3.1. INTRODUCTION

Wetland hydrology is one of the most significant components of aquatic ecosystem. When hydrologic conditions in a wetland change even slightly to divert some water into agricultural land, the biota may respond with massive changes in species composition and richness or in ecosystem productivity.

The hydrographical conditions in a wetland mainly depend on the intrusion of seawater associated with tides and influx of freshwater from rivers. The precipitation / evaporation processes also have profound effects on the hydrographical changes. In addition to these factors, the bottom topography and the geographical shape of a wetland have added influence on the hydrographical conditions in the wetland.

Studies on air temperature, humidity, rainfall and various physico chemical properties of water and soil $p^H$ of pokkali wetlands, Ernakulam district were carried out during 2006-09. The following parameters were studied.

(a) Air temperature  
(b) Humidity  
(c) Rainfall  
(d) Dissolved oxygen  
(e) Water $p^H$  
(f) Soil $p^H$  
(g) Water temperature
3.2. METHODOLOGY

Analysis of the water and soil in the pokkali wetland was carried out by using standard methods (APHA, 1996) for the above mentioned parameters. The software SPSS was used for the analysis of the data. In the present study, different weather parameters were collected from the established weather station (Meteorological department, Cochin University of Science and Technology (CUSAT), Kochi. The permission for collecting the data was obtained from Meteorological department, Trivandrum. The parameters worked out include temperature, relative humidity and rainfall.

Three types of habitats were mainly noticed in pokkali wetland. They were paddy cultivated fields (June-October), prawn culture farms (January-May) and a short transient habitat (November-December) in between them. The agricultural/farming activity of pokkali wetland was a cyclic process in which paddy cultivation season (June-October) was followed by transient period (November-December) and prawn farming season (January-May). The transient period was having only a short duration (about 60 days). Details of transient period are also included below.

3.3. RESULT AND DISCUSSION

3.3.1. Air temperature

Daily air temperature was recorded using a maximum and minimum thermometer kept at the weather station at CUSAT, Kochi, which was the nearest meteorological station of the pokkali field. The annual temperature varied from 21°C to 33°C. The average maximum temperature recorded from January 2006 to April 2009 is summarized in (Table: 3.1). The minimum and maximum temperature varied slightly in the years studied. During 2006-07 (June-April) the average maximum temperature was recorded in April (33°C) and average minimum temperature in February (21°C). During 2007-08 (June-April), the average maximum temperature
was recorded in April (33°C) and minimum temperature was recorded in February (22°C). During 2008-09 (June-April) the average maximum temperature was recorded in April (33°C) and average minimum in January (22°C).

Table: 3.1 Average maximum and minimum temperature (°C) recorded during the study period.

<table>
<thead>
<tr>
<th>Months</th>
<th>2006-07</th>
<th>2007-08</th>
<th>2008-09</th>
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<td>Average Max.</td>
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3.3.2 Relative humidity

The data on relative humidity was measured using hygrometer. The average humidity recorded varied from 68 % - 94 %. During 2006-07 (June-April) maximum average relative humidity was recorded in August (93%) and minimum in February (68%). During 2007-08 (June-April) maximum average humidity was recorded in July (94%) and minimum in January (72%). During 2008-09 (June-April) maximum average humidity was recorded in July (94%) and minimum in January (74 %) (Table: 3.2).
Table: 3.2. Average humidity recorded during the study period.

<table>
<thead>
<tr>
<th>Months</th>
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<td>82</td>
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3.3.3 Rainfall

The pokkali field receives most its precipitation from Southwest monsoon followed by Northeast monsoon. During the other months, the rainfall was considerably less. During 2006-07 (June-April) maximum average rainfall was recorded in May (38 mm) and minimum in January (2.5mm). During 2007-08 maximum average rainfall was recorded in July (29mm) and minimum in December, February and March (1mm). During 2008-09 maximum average rainfall was recorded in June (28mm) and minimum in December (2mm) (Table: 3.3).
Table 3.3. Average rainfall (mm) recorded during the study period.

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<tr>
<th>Months</th>
<th>2006-07</th>
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(Source: Meteorological Department, CUSAT, Kochi.)

The study reveals that a moderate weather condition prevails in the pokkali wetland.

3.3.4. Soil characteristics

Soil is stiff impervious clay and is more than one meter deep. The soil is hard and creates deep fissures when dry and sticky when wet. During summer months, due to ingressiion of salt water from the sea the soil become saline. But when the salinity is washed off in heavy monsoon rains the inherent acidity of the soil regenerates. The soil is normally acidic, the pH being 3.3- 6.8. Water soluble salts like sulphates and chlorides of sodium and magnesium are present in high proportion. In dry conditions white incrustations of aluminium hydroxide also develop on soil surface. Electrical conductivity of the soil during summer months
(January – May) varied from 12 - 24 mm holscm and average salt content reaches up to 18 ppt (1.8%). During rainy season (June – August) water becomes almost fresh, salt content reduces to traces and electrical conductivity ranges from 6-8 mm holscm (Tomy et al.1984).

### 3.3.5. Physico-chemical properties of water

#### (a) Dissolved Oxygen

Dissolved oxygen is important, since the existence of aquatic life is linked with availability of oxygen for their survival. The dissolved oxygen reflects the biological activity-taking place in a water body and determines these biological changes, which are brought about by aerobic and anaerobic organisms (Manjusha, 2005).

![Graph showing average dissolved oxygen (2006-09)](image)

**Fig. 3.1 Average dissolved oxygen (2006-09)**

The average dissolved oxygen recorded during 2006-09 (June-May) from pokkali wetland area is summarized in the graph (Fig. 3.1). The study shows that during 2006 – 2007, the maximum dissolved oxygen was noticed in January (5 mg/L) and minimum during September (1.4 mg/L). The average dissolved oxygen during paddy cultivation season was 2.2 mg/L, average during transient period was 3.4 mg/L and average during prawn culture season was 3.5 mg/L (Fig.3.2).

During 2007 – 2008, maximum dissolved oxygen was noticed during March (5 mg/L) and minimum during June (2.2 mg/L). The average dissolved oxygen...
during paddy cultivation season (2007-2008) was 2.7 mg/L, in transient period the average was 2.9 mg/L and during prawn culture season the average was 3.6 mg/L (Fig.3.2).

During 2008 – 2009, maximum dissolved oxygen was noticed during January (6 mg/L) and minimum during September (1.5 mg/L). The average dissolved oxygen during paddy season was 2.4 mg/L, during transient period the average was 3.2 mg/L and during prawn culture season the average was 3.7 mg/L (Fig.3.2).

In general, the dissolved oxygen ranged between 1.4 mg/L and 6 mg/L. Maximum dissolved oxygen was observed during January 2009 (6 mg/L) and minimum during September (1.4 mg/L) (Fig. 3.1). Dissolved oxygen showed a similar trend during the different years ie the maximum dissolved oxygen was noticed in January during 2007 and 2009 and in March during 2008. During these months, prawn was cultured and for the same purpose water was released into the field from outside. The release of water from outside helped in the increase of salinity of water during the prawn culture period. The minimum dissolved oxygen was noticed in September during 2006 and 2008 and in June during 2007. Paddy is cultivated during these months.
Mary Bai (1989) reported that the dissolved oxygen of unpolluted water varied from 8.8 to 9.6 mg/L. Seema (2002) noticed that dissolved oxygen varied from 3.8 to 12.4 mg/L in the wetland of Salim Ali bird sanctuary, Thattekad, Ernakulam district. Neera et al. (2003) reported that the dissolved oxygen of lake water in Jaipur ranged from 4.7 to 7.6 mg/L.

The high oxygen content in the rice field ecosystem during paddy cultivation season was also reported by Singhal et al. (1985) and Aravind (1995). Sreekanth et al. (2004) observed that the dissolved oxygen in the Kuttanad paddy field ecosystem, Kerala varied from 1.8 to 8 mg/L. Aloysius (2005) noticed that the dissolved oxygen ranged from 1.2 to 6.6 ppm during decomposition phase in Kuttanad agroecosystem.

Thomson (2001) reported that the dissolved oxygen values are normally higher during high saline period and decreases during low saline period in Kochin backwaters and dissolved oxygen usually ranged from 0.8 to 5 ml/L. A similar trend was noticed by Zeena and Chandramohanakumar (2004) in Vypin Island and Mangalavanam mangrove ecosystem, Kochi where the dissolved oxygen ranged from zero to 5.4 ml/L. Aneesh et al. (2009) reported that the dissolved oxygen varied from 5 to 7.6 ml/L in Valanthakkad mangrove ecosystem, Kochi.

The physicochemical properties of water of prawn cultivated fields at Kochi were conducted by Pronob (2004), Sasidharan (2004) and Maya (2009). Pronob (2004) noticed that the dissolved oxygen of a pond at Panangad region, Kerala varied from 3.5 mg/L to 6.2 mg/L. Sasidharan (2004) observed that the dissolved oxygen ranged from 5.2 to 7 mg/L during low saline paddy season and 5 to 8 mg/L during high saline prawn culture season in the pokkali field at Vytila, Kochi. It was also noticed that the average oxygen ranged from 5 to 8 mg/L and the dissolved oxygen levels in the rice fish integration period were satisfactory in pokkali wetland of Vytila. Maya (2009) noticed that the dissolved oxygen in the prawn filtration pond at Panangad varied from 2.1 mg/L to 9.6 mg/L.

According to Frodge et al. (1990) thick mat of grasses causes shading effects which prevent photosynthesis and leads to fall of dissolved oxygen in the wetland
ecosystem. Swarnalatha et al. (1997) noticed that presence of organic matter in higher proportions was responsible for the decrease in dissolved oxygen in the aquatic ecosystem. Saha et al. (2001) reported that generally variation in dissolved oxygen was largely governed by photosynthesis, respiration, mineralization and decomposition activities and other disturbances in the water.

Zeena and Chandramohanakumar (2004) reported that the maximum dissolved oxygen was observed during monsoon season and minimum during premonsoon season in mangrove ecosystem of Kochi. Warm temperature and photosynthesis are responsible for the increasing dissolved oxygen during monsoon and low productivity and high rate of decomposition were responsible for the decrease of dissolved oxygen during premonsoon season.

Nair et al. (1988) reported that the dissolved oxygen varied widely with tides in the paddy cum prawn culture fields. Seasonal fields being shallow showed low dissolved oxygen when compared with perennial ponds. This could be attributed to the decomposition of organic matter present at the bottom. Pronob (2004) conducted studies in prawn culture pond at Panangad, Kochi and reported that the maximum dissolved oxygen was noticed during monsoon period. This was due to low temperature and intense photosynthetic activities of phytoplankton bloom and further fall of dissolved oxygen in premonsoon season was attributed to the death and decay of plankton and presence of organic matter. Another study conducted by Maya (2009) at Panangad, Kochi concludes that the dissolved oxygen is an essential factor in the aquatic ecosystem and is an important indicator of water quality. The air-water interaction, respiration and photosynthetic processes influence dissolved oxygen status of aquatic ecosystem.

In the present study it was noticed that the maximum dissolved oxygen was recorded during prawn culture season and this may be due to high productivity, intense photosynthesis of phytoplankton and entry of fresh water from outside etc. The possible reason for the decrease in the dissolved oxygen level during paddy cultivation season may be due to disturbances in the habitat. Paddy cultivation procedures like replanting of seedlings, harvesting of rice, decomposition of stubbles
etc were noticed during the paddy cultivation period. These factors may be responsible for low oxygen content during this time.

Correlation studies showed that the dissolved oxygen shows significant positive correlation ($r = 0.61$, $p < 0.05$) with water $p^H$ during paddy cultivation season. During transient period dissolved oxygen showed significant positive correlation with soil $p^H$ ($r = 0.93$, $p < 0.01$) and significant negative correlation with water depth ($r = -0.86$, $p < 0.05$). Similar observation was made by Susan (2002) in rice fish rotational farming area at Kuttanad, Kerala.

b) Water $p^H$

$P^H$ of water mainly depends upon the interaction of various biotic and abiotic factors and substances dissolved in it. This environmental factor is dependent on the flow of effluents with high alkalinity and the assimilation of carbon dioxide in it. Therefore determination of $p^H$ may serve as an index of other environmental factors like quantity of $CO_2$, $O_2$ and dissolved solids (Kumar and Gupta, 2002).

![Figure 3.3: Average water $p^H$ (2006-09)](image)

**Fig. 3.3 Average water $p^H$ (2006-09)**

The average water $p^H$ recorded during 2006 – 2009 (June – May) from pokkali wetland is summarized in the graph (Fig. 3.3). The study results show that during 2006-07 the maximum water $p^H$ was noticed during February (7.1) and minimum during November (5.9). The average water $p^H$ during paddy season was
6.3, average water $pH$ in transient period was 6.2 and average in prawn culture season was 6.8 (Fig. 3.4).

During 2007 – 2008, maximum water $pH$ was noticed during February (7) and minimum in July (5.5). The average water $pH$ during paddy season was six and in transient period and prawn culture season, it was 6.6 (Fig. 3.4).

During 2008 – 2009 maximum water $pH$ was noticed in December (7.4) and minimum during July (5.7). The average water $pH$ during paddy season was 6.1, in transient period the average was 6.9 and in prawn culture season it was 6.7 (Fig. 3.4).

![Graph showing average water pH recorded during different seasons (2006-09)](image)

**Fig. 3.4. Average water $pH$ recorded during different seasons (2006-09)**

In general, water $pH$ was slightly acidic during paddy cultivation season, neutral or alkaline during prawn culture season and the water $pH$ ranged between 5.5 to 7.4. The maximum water $pH$ (7.4) was noticed during December 2008 and minimum (5.5) during July 2007 (Fig. 3.3). Maximum water $pH$ was noticed during prawn culture season and minimum during the paddy cultivation season. A similar trend was noticed in the case of dissolved oxygen.

Seema (2002) observed that the water $pH$ varied from 5.5 to 7.8 in the wetland area of Salim Ali bird Sanctuary Thattekad, Ernakulam district. Gleena et
al. (2008) reported that the water pH of Muriad wetland ecosystem, Trichur, varied from 5 to 7.

Mary (1994) reported that the water pH of paddy field ecosystem at Kuttanad, Kerala, varied between 6 to 6.7. Sreekanth (2004) noticed that the water pH of Kuttanad ecosystem, Kerala, varied from 6.1 to 6.7. Aloysius (2005) reported that the water pH during straw decomposition period in Kuttanad ranged between 6.4 to 7.

Thomson (2001) noticed that the water pH of the Kochin back waters varied from 6.2 to 7. Zeena and Chandramohanakumar (2004) reported that water pH varied from 6.9 to 7.9 in Vypin and Mangalavanam mangrove ecosystem, Kochi. Aneesh et al. (2009) noticed that the water pH varied from 6.8 to 8 in Valanthakkad mangrove ecosystem, Kochi.

Water quality studies of the prawn culturing fields at Kochi were conducted by Arun (1996), Pronob (2004), Sasidharan (2004) and Maya (2009). Arun (1996) noticed that the water pH of the pokkali wetland varied from 6 to 8.7. Pronob (2004) noticed that the water pH of a pond at Panangad, Kochi varied from 6.1 to 7.1. Venkatesan et al. (2001) reported that the water pH ranged from 6.5 to 9 in the culture ponds at Panangad, Kochi and reported that this range in water pH was good for fish production in culture ponds. Sasidharan (2004) reported that in the pokkali wetland at Vytila during the paddy cultivation period water pH varied from 5.5 to 7.7 and during prawn culture season the water pH varied from 7 to 9. It was also noticed that water pH of pokkali wetland at Vytila was conducive for fish growth. Maya (2009) noticed that the water pH of the prawn filtration pond at Panangad, Kochi was maximum during the month of May and minimum during July. The lowest water pH was obtained during the south west monsoon and was reported by Sankaranarayanan and Qasim (1969) at Kochi. The minimum water pH during July was reported by Mathew et al. (1987) and Susheela et al. (2006) in perennial prawn culture fields adjacent to Kochin backwaters. Highest water pH recorded during premonsoon period at Panangad by Maya (2009) agrees with the observations made by Sankaranarayanan et al. (1982).
Rainfall, decomposition of organic matter and precipitation etc were responsible for the water $p^H$ (Zeena and Chandramohanakumar, 2004). According to Goldman and Horne (1983) the high $p^H$ value during summer months may be due to high photosynthesis of micro and macro vegetation resulting in high production of free CO$_2$, shifting the equilibrium towards alkaline side. The $p^H$ controls the chemical state of many nutrients including dissolved O$_2$, Phosphate and Nitrate etc. Verma et al. (2006) observed that hydrogen ion concentration also regulates most of the biological processes and biochemical reactions in the wetland. Arun (1996) noticed that the water $p^H$ of the medium mainly depends upon many factors like photosynthetic activity, rainfall, nature of dissolved materials, discharge of effluents, sewage etc.

In the present study maximum water $p^H$ was exhibited during December (7.4). Generally the water $p^H$ was maximum during the prawn culture period (January to May) during the different years. More photosynthetic activity during summer months may be responsible for the increase in the water $p^H$ which almost agrees with the observations made by Goldman and Horne (1983). The minimum water $p^H$ was noticed in July (5.5) during the paddy cultivation season (June to October). The minimum water $p^H$ during July agrees with the observations made by Sankaranarayan and Qasim (1969), Sankaranarayan et al. (1982), Mathew et al. (1987) Susheela (2006) and Maya (2009). Rainfall, fresh water input and disturbances associated with paddy cultivation period may be responsible for the decrease of water $p^H$ in paddy cultivation season.

In the present study, water $p^H$ showed significant positive correlation with salinity ($r=0.71$, $p<0.05$) and oxygen ($r=0.66$, $p<0.05$) during the prawn culture period. Similar observations were made by Sankaranarayan et al. (1982) and Maya (2009) in the prawn filtration pond at Panangad, Kochi. During transient period water $p^H$ showed significant positive correlation with water temperature ($r=0.89$, $p<0.05$). Similar observation was made by Susan (2002) in rice fish rotational farming area at Kuttanad, Kerala.
The average soil $p^H$ recorded during 2006-09 (June-May) from pokkali wetland area is summarized in the graph (Fig. 3.5). The study result shows that during 2006 – 2007 maximum soil $p^H$ was noticed during May (7.1) and minimum in July (3.3). The average soil $p^H$ during paddy season was 5.8, average during transient period was 4.6 and average during prawn culture season was 6.2 (Fig. 3.6).

During 2007 – 2008 maximum soil $p^H$ (6.7) was noticed in March and minimum in December (4.8). The average soil $p^H$ during paddy season was 4.9; average in transient period was 5.1 and during prawn culture season it was 6.4 (Fig. 3.6).

During 2008 – 2009 maximum soil $p^H$ was noticed in February (6.8) and minimum in December (4.8). The average soil $p^H$ during paddy season was 5.5, during transient period the average was five and during prawn culture season the average was 6.6 (Fig. 3.6).
Chapter III

The Physicochemical properties of air, water and soil

Fig. 3.6. Average soil pH recorded during different seasons (2006-09)

In general, the soil pH ranged between 3.3 to 7.1. Maximum soil pH (7.1) was observed during May 2007 and minimum (3.3) during July 2006 (Fig. 3.5). Maximum soil pH was noticed during prawn culture season and minimum during transient period (Fig. 3.6).

Only a few studies related to soil pH in the similar wetland habitat were carried out in Kerala. Sheela (1988) studied that the soil pH of Kole wetlands of Trichur and reported that the soil pH varied from 2.6 to 6.3. Gleena et al. (2008) noticed that soil pH of Muriad wetland ecosystem of Trichur, before cultivation varied from 5.1 to 6.1 and after cultivation varied from 4.9 to 6.1.

Nair and Money (1972) reported that the soil pH ranged from 3 to 6.8 in the pokkali wetlands of Ernakulam district, Kerala. A comparative study of the seasonal variation in the pokkali lands of Ernakulam and Kaipad soil of Kannur districts was conducted by Kuruvilla (1967). He noticed that the soil pH ranged from 3.3 (Pokkali soil) and 3.8 (Kaipad soil). Sasidharan (2004) reported that the soil pH of pokkali wetland at Vyttila, Kochi varied from 3.7 to 3.8.

Anu (2010) noticed that rainfall affects soil pH which decreases during rainy season. It was also noticed that soil acidification may occur due to decomposition of
organic matter. Tomy et al. (1984) conducted studies at pokkali research centre, Vytila, Kochi, and reported that pokkali soils are acid-alkaline in nature. In the present study it was noticed that the soil of pokkali wetland of Kadamakudy was acidic during paddy season and alkaline during prawn culture season. This agrees with the observations made by Tomy et al. (1984).

In the present study the minimum soil $p^H$ was noticed during July 2006 (3.3). Generally the $p^H$ was minimum during transient period (November to December) during different years. This may be due to fresh water intrusion and other disturbances in the habitat associated with prawn culture. Maximum soil $p^H$ was noticed during May 2007 (7.1). Generally more soil $p^H$ was noticed during prawn culture season (January to May). This was almost similar to water $p^H$.

Even though more water and soil $p^H$ was noticed during the prawn culture period, no significant correlation was noticed between water and soil $p^H$. However a negative correlation was noticed between water and soil $p^H$ (not significant).

Soil $p^H$ showed significant positive correlation with oxygen during paddy cultivation season ($r = 0.63$, $p < 0.05$) and transient period ($r = 0.93$, $p < 0.001$). Sasidharan (2004) noticed that the tidal action significantly increased the soil $p^H$ and potassium of the pokkali wetland at Vytila, Ernakulam district. It was also noticed that soil $p^H$ showed significant positive correlation with available potassium.

d) Water Temperature

The temperature of water in an aquatic ecosystem is very important as all metabolic and physiological activities and life processes such as feeding, reproduction, movement and distribution of aquatic organisms are greatly influenced by water temperature (Thomson, 2001). Among the number of factors temperature is an influential factor, which affect the growth of aquatic plants and animals. The effect of temperature on plants and animals are partly direct and partly indirect (Manjusha, 2005).
The average water temperature during 2006-09 (June-May) from pokkali wetland is summarized in the graph (Fig. 3.7). The study result shows that during 2006 – 2007 maximum water temperature was noticed in August (35°C) and minimum in December (26°C). The average water temperature during paddy season was 32°C, in transient period it was 28°C and in prawn cultivation season the average was 30.5°C (Fig. 3.8).

During 2007 – 2008, maximum water temperature was noticed during March and April (33°C) and minimum during February (26°C). The average water temperature during paddy season was 29°C, average in transient period was 29.5°C and average in prawn culture season was 30°C (Fig. 3.8).

Average water temperature during 2008-09 ranged from 27°C to 34 °C with a maximum of 34°C during April and a minimum of 27°C during October and February (Fig. 3.7). The average water temperature during paddy season was 29.8°C, average in transient period was 29°C and average in prawn culture season was 31°C (Fig. 3.8).
In general, water temperature ranged between 26°C to 35°C. The maximum water temperature (35°C) was noticed during August 2006 and minimum (26°C) February (2008) (Fig. 3.7). Maximum water temperature was noticed during prawn culture season and minimum during paddy cultivation season except during (2006-07) (Fig. 3.8).

Mary (1994) observed that the water temperature of the paddy field ecosystem of Kuttanad, Kerala ranged from 29.7°C to 36°C. Sreekanth (2004) noticed that the water temperature varied from 29°C to 32°C in Kuttanad ecosystem, Kerala.

Thomson (2001) reported that water temperature varied from 25°C to 31°C in Kochin backwaters. Aneesh et al. (2008) noticed that the water temperature of mangrove ecosystem of Kochi varied between 27°C to 33°C.

Sasidharan (2004) recorded that water temperature of the pokkali wetland of Vytila ranged from 27°C to 34 °C. Maya (2009) noticed that low value of temperature in prawn filtration pond at Panangad, Kochi during January was due to winter effect and south west monsoon. Maximum water temperature was noticed during May. This might be due to the warm weather and maximum solar radiation.
during this period. Similar trend in paddy cum prawn culture fields of Kochin area was reported by Silas and Pillai (1975) and Nair et al. (1988).

The distribution of temperature of water in a wetland depends on the mixing of inflowing river water and tidally influenced seawater. The process like exchange of heat with atmosphere and any localized phenomena are also likely to influence the distribution. The low monsoonal values may be interpreted as the influx of freshwater from rivers and raining effect during the monsoon period. This feature was reported by earlier workers (Ramamirtham and Jayaraman, 1963; Sankaranarayanan and Quasim, 1969). Jayaraman, (2003) noticed that variation in the water temperature might be due to different timing of collection and influence of season.

In the present study relatively higher temperature was recorded in the pokkali wetland during prawn cultivation season (January-May) and may be due to low influx of fresh water from Periyar river and warm weather. These agree with the observations made by Silas and Pillai (1975) and Maya (2009). Lower water temperature was recorded during paddy cultivation season (June-October) and may be due to rainfall during monsoon and the entry of fresh water from river. This also agree with the observations made by Ramamirtham and Jayaraman (1963), Sankaranarayanan and Quasim (1969) and Maya (2009).

Water temperature showed significant positive correlation with water $pH$ during transient period ($r = 0.89 p < 0.05$). Similar observation was noticed by Susan (2002) in rice fish integrated farming area at Kuttanad, Kerala.

c) **Salinity**

Apart from temperature, salinity is also a limiting factor in aquatic environment.
The average salinity recorded during 2008-09 (June-May) from pokkali wetland area is summarized in the graph (Fig. 3.9). The study result shows that during 2008 – 2009 maximum salinity was noticed during February (21ppt) and minimum during June (0.4ppt). Average salinity of paddy cultivation season ranged from 0.4 ppt to 1ppt with a maximum of 1ppt during October and a minimum of 4 ppt during June. Average salinity of transient period ranged from 8.8 ppt to 12.5 ppt with a maximum of 12.5 ppt during December and a minimum of 8.8 ppt during November. Average salinity of prawn culture season ranged from 14.9 ppt to 21ppt with maximum of 21ppt during February and minimum of 14.9 ppt during March. Average salinity during paddy season was 0.56 ppt, and it went up to 10.65 ppt during transient period and 17.8 ppt during prawn culture season (Fig. 3.10).
In general the salinity ranged between 0.4 to 21ppt. Maximum salinity (21ppt) was observed during February 2009 and minimum (0.4ppt) in June 2008. Variation in the salinity was noticed in pokkali wetland from paddy cultivation season to prawn cultivation season. An increasing trend was noticed in the salinity from paddy cultivation season to prawn culture season which was almost similar to dissolved oxygen, water pH, soil pH and water temperature.

Mohanty (1975) showed that the minimum salinity was observed in Chilika lake during monsoon period and maximum during premonsoon period. Mary (1994) noticed that the salinity of Kuttanad agrosystem varied between 0.09 to 0.79 mg/L. Susan (2002) noticed that the salinity variation in the surface water and bottom water varied from 29.2 to 29.9 ppt in rice –fish rotational farming area at Kuttanad.

Thomson (2001) studied the salinity of Kochin backwaters and reported that the salinity varied from zero to 32 ppt in Kochi. Zeena and Chandramohanakumar (2004) noticed that the salinity of Vypin and Mangalavanam mangrove ecosystem, Kochin varied from 2.1 to 31.9 ppt. Aneesh et al. (2009) reported that salinity of Valanthakkad mangrove ecosystem, Kochi varied from 1 to 25 ppt.

Arun (1996) studied that the salinity variation in the pokkali field, Ernakulam district and noticed that the salinity varied from 6 to 8.7ppt. Sasidharan (2004) recorded the salinity of the pokkali wetland ranged from 4.1 to 12.2ppt. Maya (2009) noticed that there was salinity variation in prawn filtration pond at Panangad, Ernakulam district.

Nair and Money (1977) noticed that maximum salinity was noticed during December and minimum during February and August in pokkali wetland. Samikutty (1977) reported that seasonal variation in salinity in pokkali wetland at Kochin was maximum during prawn cultivation season and minimum during paddy cultivation season. Similar trend was noticed in the present study also. An annual salinity range of 1 to 27% in seasonal and perennial prawn fields of Kochin estuary system was observed by Susheela et al. (2006). A decrease in the salinity during south west monsoon season was mostly due to rainfall and run-off (Maya 2009). A similar observation was made in the present study also.
Imelda and Chandrika (2000) reported that maximum salinity was noticed during summer season and minimum during monsoon season in mangrove ecosystem. Salinity was minimum during monsoon season and this may be due to rainfall and dilution effect by fresh water input into the wetland. The salinity was maximum during premonsoon and was mostly due to evaporation. According to Manjusha (2005) the salinity distribution in the wetland (Kochin backwaters) largely depends upon seawater intrusion and influx of river water. However, the bottom topography and geographical shape of the wetland maintain the salinity distribution in this wetland.

In the present study, it was noticed that the salinity was maximum during prawn culture season and this agree with the observations made by Samikutty (1977), Arun (1996), Sasidharan (2004) and this may be due to the mixing up of fresh water with saline tidal water, evaporation, seawater penetration into the pokkali field and low discharge of fresh water etc. Salinity was minimum during paddy cultivation season and may be due to fresh water input and rainfall. This also agree with the observations made by Samikutty (1977), Arun (1996), Sasidharan (2004), Sankaranarayan (1987), Anon (2004) and Maya (2009).

Salinity showed significant positive correlation with water pH during paddy cultivation season ($r = 0.71 \ p < 0.05$). Similar observation was noticed by Thampy (1959) in Mandapam lagoon, Sankaranarayan (1967) in prawn culture pond at Panangad, Kochi and Susan (2002) in rice fish rotational farming area at Kuttanad, Kerala.

f) Water depth

Depth has an important bearing on the physico – chemical prospects of water and distribution of animals (Diwan and Arora, 1995).
The average water depth recorded during 2006-09 (June-May) from pokkali wetland is summarized in the graph (Fig. 3.11). The study result shows that during 2006-07 maximum water depth was noticed during November, December and March (90cm) and minimum during May (zero) (Fig. 3.11). The average maximum water depth was noticed during transient period (90cm) and minimum in paddy season (37cm) (Fig. 3.12).

During 2007 – 2008, maximum water depth was noticed in December (120cm) and minimum in May (zero). The average maximum water depth was noticed in transient period (110cm) and minimum during paddy cultivation season (37cm) (Fig. 3.12).

During 2008 – 2009 maximum water depth was noticed during December (150cm) and minimum during May (zero). Average maximum water depth was recorded in transient period (125cm) and minimum during paddy cultivation season (42cm) (Fig. 3.12).
In general the water depth ranged between zero to 150 cm. The maximum depth was noticed during December 2008 (150cm) and minimum in May during 2007, 2008 and 2009 (zero). The maximum water depth was noticed during transient period and minimum during paddy cultivation season (Fig. 3.12).

Depth of water of Ashtamudy wetland, Kerala varied from 2.5 to 6.4 m (Anon, 2008). Thomson (2001) reported that the water depth varied from 1.5 to 8 m in Kochin backwaters. Water depth of Muriad wetland ecosystem, Trichur varied from 1.6 to 4.8 m (Gleena et al. 2008).

Water levels ranged between 7.1cm to 43.25cm in rice – field farming area of Kuttanad (Mary, 1994). Aloysius (2005) noticed that the water depth of Vembanadu estuary ranged from 105cm to 125 cm in rice – fish rotational farming area in Kuttanad. It was noticed that maximum depth was noticed during November and minimum during April. Similar observation was noticed in the pokkali wetland of Ernakulam District.

Pronob (2004) reported that the water depth of a pond at Panangad region at Kochi varied from 58.5 to 140.5 cm. The maximum depth was noticed during south east monsoon and minimum during premonsoon period.

In the present study it noticed that the water depth was maximum during transient period and minimum during the paddy cultivation season in the pokkali
wetland. Similar observation was made by Aloysius (2005) in rice-fish rotational farming area in Kuttanad. Water level in the pokkali field was controlled and adjusted by means of sluice gates during paddy cultivation and prawn culture season. During transient period the fields are allowed to have free exchange of water.

Water depth showed significant correlation with soil pH ($r = 0.63$, $p < 0.05$) during paddy cultivation season. Depth showed significant negative correlation with oxygen ($r = -0.86$, $p < 0.05$) during the transient period. Similar observation was made by Raju (2002) in fresh water rivers of southern Kerala. Susan (2002) noticed significant correlation between water depth and phytoplankton count in the rice fish rotational farming area in Kuttanad.

The level of biochemical factors were studied in different periods and tested its significance with different seasons using ANOVA (Analysis of variance). A highly significant difference was noticed by the different seasons in the pokkali wetland. This shows that seasonal changes are taking place in the water and soil chemistry of the pokkali wetland area.