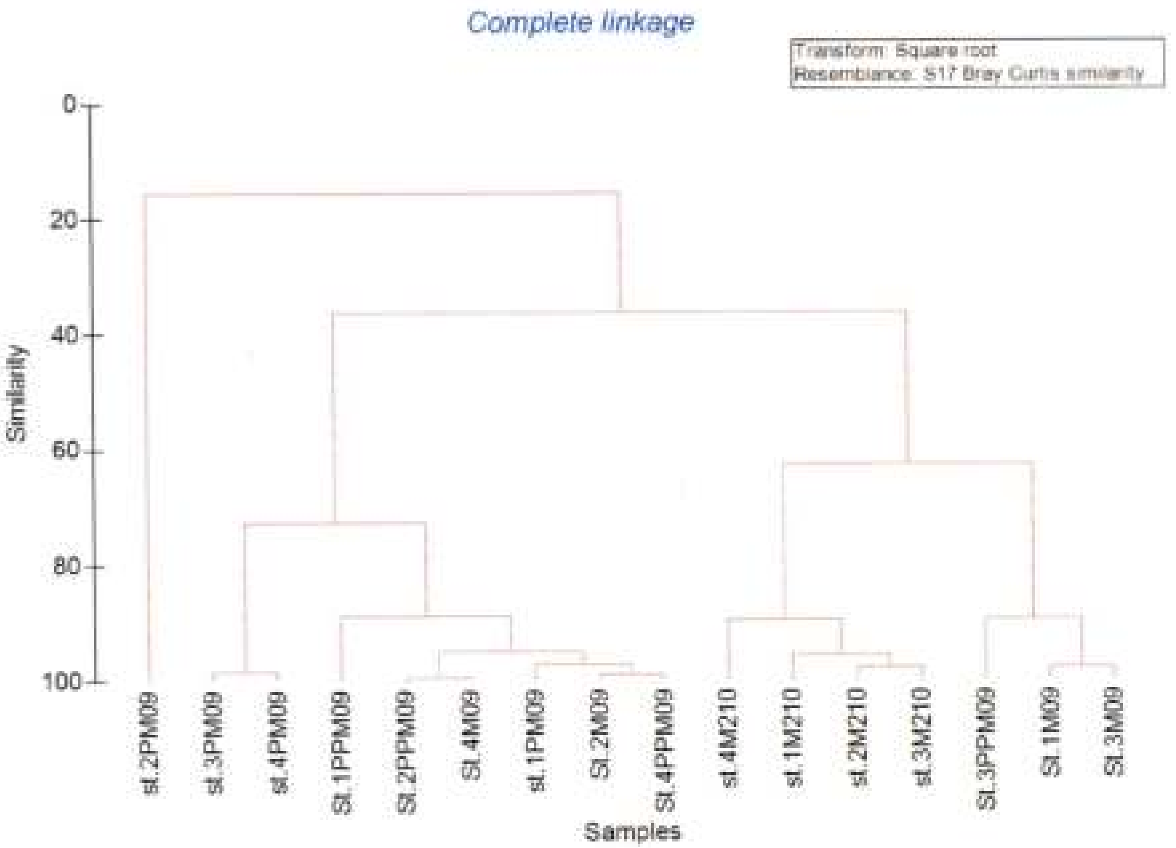


Fig.60 Season wise Bray- Curtis similarity of soil Organic Carbon in selected wetlands of Padayatti, Palakkad dring 2009-2010.

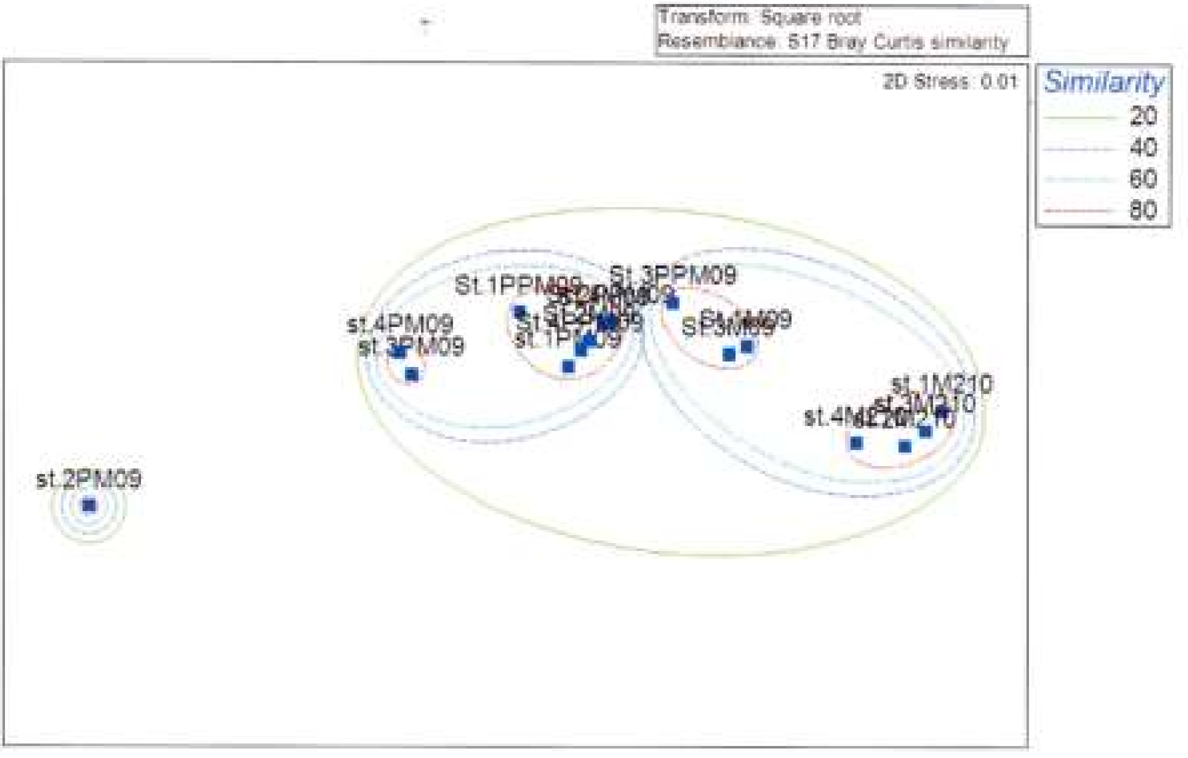


Fig.61 Multi dimensional plot (MDS) of Soil Organic Carbon in selected wetlands of Padayatti, Palakkad during 2009-2010

Table 21 ANOVA table of Microbial Biomass in Padayati wetland, Palakkad during 2009-2010

Source	df	Mean Square	F
Corrected Model	11	9.051	4.501**
Season	2	4.507	22.412**
station	3	1.409	.700
Season * station	6	9.988	.497
Error	100	2.011	
Total	112		
Corrected Total	111		
R Squared = .331 ** significant at 1% level. * significant at 5% level.			

Table.22 Post Hoc table of Total Microbial Biomass in Padayatti wetland, Palakkad 2009-2010.

Microbial Biomass			
	station	N	Subset
			1
Duncan[a]	4	28	847357.1429
	2	28	940871.4286
	1	28	1.2065E6
	3	28	1.2643E6
	Sig.		.323

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 2010873095400.000.

a. Uses Harmonic Mean Sample Size = 28.000.

6.12 BIOTA

Macrobenthos

A wide variation in the distribution of macrofauna was noted during the present study period. The distribution of macro fauna depends mainly on the hydrological pattern and the agricultural practices of the paddy wetland. Macrobenthic community in the study area was constituted mainly by two groups oligochaetea and crustaceans. Station wise analysis revealed that macro benthic communities showed highest abundance during the month of August 2009, September, December and February 2010 in St.1 with an average value of 758.33 no/m^2.

In St.2 maximum abundance of organisms were observed during the moths October 2009, November, December, January and February 2010 with an average number of 834 organisms / m^2. Station 3 showed an average of 671.875 no of organism/m^2. Station4 amended by chemical fertilizers showed the lowest number of organisms.

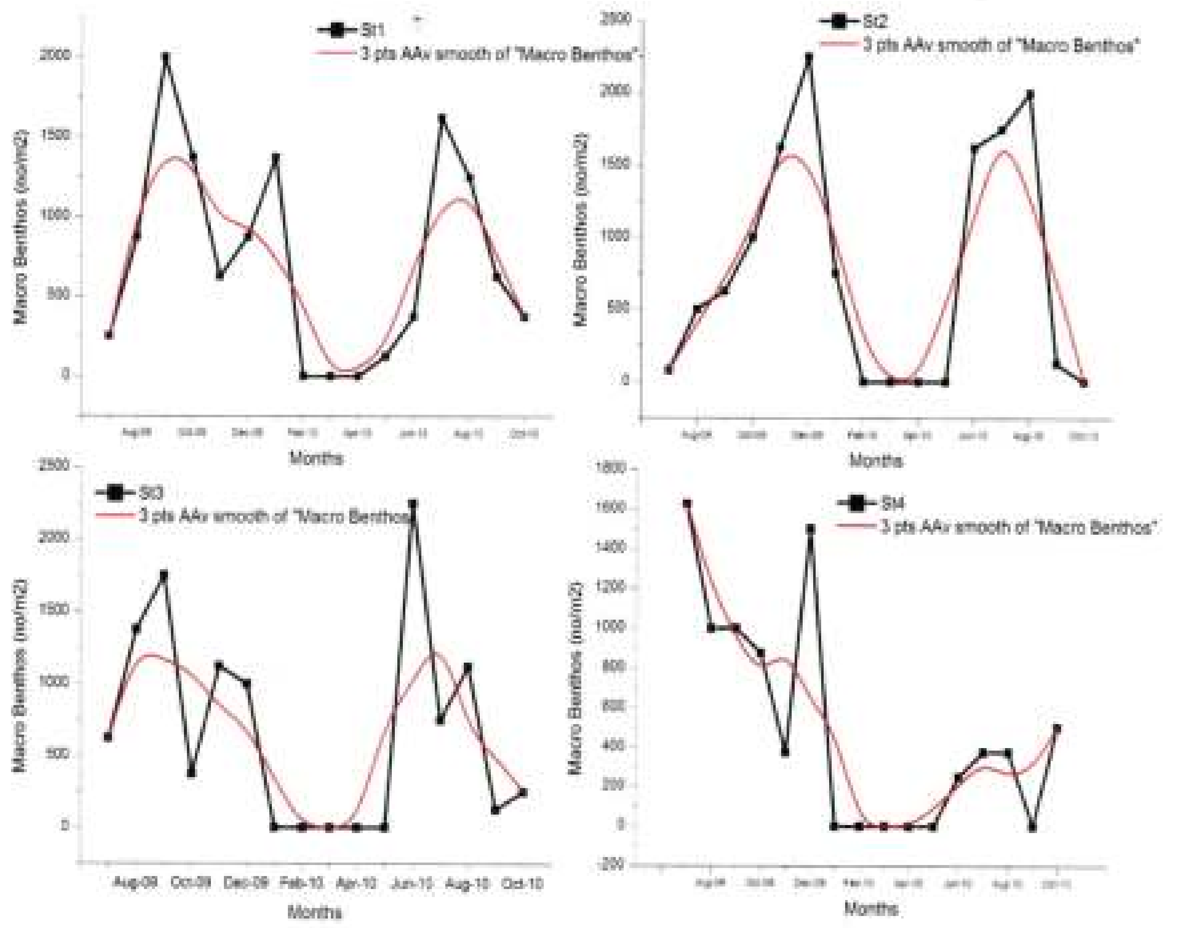


Fig. 62 Abundance of macrobenthic organisms (no/m^2) in selected stations of Padayetti wetland during 2009-2010

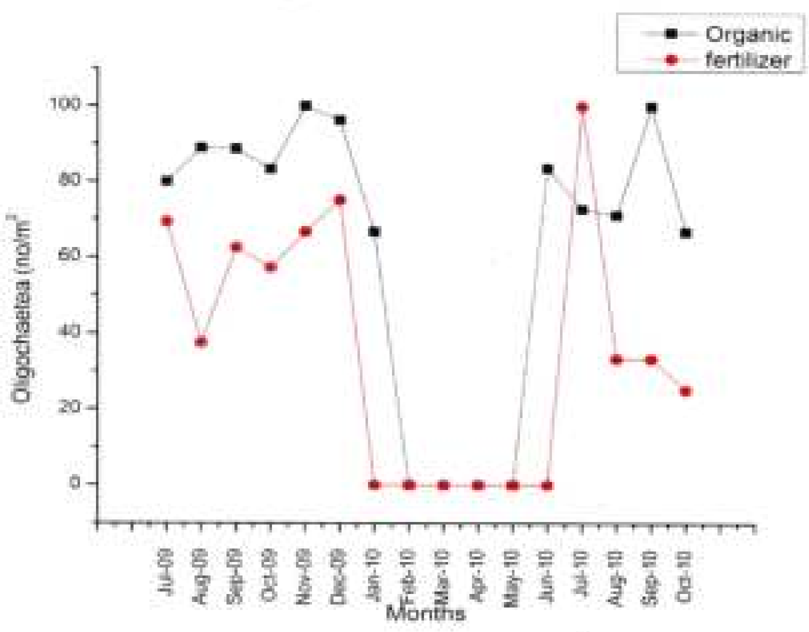


Fig. 63 Percentage abundance of oligochaetea (no/m^2) in selected wetlands of Padayatti wetland Palakkad during 2009-2010.

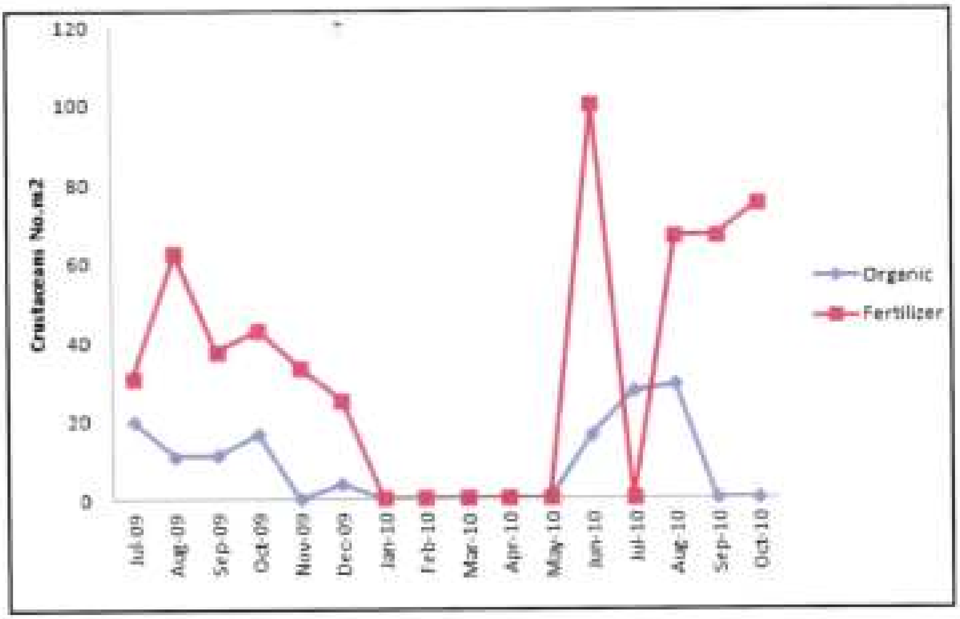


Fig.64 Percentage abundance of crustaceans (no/m^2) in selected wetlands of Padayatti wetland Palakkad during 2009-2010.

The survival and existence of macro benthic community in the study area mainly depends on the seasonal hydrological pattern and agricultural practices. During the present study the distribution and abundance of benthic organisms were low during the pre monsoon. An average of 136.15 no.m^{-2} was observed in St.1, 109.49 in St.2, 88.157 in St.3 and 97.05 in St.4 respectively.

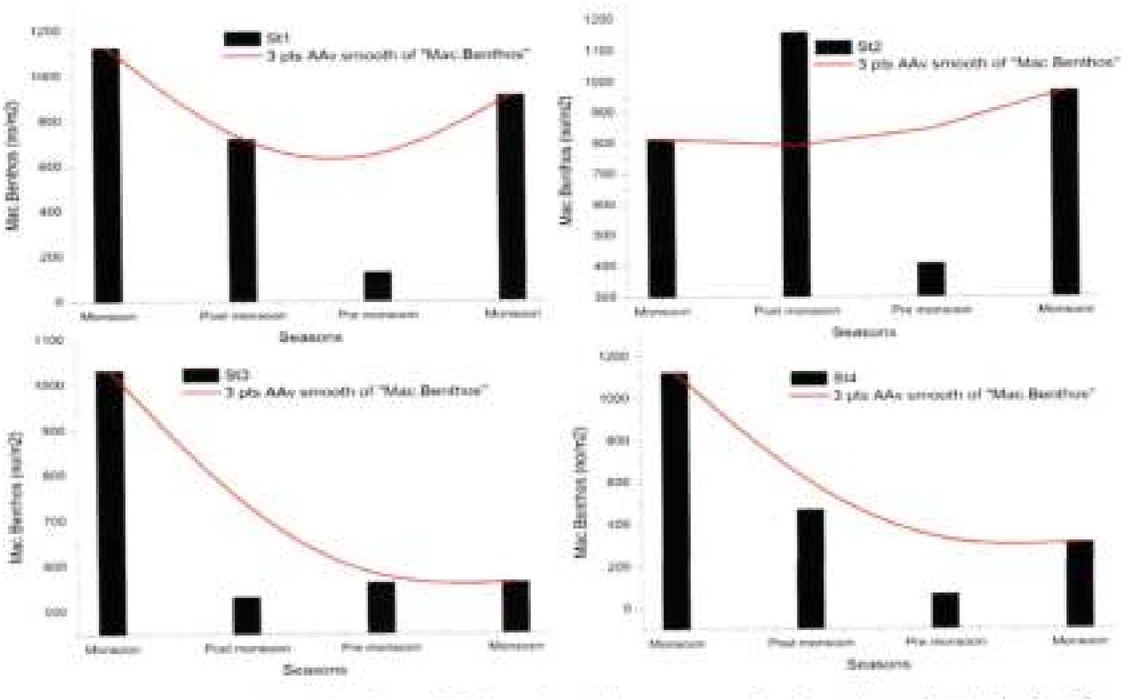


Fig. 65 Sesonal distribution of Macro benthic community in selected wetalnds of

Marobenthos has showed an intimate relation with the climatic and cropping pattern of the study site. Continuous tilling and weeding practices may be a reason for low benthic organisms. Organisms were almost nil in months with elevated temperatures. The station with fertilizer application zones showed lesser abundance of organisms than that of organic zones. Macro benthic communities in the study area were mainly constituted by crustaceans and annelids. Earth worms dominated among the observed during the study period. The number of organisms in soil is influenced by numerous factors, including soil type, type of fertiliser, crop rotation, cultivation, climate, etc. It is therefore difficult to separate the effects of organic farming from other factors.

7. Salient Observations

The salient observations during the present study from February 2009 to February 2011 indicate that soil in Padayetti under organic cultivation was able to maintain marginally increased concentration of total soil organic matter, total and available nitrogen, potassium, calcium and available phosphorous and pH as compared to the conventional fertilizer systems. The average total nitrogen concentration was 0.477% in organic and 0.492% in fertilizer zones. The available nitrogen values showed an elevated concentration of an average 117.09% in organic amended field that of 107.31% in fertilizer zones. Sodium concentration varied marginally between organic amended (0.485 mg/g) and fertilizer fields (0.395mg/g). The essential nutrient potassium showed higher concentration of 0.856 mg/g in organic stations whereas it was 0.492 mg/g in conventional fertilizer zones. Calcium concentration varied between 2.814 in organic and 2.22 mg/g in fertilizer fields. The percentage composition of organic carbon in the soil also showed an increase in the organic amended fields with 0.17% to that of 0.592 % in fertilizer fields. The organic matter and energy content of Padayatti wetland followed a same trend as that of organic carbon.

The benthic community also showed an increased abundance in organic amended stations with an average of 844no/m^2 in organic stations and 313no/m^2 in conventional fertilizer stations. The increase in benthic organisms cannot be correlated alone with organic farming because numerous other environmental factors also play a crucial role in their abundance and diversity. The mean heterotrophic bacterial count also showed an increased colony forming unit in organic stations (679698cfu/g) as compared fertilizer stations (160272cfu/g).

Long term studies from California and England in organic and conventionally managed farming systems have represented higher soil organic matter and total nitrogen with the use of organic practices (Sean Clark *et al* 1998; Lockeretz *et al*., 1981; Alvarez et al., 1993; Reganold, 1988; Reganold *et al*, 1993; Drinkwater *et al*., 1995). Soil organic carbon and total nitrogen in the present study also showed that they were greater in soil amended with organic manure, as compared with chemical fertilizers. An enhanced soil organic carbon and total nitrogen in organic fields are due to high loading of organic carbon and nitrogen and efficient metabolic activity of microorganisms and physio chemical protection of organic C and N. Studies comparing soil organically and conventionally managed farming systems have documented higher soil organic matter (OM) and total nitrogen with the use of organic practices (Lockeretz *et al*., 1981; Alvarez *et al*., 1988, 1993; Reganold, 1988; Reganold *et al*; 1993; Drinkwater *et al*,. 1995). Increase in soil OM following the transition to organic management occur slowly, generally taking years to detect (Wander *et al*., 1994; Werner, 1997), yet can have a dramatic effect on long term productivity (Tiessen *et al*; 1994). Increase in soil organic matter following the transition to organic management occur slowly taking several years, 1997) to detect (Wander et al., 1994; Drinkwater *et al*., 1995).Soil organic matter (SOM) and organic carbon contains most of the soil reserve of nitrogen (Berry et al. 2002) and large proportions of other nutrients such as phosphorus (P) etc (Stevenson 1986). Increased levels of soil organic matter, and hence increased organic reserves of nutrients, are widely reported for organic systems (Stockdale *et al*. 2001).

In the present study, even though considerable variation could be observed in the organic and fertilizer fields in the context of soil chemical and biological parameters, however they were not very much pronounced. It may take considerable time for the organic elements mainly the microflora to become effective for regulating the quality of the soil. So this time delay could also be a factor for the low variability of different parameters in certain months of the study in different stations. Therefore, it is expected that, more pronounced variability of different parameters in the study area would be evolved in the subsequent periods of the investigation.

Therefore, long term sampling and analysis are to be continued in the wetland to arrive at more definite conclusions.

8. References

1. APHA 2005, American Public Health Association Standard Methods for the examination of analysis of water and waste-water 21st edition.
2. Alfred E Brown. (2001) Benson's Microbiological Application, Laboratory Manual in General Microbiology 8th edition. Tata McGraw-Hill Companies.
3. Anderson, J.P.E and Domsch, K.H. (1980) Quantities of plant nutrients in the microbial biomass of selected soils. Soil Sci. 130:.211-216.
4. Barnes H, (1959) Apparatus and Methods in Oceanography: Part I – Chemical,(George Allen & Umwin, London).
5. Berry PM Sylvester-Bradley R Philipps L Hatch DJ Cuttle SP Rayns FW & Gosling P. (2002). Is the productivity of organic farms restricted by the supply of available nitrogen. Soil Use and Management 18, 248±255.
6. Clark, M.S., Horwath, W.R., Shennan, C., Scow, K.M. (1998) Changes in soil chemical properties resulting from organic and low-input farming practices. Agron. J. 90, 662–671.
7. Crawford, J.J., S.J. Train and O.H. Tuovinen. (2000) Bacterial degradation of artazine in redox potential gradients in fixed-film sand columns. Soil. Sci. Soc. Am. J., 64: 624-634.
8. Drinkwater, L.E., Wagoner, P., Sarrantonio, M. (1998) Legume-based cropping systems have reduced carbon and nitrogen losses. Nature 396, 262–264.
9. Dimitrov. D. (1997). Acta Hort., 462: 433-37.
10. Eswaran, H., Berg, E.V.D., Reich, P. (1993) Organic carbon in soil of the world. Soil Sci.Soc. Am. J. 57, 192–194.
11. Fauvel P. (1953) The Fauna of India including Pakistan, Ceylon, Burma and Malaya – Annelida Polychaeta, The India Press Ltd.
12. FAO 2002. Increasing incomes and food security of small farmers in West and Central Africa through exports of organic and fair-trade tropical products. Mango, Pineapple, Cocoa. Trade and Markets Division of the Food and Agriculture Organisation of the United Nations. GCP/RAF/404/GER. Rome.

13. Gray, L.C., Morant, P. (2003) Reconciling indigenous knowledge with scientific assessment of soil fertility changes in southwestern Burkina Faso. Geoderma 111, 425–437.

14. Gregorich, E.G., Carter, M.R., Angers, D.A., Monreall, C.M., Ellerta, B.H.(1994) Towards a minimum data set to assess soil organic matter quality in agricultural soils. Canadian Journal of Soil Science 74, 367e385.

15. Holme N. A and Mc Intyre A. D. (2003) Methods for study of Marine Benthos, IBP Hand book No.6, Blackwell Scientific Publications.

16. Jackson M. L. (1973) Soil Chemical Analysis Printice-hall of India Private Limited, New Delhi. El-Wakeel & Riley J P, 183, J Cons Perm Inst explor. Mer., 22 (1957).

17. Jenkinson, D.S., Rayner, J.H. (1977) The turnover of soil organic matter in some of Rothamsted classical experiments. Soil Sci. 125, 298–305.

18. Knorr,W., Prentice, I.C., House, J.I., Holland, E.A. (2005) Long-term sensitivity of soil carbon turnover to warming. Nature 433, 298–301.

19. L.R. Bulluck, M. Brosius, G.K. Evanylo, J.B. Ristaino (2002). Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms. Applied Soil Ecology 19 147–160

20. M. Sean Clark, William R. Horwath, Carol Shennan, and Kate M. Scow. (1998) Changes in Soil Chemical Properties Resulting from Organic and Low-Input Farming Practices. Agronomy journal, vol. 90.

21. Pathak. S.C. (1992). Hort. Sci. 27: 738-41

22. Prasad, B., Prasad, J., & Prasad, B. (1995) Nutrient management for sustainable rice-wheat production in calcareous soil amended with green manures and zinc. Fertilizer News, 40 (3), 39-45.

23. P. Gosling and M. Shepherd. (2004) Long-term changes in soil fertility in organic arable farming systems in England, with particular reference to phosphorus and potassium, Agriculture, Ecosystems and Environment 105 (2005) 425–432.

24. Tisdale, S.L., W.L. Nelson, J.D. Beaton, and J.L. Havlin. (1993) Soil fertility and fertilizers. 5th ed. Macmillan Publ. Co., New York.

25. Post,W.M., Emanuel,W.R., Zinke, P.J. (1982) Soil carbon pools and life zones. Nature 298, 156–159.

26. Nannipieri, P. (Eds.), Alef, K. (1995) Soil respiration. In: Alef, K., Methods in Applied Soil Microbiology and Biochemistry. Academic Press, San Diego, CA, USA, pp. 214–219.

27. McGrath, D., Zhang, C.S. (2003) Spatial distribution of soil organic carbon concentrations in grassland of Ireland. Appl. Geochem. 18, 1629–1639.

28. Nannipieri, P., Greco, S., Ceccanti, B. (1990) Ecological significance of the biological activity in soil. In: Bollag, J.M., Stotzky, G. (Eds.), Soil Biochemistry, vol. 6. Marcel Dekker, New York, pp. 293–355.

29. Rajagopal, D. and Sreeramulu, KR. (1999) Indian Fmg., 49(2): 7-10

30. Reganold, J.P., Elliott, L.F., Unger, Y.L. (1987) Long-term effects of organic and conventional farming on soil erosion. Nature 330, 370–372.

31. Reeves, D.W., 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil Tillage Res. 43, 131–167.

32. Shibahara, F., Inubushi, K. (1997) Effects of organic matter application on microbial biomass and available nutrients in various types of paddy soils. Soil Science and Plant Nutrition 43, 191e203.

33. Susanne, A., Michelle, M.W. (1998) Long-term trends of corn yield and soil organic matter in different crop sequences and soil fertility treatments on the Morrow Plot. Adv. Agron. 62, 153–197.

34. Stevenson FJ. (1986) Cycles of Soil. Carbon, Nitrogen, Phosphorus, Sulfur, micronutrients, John Wiley and Sons Inc New York.

35. Tan, Z.X., Lal, R. (2005) Carbon sequestration potential estimates with changes in land use and tillage practice in Ohio, USA. Agr. Ecosyst. Environ. 111, 140–152.

- **Scientific publications produced during the project period 2009-2010**

  Akhilesh vijay and Bijoy Nandan. (2010) Preliminary observations on soil and biological parameters in relation to organic farming practices in the kole wetlands of Palakkad, Kerala, Proceedings- National conference on challenges of modern biology