ECOLOGICAL AND PRODUCTIVITY STUDIES OF PRAWN FARMS IN CENTRAL KERALA

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DECLARATION

I hereby declare that this thesis entitled "Ecological and Productivity Studies of Prawn Farms in Central Kerala" is a record of original and bonafide research carried out by me under the supervision and guidance of Dr. (Mrs.) S. Sivakami, Scientist (SG), Central Marine Fisheries Research Institute, Cochin and that no part there of has been presented for the award of any other degree, diploma, associateship, fellowship or other similar recognition.

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CERTIFICATE

This is to certify that this thesis entitled "Ecological and Productivity Studies of Prawn Farms in Central Kerala" embodies the bonafide original research work conducted by Shri. Ignatius C.A. under my supervision and guidance. I further certify that no part of this thesis has previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles on recognition.

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CONTENTS

PREFACE

The most important seafood item which figures in international trade is prawn, by virtue of its esteemed delicacy. It is the fastest moving commodity in world trade with persistent demand and high unit value. The per capita shrimp consumption in the European Economic Community, one of the prime consuming market, has surged upward by 100% during the last decade and in Japan by more than 25%. In United States, the per capita shrimp consumption has risen by 35%. In other parts of the world, consumption figures have become higher because of the population growth.

On the flip side of this demand situation is the status of prawn supply, which gives a different picture. The world's annual shrimp production from capture fisheries has reached the maximum capacity and has levelled off at 1.8 to 2 million tonnes (Liao, 1990). There seems to be little hope of resuming an upward trend in the volume of landings, since wild stocks continue to be overfished and depleted, in addition to the high cost of shrimping due to the increased price of fuel, labour etc. The only feasible way of filling the shrimp demand - and-supply gap is through expanded and intensified shrimp culture production.

Fortunately, the volume of cultured prawns has been growing year after year. In the year 1994 production from prawn culture system is reported to account for about 22% of the total world production as against 1 or 2% during 1960's (Rosenberry, 1995). Breakthroughs in shrimp culture research over the last few decades have made the industry scopeful of offsetting the diminishing wild prawn catch.

In the present day context of booming foreign exchange earnings in India, shrimp production is being taken up on a war footing. In 1994 - 1995, India exported 2.73 lakhs tonnes marine products for a value of ₨. 3270 crores of which prawns contributed about 70% by value (MPEDA, Press report). Since 1970, shrimp production from inshore capture fishery is remaining stagnant and is infact showing a declining trend. aquaculture seems to be the only wayout for India to augment its shrimp production and maintain its production as one of the leading shrimp producing and exporting countries of the world. India having vast but meagerly utilised aquaculture potential is considered as a "sleeping giant" in the world of seafood market. Though endowed with an estimated brackishwater area of about 1.2 million hectares (MPEDA, 1994) suitable for brackishwater culture, only a neglible part of 70,700 ha is being utilised for shrimp culture producing about 60000 metric tonnes of shrimp annually.

The growth and survival of the organisms used for culture depend largely on the productivity of the pond, which in turn, is influenced by various environmental characteristics of the water and the fertility of the pond soil. In short, the water and soil conditions to a great extent determine the success or failure of the culture operation. Further, the information on the various environmental characteristics of the water and soil, availability of essential elements and the rate of organic productivity would not only help to adopt successful management principles and culture techniques but also to manipulate the ecosystem providing the necessary inputs for obtaining better production.

Organic fertilizers like cowdung, pigdung and poultry dropping are generally applied for increasing the productivity of aquaculture ponds. It enriches the nutrient and organic matter content of water and soil and acts as a substrate for bacterial growth, which is considered as a good food especially for the juveniles of the shrimps. It also reduces the cost for feeding and thus maximises the profit.

Trace elements eventhough needed in small quantities, significantly influences the growth and metabolism in crustaceans. Trace elements are found to be deficient in some water bodies, while in others it may be in excess. Aquatic organisms including prawns can accumulate trace elements in their body which on consumption is toxic to human being.

In Kerala, extensive system of shrimp farming had been in practice in and around Cochin. Recently, some of these traditional farms have been transformed to scientifically cultured semi-intensive farms with the introduction of fertilization, selective stocking of commercially important prawns and supplementary feeding, which when compared to extensive farms is more profitable.

Eventhough voluminous literature is available on the ecological aspects of extensive shrimp farms in Kerala, the recently introduced scientific semi-intensive shrimp farms are very little studied. Likewise, only very little investigations have been conducted regarding the influence of different organic manures on the ecology and productivity of prawn farms and trace metal concentration in soil, water and tissue of prawns. The present study is therefore taken up with an objective of elucidating the ecological and productivity parameters of semi-intensive shrimp farms and the influence of organic manures on these parameters including trace elements.

This thesis is presented in 3 chapters.

Chapter 1: Contains detailed reports regarding the investigation of ecological and productivity parameters of some semi-intensive prawn farms in Central Kerala.

Chapter 2: Deals with the ecological and productivity parameters in prawn ponds applied with poultry dropping, cowdung and piggery waste in comparison with a control pond where no organic manure was applied.

Chapter 3: Embodies studies on trace elements - zinc, copper and iron concentration in water, soil and tissue of prawns obtained from the ponds applied with organic manures.

Each chapter contains introduction including review of literature, material and methods, results and discussion.

These 3 chapters are succeeded by a "Summary" which highlights the important results of the study. This is followed by a list of literature consulted and cited at the end under "Reference".

CHAPTER I

ECOLOGY AND PRODUCTIVITY OF SEMI INTENSIVE PRAWN FARMS IN CENTRAL KERALA

I INTRODUCTION

Aquaculture of prawns in coastal brackishwater bodies has been recognized as one of the highly potential areas for increasing prawn production. It also derives economic benefits such as better use of unproductive and marginally productive lands, augmentation of export and foreign exchange earnings, support to food processing industries and establishment of ancillary industries. As the prawn farms are located in the rural areas, generation of employment opportunities along with the upliftment of the socio-economic conditions of the rural poor population is also made possible through prawn farming.

The driving forces behind increased aquaculture production of shrimp have been the continued market demand for shrimp and the large profit margin between the cost to produce through aquaculture and the world market price. Besides, increased demand for foreign exchange also makes shrimp farming a reality in many developing countries.

India is considered as one of the leading prawn producing and exporting nations and there is always demand from advanced countries for quality shrimp. India is in fact struggling to keep up her foremost position as the principal contributor to the world market.

In India, prawns from marine landings contribute to more than the cultured prawns. However, India's total marine landings of prawns was 1,77,000 tonnes in 1980 and 1,75,236 tons in 1993 (CMFRI, 1994). Considering the landings in the last fourteen years, a stagnation in the prawn landings could be seen despite increasing fishing effort. Thus marine landings in India is not in a position to supply more quantity to meet the ever increasing world demand of prawns. Therefore, aquaculture of prawns is the only alternative to augment the supply of prawns.

Brackishwater aquaculture is an area where the potential for development is high. India is bestowed with suitable vast coastline, mudflats, swamps and mangrooves which could be utilized for prawn farming. However, we have not been able to achieve adequate progress in this field probably because of lack of proper understanding of the productivity potential of these areas.

In India, there are four species of marine prawns suitable for culture. Among these, the tiger prawn Penaeus monodon is cultured in West Bengal, Orissa and Andhra Pradesh. The Indian white prawn P. indicus is also an important species and is cultured in states such as Tamil Nadu, Andhra Pradesh, Kerala, Karnataka, Maharashtra and Gujarat. To a lesser extent, the banana prawn P.merguiensis is cultured in Maharashtra and Gujarat. The high saline prawn P.semisulcatus available in Tuticorin area in Tamil Nadu is also cultivable, though commercial culture of this species has not been taken up anywhere in India.

Based on the intensity of culture operation, prawn farming can be classified into extensive, semiintensive, intensive and ultra-intensive systems. In extensive system, prawn seeds are allowed to enter into the fields through sluice gate during high tide and after a period of growth, they are caught by operating a catch net at the sluice gate during low tide. Semi-intensive farms are characterised by selective stocking with fast growing shrimps at a higher density of 1 to 3 lakhs/ha and supplemented with feed. In intensive system, prawns are stocked at a very high density ranging from 3 to 10 lakhs/ha and are provided with high quality feed. Ultra-intensive system uses stocking density of above 10 lakhs/ha.

Water exchange rate also varies in different systems. In semi-intensive system, it varies with tidal exchange to high water exchange rate by pumping. The daily exchange rate can therefore vary from 10 to 20%. On the other hand, in intensive system, daily water exchange amounts to more than 20%. In comparison to the above systems, heavy water exchange is resorted to in ultra-intensive system.

Artificial aeration by mechanical means is at times resorted to in semi-intensive system, but is normally not needed if the ponds are carefully monitored and water is exchanged when a critical oxygen condition is perceived to be developing. On the other hand, mechanical aerators to maintain the dissolved oxygen level is a necessity in intensive and ultra-intensive system.

Maintainence of healthy aquatic environment and production of sufficient plankton in ponds are two factors of primary importance for successful pond culture operation. It is believed that water is the primary requisite to support aquatic life while soil is essential to withhold it. To keep the aquatic habitat favourable for existence, physical and chemical factors like temperature, salinity, dissolved oxygen, pH, alkalinity, nutrients and reducing gases like hydrogen sulphide will exercise their influence individually or synergetically, while the nutrient status of water and soil play the most important role in governing the production of fish food organisms. The soil, besides retaining water, governs the storage and release of nutrients to the overlying water through various chemical and bio-chemical processes for biological production in the environment.

Water quality management is one of the key factors in aquaculture. The growing trend of intensification in pond culture of shrimp has obligated growers to adopt strict pond management measures in order to avoid disease and water quality related declines in production. Judicious management of water quality creates and maintain a healthy environment which in turn will consistently produce healthy prawns.

Water quality parameters that influence the behaviour and production of prawns include temperature, salinity, dissolved oxygen, pH, alkalinity, total hardness, nutrients, primary productivity, phytoplankton, zooplankton and heterotrophic activity.

Temperature is the most important water quality parameter influening the biochemical and physiological activity of prawns, photosynthetic activity in the water body, decomposition of organic matter on the pond bottom and microbial release of nutrients into the water. Lower water temperature has been snown to adversely affect several penaeids. As water temperature declines, growth eventually ceases (Wheeler, 1968 b; More and Elam, 1970; Lumare and Villani, 1972; Tournier, 1972), and as it declines further feeding stops (Liao, 1969; Snigueno, 1972). Studies regarding the effect of temperature on growth and survival of prawns in ponds have been conducted by Venkataramiah et al.,(1974); Menz and Bowers (1980); Rubino et al.,(1983); Aquacop (1984); Seidman and Issar (1988), Wyban and Sweeney (1989) and Padlan (1990).

Salinity is the master environmental parameter affecting the organisms living in brackishwater ecosystem which is characterised by frequent salinity variation. When shrimp is exposed to a salinity, higher or lower than its optimum requirement, it must osmoregulate more to maintain the internal salt balance, thus requiring more energy for osmoregulation which critically affects the growth.

The salinity of brackishwater pond generally depends on the salinity of the adjacent estuary. According to Balakrishnan (1957); George (1958) and George and Kartha (1963), the salinity of an estuary generally is freshwater during monsoon and rises near to seawater salinity during extreme summer months.

Dissolved oxygen is the single most environmental parameter that exerts a tremendous effect on growth and production through indirect effect on metabolism and feed consumption and direct effect on environmental conditions. A dissolved oxygen content of above 3.5 ppm is required for the proper growth of prawns (Suseelan, 1978). Higher rate of organic decomposition and heavy phytoplankton bloom reduce the dissolved oxygen content to critical levels during early morning hours. Dissolved oxygen levels below 2 ppm has been considered as a stress factor (Kramer, 1975; Seidman and Lawrence, 1985; Liao and Murai, 1986; Padlan, 1990). Studies regarding the effect of dissolved oxygen on the growth of prawns have been conducted by Egusa, (1961), Wheeler, (1967), Broom, (1970), Latapie et al., (1972), Liao and Huang, (1972), Krantz and lversen, (1973), Mackay, (1974) and Shigueno (1975).

pH is a measure of hydrogen ion concentration in water and it indicates the rate of acidity or alkalinity of water. Brackishwater is well buffered against wide varition in pH. Brackishwater with pH ranging from 7.5-8.5 is condusive for the culture of prawns (Muthu, 1980). The pH values in brackishwater ponds have been reported to be above 7.0 by Chakraborti et al., (1985 & 1986), Wyban et al., (1987), Chakraborti and Das (1988), Chen et al., (1989) and Chen and Wang, (1990) and below 7.0 by Gopinathan et al., (1982), Baticados et al., (1986) and Hudson and Lester, (1992). The coastal areas in many South East Asian countries are reported to suffer acid sulphate soils which become extremely acidic when reclaimed for shrimp ponds (Porter, 1976; Simpson and Pedini, 1985). In such ponds, mortality of prawns was noticed by Mrithunjayan and Thampy (1986) during first heavy monsoon rains as a result of reduction in pH from 7 to 4.5 due to leaching of acid sulphate soils from the bunds.

Total alkalinity of water refers to the total concentration of bases in water and is expressed in milligrams per litre of equivalent calcium carbonate. The alkalinity of water is a very important factor which influences the productivity of a pond ecosystem (Unnithan, 1985). The alkalinity of brackishwater shrimp ponds has been widely studied by Chakraborti <u>et</u> <u>al</u>., (1986), Chakraborti and Das (1988), Rajyalakshmi <u>et</u> <u>al</u>., (1988) and Boyd (1992). For best response to fertilization, ponds should be limed when total alkalinity is less than 20 ppm (Pillai and Boyd, 1985).

Total hardness of water refers to the total concentration of divalent cations in water and is also expressed in milligrams per litre of equivalent calcium carbonate. Literature dealing with total hardness of water is very less except that of Baticados <u>et</u> <u>al</u>., (1986) who reported a total hardness of 3350-6567 ppm in brackishwater ponds at Philippines.

Primary producers in ponds require certain micro-nutrients for their growth. Many of the nutrients are minor constituents of water, present only in very low concentration and their supply exerts a dominent control over production. The most important nutrients are compounds of nitrogen and phosphorus. According to Boyd (1986), lack of phosphorus and nitrogen limits phytoplankton productivity and in brackishwater ponds, nitrogen and phosphorus are observed to be far below the concentration needed for the optimum growth of plankton.

Nitrogen is pivotal to all ecosystems because of its role in the synthesis and maintenance of protein, which along with carbohydrates and fats, is a major constituent of living substance (Reid and Wood, 1976). Nitrogen occurs in natural waters in elemental state and as organic as well as inorganic nitrogenous compounds. The elemental nitrogen in water is derived mostly from the atmosphere, the other source being bacterial denitrification of nitrates, nitrites and ammonia. The organic nitrogenous compounds include decayed plant and animal tissues. Inorganic nitrogen compounds may be present in natural waters in small amounts in the form of ammonia, nitite and nitrates (Jhingran, 1982).

Nitrogen in organic compounds is returned to the environment through decomposition and to a lesser extent by excretion of nitrogenous wastes by animals. In the final phase of the ecologically important process of decomposition of nitrogenous substance, nitrite is oxidised by nitrifying bacteria to nitrate and it is in this form that nitrogen is most easily taken up by primary producers.

Although phosphorus occurs in very small quantities, this element is recognized to be the most critical single factor in the maintenance of pond fertility (Mandal, 1980). This extreme importance stems from the fact that phosphorus is vitally necessary in the operation of energy transfer systems of the cell and that it normally occurs in very small amounts (Reid and Wood, 1976). Phosphorus in natural waters can be divided into 3 components viz. in the inorganic or soluble phosphate phosphorus, soluble organic phosphorus and the particulate organic phosphorus. Phosphorus is available in water combined with a number of ions, the more common forms being phosphates of iron and calcium.

The reactive soluble orthophosphate is the fraction that is immediately useful for autotrophic plants. The ability of phytoplankton to rapidly absorb phosphate from the water and store it for further use in their cells is of great importance in determining the distribution of phosphate in water.

According to Boyd (1986), lack of phosphorus and nitrogen limits phytoplankton productivity and in brackish-water ponds, nitrogen and phosphorus are observed to be far below the concentration needed for the optimum growth of plankton. The importance of increasing the natural level of nutrients in water and especially the role of phosphate in activating trophic chains had been discussed by Seymour (1980).

According to Gopinathan et al., (1982), the nitrate values were moderate to high in brackishwater ponds located at the middle portion of Cochin estuarine system while those in northern and southern end showed lower values. In the case of phosphate, higher values were obtained in ponds both at middle and northern region of the estuary. In the studies on the ecological aspects of the prawn culture fields, Mathews (1992) observed higher nitrate concentrations at the middle (Narackal) and northern and (Cherai) of Cochin estuarine system. Likewise phosphate content was also found to vary widely between the ponds at middle portion and northern end of estuary.

Some of the nutrients like nitrite and ammonia are toxic to aquatic organisms. Nitrite is an intermediatory product in the metabolism of ammonia and is highly toxic at decreased pH because of relative proportion of toxic unionized nitrous acid increases (Colt and Tchobanoglous, 1976; Russo et al., 1981). Cole and Boyd (1986) have shown that nitrite concentration increases with increased feeding rate. Armstrong (1979) and Chen et al., (1986) opined that nitrite is more toxic than ammonia.

Ammonia is the principal nitrogenous product excreted by crustaceans (Claybrook, 1983; Chen et al., 1986) and may also accumulate in culture systems following microbial decomposition of organic material including feed (Stanier et al., 1976) and fertilizers (Boyd, 1982). In solution, total ammonia comprises unionized (NH_3) and ionized ammonia (NH_4) in equilibrium and their proportion depends mainly on pH, followed by temperature and salinity (Whitfield, 1974; 1978). Unionized ammonia is by far more toxic (Smart, 1978), the concentration of which is more at basic pH. Ionized ammonia may also becomes toxic, especially at low pH levels when the proportion of ammonia as ionized ammonia is very high (Shaw, 1960; Armstrong et al., 1978).

Ammonia is very toxic to aquatic animals and can cause impairment of many physiological activities and body organs (Smart, 1978; Colt and Armstrong, 1981). It can limit production in intensive crustacean aquaculture (Delistraty et al., 1977; Colt and Armstrong, 1981). The effect of ammonia on penaeid prawn culture system has been elaborately studied by Carpenter et al., (1986), Chin and Chen (1987), Wyban et al., (1987), Chen et al., (1989), Courtney (1989), Wajsbrot et al., (1989), Allan et al., (1990) and Chen and Wang (1990).

Though prawns are not stated to be phytophagous in habit, phytoplankters must be of importance to them in as much as they are the primary producers. Growth and production of prawns in a pond varies according to the levels of primary production. Pillai et al., (1987) and Chakraborti et al., (1985) obtained a minimum productivity of 132 mg $C/m^3/hr$ and maximum productivity of 625 $mgC/m^3/hr$ in brackishwater shrimp ponds at Kakdwip. Primary productivity of brackishwater ponds near to Cochin estuarine system has been well studied by Gopinathan et al., (1982), Devapiriyan (1990) and Mathews (1992).

Aquacop (1984) had noticed better growth of prawns in water rich in phytoplankton. The presence of diatoms in shrimp pond is a desirable condition (Philips, 1984; Shigueno, 1985). Promoting phytoplankton growth is an efficient means of removing micronutrients especially ammonia, which may be toxic, from the water column (Krom et al., 1985). The phytoplankton by reducing the light penetration in the pond, reduces the benthic algal growth which are often harmful because it encourages the production of a subsurface reducing layer rich in hydrogen sulphide (Erez et al., 1990). Inorganic nutrients released to the water from the microbial decomposition of uneaten food and shrimp faeces stimulate heavy phytoplankton bloom (Boyd, 1992).

The phytoplankton concentration in brackishwater ponds near to Cochin estuarine system has been studied by Gopinathan et al., (1982). Gopalakrishnan et al., (1988), Jose et al., (1988), Nair et al., (1988) and Mathews (1992). According to Mathews (1992), the phytoplankton in brackishwater ponds off Cochin estuarine system consisted of groups such as bacillariophyceae, myxophyceae and Dinophyceae.

Studying the zooplankton concentration in brackishwater ponds, Rubright et al., (1981), Jose et al., (1988) and Rajyalakshmi et al., (1988) have reported the dominance of copepods in zooplankton community. However, according to Gopinathan et al., (1982), the rotifers was the dominant group of zooplankton in brackish water ponds off Cochin estuarine system. Contrary to the reports mentioned above, in brackishwater ponds of the same area, the dominance of amphipods in the zooplankton community was observed by Gopalakrishnan et al., (1988) and Nair et al., (1988).

Soil plays an important role on the balance of pond ecosystem and concomittantly on the growth and survival of aquatic organisms. Soil is generally considered as the "laboratory of the pond" because many chemical reactions are governed by soil quality parameters (Hickling, 1971). According to Hickling (1971) soil quality is reported to play a more important role than the water quality does in brackishwater productivity. Sediment has a considerable buffering capacity on the quality of the layer of water above it. It provides the water with nutrients and serves as a biological filter through the adsorption of the organic residues of food, body excretions and algal metabolities (Chien 1989).

According to Boyd (1992) shrimp pond soils vary greatly in pH because of natural differences in soil pH. Brackishwater usually has a pH of 7.5 to 8 and this water buffers the soil and therefore acidic conditions usually do not develop in the surface layer of soil. However, ponds constructed on acid sulphate soils may have soil pH values as low as 2 or 3. Highly acidic conditions in soil impede organic matter decomposition and recycling of nutrients, decrease the availability of phosphate through the formation of insoluble iron and aluminium phosphate and have direct inhibitory effects on benthos and shrimp (Boyd, 1992).

Among the various soil quality parameters, organic carbon is of much importance. Organic carbon is an indication of the quantity of organic matter which enriches the soil with nutrients. Brackishwater pond soil is considered to be poor in organic carbon content (Chakraborti et al., 1985). The organic matter content in bottom soil increases with increasing water depth (Boyd, 1977). According to Tang and Chen (1967), increase in organic carbon content increases the yield. Chakraborti, et al., (1985) observed that brackishwater soil with more than 1% organic carbon shows better production of prawns per unit area.

Very low organic carbon content was reported by Gopinathan et al., (1982) in brackishwater ponds off Cochin estuarine system. On the other hand, Eswaraprasad (1982) and Ramesan (1990) reported higher values of organic carbon in the same area. Values close to that observed by Gopinathan et al., (1982) were also reported by Rajyalakshmi et al., (1988) in brackishwater ponds off Chilka lake.

Caillouet et al., (1972) and Gould et al., (1973) emphasized the importance of various benthic organisms like polychaetes and mysids as food items for prawns. Since prawns are primarily inhabitants of the benthic region, the distribution and abundance of the benthic population is of great significance when the ecological conditions for prawn culture are assessed and evaluated.

According to Maguire et al., (1984), Jose et al., (1988) and Ordner et al., (1990), benthos in shrimp ponds are dominated by polychaetes. Rajyalakshmi et al., (1988) conducted studies about the benthos community of brackishwater ponds at Chilka lake. Studying the benthos community in brackishwater ponds off Cochin estuarine system, Gopinathan et al (1982) observed that the benthic fauna was dominated by molluscs followed by polychaetes, amphipods, kinorhinchids, isopods and cumaceans. The general pattern of their distribution indicated an abundance in ponds near to the barmouth. Aravindakshan et al., (1992) recorded more benthos in substratum comprising fine sand, silt and clay with not less than 20% fine sand. According to the above author, polychaetes is the chief component of benthic organisms in brackishwater ponds off Cochin estuarine system.

Cochin backwater with an extensive area of 12,700 ha (Gopalan, et al., 1983) has about 89600 ha of adjacent low lying areas suitable for shrimp farming (Anon, 1978). Among the different types of shrimp culture systems, semi-intensive type is by far the most suitable by virtue of the natural flushing and aeration through tidal exchange, moderate stocking density and therefore less expensive. However, due to the paucity of adequate information on the productivity of this system, farmers resort more to extensive system which yields lesser production. The pesent investigation is therefore taken up with the bifold objective of elucidating the productive potential of semi-intensive shrimp farms and to evaluate the influence of barmouth on the ecosystem of these shrimp farms lying in the middle (Chellanam) and north (Poyya) of Cochin estuarine system.

2. MATERIAL AND METHODS

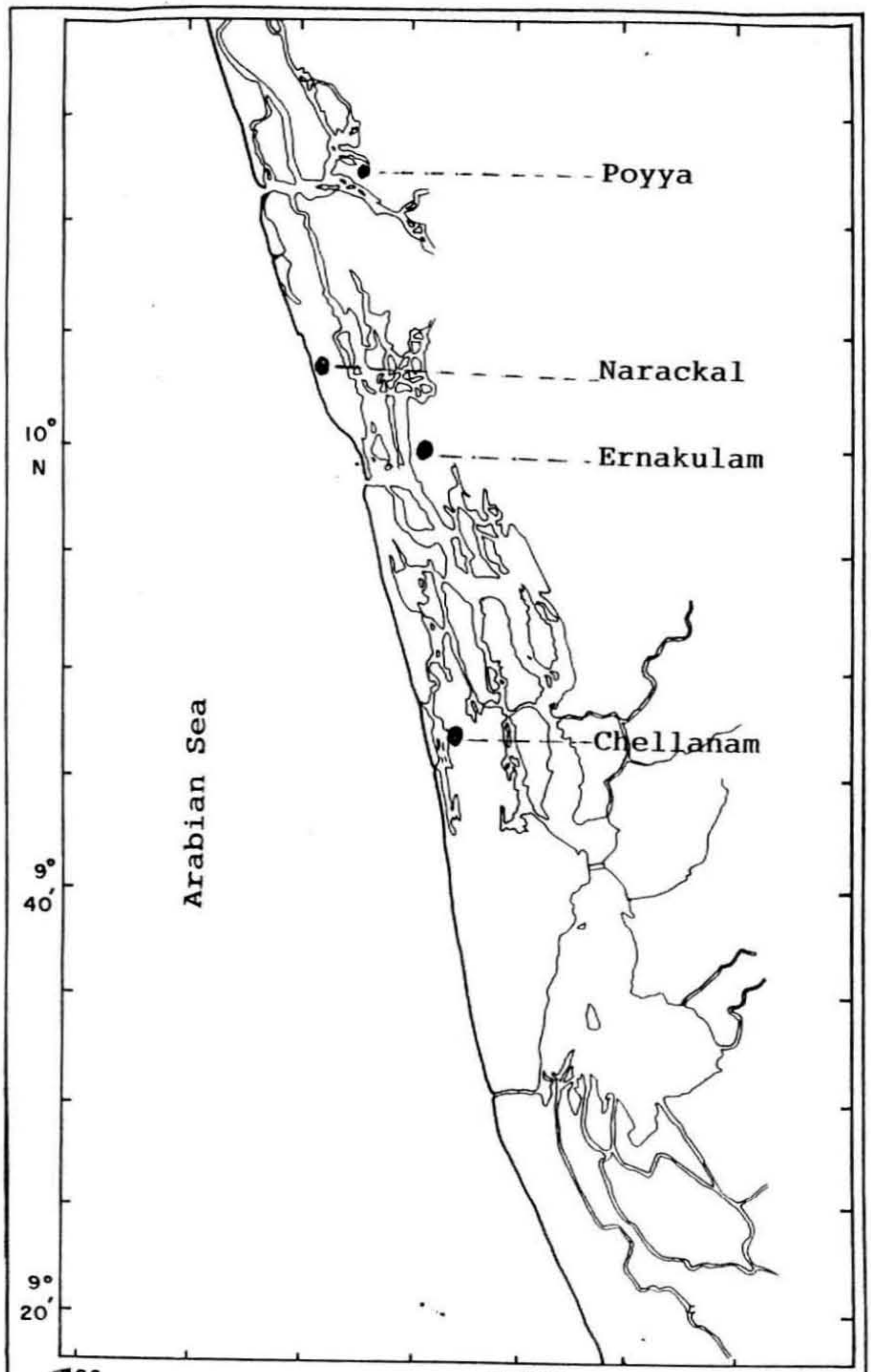
2.1. DESCRIPTION OF PONDS

This study was conducted in prawn farms at Poyya in Trichur district and at Chellanam in Ernakulam district, situated at the northern and middle portions respectively of the Cochin estuarine system (figure 1.) As these sites are wide apart at a distance of about 65 Km, there is a possibility of difference in major ecological parameters. Due to the paucity of scientifically managed farms, no farm could be selected from the southern end of the estuary. Three ponds were selected in each station and the study in both sites was conducted during January 1991 to May 1991.

Among the three ponds at Poyya, two belonged to Kerala State Fisheries Department and the third belonged to a Private Limited company. Department ponds had an average depth of 1 M and the private company's pond had 1.2 M. In this study pond No.1 and 2 indicate department ponds and pond No.3 indicates private company's pond. The area of ponds were 0.4, 0.2 and 0.7 ha respectively.

At Chellanam, three ponds belonging to a private farmer were taken up for investigation. The ponds had an area of 0.5,

Fig. 1 Map of Cochin estuarine system showing the sites Poyya and Chellanam selected for the study in chapter I and Naracal selected for the study in chapter II & III.



0.6 and 0.8 ha with an average depth of 1 M. They are numbered as pond No. 4, 5 and 6.

Since the ponds at Poyya and Chellanam belonged to different farmers and also located in different ecological regions, different methods of preparation, fertilization, water exchange, stocking and feeding were resorted to.

At Poyya, the ponds were drained and the weed fishes and predators were eradicated manually. No organic manure was applied. Urea as inorganic fertilizer was applied at the rate of 10Kg/ha. In the department ponds, 10 to 15% of water was exchanged daily by tidal flow. Post larvae (PL 18) of the white prawn <u>Penaeus indicus</u> with an initial average length and weight of 11 mm and 0.006 gm were stocked in department ponds. The same prawn (PL 35) of average length and weight of 17 mm and 0.044 gm respectively was stocked in private company's pond. The numbers stocked were 87,600 (2,19,000/ha) 46,600 (2,33,000/ha) and 1,50,000 (2,14,000/ha) respectively in ponds 1, 2 and 3 respectively. Prawns in ponds 1 and 2 were fed with pellated feed manufactured by Him's Feed India Ltd. and those in pond 3 were fed with slaughter house waste. The period of culture in ponds 1, 2 and 3 was 128, 95 and 77 days respectively.

At Chellanam, the ponds were depredated with 250 ppm mahua oil cake and later were completely drained and dried.

Triple superphosphate was added in each pond at the rate of 25 kg/ha. In these ponds, in addition to the tidal exchange, water was pumped at the rate of 10 to 15% daily. These ponds were stocked with post larvae (PL 50) of P. indicus having an average length and weight of 22 mm and 0.124 gm. The numbers stocked were 70,950 (1,41,900/ha), 1,39,000 (2,31,666/ha) and 82,400 (1,03,000/ha) and the culture period was 76 days. Trudina shrimp feed manufactured by Trudina Feed Corporation, Singapore was given to the prawns.

2.2. COLLECTION OF SAMPLES

Samples of water, soil and shrimps were collected once in every fortnight from each pond for estimating various hydrobiological and soil quality parameters and growth of shrimps. The samples were collected in triplicate and the average values were reckoned in presenting the data. The samples were collected before 08.00 hrs. in the morning except in the case of dissolved oxygen, where the water samples were taken at 06.00 hrs. Water samples were collected from the column of the pond using an underwater sampler bottle.

2.3. WATER QUALITY PARAMETERS

Water sample for determination of dissolved oxygen after collection without any air bubble was fixed with Winkler solution A and B at the site itself. Water samples for other parameters were brought to the laboratory in insulated containers filled with ice. In the laboratory at room temperature, pH, total alkalinity and total hardness were determined immediately. Water samples were then immediately frozen for storage. Before analysis of nutrients, water samples were thawed and brought to room temperature.

2.3.1 TEMPERATURE

Temperature of water was measured in the pond site itself using a 0-50°C high precision thermometer with an accuracy of 0.5°C.

2.3.2 SALINITY

Mohr titration method was used for the determination of salinity (Strickland and Parsons, 1972).

10 ml of water sample was titrated against standard silver nitrate solution with potassium chromate as the indicator. Silver nitrate was standardised using standard sea water of 35 ppt salinity supplied by the Oceanographic Institute, Copenhagen. Titration was done in triplicate and the mean value reckoned in presenting the data. Salinity was

calculated using the formula;

$$\text{Salinity (ppt)} = \frac{V_1 \text{ X } S}{V_2}$$ where V_1 is the volume of silver nitrate for titrating 10 ml of the sample, V_2 the volume of silver nitrate used for titrating 10 ml of standard sea water and S is the salinity of the standard seawater.

2.3.3 DISSOLVED OXYGEN

For the determination of dissolved oxygen, standard Winkler method with azide modification was used (FAO, 1975).

2 ml of manganous sulphate solution and 2 ml of alkali-iodine-azide solution were added to the water sample in 125 ml standard BOD bottle. The solution was mixed thoroughly and the precipitate was allowed to settle. Later, this precipitate was dissolved by adding 2 ml of concentrated sulphuric acid. From this solution, 100 ml was taken into a 250 ml beaker and was titrated with standard sodium thiosulphate solution to a pale straw colour. A few drops of starch indicator solution was added until the solution developed a blue colour. Titration was continued until the blue colour disappeared. Concentration of dissolved oxygen was then determined by using the formula;

$$\text{Dissolved oxygen (ppm)} = \frac{T \text{ X } N \text{ X } 8000}{S}$$ where T and N are the volume and normality of standard sodium thiosulphate and S the sample volume.

2.3.4 pH

pH was measured by an Elico pH meter model LI-120 having a combination electrode. The instrument was calibrated with pH buffers 4.0, 7.0 and 9.2. After taking the pH meter reading, the in situ pH was calculated using the formula described by FAO (1975).

pH in Pond = pH measured + 0.0118 $(t_2 - t_1)$ where t_1 and t_2 are temperatures measured in pond and at the time of measurement.

2.3.5 TOTAL ALKALINITY

The amount of acid required to neutralise the base in water is a measure of alkalinity (APHA *et al.*, 1981)

To 100 ml sample, 4 to 8 drops of methyl orange indicator solution was added and titrated against standard sulphuric acid solution until the colour of the solution changed from yellow to faint orange.

Total alkalinity (ppm) = $\frac{T \times N \times 50{,}000}{S}$ where T and N are the volume and normality of the acid and S is the sample volume.

2.3.6 TOTAL HARDNESS

The method described by Boyd and Pillai (1985) was used for measuring hardness. 2 ml buffer solution (ammonium chloride and ammonium hydroxide) was added to 100 ml sample followed by 8 drops of Eriochrome Black T indicator. After mixing, this was titrated against standard EDTA solution.

Total hardness was measured following the formula, Total hardness (ppm) = $\frac{T \text{ X } M \text{ X } 1{,}00{,}000}{S}$ where T and M are the volume and normality of the standard EDTA solution and S the sample volume.

2.3.7 NUTRIENTS

A. NITRATE - NITROGEN

Nitrate - nitrogen was estimated following the method of Morris and Riley and modified by Strickland and Parsons (1972).

To 50 ml water sample, 2 ml buffer reagent (phenol and sodium hyroxide) was added and with rapid mixing, 1 ml reducing agent (copper sulphate and hydrazine sulphate) was also added. The sample was kept in dark for 20 hours. 2 ml of acetone was added followed by 1 ml each of sulphanilamide and NNED. After 10 minutes, the absorbance was measured at a wave length of 543 mm in a spectrophotometer (Spectronic 20). Absorbance for standard nitrate solution and blank was also measured following the above procedure. Concentration of nitrate (ppm) in the sample was read from the standard graph.

B. PHOSPHATE - PHOSPHORUS

The method given by Murphy and Riley and described by Strickland and Parsons (1972) was used for the determination of reactive phosphorus.

5 ml of mixed reagent (Molybdic acid, ascorbic acid and potassium antimony tartrate was added to 50 ml of water sample. The resulting complex was reduced to a blue solution. After 5 minutes and preferably within 2 to 3 hours, the absorbance of the solution was measured at 885 nm in a spectrophotometer. Sample concentration was read from the standard graph drawn with different concentration of potassium dihydrogen orthophosphate.

C. NITRITE - NITROGEN

Nitrite nitrogen was estimated by the method of Morris and Riley and described by Strickland and Parsons (1972).

1 ml slphanilamide solution was added to 50 ml sample followed by 1 ml NNED. The solution was mixed thoroughly. Concentration of nitrite in the sample was read from the standard graph drawn with the absorbance of the standard nitrite solution.

D. AMMONIA - NITROGEN

Ammonia - nitrogen was determined by the phenol hypochlorite method (Solarzano, 1969).

To 50 ml water sample, 2 ml of phenol solution, 2 ml of sodium nitroprusside solution and 5 ml of oxidising reagent were added with thorough mixing. After an hour, absorbance was measured at 640 nm. Standard ammonia solution was prepared at different concentrations and the absorbance was noted. Sample concentration (ppm) was recorded from the standard graph.

2.3.8 GROSS PRIMARY PRODUCTIVITY

Oxygen technique (Gaarder and Gran, 1927) was used for the estimation of primary productivity.

In this method, composite samples were collected in 125 ml corning bottle with glass stopper. These bottles were categorised into light bottle and dark bottle, the later ones being painted with black colour. These bottles were kept suspended in the water column by means of a pole and string for a period of 3 hours from 10.00 hrs. to 13.00 hrs. In the dark bottle, only respiration takes place whereas in the light bottle both photosynthesis and respiration take place. The difference in the oxygen content between light and dark bottle was taken for estimating the gross primary productivity.

$$\text{Gross primary productivity } \text{mgC/M}^3\text{/hr} = \frac{\text{L-D X 0.375 x 1000}}{\text{1.25 X A.}}$$

where L is the dissolved oxygen in the light bottle and D the dissolved oxygen in the dark bottle after incubation, 1.25 is the photosynthetic quotient and A is the number of hours of incubation.

2.3.9 PHYTOPLANKTON AND ZOOPLANKTON

For determining the phytoplankton and zooplankton concentration, the method followed by Rajalakshmi *et al.*, (1988) was used.

50 litres of water sample was collected from the water column using a bucket. This water was poured into a nylon zooplankton net of 50 micron mesh size. The net is connected to a perspex cylinder of 100 ml volume, so that whatever residue filtered is finally collected in this bottle. Sediment was removed by decanting the supernatant liquid several times. The entire content was then transferred into a 250 ml measuring cylinder and a few drops of formalin was added. After settlement, the volume of zooplankton was noted and calculated for 1 M^3 of water.

50 litre water sample after separation of zooplankton by the above method was used for estimating the volume of phytoplankton. For this, the above water was poured into a

nylobolt phytoplankton net. As above, the phytoplankters filtered was finally collected in a 100 ml bottle. The whole content was transferred into a 250 ml measuring cylinder and the settled volume of phytoplankton was measured.

2.4 SOIL QUALITY PARAMETERS

Soil samples in triplicate were taken by means of a Van Veen grab having an area of 0.05 M^2.

Collected soil samples after bringing to laboratory was used for determining pH. Afterwards the soil samples were dried at 100°C for 16 hrs which were then powdered and stored in tight glass vials.

2.4.1 pH

The pH of soil in wet condition was determined using an Elico digital pH meter.

2.4.2 ORGANIC CARBON

Chromic acid method of Walkley and Black (1965) was used for the determination of organic carbon.

1 gm powdered soil sample was taken in a 500 ml conical flask. To this, 10 ml of I N dichromate solution was added and

mixed by swirling. 20 ml concentrated sulphuric acid containing 1.25% silver sulphate was added to the sample and was allowed to react for 30 minutes. The sample was then diluted to 200 ml with distilled water and to this 10 ml of concentrated phosphoric acid was added. It was then back titrated with 0.4 N ferrous ammonium sulphate solution using 1 ml diphenylamine indicator. At the end point, the colour changed from blue to brilliant green. Along with the sample, a blank was also run. The percentage of organic carbon was calculated by the formula:

$$\text{Organic carbon (\%)} = \frac{3.95}{g} \quad (1-\frac{T}{S})$$

where T and S are the volume of ammonium sulphate used for sample and blank respectively and g, the weight of soil sample in grams.

2.4.3 GRAIN SIZE ANALYSIS

Soil texture or grain size analysis of the soil was conducted by following the sieve and pipette method of Krumbein and Petti John (1938).

25 gm dried sediment sample was taken in one litre beaker and 100 ml 6% hydrogen peroxide was added. The sample was kept overnight and the next morning it was heated gently over a water bath adding small quantities of hydrogen peroxide until

there was no reaction. The contents of the beaker was washed down to a whatman No 42 filter paper. The sediment was then washed from the filter paper into a one litre beaker and 100 ml sodium hexametaphosphate was added and stirred for 15 minutes. The sample was left overnight.

The sediment was then transferred to the surface of a clean 62 micron sieve placed in a flat bottomed white enamel basin. 400 ml of distilled water was added while agitating the seive and the sieve with contents were kept in an oven at 100°C for 1 hour. The dried sieve with its contents was agitated over a large sheet of glazed white paper and any material which passed through it was transferred to the suspension in the basin. The fraction retained on the sieve was then weighed to get the weight of sand.

The contents in the basin was washed down to a one litre cylinder with distilled water and was shaken well. Exactly after 7 minutes 44 seconds, a 20 ml pipette sample was withdrawn from a depth of exactly 10 cm below the surface of the suspension and was transferred to a preweighed China dish. It was then dried in the oven at 100°C and the difference in weight was taken as the weight of silt fraction in the 20 ml sample. This was later computed to the weight of silt in one litre of the sample. Then the weight of sand and silt fractions were added and deducted from 100 which gave the proportion of clay.

2.4.4 BENTHOS

Soil sample along with the benthos was collected by means of a Van Veen grab having an area of 0.05 m^2. The soil thus collected was sieved through a 300 micron mesh to collect the macro-benthos. Small quantity of the stain rose bengal was added to the soil for the easy identification of benthos which were then collected by means of a forcep (Mason and Yevich, 1967). The collected benthos was preserved in 5% formalin and later the wet biomass of benthos was determined and computed for one square meter area of pond bottom. According to Damodaran (1973), the shell weight of molluscs should be included in the biomass of benthos. But in the present study no shelled organisms were encountered because of the seasonality of the experiment.

2.5 GROWTH AND SURVIVAL RATE OF PRAWNS

20 prawns were weighed in a small spring balance and the average weight of a prawn was taken. Like this 3 samples were taken. From this average daily growth in terms of gms/day was calculated. Survival rate of prawns was estimated after harvesting by complete draining of the pond.

2.6 STATISTICAL ANALYSIS

One way analysis of variance was used for testing the significance of various parameters among different ponds of both Poyya and Chellanam (Snedecor and Cochran, 1967; Lanari et al., 1989). In the case of any significant difference, pairwise comparison among different ponds was found out by Scheffe's test (Downie and Heath, 1970) to evaluate whether the ponds are significantly different from each other. Correlation analysis was conducted for determining the relationship between each parameter and the growth of prawns (Snedecor and Cochran, 1967).

3. RESULTS

3.1 WATER QUALITY PARAMETERS

3.1.1 TEMPERATURE

Particulars regarding the water temperature in different commercial shrimp farms are shown in figure 2 and table 1. It may be seen that in all the ponds, there is a gradual increase in temperature from the day of stocking to the day of harvesting. In pond 1, 2 and 3 at Poyya, the temperature ranged between 26.52° and 32.06°C, 27.00° and 32.00°C and

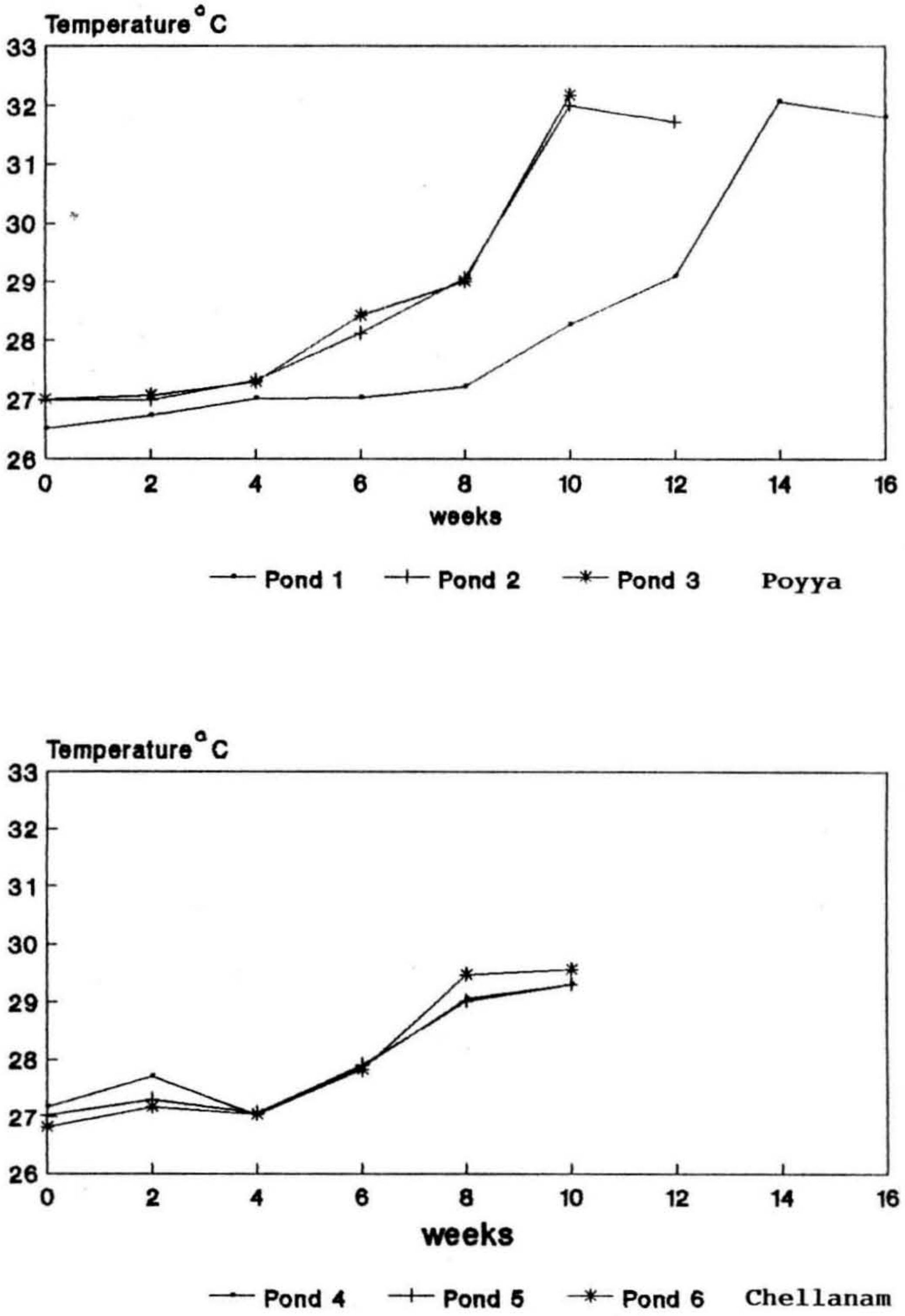
TEMPERATURE °C

Location		Poyya			Chellanam	
Pond No. Weeks	1	2	3	4	5	6
0	26.52	27.00	27.01	27.17	27.03	26.82
2	26.74	27.00	27.07	27.71	27.30	27.17
4	27.02	27.32	27.30	27.03	27.07	27.04
6	27.03	28.12	28.42	27.87	27.90	27.82
8	27.22	29.05	29.00	29.05	29.02	29.47
10	28.26	32.00	32.17	29.31	29.30	29.57
12	29.09	31.72				
14	32.06					
16	31.81					
Mean	28.42 A	28.89 A	28.50 A	28.02 A	27.94 A	27.98 A
Correlation r Value	0.940 S	0.914 S	0.809 NS	0.844 S	0.940 S	0.911 S

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 1. Temperature of water recorded in different ponds at Poyya and Chellanam.

Fig. 2 **Temperature of water recorded in different ponds at Poyya & Chellanam**



27.01° and 32.17°C respectively. The temperature recorded was within the range of 27.03° and 29.31°C, 27.03° and 29.30°C and 26.82° and 29.57°C in pond no 4, 5 and 6 respectively at Chellanam.

The average temperature recorded was 28.42°, 28.89°, 28.50°, 28.02°, 27.94° and 27.98°C in ponds 1, 2, 3, 4, 5 and 6 respectively.

Analysis of variance of temperature in different ponds (table 20) showed no significant difference ($P>0.05$). Correlation analysis between temperature and growth of prawns in each pond showed significant relationship except in pond 3.

3.1.2 SALINITY

The salinity values at different ponds in Poyya and Chellanam are given in figure 3 and table 2.

POYYA

The salinity values in the ponds studied at Poyya showed wide variations during the zero week, the values being 12.86, 28.32, and 28.64 ppt in ponds 1, 2 and 3 respectively. In pond 1, the values gradually increased to a maximum of 35.86 ppt during the 14th week. In pond 2, the salinity gradually increased from 28.32 ppt in zero week to about 35 ppt during the 10th and 12th weeks. In pond 3 also, the salinity was found increasing gradually from 28.64 in the zero week to 34.43 ppt in the 10th week. The average salinity values, were 28.30, 31.57 and 30.58 ppt in ponds 1, 2 and 3 respectively.

CHELLANAM

In ponds 4, 5 and 6 at Chellanam the salinity indicating comparatively low values, increased from 18.29, 18.58 and 17.57 ppt during zero week to 22.52, 22.47 and 21.50 ppt respectively in the 2nd week. The lowest salinity values of 10.13, 17.53 and 15.01 ppt were recorded during the 6th week in ponds 4, 5 and 6 respectively. The salinity during the 10th week was 16.23, 17.86 and 16.47 ppt in ponds 4, 5 and 6 respectively. The average salinity was 16.94, 19.29, and 17.50 ppt in ponds 4, 5 and 6 respectively.

Anova of salinity at different ponds (table 20) showed significant difference (P<0.01). Pairwise comparison indicated that the salinity values of ponds 1, 2 and 3 were significantly different from those of ponds 4, 5 and 6. The correlation analysis showed that the salinity of water is not significantly affecting the growth in any of the ponds.

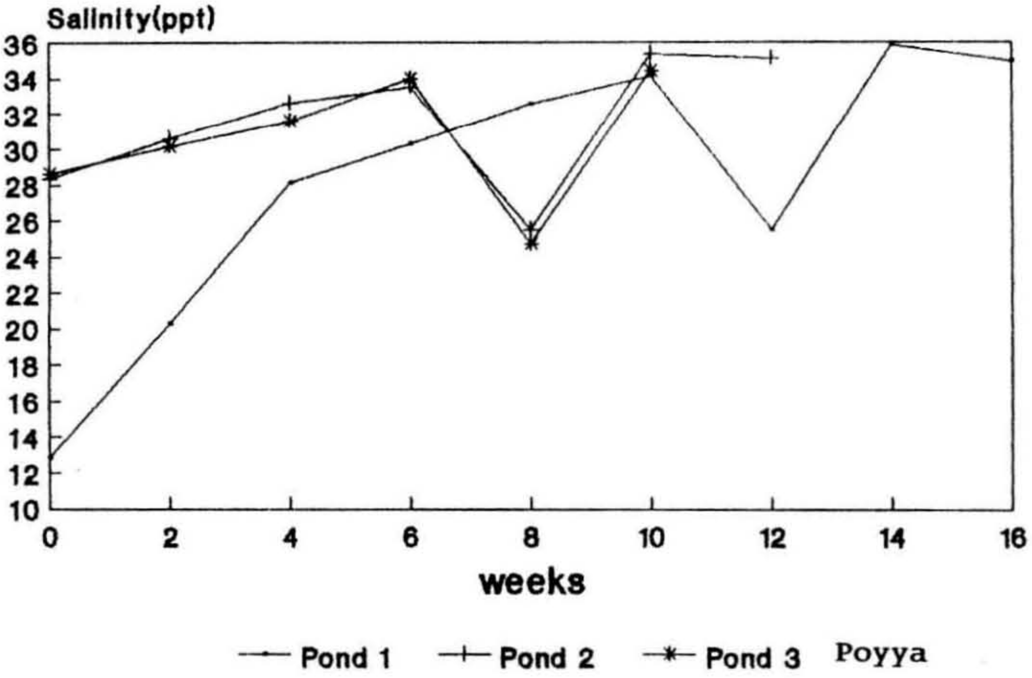
SALINITY (ppt)

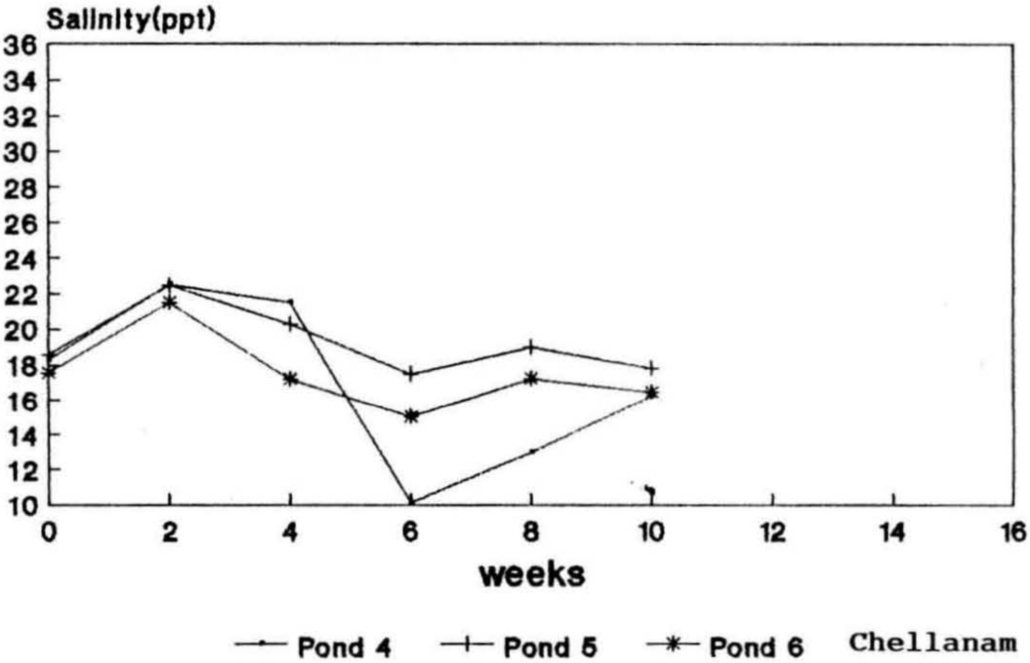
Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	12.86	28.32	28.64	18.29	18.58	17.57
2	20.31	30.58	30.14	22.52	22.47	21.50
4	28.15	32.61	31.59	21.49	20.28	17.23
6	30.32	33.48	34.01	10.13	17.53	15.01
8	32.56	25.52	24.72	12.98	19.03	17.27
10	34.14	35.39	34.43	16.23	17.86	16.47
12	25.50	35.12				
14	35.86					
16	35.00					
Mean	28.30*A	31.57 A	30.58 A	16.94*B	19.29 B	17.50 B
Correlation r Value	0.658 NS	0.411 NS	0.282 NS	-0.618 NS	-0.568 NS	-0.621 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 2. Salinity of water recorded in different ponds at Poyya and Chellanam.

Fig. 3 **Salinity of water recorded in different ponds at Poyya and Chellanam**





3.1.3 DISSOLVED OXYGEN

Particulars regarding the dissolved oxygen content in water at mid depth of different ponds in Poyya and Chellanam are given in table 3 and figure 4.

POYYA

In pond 1, the dissolved oxygen content was 5.86 ppm during the zero week. Maximum dissolved oxygen concentration of 7.79 ppm was recorded in the 8th week, which decreased to 6.33 ppm in the 16th week. The average dissolved oxygen content was 6.50 ppm.

In pond 2, the average dissolved oxygen content was 6.11 ppm with a concentration of 5.64 ppm in zero week, which increased to about 7 ppm during the 8th and 10th weeks.

In the 3rd pond, the concentration was between 4.45 and 4.85 ppm during zero week to 4th weeks which has increased to 5.85 ppm in the 10th week. The average dissolved oxygen concentration recorded was 5.08 ppm.

CHELLANAM

In pond 4 at Chellanam, the dissolved oxygen concentration was 4.24 and 4.76 ppm during the zero and second week respectively with the maximum value of 5.95 ppm recorded during the 4th week. Thereafter, the values decreased to 3.93 ppm in the 10th week. The average concentration was 4.73 ppm.

In pond 5, the concentration of dissolved oxygen above 5 ppm was recorded only in the 2nd week. The dissolved oxygen concentration was below 5 ppm during the other weeks with a concentration of 4.64 ppm in zero and 4.63 ppm in 10th weeks. Average concentration was 4.67 ppm.

In pond 6, the concentration was 4.74, 5.89 and 6.27 ppm during zero, 2nd and 4th weeks respectively. The concentration recorded was 5.76 ppm in the 10th week with the average concentration recorded being 5.51 ppm.

Anova of dissolved oxygen concentration at different ponds showed significant difference ($P<0.01$). The dissolved oxygen content of pond 1 was significantly different from that of ponds 3, 4 and 5. Correlation analysis of dissolved oxygen contents in various ponds showed that in ponds 1, 2 and 3, there exist a significant positive correlation between dissolved oxygen and growth of prawns.

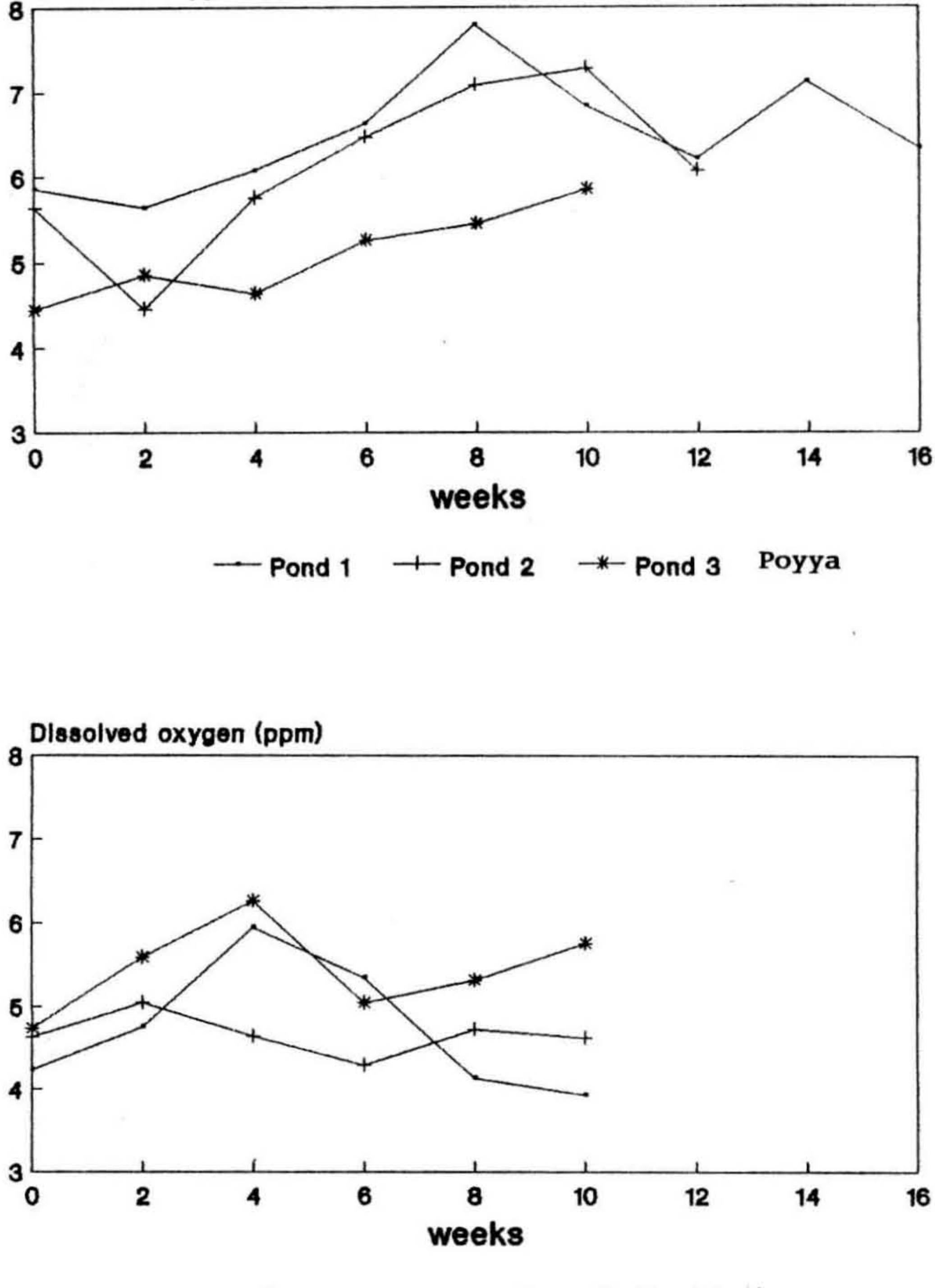
DISSOLVED OXYGEN (ppm)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	5.86	5.64	4.45	4.24	4.64	4.74
2	5.64	4.45	4.85	4.76	5.05	5.89
4	6.08	5.76	4.64	5.95	4.65	6.27
6	6.63	6.47	5.26	5.35	4.29	5.05
8	7.79	7.98	5.45	4.14	4.73	5.32
10	6.84	7.28	5.85	3.93	4.63	5.76
12	6.21	6.07				
14	7.12					
16	6.33					
Means	6.50 A	6.11 AB	5.08 BC	4.73 C	4.67 C	5.51 AC
Correlation r Value	0.708 S	0.772 S	0.875 S	-0.223 NS	-0.408 NS	0.060 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 3. Dissolved Oxygen in water recorded in different ponds at Poyya and Chellanam.

Fig.4 Dissolved Oxygen recorded in different ponds at Poyya and Chellanam



3.1.4 WATER pH

POYYA

In pond 1, the water pH of 7.71 during zero week was decreased to 7.11 during the 2nd week. Thereafter the values started increasing reaching a maximum value of 7.76 during the 10th week of culture. During the next four weeks, the values started declining to a low of 7.32 which later got stabilised till the end of culture period and the average pH was 7.48 (table 4, figure 5).

In the 2nd pond, the pH values ranged between 7.03 and 7.30, the lower values being observed during the beginning of the experiment and higher values during the end. The average value was 7.12.

In pond 3, the pH value ranged between 6.65 and 7.28, the lower values being observed towards the end of the experiment and higher values during the beginning, the average value being 7.03.

CHELLANAM

In pond 4, at Chellanam, the pH was 8.39 during the zero week. The highest value of 8.44 was recorded during the 8th week of culture. The average value was 8.23.

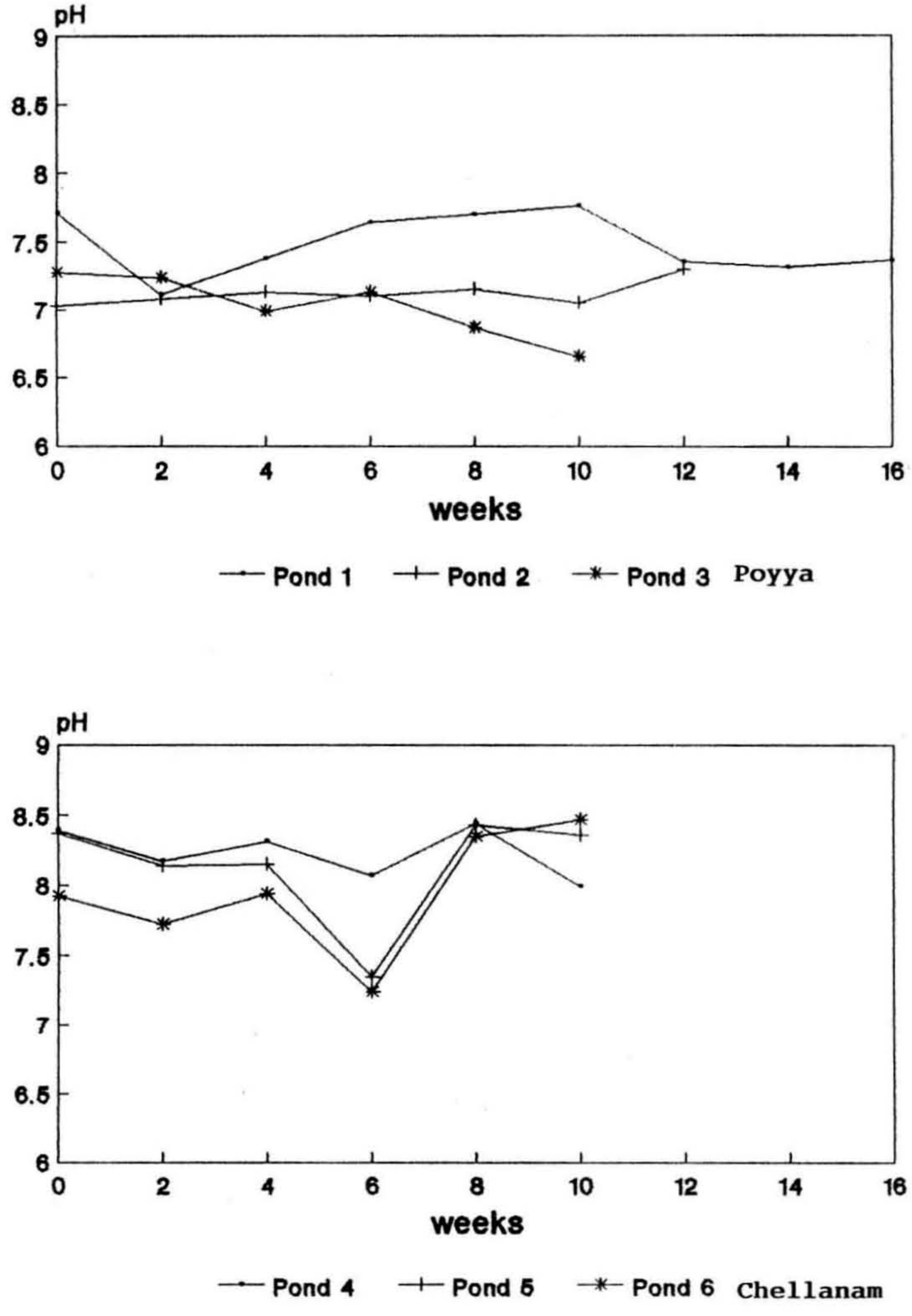
WATER P^H

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	7.71	7.03	7.28	8.39	8.37	7.92
2	7.11	7.08	7.24	8.17	8.14	7.72
4	7.38	7.13	6.99	8.31	8.15	7.94
6	7.64	7.10	7.13	8.07	7.35	7.24
8.	7.70	7.15	6.87	8.44	8.43	8.35
10	7.76	7.05	6.65	7.99	8.36	8.47
12	7.36	7.30				
14	7.32					
16	7.37					
Mean	7.48 A	7.12 A	7.03 A	8.23 B	8.13 B	7.94 B
Correlation r Value	-0.192 NS	0.604 NS	-0.875 S	-0.358 NS	-0.009 NS	0.425 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 4. P^H of water recorded in different ponds at Poyya and Chellanam.

Fig.5 pH of water recorded in different ponds at Poyya and Chellanam



In pond 5, the pH varied between 7.35 and 8.43. It may be noted that values of around 8.3 were recorded during the first and last week of culture. The average value was 8.13.

In pond 6, pH values of less than 8 were recorded during the first six weeks of culture and values above 8 were noticed during 8th and 10th week. The average value was 7.94. A comparison of pH values among the ponds showed that the pH of ponds 4, 5 and 6 at Chellanam are more than those in ponds 1, 2 and 3 at Poyya.

Anova of water pH in different ponds showed significant difference (P<0.01). Results of pairwise comparison between ponds indicated that the pH in ponds 1, 2 and 3 at Poyya are significantly different from that of ponds 4, 5 and 6 at Chellanam. Correlation analysis showed that only in pond 3, there exists a significant negative relationship between growth of prawns and pH of pond water.

3.1.5 TOTAL ALKALINITY

Particulars regarding the total alkalinity of water in various ponds are given in table 5 and figure 6.

POYYA

In pond 1, the total alkalinity was 147.52 ppm in the zero week which decreased to 70.00 and 50.01 ppm in the 2nd and

4th weeks respectively. The values increased to around 140 ppm during the 8th and 10th weeks, which again decreased to 102.53 ppm during the 16th week.

In pond 2, the alkalinity value was 80.36 ppm in the zero week with the maximum concentration of 110.87 ppm recorded during the 12th week.

In pond 3, total alkalinity value recorded was 117.58 ppm during the zero week which gradually got reduced to 62.58 ppm in the 10th week.

CHELLANAM

In pond 4, the total alkalinity during the zero week was 140.87 ppm which gradually decreased to 125.38 ppm during the 6th week. Maximum value of 190.69 ppm was recorded during the 10th week.

In pond 5, the alkalinity recorded was 160.68 ppm in the zero week. The minimum value of 140.37 ppm and the maximum value of 172.56 ppm were recorded during the 6th and 10th weeks respectively.

In pond 6, the value during the zero week was 137.59 ppm which increased to 152.98 ppm in the 4th week. The maximum value of 165.89 ppm was recorded in the 10th week.

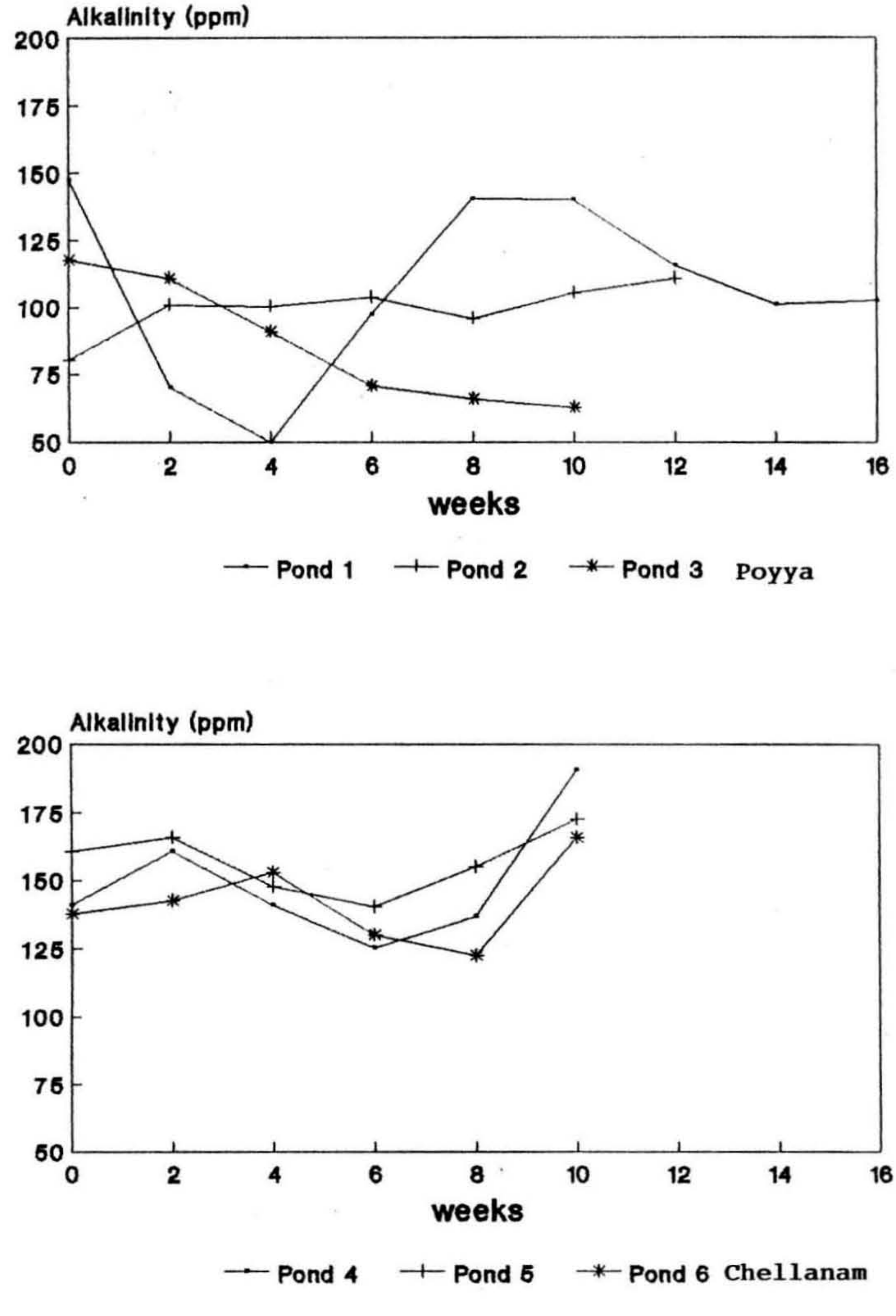
TOTAL ALKALINITY (ppm)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	147.52	80.36	117.58	140.87	160.68	137.59
2	70.00	100.68	110.78	160.68	165.93	142.53
4	50.01	100.10	90.98	140.87	147.68	152.98
6	97.53	103.68	70.68	125.38	140.37	130.21
8	140.24	95.67	65.87	136.89	154.89	122.61
10	140.03	105.37	62.58	190.69	172.56	165.89
12	115.74	110.87				
14	100.98					
16	102.53					
Mean	107.18*AB	99.53 AB	86.41 B	149.23*C	157.02 C	141.97 AC
Correlation r Value	0.150 NS	0.675 NS	-0.989 S	0.297 NS	0.051 NS	0.127NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 5. Total Alkalinity of water recorded in different ponds at Poyya and Chellanam.

Fig. 6 Total Alkalinity of water recorded in different ponds at Poyya & Chellanam



The average total alkalinity values were higher being 149.23, 157.02, and 141.97 ppm in ponds 4, 5 and 6 respectively at Chellanam. At Poyya, the values were lower being 107.18, 99.53 and 86.41 ppm in ponds 1, 2 and 3 respectively.

Anova of total alkalinity in different ponds showed significant variation (P<0.01). Pairwise comparison between ponds showed that pond 1 and 2 were significantly different from the ponds 4 and 5 with respect to total alkalinity and pond 2 was significantly different from the ponds 4 and 5 and pond 3 was significantly different from ponds 4, 5 and 6. Correlation analysis showed that only in pond 3, alkalinity has got a negative correlation with growth. In other ponds no positive or negative correlation was observed.

3.1.6 TOTAL HARDNESS

Details regarding the total hardness recorded in different ponds are shown in table 6 and figure 7.

POYYA

In pond 1, the total hardness was within a range of 11000 and 12000 ppm during the zero and 6th weeks and between 5000 and 6000 ppm during the 2, 8, 10, 12, 14 and 16th weeks.

In pond 2, the value was 6488.32 ppm during the zero week. The maximum value of 14915.85 ppm was recorded during the 2nd week. Thereafter the values gradually got reduced to 5409.18 ppm in the 8th week and this later increased to 7923.67 ppm in the 12th week.

In pond 3, the total hardness was above 10,000 ppm during zero, 2 and 4th weeks. However during 6, 8 and 10th weeks, the values were 5538.69, 3143.80 and 3408.64 ppm respectively.

CHELLANAM

In pond 4, the total hardness was above 5000 ppm during the zero and 2nd weeks and the values gradually decreased to a minimum of 2618.52 ppm during the 10th week.

In pond 5, the value was 4705.89 ppm during the zero week. Maximum value of 5018.88 ppm was recorded during the 2nd week which got reduced to 2759.95 and 3918.90 ppm during the 8th and 10th weeks respectively.

In pond 6, the values were in between 4000 and 4600 ppm during the zero, 2, 4 and 6th weeks and were reduced to 2608.93 and 3484.68 ppm during the 8th and 10th weeks respectively.

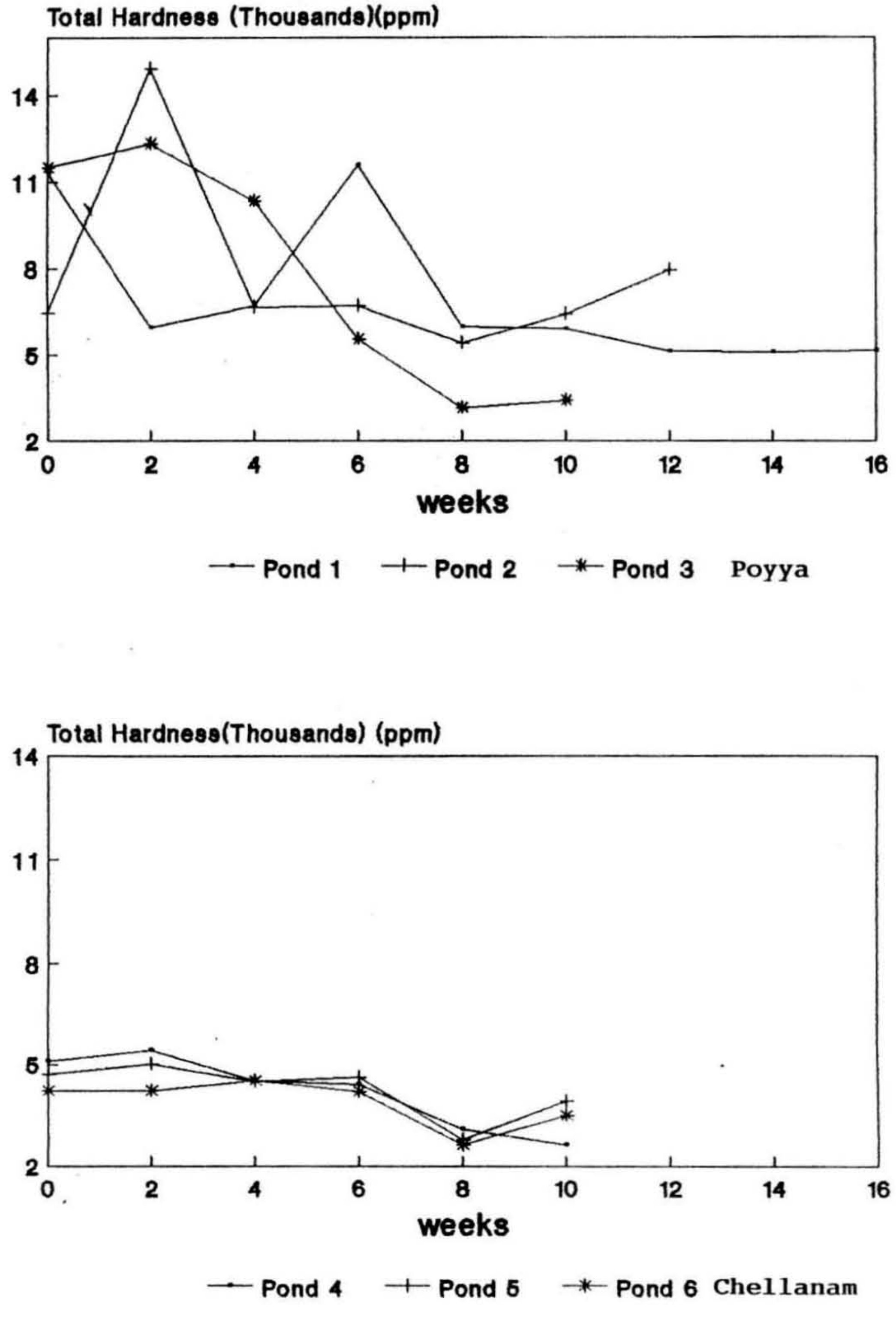
TOTAL HARDNESS (ppm)

Location	Poyya			Chellanam		
Pond No. Week	1	2	3	4	5	6
0	11309.61	6488.32	11508.23	5104.32	4705.89	4206.78
2	5965.38	14915.85	12318.67	5433.63	5018.88	4206.08
4	6717.83	6663.21	10329.86	4510.63	4508.31	4529.86
6	11575.39	6719.37	5538.69	4419.07	4633.63	4203.91
8	5999.82	5409.18	3143.80	3067.85	2759.95	2608.93
10	5918.97	6411.79	3408.64	2618.52	3918.90	3484.68
12	5119.83	7923.67				
14	5103.95					
16	5145.28					
Mean	6984.01 A	7790.20 B	7707.98 B	4192.34 C	4257.59 C	3873.37 C
Correlation r Value	-0.587 NS	-0.477 NS	-0.921 S	-0.951 NS	-0.725 NS	-0.655 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 6. Total Hardness of water recorded in different ponds at Poyya and Chellanam.

Fig. 7 Total Hardness of water recorded in different ponds at Poyya & Chellanam



The average total hardness recorded were 6984.01, 7790.20, 7707.98, 4192.34, 4257.59 and 3873.37 ppm in ponds 1, 2, 3, 4, 5 and 6 respectively. The average value was found to be the highest in pond 2 and the lowest in pond 6. In all the ponds a gradual decrease in the value was noticable towards the end of culture period. It may also be seen that the ponds at Poyya showed higher values compared to the ponds at Chellanam.

Anova of total hardness at various ponds showed significant difference $(P<0.05)$. Pairwise comparison showed that the total hardness in pond 1 is significantly different from that of all other ponds. The total hardness in pond 2 was also significantly different from that of ponds 4, 5 and 6. Likewise total hardness in pond 3 was significantly different from that of ponds 4, 5 and 6. However there is no difference among ponds 4, 5 and 6 with respect to total hardness. Analysis of correlaton co-efficient showed that in ponds 3 and 4 there exists a significant negative relationship between total hardness and growth of prawns.

3.1.7 NUTRIENTS

A. NITRATE - NITROGEN

Particulars regarding the concentration of nitrate-nitrogen in water at different ponds are given in table 7 and figure 8.

POYYA

In pond 1, the highest concentration of 0.038 ppm was recorded during the zero week. Thereafter, the value gradually decreased to 0.013 ppm during the 8th week. Again it increased to 0.025 ppm during the 14th week and the concentration in 16th week was 0.019 ppm.

In pond 2, the concentration during the zero week was 0.017 ppm which suddenly dropped to 0.008 ppm during the 2nd week of the culture. The concentration recorded during the 10th and 12th week was 0.004 ppm.

In pond 3, the concentration recorded during zero week was 0.011 ppm which suddenly dropped to 0.004 ppm during the 2nd week. The nitrate conc. was 0.006 ppm in 4th and 10th weeks and the maximum concentration of 0.013 ppm was recorded during the 8th week.

CHELLANAM

In pond 4, the concentration during the zero week was 0.008 ppm which increased to 0.009 ppm in the 2nd and 6th weeks and 0.004 ppm during 4th and 8th weeks. The concentration during 10th week was 0.005 ppm.

In pond 5, the concentration was 0.013 ppm during the zero and 2nd weeks. The maximum concentration of 0.019 ppm was recorded during the 8th week.

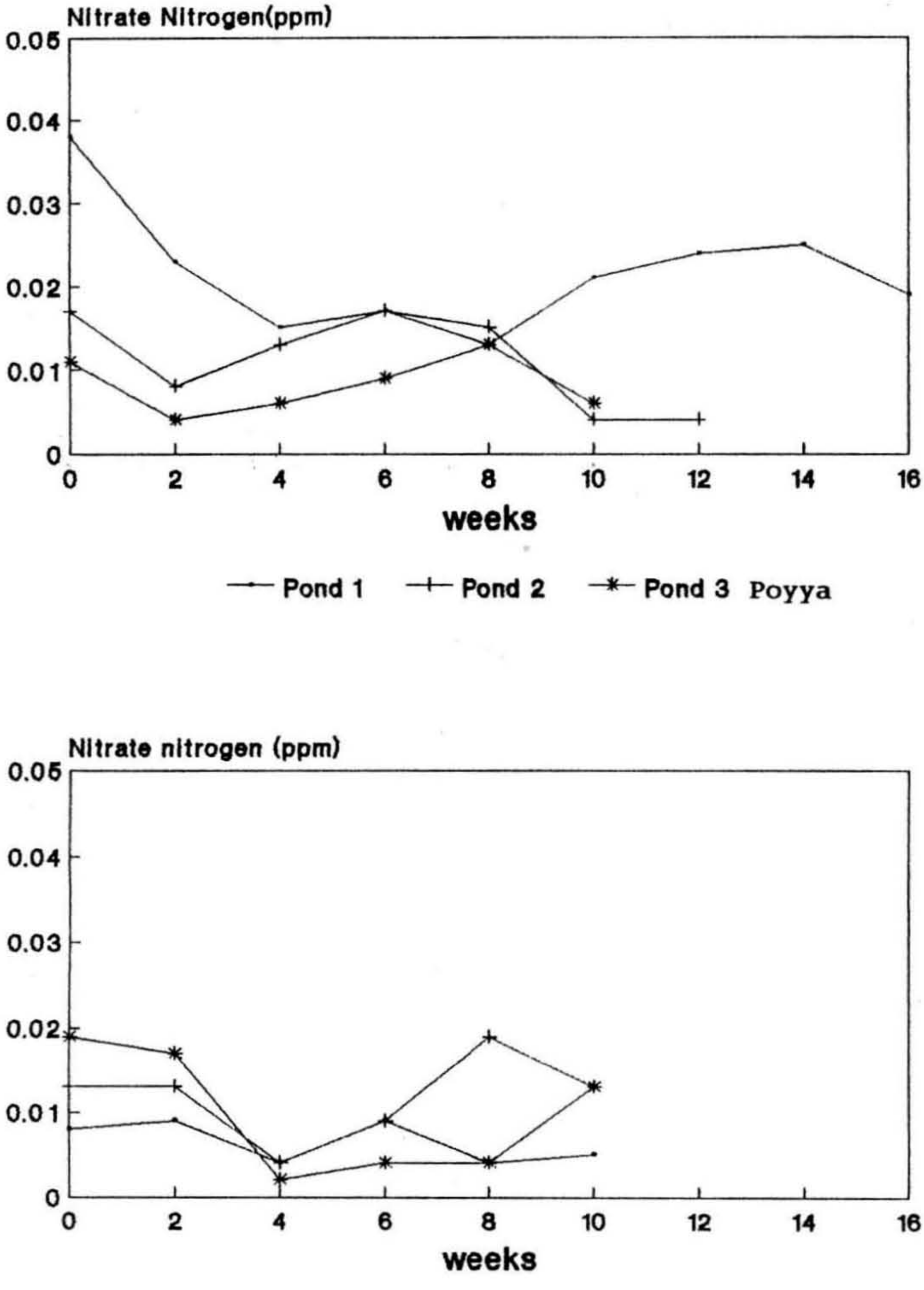
NITRATE NITROGEN (ppm)

Location	Poyya			Chellanam		
Pond No. Week	1	2	3	4	5	6
0	0.038	0.017	0.011	0.008	0.013	0.019
2	0.023	0.008	0.004	0.009	0.013	0.017
4	0.015	0.013	0.006	0.004	0.004	0.002
6	0.017	0.017	0.009	0.009	0.009	0.004
8	0.013	0.015	0.013	0.004	0.019	0.004
10	0.021	0.004	0.006	0.005	0.013	0.013
12	0.024	0.004				
14	0.025					
16	0.019					
Mean	0.022 A*	0.011 B	0.008 B	0.007 B*	0.012 AB	0.010 B
Correlation r Value	-0.104 NS	-0.517 NS	0.105 NS	-0.577 NS	0.296 NS	-0.525 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 7. Nitrate-Nitrogen concentration in water recorded in ponds at Poyya and Chellanam.

Fig. 8 Nitrate Nitrogen of water recorded in different ponds at Poyya & Chellanam



In pond 6, the highest concentration 0.019 ppm and the minimum concentration of 0.002 ppm were recorded during the zero and 4th weeks respectively. The concentration was 0.004 ppm during the 6th and 8th weeks which increased to 0.013 ppm during the 10th week.

The average concentration of nitrate was 0.022, 0.011, 0.008, 0.007, 0.012 and 0.010 in ponds 1, 2, 3, 4, 5 and 6 respectively. The highest average concentration of 0.022 ppm and the lowest average concentration of 0.007 ppm were recorded in ponds 1 and 4 respectively.

Anova of nitrate concentration at different ponds showed significant difference $(P<0.01)$ · Pairwise comparison showed that the concentration in pond 1 was significantly different from that of ponds 2, 3, 4 and 6 while there was no difference between ponds 1 and 5. Correlation co-efficient analysis indicated no significant relationship between nitrate concentration and growth of prawns.

B. PHOSPHATE - PHOSPHORUS

The concentration of nutrient phosphate in different ponds is shown in table 8 and figure 9.

POYYA

In pond 1, the highest concentration of 0.097 ppm was noticed during the zero week. Thereafter the concentration showed a reduction to 0.043 ppm during the 6th week. However, the values further increased to 0.065 ppm during 14th and 16th weeks.

In pond 2, the phosphate concentration was 0.057 ppm during the zero week which gradually got reduced to 0.042 ppm during the 4th week. The values further increased to 0.076 ppm during the 6th week, with the highest concentration of 0.081 ppm recorded during the 10th week.

In pond 3, the concentration in zero week was 0.049 ppm and the values ranged between 0.043 and 0.051 ppm during the subsequent weeks.

CHELLANAM

In pond 4, a concentration of 0.074 ppm was obtained during the zero week which was reduced to 0.040 ppm in the 2nd week. Nevetheless, during the subsequent weeks, the phosphate concentration increased ranging between 0.062 and 0.066 ppm with the maximum concentration of 0.089 ppm recorded during the 10th week.

Indicating comparatively high values, the phosphate concentration in pond 5 was 0.105 ppm during the zero weeks,

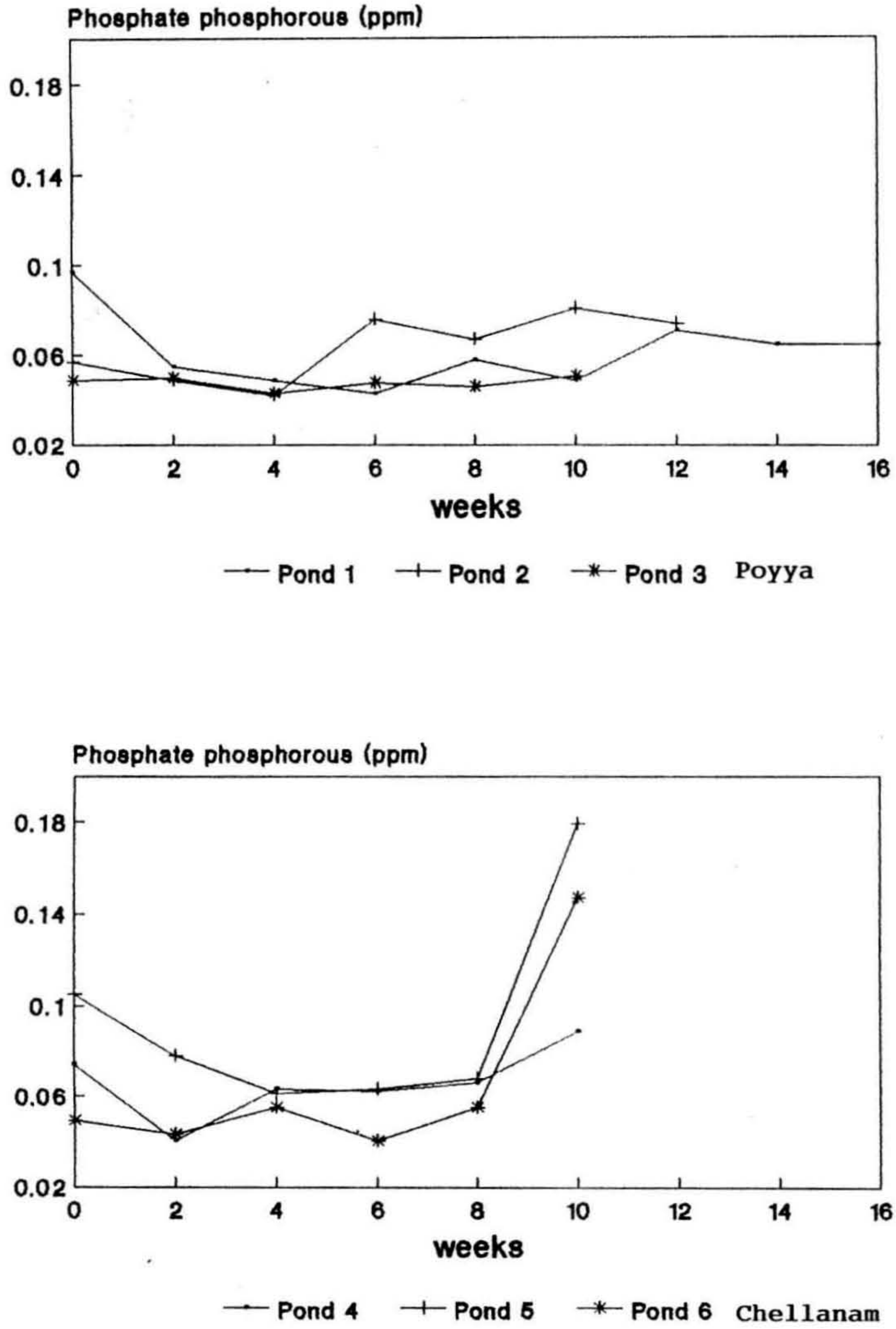
PHOSPHATE PHOSPHORUS (ppm)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	0.097	0.057	0.049	0.074	0.105	0.049
2	0.055	0.049	0.050	0.040	0.078	0.043
4	0.049	0.042	0.043	0.063	0.061	0.055
6	0.043	0.076	0.048	0.062	0.063	0.040
8	0.058	0.067	0.046	0.046	0.068	0.055
10	0.049	0.081	0.051	0.089	0.179	0.147
12	0.071	0.074				
14	0.065					
16	0.065					
Mean	0.061 A	0.064 A	0.048 A	0.066 A	0.092 A	0.065 A
Correlation r Value	0.042 NS	0.730 NS	-0.281 NS	-0.486 NS	0.387 NS	0.661 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 8. Phosphate-Phosphorus concentration in water recorded in different ponds at Poyya and Chellanam

Fig. 9 Phosphate Phosphorous in water recorded in different ponds at Poyya & Chellanam



which was reduced to 0.078 ppm in the 2nd week. During the subsequent weeks, the concentration showed a further decrease ranging between 0.061 and 0.068 ppm in the 4th and 8th weeks respectively. The highest concentration of 0.179 ppm was noticed during the 10th week.

In pond 6, with a comparatively low concentration, phosphate value ranged between 0.040 ppm in the 6th week to 0.147 ppm recorded during the 10th week.

The average concentrations of phosphate were 0.061, 0.064, 0.048, 0.066, 0.092 and 0.065 ppm in 1, 2, 3, 4, 5 and 6th ponds respectively. Between the ponds of the two regions, the phosphate concentration observed was comparatively high in ponds at Chellanam. Anova of phosphate concentration in different ponds showed no significant difference (P>0.05) and correlation analysis between phosphate concentration and growth also did not show any significant relationship in any pond.

C. NITRITE - NITROGEN

Details regarding nitrite - nitrogen concentration in water are presented in table 9 and figure 10.

POYYA

During the zero week in ponds 1 and 2, the concentration was very low being 0.002 and 0.004 ppm respectively. The concentration in pond 3 was so low that it was undetectable.

In pond 1, the nitrite concentration increased to 0.011 and 0.018 ppm during the 2nd and 4th weeks respectively. During the subsequent weeks, the concentration again reduced to values between 0.001 and 0.009 ppm.

In pond 2, the concentration was 0.002 ppm during the second week ranging thereafter between 0.004 and 0.007 ppm.

In pond 3, the nitrite concentration increased to 0.003 ppm during the 2nd week. The concentration in this pond was 0.002 and 0.001 ppm during the 4th and 6th weeks respectively and thereafter the concentration was undetectable.

CHELLANAM

In pond 4, the nitrite concentration was 0.001 ppm during the 8th week and was undetectable during the rest of the period.

In pond 5, the concentration was undetectable during zero and 2nd weeks and the concentration was 0.002 ppm during the 4th and 6th weeks and 0.007 ppm during 8th and 10th weeks.

In pond 6, the concentration was undetectable during zero to 4th weeks and 0.001 ppm during the 6th and 8th weeks and 0.007 ppm during the 10th week.

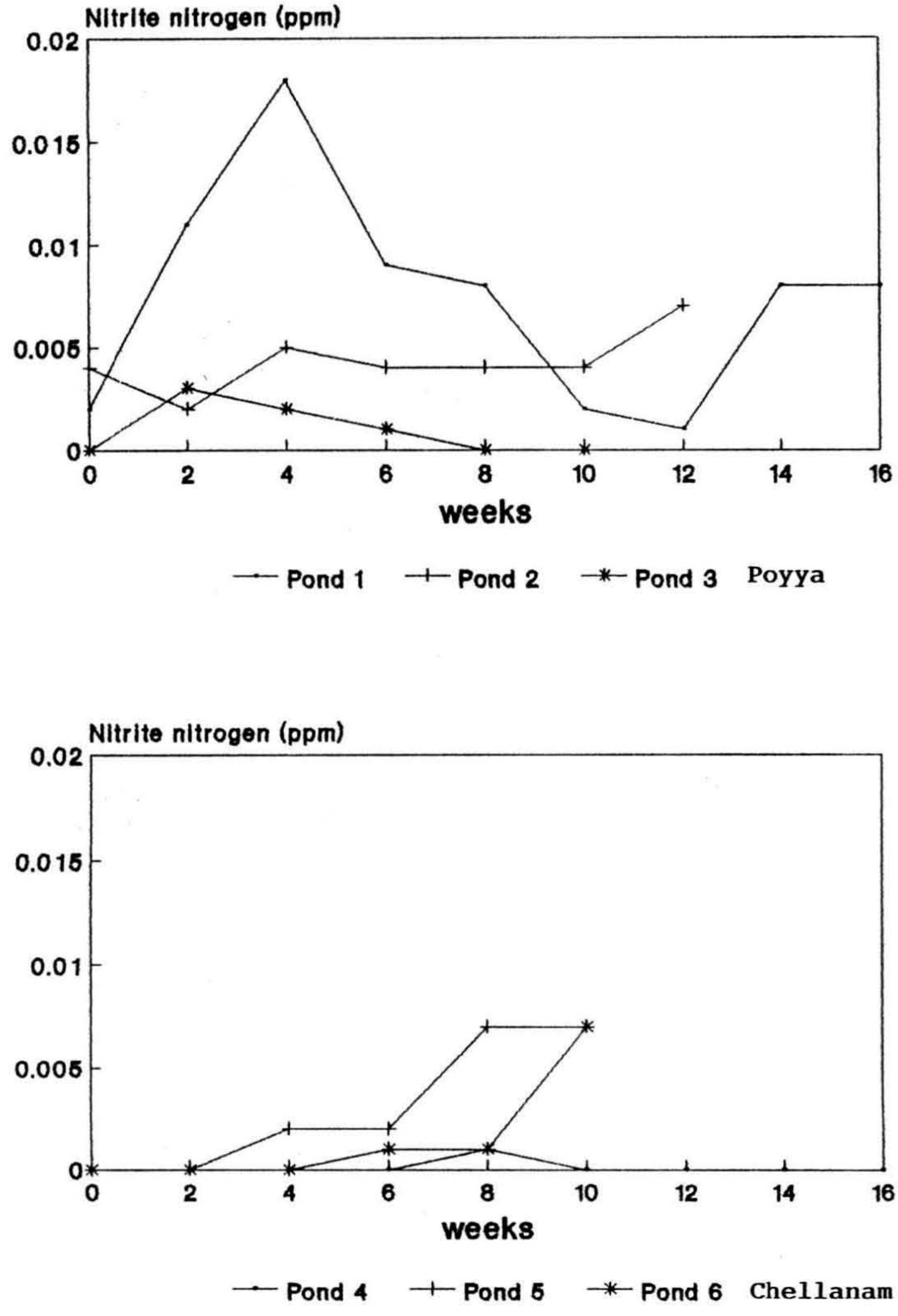
NITRITE NITROGEN (ppm)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	0.002	0.004	0	0	0	0
2	0.011	0.002	0.003	0	0	0
4	0.018	0.005	0.002	0	0.002	0
6	0.009	0.004	0.001	0	0.002	0.001
8	0.008	0.004	0	0.001	0.007	0.001
10	0.002	0.004	0	0	0.007	0.007
12	0.001	0.007				
14	0.008					
16	0.008					
Mean	0.007 A*	0.004 AB	0.001 B	0.0002 B*	0.003 AB	0.002 B
Correlation r Value	-0.318 NS	0.620 NS	-0.401 NS	0.414 NS	0.935 S	0.729 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 9. Nitrite-Nitrogen concentration in water recorded in ponds at Poyya and Chellanam.

Fig. 10 Nitrite concentration in water recorded in different ponds at Poyya & Chellanam



Average concentration in ponds 1, 2, 3, 4, 5 and 6 were 0.007, 0.004, 0.001, 0.002, 0.003 and 0.002 ppm respectively. It is obvious that there exists remarkable variation in nitrite concentration among the ponds of both regions with lower values noticeble at Chellanam.

Anova of nitrite concentration in different ponds showed significant difference among the ponds $(P<0.01)$. Pairwise comparison showed that the concentration in pond 1 was different from those numbering 3, 4, and 6. Correlation analysis showed that only in pond 5, there exists a significant positive relationship between nitrite concentration and growth of prawns.

D. AMMONIA - NITROGEN

The results of ammonia concentration in different ponds are given in table 10 and figure 11.

POYYA

During the zero week, the concentration was 0.028, nil and 0.084 ppm in ponds 1, 2 and 3 respectively. In pond 1, the concentration was in the range of 0.028 to 0.091 ppm during 2nd to 12th weeks, the values increasing thereafter to 0.119 and 0.113 ppm during 14th and 16th weeks respectively.

In pond 2, the concentration increased to the maximum level of 0.196 ppm in 6th week, the values decreasing thereafter to 0.028 ppm in the 8th week. During the subsequent weeks, the values increased reaching upto 0.182 ppm in the 12th week.

In pond 3, the concentration was in the range of 0.168 and 0.196 ppm during the 2nd to 6th weeks and the value was 0.203 and 0.245 ppm during 8th and 10th weeks respectively.

CHELLANAM

In pond 4, at Chellanam, the concentration of ammonia was undetectable during the initial 4 weeks. Thereafter the concentration increased to 0.084, 0.098 and 0.042 ppm during the 6, 8 and 10th weeks respectively. Like-wise, in pond 5 also, the concentration was low during the initial 4 weeks (0.021-0.042 ppm) which increased to 0.140, 0.203 and 0.084 ppm in 6, 8 and 10th weeks respectively. In pond 6 also, the concentration was low during initial 4 weeks (range 0.000-0.021) and high during 6, 8 and 10th weeks (0.084, 0.112 and 0.035 ppm) respectively.

The average concentrations in ponds 1, 2, 3, 4, 5 and 6 were 0.060, 0.082, 0.179, 0.037, 0.086 and 0.044 ppm respectively and the concentration was found to be the highest in pond 3. Between the ponds at Poyya and Chellanam, the ammonia nitrogen was of a lower order at Chellanam.

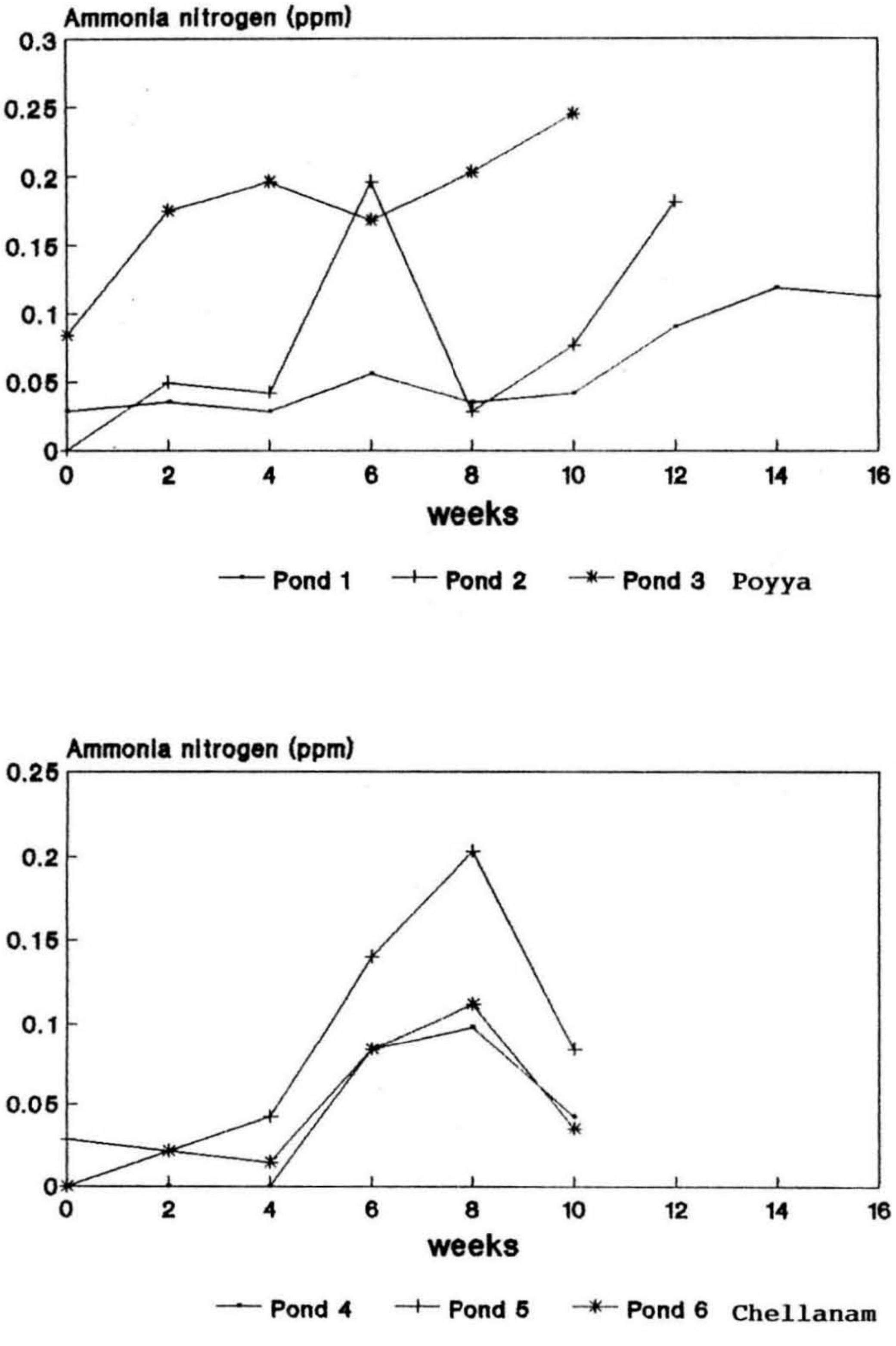
AMMONIA NITROGEN (ppm)

Location	Poyya			Chellanam		
Pond No. Week	1	2	3	4	5	6
0	0.028	0	0.084	0	0.028	0
2	0.035	0.049	0.175	0	0.021	0.021
4	0.028	0.042	0.196	0	0.042	0.014
6	0.056	0.196	0.168	0.084	0.140	0.084
8	0.035	0.028	0.203	0.098	0.203	0.112
10	0.042	0.077	0.245	0.042	0.084	0.035
12	0.091	0.182				
14	0.119					
16	0.113					
Mean	0.061 A	*0.082 AB	0.179 B	*0.037 A	0.086 AB	0.044 A
Correlation r Value	0.929 S	0.489 NS	0.821 S	0.732 NS	0.739 NS	0.670 NS

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 10. Ammonia-Nitrogen concentration in water recorded in different ponds at Poyya and Chellanam.

Fig. 11 **Ammonia concentration in water recorded in different ponds at Poyya & Chellanam**



Anova of ammonia concentration in different ponds showed significant difference (P<0.01) between ponds. Pairwise analysis showed that the concentrations between ponds 1 and 3, 3 and 4, and 3 and 6 were significantly different. Collrelation analysis showed that there exists a significant positive relationship between ammonia concentration and growth in ponds 1 and 3. In other ponds there was no significant relationship between growth and ammonia concentration.

3.1.8 PRIMARY PRODUCTIVITY

The results of primary productivity in different ponds are shown in table 11 and figure 12.

POYYA

In pond 1 at Poyya the primary productivity during the zero week was 281.24 mgC/M^3/hr, increasing thereafter to 583.91 mgC/M^3/hr during the 6th week. During the subsequent weeks of culture, the values gradually decreased to reach 324.33 mgC/M^3/hr in the 16th week.

The primary productivity values in pond 2 was 198.42 mgC/M^3/hr in the zero week. From the 4th week onwards the values gradually increased and reached a maximum of 541.67 mgC/M^3/hr in the 12th week.

In pond 3, the primary productivity was 143.36 mgC/M^3/hr in the zero week which decreased to 121.36 mgC/M^3/hr in 2nd week. The primary productivity then increased to 299.32 mgC/M^3/hr in the 8th week declining thereafter to 286.34 mgC/M^3/hr in the 10th week.

CHELLANAM

Evincing a comparatively high primary productivity, pond 4 at Chellanam indicated a value of 468.14 mgC/M^3/hr in zero week, which increased to 796.36 mgC/M^3/hr in the 4th week. The lowest productivity of 345.36 mgC/M^3/hr was recorded in the 6th week. The values later increased to 786.53 and 844.38 mgC/M^3/hr during 8th and 10th weeks respectively.

In pond 5, the productivity was 181.73 mgC/M^3/hr during the zero week. During the 2nd and 4th weeks, the productivity values were 124.38 and 131.38 mgC/M^3/hr respectively. There was an increase in value during the subsequent weeks, the recorded values being 193.96, 341.58 and 423.56 mgC/M^3/hr during the 6th, 8th and 10th weeks respectively.

In pond 6, the vlaue was 421.86 mgC/M^3/hr during the zero week. From 4th week onwards, there was an increase in productivity reaching to a maximum value of 823.32 mgC/M^3/hr in 10th week.

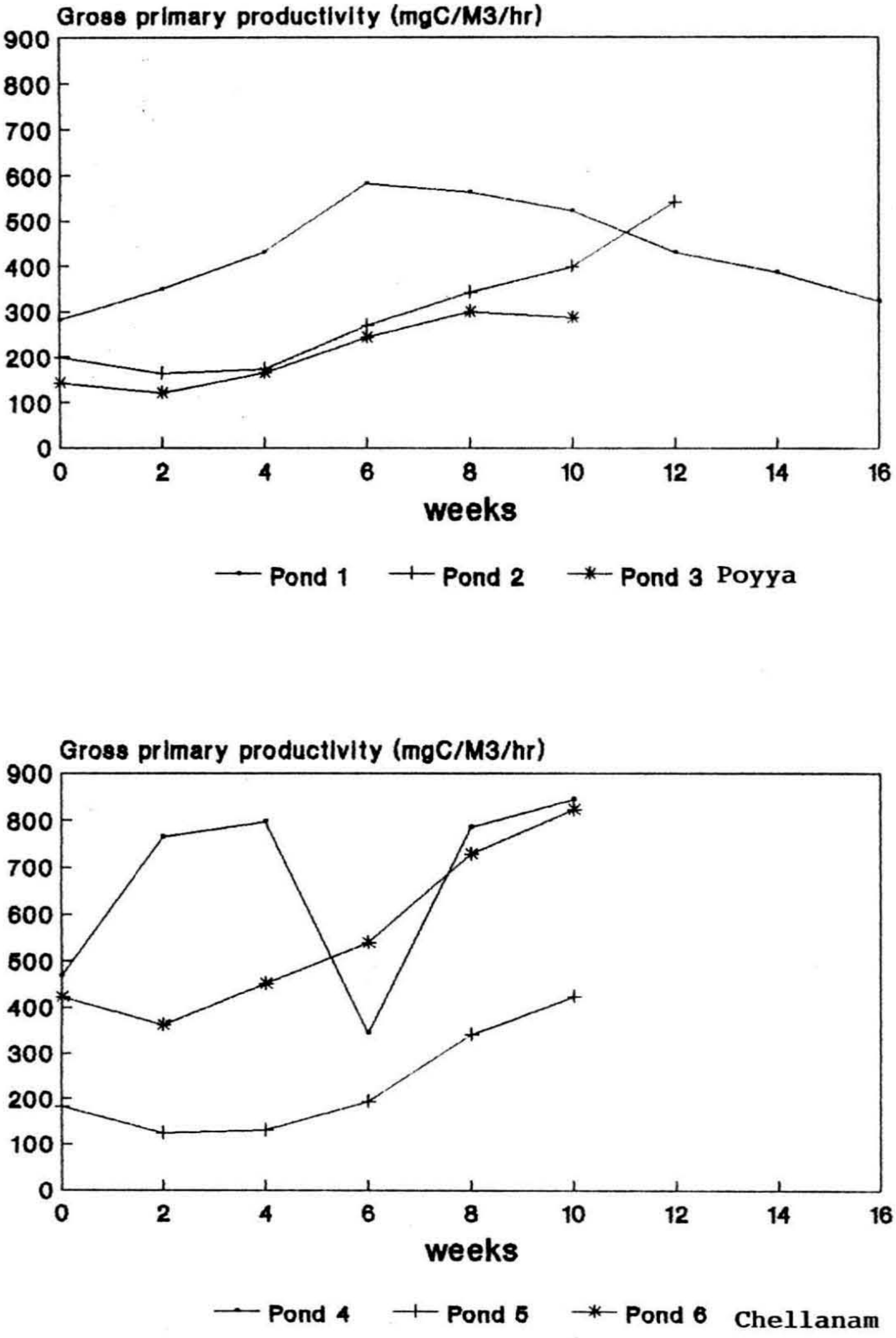
GROSS PRIMARY PRODUCTIVITY (mgC/m^3/hour)

Location	Poyya			Chellanam		
Pound No. Week	1	2	3	4	5	6
0	281.24	198.42	143.36	468.14	181.73	421.86
2	348.41	162.31	121.36	764.32	124.38	361.73
4	431.32	174.19	164.39	796.36	131.38	451.38
6	583.91	268.23	243.23	345.36	193.96	539.11
8	564.12	341.67	299.32	786.53	341.58	729.16
10	524.12	398.44	286.34	844.38	423.56	823.32
12	431.89	541.67				
14	386.14					
16	324.33					
Mean	430.61*AB	297.85*AC	209.67*A	667.52 B	232.77 A	554.43 BC
Correlation r Value	-0.088 NS	0.893 S	0.913 S	0.317 NS	0.867 S	0.938 S

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 11. Gross primary productivity recorded in ponds at Poyya and Chellanam.

Fig. 12 **Gross Primary Productivity recorded in different ponds at Poyya & Chellanam**



The average primary productivity of 1, 2, 3, 4, 5 and 6th ponds were 430.61, 297.85, 209.67, 667.52, 232.77 and 554.43 mgC/M^3/hr respectively, anova of which showed significant variation ($P<0.01$). Correlation analysis showed that in ponds 2, 3, 5 and 6, there exists a significant positive relationship between primary productivity and growth of prawns.

3.1.9 PHYTOPLANKTON

Table 12 and figure 13 illustrate, the details regarding the phytoplankton concentration in different commercial ponds.

POYYA

In pond 1, the phytoplankton concentration during the zero week was 1.14 ml/M^3 of water. From 2.32 ml/M^3 of the 2nd week, the value increased to the maximum of 3.34 ml/M^3 in the 6th week. Later the values were found decreasing to 1.72, 1.84 and 1.39 ml/M^3 during 12, 14 and 16th weeks respectively.

With a comparatively low concentration of phytoplankton, pond 2 showed the minimum value of 0.81 ml/M^3 during the 2nd week. Subsequently during 6th week, the concentration was found increasing to 1.30 ml/M^3 and reaching the maximum vlaue of 1.73 ml/M^3 during the 12th week.

In pond 3, the concentration during the zero week was 0.77 ml/M^3 which was reduced to a minimum value of 0.42 ml/M^3 during the 4th week. Thereafter the value increased to the maximum of 1.43 ml/M^3 in the 10th week.

CHELLANAM

Indicating a richer concentration of phytoplankton, pond 4 at Chellanam showed a value of 2.12 ml/M^3 during the zero week. During the 2nd and 4th weeks, the values were found increasing to 3.35 and 3.47 ml/M^3. The minimum (2.04 ml/M^3) and maximum (3.92 ml/M^3) values were recorded during the 6 and 10th weeks respectively.

Pond 5 showed a concentration of 0.87 ml/M^3 in zero week, which decreased to the lowest concentration of 0.62 ml/M^3 during the 4th week. The concentratons in the subsequent weeks were higher and the maximum concentration 1.72 ml/M^3 was recorded in the 10th week.

In pond 6, a concentration of 3.45 ml/M^3 was recorded during the zero week. The value was found decreasing to the lowest concentration of 2.86 ml/M^3 during the 2nd week. The concentration increased thereafter to reach the maximum value of 4.90 ml/M^3 in the 8th week.

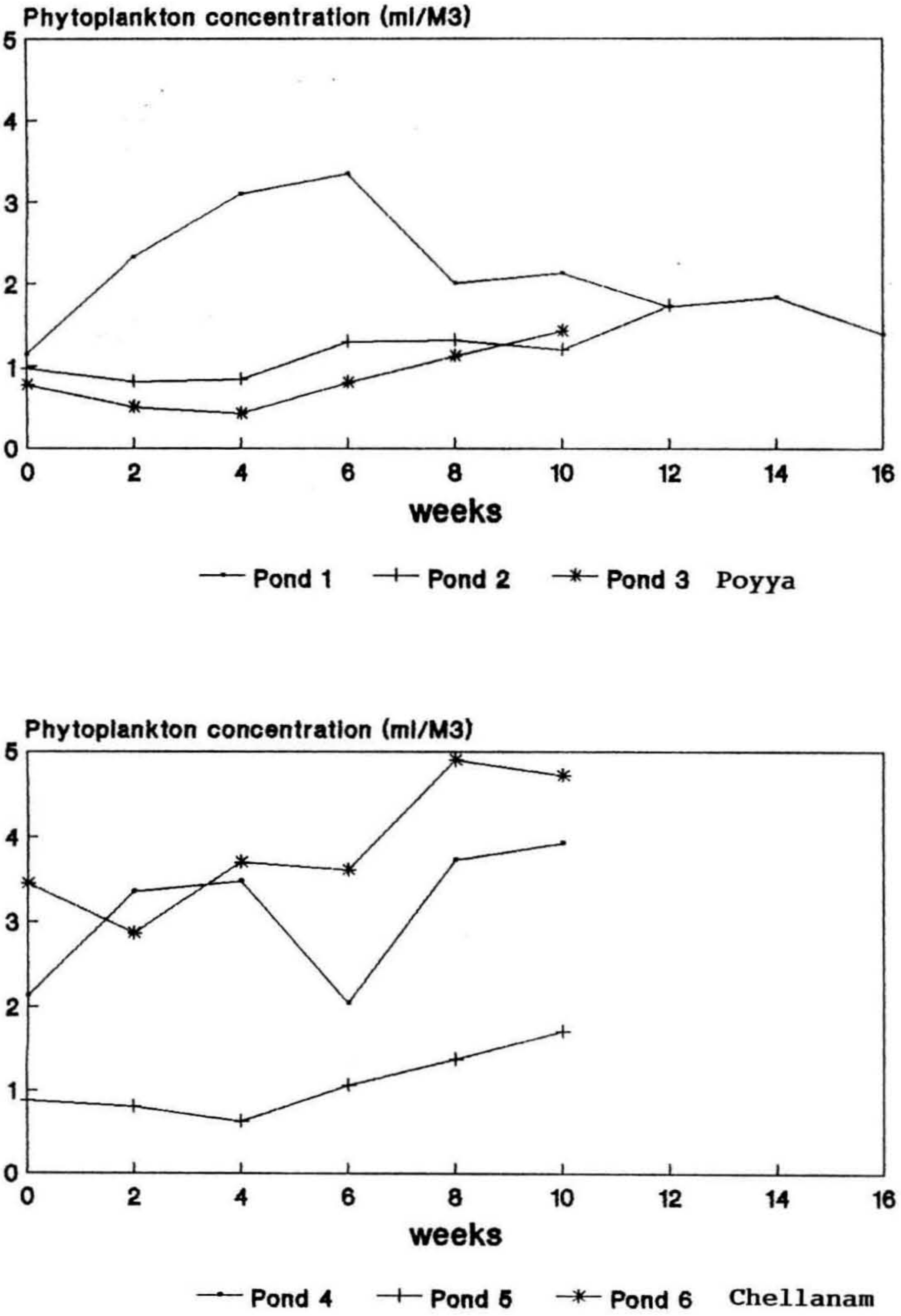
PHYTOPLANKTON (ml/m^3)

Location	Poyya			Chellanam		
Pond No. Week	1	2	3	4	5	6
0	1.14	0.97	0.77	2.12	0.87	3.45
2	2.32	0.81	0.50	3.35	0.80	2.86
4	3.10	0.84	0.42	3.47	0.62	3.70
6	3.34	1.30	0.80	2.04	1.06	3.61
8	2.01	1.31	1.12	3.73	1.38	4.90
10	2.13	1.20	1.43	3.92	1.72	4.72
12	1.72	1.73				
14	1.84					
16	1.39					
Mean	2.11*AD	1.17*AC	0.84*CE	3.11*BD	1.08 AE	3.87 B
Correlation r Value	-0.418 NS	0.801 S	0.678 NS	0.503 NS	0.869 S	0.867 S

* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 12. Concentration of Phytoplankton recorded in ponds at Poyya and Chellanam.

Fig. 13 Phytoplankton concentration recorded in different ponds at Poyya & Chellanam



The average phytoplankton concentration was 2.11, 1.17, 0.84, 3.11, 1.08, and 3.87 ml/M^3 in ponds 1, 2, 3, 4, 5 and 6 respectively. It is discernible that regionwise, ponds 4 and 6 at Chellanam indicated denser concentration.

Anova of phytoplankton concentration at different ponds showed significant difference ($P<0.01$). Pairwise comparison showed significant difference between ponds 1 and 3, 1 and 6, 2 and 4, 2 and 6, 3 and 4, 3 and 6, 4 and 5, and 5 and 6. Correlation analysis indicated positive significant relationship between phytoplankton concentration and growth of prawns in ponds 2, 5 and 6.

3.1.1 ZOOPLANKTON

Particulars regarding the variation of zooplankton during the culture period in different ponds at Poyya and Chellanam are depicted in table 13 and figure 14.

POYYA

The zooplankton concentration in pond 1 varied between 0.69 and 1.78 ml/M^3 of water. The zooplankton content which was 0.86 ml/M^3 in the zero week, was found increasing to 1.34, 1.78 and 1.01 ml/M^3 during 2, 4 and 6th weeks respectively. The zooplankton concentration was found decreasing to below 1 ml/M^3 during the subsequent weeks.

In pond 2, values were below 2 during zero week (1.93 ml/M^3) and 12th week (1.84 ml/M^3). The highest value of 2.62 ml/M^3 was observed in the 8th week.

In pond 3, the zooplankton concentration was less, varying between 0.20 and 0.45 ml/M^3.

CHELLANAM

The zooplankton content in pond 4 was 1.45 ml/M^3 during the zero week. Thereafter the values gradually increased to 1.52, 1.98 and 2.43 ml/M^3 during the 2nd, 4th and 6th weeks respectively. During the 8th week, the zooplankton concentration was drastically reduced to 0.31 ml/M^3.

In pond 5, the zooplankton content was below 1 ml/M^3 throughout the study period except during the 4th week. The lowest value of 0.42 ml/M^3 and the highest value of 1.42 ml/M^3 were observed during zero and 4th weeks respectively.

In pond 6, the values were above 2 ml/M^3 during all the weeks except 4th week where the value noticed was 1.31 ml/M^3. The highest value of 2.67 ml/M^3 was obtained in 10th week.

The average zooplankton concentration observed in ponds 1, 2, 3, 4, 5 and 6 were 0.99, 2.20, 0.30, 1.43, 0.81 and 2.17 ml/M^3 respectively.

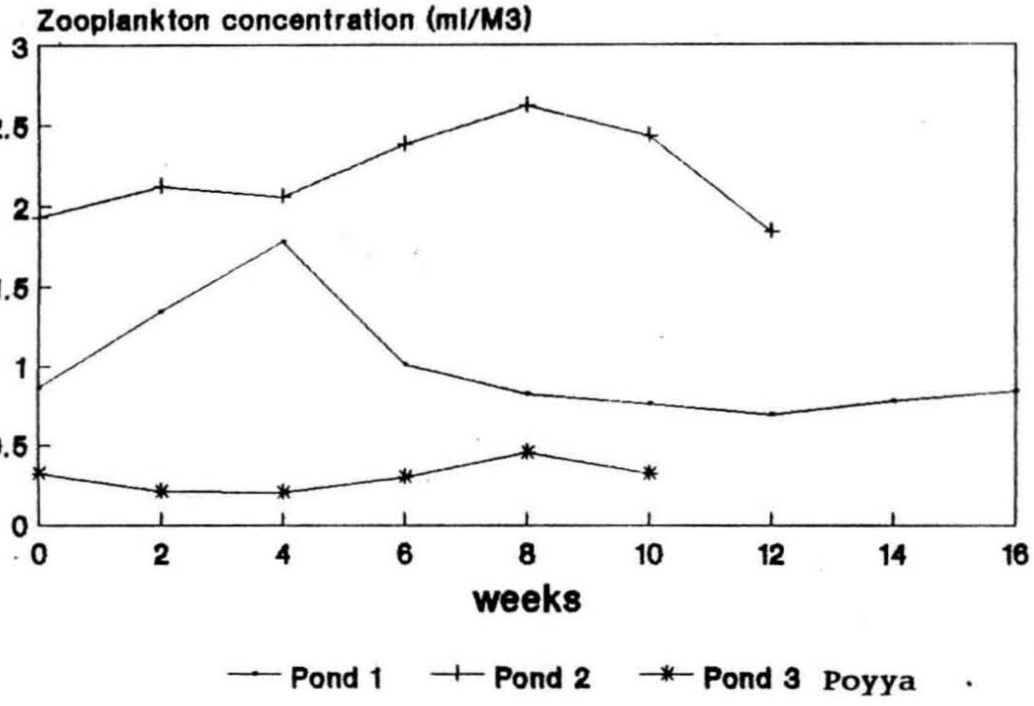
ZOOPLANKTON (ml/m^3)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	0.86	1.93	0.32	1.45	0.42	2.10
2	1.34	2.12	0.21	1.52	0.78	2.02
4	1.78	2.06	0.20	1.98	1.42	1.31
6	1.01	2.38	0.30	2.43	0.80	2.42
8	0.82	2.62	0.45	0.31	0.71	2.52
10	0.76	2.43	0.32	0.90	0.72	2.67
12	0.69	1.84				
14	0.78					
16	0.84					
Mean	0.99*AC	2.20*B	0.30*AD	1.43*CB	0.81 CD	2.17 B
Correlation r Value	-0.594 NS	0.325 NS	0.405 NS	-0.405 NS	0.029 NS	0.616 NS

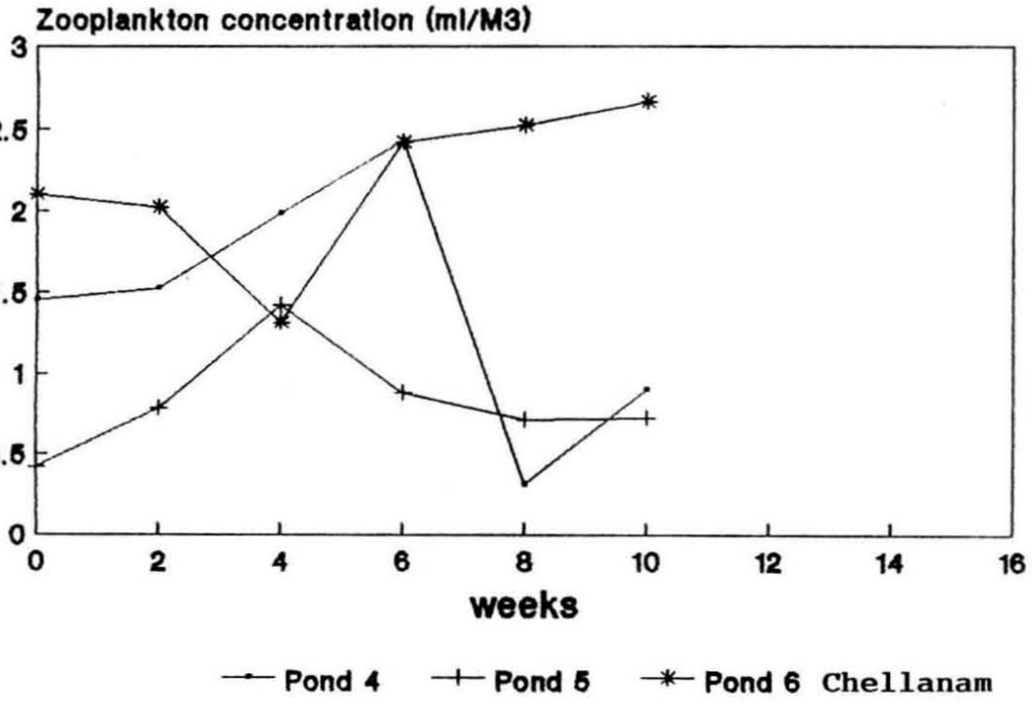
* Any two means having a common letter are not significantly different. S- Significant, NS- Not Significant

Table 13. Concentration of Zooplankton recorded in ponds at Poyya and Chellanam.

Fig. 14 **Zooplankton concentration recorded in different ponds at Poyya & Chellanam**



Poyya



Chellanam

Anova of zooplankton concentration at different ponds showed significant variation (P<0.01). Pairwise comparison showed significant variation between ponds, 1 and 2, 1 and 6, 2 and 3, 2 and 5, 3 and 4, 3 and 6 and 5 and 6. Correlation analysis showed no significant relationship between zooplankton concentration and growth of prawns in all ponds.

3.2 SOIL QUALITY PARAMETERS

3.2.1 SOIL pH

The pH values of soil from ponds at Poyya and Chellanam in the wet condition are shown in table 14 and figure 15.

POYYA

Indicating a general slant towards the acidic side, the pH in pond 1 at Poyya was in the range of 6.50 to 6.93 during the zero to 6 weeks. During the 8th week, the pH value increased to a high of 7.43. Later there was a slight decrease in pH, reaching to 6.60 during the 16th week.

In pond 2, the soil pH was in the range of 5.61 and 5.96 during the zero to 6th weeks. During the 8th week the pH value increased reaching a maximum of 6.94 during the 10th week.

In pond 3, the pH values throughout the experiment were below 7 ranging between 6.32 and 6.90.

CHELLANAM

From the table 14 and figure 15, it is evident that the pond soil at Chellanam is more of alkaline nature. In pond 4, the pH was 7.39 and 7.01 during zero and 2nd week, which however decreased to 6.98 during the 4th week. In the 6th and 8th week, the values again increased to 7.29 and 7.26 respectively.

In pond 5, the pH was in the range of 7.10 and 7.34 during the zero and 6th weeks. The values were found declining to 6.94 and 6.81 during the 8th and 10th weeks respectively.

In pond 6, the pH was always above 7 (range 7.07 - 7.90).

The average pH values were 6.91, 6.19, 6.60, 7.07, 7.13 and 7.36 in ponds 1, 2, 3, 4, 5 and 6 respectively.

Anova of soil pH in different ponds showed significant difference (P<0.01). Pairwise comparison showed significant difference between ponds 1 and 2, 2 and 4, 2 and 5, 2 and 6, 3 and 4, and 3 and 6. Correlation analysis indicated that only in pond 2, there exists a positive relationship between growth of prawns and soil pH.

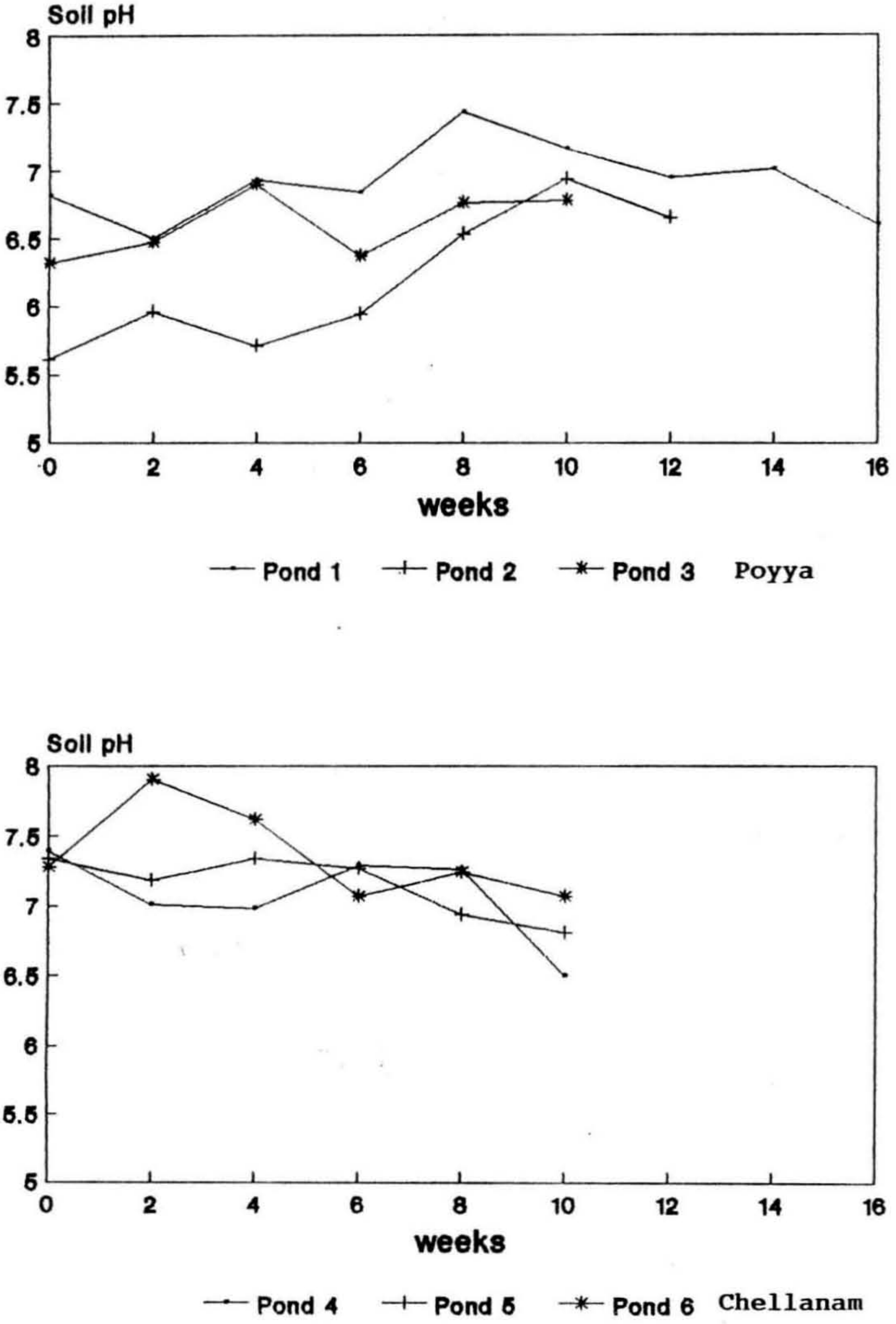
SOIL P^H

Location	Poyya			Chellanam		
Pond No. / Weeks	1	2	3	4	5	6
0	6.82	5.61	6.32	7.39	7.34	7.28
2	6.50	5.96	6.47	7.01	7.10	7.90
4	6.93	5.71	6.90	6.98	7.34	7.62
6	6.84	5.94	6.37	7.29	7.27	7.07
8	7.43	6.53	6.76	7.26	6.94	7.24
10	7.10	6.94	6.78	6.50	6.81	7.07
12	6.95	6.65				
14	7.01					
16	6.60					
Mean	6.91*AC	6.19*B	6.60 CBD	7.07 A	7.13 AD	7.36 A
Correlation r Value	0.032 NS	0.837 S	0.591 NS	-0.490 NS	-0.753 NS	-0.683 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 14. Soil P^H recorded in ponds at Poyya and Chellanam.

Fig. 15 **Soil pH recorded in different ponds at Poyya & Chellanam**



3.2.2 ORGANIC CARBON

Particulars regarding the organic carbon content of soil in ponds at Poyya and Chellanam are given in figure 16 and table 15.

POYYA

In pond 1, the organic carbon concentration in the soil was 3.18% during the zero week, which decreased to 2.39% and 2.86% in the 2nd and 4th weeks respectively. Later the value increased to 3.26% in the 6th week and to the highest value of 3.47% during the 10th week of culture.

In pond 2, the organic carbon content of 3.04% observed during the zero week was found increasing to 3.16% during the 2nd week. The value however decreased subsequently, reaching the lowest concentration of 2.78% during the 12th week. The highest concentration of 3.21% was recorded during the 10th week of culture.

In pond 3, the concentration was in the range of 3.01 and 3.51% throughout the period of culture without much flunctations.

CHELLANAM

In pond 4, the highest organic carbon content of 1.12% was recorded during the 4th week, while the lowest concentration of 0.45% was recorded in the zero week. During rest of the period, the organic carbon content varied between 0.56 and 0.97%.

In pond 5, the organic carbon concentration was 0.86, 0.91 and 0.96% during the zero,2 and 10th weeks respectively. The organic carbon content in the 4th, 6th and 8th weeks were 1.26, 1.37 and 1.10% respectively.

In pond 6, the lowest concentration of 0.80% was recorded in the 4th week. During the rest of the period, the organic carbon content was above 1% ranging between 1.06 and 1.31%.

The average organic carbon concentration was 3.04, 3.02, 3.33, 0.79, 1.08 and 1.13% in ponds 1, 2, 3, 4, 5 and 6 respectively. This indicates that organic carbon content in ponds at Poyya is much higher than that of the ponds at Chellanam.

Anova of organic carbon content in different ponds showed significant difference (P<0.01). Between the ponds, pairwise comparison showed that ponds at Poyya are significantly different from the ponds at Chellanam with regard to organic

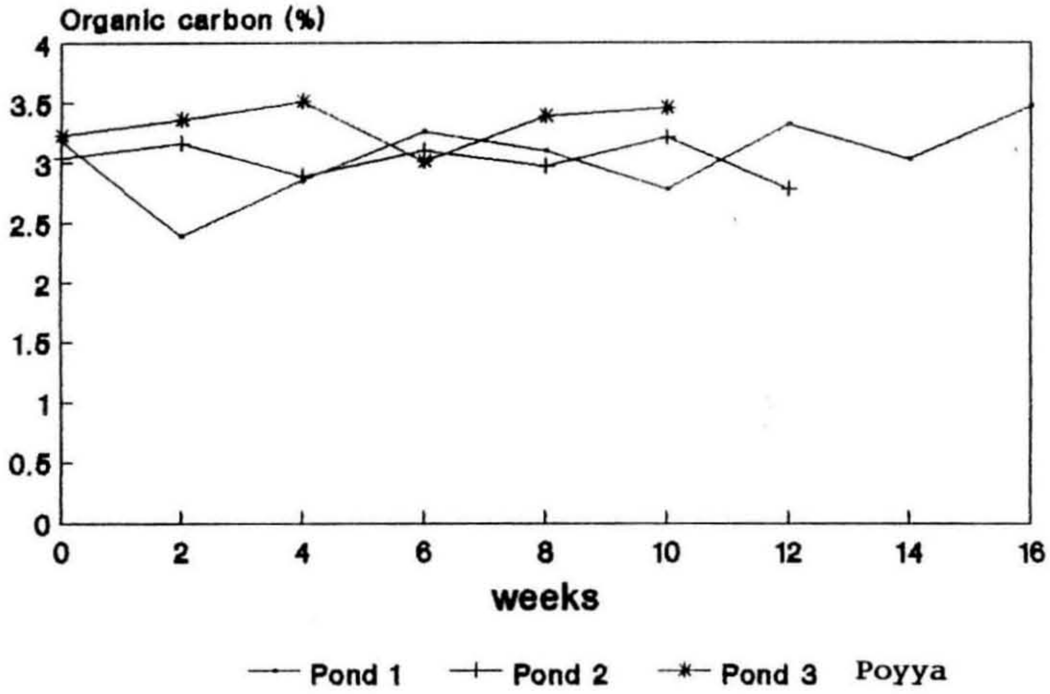
ORGANIC CARBON (%)

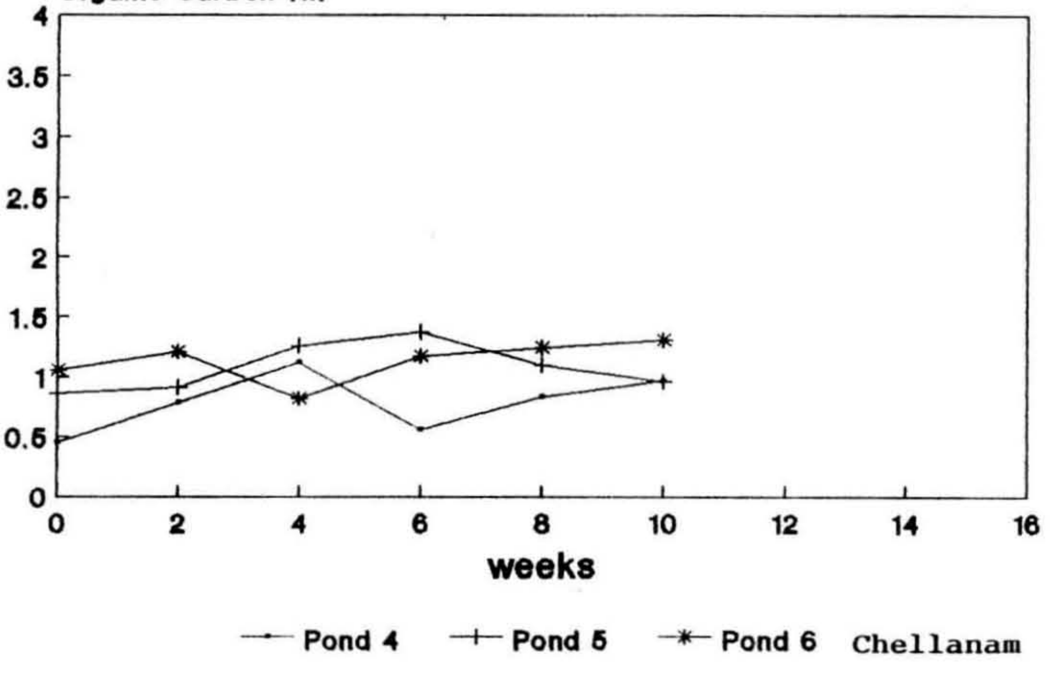
Location	Poyya			Chellanam		
Pond No. / Weeks	1	2	3	4	5	6
0	3.18	3.04	3.23	0.45	0.86	1.06
2	2.39	3.16	3.36	0.78	0.91	1.21
4	2.86	2.89	3.51	1.12	1.26	0.80
6	3.26	3.10	3.01	0.56	1.37	1.17
8	3.10	2.97	3.39	0.83	1.10	1.24
10	2.78	3.21	3.46	0.97	0.96	1.31
12	3.32	2.78				
14	3.03					
16	3.47					
Mean	3.04*A	3.02 A	3.33 A	0.79*B	1.08 B	1.13 B
Correlation r Value	0.543 NS	-0.283 NS	0.133 NS	0.420 NS	0.306 NS	0.468 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 15. Organic Carbon content recorded in ponds at Poyya and Chellanam.

Fig. 16 Organic Carbon recorded in different ponds at Poyya & Chellanam





carbon content but no significant difference is found to exist between the ponds of the same area. Correlation analysis showed no significant relationship in any pond between growth of prawns and organic carbon content.

3.2.3 GRAIN SIZE OF SEDIMENT

For grain size analysis, a total of eight soil samples were collected from different areas of each pond which were mixed together and a subsample was analysed.

In the department ponds 1 and 2 at Poyya, the soil sample contained 67.35% and 74.02% gravel. After separating the gravel, the remaining soil sample in pond 1 and 2 contained 41.35 and 36.38% sand, 29.74 and 29.08% silt and 28.91 and 34.54% clay respectively. In pond 3, the sand, silt and clay contents recorded were 32.87, 28.94 and 38.19% respectively.

The sand, silt and clay content recorded in pond 4 at Chellanam were 60.35, 20.21 and 19.44% respectivley. In pond 5, the corresponding values recorded were 60.78, 24.97 and 14.25% respectively. The composition of sand, silt and clay observed in pond 6 were 66.47, 21.52 and 12.01% respectively.

It may be noticed that, in pond soil at Poyya, the sand content was low (32.87 to 41.35%) when compared to that of the ponds at Chellanam (60.35 to 66.47%). Obviously, the silt

(28.94 to 29.74%) and clay content (28.91 to 38.19%) were high at Poyya and low at Chellanam (Silt 20.21 to 24.97%; clay 12.01 to 19.44%).

3.2.4 BENTHOS

The wet weight of macrobenthic community observed in various commercial ponds is illustrated in table 16 and figure 17.

POYYA

In pond 1 at Poyya, no macrobenthos was observed during the zero, 2, 4, 10, 12, 14 and 16th weeks. The macrobenthos concentration was 1.34 and 3.06 mg/M^2 in 6th and 8th weeks respectively.

In pond 2, macrobenthos was not observed, during the zero, 2, 6 and 8th weeks. The concentration observed was 2.01, 2.43 and 4.29 mg/M^2 during 4, 10 and 12th weeks respectively.

In pond 3, the concentrations recorded were 7.68 and 6.48 mg/M^2 in the 4 and 8th weeks, while during other weeks no benthos was observed.

CHELLANAM

Compared to the ponds at Poyya, the ponds at Chellanam were rich in benthos. In pond 4, the macrobenthos concentration observed was 5.19 mg/M^2 during the zero week. After recording the lowest value of 3.89 mg/M^2 during the 4th week, there was a sudden increase during the 6th week, the value being 12.86 mg/M^2. The values observed were 11.33 and 8.67 mg/M^2 during the 8th and 10th weeks respectively.

In pond 5, the concentration during the zero week was the highest being 18.63 mg/M^2. Later the value was found decreasing to 13.22 and 6.81 mg/M^2 during the 2nd and 4th weeks respectively. After showing an increase in 6th week to 14.60 mg/M^2, the concentration again was reduced to 10.24 mg/M^2 in 8th week and to 8.48 mg/M^2 in the 10th week.

In pond 6, also the highest concentration of 11.69 mg/M^2 was noticed during the zero week which gradually reduced to 10.39, 7.86 and 4.61 mg/M^2 during the weeks 2, 4 and 6 respectively. After an increase in concentration to 10.33 mg/M^2 in 8th week, the concentration again was reduced to 7.43 mg/M^2 in the 10th week.

The average concentration of benthos in ponds 1, 2, 3, 4, 5 and 6 was 0.49, 1.25, 2.36, 7.71, 12.00 and 8.72 mg/M^2 respectively.

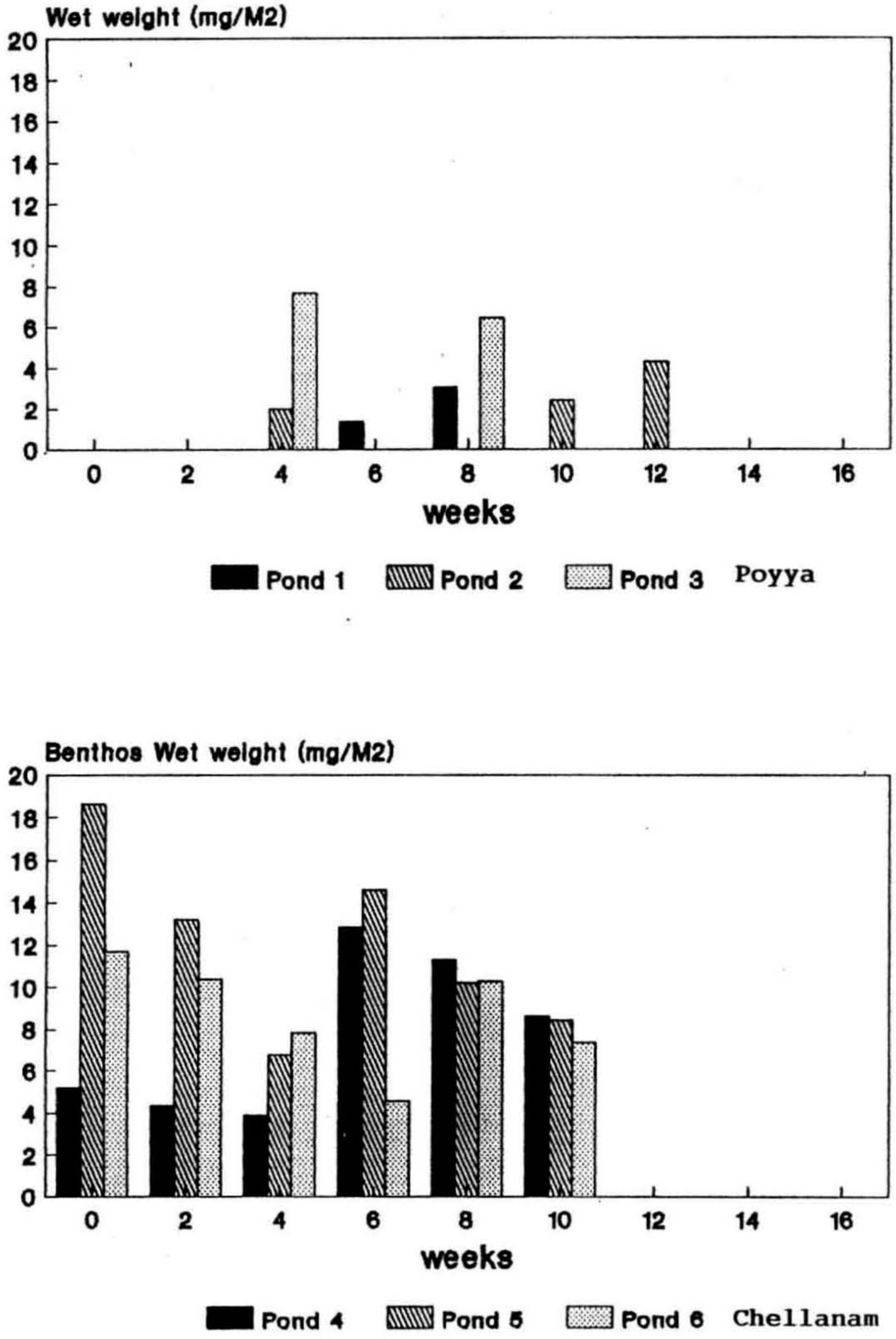
BENTHOS Wet Weight mg/m^2)

Location		Poyya			Chellanam	
Pond No. Weeks	1	2	3	4	5	6
0	0	0	0	5.19	18.63	11.69
2	0	0	0	4.34	13.22	10.39
4	0	2.01	7.68	3.89	6.81	7.86
6	1.34	0	0	12.86	14.60	4.61
8	3.06	0	6.48	11.33	10.24	10.33
10	0	2.43	0	8.67	8.48	7.43
12	0	4.29				
14	0					
16	0					
Mean	0.49*A	1.25 A	2.36*AC	7.71*BC	12.00 B	8.72 B
Correlation r Value	-0.187 NS	0.697 NS	0.259 NS	0.784 NS	-0.564 NS	-0.539 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Signficant

Table 16. Concentration of Benthos recorded in ponds at Poyya and Chellanam.

Fig. 17 Benthos concentration recorded in different ponds at Poyya & Chellanam



Anova of macrobenthos concentration at different ponds showed significant variation between 1 and 4, 1 and 5, 1 and 6, 2 and 4, 2 and 5, 2 and 6, 3 and 5 and 3 and 6. Analysis of correlation revealed that in no ponds, significant relationship existed between benthos concentration and the growth of prawns.

3.3 GROWTH RATE, SURVIVAL RATE AND PRODUCTION

The average weight (gm), growth rate (gm/day), survival rate (%) and production (kg) of prawns in different ponds are given in table 17, 18 and 19 and figure 18.

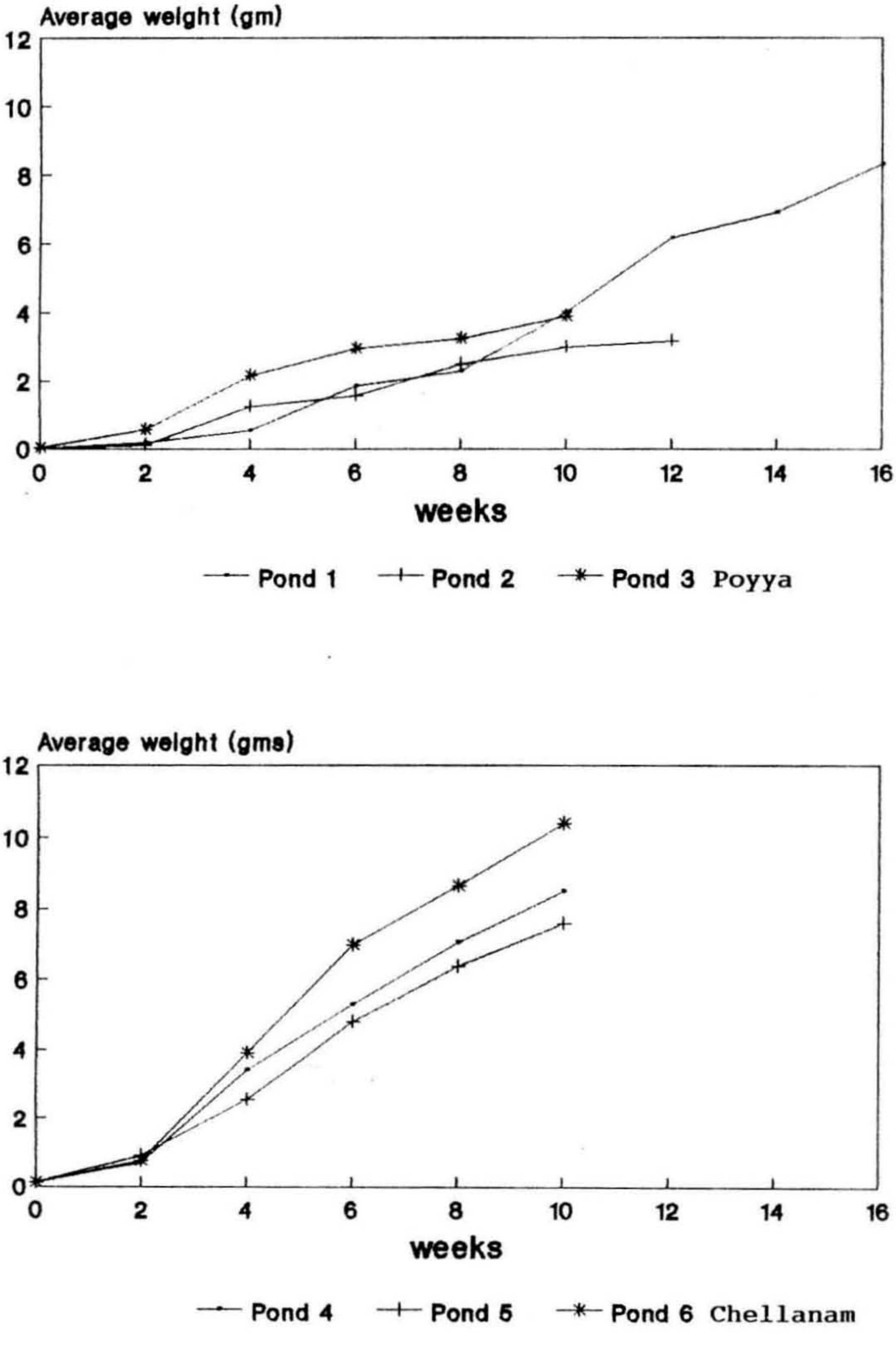
In pond 1, the average weight of the prawns at stocking was 0.006 gm which increased to 0.170 gm in the second week, registering a growth rate of 0.011 gm/day for the period zero to 2 weeks. With a growth rate of 0.026 gm/day, the prawns showed an increase in average weight to 0.540 gm in the 4th week. Thereafter with a gradual increase, the average weight reached to 6.178 gms in the 12th week. The highest average grwoth rate of 0.154 gm/day was recorded during the weeks 10 to 12. However during the next weeks of 12 to 14 and 14 to 16, the growth rate reduced to 0.053 and 0.99 gm/day. The average weight of prawn at harvesting was 8.338 gms.

AVERAGE WEIGHT OF PRAWNS (gms)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0	0.006	0.006	0.044	0.124	0.124	0.124
2	0.170	0.104	0.554	0.680	0.896	0.739
4	0.540	1.238	2.163	3.412	2.534	3.898
6	1.852	1.567	2.953	5.297	4.793	6.964
8	2.293	2.497	3.236	7.033	6.378	8.631
10	4.013	2.993	3.894	8.490	7.584	10.384
12	6.178	3.168				
14	6.942					
16	8.338					

Table 17. Average weight of Prawns recorded during different weeks in ponds at Poyya and Chellanam.

Fig. 18 Average weight of prawns recorded in different ponds at Poyya & Chellanam



GROWTH RATE (gm/day)

Location	Poyya			Chellanam		
Pond No. Weeks	1	2	3	4	5	6
0 - 2	0.011	0.007	0.036	0.039	0.05	0.043
2 - 4	0.026	0.081	0.114	0.195	0.117	0.225
4 - 6	0.093	0.023	0.056	0.134	0.161	0.219
6 - 8	0.031	0.066	0.020	0.124	0.113	0.119
8 - 10	0.122	0.035	0.047	0.104	0.086	0.125
10 - 12	0.154	0.012				
12 - 14	0.053					
14 - 16	0.099					
Mean	0.074 A	0.037 *A	0.055 A	0.119 B	0.106 *B	0.146 *B

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 18: Growth of prawns recorded in diffeent ponds at Poyya and Chellanam.

In pond 2 also, the average weight at stocking was 0.006 gms which increased to 0.104 gm (0.007 gm/day) and 1.238 gms (0.081 gm/day) during 2 and 4th weeks respectively. The average weight further increased to 2.497 and 2.993 gms with growth rate of 0.066 and 0.035 gms/day during 8 and 10th weeks respectively. The average weight at harvesting was very low, the value being 3.168 gms.

In pond 3, the average weight at stocking was 0.044 gm which increased to 0.554 gm in the 2nd week (0.036 gm/day). The growth rate further increased to 0.114 gm/day during 4th week and the corresponding average weight was 2.163 gms. The growth rate was again found to be decreasing to 0.056 gm/day during the period 4 to 6th weeks. The average weight at harvesting was 3.894 gms which was higher compared to that of 3.168 gm recorded in pond 2.

CHELLANAM

In all the ponds at Chellanam, the average weight at stocking was 0.124 gms which increased to 0.680, 0.896, and 0.739 gms during the 2nd week in ponds 4, 5 and 6 respectively. The corresponding growth rates were 0.039, 0.055 and 0.043 gm/day.

In pond 4, the average weight during the 4th week was 3.412 gms which increased to 5.297 gm during the 6th week. The average growth rates recorded were 0.195 and 0.134 gm/day in weeks 2 to 4 and 4 to 6 respectively, the former being the highest growth rate recorded in this pond. The average weight at harvesting was 8.490 gms and the growth rate recorded was 0.104 gm/day (8-10 weeks).

In pond 5, the average weight in the 4th week was 2.534 gms which increased to 4.793 and 6.378 gms during the weeks 6 and 8 respectively. The highest growth rate of 0.161 gm/day was recorded in 4 to 6th weeks period. The average weight at the time of harvesting was 7.584 gms.

In pond 6, the average weight obtained during the 4th week was 3.898 gms followed by 6.964 and 8.631 gms in 6 and 8th weeks (growth rate 0.219 and 0.119 gm/day) respectively. The average weight at harvesting was 10.384 gms which was the highest average weight recorded among all the ponds.

The prawns in all ponds at Chellanam were harvested in the 10th week and the average size of prawns was 8.490, 7.584 and 10.384 gms in ponds 4, 5 and 6 respectively. The average daily growth in ponds 1, 2, 3, 4, 5 and 6 were 0.074, 0.037, 0.055, 0.119, 0.106 and 0.146 gms/day respectively.

Pond No.	Area (ha)	stocking density No./ha	Days of culture	Survival rate %	Production Kg/pond	Production Kg/ha/90 days
1	0.4	2,19,000	128	10.09	73.74	129.62
2	0.2	2,33,000	95	26.08	38.51	182.43
3	0.7	2,14,000	77	37.13	216.92	362.20
4	0.5	1,41,900	76	72.29	435.50	1090.33
5	0.6	2,31,666	76	61.30	646.20	1376.34
6	0.8	1,03,000	76	79.79	682.79	981.28

Table 19: Area of pond, stocking density, survival rate and production recorded in different ponds at Poyya and Chellanam.

Table 20: Analysis of variance of various parameters recorded in Chapter I

				F Value	
Source	D.F.	S.S	M.SS	Calculated	Tabled
Temperature (table 1)					
Treatment	5	4.60	0.920	0.319	2.49
Error	34	98.05	2.883		
Total	39	102.65			
Salinity (table 2)					
Treatment	5	1501.83	300.36	13.247	3.61
Error	34	770.94	22.67		
Total	39	2272.77			
Dissolved oxygen (table 3)					
Treatment	5	20.32	4.06	8.875	3.61
Error	34	15.59	0.45		
Total	39	35.92			
pH (table 4)					
Treatment	5	8.44	1.68	21.379	3.61
Error	34	2.71	0.07		
Total	39	11.15			
Total Alkalinity (table 5)					
Treatment	5	27308.05	5461.61	11.117	3.61
Error	34	16703.05	491.26		
Total	39	44011.1			
Total Hardness (Table 6)					
Treatment	5	1136300	2272.60	3.605	2.49
Error	34	2142900	63026.47		
Total	39	3279200			

				F Value	
Source	D.F.	S.S.	M.SS	Calculated	Tabled
Nitrate (table 7)					
Treatment	5	0.0011	0.00022	6.875	3.61
Error	34	0.0011	0.000032		
Total	39	0.0022			
Phosphate (table 8)					
Treatment	5	0.007	0.0014	2.089	2.49
Error	34	0.023	0.00067		
Total	39	0.03			
Nitrite (table 9)					
Treatment	5	0.0003	0.00006	6.818	3.61
Error	34	0.0003	0.0000088		
Total	29	0.0006			
Ammonia (table 10)					
Treatment	5	0.08	0.016	5.161	3.61
Error	34	0.106	0.0031		
Total	39	0.186			
Primary Productivity (table 11)					
Treatment	5	1040060	208012	10.185	3.61
Error	34	694360	20422		
Total	39	1734420			
Phytoplankton (table 12)					
Treatment	5	46.59	9.318	24.65	3.61
Error	34	12.87	0.378		
Total	39	59.46			

				F Value	
Source	D.F.	S.S.	M.SS	Calculated	Tabled
Zooplankton (table 13)					
Treatment	5	18. 65	3.73	20.726	3.61
Error	34	6.12	0.180		
Total	39	24.77			
Soil pH (table 14)					
Treatment	5	5.79	1.159	10.348	3.61
Error	34	3.81	0.112		
Total	39	9.61			
Organic Carbon (table 15)					
Treatment	5	45.10	9.021	166.74	3.61
Error	34	1.84	0.054		
Total	39	46.94			
Benthos (table 16)					
Treatment	5	744.78	148.95	17.155	3.61
Error	34	295.23	8.68		
Total	39	1040.01			
Growth rate (table 18)					
Treatment	5	0.046	0.0092	3.68	2.56
Error	28	0.07	0.0025		
Total	33	0.116			

....

Anova of daily growth rate in different ponds showed significant difference $(P<0.05)$. Pairwise comparison showed significant difference in average daily growth rate between ponds of Poyya and Chellanam.

Between the ponds of the two regions, the survival rate of prawns in ponds at Poyya ranging 10.09 and 37.13% was very low when compared with the survival rate of 61.30 to 79.79% recorded in ponds at Poyya. Corresponding to the low survival rate, the quantity of prawns harvested was also low in ponds at Poyya. For comparison, the quantity harvested in each pond was computed for 90 days culture per hectare, eventhough the culture period was different in various ponds. The estimated quantity harvested in ponds 1, 2 and 3 at Poyya was 129.62, 182.43 and 362.20 kg/ha/90 days respectively. On the other hand, in ponds 4, 5 and 6 at Chellanam, the quantity harvested was 1090.33, 1376.34 and 981.28 kg/ha/90 days. These data indicate that ponds at Chellanam are more productive than the ponds at Poyya.

4. DISCUSSION

Prawns form a prominent export commodity among marine products. Due to very high export demand, prawn farming has been undertaken on a war footing in India. Prawns are primarily grown in brackishwater areas and the medium of brackishwater is characterised by frequent changes in environmental parameters. Prawns appear to have a wide range of environmental requirements and a thorough understanding of the same is an essential prerequisite for locating designing and managing prawn farms successfully.

Environmental parameters include water quality, soil quality and biological characteristics of which water quality is of prime importance. A chinese proverb in aquaculture states "Cultivating water is a must for aquaculture" which emphasizes the importance of water quality management in aquaculture. A sufficient quantity of good quality brackishwater is essential for any aquaculture operation. The factors controlling the composition of pond water are extremely varied and they include physical, chemical and biological processes. To keep water properties within safe levels, one must understand those processes so that the elements inhibiting prawn growth and survival can be detected and their impact minimized. The practice of semi-intensive and intensive culture systems usually results in pollution of the culture water from uneaten food and waste products of cultured organisms. Therefore, water quality management is one of the most important culture practices, especially in semi-intensive and intensive culture systems.

Water quality parameters which require judicious management include temperature, salinity, disolved oxygen, pH, alkalinity, hardness, nutrients and productivity.

Temperature is considered to be the most important parameter influencing the various hydrobiological parameters in an ecosystem. In commercial farms at Poyya, in the present study, temperature varied widely between 26.52° and 32.17°C because of extended culture period during the summer from January to April. On the other hand, ponds at Chellanam recorded a narrow range of temperature varying between 26.82° and 29.57°C which may be because of the short duration of culture during January - March which does not cover the entire summer season. Eventhough the range is different in ponds at Poyya and Chellanam, there exists no significant difference in temperature between the ponds statistically. An evaluation of the influence of temperature on the growth of prawns showed that there exists a positive relationship between the two in all the ponds except in pond 3 at Poyya. According to Cruz, (1991), temperature is considered to have a governing effect on the apetite of shrimps. Shrimps are poikilotherms and hence are greatly influenced by the ambient temperature. Similar observations establishing the influence of temperature on the growth of shrimp are also made by Zein-Eldin and Griffith, (1969); Liao, (1969); Venkataramaiah <u>et al</u>., (1974) and

Farmanfarmaian and Moore, (1978). In pond 3 at Poyya, the non significant effect of temperature on the growth of prawns may be due to the comparatively low productivity.

Aquacop (1984) has reported that the optimum temperature for the growth of shrimp P. indicus and P. monodon are 22 to 33°C and 24 to 34°C respectively. According to Padlan (1990), the desirable temperature range suitable for the growth of P. monodon is 28 to 33°C. It may be therefore surmised that the temperature range of 26.52° to 32.17°C observed in the ponds at Poyya and Chellanam in the present case is ideal for the growth of

Salinity is the master environmental factor affecting the physiological mechanisms of estuarine organisms (Kinne, 1966). The average salinity in ponds at Poyya ranged between 28.30 and 31.57 ppt. Analysis of variance showed no significant difference in salinity between different ponds at Poyya. Likewise, the average salinity in ponds at Chellanam narrowly ranged between 16.94 and 19.29 ppt and hence there was no significant difference in salinity among the ponds.

Nevertheless, between the ponds at Poyya and Chellanam, the average salinity level at Poyya was found to be at a higher level of above 28.30 ppt which may be due to the proximity of the region to the barmouth when compared to the ponds at

Chellanam situated away from the barmouth where the average salinity was less than 19.29 ppt. Gopinathan et al., (1982) also reported higher salinity in ponds at the northern end of Cochin backwater which also includes Poyya. Since there was significant difference in salinity, ponds at Poyya and Chellanam may be considered as belonging to two different salinity regimes. Notwithstanding the above fact, low salinity observed during some weeks at Poyya may be owing to the dilution of salinity with rain water.

According to Muthu (1980), the salinity ideal for the growth of P. indicus is 10 to 35 ppt. Since the same species was used in the present study, the salinity values ranging between 12.86 and 35.39 ppt and 10.13 and 22.52 ppt recorded in ponds at Poyya and Chellanam respectively may be considered as optimum for their growth.

Dissolved oxygen concentration in brackishwater ponds is very important both as a regulator of metabolic process of plants and animals and as an indicator of condition of water. Low dissolved oxygen is one of the most common causes of reduced growth and survival of prawns. According to Suseelan (1978), Liao and Murai (1986) and Courtney (1989), the favourable dissolved oxygen concentration for the growth of prawns is above 3 to 4 ppm. The dissolved oxygen values of

4.45 to 7.79 ppm in ponds at Poyya and 3.93 to 6.27 ppm in ponds at Chellanam in the present study also lie within the optimum range reported by the above said authors.

Nevertheless, a comparison of dissolved oxygen content between the ponds at Poyya and Chellanam showed slightly higher values in ponds at Poyya. This may be on account of the mode of exchange of water exclusively by pumping resulting in thorough agitation in ponds at Poyya in contrast to the water exchange both by pumping and tidal exchange in ponds at Chellanam.

pH of water is a significant parameter influencing the concentration of various compounds in water and also the different physiological functions in the body of aquatic organisms. The pH in a water body can be influenced by various factors such as alkalinity, salinity, temperature and organic matter content. In the present study, it is noticable that in ponds at Poyya which are situated nearer to the sea, pH values were generally less than 7.5 with a range of 6.65 to 7.76. At Chellanam on the other hand, the pH was generally higher than 7.5 ranging between 7.24 and 8.47, thereby showing that the ponds at Poyya and Chellanam belong to two different ecological systems with respect to pH.

A pH range of 7.5 to 8.5 is reported to be ideal for the farming of penaeid prawns (Muthu, 1980). However according to

Chiang et al., (1989), the ideal pH range for culture of prawn is 7.5 to 9.0. In the present study, it is noticable that in ponds at Poyya, pH values were generally less than 7.5. On the other hand, in ponds at Chellanam pH was mostly above 7.5, which shows that ponds at Chellanam are more suitable for prawn farming.

It is an established fact that the pH of water is a manifestation of soil pH (Unnithan, 1985). An evaluation of the soil pH in the present case also shows lower pH as in water at Poyya thereby substantiating that the soil pH can be one of the factors influencing the water pH. It may also be observed that eventhough ponds at Poyya are nearer to the sea, the expected high pH is not recorded, probably because of the leaching effect of the organic residues, an observation made also by Gopinathan et al., (1982) and Gopalan et al., (1983) in the same area. Boyd (1992), also found that the pH of water can be reduced to low values because of the leaching of acid causing material from organic residues.

The pH observed in the present study varied very little and ranged between 6.65 and 7.76 in ponds at Poyya and 7.24 an 8.47 in ponds at Chellanam. A narrow pH range in shrimp ponds was also reported by Chakraborti et al., (1985 and 1986) and

Cheng and Chen (1990). This may be on account of the buffering action of estuarine water as has been also described by Reid and Wood (1976).

Total alkalinity provides carbon dioxide, a vital compound for photosynthesis in aquatic systems (Unnithan, 1985). Boyd (1982) reported that the alkalinity and pH in water are interrelated. This is clearly demonstrated in the present context also. As seen in fig. 5 and 6, in pond 1 at Poyya, when alkalinity decreased to 70.00 ppm during the 2nd week from 147.52 ppm in the zero week, pH also decreased to 7.11 in the 2nd week from 7.71 ppm in the zero week. Again, when the alkalinity increased to 140.24 ppm, pH also increased to 7.70 in the 8th week. Further, the low alkaline values recorded in the present study at Poyya in comparison with that at Chellanam may be owing to the low pH in water that prevailed in ponds at Poyya.

While evaluating the productivity factors in some brackishwater ponds, Mathews (1992) recorded low alkalinity values of 22.5 to 45 ppm and 54 to 111 ppm in ponds at Chittoor and Narackal respectively. On the other hand, Chakraborti et al., (1985) and Chakraborti and Das (1988) reported alkalinity values ranging between 58 to 172 ppm and 89 to 153 ppm respectively in brackishwater ponds at Kakdwip. The recorded alkalinity values of 50.01 ppm and 147.52 ppm in ponds at Poyya and 122.61 ppm and 190.69 ppm in ponds at Chellanam in the present study are in agreement with the observations made at Kakdwip.

In general, fish farms with alkalinities of more than 50 ppm are reported to be most productive, while waters with less than 10 ppm rarely produce large crops, and water intermediate between these groups may produce useful results (Banerjea, 1967). Based on this, the ponds at Poyya and Chellanam with alkalinity values of 50.01 to 147.52 and 122.61 to 190.69 ppm respectively can be considered as most productive. However, between the ponds at Poyya and Chellanam, the alkalinity values at Poyya are comparatively low in accordance with low pH values observed in these ponds.

Gopinathan et al., (1982) reported that the nitrate concentration in brackishwater ponds near to Cochin estuarine system widely ranged between 0.003 and 0.069 ppm with moderate or high values in the middle region and low values at both southern and northern regions of the estuary. Similar observation was also made by Gopalakrishnan et al., (1988), who reported higher nitrate concentration (0.038 - 0.160 ppm) in ponds at the middle region and low concentration (0.005 - 0.062 ppm) in ponds at the northern end of Cochin estuarine system.

Devapiriyan (1990) and Mathews (1992) have also observed higher concentrations of nitrates (0.067 - 0.186 and 0.002 - 0.032 ppm) in brackishwater fields at Vypeen Island situated in the middle region of the estuary. However in the present study lower values (0.002 to 0.019 ppm) were obtained in the middle region (Chellanam) and higher values (0.004 - 0.038 ppm) in the northern region (Poyya) of the Cochin estuarine system. This difference may be due to the variations in sampling time, season and addition of fertilizers and manures (Boyd, 1982).

A scrutiny of the nitrate concentration in different ponds at Poyya and Chellanam showed that the values fluctate widely during the culture period. Such wider variation may be on account of the biological utilization (Upadhayay, 1988) and regeneration from bottom sediment (Mollah, et al., 1979).

According to Seymour (1980), the increasing natural level of nutrients especially phosphorus is essential for activating trophic chains. Orthophosphate is a limiting factor in aquatic systems influencing the algal growth (Heath et al., 1980). In brackishwater ponds near to Cochin backwaters, Gopalakrishnan et al., (1988), Devapiriyan (1990) and Mathews (1992) reported phosphate concentration of 0.005 to 0.160, 0.042 to 0.159 ppm and 0.004 to 0.144 ppm respectively. In comparison to their observation, the phosphate concentration of 0.043 to 0.097 and 0.040 to 0.179 ppm recorded in ponds at Poyya and Chellanam respectively in the present study are less. This may be on account of the variations in the utilization (Nair et al., 1988; Upadhayay, 1988).

A minimum of 0.2 ppm phosphate is considered to be the concentration required for high aquatic productivity (Eren et al., 1977). Based on this, the phosphate concentration 0.040 to 0.179 ppm observed in the present study may be considered as deficient for high aquatic productivity. However, between the ponds at Poyya and Chellanam, the latter showed comparatively high phosphate values especially towards the end of culture period, which may be due to the entry of water with high phosphate concentration released from the nearby agricultural fields (Nair et al., 1988).

While investigating the ecological parameters of brackishwater ponds near to Cochin estuarine system, Gopinathan et al., (1982) recorded nitrite concentration of 0.003 to 0.015 ppm. In the same area, Devapiriyan (1990) recorded slightly higher nitrite concentration of 0.010 to 0.033 ppm. The average nitrite concentration of 0.001 to 0.007 ppm in ponds at Poyya and 0.002 to 0.003 ppm in ponds at Chellanam obtained in the present study was low compared to the concentrations obtained by the above authors.

An upper limit of 0.180 ppm nitrite nitrogen was recommended as the safe level for the growth of P. indicus (Jayasankar and muthu, 1983). On the other hand, Law (1988) reported a high nitrite concentration of 1.28 ppm as the safe level for the growth of P. monodon. The concentration of nitrite obtained in the present study is thus well below the critical concentration with minimum effect on the growth of prawns.

Ammonia is widely recognised as a common pollutant in aquatic environment and is the principal end product of protein catabolism in crustaceans. Ammonia accounts for 40 to 90% of nitrogenous excretion (Hartenstein, 1970; Kinne, 1976; Claybrook, 1983). Nair et al., (1988), Devapiriyan (1990) and Mathews (1992) reported a value of 0.007 to 0.035, 0.034 to 0.230, and 0.027 to 1.275 respectively as the concentration of the ammonia in some brackishwater ponds near Cochin estuarine system. In the present case, an average ammonia concentration of 0.061 - 0.179 and 0.037 - 0.086 ppm was observed in ponds at Poyya and Chellanam respectively.

Significantly high values of ammonia concentration observed in pond 3 (0.084 - 0.245 ppm) in the present study at Poyya may be either because of low phytoplankton concentration with lesser utilisation of ammonia as a source of nitrogen (Tsai, 1989) or because of feeding the prawns with slaughter house waste which may release ammonia during degradation process. Concurrently, the lower average concentration of 0.037 and 0.044 ppm in ponds 4 and 6 at Chellanam and 0.061 ppm in pond 1 at Poyya may be owing to the high phytoplankton concentration. Likewise, the comparatively high concentration of ammonia in pond 5 at Chellanam may be because of high stocking density of 2,50,000 prawns per hectare.

A safer concentration of total ammonia of 3.51, 3.7, 3.2 and 4.03 ppm was reported for the growth of juveniles of P. chinensis, P. monodon, P. penicillatus and P. japonicus by Chen et al., (1990), Chen and Lei (1990), Chen and Lin, (1991) and Kuo and Chen (1991) respectively. In the present investigation, the concentration of total ammonia observed in ponds at Poyya and Chellanam is within the range of 0 and 0.245 ppm, which is thus within the safer limit required for the growth of prawns.

The carrying capacity of any culture pond depends mainly on the primary productivity. Aquacop (1984) has emphasized that natural productivity should be considered as an important factor for the growth and survival of prawns. In shrimp ponds off Cochin estuarine system, a gross primary productivity ranging between 35 to 369, 200 to 659 and 25 to 637 $mgC/M^3/hr$ were reported by Gopinathan et al., (1982), Devapiriyan (1990) and Mathews (1992) respectively. In the present study, the average values of 209.67 to 430.61 and 232.77 to 667.52 mgC/M^3/hr recorded in ponds at Poyya and Chellanam respectively conform to the productivity values reported by the above mentioned authors.

The data on primary productivity showed higher vlaues in ponds at Chellanam compared to those at Poyya which indicates that the ponds at Chellanam are more productive and suitable for shrimp farming which may be on account of higher pH and alkalinity and lower hardness.

The role of nutrients in the productivity of a pond is a matter of interest. According to Thomas (1966), Collier (1970) and Vince and Valiela (1973), nitrogen is a limiting factor, while according to Cole (1975), Chattopadhyay (1980) and Mandal (1980), phosphate restricts the productivity of brackishwater ponds. Boyd (1986) states that both nitrogen and phosphorus have a significant relationship with phytoplankton production, while according to Lanari <u>et</u> <u>al</u>., (1987), there exists no relationship between nutrient concentration and plankton biomass. In the present study, significantly high phytoplankton content of 2.11 ml/M^3/hr and high productivity of 430.61 mgC/M^3/hr were observed in pond 1 at Poyya along with high average concentration of 0.022 ppm nitrate and 0.061 ppm phosphate. Likewise in pond 3, at Poyya, low phytoplankton (0.84 ml/M^3) was noticed with low concentration of nitrate (0.008 ppm) and phosphate (0.048 ppm) thereby showing that there exists a significant relationship between nutrients such as nitrate and phosphate and phytoplankton production as has also been observed by Gopalakrishnan et al., (1988) and Nair et al., (1988).

Nevertheless, in pond 5 at Chellanam, a low phytoplankton concentration of 1.08 ml/m^3 was noticable in spite of a higher concentration of 0.012 ppm nitrate and 0.092 ppm phosphate. This may be due to the high stocking density in this pond, where the prawns would have indirectly utilized phytoplankton especially diatoms which increase the apetite of prawns (Wyban et al., 1989).

Eventhough prawns are not stated to be phytophagous in habit, phytoplankton is of importance to them in as much as they are the primary producers in an aquatic ecosystem. Aquacop (1984) and Shigueno (1985) have also opined that prawns grow well in ponds with pytoplankton dominance. In the present context also, significant relationship was observed between growth of prawns and phytoplankton concentration especially in pond 2 at Poyya and ponds 5 and 6 at Chellanam. Likewise, primary productivity also evinced positive correlation with growth of prawns in ponds 2 and 3 at Poyya and 5 and 6 at Chellanam (Table 11).

Although the interaction between plant and animal population is difficult to elucidate, the grazing rate of herbivorus zooplankton is certainly one of the factors which regulates the standing stock of phytoplankton and therefore influences the production rate. In almost all the aquatic ecosystems, zooplankton plays an important role in the transfer of energy at the secondary trophic level.

The zooplankton concentration in the present investigation, was found to be comparatively low in pond 3 at Poyya and pond 5 at Chellanam. While the significantly low average zooplankton content of 0.30 ml/m^3 in pond 3 may probably be due to the low primary productivity and phytoplankton content, the relatively low zooplankton concentration in pond 5 may be on account of higher consumption rate of zooplankton by the prawns which were stocked at a higher density. Likewise, the general reduction of zooplankton observed towards the end of experiment in many ponds may be because of increased consumption of zooplankton by the prawns. In most of the ponds in the present study a relationship between phytoplankton and zooplankton was also observed thereby indicating a direct relationship between primary and secondary production (Rubright <u>et al</u>., 1981).

Soil plays a major role in determining the production of animals present in that system. Pond sediment significantly influences the balance of aquacultural systems, acts as a buffer against variation in pH and provides water with nutrients. Inadequate pond bottom condition is one of the most critical problems currently facing shrimp growers. Even when ponds are well managed, heavy organic matter inputs such as feed, fertilizers and plankton associated with the large biomasses maintained in semi intensive and intensive shrimp ponds can result in accumulations of anaerobic reduced materials on the pond bottom.

pH is the most important soil quality parameter influencing the release of nutrients to water body and decomposition rate of organic matter. Gopinathan _et_ _al_., (1982) reported a wide range soil pH of 3.5 to 7.0 with low values recorded at southern and northern parts and higher values in the middle region of the Cochin estuarine system. The low pH areas at northern and southern end are characterised by weed deposites. The comparatively high soil pH of 6.50 to 7.90 in ponds at Chellanam in the present study agrees with the above view since Chellanam lies in the middle of the estuary and therefore may be considered more suitable for prawn farming. Since Poyya is situated at the northern end, the low pH values (5.61 to 7.43) recorded in the present experiment is in agreement with the observation made by Gopinathan _et_ _al_., (1982). Further acidic conditions of soil are unfavourable for successful prawn farming, since the same impede organic matter decomposition and recycling of nutrient which in turn decreases the availability of phosphorus and has direct inhibitory effects on benthos and shrimps (Boyd, 1992).

In ponds at Poyya, while the soil pH was comparatively low during the initial weeks, there was an increase in pH towards the end of the culture period. On the other hand, in ponds at Chellanam, the higher soil pH during the initial weeks showed a reduction during later half of the experiment. These observations are in accordance with that of Mandal (1980), who reported that the pH of slightly acidic soils increases and that of alkaline soils decreases during a culture period.

According to Gopinathan <u>et</u> <u>al</u>., (1982), Ramesan (1990) and Mathews (1992), the organic carbon content in some of the ponds nearer to the Cochin estuarine system ranged between 0.5 and 4.5, 0.39 and 2.92 and 2.41 and 3.79% respectively. On the other hand, Eswaraprasad (1982) and Nasser (1986) recorded comparatively higher values of 1.12 to 6.48 and 2.47 to 8.85% respectively in some of the ponds of the same area. The average organic carbon content observed in the ponds under study at Poyya and Chellanam ranged between 3.02 to 3.33% and 0.79 to 1.13% respectively, thereby showing that the values were higher at Poyya.Gopinathan et al., (1982) have reported that the area in and around Poyya had dense mangroove vegetation in the ancient times. Therefore it may be concluded that the higher organic carbon content in these ponds may be on account of the weed deposits probably caused by the submersion of mangrooves, as has also been reported by Gopalan et al., (1983). A comparison of the grain size composition of ponds at Poyya and Chellanam with the respective organic carbon content indicates that, ponds at Poyya had higher organic carbon content coupled with higher silt (28.94 to 29.74%) and clay content (28.91 to 38.19%). Here it may be added that, in the present study, the grain size analysis was conducted in ponds 1 and 2 after segregating the gravel which formed 67.35% to 74.02%. This probably points to more of a gravelly substratum not condusive for the growth of benthos and prawns.

Since prawns feed in the benthic region, benthos is a major component in the food of prawns. The abundance and distribution of benthos in brackishwater environment is governed by factors such as temperature, salinity, dissolved oxygen, organic matter content and texture of soil. According to Datta and Sarangi (1986), Polychaete dominate in areas of relatively high salinity and low organic matter whereas amphipods and tanaids are found more frequently in low saline zones having higher organic matter content. A positive correlation of organic carbon with faunal abundance was observed by Bader (1954), Sanders (1956), Damodaran (1973) and Harkantra et al., (1980). However, higher organic carbon content of above 3 to 6% may actually decrease the benthos, probably caused by the decomposition of organic matter leading to the decline in available oxygen. (Bader, 1954; Sanders, 1956; Srinivasan, 1982). According to Desai and Krishnankutty (1969), medium sand and small amount of silt and clay are suited for the abundance of benthos. Panikkar and Aiyer (1937) observed absence of bottom animals in substratum of thick clay and their great abundance in loose substratum. According to Rao and Murthy (1988), clayey - silt and fine sand with detritus are suitable for benthos colonization.

The average benthos concentration in pond 1 and 2 at Poyya was found to be comparatively very low. A detailed investigation of the grain size analysis of ponds 1 and 2 showed higher content of gravel. The reason for this may be attributed to the addition of soil containing large gravels from other areas known to have basic pH into the ponds at Poyya to correct the lower pH. The sediment with more gravel content is not a favoured substratum for the growth of benthos (Rao and Murthy, 1988; Aravindakshan et al., 1992). This coupled with reduced soil pH might have lead to the reduction in the benthos concentration in these ponds. The statement of

Boyd (1992) that lower pH in soil can reduce the benthos concentration holds good in this context.

The average benthos content observed in the present study was 0.49 - 2.36 mg in ponds at Poyya and 7.71 to 12.00 mg/m^2 at Chellanam. On the other hand, Gopalakrishnan et al., (1988) observed very high benthos content of 31.2 - 83.2 mg/m^2 in brackishwater ponds of the same area, which may be on account of the presence of bivalves and gastropods having more shell weight compared to the absence of such organisms in the present study.

In pond 5 at Chellanam, the benthos content of 18.63 mg/m^2 was drastically reduced to 8.48 mg/m^2 during the last week. Such drastic reduction from zero week was not observed in any other pond. This may be because of more prawns stocked per unit area in pond 5 which might have consumed the benthos, an observation which is also made by virnstein (1977), Rubright et al., (1981), Commito (1982), Gopalakrishnan et al., (1988) Rajyalakshmi et al., (1988) and Ordner et al., (1990). In other ponds at Chellanam also, the benthos concentration decreased during the last weeks of culture. According to Rubright et al., (1981), populations of benthic polychaetes, copepods and nematodes in a shrimp pond diminished to very low densities after 50th day of culture, probably because of grazing by shrimp. Similar observation was also made by Rajyalakshmi et al., (1988), who while conducting ecological studies of prawn farms nearer to Chilka lake found an average benthos content of 775 numbers/m^2 in ponds not stocked with prawns, compared to the nil to 25 numbers/m^2 in stocked ponds.

In the present investigation, lower survival rates of the stocked prawns ranging from 10.09 to 37.13% was noticed in ponds at Poyya, when compared to the higher survival rates ranging from 61.30 to 79.79% in ponds at Chellanam. The lowest survival rate of 10.09% in pond 1 at Poyya may be on account of prolonged culture period of 128 days compared to the lesser period of 95 and 77 days in 2nd and 3rd ponds respectively. The average growth rate of prawns was also low in ponds at Poyya (0.0037 to 0.074 gm/day) when compared to the ponds at Chellanam (0.016 to 0.146 gm/day). Simultaneous with lower survival rate and growth rate, low average weight of the cultured animals at harvest was also found in ponds at Poyya. The reason for the low survival rate coupled with low average weight may be attributed to the various ecological parameters such as low water pH, soil pH, alkalinity, and benthos content and high salinity, hardness, ammonia and nitrite concentrations in ponds at Poyya.

While ponds nearer to the barmouth are influenced to a great extent by the tidal exchange resulting in increased salinity and dissolved oxygen, ponds away from barmouth are not highly influenced by the tidal action. In the present investigation, the ponds at Poyya are lying adjacent to the barmouth and is towards the north, while those at Chellanam are away from the barmouth situated in the middle of the Cochin estuarine system. Based on the various environmental parameters studied, it is discernible that the ponds at Poyya though with higher salinity and dissolved oxygen, have lower range of water pH, soil pH, alkalinity and benthos content and higher total hardness and gravel content. It is probable that the presence of weed deposites underneath the pond bottom has led to reduced water pH, soil pH, alkalinity and benthos content. Introduction of soil having high gravel content to the bottom of ponds at Poyya also might have caused for the low benthos production. On the other hand, ponds at Chellanam indicated more favourable environmental conditions such as moderate salinity, water pH, soil pH, alkalinity, hardness, nitrite and ammonia.

The prodctivity of shrimp farms has a significant role in augmenting the production of a quality shrimp and is a subject to be studied with top priority. The facts that marine landings of penaeid prawns is at a stagnating level and that there is great demand for quality shrimp necessitate the investigations on the productivity of available farms. However, the productivity of vast areas of shrimp farms is not studied in relation to their ecological conditions. It is therefore felt that studies in this line if taken up can fill the gap in the knowledge of the positive and negative aspects of ecology and productivity of farms, so that necessary improvements in terms of fertilization, liming, aeration and other managerial measures can be resorted to in lesser productive semi intensive shrimp farms. This in the long run will enable the shrimp farmers in boosting up shrimp production.

C H A P T E R II

INFLUENCE OF ORGANIC MANURES ON THE ECOLOGY AND PRODUCTIVITY OF BRACKISHWATER PRAWN FARMS

I. INTRODUCTION

Successful pond culture operations depend primarily on the maintenance of a healthy aquatic environment and the production of sufficient fish food organisms. Of the primary factors limiting the productivity of a water body, the most important is the quantity of available nutrients, which form basic materials for the growth and survival of living organisms. Fertilization techniques promote supply of these nutrients in optimal quantities thereby overcoming natural deficiencies. Nutrient enrchment also enables making up or providing the essentially needed nutrients for the production of aquatic biota, which serve either directly or indirectly as the food of prawns. The natural productivity of a pond can thus be greatly enhanced by using fertilizers, so that the maximum possible yield can be obtained from a water body.

Fertilization in shrimp farms involves the use of both inorganic and organic fertilizers. The important inorganic fertilizers used are urea, ammonium nitrate, ammonium sulphate, single superphosphate and triple superphosphate, while the organic manures in common use are cowdung, poultry dropping and piggery waste.

Inorganic fertilizers, eventhough are refined with known concentration of nutrients are disadvantageous over organic fertilizers in several ways. According to Hepher (1962) increasing the rate of chemical fertilization beyond certain levels does not result in increased primary production. Self shielding by dense crops of phytoplankton limits sunlight penetration into the water and with development of sufficiently dense surface layer of plankton, primary productivity may actually decrease with increased chemical fertilization.

Organic manuring, on the other hand, though of varying nutrients concentration, are of manifold advantages. First and foremost attraction of organic manure is that it directly leads to heterotrophic production like zooplankton, benthos and associated biota which is not directly light dependent.

In any successful shrimp farming system, cost of feed amounts to half of the total cost (Schroeder, 1978; wohlfarth and Hulata, 1987). Manure in addition to enhancing productivity can also act as feed in culture system (Tang, 1970; Wohlfarth and Schroeder 1979; Banerjea, 1980; Clifford, 1992). According to Schroeder (1978) and Wohlfarth and Hulata (1987), the low cost of manure can drastically reduce the feed cost.

Organic manures also lead to detritus formation which acts as a substrate for microbial development (Sharma, 1981;

Clifford, 1992). Detritus loaded with microorganisms is nutritionally considered to be a good feed (Kumari et al., 1978; Qasim and Easterson, 1974) especially for detritus feeding organisms like prawns (Hall, 1962; Thomas, 1972; Marte, 1980). Further, the organic fertilizers can also enhance the growth of benthic algae and its associated biota (Primavera and Apud, 1976).

Culture of prawns with fertilization has been widely employed in extensive and semi intensive shrimp production (Hanson and Goodwin, 1977; Perrot, 1979; Wyban et al., 1987). Organic manuring in pond aquaculture is a practise that enhances shrimp performance and natural pond productivity. (Schroeder, 1978; Farness and Aldrich, 1979; Stickney, 1979; Rubright et al., 1981; Geiger, 1983; Perschbacher and Strawn, 1984; Garson et al., 1986).

According to Schroeder et al., (1990), the use of organic manure in ponds is based on the assumption that the organic matter of the manure provides a source of reduced carbon for heterotrophic grazing while the mineral fraction of the manure is used by both autotrophs and microbial heterotrophs (Werner and Hall, 1976; Buck et al., 1978; Bowen; 1981; Wohlfarth et al., 1985; Edwards, 1987; Green et al., 1989). Well decomposed organic matter though transforms at a slower rate in brackishwater than in freshwater, mitigates the harmful effects of salinity, reduces the leaching loss of nutrients from the water body during water exchange and develops a debris (grazing) bed at the bottom.

Growth and survival which together determine the ultimate yield are influenced by a number of ecological parameters and managerial measures. In ponds, favourable ecological parameters are to be maintained for the high growth and survival of prawns. Even slight variation in ecological parameters can cause stress to the prawns and ultimately decrease the growth and survival of prawns.

Organic manure application can change many ecological parameters, while some ecological parameters are also found influencing the behaviour and decomposition of organic manure. Amoung various parameters affecting the mineralisation rate of organic manure, water temperature is the most important one. Water temperature is dependent on the local climatic conditions. According to Boyd (1992), water temperature of 25° to 35°C is ideal for organic matter decomposition as microorganisms usually grow best at this temperature range.

Variations in salinity also affects the mineralisation rate of organic matter in brackishwater ponds. Mandal (1962), Ghosh (1975) and Chattopadhyay (1980) evaluated the mineralisation rate of organic manures at different salinities. Salinity also influences the availability of nutrients in the soil.

Fertilization has been found to increase oxygen levels in ponds by stimulating algal growth and hence photosynthesis (Shigueno, 1972). However when microorganisms rapidly decompose organic matter, dissolved oxygen may be consumed faster than it can be delivered to the soil-water interface by natural and mechanically induced water movement, and it can lead to severe oxygen depletion especially at night which can cause mass mortality (Wheeler, 1967 & 1968; Rickards, 1974; Hanson and Goodwin, 1977). The influence of manuring on the dissolved oxygen level in culture systems has been studied extensively. Wyban et al., (1987) and Lanari et al., (1989) reported significant variation in dissolved oxygen between manured and nonmanured ponds, while Chakraborti (1984) and Chakraborti et al., (1986) recorded no such difference.

According to Boyd (1992), the brackishwater used for water exchange usually has a pH of 7.5 to 8.0 and this water buffers the soil so that acidic conditions usually do not develop in the surface layer of soil. According to the above author, the best pH for decomposition of soil organic matter lies between 7.5 and 8.5.

Chakraborti et al., (1986) have observed that there is no significant difference in the alkalinity between fertilised and unfertilised ponds. Studies regarding the alkalinity of water in ponds applied with organic manures were also conducted by Chakraborti and Das (1988) and Rajyalakshmi et al., (1988).

The productivity of any aquaculture pond depends on the nutrient status of the water and soil which can be increased by the application of organic manure. Organic manures slowly release the nutrients into the soil and water and regulate the productivity. Among the nutrients controlling the productivity, the most important ones are nitrate and phosphate. The nitrogen and phosphorus content of different organic manures have been evaluated by Taiganides (1978). A more comprehensive evaluation of the manures under Indian conditions by Gaur et al., (1990) showed 0.35, 1.47 and 0.6% nitrogen and 0.125, 1.15 and 0.5% phosphorus in fresh cowdung, poultry dropping and piggery waste respectively.

Chattopadhyay and Mandal (1982), Chakraborti (1984) and Fortes et al.,(1986) observed more nitrate nitrogen and phosphate phosphorus in ponds applied with organic manures compared to the control ponds. However, rapid disappearance of added phosphate through fertilization in brackishwater ponds was reported by Wahby (1974), Sivakami (1988) and Lanari et al., (1989).

Nitrite is an intermediatory product in the metabolism of ammonia and is highly toxic to aquatic organisms. Ammonia is another toxic compound in water and is the principal nitrogenous product excreted by crustaceans (Claybrook, 1983; Chin and Chen 1987). Ammonia gets accumulated in culture systems following microbial decomposition of organic manure. More organic manure can deteriorate the pond bottom, the major limiting factor being ammonia (Shilo and Rimon, 1982). Ammonia is found to have lethal growth inhibiting effect on penaeid prawns (Mevel and Camrauz, 1981; Chen, 1986). It is also observed that low dissolved oxygen increases the toxicity of ammonia (Allan et al., 1990; Llyod, 1961).

While investigating the influence of manuring on brackishwater ecosystem, Fortes et al., (1986) recorded more nitrite and ammonia concentration in ponds applied with organic manures. According to Subosa and Bautista (1991), ammonia and nitrite concentration showed higher values 3 days after application of manures and soon decreased to pre-treatment levels. Such increase in nitrite and ammonia concentration immediately after application of manure was also reported by Lumare et al., (1989). In another manuring experiment, Lumare et al., (1987) observed more nitrite and ammonia concentration during the later half of the experiment.

The carrying capacity of a pond and growth rate of aquatic organisms are primarily dependent on the primary productivity of water. Additions of organic fertilizers are observed to have significant influence on the productivity of water in shrimp ponds. Chakraborti et al., (1986) studying the effect of organic manures, noticed a wider difference in the primary productivity between manured and non manured ponds. However no such difference was observed by Fortes et al., (1986) among manured and non manured ponds stocked with penaeid prawns. Similar studies were also undertaken by Chakraborti et al., (1985; 1986) Fortes et al., (1986), and Pillai et al., (1987).

Fertilizers increase the natural productivity of a pond by increasing the phytoplankton production which in turn promotes the zooplankton and then the macrobenthic organisms that enter in the natural feeding of prawns (Lumare et al., 1985). According to Hickling (1971), organic fertilizers are especially efficient in enhancing production of zooplankton and benthic organisms. However, Rappaport et al., (1977) observed higher content of phytoplankton in organic manured ponds. Chen (1992) described the importance of phytoplankton in brackishwater ponds. In addition to its role as a primary producer, it enriches the ecosystem with oxygen and lowers the toxicity of many compounds.

The importance of phytoplankton and zooplankton in brackishwater ponds applied with manures has been discussed by

Chattopadhyay and Mandal (1982), Fortes et al., (1986), Lanari et al.,, (1987) and Wyban et al., (1987). According to them organic manuring leads to the production of phytoplankton followed by zooplankton and benthos. They also observed higher phytoplankton and zooplankton content in manured ponds. Chattopadhyay and Mandal (1982) and Chakraborti (1984) noticed blue green algae as the chief component of Phytoplankton while Lanari et al., (1987) observed the dominance of dinoflagellates and diatoms in the phytoplankton. On the other hand Wyban et al., (1987) recorded diatoms as the chief component.

According to Chattopadhyay and Mandal (1982), the main component of the zooplankton content is copepods followed by crustacean larvae. On the other hand,Chakraborti (1984) opined that copepods followed by rotifers constituted the bulk of the zooplankton. The dominance of copepods in zooplankton community of brackishwater ponds applied with organic manure was also reported by Lanari et al., (1987).

Microbial activity in a water body can be indirectly determined by measuring the heterotrophic activity of water. During the evaluation of heterotrophic activity of water in a freshwater pond applied with organic manures, Schroeder et al., (1990) observed slightly higher values. According to Milstein et al., (1991), the heterotrophic activity was higher during mid culture period and low during beginning and end of the experiment.

Study of soil in maured ponds is of added significance since organic manures applied, settle to the bottom and change the soil quality parameters. The mineralisation rate of organic manure is primarily dependent on various soil quality parameters among which pH is one of the most important one. Mandal (1980), Chattopadhyay and Mandal (1982), Chakraborti (1984), Subosa and Bautista (1991) have discussed the importance of pH on the decomposition of organic manures and activity of prawns in brackishwater ponds.

Organic manure application increases the organic carbon content of the soil and therefore, the analysis of organic carbon content in manured ponds is of much significance. According to Chakraborti et al., (1985), brackishwater pond soil requires manuring because of poor organic carbon content. The organic carbon content in the soil of culture pond varies with season (Chakraborti et al., 1985), depth of water, (Boyd, 1977) and depth of soil from the soilwater interface (Ayub, 1992).

As organic carbon, the nitrogen content of soil is also important. Organic matter contains many nutrients required for the primar productivity. During decomposition, manure slowly releases nutrients. The addition of organic manure can alter the nitrogen content in the soil. Excess nitrogen can be stored in sediment which upon demand will be released in to the water. Chakraborti et al., (1985), Baticados et al., (1986), Nasser (1986), Rajyalakshmi et al., (1988) and Boyd, (1992) evaluated the nitrogen content of soil in brackishwater ponds fertilized with organic manures.

According to Boyd (1992), the carbon to nitrogen (C/N) ratio is especially important, because microorganisms contain a large percentage of nitrogen in their biomass. Evaluating the soil conditions of shrimp farms in Thailand, Boyd (1990) observed that organic matter with a C/N ratio of 10 to 15 is optimal for proper decomposition.

As in the case of nitrogen, phosphorus content in soil is also important as phosphorus is stored in soil and also because of its significant effect in increasing the yield (Hickling 1971; Mandal, 1980). Gilbert (1985), while surveying brackishwater ponds near to Cochin estuary recorded more total phosphorus in soils of brackishwater ponds at Chellanam compared to the ponds at Thykkattusseri and Narackal.

In shrimp ponds, the water column and pond sediment are the major consumers of oxygen (Madenjian et al., 1987 and and 1988). Respiration of cultivated organisms is usually a minor fraction of total products of aquaculture ponds (Boyd, et al., 1978; Romaire, 1979). The possible reduction in the dissolved oxygen content in the water can be thus predicted based on the evaluation of respiration rate and heterotrophic activity of mud. Shigueno (1975) conducted studies regarding the respiration rate of mud in some shrimp ponds of Japan.

According to Schroeder et al., (1990), there was only very less increase in heterotrophic activity of mud in freshwater ponds applied with organic manures. A very high reduction in heterotrophic activity of mud from 5-6% at the beginning to about 2% at the end was reported by Milstein et al., (1991) in freshwater ponds applied with organic manures.

Natural producers that contribute to the nutritional requirement of shrimp also include benthos in addition to plankton. Chakraborti et al., (1986) and Rajyalakshmi et al., (1988) surveyed the benthic population of many manured brackishwater ponds in Orissa and West Bengal. Caillouet et al., (1972) and Gould et al., (1973) emphaized the importance of various benthic organisms in shrimp farms. The dominence of polychaete worms in brackishwater ponds has been reported by Maguire et al., (1984) and Ordner et al., (1990).

The effect of organic manures on prawn survival, growth and production has been emphasized by Maguire (1980), Wyban et al., (1987), Jose et al., (1988), Rajyalakshmi et al., (1988) and Courtney (1989). High growth and yield of prawn in fertilised ponds have been reported by the above authors. Studies related to the effect of cowdung, piggery waste and poultry dropping are very less, except for the study of Garson et al., (1986) who reported no difference in survival, growth and yield in P. vannamei and P. stylirostris applied with cowdung and chicken dropping.

In semi-intensive shrimp farms, organic manuring plays a role equal to that of feed in providing rich food for the growing shrimp. In spite of the fact that there are a variety of organic manures of low cost available, most of the shrimp farmers resort to only poultry dropping, probably because of the paucity of information on the potential of other organic manures.

It has been found that investigation on the effect of organic manures on the brackishwater pond ecosystem are limited, though similar studies are extensively made in freshwater ponds. A comparative evaluation on the effect of various organic manures on the pond ecosystem and on the growth of the cultured prawns is therefore an essential prerequisite for their proper utilization. The present investigation deals with the impact of manures such as poultry dropping, cowdung and piggery waste on the water and soil quality parameters, primary, secondary and benthos production and on the growth and survival of the prawns.

2. MATERIAL AND METHODS

The study to evaluate the effect of organic manures on the brackishwater pond ecosystem was conducted in four small ponds lying adjacent to each other at Krishi Vigyan Kendra of CMFRI, Narackal, Cochin (figures 1 and 19).

2.1. EXPERIMENTAL METHODOLOGY

The experiment was started in March 1992 and extended for three months. The ponds were designated as A,B,C and D with ponds A and B having an area of 0.04 ha each and ponds C and D of 0.05 ha and 0.03 ha respectively. They had an average depth of 1.1 m.

At the outset of the experiment, the bunds of the ponds were strengthened with a view to prevent leaching of water from one pond to another. The ponds were then drained completely and all the weed and predatory fishes were eradicated by repeated netting. After testing the pH of soil, liming was done at the rate of 200 kg/ha.

Fig. 19: Brackishwater ponds of Krishi Vigyan Kendra, Narackal used for the experiment.

Organic manures like poultry dropping, cowdung and piggery waste were used in this experiment. The organic matter, organic carbon, nitrogen and phosphorus content of each manure were determined by the procedure described by Iswaran (1980) and the details are presented in table 21. Ponds A, B and D were applied with poultry dropping, cowdung and piggery waste respectively, while pond B was kept as control without any manuring.

Boyd (1986) reported that lack of phosphorus and nitrogen limits phytoplankton productivity and that the concentration of nitrogen and phosphorus in brackishwater ponds are considered to be low for the optimum growth of phytoplankton.

The role of phosphorus in increasing the productivity of aquatic environment has been widely discussed by Collier (1970). However, according to Thomas (1966), during nutrient uptake, the algae would remove all the nitrate before all the phosphate was removed, indicating that nitrate is more likely to be the limiting nutrient than phosphate. Ryther and Dunastan (1971) have determined that nitrogen rather than phosphorus is the primary limiting factor controlling algal growth in coastal waters. Vince and Valiela (1973) also noticed rapid growth of phytoplankton when nitrogen fertilizers were applied rather than phosphorus fertilizers.

Table 21. Composition of manures used for the experiment

Manure	Moisture (%)	Organic matter (%)	Organic Carbon (%)	Nitrogen (%)	Phosphorus (%)
Poultry dropping	13.68	43.01	22.63	3.74	3.46
Cowdung	15.14	49.98	26.31	2.10	1.16
Piggery waste	12.64	19.33	10.17	2.80	2.54

The role of organic carbon in increasing the productivity of aquatic systems has been studied by Banerjea (1967), Schroeder (1978), Chattopadhyay (1980), Chattopadhyay and Mandal (1982), Chakraborti (1984), Lanari et al., (1989), Boyd (1990) and Schroeder et al., (1990). According to Chakraborti et al., (1985), brackishwater ponds having 1.02% to 1.45% organic carbon gave better production of the prawn P. monodon Edwards (1977) observed that juvenile P. vannamei needs a substrate highly rich in organic matter for proper growth. Tang and Chen (1967) also opined that increase in organic carbon content of pond soil increases the yield in aquaculture ponds. Lumare et al., (1987) obtained better production and higher average weight at harvest in case of P. japonicus with 4% organic carbon compared to the low production and average weight in ponds with 1% organic carbon. However, excessive organic carbon of above 3 to 6% has been reported to be adversely affecting the growth of benthos, probably caused by the reduced dissolved oxygen content due to the decomposition of organic matter (Bader, 1954; Damodaran 1973; Rao and Murthy 1988). The reduction of oxygen in the pond bottom also adversely affects the growth and survival rate of prawns.

The above observation point to the fact that in brackishwater ponds, between nitrogen and phosphorus, nitrogen is considered to be the limiting factor. However, since organic carbon content of organic manure has a decisive role in the benthis productivity, this factor was also taken into consideration. The present investigation, therefore aims to evaluate the role of nitrogen and organic carbon in the productivity of brackishwater ponds and the growth and survival rate of prawns. The quantity of various manures to be used in this experiment was therefore adjusted in such a way that, the phosphorus content is kept constant in all treatments but with varying nitrogen and organic carbon content.

For the determination of doze, cowdung was taken as standard, which is generally applied at the rate of 2000 kg/ha (Chattopadhyay and Mandal, 1982). The phosphorus content of cowdung determined in the present study was 1.16%. Thus, 2000 kg cowdung per hectare provides 23.20 kg phosphorus. The quantity of other manures was adjusted in such a way that each manure provides 23.20 kg phosphorus. Thus 670.52 kg poultry dropping and 913.38 kg of piggery waste having 3.46 and 2.54% phosphorus respectively provide 23.20 kg phosphorus. When applied in the above mentioned doze per hectare, poultry dropping having 3.74% nitrogen and 22.63% organic carbon prvided 25.07 kg nitrogen and 151.73 kg organic carbon. Likewise 2000 kg cowdung and 913.38 kg piggery waste having 2.10% nitrogen and 26.31% organic carbon and 2.80% nitrogen and

10.17% organic carbon provided 42.00 kg nitrogen and 526.20 kg organic carbon and 25.57 kg nitrogen and 92.89 kg organic carbon respectively per hectare.

All the ponds were stocked with late post larvae (PL 40 - PL 55) of *P. indicus* having an average length of 22 mm and weight of 0.084 gms collected from the nature at a density of 50000nos./ha. After application of manure, sluice gate was completely closed with mud so that there was no water exchange. The stocked prawns were harvested after 68 days of culture.

2.2 DETERMINATION OF WATER QUALITY PARAMETERS

Water samples were taken weekly from the water column with the help of a underwater sampler bottle to determine the salinity, dissolved oxygen, pH, alkalinity, hardness and nutrients. The samples were collected in triplicate and the average values were reckoned in presenting the data. The samples were collected before 08.00 hrs in the morning except in the case of dissolved oxygen, where the water samples were taken at 00.00, 06.00, 12.00 and 18.00 hrs.

The same procedures described in Chapter I were used for measuring the above mentioned parameters. Water samples in triplicate were taken once in a week for determining phytoplankton and zooplankton concentrations. The same procedures described in Chapter I were used here also for determining phytoplankton and zooplankton contents.

2.2.1 HETEROTROPHIC ACTIVITY OF WATER

Heterotrophic activity of water was measured by using the technique developed by Egglishaw (1972).

In the present study, the heterotrophic activity of water was determined biweekly. For this, a piece of cotton strip having an area of 0.1 M^2 was kept spread in water column by means of two poles. The initial weight of cotton strip was taken and washed the adhering material and was kept in an oven for 1 hour at 105°C. The weight of the cotton strip was noted again and the difference in weight before and after incubation was found out. From this, the percentage loss in weight was determined for one day. Heterotrophic activity was expressed as percentage reduction in weight per day. The experiment was conducted in triplicate and the average value was calculated.

2.3 DETERMINATION OF SOIL QUALITY PARAMETERS

Soil samples were collected at fortnightly intervals for the determination of pH, organic carbon, total nitrogen, C/N ratio, total phosphorus, heterotrophic activity of mud and respiration rate of mud. Benthos concentration was analysed once in a week while grain size analysis was done only once.

For the determination of pH, organic carbon, benthos content and grain size of sediment, the same methods described in Chapter I were used.

2.3.1 TOTAL NITROGEN

Total nitrogen in the sediment was estimated by Kjeldahl method modified to include the nitrogen of nitrate (Iswaran, 1980).

1 gm of soil sample was taken in a digestion flask and 30 ml of concentrated, sulphuric acid containing 2 gm of salicylic acid was added. The sample was shaken until thoroughly mixed and was allowed to stand for atleast 30 minutes. Afterwards, 5 gm of sodium thiosulphate was added and was heated for 5 minutes. To this, 10 gm of potassium sulphate and 1 gm copper sulphate were added. The mixture was very gently heated until foaming ceased and the digestion was continued.

For distillation 150 ml of 30% sodium hydroxide was added through the side of the flask. The distillate was collected in 4% boric acid containing mixed indicator (bromocresol green and bromothymol blud). Distillation was continued until no trace of ammonia was noticed with a blue litmus paper. After distillation, the ammonia absorbed was titrated against 0.1 N sulphuric acid until the colour changed from blue to pale pink at the end point.

Concentration of total nitrogen (%) was determined using the formula A-B X N X 0.14 where A and B were the volume of standard acid used in sample titration and blank titration respectively and N, the normality of the acid.

2.3.2 C/N RATIO

The organic carbon and total nitrogen values were used for the determination of C/N ratio. The organic carbon content of the soil sample was divided by the total nitrogen content to obtain the C/N ratio.

2.3.3 TOTAL PHOSPHORUS

The total phosphorus was determined by the method described by FAO (1975).

0.5 gm of powdered soil sample was taken in a 500 ml Kjeldahl flask. 2 ml each of concentrated nitric acid and perchloric acid were added and the mixture was heated and gently cooled. Addition of above mentioned acids and heating were continued until the mixture was dried fully. 21 ml of dilute sulphuric acid (1.8 N) was added and was boiled for 10 minutes. After cooling, the solution was filtered by Whatman No.42 filter paper and diluted to 250 ml.

From the above solution, 5 ml was taken and diluted to 30 ml with distilled water. 5 drops of ascorbic acid and 1 ml sulphuric acid - ammonium molybdate solution was added. After 5 minutes, the absorbance was measured at 882 nm. Sample concentration (ppm) was read from the standard graph drawn with the absorbance of the standard phosphorus solution.

2.3.4 HETEROTROPHIC ACTIVITY OF MUD

The method used for water is also used here (Egglishaw, 1972).

A cotton strip (0.1 M^2) was spreaded horizontally over the pond bottom. From the difference in weight after 5 days of incubation, the percentage reduction in weight per day was determined.

2.3.5 RESPIRATION RATE OF MUD

Respiration rate of mud was determined by the method described by Shigueno (1975).

Mud from the top surface of the pond bottom was collected using a plastic petridish. 100 ml of this mud was transferred to a wide mouthed 500 ml reagent bottle containing filtered water of 15 ppt salinity made by diluting seawater. The reagent bottle was stoppered in order to prevent evaporation. 15 ppt salinity was selected for measuring the respiration rate of mud because the pond salinity ranged between 12 and 20 ppt. The dissolved oxygen content of this water was measured initially. The bottle was then incubated at dark for 3 hours. After incubation, the dissolved oxygen was again measured.

From the difference in dissolved oxygen content, the oxygen consumed for the respiration of mud was found out based on the chemical formula that 1 ml of 0.5 N sodium thiosulphate is equivalent to 0.25 mg atom oxygen (Strickland and Parsons, 1972).

2.4 GROWTH AND SURVIVAL RATE AND STATISTICAL ANALYSIS

Sampling of prawns was done at fortnightly intervals to determine the average weight of prawns. From this, the average growth rate in terms of increase in average weight per day was found out. Survival rate of prawns was determined after harvesting the prawns by complete draining. The same statistical methods used in Chapter I is used here also for the analysis of data.

3. RESULTS

3.1 WATER QUALITY PARAMETERS

3.1.1 TEMPERATURE

Data on water temperature collected from ponds fertilized with different organic manures during the culture period is given in table 22 and figure 20.

It may be observed that invariably in all the ponds the temperature observed during the zero week after the application of organic manures ranged between 29.16 and 29.50°C which increased to 31.5 to 31.66°C. During the 1st week of culture, the temperature showed a decline ranging between 30.50 and 31.00°C in different ponds. However subsequently during 8th week, the temperature increased ranging between 32.00 and 32.66°C which later started declining during the subsequent weeks reaching a lower range of 30.50 and 31.16°C during the 11th week in different ponds.

The average temperature recorded in ponds A, B, C and D was 30.93°, 30.88°, 30.95° and 30.90°C respectively.

Anova of temperature at different ponds showed no significant difference (P>0.01). Correlation analysis indicated no significant relationship between temperature and growth of prawns in all ponds.

3.1.2 SALINITY

Particulars regarding the salinity of water in different ponds are presented in table 22 and figure 20. It is discernible that in pond A fertilised with poultry manure, the salinity during the zero week was 13.49 ppt which gradually increased to 20.48 ppt during the 6th week and this level was maintained till 9th week. Thereafter, the salinity decreased to 14.91 ppt during 11th week of culture.

In control pond B, the salinity showed a wider flunctation with the lowest value of 12.34 ppt during the zero week which gradually increased through the 2nd, 4th and 6th week reaching to the highest value of 19.87 ppt during the 9th week. It may also be noticed that the salinity was of a lower profile towards the end of experiment registering a value of 13.41 ppt during 11th week.

The salinity in pond C for the zero week was 12.48 ppt which gradually increased to the highest value of 18.92 ppt during the 9th week. Thereafter the salinity showed a decreasing trend reaching upto 14.00 ppt during 11th week.

In pond D, the salinity value gradually increased from 13.89 ppt during the zero week to 20.35 ppt during the 6th week. Later the salinity gradually decreased to 13.77 ppt during the 11th week.

The average salinity values recorded were 18.15, 16.64, 16.05 and 17.50 ppt in ponds A, B, C and D respectively.

Anova of salinity at different ponds showed no significant difference ($P>0.05$). Correlation analysis revealed no significant relationship between salinity of water and growth of prawns in all ponds.

3.1.3 DISSOLVED OXYGEN

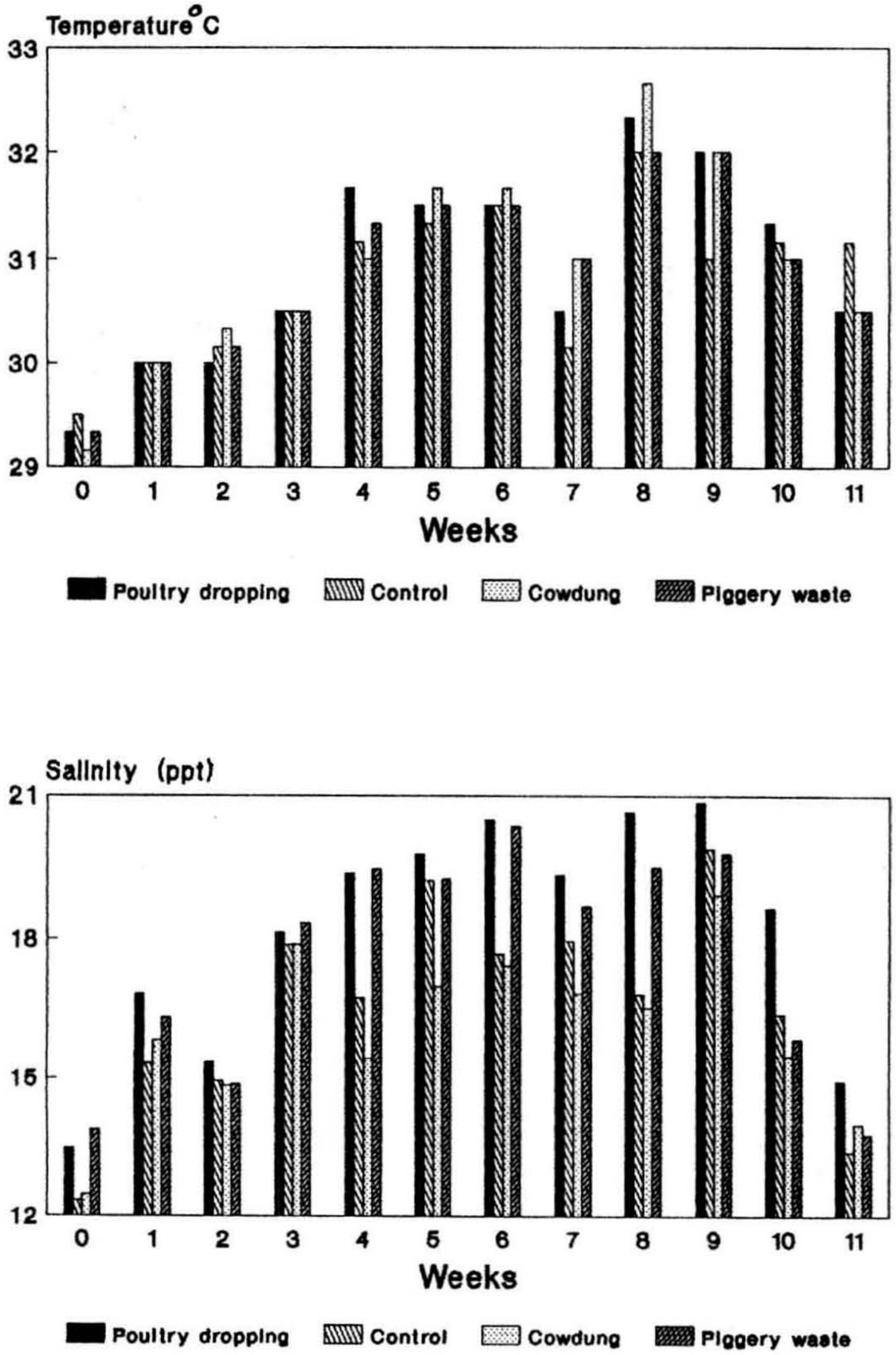
The dissolved oxygen content in ponds applied with organic manures were monitored once in a week at 00.00, 06.00, 12.00 and 18.00 hrs. The details are given in tables 23 and 24 and figures 21 and 22.

	TEMPERATURE °C				SALINITY (ppt)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	29.33	29.50	29.16	29.33	13.49	12.34	12.48	13.89
1	30.00	30.00	30.00	30.00	16.83	15.31	15.84	16.33
2	30.00	30.16	30.33	30.16	15.34	14.93	14.83	14.86
3	30.50	30.50	30.50	30.50	18.13	17.86	17.88	18.32
4	31.66	31.16	31.00	31.33	19.36	16.74	15.43	19.46
5	31.50	31.33	31.66	31.50	19.76	19.21	16.98	19.24
6	31.50	31.50	31.66	31.50	20.48	17.67	17.43	20.35
7	30.50	30.16	31.00	31.00	19.33	17.94	16.84	18.68
8	32.33	32.00	32.66	32.00	20.64	16.83	16.54	19.48
9	32.00	31.00	32.00	32.00	20.84	19.87	18.92	19.78
10	31.33	31.16	31.00	31.00	18.63	16.38	15.46	15.86
11	30.50	31.16	30.50	30.50	14.91	13.41	14.00	13.77
Mean	30.92 A	30.80*A	30.95*A	30.90 A	18.14 A	16.54 A	16.05*A	17.50 A
Correlation r value	0.460 NS	0.244 NS	0.490 NS	0.772 NS	0.175 NS	-0.104 NS	0.106 NS	0.449 NS

* Any two means having a common letter are not significantly different. S-Significant, NS-Not Significant

Table 22: Temperature and salinity of water recorded in ponds applied with (A) poultry dropping (B) control (C) cowdung and (D) piggery waste.

Fig.20 **Temperature & Salinity of water recorded in ponds applied with organic manures**



A. DISSOLVED OXYGEN AT 00.00 HOURS

The dissolved oxygen content in pond A fertilized with poultry manure for the zero week was 7.20 ppm which slightly increased to 8.32 ppm during the first week. During the weeks 3 to 6, the values ranged between 5.43 and 7.64 ppm. The value again increased to 8.39 ppm during the 7th week. After this, the dissolved oxygen content gradually got reduced to a low of 4.90 ppm during the 11th week.

In pond B, which is the control pond, the dissolved oxygen content during the zero week was 6.01 ppm which gradually increased to 7.64 ppm during the 5th week. The value decreased to a low of 3.34 ppm during the 8th week, which later increased to 5.42 ppm during the 11th week.

In pond C, where cowdung was used as a manure, the dissolved oxygen recorded during the zero week was 6.98 ppm which gradually increased to reach a high of 9.32 ppm during the 3rd week, the values varying between 3.16 and 5.91 ppm during the weeks 4 to 10. The value observed during the 11th week was 2.93 ppm, which was the lowest value noticed in this period.

In pond D applied with piggery waste, the dissolved oxygen during the zero week was 5.46 ppm which increased to the highest value of 8.32 ppm during the 2nd week. The minimum value of 4.62 ppm was recorded during the 3rd week. The values ranged between 4.89 and 8.24 ppm during 4th to 11th weeks.

The average dissolved oxygen content measured in ponds A, B, C and D were 6.69, 6.11, 5.56 and 6.44 ppm.

Anova of dissolved oxygen content at 00.00 hrs in different ponds showed no significant difference (P>0.05). Correlation analysis indicated no significant relationship between dissolved oxygen content and growth in all ponds except in pond C, which recorded a negative relationship.

B. DISSOLVED OXYGEN AT 06.00 HOURS

In pond A, the dissolved oxygen concentration at 06.00 hrs was 5.66 ppm during zero week (table 23 and figure 21). The next three weeks recorded values in between 4.01 and 4.84 ppm. After recording a lower value of 2.72 ppm during 4th week, the succeeding 3 weeks recorded values in between 3.03 and 3.69 ppm. Thereafter, the values ranged between 2.47 and 4.23 ppm.

The dissolved oxygen content was 5.20 ppm during the zero week in pond B which was the highest value recorded in this pond. It varied between 3.63 and 4.73 ppm during 1st to 7th weeks. The lowest value of 2.87 ppm was recorded during 8th week.

In pond C, the dissolved oxygen at 06.00 hrs was 5.02 ppm during the zero week followed by 5.62 ppm during the first week which was the highest value. The weeks 4, 6 and 7 recorded values between 2.32 and 2.65 and the weeks 8, 10 and 11 recorded values between 1.61 and 1.86 ppm.

In pond D, the dissolved oxygen during the zero and first weeks were 5.25 and 5.58 ppm respectively. The weeks, 2, 5, 9 and 11 recorded values in between 3.86 and 4.84 ppm. The values recorded during 3, 4, 7 and 10th weeks ranged between 2.12 and 2.87 ppm.

The average dissolved oxygen recorded in ponds A, B, C and D were 3.73, 4.16, 3.31 and 3.46 ppm respectively.

Anova of dissolved oxygen values at different ponds showed no significant difference (0.05). Correlation analysis revealed no significant relationship between dissolved oxygen consent and growth of prawns in all ponds except in pond C, where the relationship was negative.

C. DISSOLVED OXYGEN AT 1200 HOURS

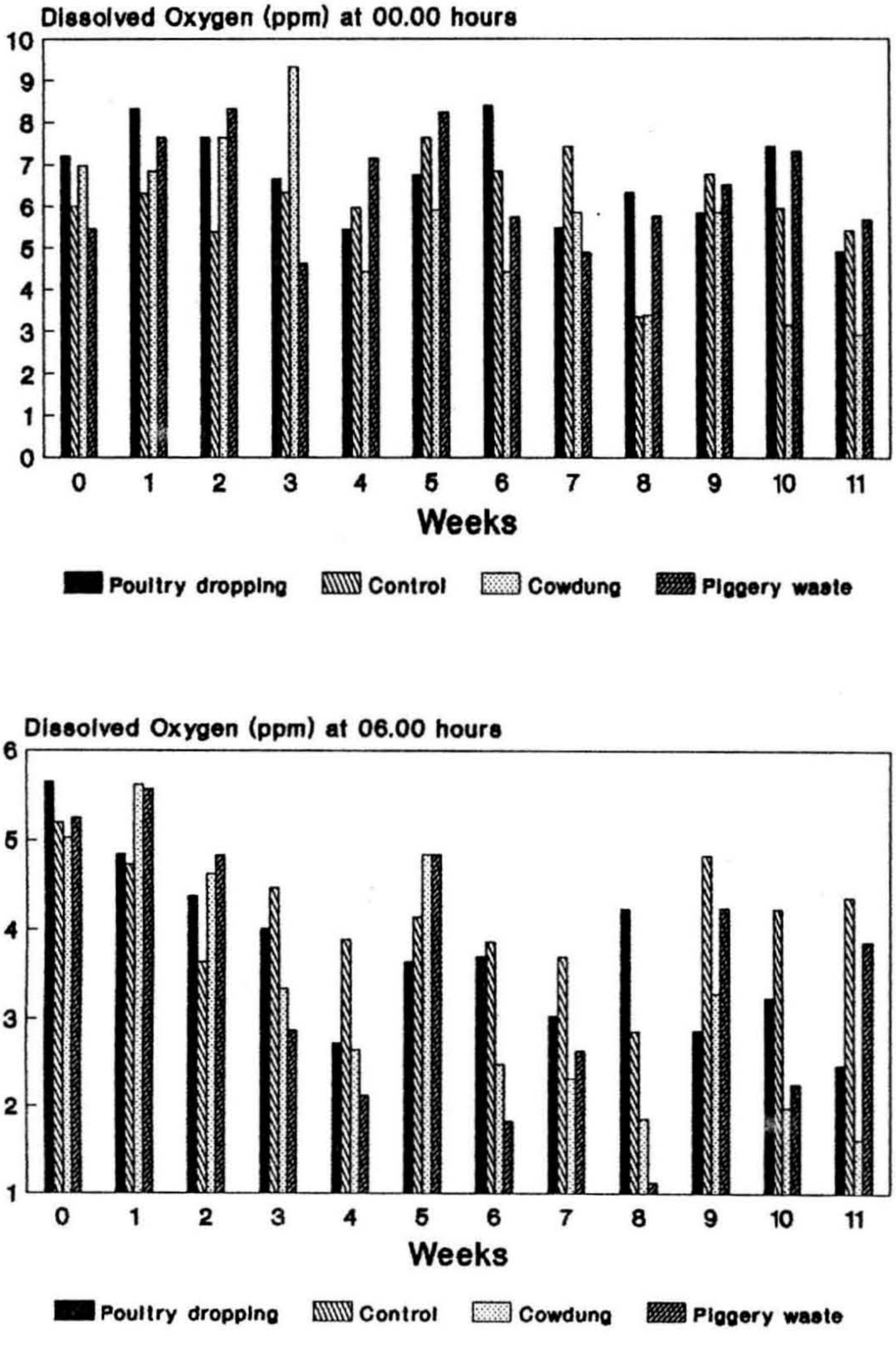
Table 24 and figure 22, depicts the dissolved oxygen concentration in different ponds at 12.00 hrs.

	DISSOLVED OXYGEN (ppm) AT 0000 hrs				DISSOLVED OXYGEN (ppm) AT 06 00 hrs			
Treatment Weeks	A	B	C	D	A	B	C	D
0	7.20	6.01	6.98	5.46	5.65	5.20	5.02	5.25
1	8.32	6.30	6.83	7.64	4.84	4.73	5.62	5.57
2	7.64	5.38	7.64	8.32	4.37	3.63	4.62	4.83
3	6.64	6.33	9.32	4.62	4.01	4.47	3.34	2.87
4	5.43	5.96	4.43	7.10	2.72	3.88	2.65	2.12
5	6.74	7.64	5.91	8.24	3.63	4.14	4.84	4.84
6	8.39	6.83	4.43	5.73	3.69	3.86	2.48	1.82
7	5.48	7.42	5.85	4.89	3.03	3.69	2.32	2.64
8	6.31	3.34	3.38	5.76	4.23	2.86	1.86	1.12
9	5.84	6.76	5.86	6.52	2.87	4.83	3.28	4.24
10	7.43	5.94	3.16	7.31	3.23	4.23	1.98	2.25
11	4.90	5.42	2.93	5.68	2.47	4.36	1.61	3.86
Mean	6.69*A	6.11A	5.56 A	6.44 A	3.73 A	4.16*A	3.30 A	3.45 A
Correlation r value	-0.613 NS	-0.230 NS	-0.990 S	-0.822 NS	-0.722 NS	-0.299 NS	-0.98 S	-0.830 NS

* Any two means having a common letter are not significantly different. S-Significant, NS-Not Significant

Table 23: Dissolved Oxygen concentration in water recorded at 00.00 and 06.00 hrs in ponds applied with

Fig. 21 Dissolved Oxygen concentration recorded in ponds applied with organic manures



In pond A fertilized with poultry manure, the dissolved oxygen concentration for the zero week was 7.27 ppm which suddenly increased to 10 ppm in the following two weeks. The weeks 4, 5, 6, 9 and 11 showed values ranging between 10.33 and 12.43 ppm. The lower value of 7.07 ppm and the highest value of 14.86 ppm were recorded during 8th and 10th weeks respectively.

In control pond B, values ranging between 10.06 and 10.64 ppm were recorded during the weeks 3, 5 and 9th weeks. Remaining weeks showed values in between 6.06 and 8.69 ppm. From the figure it can be seen that values were generally lower in this pond compared to other ponds.

The dissolved oxygen concentration for the zero week was 6.34 ppm in pond C applied with cowdung which increased gradually to 11.84, 12.34, 14.80 and 14.66 ppm during 1, 2, 3 and 4 weeks respectively. The remaining weeks showed values in between 5.46 and 10.48 ppm. The lowest value of 5.46 ppm was observed in 11th week .

In pond D, the dissolved oxygen concentration increased suddenly from 6.42 ppm in the zero week to 13.97, 15.03 and 15.96 ppm during 1, 2 and 3rd weeks respectively. Thereafter, the value decreased to 10.69, 11.43, 13,64 ppm during 4, 5 and 6th weeks respectively. Afterwards the value decreased to 7.14 ppm in 11th week.

The average dissolved oxygen concentration in ponds A, B, C and D were 10.37, 8.25, 9.53 and 11.03 ppm respectively.

Anova of dissolved oxygen at different ponds indicated no significant difference (P>0.05). Correlation analysis showed no significant relationship between dissolved oxygen concentration at 12.00 hrs and growth in all ponds.

D. DISSOLVED OXYGEN AT 18.00 HOURS

The dissolved oxygen concentration at 18.00 hrs in different ponds is given in table 24 and figure 22.

In pond A, the concentration was 9.07 ppm for the zero week. The value increased to 13.67 and 12.33 ppm during the first and second weeks respectively. The dissolved oxygen concentration recorded was in between 10.64 and 13.64 ppm during 3, 4, 7, 8, 9 and 11th weeks. Values of 14.36 and 14.98 ppm were recorded during 4th and 6th weeks respectively. The highest value of 17.63 ppm was recorded during the 10th week.

In pond B which is the control pond,comparatively lower values were recorded. The dissolved oxygen noticed during the zero week was 7.46 ppm which increased to 9.34, 11.00 and 11.78 during 1, 2 and 3rd weeks respectively. Values between 7.64 and 9.64 ppm were recorded during 4, 6, 7, 8, 10 and 11th weeks. Higher values of 11.08 and 12.62 ppm were noticed during 8 and 5th weeks respectively.

In pond C applied with cowdung, the dissolved oxygen concentration was 8.39 ppm during the zero week which increased to 13.04, 15.47, 16.06 and 15.43 ppm during the 1, 2, 3 and 4th weeks respectively. The concentration ranged between 10.04 and 10.47 ppm during 6, 7 and 9th weeks. It was in between 6.48 and 7.67 ppm, during the weeks 5, 10 and 11th weeks.

In pond D, the concentration of dissolved oxygen was found increasing from 6.32 ppm in the zero week to 16.82, 16.94 and 17.48 ppm during 1, 2 and 3rd weeks respectively. The concentration recorded was between 13.34 and 15.48 ppm during 4, 5, 6 and 9th weeks which however declined to values ranging between 8.33 and 10.68 ppm during 7, 8, 10 and 11th weeks respectively.

The average concentration recorded in A, B, C and D ponds were 12.71, 9.67, 11.09 and 13.17 ppm respectively.

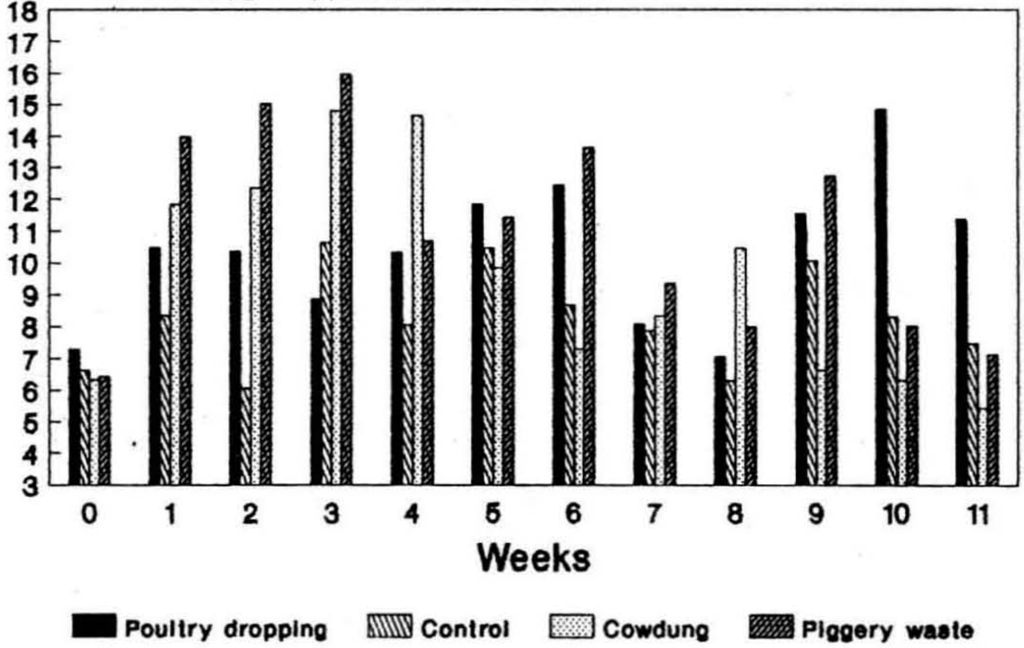
Anova of dissolved oxygen concentration at 18.00 hrs in different ponds showed significant difference ($P<0.05$). Pairwise comparison indicated significant difference in dissolved oxygen between ponds B and D and not among any other ponds. Correlation analysis indicated no significant

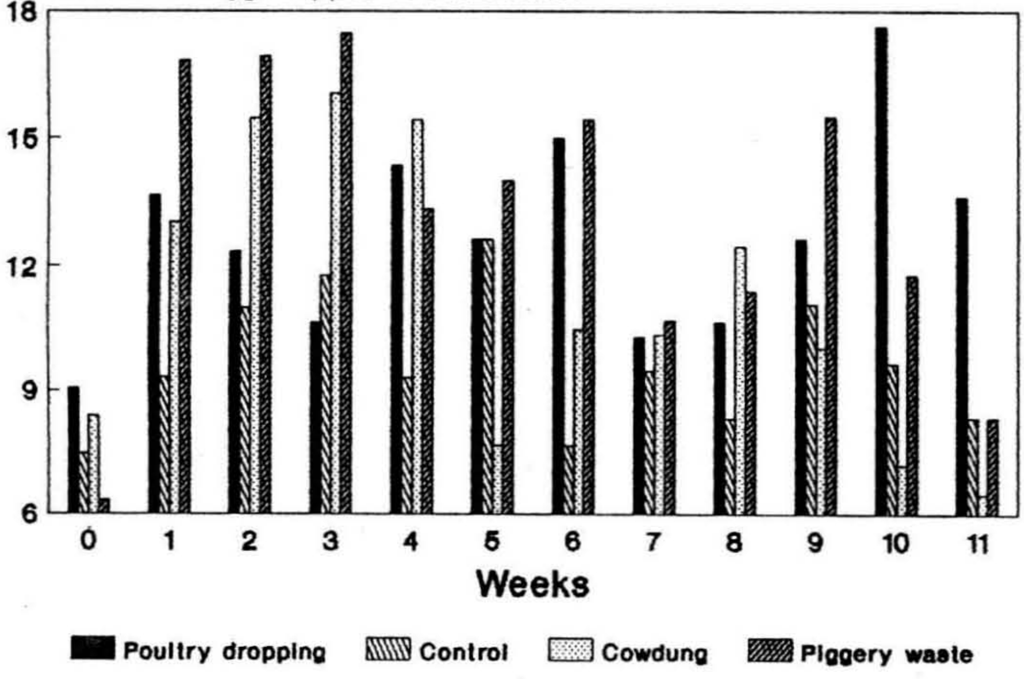
	DISSOLVED OXYGEN (ppm) AT 1200 hrs				DISSOLVED OXYGEN (ppm) AT 1800 hrs			
Treatment Weeks	A	B	C	D	A	B	C	D
0	7.27	6.63	6.34	6.42	9.07	7.46	8.39	6.32
1	10.46	8.34	11.84	13.97	13.67	9.34	13.04	16.82
2	10.35	6.06	12.34	15.03	12.33	11.00	15.47	16.94
3	8.86	10.64	14.80	15.96	10.64	11.78	16.06	17.48
4	10.33	8.06	14.66	10.69	14.36	9.32	15.43	13.34
5	1[illegible].83	10.47	9.84	11.43	12.64	12.62	7.67	14.01
6	12.43	8.69	7.32	13.64	14.98	7.64	10.47	15.43
7	8.08	7.88	8.33	9.36	10.30	9.48	10.36	10.68
8	7.07	6.33	10.48	8.00	10.64	8.30	12.46	11.40
9	11.55	10.06	6.60	12.76	12.64	11.08	10.04	15.48
10	14.86	8.32	6.34	8.01	17.63	9.64	7.19	11.78
11	11.39	7.47	5.46	7.14	13.64	8.32	6.48	8.33
Mean	10.37 *A	8.25 A	9.53 A	11.03 A	12.71 *AB	9.67 A	11.09 AB	13.17 B
Correlation r value	0.177 NS	0.326 NS	-0.676 NS	-0.768 NS	0.300 NS	-0.349 NS	-0.749 NS	-0.699 NS

* Any two means having a common letter are not significantly different. S-Significant, NS-Not Significant

Table 24: Dissolved oxygen concentration in water recorded at 12.00 and 18.00 hrs in ponds applied with (A) Poultry dropping (B) Control (C) Cowdung and (D) Piggery Waste.

Fig. 22 Dissolved Oxygen concentration recorded in ponds applied with organic manures


Dissolved Oxygen (ppm) at 12.00 hours


Dissolved Oxygen (ppm) at 18.00 hours

relationship between dissolved oxygen concentration at 18.00 hrs and growth rate in any pond.

A comparison of dissolved oxygen at different times shows that the value was highest at 18.00 hrs in all ponds followed by 12.00 hrs and 00.00 hours. The least values were recorded during early morning hours at 06.00 hrs.

3.1.4 pH

pH values observed during the culture period in different ponds are shown in table 25 and figure 23.

In pond A fertilised with poultry manure,the pH value during the zero and fourth weeks were 8.46 and 8.24 respectively which further showed an increase to 8.12 and 8.24 during the period of 5 and 6th weeks of culture. The lowest pH of 7.77 and the highest pH of 8.83 were recorded during the 7th and 9th weeks respectively. The pH was above 8 during the period 8 to 11 weeks.

In control pond B, the pH values were in between 8.43 and 8.76 during zero to 3rd weeks. After showing a decrease to 8.13 and 7.98 during 4th and 5th weeks respectively, the value again increased to 8.36 and 8.92 during 6th and 7th weeks respectively. The lowest value of 7.63 was recorded during the

8th week. The weeks 9 to 11 showed pH values lying between 8.14 and 8.36.

In pond C, where cowdung was applied as a manure, the pH value showed an increase from 8.39 during zero week to 8.86 during first week. The values were in between 8.32 and 8.86 (the highest value) during 2nd to 5th weeks. The values again decreased to 7.83, 7.56 and 7.39 (the least value) during the 6, 7 and 9th weeks respectively except during 8th week where a pH value of 8.34 was recorded. pH values were found to be low during the later half of the experiment.

Following a trend similar to that in pond C, the pH in pond D applied with piggery waste ranged between 8.28 during zero week to 8.71 during the 3rd week. The value further showed a decline to 7.92 during 5th week maintaining a narrower range of 8.43 to 8.64 during 7th to 11th weeks.

The average pH value recorded in ponds A, B, C and D were 8.24, 8.37, 8.25 and 8.42 respectively, thereby indicating the alkaline nature of the ponds.

Anova of pH at different ponds showed no significant difference ($P>0.05$). Correlation analysis between water pH and growth of prawns indicated no significant relationship in all ponds.

3.1.5 TOTAL ALKALINITY

Weekly variations in the total alkalinity in water in different ponds are shown in table 25 and figure 23.

In pond A, the total alkalinity was found maintaining a narrow range between 143.43 ppm during the zero week to 122.41 ppm during the 5th week. The total alkalinity was found increasing later by 8 and 9th weeks, the values being 220.67 and 210.89 ppm respectively. Towards the end of the culture period, the value was found declining reaching a minimum of 64.12 ppm during the 11th week.

The total alkalinity in pond B, for the zero week was 162.28 ppm. The value then showed a decline ranging between 118.98 and 153.94 ppm during 1st to 7th weeks. As in pond A, the values showed an increasing trend during 8 and 9th weeks, declining thereafter towards the end of the culture period. The minimum and maximum values of 45.11 and 270.26 ppm were recorded during 11 and 9th weeks respectively.

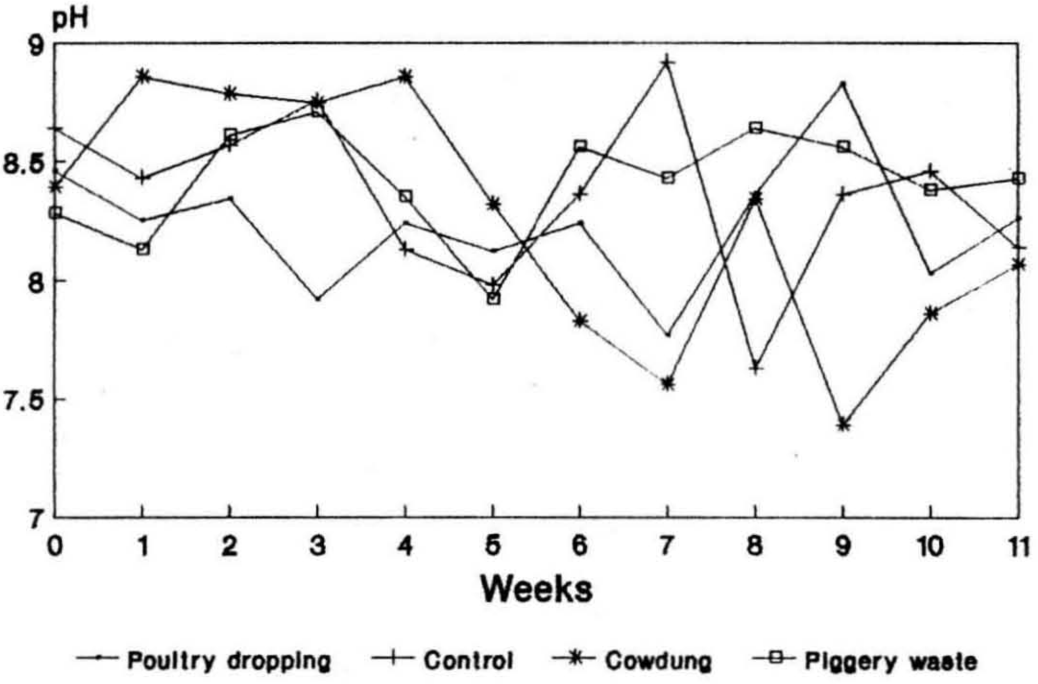
Pond C fertilised with cowdung also showed a similar trend as in ponds A and B. Nevertheless, during the 9th week of culture, the total alkalinity was found showing the highest value of 290.87 ppm, the lowest value of 73.86 ppm was observed during 11th week of culture.

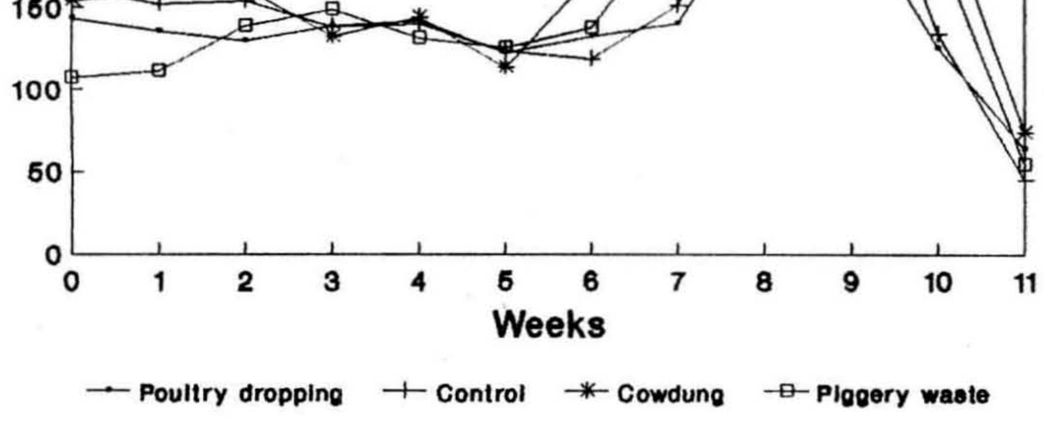
	P^H				TOTAL ALKALINITY (ppm)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	8.46	8.64	8.39	8.28	143.43	162.28	154.13	106.97
1	8.25	8.43	8.86	8.13	135.68	151.69	158.76	110.86
2	8.34	8.57	8.79	8.61	129.93	153.94	161.68	138.58
3	7.92	8.76	8.75	8.71	138.67	138.13	132.45	148.64
4	8.24	8.13	8.86	8.35	141.86	139.43	143.58	131.48
5	8.12	7.98	8.32	7.92	122.41	123.49	113.64	125.69
6	8.24	8.36	7.83	8.56	132.38	118.98	168.23	137.54
7	7.77	8.92	7.56	8.43	140.01	150.87	213.32	206.23
8	8.36	7.63	8.34	8.64	220.67	261.31	235.26	249.68
9	8.83	8.36	7.39	8.56	210.89	270.26	290.87	220.01
10	8.03	8.46	7.86	8.38	125.76	133.89	219.62	187.90
11	8.26	8.14	8.07	8.43	64.12	45.11	73.86	54.38
Mean	8.24 *A	8.37 A	8.25 A	8.42 A	142.15*A	154.12 A	172.12 A	151.50 A
Correlation r value	-0.405 NS	-0.412 NS	-0.684 NS	-0.223 NS	-0.199 Ns	-0.088 NS	0.105 NS	0.317 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 25: P^H and Total Alkalinity in water recorded in ponds applied with (A) poultry dropping (B) control (C) cowdung and (D) piggery waste

Fig. 23 pH & Total Alkalinity of water recorded in ponds applied with organic manures





The lowest value of 106.97 ppm during the zero week was recorded in pond D. It gradually increased to reach a highest value of 249.68 ppm during 8th week. As in other ponds, the least value of 54.38 ppm was recorded during 11th week.

The average total alkalinity values recorded were 142.15, 154.12, 172.17 and 151.50 ppm in ponds A, B, C and D respectively, indicating a comparatively higher average value in pond applied with cowdung.

Anova of total alkalinity values at different ponds showed no significant difference (P>0.05). Correlation analysis also indicated no significant relationship between growth and total alkalinity in all ponds.

3.1.6 TOTAL HARDNESS

Details regarding the total hardness in different ponds are given in table 26 and figure 24.

In pond A and B fertilised with poultry dropping and control pond, the total hardness during the zero to 7th weeks remains almost steady within a range of 1343.31 ppm and 2642.89 ppm. However during the subsequent weeks, the values were found shooting up reaching a peak value of 7268.91 and 6008.78 ppm in pond A and B respectively during the 9th week.

Remaining within a comparatively low range of 1343.91 ppm and 3205.72 ppm, the total hardness in pond C was found increasing towards the end of the culture period, the highest values being obtained during 9 and 10th weeks.

Evincing a different picture from that of other ponds, the total hardness values in pond D applied with piggery waste was found increasing from 1268.32 ppm during zero week to 3418.64 ppm in the 4th week to 4216.33 ppm in 5th week. The values which remained almost steady till 10th week, started declining reaching a low of 1619.82 ppm in the 11th week.

Among the different ponds applied with manures, the total hardness in ponds A and B remained low during the first half of the experiment, increasing thereafter during the 2nd half of the culture period. In pond manured with cowdung, however, the total hardness though increased towards the end of the culture period was of a comparatively low range. While in pond D manured with piggery waste, the total hardness was found increasing from 2nd week onwards maintaining a higher concentration till 11th week of culture.

The average total hardness recorded were 2285.61, 2535.56, 2062.55 and 2895.08 ppm in ponds A, B, C and D respectively, anova of which showed no significant difference (P>0.05). Correlation analysis also did not show any significant relationship between total hardness and growth of prawns in any pond.

3.1.7 NUTRIENTS

A. NITRATE - NITROGEN

The nitrate nitrogen concentration in different ponds applied with organic manures is given in table 26 and figure 24.

In pond A, nitrate concentration during the zero week was 0.19 ppm which got reduced to 0.16 ppm during the first week. The highest concentration of 0.22 ppm was recorded during the 3rd week which declined gradually till 6th week (0.09 ppm), increasing later to 0.12 ppm by 7th week. The values then gradually declined to 0.09 ppm by the end of 10th week of culture.

In control pond B, the nitrate nitrogen was found decreasing gradually reaching a minimum of 0.02 ppm during 5th week. The values though increased during the subsequent weeks remained low within a range of 0.04 and 0.10 ppm.

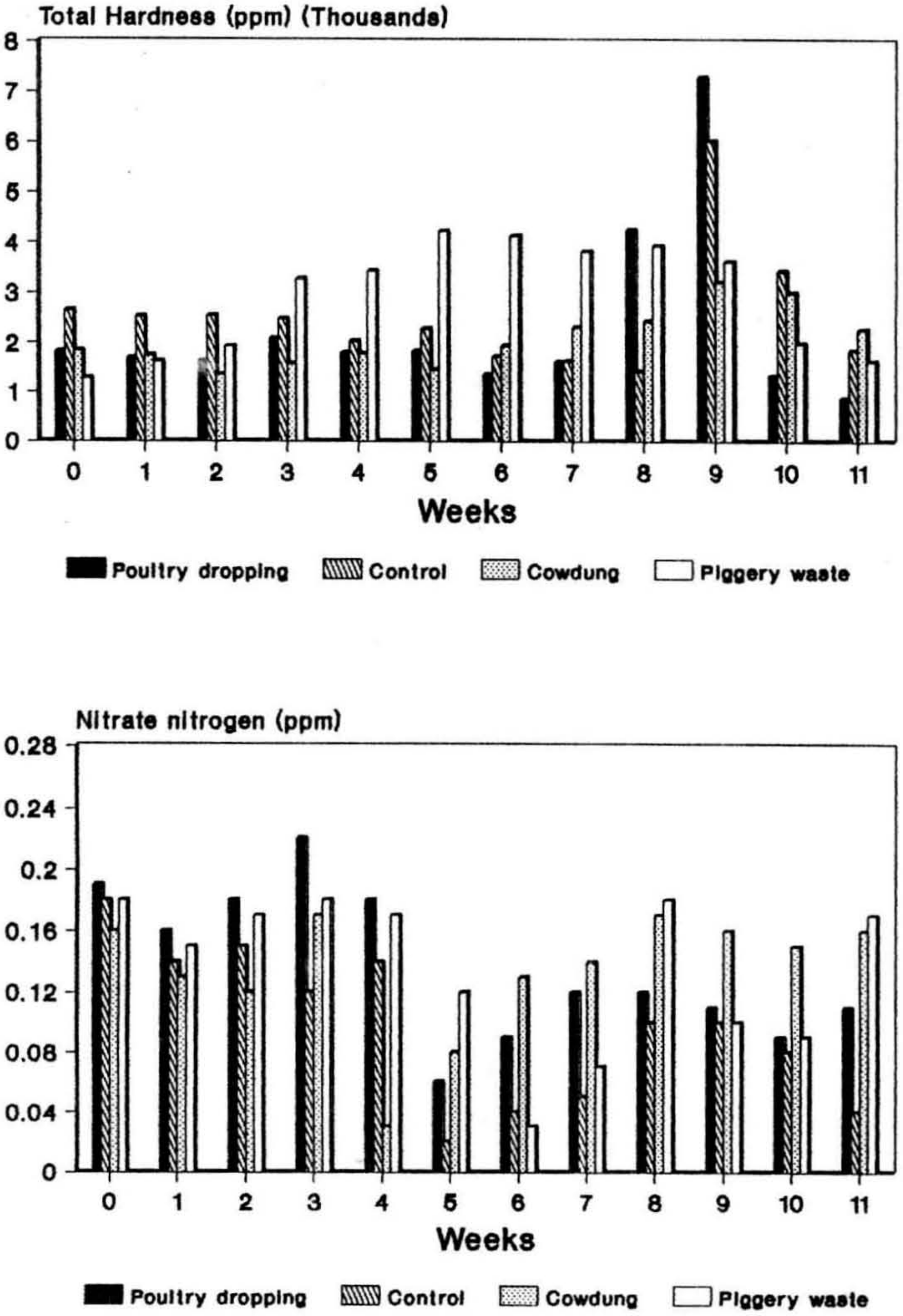
In pond C, the concentration was 0.16 ppm during the zero week and it decreased to 0.13 during the first week. The lowest and highest concentration of 0.03 and 0.17 ppm were

	TOTAL HARDNESS (ppm)				NITRATE NITROGEN (ppm)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	1813.42	2642.89	1832.67	1268.32	0.19	0.98	0.16	0.18
!	1672.95	2513.83	1742.31	1618.99	0.16	0.14	0.13	0.15
2	1618.35	2529.45	1343.91	1916.87	0.18	0.15	0.12	0.17
3	2063.64	2466.81	1564.32	3266.13	0.22	0.12	0.17	0.18
4	1788.32	2018.64	1769.48	3418.64	0.18	0.14	0.03	0.17
5	1818.79	2268.53	1438.67	4216.33	0.06	0.02	0.08	0.12
6	1343.31	1706.99	1918.92	4118.93	0.09	0.04	0.13	0.03
7	1604.10	1605.89	2293.67	3806.11	0.12	0.05	0.14	0.07
8	4245.67	1415.31	2415.63	3916.18	0.12	0.10	0.17	0.18
9	7268.91	6008.78	3205.72	3604.83	0.11	0.10	0.16	0.10
10	1325.72	3410.91	2981.61	1969.76	0.09	0.08	0.15	0.09
11	864.11	1838.64	2243.73	1619.82	0.11	0.04	0.16	0.17
Mean	2285.61 A	2535.56 *A	2062.55 A	2895.08 A	0.14 A	0.10 A	0.13 *A	0.13 A
Correlation r value	0.046 NS	0.182 NS	0.854 NS	0.448 NS	-0.750 NS	-o.512 NS	0.907 S	-0.119 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 26: Total Hardness and Nitrate Nitrogen in water recorded in ponds applied with (A) poultry dropping (B) control (C) cowdung and (D) piggery waste.

Fig.24 **Total Hardness and Nitrate Nitrogen recorded in ponds with organic manures**



recorded during the 4th and 3rd weeks respectively. The concentration recorded were between 0.12 and 0.17 ppm during the weeks 2, 6, 7, 8, 9, 10 and 11th weeks.

In pond D, which was manured with piggery waste, the nitrate concentration indicated the least value of 0.03 during 6th week while the highest value of 0.18 was observed during the zero, 3 and 8th weeks. The nitrate nitrogen concentration in this pond was found fluctating widely with lower values obtained towards the middle of the culture period.

The average nitrate nitrogen concentration in A, B, C and D ponds were 0.14, 0.10, .0.13 and 0.13 ppm respectively.

Anova of nitrate nitrogen concentration at different ponds showed no significant difference (P>0.05). Correlation analysis indicated significant positive relationship between nitrate concentration and growth in pond C. In other ponds no relationship was observed.

B. PHOSPHATE - PHOSPHORUS

The nutrient phosphate concentration in ponds applied with different organic manures is given in table 27 and figure 25.

The concentration recorded in pond A was 0.37 ppm during the zero week which decreased to 0.33 ppm during the first week. The values further showed 2 peaks during the 3rd and 6th weeks, the latter being the maximum value (0.62 ppm) recorded in this pond. During the period 8 to 10th weeks of culture, the phosphate concentration was found steadily declining reaching the lowest range of 0.25 ppm during the 10th week, increasing thereafter to 0.47 ppm during the 11th week.

In control pond B with an obviously lower phosphate regime, the concentration during the zero week was 0.37 ppm which was reduced slightly to 0.35 ppm during dthe first week. During all other weeks, the concentration ranged between 0.20 and 0.34 ppm.

In pond C, where cowdung was used as manure, the phosphate concentration was comparatively high. The concentration recorded during the zero week was 0.46 ppm which declined to 0.27 ppm in the first week. Reflecting the impact of the manure used, the 3rd week recorded the highest value of 1.02 ppm, which however declined during the subsequent weeks to the lowest value of 0.26 ppm during the 10th week. The value showed an increase to 0.49 ppm during the 11th week of culture.

In pond D, where piggery waste was used, the phosphate concentration recorded during the zero week was 0.57 ppm which was found declining to 0.23 ppm during the first week. Maintaining a comparatively low range during the subsequent weeks, the concentration ranged between 0.18 ppm during the 10th week to 0.45 ppm during the 8th week of culture.

The average phosphate concentration recorded was 0.38, 0.29, 0.56 and 0.32 ppm in ponds A, B, C and D respectively.

Anova of phosphate concentration in different ponds showed significant difference ($P<0.05$). Pairwise comparison indicated significant difference in phosphate concentration between ponds A and C, B and C and C and D. Correlation analysis recorded no significant relationship between phosphate concentration and growth of prawns in all ponds.

C. NITRITE - NITROGEN

Table 27 and figure 25 illustrate the nitrite concentration in the ponds applied with various organic manures.

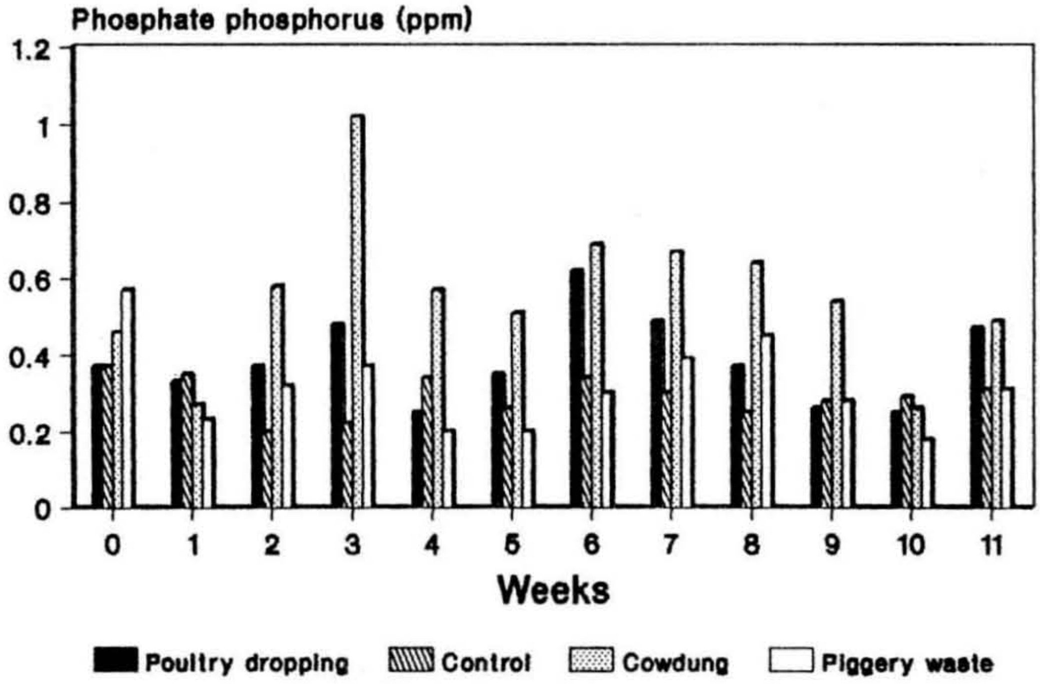
In pond A and C, the values ranged from 0.001 to 0.003 ppm with the higher values noticed during the earlier weeks of culture.

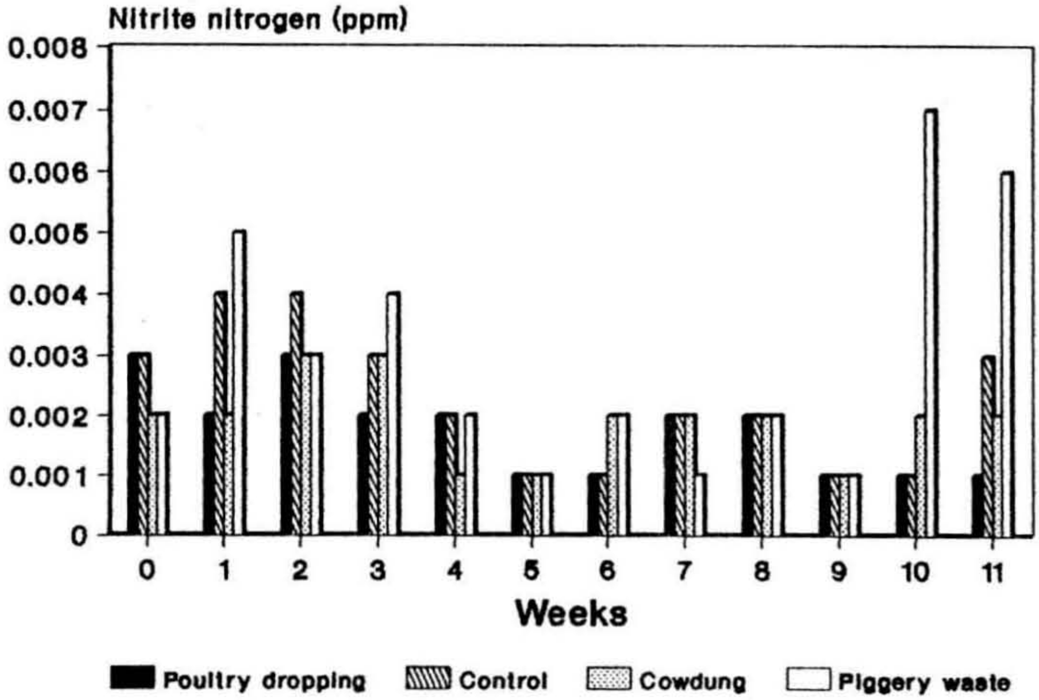
	PHOSPHATE PHOSPHORUS (ppm)				NITRITE NITROGEN (ppm)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	0.37	0.37	0.46	0.57	0.003	0.003	0.002	0.002
1	0.33	0.35	0.27	0.23	0.002	0.004	0.002	0.005
2	0.37	0.20	0.58	0.32	0.003	0.004	0.003	0.003
3	0.48	0.22	1.02	0.37	0.002	0.003	0.003	0.004
4	0.25	0.34	0.57	0.20	0.002	0.002	0.001	0.002
5	0.35	0.26	0.51	0.20	0.001	0.001	0.001	0.001
6	0.62	0.34	0.69	0.30	0.001	0.001	0.002	0.002
7	0.49	0.30	0.67	0.39	0.002	0.002	0.002	0.001
8	0.37	0.25	0.64	0.45	0.002	0.002	0.002	0.002
9	0.26	0.28	0.54	0.28	0.001	0.001	0.001	0.001
10	0.25	0.29	0.26	0.18	0.001	0.001	0.002	0.007
11	0.47	0.31	0.49	0.31	0.001	0.003	0.002	0.006
Mean	0.38*A	0.29 A	0.56*B	0.32 A	0.002 A	0.002*AB	0.002 A	0.003 *B
Correlation r Value	-0.174 NS	0.405 NS	-0.272 NS	0.214 NS	-0.766 NS	-0.462 NS	-0.938 S	0.110 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 27: Phosphate Phosphorus and Nitrite Nitrogen concentrations in water record in ponds applied with (A) poultry dropping (B) control (C) Cowdung and (D) piggery waste.

Fig. 25 **Phospate Phosphorus & Nitrite Nitrogen recorded in ponds with organic manures**





In pond B also, the concentration ranged between 0.001 and 0.004 ppm with the higher values recorded during the earlier weeks.

In pond D, the values ranged between 0.001 and 0.007 ppm. The lowest value of 0.001 ppm being recorded during the weeks 5, 7 and 9. The highest value of .007 ppm was recorded during the 10th week. Comparatively higher values were recorded during earlier weeks.

The average nitrite nitrogen concentration in ponds A, B, C and D were 0.002, 0.002, 0.002 and 0.003 ppm respectively, thereby registering the highest average value in pond applied with piggery waste.

Anova of nitrite concentration in different ponds indicated significant difference ($P<0.01$). Pairwise comparison revealed that the nitrite concentration in pond D is significantly different from that of ponds A and C. Correlation analysis indicated a strong negative relationship between nitrite concentration and growth rate of prawns in pond C.

D. AMMONIA - NITROGEN

The ammonia concentration in different ponds applied with organic manures is given in table 28 and figure 26.

In pond A, applied with poultry manure, the ammonia concentration was found decreasing from the highest value of 0.34 ppm during the zero week to 0.26 ppm in the first week which again decreased during the subsequent weeks. The value varied between 0.10 and 0.17 ppm during the weeks 2, 6, 7, 8 and 11. The concentration was below 0.1 ppm during the weeks 3, 4, 5, 9 and 10.

Maintaining a lower level of ammonia in control pond B, the concentration was 0.12 ppm in the zero week which decreased to 0.09 during the 2nd week of culture. The values later showed an increase to 0.16 ppm during the 3rd week and again during the 6th week (0.10 ppm). The concentration later started declining to a minimum of 0.02 ppm during the 9th week. The highest value of 0.17 ppm was recorded during the 11th week.

In pond C manured with cowdung, the concentration for the zero week was 0.23 ppm which increased to 0.32 ppm in the first week. Thereafter, the value decreased sharply to 0.03 ppm in 3rd and 8th week which further increased 0.31 ppm during 11th week.

In pond D, the concentration during the zero week was 0.17 ppm which increased to 0.18 ppm during the first week. During the subsequent weeks, the value showed a decreasing trend, reaching a low 0.01 ppm during 6th week. The concentration again showed an increase to 0.08 ppm during 10 and 11th weeks.

It is evident from the figure that the ammonia concentration during zero week was high in pond applied with poultry manure but during the last weeks, it was high in pond applied with cowdung.

The aveage ammonia concentration in ponds A, B, C and D was 0.14, 0.09, 0.13 and 0.09 ppm respectively.

Anova of ammonia concentration in different ponds showed no significant difference (P>0.05). Correlation analysis showed that in all ponds there exist no significant relationship between ammonia concentration and growth rate of prawns.

3.1.8 GROSS PRIMARY PRODUCTIVITY

The gross primary productivity values of different ponds applied with organic manures are given in table 28 and figure 26.

In pond A, gross primary productivity was generally showing an increasing trend towards the end of the culture period, the values ranged between 321.94 mgC/M^3/hr of zero week to 2092.35 mgC/M^3/hr during 9th week. The values later decreased to 844.23 mgC/M^3/hr during 11th week.

In control pond B also the gross primary productivity was found decreasing from 423.83 of zero week to 186.30 during 6th week. Subsequently,the value ranged between 698.35 mgC/M^3/hr during 8th week to 1029.13 mgC/M^3/hr during the 9th week. Comparatively lower values were recorded in this pond.

In pond C where cowdung was used as the manure, the primary productivity value was found shooting up from 351.03 mgC/M^3/hr of zero week to 1276.76 mgC/M^3/hr during 4th week. The values later declined to 477.85 mgC/M^3/hr during the 6th week. The maximum value 1117.12 mgC/M^3/hr was noticed during the 7th week, which subsequently declined to 339.58 mgC/M^3/hr during 11th week, towards the end of the experiment.

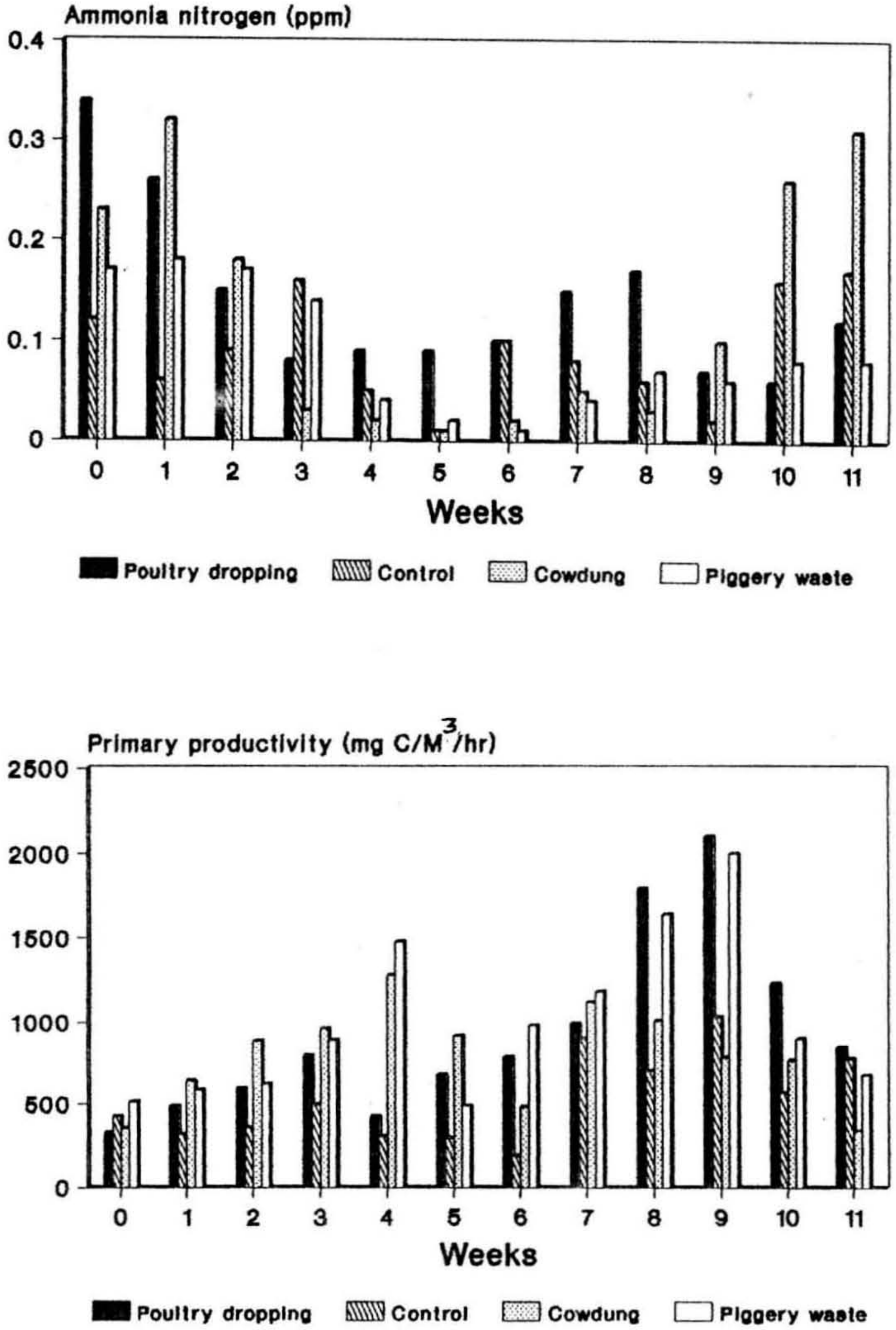
The gross primary productivity in pond D fertilized with piggery waste during the zero week was 511.88 mgC/M^3/hr which was the lowest value observed in this pond. The value gradually increased to 1476.43 mgC/M^3/hr during the 4th week. After showing a reduction to 485.84 mgC/M^3/hr during 5th week, the value again increased to 1178.25, 1636.36 and 1993.95 mgC/M^3/hr during 7, 8 and 9th weeks respectively. The highest gross productivity of 1993.95 mgC/M^3/hr was noticed during the 9th week.

	AMMONIA NITROGEN (ppm)				PRIMARY PRODUCTIVITY (mg. c/m^3/hr)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	0.34	0.12	0.23	0.17	321.94	423.83	351.03	511.88
1	0.26	0.06	0.32	0.18	483.96	314.66	640.81	581.69
2	0.15	0.09	0.18	0.17	592.31	353.38	883.53	616.84
3	0.08	0.16	0.03	0.14	792.07	490.90	960.94	889.27
4	0.09	0.05	0.02	0.04	421.85	302.06	1276.76	1476.43
5	0.09	0.01	0.01	0.02	673.81	291.38	915.94	485.84
6	0.10	0.10	0.02	0.01	781.75	186.30	477.85	979.35
7	0.15	0.08	0.05	0.04	989.50	897.73	1117.12	1178.25
8	0.17	0.16	0.03	0.07	1785.45	698.35	1008.61	1636.36
9	0.07	0.02	0.10	0.06	2092.35	1029.13	780.95	1993.95
10	0.06	0.16	0.26	0.08	1227.56	565.31	765.50	896.04
11	0.12	0.17	0.31	0.08	844.23q	771.59	339.58	672.64
Mean	0.14 *A	0.09 A	0.13 A	0.09 A	917.23*AB	527.05 A	793.22 AB	993.21 B
Correlation r Value	-0.381 NS	0.567 NS	0.099 NS	-0.765 NS	0.553 NS	0.763 NS	-0.217 NS	0.680 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 28: Ammonia-Nitrogen conncentration and primary productivity recorded in water in ponds applied with (A) poultry dropping (B) control (C) cowdung and (D) piggery waste.

Fig. 26 **Ammonia Nitrogen & Primary Productivity recorded in ponds with organic manures**



In all ponds except pond C, the highest value was recorded during the beginning of the later half. In pond C, the highest value was recorded during the end of the first half.

The average gross primary productivity in A, B, C and D ponds were 917.23, 527.05, 793.22 and 993.21 $mgC/M^3/hr$ respectively.

Anova of gross primary productivity in different ponds showed significant difference ($P<0.05$). Pairwise comparison indicated significant difference in values between B and D only. Correlation analysis showed no significant relationship between gross primary productivity and growth of prawns in all ponds.

3.1.9 PHYTOPLANKTON

Details regarding the phytoplankton concentration in ponds fertilised with different manures are furnished in table 29 and figure 27.

It may be seen that invariably in all ponds, the phytoplankton concentration is increasing from the second week of the culture period.

The value of phytoplankton in pond A during the zero week was low being 1.34 ml/M^3 which increased to 4.01 ml/M^3 during the first week. The highest value of 8.36 ml/M^3 was recorded during the 9th week, which however decreased to 5.98 and 5.10 ml/M^3 during 10 and 11th weeks respectively.

In control pond B, genrally low phytoplankton concentration was noticed. During the zero week the value was 0.86 ml/M^3 which increased to 3.84 ml/M^3 during the first week. During the subsequent weeks of culture, the values showed a decreasing trend reaching a low value of 1.86 ml/M^3 during 6th week which however increased to reach a maximum of 5.41 ml/M^3 during the 9th week.

In pond C fertilised with cowdung the lowest concentration of 1.89 ml/M^3 was recorded during the zero week, which gradually increased to the highest value of 6.71 ml/M^3 in the 5th week. The phytoplankton production was found decreasing during the subsequent weeks ranging between 5.66 during 7th week to 2.55 ml/M^3 during the 11th week.

In pond D where piggery waste was used as the manure, the lowest concentration of 1.43 ml/M^3 was recorded in the zero week which gradually increased to a high of 5.40 ml/M^3 during the 5th week. During the subsequent weeks the values within a range of 3.57 and 5.12 ml/M^3 did not show much fluctuation.

The average concentration of phytoplankton in ponds A, B, C and D were 5.09, 3.37, 4.58 and 4.03 ml/M^3 respectively.

Anova of phytoplankton concentration in different ponds applied with organic manures showed significant difference ($P<0.05$). Pairwise comparison indicated significant difference in phytoplankton concentration only between ponds A and B indicating that poultry manure can increase the phytoplankton. Correlation analysis revealed no significant relationship between phytoplankton concentration and growth of prawns in all ponds.

3.1.10 ZOOPLANKTON

Details regarding the zooplankton concentration in different ponds are given in table 29 and figure 27.

As in phytoplankton, zooplankton concentration also indicated an increasing trend towards the second half of the culture period.

In pond A applied with poultry dropping, the concentration was 1.24 ml/M^3 of water during the zero week. After showing a gradual increase to 2.82 ml/M^3 in the 3rd week, the concentration decreased to 1.37 ml/M^3 in 5th week. During the second half of the experiment, the zooplankton concentration was found increasing reaching a maximum of 4.86 ml/M^3 during the 9th week.

In the control pond B with generally a lower range of zooplankton concentration, the values varied between 0.99 ml/M^3 of the first week to 2.32 ml/M^3 of the 7th week.

Among the manured ponds,with a lower range of zooplankton production pond C showed an initial low value of 0.79 ml/M^3 during the zero week which gradually increased to 2.57 ml/M^3 during 3rd week. After showing a reduced value of 1.74 ml/M^3 in 4th week, the concentration again increased to a high of 2.96 ml/M^3 in the 8th week. The value however decreased to 0.62 ml/M^3 during the 10th week.

In pond D fertilized with piggery waste, the zooplankton concentration showed higher values during the 2nd half of the culture period and the maximum concentration obtained was 5.43 ml/M^3 during 8th week. During the first 6 weeks, the values were almost in line with those of other ponds.

The average concentration of zooplankton was 2.70, 1.61, 1.70 and 3.10 ml/M^3 in ponds A, B, C and D respectively.

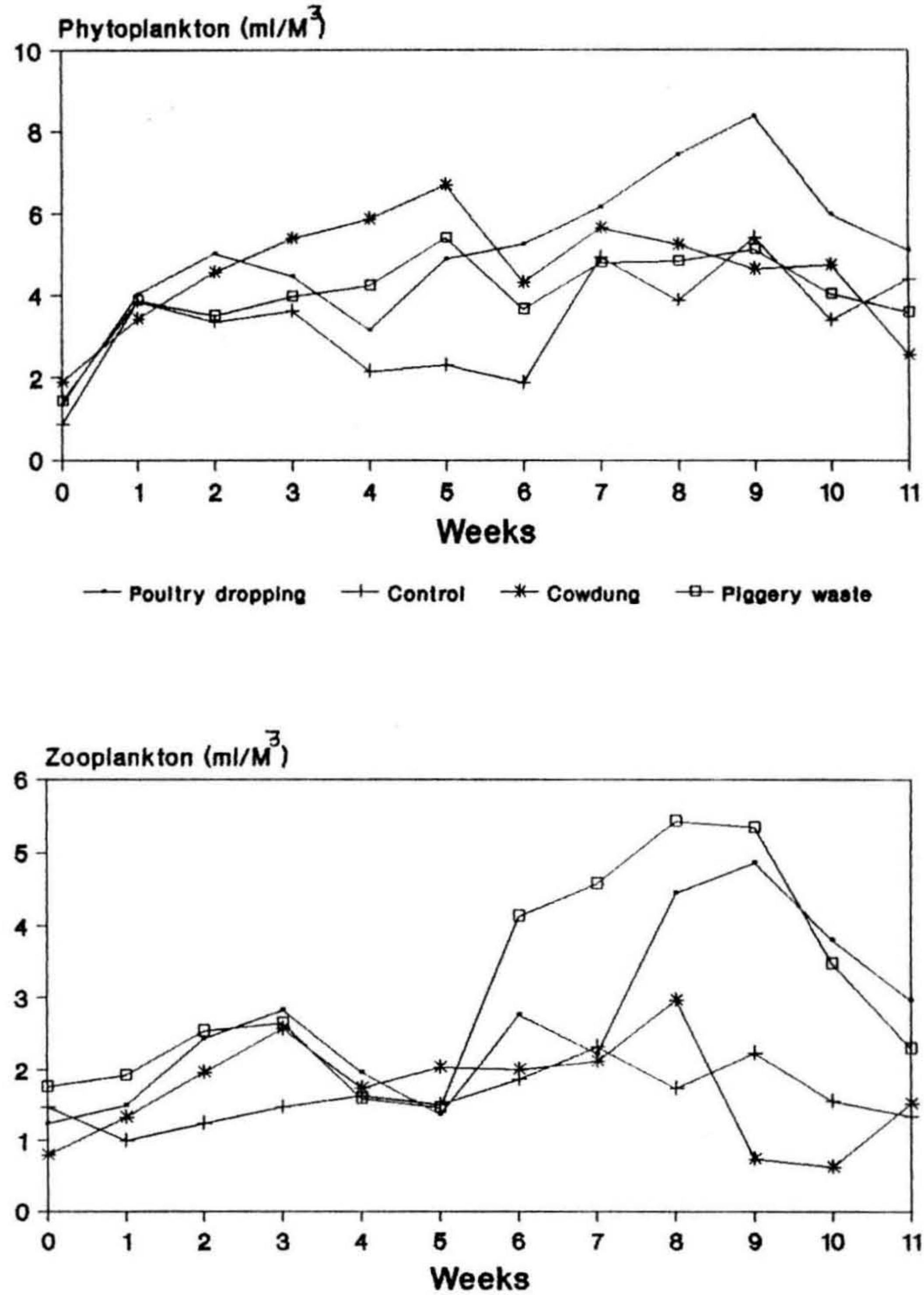
Anova of zooplankton concentration in different ponds showed significant difference ($P<0.01$). Pairwise comparison indicated significant difference between ponds B and D and C and D. Correlation analysis revealed no significant relationship between zooplankton concentration and growth of prawns.

	PHYTOPLANKTON (ml/m^3)				ZOOPLANKTON (ml/m^3)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	1.34	0.86	1.89	1.43	1.24	1.47	0.79	1.76
1	4.01	3.84	3.41	3.86	1.49	0.99	1.32	1.92
2	5.02	3.33	4.56	3.49	2.43	1.24	1.96	2.53
3	4.45	3.60	5.39	3.95	2.82	1.47	2.57	2.64
4	3.14	2.14	5.87	4.23	1.96	1.63	1.74	1.59
5	4.89	2.29	6.71	5.40	1.37	1.50	2.03	1.46
6	5.25	1.86	4.30	3.64	2.76	1.87	2.00	4.13
7	6.16	4.93	5.66	4.79	2.23	2.32	2.12	4.57
8	7.43	3.86	5.23	4.83	4.45	1.74	2.96	5.43
9	8.36	5.41	4.64	5.12	4.86	2.24	0.74	5.35
10	5.98	3.37	4.72	4.01	3.80	1.56	0.62	3.47
11	5.10	4.38	2.55	3.57	2.96	1.34	1.53	2.30
Mean	5.09 *A	3.32 *B	4.58 AB	4.03 AB	2.70 *AB	1.61 *A	1.70 A	3.10 B
Correlation r Valaue	0.392 NS	0.518 NS	-0.158 NS	0.653 NS	0.623 NS	0.146 NS	-0.080 NS	0.623 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 29: Phytoplankton and Zoplankton concentration recorded in ponds applied with (A) Poultry dropping (B) control (C) cowdung and (D) piggery waste.

Fig. 27 Phytoplankton & Zooplankton conc. recorded in ponds with organic manures



3.1.11 HETEROTROPHIC ACTIVITY

Heterotrophic activity in water in ponds fertilised with organic manures was determined by the reduction in weight of a cotton strip suspended for 5 days and expressed as percentage reduction in weight per day.

In pond A fertilised with poultry manure, the heterotrophic activity was 0.25% during the zero week which increased to 0.59% during 8th week. The values later decreased to 0.33% during the 11th week.

In control pond B, the value for the zero week was 0.33% which was the lowest value observed during the culture period. Later the value increased to a high of 0.50% during the 4th week and further decreased to reach a value of 0.40% during the 11th week.

In pond C fertilised with cowdung, the activity was 0.53% during the zero week which increased to the higher value of 0.84% during the 6th week. The lowest value recorded was 0.52% during the 8th week.

In pond D, manured with piggery waste, the value increased to the highest level of 1.13 during the 6th week from 0.33% of the zero week. The value recorded during the last week was 0.83%.

	HETEROTROPHIC ACTIVITY OF WATER (% Reduction in weight/day)			
Treatment Weeks	A	B	C	D
0	0.25	0.33	0.53	0.33
2	0.23	0.49	0.64	0.28
4	0.31	0.50	0.65	0.33
6	0.37	0.43	0.84	1.13
8	0.59	0.39	0.52	1.05
10	0.43	0.36	0.56	0.99
11	0.33	0.40	0.53	0.83
Mean	0.36 A	0.41 *AB	0.61 AB	0.71 *B
Correlation r Value	0.580 NS	-0.941 S	-0.427 NS	0.914 S

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 30: Heterotrophic Activity of water recorded in ponds applied with (A) poultry dropping (B) Control (C) Cowdung and (D) Piggery waste

In all ponds, the value was found be higher during the middle period.

The average heterotrophic activity in A, B, C and D ponds were 0.36, 0.41, 0.61 and 0.71% respectively. The highest average value was recorded in pond applied with piggery waste.

Anova of heterotrophic activity of water in different ponds showed significant difference ($P<0.05$) and pairwise comparison indicated significant difference between ponds A and D and not among any other ponds. Correlation analysis showed significant negative relationship between heterotrophic activity in water and growth of prawns in pond B and positive relationship in pond D.

3.2 SOIL QUALITY PARAMETERS

3.2.1 SOIL pH

Details regarding the pH of soil in different ponds applied with organic manures are given in table 31 and figure 28.

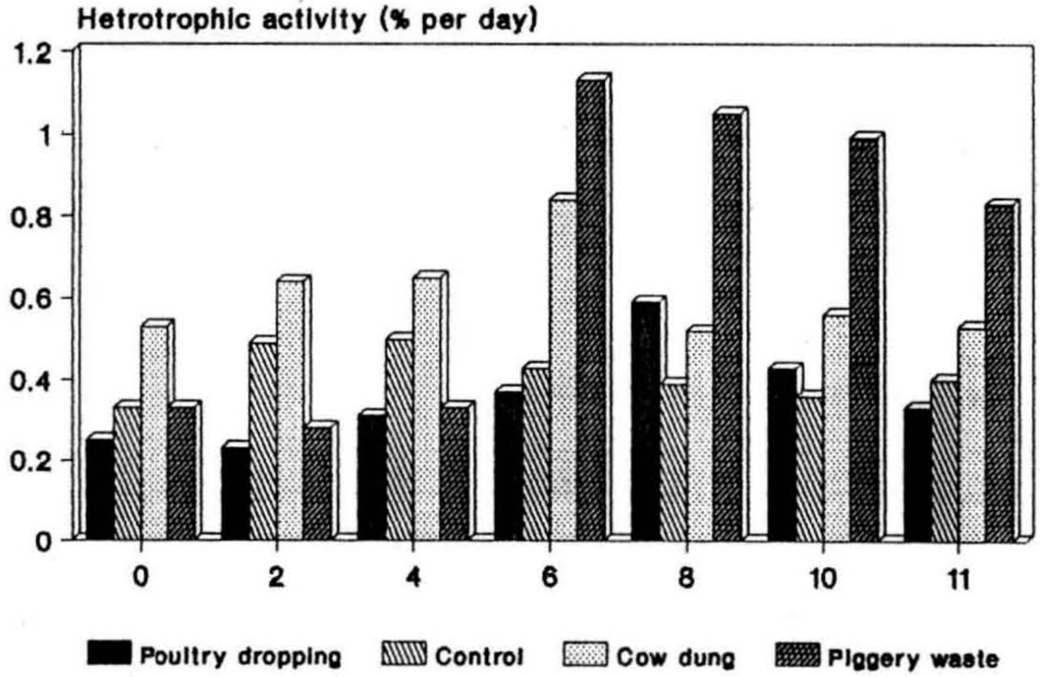
In pond A, the soil pH was 7.71 during the zero week which increased to a minimum of 7.04 during the 10th week. The value recorded during the 11th week was 6.99.

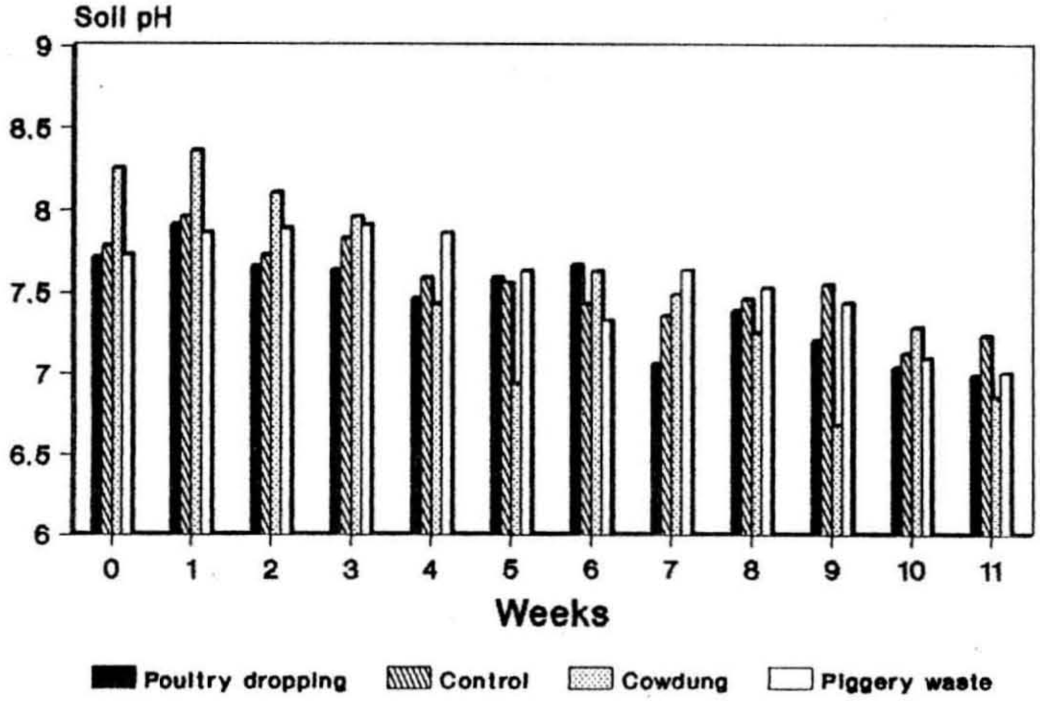
	SOIL P^H			
Treatment Weeks	A	B	C	D
0	7.71	7.78	8.25	7.73
1	7.91	7.96	8.36	7.86
2	7.66	7.73	8.10	7.89
3	7.64	7.83	7.96	7.91
4	7.46	7.59	7.43	7.86
5	7.59	7.56	6.94	7.63
6	7.67	7.43	7.63	7.33
7	7.06	7.36	7.49	7.64
8	7.39	7.46	7.26	7.53
9	7.21	7.55	6.68	7.44
10	7.04	7.13	7.29	7.10
11	6.99	7.24	6.86	7.01
Mean	7.44 *A	7.55 A	7.52 *A	7.58 *A
Correlation r Value	-0.867 S	-0.899 S	-0.918 S	-0.666 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 31: Soil P^H recorded in ponds applied with
(A) poultry dropping, (B) control (C) cowdung and (D) piggery waste.

Fig. 28 Heterotrophic activity & Soil pH recorded in ponds applied with organic manures





In pond B, the pH was 7.78 during the zero week which increased to the highest value of 7.96 during the first week. The minimum value of 7.13 was recorded during the 10th week.

In pond C, the pH recorded in zero and first week were 8.25 and 8.36 respectively. The lowest value of 6.68 was recorded in the 9th week and the highest value of 8.36 during the first week.

In pond D, the pH was 7.73 in the zero week which gradually increased to the highest value of 7.91 during the 3rd week. Thereafter the values gradually decreased to 7.01 in the 11th week.

The average soil pH values recorded in ponds A, B, C and D were 7.44, 7.55, 7.52 and 7.58 respectively.

Anova of soil pH at different ponds showed no significant difference (P>0.005). Correlation analysis indicated significant negative relationship between soil pH and growth of prawns.

3.2.2 ORGANIC CARBON

In pond A, the organic carbon during the zero week was 2.38% followed by an increase to 2.50 during the second week. The values were found declining thereafter reaching to a minimum of 1.04% during the 8th week. (table 32 and figure 29).

In control pond B, the organic carbon content was 0.96% during the zero week which increased to the highest value of 1.19% during the 8th week. The 10th week indicated the lowest value of 0.79%. In general the organic carbon in pond B was comparatively low than those of other ponds.

Pond C showed a value of 3.32% during the zero week followed by 3.56% in the second week. The values ranged between 2.08% and 2.93% during the weeks 4 to 10 and the lowest value of 1.81% was recorded during the 11th week. Among different ponds, in all weeks, higher values were recorded in this pond indicating that application of cowdung can increase the organic carbon content.

The soil in pond D was with less (0.50%) organic carbon content during the zero week, which increased gradually through the culture period reaching the highest value of 1.41% during the 11th week.

The average organic carbon content in ponds A, B, C and D were 1.64, 1.02, 2.62 and 1.01% respectively, anova of which showed significant difference ($P<0.05$). Pairwise comparison showed that the organic carbon content was significantly different among the ponds B and C and C and D. Correlation analysis indicated that in ponds A and C, there exists significant negative relationship between organic carbon content and growth of prawns.

3.2.3 TOTAL NITROGEN

Particulars regarding the total nitrogen concentration in soil in different ponds are given in table 32 and figure 29.

In pond A, the concentration was 0.09% during the zero week. The value increased to the highest value of 0.17% during the second week, which however decreased to 0.15% during the 4th week. The lowest value of 0.06% was recorded during 6th and 8th week. During the other weeks of culture also the values recorded were below 0.1%.

In pond B, zero week indicated the highest concentration of 0.15% which declined steepily to a low of 0.06% in the second week. The values recorded subsequently during the 4, 6 and 8th weeks were above 0.1% with the concentrations declining thereafter.

In pond C, the concentration increased from 0.19% during the zero week to 0.21% in the 2nd week and 0.24% in 4th week. Thereafter the values ranged between 0.14 and 0.18%. Among all pond, this pond showed higher values.

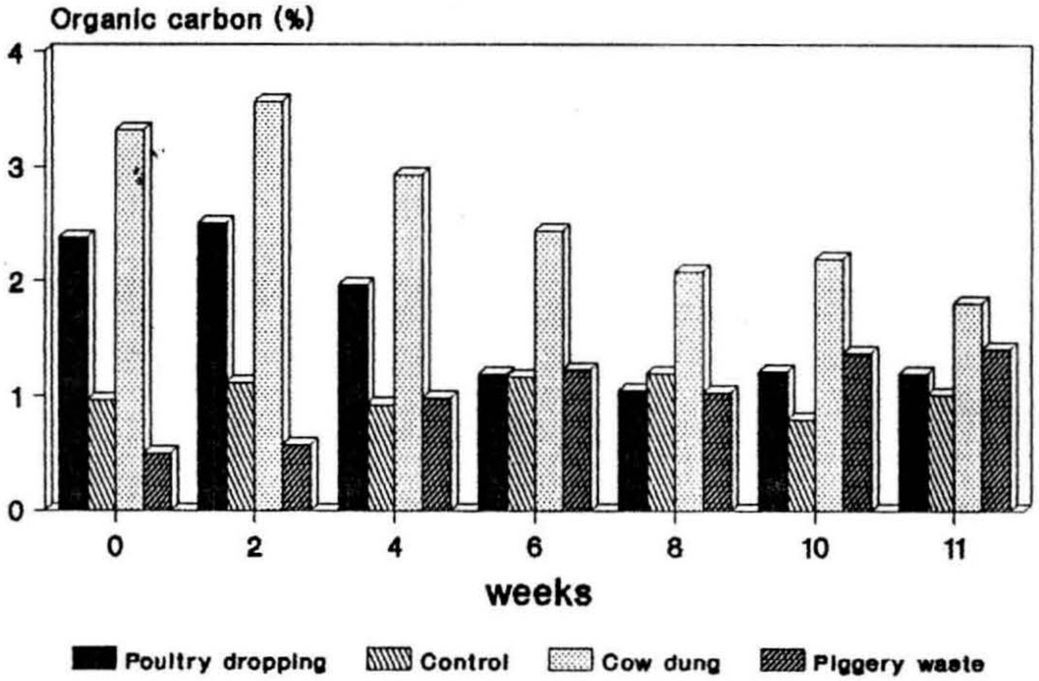
In pond D, the concentration during the zero week was 0.06% followed by 0.05% in the second week. The weeks 4 to 11 showed values ranging between 0.09 and 0.14%.

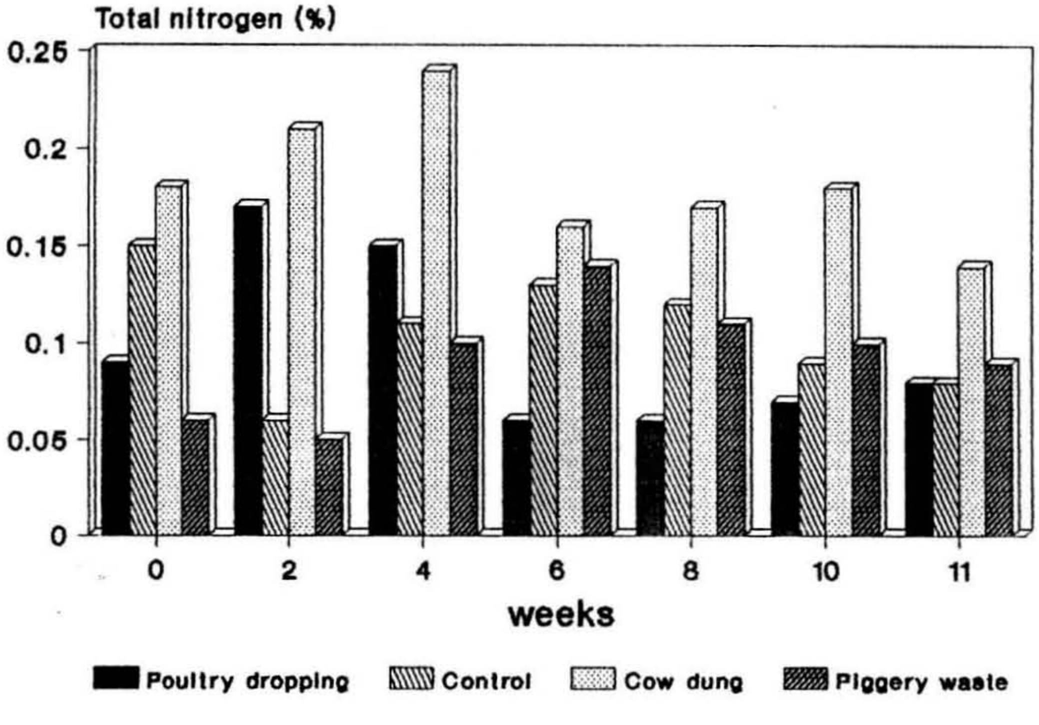
	ORGANIC CARBON %				**TOTAL NITROGEN %**			
Treatment Weeks	A	B	C	D	A	B	C	D
0	2.38	0.96	3.32	0.50	0.09	0.15	0.18	0.06
2	2.50	1.11	3.56	0.57	0.17	0.06	0.21	0.05
4	1.96	0.92	2.93	0.98	0.15	0.11	0.24	0.10
6	1.18	1.16	2.44	1.22	0.06	0.13	0.16	0.14
8	1.04	1.19	2.08	1.03	0.06	0.12	0.17	0.11
10	1.21	0.79	2.20	1.37	0.07	0.09	0.18	0.10
11	1.19	1.01	1.81	1.41	0.08	0.08	0.14	0.09
Mean	1.64	1.02	2.62	1.01	0.10	0.11	0.18	0.09
Correlation r Value	-0.861 S	-0.607 NS	-0.977 S	0.760 NS	-0.749 NS	0.164 NS	-0.775 NS	0.721 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 32: Organic Carbon and Total Nitrogen in Soil recorded in ponds applied with (A) poultry dropping (B) control, (C) cowdung and (D) piggery waste.

Fig. 29 **Organic Carbon & Total Nitrogen recorded in ponds applied with organic manures**





The average values recorded in ponds A, B, C and D were 0.10, 0.11, 0.18 and 0.09% respectively. Anova of total nitrogen at different ponds showed significant difference ($P<0.01$). Pairwise comparison indicated that the value in pond C is significantly different with the values in all other ponds. Correlation co-efficient revealed no significant relationship between total nitrogen and growth of prawns.

3.2.4 C/N RATIO

The ratio between the organic carbon and total nitrogen content of the soil was reckoned as the C/N ratio.

In pond A, the C/N ratio indicated the maximum value of 25.31 during the zero week. Subsequently, the ratio declined to a minimum of 13.38 in the 11th week.

In pond B, the lowest C/N ratio observed was 6.13 during the zero week, which increased to the highest value of 17.39 during the second week. C/N ratio later was decreased to 8.19 and 12.55 during the 10th and 11th weeks respectively.

In pond C, however, the maximum value of 17.95 was noticed in the zero week. Subsequently the value decreased to a low of 11.86 during the 10th week.

As in pond B, the C/N ratio in pond D also was the lowest, the value being 7.38. Later the C/N ratio increased gradually reaching to the highest value of 15.08 during the 11th week.

The average value of C/N ratio were 16.83, 10.10, 13.98 and 10.38 in ponds A, B, C and D respectively, indicating the highest value in pond applied with poultry dropping.

Anova of C/N ratio in different ponds showed significant difference ($P<0.01$). Pairwise comparison indicated that C/N ratio in pond A is significantly different from that of ponds B and D. Correlation co-efficient showed negative relationship only in pond C between C/N ratio and growth of prawns.

3.2.5 TOTAL PHOSPHORUS

Details regarding the concentration of total phosphorus in different ponds applied with organic manures are given in table 33 and figure 30.

In pond A, fertilised with poultry manure the concentration of phosphorus during the zero week was 608.23 ppm. The lowest and the highest values of 598.57 and 808.10 ppm were observed during the 6th and 10th weeks respectively.

In pond B which is the control, the value obtained during the zero week was 714.43 ppm which got reduced to the lowest value of 673.54 ppm during the 2nd week. The highest value of 899.34 ppm was recorded during the 11th week.

In pond C, manured with cowdung, the total phosphorus content of soil in general was comparatively high. The phosphorus content during the zero week was 827.54 ppm, which showed an increase to 941.56 ppm during the 2nd week. The value later got reduced to a low of 814.58 ppm during the 6th week. The highest value of 1163.81 ppm was observed in the 10th week.

In pond D, fertilised with pigdung, the phosphorus content was comparatively low. In this pond the total phosphorus content in the soil during the zero week was 692.23 ppm which reduced to the lowest value of 605.38 ppm in the 4th week. The highest value of 787.10 ppm was recorded during the 11th week.

The average concentration of total phosphorus in ponds A, B, C and D were 723.81, 752.36, 985.39 and 690.43 ppm respectively.

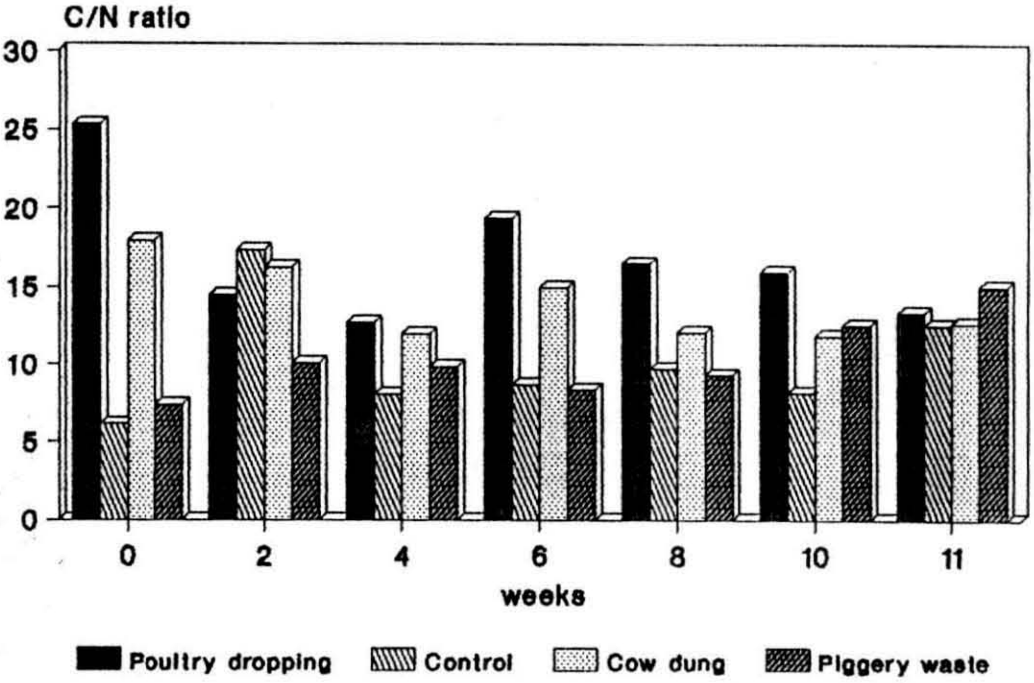
Anova of total phosphorus at different ponds showed significant difference ($P<0.01$). Pairwise comparison indicated that total phosphorus in pond C is significantly different from that of ponds A, B and D. Correlation analysis revealed that, in no ponds there exists a significant relationship between total phosphorus and growth rate of prawns.

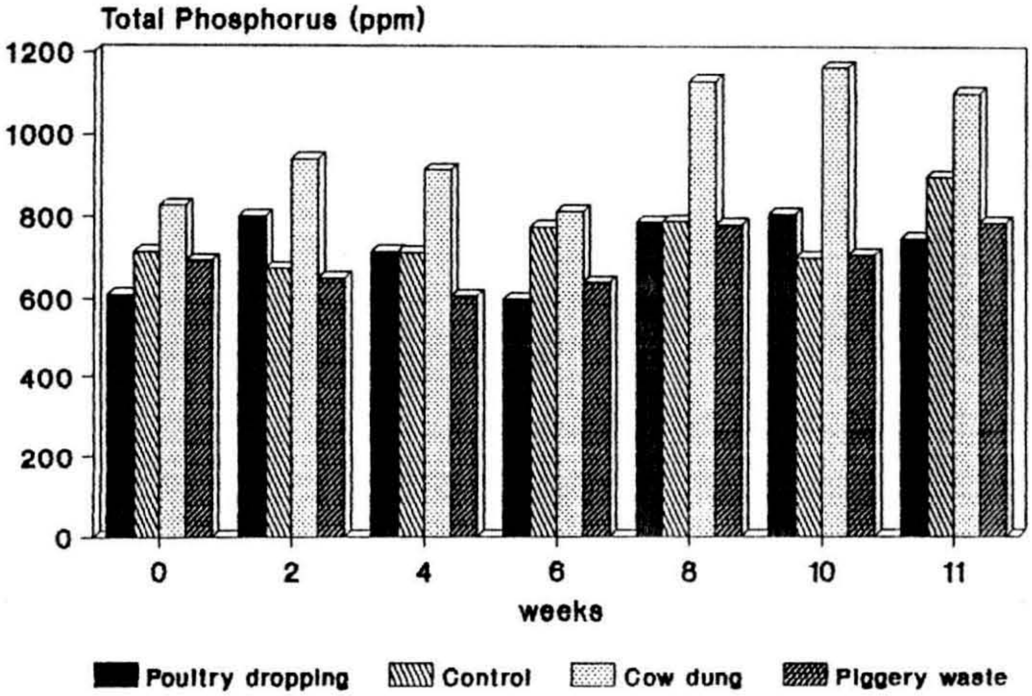
	C/N RATIO				TOTAL PHOSPHORUS (ppm)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	25.31	6.13	17.95	7.38	608.23	714.23	827.54	692.23
2	14.46	17.39	16.26	10.10	801.54	673.54	941.67	648.63
4	12.76	8.06	12.00	9.84	714.37	711.83	914.67	605.38
6	19.39	8.68	15.01	8.37	598.57	776.52	814.58	639.61
8	16.53	9.72	12.13	9.31	787.54	789.53	1131.25	752.39
10	15.98	8.19	11.86	12.57	808.10	701.37	1163.81	707.67
11	13.38	12.55	12.68	15.08	748.31	899.34	1104.32	787.10
Mean	16.83 A	10.10 *B	13.98 *AB	10.38 *B	723.81 A	752.36 *A	985.39 *B	690.43 A
Correlation r value	-0.112NS	-0.625 NS	-0.928 S	0.114 NS	0.096 NS	0.429 NS	0.626 NS	0.603 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 33: C/N ratio and Total Phosphorus in soil recorded in ponds applied with (A) poultry manuring (B) control (C) cowdung and (D) piggery waste.

Fig. 30 C/N ratio and Total Phosphorus recorded in ponds applied with organic manures.





3.2.6 GRAIN SIZE ANALYSIS

For grain size analysis, a total of 8 soil samples were taken from different areas and were pooled together. A subsample was then taken for analysis.

In pond A, the sand, silt and clay content recorded were 70.59%, 13.05 and 16.36% respectively. In pond B, the corresponding values were 64.72%, 15.28% and 20.00% respectively. In pond C and D, the sand, silt and clay content were 75.92 and 67.50%, 8.63 and 12.78% and 15.45 and 19.72% respectively.

3.2.7 HETEROTROPHIC ACTIVITY

Heterotrophic activity was measured as percentage reduction in weight/day of a spreaded cotton strip over the bottom and the values obtained in different ponds are given in table 34 and figure 31.

In pond A, the values during the weeks zero to 8 were between 2.01% and 2.91%/day. The values observed during the 10th and 11th weeks were 1.62 and 1.89%/day respectively.

In pond B, the values obtained were of a low range varying between 0.86% of the 2nd week to 1.53% in the 11th week.

In pond C, except during 4th week, the rest of the culture period showed values ranging between 1.02 and 1.62%/day. During the 4th week, the value observed was 0.94%/day.

In pond D, during the zero week, the value observed was 1.93%/day, which increased to reach the highest value of 2.98%/day during the 8th week. During the subsequent weeks of culture, the values got reduced with the lowest value of 1.71%/day recorded during the 11th week.

The average heterotrophic activity in sediment of ponds A, B, C and D were 2.29, 1.16, 1.14 and 2.23%/day respectively indicating that the values were higher in ponds applied with poultry dropping and piggery waste.

Anova of heterotrophic activity at different ponds indicated significant difference (P<0.01). Pairwise comparison showed that the ponds A and B, A and C, B and D, and C and D were significantly different with respect to heterotrophic activity. Correlation co-efficient showed no significant relationship between heterotrophic activity of mud and growth of prawns.

3.2.8 RESPIRATION RATE OF MUD

The respiration rate of mud in different ponds is given in table 34 and figure 31.

In pond A, the lowest value of 0.11 mg O_2/hr was recorded during the zero week. The value increased to a high of 0.56 mg O_2/hr during the 4th week. Subsequently, the value decreased to 0.22 mg O_2/hr during the 8th and 11th week.

In pond B also the lowest value of 0.16 mg O_2/hr was noticed during the zero week. After recording a high of 0.73 mg O_2/hr in the 4th week, the value again decreased to 0.33 mg O_2/hr in the 11th week.

Indicating a low value 0.21 mg O_2/hr during the zero week in pond C, the respiration rate increased to a high of 0.91 mg O_2/hr in the 10th week.

In pond D, also the lowest value of 0.14 mg O_2/hr was recorded in the zero week. Subsequently, the value increased to a maximum of 0.91 mg O_2/hr in the 6th week, which decreased to 0.20 mg O_2/hr in the 11th week. In all ponds, the values were higher which indicated that manure application can increase the respiration rate of mud.

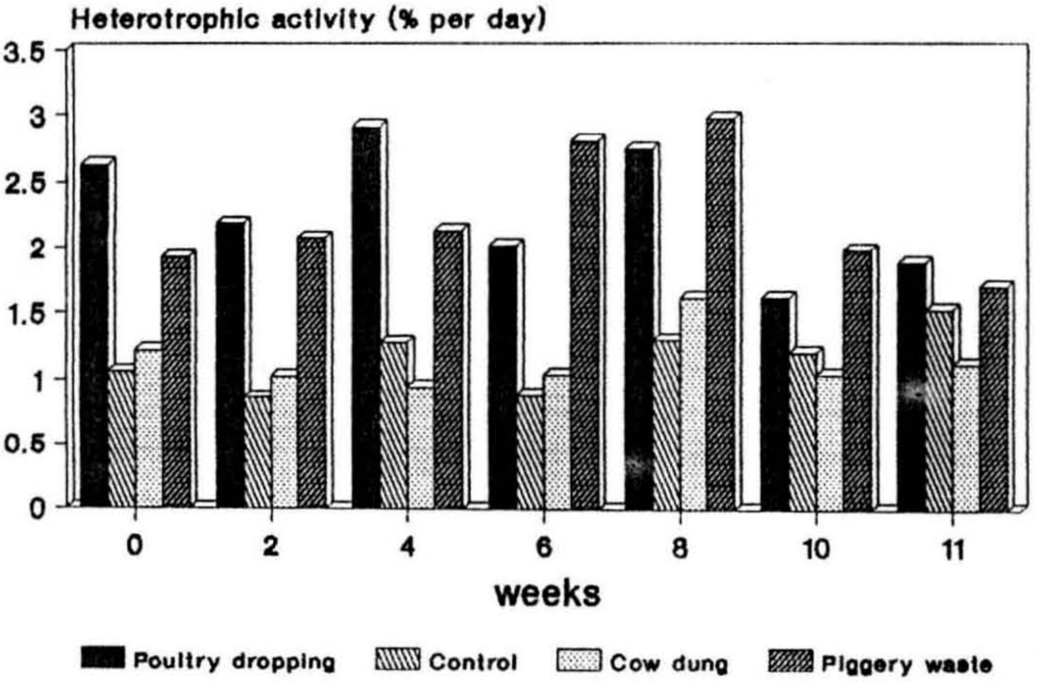
The average respiration rate of mud in ponds A, B, C and D were 0.31, 0.33, 0.58 and 0.46 mg O_2/hr respectively.

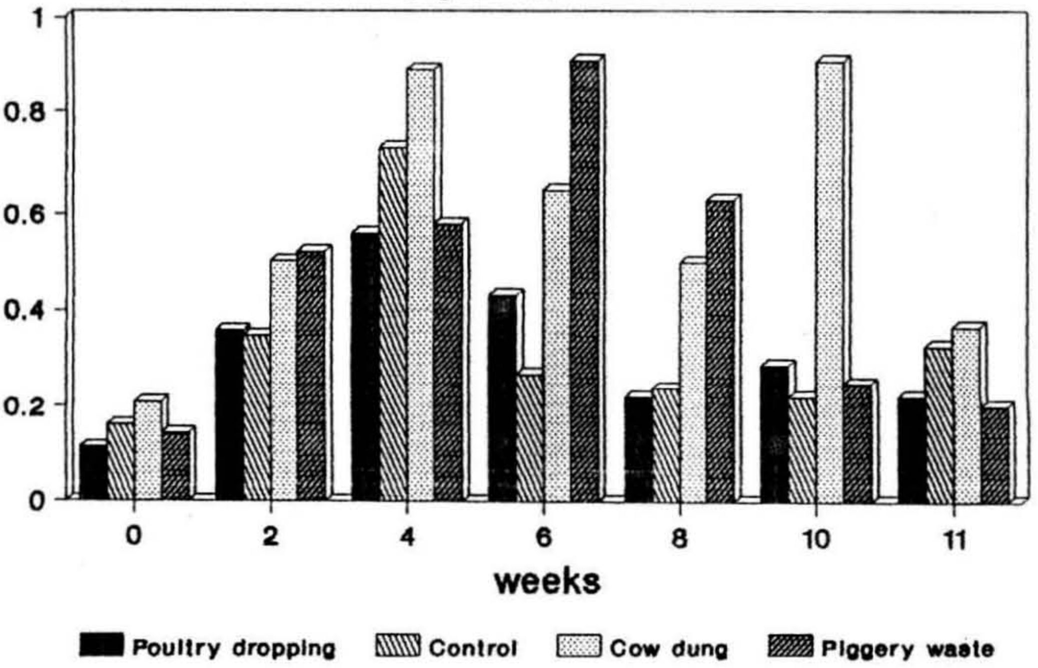
	HETEROTROPHIC ACTIVITY OF SEDIMENT % reduction in weight/day				RESPIRATION RATE OF MUD (mg.02/hr/100 ml mud)			
Treatment Weeks	A	B	C	D	A	B	C	D
0	2.26	1.06	1.22	1.93	0.11	0.16	0.21	0.14
2	2.18	0.86	1.02	2.07	0.36	0.35	0.50	0.52
4	2.91	1.28	0.94	2.13	0.56	0.73	0.89	0.58
6	2.01	0.88	1.03	2.81	0.43	0.27	0.65	0.91
8	2.75	1.30	1.62	2.98	0.22	0.24	0.50	0.63
10	1.62	1.20	1.03	1.98	0.29	0.22	0.91	0.25
11	1.89	1.53	1.11	1.71	0.22	0.33	0.37	0.20
Meam	2.29 A	1.16 B	1.14 B	2.23 A	0.31 A	0.33 A	0.58 A	0.46 A
Correlation r value	-0.217 NS	0.823 NS	0.468 NS	0.374 NS	-0.712 NS	-0.597 NS	0.126 NS	-0.015 NS

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 34: Heterotrophic activity and Respiration rate of mud recorded in ponds applied with (A) poultry dropping (B) control (C) cowdung and (D) piggery waste.

Fig. 31 Heterotrophic activity and Respiration rate of mud recorded in ponds





Anova of respiration rate of mud at different ponds showed no significant difference ($P>0.05$). Correlation analysis showed no significant relationship between respiration rate of mud and growth of prawns in all ponds.

3.2.9 BENTHOS

Particulars on the wet weight of benthos collected from sediment at different ponds are given in table 35 and figure 32.

In pond A, fertilised with poultry manure, the biomass of benthos during the zero week was 14.68 mg/M^2 which after showing a reduction during the first week to 10.54 mg/M^2 increased further to a high of 24.34 mg/M^2 during the 3rd week. Thereafter the value declined reaching a low of 3.32 mg/M^2 during the 6th week. During the subsequent weeks, the values ranged between 5.68 mg/M^2 during 8th weeks to 10.64 mg/M^2 during 7th week.

In pond B, which is the control pond, the benthic biomass was high during the zero week to 5th week . The values ranged between 15.80 to 17.04 mg/M^2, with the peak value of 22.68 mg/M^2 recorded during the 2nd week. The concentration indicated a drastic reduction to 1.30 mg/M^2 during the 6th week and continued to remain comparatively low within the range of 2.63 to 8.36 mg/M^2 during the rest of the culture period.

In pond C, fertilized with cowdung, the highest concentration of 18.64 mg/M^2 recorded in zero week started declining to 3.37 mg/M^2 in 2nd week. During the second half of the experiment also, the benthic biomass was low except during the 7th week, when the value indicated a high of 14.04 mg/M^2.

With a sharp decline in the benthic biomass during the culture period, pond D fertilized with piggery waste had the maximum value of 13.86 mg/M^2 during the first week. The value declined to 0.87 mg/M^2 during the 11th week, towards the end of the experiment. It may be noticed that the benthic biomass in all the ponds showed a decline towards the end of culture period.

The average concentration of benthos recorded in ponds A, B, C and D were 11.50, 10.40, 7.01 and 5.09 mg/M^2 respectively indicating higher values in pond applied with poultry dropping.

Anova of benthos concentration in different ponds applied with organic manures showed significant difference ($P<0.05$). Pairwise comparison indicated significant difference only between A and D ponds. Correlation analysis revealed a strong negative relationship between benthos concentration and growth of prawns in pond D only.

BENTHOS wet weight (mg) / m^2				
Treatment weeks	A	B	C	D
0	14.68	15.80	18.64	7.49
1	10.54	13.64	9.83	13.86
2	16.01	22.68	3.37	13.32
3	24.34	15.33	3.64	5.64
4	21.03	12.67	4.05	6.05
5	9.64	17.04	9.06	4.32
6	3.32	1.30	5.03	4.15
7	10.64	3.34	14.04	2.24
8	5.68	8.36	4.62	1.01
9	5.37	5.35	3.89	1.04
10	7.38	2.63	4.93	1.16
11	9.39	6.68	3.00	0.87
Mean	11.50*A	10.40 *AB	7.01 AB	5.09 B
Correlation r value	-0.557 NS	-0.638 NS	0.316 NS	-0.961 S

* Any two means having a common letter are not significantly different. S - Significant, NS - Not Significant

Table 35: Benthos concentration recorded in ponds applied with (A) poultry dropping (B) control (C) cowdung and (D) piggery waste.

3.3 GROWTH AND PRODUCTION

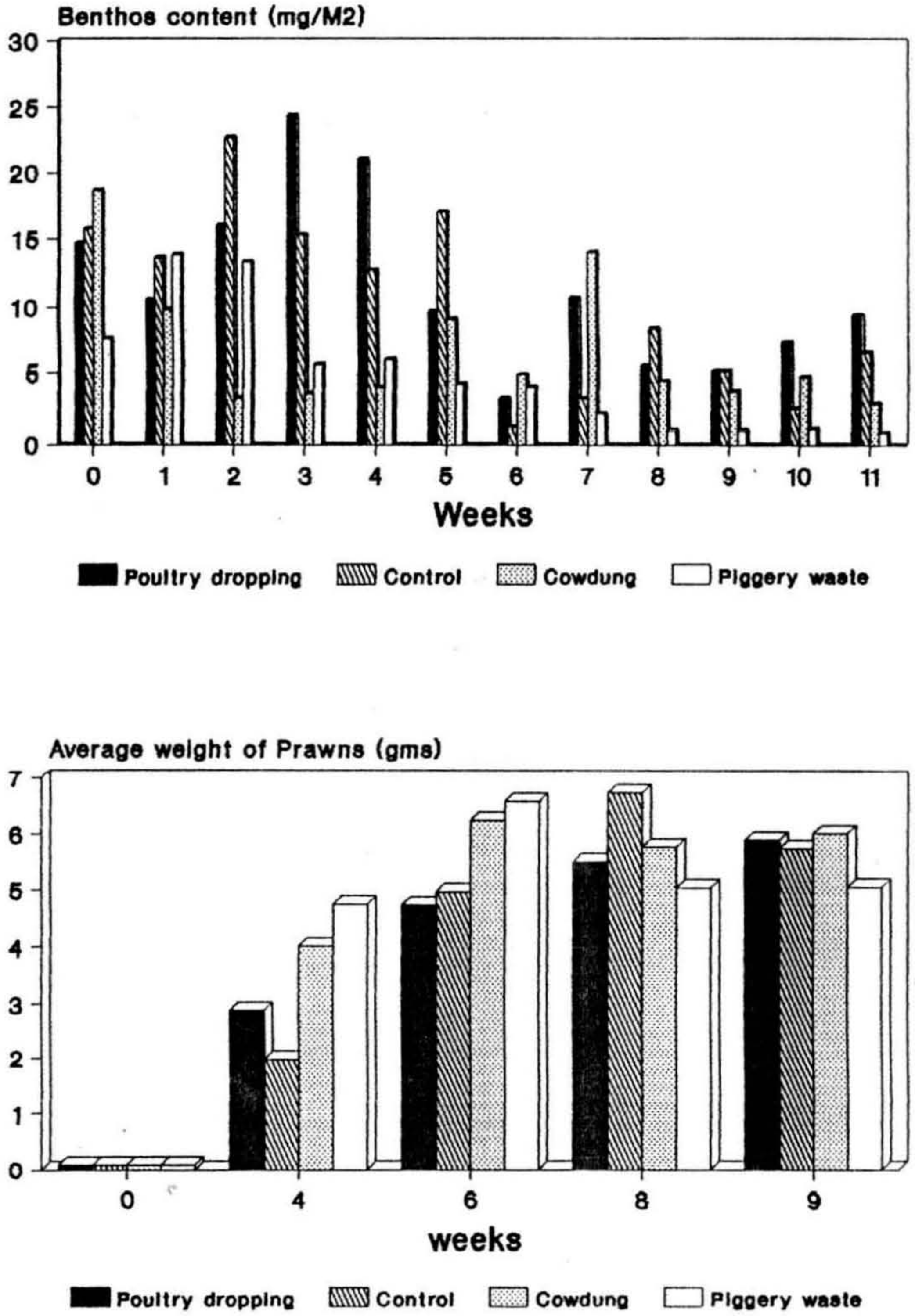
Average weight, growth rate per day, survival rate and estimated production of prawns in ponds applied with different organic manures are given in table 36 and 37 and figure 32.

In all ponds, the average weight of prawns at the time of stocking was 0.084 gms. It is noticable that the average weight of prawns in all four ponds during the fourth week registered an increase, the values being 2.876, 4.007 and 4.761 gms in ponds applied with poultry dropping, cowdung and piggery waste respectively. In the control pond, the average weight recorded was 1.988 gms. The growth rates of prawns for the period zero to 4th weeks were 0.009, 0.140 and 0.167 gms/day in ponds applied with poultry dropping, cowdung and piggery waste respectively, while in control pond it was 0.680 gms/day indicating that the growth rate is highest in pond applied with piggery waste followed by the pond applied with cowdung. Subsequently after the 5th week, difference in growth at different ponds was discernible. From table 36, it can be seen that while there is an increase in average weight in ponds applied with poultry manure and control pond, a decrease in average weight was observed in ponds applied with cowdung and piggery waste. Therefore in these two ponds a negative growth rate (-0.033 and -0.109 gms/day) was observed. However, anova of average weight at different ponds applied with organic manures showed no significant difference ($P<0.05$).

AVERAGE WEIGHT (gms)					GROWTH RATE gm/day				
Treatment Weeks	A	B	C	D	Weeks	A	B	C	D
0	0.084	0.084	0.084	0.084	0 - 4	0.099	0.068	1.140	0.167
4	2.876	1.988	4.007	4.761	4 - 6	0.133	0.214	0.161	0.131
6	4.745	4.984	6.262	6.601	6 - 8	0.056	0.127	-0.633	-0.109
8	5.530	6.762	5.795	5.067	8 - 9	-0.055	-0.141	0.035	0.013
9	5.916	5.771	6.041	5.080					

Table 36: Average weight and growth rate of prawns recorded in different ponds applied with (A) poultry dropping (B) control (C0 cowdung and (D) piggery waste.

Fig. 32 **Benthos content & Average wt. of Prawns in ponds applied with organic manures**



Pond No	Area (ha)	Stocking density No./ha	Survival rate %	Production Kg/ha
A	0.04	50,000	91.19	269.73
B	0.04	50,000	62.46	180.23
C	0.05	50,000	43.97	132.83
D	0.03	50,000	77.48	196.78

Table 37: Area of pond, stocking density, survival rate and production recorded in ponds applied with (A) poultry manure (B) control (C) cowdung and (D) piggery waste.

Table 38: Analysis of variance of various parameters recorded in Chapter II.

				F Value	
Source	D.F	S.S.	M.SS	Calculated	Tabled
Temperature (table 22)					
Treatment	3	0.159	0.053	0.035	2.82
Error	44	65.687	1.492		
Total	47	65.846			
Salinity (table 22)					
Treatment	3	31.92	10.64	2.130	2.82
Error	44	219.73	4.99		
Total	47	251.65			
Dissolved Oxygen at 00.00 hrs (table 23)					
Treatment	3	8.20	2.734	1.19	2.82
Error	44	101.04	2.296		
Total	47	109.25			
Dissolved oxygen at 06.00 hrs (table 23)					
Treatment	3	5.79	1.932	1.789	2.82
Error	44	47.52	1.080		
Total	47	53.32			
Dissolved oxygen at 12.00 hrs (table 24)					
Treatment	3	52.00	17.336	2.386	2.82
Error	44	319.69	7.265		
Total	47	371.70			

				F value	
Source	D.F.	S.S.	M.SS	Calculated	Tabled
Dissolved oxygen at 18.00 hrs (table 24)					
Treatment	3	92.24	30.74	3.796	2.82
Error	44	356.37	8.09		
Total	47	448.62			
pH (table 25)					
Treatment	3	0.278	0.092	0.0259	2.82
Error	44	5.517	0.125		
Total	47	5.795			
Total Alkalinity (table 25)					
Treatment	3	5653.65	1884.55	0.641	2.82
Error	44	129229.21	2937.02		
Total	47	134882.86			
Total hardness (table 26)					
Treatment	3	4589000	1529666	0.982	2.82
Error	44	68528000	1557454		
Total	47	73117000			
Nitrate (table 26)					
Treatment	3	0.0137	0.0045	2.045	2.82
Error	44	0.101	0.0022		
Total	47	0.115			
Phosphate (table 27)					
Treatment	3	0.524	0.175	10.294	4.26
Error	44	0.752	0.017		
Total	47	1.276			

Source	D.F.	S.S.	M.SS	F Value	
				Calculated	Tabled
Nitrate (table 27)					
Treatment	3	0.00005	0.000016	14.545	4.26
Error	44	0.00005	0.0000011		
Total	47				
Ammonia (table 28)					
Treatment	3	0.027	0.009	1.285	2.82
Error	44	0.315	0.007		
Total	47	0.342			
Primary productivity (table 28)					
Treatment	3	15046174	501539	2.909	2.82
Error	44	7585066	172387		
Total	47	9089684			
Phytoplankton (table 29)					
Treatment	3	20.82	6.94	3.378	2.82
Error	44	90.45	2.05		
Total	47	111.28			
Zooplankton (table 29)					
Treatment	3	19.38	6.46	5.978	4.26
Error	44	47.57	1.08		
Total	47	66.96			

				F Value	
Source	D.F.	S.S.	M.SS	Calculated	Tabled
Heterotrophic activity of water (table 30)					
Treatment	3	0.560	0.186	4.325	3.01
Error	24	1.050	0.043		
Total	27	1.610			
Soil pH (table 31)					
Treatment	3	0.121	0.04	0.289	2.82
Error	44	6.096	0.138		
Total	47	6.217			
Organic Carbon (table 32)					
Treatment	3	4.823	1.607	2.948	3.01
Error	24	13.085	0.545		
Total	27	17.908			
Total nitrogen (table 32)					
Treatment	3	0.038	0.012	10	4.72
Error	24	0.030	0.0012		
Total	27	0.068			
C/N Ratio (table 33)					
Treatment	3	215.54	71.847	6.264	4.72
Error	24	275.26	11.469		
Total	27	490.80			

				F Value	
Source	D.F.	S.S.	M.SS	Calculated	Tabled
Total Phosphorus (table 33)					
Treatment	3	377112	125704	12.798	4.72
Error	24	235722	9821		
Total	27	612834			
Heterotrophic activity (table 34)					
Treatment	3	8.616	2.872	20.225	4.72
Error	24	3.425	0.142		
Total	27	12.041			
Respiration rate of mud (table 34)					
Treatment	3	0.323	0.107	2.14	2.82
Error	24	1.208	0.05		
Total	27	1.531			
Benthos (table 35)					
Treatment	3	316.82	105.607	3.206	2.82
Error	44	1449.31	32.93		
Total	47	1766.13			
Average weight of prawns (table 36)					
Treatment	3	1.32	0.441	0.067	2.82
Error	16	105.46	6.591		
Total	19	106.78			

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The highest survival rate of 91.19% was recorded in pond A applied with poultry manure followed by 77.48% in the pond with piggery waste. The lowest survival rate of 43.97% was observed in the pond applied with cowdung. Corresponding with the highest survival rate, highest production of 269.73 kg/ha/68 days also was obtained in pond applied with poultry dropping. The lowest production of 132.83 kg/ha/ 68 days was recorded in the pond applied with cowdung having lowest survival rate. The survival rate and production obtained in control pond were 62.46% and 180.23 kg/ha/68 days respectively.

4 DISCUSSION

The use of manures in aquaculture enables the production of a highly valuable protein rich food from inputs of little nutrient value to man. Intensive manuring of ponds stimulates natural food webs thereby generating considerable quantity of phytoplankton, zooplankton and benthos. As a result of sedimentation of phytoplankton and zooplankton, microbial activity increases upon which thrives the benthic biomass. An increase in benthic biomass is likewise be expected to increase shrimp production. Besides, decay of organic manure can substantially influence various hydrographical parameters including dissolved oxygen, pH, alkalinity and nutrients.

Constituents of organic compounds such as nitrogen and phosphorus are liberated from organic material during the formation of soil organic matter by microbial activity. Organic fertilization is one of the most important factors controlling the final live weight and ultimate yield. This dynamic interaction triggered by organic fertilization on the brackishwater shrimp pond ecology is discussed here.

Temperature is an important parameter affecting the decomposition rate of organic manure in the pond bottom. Fortes _et_ _al_., (1986) observed the temperature to increase in the treatments that are added with organic manures regardless of their type. These authors quoting NRC (1976) State that soil with organic inputs behaved like organic matter - amended soil where heat was liberated increasing temperature. In the present case also a similar observation was made where the temperature in all the ponds during the zero week was about 29°C which increased gradually to about 32°C during the 8th week. However during the 10th and 11th weeks, the temperature decreased to about 30°C to 31°C which may be due to premonsoon rain during the month of May in the culture period. As temperature was more or less same between the ponds treated with different manures, no significant variation was obtained.

Water temperature of 18° to 32°C have been found adequate for successfully managed intensive manured ponds (Schroeder, 1990). Rajyalakshmi et al., (1988) have opined that water temperature ranging between 30°C and 33°C in brackishwater ponds manured with cowdung did not affect metabolism in the prawn. If the temperature falls below 28°C, the metabolism reduces and so does the active behaviour and growth of prawns (Cruz, 1991). The temperature range in the present investigation may thus be considered to be ideal for the growth of prawns. Since the temperature recorded was within the ideal range, correlation analysis did not show any significant relationship between temperature and growth of prawns.

The data regarding the salinity indicated that the variation in salinity in ponds applied with organic manures and control pond were the same as the ponds were situated in the same locality. The average salinity recorded were 18.14, 16.05, 17.50 and 16.54 ppt in ponds applied with poultry dropping, cowdung, piggery waste and control pond respectively.

According to Chattopadhyay (1980), the rate of decomposition of organic manures decline with increase in water salinity. However, according to Ghosh (1975), the mineralisation rate of poultry dropping is more in 10 to 20 ppt saline water than in freshwater. On the other hand, the mineralisation rate of cowdung is not widely varied in different salinity levels. Mandal (1962) observed that applied nitrogen remained in the available form in comparatively higher amount under higher salinity levels and attributed this phenomenon towards lower rate of nitrification under higher salinity. Salinity is also found to influence the availability of nitrogen and phosphorus in soil. According to Mandal (1962), available nitrogen in soil decreases with increase in water salinity while Chattopadhyay and Ghosh (1976) reported that available phosphorus in soil decreased with increasing salinity. However, as the variation in salinity was less (12.34 to 20.84 ppt) the phenomenon mentioned above could not be observed in the present study.

Wyban *et al*., (1987) and Lanari *et al*., (1989) reported significant variation in dissolved oxygen between non manured and manured ponds with poultry dropping. On the other hand, Chakraborti (1984) and Chakraborti *et al*., (1986) recorded no difference in dissolved oxygen between manured and non-manured ponds. In their studies on the productivity of *Penaeus vannamei* in cattle manure enriched ecosystem in Hawaii, Lee and Shleser (1984) observed that addition of manure did not cause any depletion of dissolved oxygen. In the present study also, no difference in dissolved oxygen concentration was observed between ponds applied with organic manures and control pond. Nevertheless, dissolved oxygen at 18.00 hrs was significantly higher in pond applied with piggery waste compared to the control pond which may be on account of increased photosynthetic activity which enriches the water with oxygen at 18.00 hrs (Boyd and Pillai, 1985).

According to wheeler (1967; 1968 a), Rickards, (1974) and Hanson and Goodwin (1977), organic manuring can lead to severe oxygen depletion especially at night. Large scale mortality has frequently been attributed to oxygen depletion in penaeid shrimp ponds (Wheeler, 1969; Latapie <u>et</u> <u>al</u>., 1972; Liao and Huang, 1972; Shigueno, 1975). It is believed that shrimps are under stress when dissolved oxygen falls below 2 ppm (Wickens, 1976). Although experimentally determined lethal dissolved oxygen levels for penaeids has often been less than 1 ppm (Egusa, 1961; Tournier, 1972; Liao and Huang, 1975), several workers have emphasized the importance of maintaining dissolved oxygen levels above 2 ppm to avoid mortality (Mackay, 1974; Kramer, 1975; Wickens 1976).

Garson et al., (1986) have reported frequent reduction of dissolved oxygen below 2 ppm in ponds applied with poultry dropping which resulted in a high mortality of 73%. In the present study, dissolved oxygen level of less than 2 ppm during early morning was observed thrice in pond applied with cowdung, probably caused by the decomposition of cattle manure (Schroeder, 1974; Collis and Smitherman, 1978). The least survival rate of 43.97% in this pond may thus be attributed to the low dissolved oxygen content during the morning hours. However, in the case of poultry manure, dissolved oxygen of less than 2 ppm was not observed parallel with the maximum survival of 91.19%. Chakraborti (1984) also reported that the dissolved oxygen concentration in pond water enriched with poultry dropping remained at a favourable level.

In the present case, the observed low dissolved oxygen content especially during second half of the culture period in pond applied with cowdung in the early morning hours may be because of high consumption rate of dissolved oxygen for the respiration of plankton and prawns and for the decomposition of organic matter coupled with absence of photosynthesis resulting in reduced production of oxygen as a byproduct (Boyd, 1982). The high average concentration of 8.25 to 11.03 and 9.67 to 13.17 ppm during 12.00 and 18.00 hrs respectively may be on account of photosynthesis which reaches its peak during afternoon hours.

Supersaturation of oxygen can be detrimental to the growth and survival of shrimps. According to Brisson (1985) dissolved oxygen levels even 9.5 ppm in water can cause convulsions due to air bubbles within body cavities and fluids in the prawns. A 100% mortality of adult Penaeus brasiliensis and P. paulensis as a result of gas bubble disease caused by the supersaturation of dissolved oxygen was reported by the author. Lee and Shleser (1984) and Wyban et al., (1987) obtained dissolved oxygen values as high as 20 ppm unlike in the present experiment where the maximum recorded oxygen value was 17.63 ppm. The high survival and growth rate obtained by Lee and Shleser (1984) and Wyban et al., (1987) and in the present case also show . that supersaturation of dissolved oxygen is not detrimental to the growth and survival of prawns. This is further substantiated by the statement of Courtney (1989) that oxygen supersaturation is unlikely to be a problem in shrimp ponds during grow out phase.

According to Sanares et al., (1986), the pH fluctuates with photosynthetic activity and respiration from a low at dawn to a high at midafternoon in fertilised ponds. Lanari et al., (1989) recorded more pH in ponds enriched with poultry dropping and attributed the reason to the increased photosynthesis. On the other hand, Chakraborti (1984), Chakraborti et al., (1986) and Chattopadhyay and Mandal (1982) reported no difference in pH between fertilised and unfertilised ponds, probably adjusted by the buffering capacity of brackishwater. In the present case also in different ponds, pH was not found varying in response to organic manuring and the pH recorded was in the range of 7.77 to 8.83 in pond A applied with poultry dropping, 7.39 to 8.86 in pond C applied with cowdung. 7.92 to 8.71 in pond D applied with piggery waste and 7.63 to 8.92 in control pond without manure.

Gradual reduction in pH towards the end of the culture period was reported by Chen et al., (1989) and Chen and Wang (1990). In the present study also such a reduction in pH was noted during the last days of culture in all ponds applied with organic manures. This may be because of the decomposition of organic matter and detritus, producing carbon dioxide as a byproduct which can reduce the pH and also because of the increased release of carbon dioxide through the respiration of the growing prawns during the culture period.

pH is an important parameter which affects metabolism and other physiological processes of prawns and in culture ponds a pH range of 6.8 and 8.7 should be maintained for the good growth and production of prawns (Cruz, 1991). According to Muthu (1980), alkaline water with pH ranging from 7.5 to 8.5 is condusive for the culture of prawns. Therefore, a deviation from the optimum pH can adversely affect the growth of prawns. In the present study, no significant relationship was obtained between pH and growth of prawns since the recorded pH was within the optimum range.

According to Chakraborti et al., (1986) there is no difference in total alkalinity between manured and nonmanured ponds. The findings in the present experiment with organic manures where no significant difference in alkalinity was obtained between manured and nonmanured ponds are in agreement with the above observation. This may again be due to the buffering action of brackishwater unlike the freshwater ponds where organic manuring can influence the alkalinity to a great extent.

Thomaston and Zeller (1961) have opined that for best response to fertilization, alkalinity should be always above 20 ppm. Since the values recorded in the present case were always above 20 ppm, it can be considered as condusive for the response of fertilization.

The general decrease in alkalinity during the last week in all ponds in the present case may be due to monsoon shower during the month of May, an observation which is also made by Gopinathan et al., (1982) and Chakraborti et al., (1985).

According to Boyd and Pillai (1985) the desirable levels of total alkalinity varies between 20 and 300 ppm. Since the average values of 142.15 to 172.17 ppm noticed in the present experiment are well within this range, no significant influence of alkalinity on growth of prawns was noticed.

Organic manures favour a gradual release of nutrients into the water body which in turn stimulates primary productivity. According to Schroeder et al., (1990), organic manuring (poultry dropping) at a rate of 50 kg/ha/day provided an average of 3 g carbon and 0.3 g nitrogen and approximately 0.3 gm of phosphorus/M^2/day. These authors have also found that 24 hr net primary productivity added an average of 4 algal carbon per M^2 which accounted for 90% of the yield in organically manured ponds. The lack of phosphorus and nitrogen limits phytoplankton production in pond (Boyd, 1986) and in brackishwater ponds nitrogen and phosphorus are observed to be far below the concentration needed for optimum growth of plankton. These nutrients are either present in lower quantities or the added quantity is lost through leaching and precipitation and hence rendered unavailable. Prolonged maintainence of these nutrients for the optimum growth of plankton therefore depends on the rational use of organic manures.

Chakraborti et al., (1985), Fortes et al, (1986), Lanari et al., (1987) and Lumare et al., (1987) recorded average nitrate concentration of 0.23 to 1.05, 0.3 to 0.66, 0 to 0.50 and 0.03 to 0.38 ppm in shrimp ponds applied with poultry dropping at a rate of 500, 2000, 1500 and 500 Kg per ha respectively. The nitrate concentration recorded in the present study was 0.06 to 0.22 ppm in pond applied with poultry dropping at a rate of 670.52 Kg per ha. The high nitrate concentration recorded by Fortes et al., (1986) and Lanari et al., (1987) may be due to the increased rate of application of poultry manrue, which is highly fertile. Chakraborti et al., (1985) and Lumare et al., (1987) have reported a higher nitrate concentration of 0.23 to 1.05 and 0.03 to 0.39 ppm in ponds applied with poultry dropping at the rate of 500 Kg/ha, compared to the present study where the nitrate concentration recorded was 0.00 to 0.22 ppm when applied with 670.52 Kg poultry dropping per ha. This may be due to the influence of other factors like release of nitrogen from soil, utilization by phytoplankton and bacteria and various chemical processes like nitrification, denitrification and ammonification.

As in commercial ponds at Poyya and Chellanam, the nitrate in different ponds in the present case exhibited wider flunctations and the reason may be attributed to the biological utilization and nutrient regeneration (Upadhayay, 1988). Further according to Schroeder (1987), the rate at which nitrogen was removed from the water column was almost 4 times the rate at which it was added by manures and fertilizers.

In the present study, the nitrate concentration does not vary much among different ponds applied with organic manures (table 26 and figure 24), eventhough the quantity of nitrogen provided was different to the order of 25.07 Kg, 42.00 Kg and 25.27 Kg per hectare in ponds applied with poultry dropping, cowdung and piggery waste respectively. Although very high quantity of 42.00 Kg nitrogen was provided, the lowest survival rate (43.97%) and the lowest production (132.83 Kg/ha/68 days) were recorded in pond applied with cowdung. This indicates that the quantity of nitrogen (42 Kg) supplied to this pond was a little high and a quantity of around 25 Kg nitrogen per hectare supplied to the ponds applied with poultry dropping and piggery waste may be optimum, since high survival rates of 91.19 and 77.48% and high production of 269.73 and 196.78 Kg/ha/68 days were recorded in these ponds applied with poultry dropping and piggery waste respectively.

Phosphorus is called as "Key to Life" because it is directly involved in most life processes and ranks next to nitrogen in importance (Hicking, 1971).

In ponds applied with poultry dropping, Chakraborti (1984), Fortes et al., (1986), Lanari et al., (1987 & 1989), Lumare et al., (1989) reported high phosphate concentration compared to the control pond without manure. However, the phosphate concentration in pond applied with poultry dropping in the present experiment was not significantly different from that of the control pond. This may be on account of the increased utilization of phosphate by the high phytoplankton content in pond applied with poultry dropping as is also reflected by the comparatively high productivity values recorded in this pond. However the phosphate concentration in the pond applied with cowdung was significantly higher from that in ponds applied with poultry dropping, piggery waste and control pond. The comparatively high concentration in pond applied with cowdung may be due to its non utilization which is reflected by the low productivity and phytoplankton concentration observed in this pond. In pond applied with cowdung, the phosphorus content in sediment was also found to be high and it may be because of the storage of phosphate in the sediment.

Subosa and Bautista (1991) quoting Hepher (1963) state that even with intensive fertilization, the nutrient concentration rarely exceeds 0.5 ppm for phosphate which disappears fastly. According to Eren _et_ _al_., (1977) a concentration of 0.2 ppm phosphate is considered to be the minimum concentration required for high aquatic productivity. In the present case, the phosphate concentration in all the ponds was more than 0.2 ppm, thus remaining above the minimum concentration. It is reported that among the various organic manures (Ghosh, 1975) poultry dropping mineralises faster than cowdung. However in the present case, higher phosphorus is found in pond applied with cowdung than in the pond with poultry dropping. Parallel to this, it may be observed that the phytoplankton concentration is at a low level in pond with cowdung than in pond with poultry dropping. Therefore it may be concluded that in ponds applied with cowdung, the phosphorus released through mineralisation is not found utilized by phytoplankton.

The nitrite concentration recorded in the present study was 0.002, 0.002, 0.003 and 0.002 ppm in ponds applied with poultry dropping, cowdung and piggery waste and in control pond respectively. Subosa and Bautista (1991) applied 2 tons of poultry dropping in brackishwater ponds and reported a nitrite concentration of 0.0028 to 0.0024 ppm which is in conformity with the concentration of 0.001 to 0.003 ppm recorded in the present study with poultry manure. On the other hand, Fortes et al., (1986) reported a comparatively high concentration of 0.017 to 0.023 ppm in brackishwater ponds applied with 2 tons of poultry manure and the high concentration may be due to the increased rate of poultry manure. Though applied poultry dropping at a lower rate of 500 to 600 kg/ha which is a comparable rate with the present study, Lumare et al., (1987 & 1989) recorded a higher concentration of 0.001 to 0.210 ppm in comparison to the concentration obtained in the present study. In addition to the various ecological parameters, water exchange and metabolism of prawn can affect nitrite concentration. In the present study, the high concentration during beginning may be due to the manuring and the low during mid period may be due to utilization by phytoplankters and again the high concentration during the end may be due to the excretion by test animals.

The nitrite concentration of 0.001 to 0.007 ppm in the present experiment is well above the safer limit of 0.180 ppm (Jayasankar and Muthu, 1983) and 1.28 ppm (Law, 1988). It may also be pointed out that the comparatively low concentration of 0.001 to 0.002 ppm nitrite during the mid culture period may be due to the utilisation of nitrite by phytoplankton (Maguive, 1980; Tsai, 1989).

The reported statement by Chien (1992) that high nitrite concentration occurs only when either ammonia or nitrate concentrations are high, which are seldom the case in pond systems, seems to be true in the present study where nitrite concentration recorded was low, parallel with low values of ammonia and nitrate.

Ammonia is the major nitrogenous waste product excreted by aquatic crustaceans (Parry, 1960). Unionized form of ammonia is highly toxic to many aquatic organisms (EPA, 1983). High concentration of ammonia has a detrimental effect on cultured crustaceans (Chen _et al_., 1986 and Mevel and Chamroux, 1981) and can limit production in intensive crustacean aquaculture (Delistraty _et al_., 1977). According to Shilo and Rimon (1982), the production of ammonia due to the decomposition of organic matter is a constraint in the application of organic manure.

Compared to the ammonia concentration of 0.14 ppm in the pond applied with poultry dropping in the present case, Lumare _et al_., (1987 & 1989) and Chen and Wang (1990) reported higher ammonia concentration of 0.02 to 6, 0.055 to 1.497 and 0 to 0.445 ppm in ponds applied with poultry manure. On the other hand, Fortes _et al_., (1986) and Subosa and Bautista (1991) reported less concentration of 0.043 to 0.076 and 0.00001 to 0.0078 ppm in brackishwater ponds applied with poultry dropping.

In the present study, the average concentration of ammonia recorded in ponds applied with poultry manure, cowdung, piggery waste and control pond was 0.14, 0.13, 0.09 and 0.09 ppm respectively, thus registering the highest concentration in pond applied with poultry manure. Since the highest survival rate of 91.19% was recorded in this pond, the increased ammonia concentration may be due to the excretion by the more number of prawns.

According to Lumare <u>et</u> <u>al</u>., (1989) ammonia concentration increased immediately after manure application and declined within a few days. The same pattern was also observed in the present study where in the ponds applied with organic manures high concentration of ammonia was noticed during the first two weeks probably released from the respective manures used and subsequently phytoplankton utilise ammonia as a nutrient source and reduces the ammonia concentration (Tsai, 1989). The high ammonia content towards the end of the culture period may be due to the excretion by animals.

Carpenter <u>et</u> <u>al</u>., (1986) reported that ammonia nitrogen is readily metabolised in brackishwater pond and that it rarely attained high concentration. This statement appears to be true in the present case where the concentration of total ammonia increased to a limited extent only. However, the variation in ammonia may be due to the influence of factors like rate of manuring, stocking density and environmental parameters like dissolved oxygen, pH, temperature, nitrate and nitrite.

In most shrimp farming studies, combined use of organic and chemical fertilizers is reported to influence primary and secondary productivity (Schroeder, 1987; Lee and Shleser, 1984). Mandal (1980) and Chattopadhyay and Mandal (1982) have suggested that fertilization of brackishwater ponds by inorganic and organic fertilizers help in the growth of biotic communities and subsequent high production of prawns. Chakraborti (1984) has observed that production of plankton in treated pond was more than that of the control pond and attributed the reason to increased availability of different nutrient elements owing to the application of fertilizer and manure. Chakraborti _et_ _al_., (1986) reported a lower productivity of 83 to 136 mgC/M^3/hr in unfertilized ponds when compared to the higher productivity of 107 to 355 mgC/M^3/hr in ponds fertilized with 1000 Kg. of poultry dropping. The higher average primary productivity values of 793.22, 917.23 and 993.21 mgC/M^3/hr recorded in the present case in ponds treated with cowdung, poultry and piggery waste respectively when compared with the lower primary productivity value of 527.05 mgC/M^3/hr of the control pond, thus substantiate the utilization of nutrients released from manure for increased primary productivity. Nevertheless, Fortes _et_ _al_., (1986) and Wyban _et_ _al_., (1987) in their experiments with poultry dropping and cattle manure respectively, observed no apparent relationship between nutrient content and primary productivity. An evaluation of the primary productivity in the 3 treatments during the present study shows that piggery waste indicated the maximum primary productivity value of 993.21 mgC/M^3/hr.

The Superior quality of poultry dropping as an organic manure has been well studied. Lanari _et_ _al_., (1987) have emphasized the positive role of poultry manure in activating natural trophic chain. Poultry manure is considered to be very fertile because of the higher nitrogen and phosphorus contents, biological oxygen demand and also because of the presence of some directly digestible protein and carbohydrate (Schroeder, 1990). According to this author, nitrogen is a key factor in the growth of phytoplankton and bacteria and since biological oxygen demand is a measure of the rate of conversion of crude organic matter into microbial cells, poultry manure may be a better manure for aquaculture. In the present study also, the pond treated with poultry manure, with the maximum average nitrate nitrogen of 0.14 ppm and ammonia nitrogen of 0.14 ppm indicated higher primary productivity of 917.23 mgC/M^3/hr.

Among the ponds treated with the three different organic manures in the study under review, the one with cowdung indicated comparatively low average primary productivity of 793.22 mgC/M^3/hr. The reason for this may be attributed to the low decomposition rate, since cowdung contains more fibre content. Garson et al., (1986) have reported 28.09% of crude fibre in cowdung in comparison with 18.10% in chicken manure. According to Schroeder (1990) cowdung contains low concentration of nitrogen and little, if any, directly digestible protein and carbohydrates.

Slow dissolution of fertilizer granules and steady mineralisation have positive influence on the pond ecology. According to Lanari et al., (1987), slow dissolution of granules sustaining a greater zooplankton biomass can allow a more continuous energy flow through the trophic chain, increasing the number and amount of a variable food for shrimp. In all the ponds except the one applied with cowdung in the present study, primary productivity was high because of slow but increased rate of mineralisation. In the pond applied with cowdung,the productivity was low probably because of the higher fibre content and the resultant low rate of decomposition and mineralisation.

Phytoplankton is beneficial to prawn culture in many ways (Anon, 1993). They are,

1. Stabilizes the water quality, through absorption of inorganic mineral and other mechanism.

2. Provides nutrition resource in direct form or indirect form and reduce the feeding quantity.
3. Increases the thermal capacity of the water. The pond temperature fluctuate less.
4. Provides oxygen by photosynthesis during the day, although it consumes some oxygen during night time.
5. Environmental indicator on the process of mineralisation and eutropication.
6. Stabilizes the pond environment that can affect the prawn behaviour.
7. Reduces the toxic effect of ammonia, hydrogen sulphide and other toxins.
8. Inhibits the development of benthic algae and filamentous algae.
9. Competes with bacteria and this may decrease the possibility and frequency on the occurence of the disease.

Fertilization in shrimp culture ponds causes a good source of phytoplankton which is made possible by the release of nutrients like nitrogen and phosphorus from the fertilizers.

Wahby (1974) states that the concentration of water nutrients in fertilized pond was lower than expected indicating fast absorption by phytoplankton. Rappaport et al., (1977), Chattopadhyay and Mandal (1982) and Chakraborti (1984) have observed higher content of phytoplankton in organically manured ponds. In the present study, the phytoplankton contents of 5.09, 4.58 and 4.03 ml/M^3 in ponds applied with poultry dropping, cowdung and piggery waste were significantly higher than that of 3.32 ml/M^3 recorded in control pond. This is corroborated with the higher concentration of nitrate and phosphate in treated ponds with the low concentration in the control pond (table 26, 27 and figure 24, 25).

Prawns do not feed directly on Phytoplankton (Cruz, 1991). They feed on the small animals and zooplankton that eat phytoplankton or on bacteria that grow on the dead phytoplankton which accumulate in the bottom. Nevertheless, the growth of shrimp is better in ponds in which diatom is the common algae and poor when phytoflagellate predominate. It has been observed in the present study, that in the control pond and the pond with cowdung, Enteromorpha a filamentous algae developed initially followed by another filamentous algae Chaetomorpha. An evaluation of growth and survival in these ponds showed lower values, which may be due to the entangling of prawns in filamentous algae resulting in mortality. According to Tseng and Cheng (1981) fertilizers high in nitrates or having high nitrogen to phosphorus ratios tend to promote filamentous algae. Cowdung is a manure with high N/P ratio (1.81) as observed in the present study and this may be a reason for the growth of filamentous algae.

Lumare et al., (1989) state that fertilizers increase the natural productivity of a pond by increasing the phytoplankton production which in turn promotes zooplankton and then the macrobenthic organisms that enter to the natural feeding of prawns. According to Nayak and Mandal (1990) organic manures are efficient in enhancing production of zooplankton. The significantly high zooplankton content of 2.30 and 2.96 ml/M^3 recorded in ponds applied with piggery waste and poultry dropping respectively may be on account of high primary productivity and phytoplankton. Correspondingly, the low zooplankton content in control pond may be due to low primary productivity, phytoplankton and organic carbon content thereby showing that organic manuring has positive influence on zooplankton production.

Zooplankton contributes to the detritus pool by producing faeces, exuviae and corpses. Upto 200 fecal pellets/copepod/ day can be produced during phytoplankton blooms (Honjo and Roman, 1978). Faeces also serves to transform phytoplankton into detritus (Smetacek, 1980). Since the phytoplankton is not directly consumed by shrimps, a time lag between the end of plankton bloom and measured increase in shrimp growth is expected. This statement is clearly substantiated in the present observation, where in the pond treated with poultry, when there is a higher phytoplankton production of 5.02 ml/M^3 in the 2nd week of culture, shrimp reached an average weight of 2.876 g. in the 4th week from 0.084 g of zero week. Likewise in the pond treated with cowdung, the phytoplankton peak of 6.71 ml/M^3 recorded during the 5th week was reflected in the maximum growth of 6.262 g in the 6th week of culture. In the treatment with piggery waste also, a time lag from peak plankton production in the 5th week (5.40 ml/M^3) to maximum average weight of 6.601 g in the 6th week was noticable. Evidently in the control pond, which received no fertilizer, no significant relationship between phytoplankton production and shrimp growth was noticed except for the maximum phytoplankton production of 5.41 ml/M^3 during the 9th week.

Fertilization of marine shrimp ponds with cattle manure stimulates a food web which allows outstanding growth rates (Wyban et al., 1987). According to Chattopadhyay and Mandal (1982) phytoplankton and zooplankton produced in ponds treated with cowdung appear to influence the dissolved oxygen content of the water, while Hickling (1971) opined that cowdung enhances production of zooplankton. Rappaport et al., (1977) observed higher content of phytoplankton in organically manured ponds. In the present study zooplankton content was found to be low in cowdung treatment with corresponding increase in phytoplankton concentration. This may be due to the increased microbial activity enabling rapid release of nutrients (Nayak and Mandal, 1990). Further, the comparatively high zooplankton concentration recorded in the second half of the culture period may be because of the effect of application of manure during the subsequent months of April and May and also due to the reduced grazing rate of zooplankton by the prawns as its feeding habit changes from zooplankton during juvenile period to omnivores during adult phase.

Measurement of heterotrophic activity in water is an indirect method of determining the microbial activity in water. Shigueno (1975) demonstrated that the total oxygen consumption of prawns in ponds is very much lower than that for the rest of the biota like phytoplankton, zooplankton, benthos, bacteria and sediment. Schroeder et al., (1990) reported a heterotrophic activity of 3.6%, and 3.9% in freshwater ponds applied with inorganic fertilizers and also with poultry manure and the values were not significantly different from each other. In the present study also, the average heterotrophic activity of 0.36% in the pond applied with poultry manure was not significantly different from the heterotrophic activity of 0.41% per day in control pond. However, heterotrophic activity of 0.71% per day in pond applied with piggery waste was significantly different from that in the pond applied with poultry dropping. The high heterotrophic activity in pond applied with piggery waste indicates increased microbial activity.

Heterotrophic activity is reported to decrease with time (Milstein _et_ _al_., 1991). According to this author, the heterotrophic digestion in water was upto 1% per day during the first month, about 2% per day afterwards and declining thereafter towards the end of the culture period. In the present case also, a general increase in ponds treated with pig dung (0.33 to 1.13%) cowdung (0.52 to 0.84%) and poultry manure (0.31 to 0.59%) was discernible by the 4 to 8th week of culture, declining thereafter in all the treatment.

While autotrophic activity increased the pH through absorption of carbondioxide, heterotrophic activity decreased pH through respiration (Milstein _et_ _al_., 1991). Wohlfarth and Hulata (1987) state that the process of manure decomposition and utilization of its degradation products are influenced by factors such as temperature, nutrient, solar radiation and dissolved oxygen. A comparison of the heterotrophic activity with pH in the treatments under review shows that the heterotrophic values in all the treatments increased till 6th to 8th week with a corresponding decline in pH during the 5th to 7th weeks of culture.

Soil quality seems to play an important role in relation to the effect of organic fertilization. Manure loading appears to affect sediment more than the water body. Fertilization of the soil depends on the availability of soluble forms of nutrients such as nitrogen, phosphorus, organic carbon and trace elements. Organic matter of the manure provides a source of reduced carbon for heterotrophic grazing while the mineral fraction of the manure is used both by autotrophs and microbial heterotrophs (Werner and Hall, 1976).

Application of organic manures is reported to cause a decrease in the soil pH of the treated pond especially during the initial period of study (Chattopadhyay and Mandal, 1982). According to Fortes et al., (1986), the dry pH of the soil decreased as the percentage of organic matter increased. A comparison of the soil pH values in the ponds under study, also showed that irrespective of the treatments, there is a significant decrease from 7.71 to 6.99 in the treatment with poultry dropping, from 8.25 to 6.86 in treatment with cowdung, from 7.73 to 7.01 in treatment with piggery waste and from 7.78 7.24 in the control pond. It is possible that the increase in acidity of the sediment has resulted when the organic matter decomposed under anaerobic condition releasing organic acids

(Chattopadhyay and Mandal, 1982; Watanabe, 1984). Further, it may also be noticed that in the pond treated with cowdung, the reduction in pH was of an increased rate (8.25 to 6.86) which may obviously be on account of the increased rate of decomposition of organic matter.

Chakraborti (1984) reported a soil pH range of 7.8 to 8.2 and 7.9 to 8.2 in ponds treated with poultry dropping along with inorganic fertilizers and in the control pond respectively. According to Chattopadhyay and Mandal (1982), the soil pH value was within a narrow range of 7.9 to 8.2 and 8.1 to 8.2 in the treated (cowdung) and control ponds respectively. Subosa and Bautista (1991) reported a low soil pH range of 6.3 to 7.2, while Subosa (1992) states that the soil pH increased to slightly alkaline levels in treatment with chicken manure. According to Boyd (1992), the favourable pH range for the decomposition of soil organic matter was between 7.5 to 8.5. Since the average soil pH in the present study ranged between 7.44 to 7.58, it may safely be concluded that the soil pH in the present experiment is nearly optimum for the decomposition of organic manures.

In spite of the fact that the soil pH indicated a decline with added organic matter, no marked variation was observed in the pH value of the soil between the treated and the control pond (Chakraborti, 1984; Subosa and Bautista, 1991). In the present study also, no significant difference was noticed in the soil pH between the ponds applied with manures and the control pond and the reason for this may be attributed to the buffering capacity of brackishwater system.

Brackishwater pond soils are known to be poor in organic carbon content. Chattopadhyay and Mandal (1982) have recorded low organic carbon in the soil of brackishwater ponds in west Bengal. Rajyalakshmi _et_ _al_., (1988) studying the physico-chemical characters of brackishwater ponds off Chilka area also observed low organic carbon content between 0.297 and 0.404%. Chakraborti _et_ _al_., 1985 reported that in Kakdwip farms at West Bengal inspite of manuring the ponds with poultry manure and feeding with pellets, the organic carbon content did not exceed 1.45%. In the present study, the average organic carbon content in ponds treated with poultry dropping, cowdung and piggery waste were 1.92, 2.62 and 1.01% respectively, while in the control pond, the value was 1.02%, thereby indicating that enriching brackishwater ponds with organic manure can enhance the fertility of the soil.

A comparison of the organic carbon content in different treatments in the present study shows that treatment with cowdung had the highest concentration (2.62%) followed by poultry dropping (1.92%) and piggery waste (1.01%). This is quite reasonable since among all the manures used, cowdung has the highest organic matter content of 49.98%, while in pigdung the organic matter content is 19.33% (table 21).

Gately (1990) showed that the organic carbon of 1.53% during initial period of culture increased to 2.49% during last weeks. A similar increase in organic carbon content was also reported in the present study with piggery waste where organic carbon content increased from 0.50 to 1.41% during last days. This may be due to the settling of the remains of phytoplankton, zooplankton and other aquatic organisms and shrimp faeces which increases the organic carbon content (Boyd, 1992). On the other hand, Subosa and Bautista (1991) observed a reduction in organic carbon content from 3.63 to 4.26 during initial weeks to 2.32 to 3.95% during last weeks. Such a reduction was also noticed in the present study with poultry dropping and cowdung where the organic carbon content of 2.38 and 3.32% during zero week was reduced to 1.19 and 1.81% during IIth week respectively. This decrease in organic carbon content may be due to the increased mineralisation of poultry dropping and cowdung.

Chakraborti et al., (1985) observed that ponds having 1.02 to 1.45% organic carbon can give better production of prawns, which seems to be relevant in the present context also where higher production of 269.73 and 196.78 kg/ha/68 days were obtained in ponds applied with poultry dropping and piggery waste when organic carbon content was 1.92 and 1.01% respectively. On the other hand lower production of 132.83 Kg/ha/68 days was obtained in pond applied with cowdung having higher organic carbon content of 2.62%.

Pillai et al., (1962) reported that the productivity of brackishwater ponds was directly related with nitrogen and phosphorus content of bottom soil. According to Baticados et al., (1986) the total nitrogen in shrimp ponds in philippines varied between 0.04% and 0.36% with a mean value of 0.19%. On the other hand, Ghosh (1975) reported total nitrogen value of 0.069% in the brackishwater fish farm at Kakdwip. In the present study also, the average total nitrogen values of 0.09 to 0.18% are comparable with that mentioned above. On the other hand, Subosa and Bautista (1991) reported an increased total nitrogen content of 0.33 to 0.43% in ponds applied with poultry manure.

Rajyalakshmi et al., (1988) recorded the available nitrogen content in soils of brackishwater ponds near Chilka lake as 0.12 to 0.20% which according to her indicates nutrient limitation. However, Chakraborti et al., (1985) opined that available nitrogen concentration of 0.012 to 0.016% is condusive for the growth of prawns. Eventhough not determined in the present study, the available nitrogen must be well above

0.012 to 0.016% required for the growth of prawns as the total nitrogen content of 0.09 to 0.18% recorded was sufficiently high to provide an available nitrogen concentration of the above said range.

The high total nitrogen content of 0.18% recorded in pond applied with cowdung in the present study may be due to less mineralisation rate. Ghosh (1975) reported that in brackishwater ponds the mineralisation rate of cowdung is less compared to poultry dropping. The least total nitrogen content in ponds applied with piggery waste may be due to the increased mineralisation rate, which may be a reason for the increased growth rate in this pond. In control pond also where no organic manure was applied, the total nitrogen content ranged between 0.06 and 0.15% thereby showing that there is no relationship between total nitrogen content and manuring and hence it can be due to factors other than manuring. However, it may be also possible that the increased nitrogen from organic manure might have been utilized by the denser phytoplankton present in manured ponds.

The carbon to nitrogen ratio is an important factor in soil fertility, as it indicates the rate of decomposition of organic matter. Since the decomposition of organic matter will be higher at higher temperatures, there is a tendency towards higher ratios in cool climate than in warm climates.

If the C/N ratio of the soil organic matter is wide, the micro-organisms have plenty of carbon for synthesis and for energy but there may not be enough nitrogen for synthesis. As a consequence of wide C/N ratio, the process of decomposition will be slow. At this stage, if available nitrogen is added the process of decomposition will be accelerated. Decomposition of organic matter is increased by micro-organisms when the C/N ratio becomes narrow. That is why the soil with a higher content of nitrogen decomposes at a faster rate than the material of low nitrogen content. Generally silty loam soils had higher values of C/N ratio. The more the soil is sandy, the more decomposition will be possible due to better aeration (Pillai and Sreenivasan 1975). Most fresh organic matter has around 45 to 55% carbon, but its nitrogen content can very greatly. Organic matter with a C/N ratio of 10 to 15 will decompose much faster than organic matter with higher C/N ratio (Boyd, 1990).

According to Boyd (1992) the average C/N ratio of brackishwater ponds in Philippines was 5.87 but some soils had C/N ratio as high as 40. The large C/N ratio was found in semi-intensive ponds with fairly high concentration of organic carbon. The C/N ratio of 16.83, 13.98, 10.38 and 10.10 in ponds applied with poultry dropping, cowdung, piggery waste and control pond recorded in the present study agrees well with the values observed by the above author. The significantly high C/N ratio of 16.83 obtained in the pond applied with poultry dropping may be due to the increased mineralisation rate of poultry manure which reduced the nitrogen content and thereby registering high C/N ratio.

According to Subosa and Bautista (1991) the total phosphorus in brackishwater pond soil applied with 2000 Kg poultry manure varies from 6.8 to 8.7 ppm during initial period to 12.8 to 15.4 ppm during final period. On the other hand, Chakraborti et al., (1985) recorded still higher total phosphorus content of 10.8 to 28.6 ppm in brackishwater ponds at Kakdwip manured with 250 Kg poultry manure. Compared to these observations, in the present case extremely high total phosphorus content of 723.81, 985.39, 690.43 and 752.36 ppm was recorded in ponds applied with poultry dropping, cowdung, piggery waste and control pond respectively. Values close to the present study were obtained by Gilbert (1985) and Nassar (1986) who reported 586 to 693 and 700 to 1400 ppm in soils of the same area.

The heterotrophic activity in the sedimend of ponds in the present study was almost same in ponds applied with cowdung and control pond, indicating that cowdung application can not increase the heterotrophic activity of mud. On the other hand, the average heterotrophic activity of 2.29 and 2.23%/day in pond applied with poultry dropping and piggery waste respectively were significantly very high compared to the control pond and the pond applied with cowdung which recorded values of 1.16 and 1.14%/day respectively. This indicates that application of poultry dropping and piggery waste can increase the microbial community in the sediment, and cowdung probably may not be a good substrate for bacterial development. Moreover, the low dissolved oxygen content in pond applied with cowdung might have caused for the reduced growth of micro-organisms.

Milstein et al., (1991) reported that in freshwater ponds applied with poultry dropping, the heterotrophic digestion in sediment decreased from 5 to 6% at the beginning of the growing season to about 2% at the end. However, in the present study with the application of poultry dropping, the heterotrophic activity decreased from 2.62% at the beginning to about 1.89% at the end. This reduction in heterotrophic activity may be because of the grazing of detritus containing heavy bacterial load by the prawns.

According to Hickling (1971), organic manure application in brackishwater soil is the best means to increase benthos which is a favourable food for the prawns.

Chakraborti et al., (1986) observed no difference in benthos quantity in ponds at Kakdwip between manured and non manured ponds. In the present study also, no difference in benthos content between pond applied with poultry manure and control pond was noticed. On the other hand, Chattopadhyay and Mandal (1982) noticed reduced concentration of benthos in treated ponds with 2000 Kg cowdung per hectare. In the present study reduced benthos concentration was noticed in ponds applied with cowdung and the reason can be attributed to the reduced dissolved oxygen concentration caused by the decomposition of organic matter which is also reported by Rao and Murthy (1988). The lowest benthos content of 5.09 mg/M^2 in pond applied with piggery waste may be because of the higher consumption of benthos by prawns which is further substantiated by the higher survival rate of prawns in this pond. In addition, the benthos concentration can be influenced by salinity, pH, nutrients, organic matter and texture of soil. The reduced benthos concentration towards the end of the experiment may be either due to the increased consumption of benthos as the planktophagous young prawns change to omnivorus during juvenile stage. Moreover the reduction of oxygen due to the decomposition of organic matter and certain products of decomposition of organic matter (organic acids) also might have caused for the reduction of benthos (Watanabe, 1984).

The data regarding the average weight in the present study shows that during 6th week, the growth of prawns was high in pond applied with piggery waste where the average weight was 6.601 gm compared to the 4.745, 6.262 and 4.984 gm in pond applied with poultry dropping, cowdung and control pond respectively. However, the average weight in pond applied with piggery waste was found reduced during the subsequent weeks. This indicates that piggery waste boosts up the production during the initial period.

Among all treatments the lowest survival rate of 43.97% was observed in pond applied with cowdung. The low survival rate in this pond may be ascribed to the mortality of prawns due to

1) dissolved oxygen concentration of below 2 ppm during early morning observed thrice.

2) the entangling of prawns in filamentous algae developed in this pond.

3) low rate of decomposition as cowdung contains more cellulose which blankets the pond bottom.

4) liberation of abnoxious compounds produced during the decomposition of organic matter (Watanabe, 1984).

5) low productivity and zooplankton content.

From the figure 32 it can be seen that a gradual and steady growth of prawns was noticed only in pond applied with poultry manure. The fact that dissolved oxygen was not reduced to below 2 ppm during early morning in this pond also favoured high growth and survival rate of prawns.

An evaluation of nitrate, a major form of nitrogen in water at different ponds applied with organic manures showed that the values do not vary much, eventhough the quantity of nitrogen provided was more in the pond applied with cowdung (42.00 kg)., compared to 25 kg nitrogen applied each in ponds applied with poultry dropping and piggery waste. The low survival rate (43.97%) and low production (132.83 kg/ha/68 days) in the pond applied with cowdung, indicates that either the nitrogen quantity provided may be more or other than nitrogen some other factors critically affects the growth and survival rate of prawns. Analysis of organic carbon in different ponds showed higher average concentration of 2.62% in pond applied with cowdung. On the other hand, in pond applied with poultry dropping, the average organic carbon content was 1.63%, where the highest survival rate of 91.19% and highest production of 269.73 kg/ha/68 days was observed. This clearly shows that organic carbon content of above 2% may not be favourable for growth. The reason can be attributed to the reduction of oxygen and production of abnoxious compounds produced during the decomposition of organic matter (Watanabe, 1984), which either in combination or alone adversely affect the growth of prawns. Hence while selecting the organic manures for increasing the productivity of shrimp farms, major consideration should be given to the organic matter content. This study shows that poultry manure can be safely added to shrimp ponds in split dozes which can generally maintain the ecological parameters with in a optimum level.

According to Gaur et al., (1990) poultry manure is a rich organic matter since liquid and solid excreta are excreted together resulting in no urine loss. Garson et al., (1986) observed that poultry dropping has almost double quantity of crude protein and minerals compared to cowdung. Ray and David (1969) opined that most of the important soluble inorganic salts required for imparting productivity in water are present in large quantities in poultry manure. According to Banerjea et al., (1979) the rate of release of inorganic nitrogen is more in poultry manrue as compared to cowdung and a considerable portion of nitrogen is initially present in inorganic form (13.10 to 36.27%), which readly supplies ammonia and nitrate to water phase by the process of mineralisation. He also observed that the consumption of dissolved oxygen is more when applied with poultry manure, which is a positive index of high biodegredability. Wide fluctuations in the pH values supported by high alkalinity and plankton production was also observed by the above author.

In the present study in addition to poultry dropping, piggery waste was also found to yield encouraging results with a survival rate of 77.48% and production of 196.78 kg/ha/68 days. According to Sharma (1981) piggery waste is in a semidigested form and is rich in various growth promoting elements.

The increased productivity, phytoplankton, zooplankton, survival rate and growth rate obtained in ponds applied with poultry dropping and piggery waste compred to the control pond in the present study strongly suggest the need to manuring shrimp ponds with poultry dropping followed by piggery waste.

Organic manures are very useful in conditioning the soil of a new pond and providing a readymade mass of organic matter containing the necessary inputs. The organic matter helps in the formation of good pond mud, promote nitrification and formation of a good colloidal structure.

CHAPTER III

TRACE ELEMENTS CONCENTRATION IN BRACKISHWATER SHRIMP PONDS APPLIED WITH ORGANIC MANURES

I. INTRODUCTION

Investigations on the deposition of heavy metals in the body of decapod crustaceans is a field of interest because of the frequent shedding and renewal of the exoskeleton, the role of metals in osmoregulation, enzymatic and respiratory functions and also in tracing pathways of pollution. Heavy metals are toxic if in excess, yet some like zinc and copper are essential in lower concentration for the metabolism of animals. The higher metal content in crustaceans may lead to toxicity to human being on the one side and to the aquatic food chain on the other. Inorder to survive accumulation of high level of toxic metals many invertebrates employ biological and physiological detoxification. However, in aquatic ecosystem the role of micronutrients is significant by virtue of their role in enhancing productivity and accelerating the interaction of various trophic levels of food chain.

Among the different heavy metals, zinc, copper and iron are considered as essential micronutrients, while others such as cadmium and lead are categorised as non-essential (Martin 1974, Martin _et al_., 1977, Qasim _et al_., 1988). While trace metals such as zinc is an essential element for most of the biological functions, copper is the basic constituent of the body fluid in crustaceans. The role of iron in the formation of chlorophyll and photosynthesis emphasizes the importance of this element in producing primary food organisms in fish ponds.

Metal content in aquatic organisms is highly dependent on the metal content in water. A slight increase in water could lead to significant increase in the body of organisms. Nevertheless, the net trace metal uptake is influenced to a great extent by water quality parameters such as salinity, temperature, concentration of chelating agents and other metals (Phillips 1977).

The characteristics of the sediment phase play a dominent role in determining the bioavailability of the metal. As a result of various physiological changes and reactions in aquatic environment, a major fraction of the metals is associated with the bottom sediment. Metal contents of the sediments are manifold higher than the values for the overlying water. According to Chattopadhyay and Saha (1980), soil characters such as pH, calcium carbonate, electrical conductivity and textural composition of soil influence the availability of micronutrients. Further under appropriate conditions, the metals could leach out of the sediment to pollute the water column. Thus estimation of metal concentration in suspended particles in aquatic organisms and in sediment will yield a sensitive information on the metal concentration than a study of metals in water alone.

In view of the significant role played by micronutrients in aquatic system, these elements have been a subject of constant investigation particularly in brackishwater ponds (Chattopadhyay and Chakraborti, 1980, Chattopadhyay and Saha 1980, Chattopadhyay and Mandal 1980). Subash Chander (1986) and Joshi (1990), while investigating the trace element concentration in prawn culture fields of Cochin, noticed that the adjoining Cochin estuarine system plays an important role as the source of trace elements in these culture systems. Murthy and Veerayya (1981), Rajendran and Kurien (1986), Subash Chander (1986), Joshi (1990), Anikumari (1992) and Mohapatra (1993) conducted detailed studies regarding the trace metals in brackishwater fields near to Cochin estuarine system. According to Rajendran and Kurien (1986), copper concentration was less in Cochin backwaters and ranged between 0.10 to 1.20 ppb. Sankaranarayanan and Qasim (1969) and Venugopal et al., (1982) reported an increase in copper content in water of Cochin estuary during monsoon and postmonsoon months resulted by the increased land drinage. Anikumari (1992) observed a negative correlation of copper with salinity and showed that copper content will be more during low saline monsoon season. Murthy and Veerayya (1981) studied the effect of grain size and organic matter on the concentrations of metals and established strong correlation between metal content and organic matter content in sediment. Murthy and Veerayya (1981) and Anikumari

(1992) reported a clear correlation between copper content and organic matter.

Concentration of heavy metals such as copper and zinc are reported to get accumulated in organs such as muscle, hepatopancreas, stomach and blood (Bryan, 1968). Darmono and Denton (1990) made an extensive study on the heavy metal concentration in prawns, Penaeus merguiensis and P. monodon and concluded that the levels of zinc, copper, mercury and cadmium in the muscle tissue were below the toxic levels. Bryan (1964) studying the zinc regulation in the lobster Homarus vulgaris concluded that extra zinc is absorbed from high seawater via the gills and the excess zinc is removed by urinary excretion. Rainbow (1985) interpreted that there is a regulatory mechanism to maintain constant concentration of zinc, copper and cadmium. Similar attempts on crustaceans particularly prawns in Cochin estuarine system are seldom attempted except for the studies made on the trace metal concentrations of the muscle of prawns cultured in brackishwater ponds near Cochin estuarine system by Joshi (1990) and Anikumari (1992).

Micronutrients, the basic requirement for the production of shrimp food organisms may get exhausted in the pond ecosystem unless they are constantly replaced. Fertilization of both organic and inorganic can promote to a great extend, the addition of the required micronutrients to the pond.

Nutrients released from the organic manures and inorganic fertilizers are transferred to the pond soil and water through bacterial decomposition. Aquatic organisms in the cultivable medium tend to accumulate some of the micronutrients like zinc, copper and iron which are essential for their metabolic activity. Nutrient potential of different organic manures if documented can help a long way in formulating the schedules for their selection and application.

A scrutiny of the foregoing literature shows that the effect of manuring on the trace elements in the pond ecosystem and their rate of accumulation in the tissue of cultured animals in manured ponds is not hitherto been studied. Therefore, the present investigation on the effect of organic manures such as poultry dropping, cowdung and piggery waste was taken up where the trace metals such as zinc, copper and iron are studied in the water, soil and tissue of prawns.

2. MATERIAL AND METHODS

This study was conducted in 4 small brackishwater ponds belonging to Krishi Vigyan Kendra at Narackal where the study described under chapter II was conducted to evaluate the influence of organic manures on the ecology and productivity of brackishwater shrimp ponds. In this experiment water, soil and prawn tissue samples were collected during the course of experiment applied with various organic manures and analysed for zinc, copper, iron concentrations.

The 4 ponds are designated as A, B, C and D having an area of 0.04 ha, 0.04 ha, 0.05 ha and 0.03 ha respectively. The quantity of manure applied was 670.52 kg poultry dropping in pond A, 2000 Kg cowdung in pond C and 913.38 Kg piggery waste in pond D. Pond B was kept as control. The concentrations of zinc, copper and iron determined in different manures applied in the ponds are given in table 39. The duration of the experiment was 3 months.

2.1 TRACE ELEMENTS IN WATER

The water samples were preserved in the farm site itself by adding 2 ml of redistilled concentrated nitric acid per litre of water (Menasveta, 1978) to reduce the pH to 3 to 4 as the heavy metals will not adsorb to the container walls.

Table 39: Concentration of Zinc, Copper and Iron in different manures used for experiment.

Manure	Zn %	Cu %	Fe %
Poultry dropping	1.38	1.09	2.04
Cowdung	0.36	0.54	0.78
Piggery waste	1.07	0.99	1.75

The trace elements were then determined by the extraction of their complexes with ammonium pyrollidine dithiocarbamate (APDC) into methyl iso butyl ketone (MIBK) and subsequent analysis was done in atomic absorption spectrophotometer (Brookes et al., 1967).

Preconcentration of dissolved trace elements from water after filtering through a 0.45 nm millipore filters under vacuum was achieved by chelating them with APDC followed by extraction of the metal chelates into MIBK. Again the organic extract was back extracted into final inorganic form using concentrated nitric acid. The extract was diluted to 20 ml and was analysed in a Perkin Elmer - 2380 model atomic absorption spectrophotometer. The method of estimation was followed as per the guidelines of Brookes et al., (1967) and Sengupta et al., (1978). The wavelengths used for zinc, copper and iron were 213.8, 324.8 and 248.3 nm respectively. The values were obtained from the standard graph drawn with the values obtained for standard chemicals for zinc, copper and iron. The values are given in parts per billion.

2.2 TRACE ELEMENTS IN SEDIMENT

The sediment was oven dried at 90°C to constant weight and was ground in a ceramic grinder. The powdered sediment was allowed to pass through a 100 nm screen. The finer sediment particles were kept airtight in plastic bottles for digestion and further analysis.

The digestion of soil samples of known weight was done in a mixture of perchloric acid and nitric acid as recommended by Lithner (1975). Three drops of sodium chloride (30 g/100 ml) was added to the digested sample and was then diluted to 50 ml with double distilled water. Filtration was done with whatman No. 42 filter paper and final samples were stored in 50 ml plastic bottles. Simultaneously blank were also prepared. Estimation was done as in water sample and the result is expressed in ppm.

2.3 TRACE ELEMENT IN MUSCLE

Prawns were cleaned thoroughly with tap water and later in double distilled water. The muscle was separated using stainless steel dissection tools. The muscle was taken in a clean watch glass and dried for 3 days at 60°C in an oven (Szefer et al., 1990). The dried samples were powdered and packed airtight in clean glass vials for further estimation.

One gram of dried and powdered muscle was taken in a silica crucible covered with silica lid and was transferred to a cool muffle furnace and the temperature was slowly raised to 450-500°C. The sample was held at this temperature for 1 hr. The crucible was removed and cooled. The nitric acid treatment was done as and when required to obtain clean and practically carbon free ash. Afterwards 10 ml of 1 N hydrochloric acid was added and the ash was dissolved by heating cautiously on a hot plate. The mixture thus prepared was transferred to 25 ml volumetric flask adding hydrochloric acid, cooled and diluted to volume (AOAC, 1980). Metal analysis was carried out after suitable dilution/extraction of the digested sample and the procedure followed was the same as for metal analysis in water. The result is expressed in ppm dry weight of the muscle.

3. RESULTS

3.1 TRACE ELEMENT IN WATER

3.1.1 ZINC

Particulars regarding the zinc concentration of water in different ponds applied with organic manure are given in table 40 and fig 33.

In pond A applied with poultry manure, the concentration was 14.17 ppb during the zero week. The lowest and highest values of 0.53 and 18.56 ppb were recorded during the 8th week and 6th week respectively.

In control pond B, the values during the zero and first weeks were 7.47 and 8.59 ppb respectively. The lowest and highest values of 2.61 and 9.81 ppb were recorded during the 6th and 8th weeks respectively.

In pond C applied with cowdung, the concentration was 3.69 ppb during the zero week which was the lowest value obtained during the culture period. The highest value of 10.30 ppb was recorded in the 9th week.

In pond D applied with poultry waste, the concentration was 13.72 ppb during the zero week which decreased to 2.38 ppb in the 8th week. The highest concentration of 33.54 ppb was recorded in the 9th week.

The average concentration of zinc in water in ponds applied with poultry manure, cowdung, piggery waste and control pond were 9.96, 7.25, 12.72 and 6.40 ppb respectively.

Anova of zinc concentration in water at different ponds showed no significant difference ($P>0.05$). Correlation analysis showed no significant relationship between zinc content in water and growth rate of prawns.

3.1.2 COPPER

Copper concentration in water of different ponds applied with various organic manures is given in table 40 and fig. 33.

The concentration in pond A applied with poultry dropping was 1.96 ppb for the zero week which was the highest recorded value. The value decreased slowly to the lowest value of 0.54 ppb recorded in the 8th week, which later increased to 1.62 ppb in the 9th week.

In the control pond B the copper concentration during the zero week was 6.86 ppb which decreased gradually to the lowest value of 0.57 ppb in the 8th week. The concentration suddenly shot up to the highest value of 22.46 ppb in 9th week.

The concentration recorded in pond C, applied with cowdung, was 0.78 ppb during the zero week which increased to 1.58 ppb in the 4th week. The 6th week recorded the lowest value of 0.54 ppb with the highest value 11.57 ppb recorded during the 8th week.

In pond D applied with piggery waste, the concentration was 7.67 ppb in the zero week which gradually decreased to a vlaue of 0.56 ppb in the 8th week. The highest value of 16.54 ppb was recorded during the 9th week.

The average concentration of copper in ponds applied with poultry manure, cowdung, piggery waste and control pond were 1.10, 3.63, 7.05 and 7.27 ppb respectively.

Anova of copper concentration in different ponds indicated no significant difference (P>0.05). Correlation analysis showed no significant relationship between copper concentration in water and growth rate of prawns.

3.1.3 IRON

Particulars regarding the iron concentration in water of different ponds applied with organic manures are given in table 40 and fig. 33.

The concentration in pond applied with poultry manure for the zero week was 2.45 ppb, which was the lowest value recorded. Thereafter the value increased to a high of 27.68 ppb in the 8th week. During the 9th week, the concentration was 18.97 ppb.

In the control pond B, the concentration of iron was 4.66 ppb for the zero week, the lowest and the highest value of 2.85 and 20.21 ppb being recorded during 6th and 8th weeks respectively.

In pond C applied with cowdung, the lowest value of 1.84 ppb was recorded during the zero week. Thereafter, the value increased gradually to the highest value of 40.83 ppb during the 9th week.

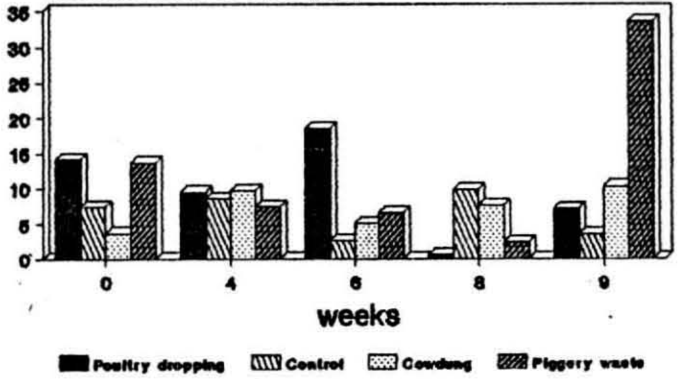
Table 40: Concentrations of Zn, Cr and Fe (ppb) in water recorded in ponds applied with different organic manures.

Treatment Weeks	Poultry dropping A	Control B	Cowdung C	Piggery waste D
Zinc				
0	14.17	7.47	3.69	13.72
4	9.54	8.59	9.68	7.48
6	18.56	2.61	4.98	6.52
8	0.53	9.81	7.61	2.38
9	7.01	3.54	10.30	33.54
Mean	9.96 *A	6.40 *A	7.25 A	12.72 A
Correlation r value	-0.449 NS	-0.225 NS	0.525 NS	-0.103 NS
Copper				
0	1.96	6.86	0.78	7.67
4	0.83	4.33	1.58	8.98
6	0.56	2.16	0.54	1.54
8	0.54	0.57	11.57	0.56
9	1.62	22.46	3.69	16.54
Means	1.10 *A	7.27 A	3.63 *A	7.05 A
Correlation r value	-0.536 NS	0.111 NS	0.387 NS	-0.187 NS
Iron				
0	2.45	4.66	1.84	7.86
4	9.60	18.33	7.77	8.83
6	7.42	2.85	8.96	10.34
8	27.68	20.21	15.23	19.87
9	18.97	13.04	40.83	4.36
Means	13.22 A	11.81 *A	14.92 *A	10.25 A
Correlation r value	0.777 NS	0.359 NS	0.576 NS	0.216 NS

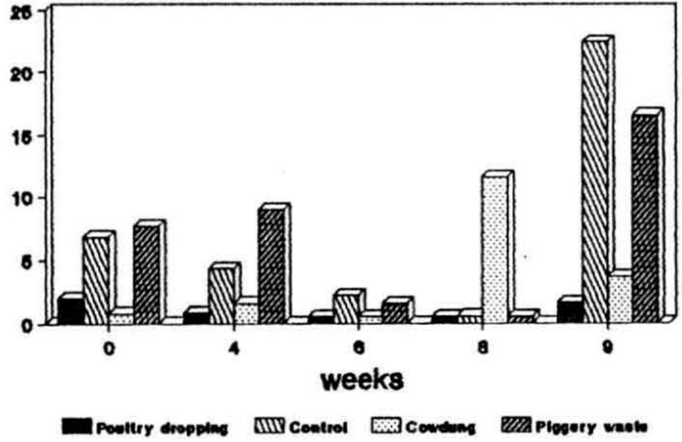
* Any two means having a common letter are not significantly different.
S - Significant, NS - Not Signficant.

Fig. 33 Zn, Cu and Fe conc. recorded in water ponds applied with Organic manures

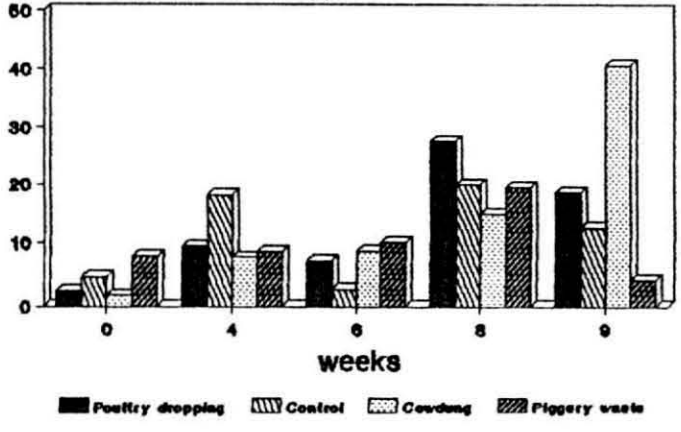
Concentration of Zinc (ppb)



Concentration of Copper (ppb)



Concentration of Iron (ppb)



The concentration during the zero week in pond applied with piggery waste was 7.86 ppb. The highest and the lowest values of 19.87 and 4.36 ppb were observed during the 8th and 9th weeks respectively.

Anova of iron concentration in different ponds showed no significant difference (P>0.05). Correlation analysis revealed no significant relationship between iron concentration in water and growth rate of prawns in any of the ponds.

3.2 TRACE ELEMENTS IN SEDIMENT

3.2.1 ZINC

Details regarding the concentration of zinc in the sediment of different ponds are given in table 41 and fig. 34.

In pond A applied with poultry dropping, the concentration for the zero week was 20.43 ppm dry sediment.

In the control pond B, during the zero week the concentration was 17.00 ppm which increased to 28.69 ppm during the 4th week. The lowest value of 14.54 ppm was recorded during the 6th week. The 9th week recorded the highest value of 36.54 ppm.

The concentration of zinc recorded in pond applied with cowdung during the zero week was 27.67 ppm which increased to

32.31 pm in the 4th week. The highest and lowest concentration of 41.33 and 23.54 ppm were recorded during the 8th and 9th week respectively.

In pond D applied with piggery waste, zinc concentration was 15.31 ppm during the first week. Subsequently the values ranged between 13.69 and 17.64 ppm during the 9th and 6th weeks respectively.

The average concentration of zinc in ponds applied with poultry dropping, cowdung and piggery waste and control pond was 18.66, 29.71, 16.34 and 24.68 ppm respectively.

Anova of the concentration at different ponds showed significant difference (P<0.05). Pairwise comparison indicated significant difference between ponds applied with cowdung and piggery waste.

Correlation analysis showed no significant difference between zinc content in soil and growth rate of prawn.

3.2.2 COPPER

Particulars regarding the concentration of copper in the sediment in different ponds applied with organic manures are given in table 41 and fig. 34.

The copper concentration in pond applied with poultry dropping during the zero week was 4.68 ppm. The lowest and highest concentration of 3.73 and 11.56 ppm were recorded during the 4th and 9th weeks respectively.

In control pond, after recording a vlaue of 9.86 ppm during the zero week, the value increased to 13.54 ppm in the 4th week. The lowest and the highest concentration of 7.61 and 13.63 ppm were recorded during the 6th and 9th weeks respectively.

In pond C applied with cowdung, the value recorded during the zero week was 8.39 ppm which decreased to a low of 6.33 ppm in the 4th week. The highest value of 11.54 ppm was recorded during the 6th week.

In pond D applied with piggery waste, the concentration was 8.45 ppm during the zero week. The highest and the lowest concentration of 10.54 and 3.49 mg/kg were recorded during the 4th and 9th weeks respectively.

The average concentration of copper were 6.80, 8.85, 7.51 and 10.83 ppm in ponds applied with poultry dropping, cowdung, piggery waste and control pond respectively. Anova of concentration in sediment of different ponds showed no significant difference (P>0.05).

Correlation analysis indicated no significant relationship between copper concentration and growth rate of prawns.

3.2.3 IRON

Details regarding the concentration of iron in sediment of different ponds applied with organic manures are given in table 41 and fig. 34.

In pond A applied with poultry dropping, the lowest and the highest values of 5.32 and 29.44 ppm were recorded during the 8th and 6th weeks respectively.

In the control pond B, the highest value of 24.33 ppm was recorded duirng the 4th week. The lowest value of 9.83 ppm was observed during the 9th week.

In pond C applied with cowdung, the lowest value of 7.43 and the highest value of 49.38 ppm were recorded during the 6th and 8th weeks respectively.

In pond D applied with piggery waste, the lowest and the highest values of 4.32 and 21.49 ppm were recorded during the 9th and 8th weeks respectively.

The average concentration of iron in ponds applied with poultry dropping, cowdung, piggery waste and control pond were 15.43, 19.10, 11.53 and 16.02 ppm respectively.

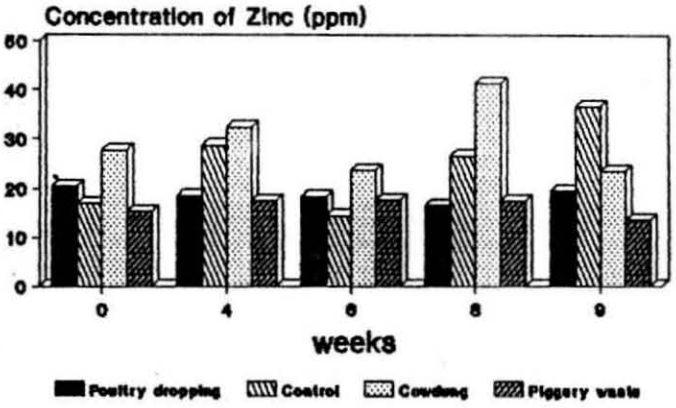
Table 41: Concentration of Zn, Cr and Fe (ppm) recorded in the sediment of different ponds applied with organic manures.

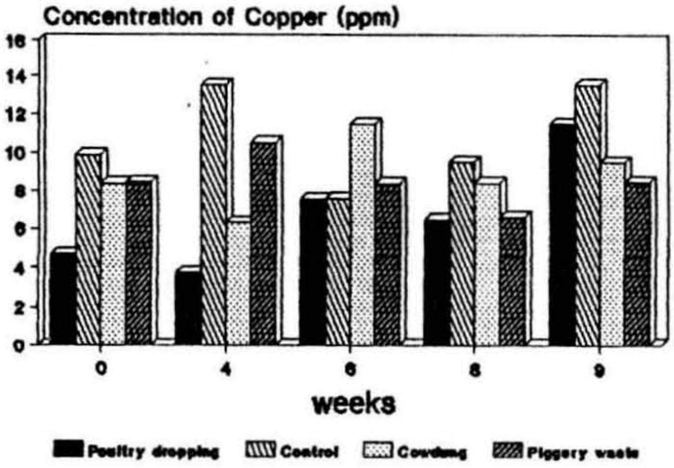
Treatment Weeks	Poultry dropping A	Control B	Cowduung C	Piggery waste D
Zinc				
0	20.43	17.00	27.67	15.31
4	18.51	28.69	32.31	17.56
6	18.36	14.54	23.71	17.64
8	16.56	26.67	41.33	17.53
9	19.48	36.54	23.54	13.69
Mean	18.66 AB	24.68 *AB	29.71 *A	16.34 *A
Correlation r value	-0.622 NS	0.384 NS	0.034 NS	0.383 NS
Copper				
0	4.68	9.86	8.39	8.45
4	3.73	13.54	6.33	10.54
6	7.56	7.61	11.54	8.39
8	6.51	9.54	8.43	6.68
9	11.56	13.63	9.56	3.49
Mean	6.80 *A	10.83 *A	8.85 *A	7.51 *A
Correlation r value	0.717 NS	-0.115 NS	0.434 NS	-0.166 NS
Iron				
0	17.78	12.90	9.46	10.48
4	11.33	24.33	18.81	8.04
6	29.44	15.69	7.43	13.33
8	5.32	17.34	49.38	21.48
9	13.29	9.83	10.43	4.32
Mean	15.43	16.02	19.10	11.53
Correlation r value	-0.158 NS	-0.199 NS	0.265 NS	0.139 NS

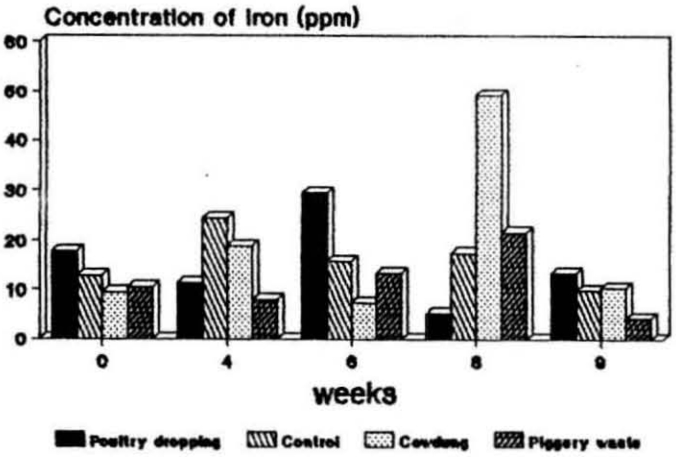
* Any two means having a common letter are not significantly different.

S - Significant, NS - Not Significant.

Fig. 34 Zn, Cu and Fe conc. recorded in soil in ponds applied with Organic manures







Anova of iron concentration in sediment of different ponds showed no significant difference (P>0.05). Correlation analysis indicated no significant difference between iron concentration and growth rate of prawns in any of the ponds.

3.3 TRACE ELEMENTS IN MUSCLE

3.3.1 ZINC

Particulars regarding the concentration of zinc in the muscle of prawns in different ponds are given in table 42 and fig. 35.

It is evident from the figure that in all the ponds the prawns showed a high zinc content of 37.23 - 44.11 ppm dry weight of muscle. However during the 4th week, the values decreased in all the ponds. During 6th week the values increased in prawns collected from ponds applied with poultry dropping, cowdung and the control pond, while in pond applied with piggery waste, a decrease in zinc content was noticed. Nevertheless, after a low during the 8th week, the zinc content further increased in the prawn muscle from all the ponds. The zinc concentration ranged between 37.66 and 44.11, 36.39 and 43.78, 37.23 and 43.78 and 37.43 and 43.78 ppm weight in ponds applied with poultry dropping, cowdung, piggery waste and control pond respectively.

Anova of zinc concentration in the muscle of prawns obtained from different ponds showed no significant difference (P>0.05). Correlation analysis indicated no significant relationship between zinc concentration in muscle and growth rate of prawns.

3.3.2 COPPER

Particulars regarding the copper concentration in the muscle of prawns cultured from different ponds are given in table 42 and fig 35.

In all the ponds, the concentration during the zero week was the same, the value being 28.69 ppm dry weight. Subsequently during the 4th week, the values showed an increasing trend reaching a high of 39.13 ppm during the 6th week in pond applied with poultry dropping and 35.74 mg/ka during the 4th week in pond applied with cowdung. In pond applied with piggery waste and control pond, the concentration suddenly decreased to 22.48 and 23.46 ppm respectively during the 4th week. The copper concentration started declining thereafter in all the tissues except in that collected from the control pond.

The average copper concentration in the muscle of prawns collected from the ponds applied with poultry dropping, cowdung, piggery waste and control pond were 31.25, 29.40, 26.75 and 27.48 ppm respectively, anova of which showed no significant difference (P>0.05). Correlation analysis revealed no significant relationship between copper concentration and growth of prawns.

3.3.3 IRON

Details regarding the iron content in the muscle of prawns are given in table 42 and fig. 35.

In all the ponds, the concentration of iron recorded during the zero week was the same and the value was 7.86 ppm In all the ponds except the pond applied with piggery waste, the vlaue increased during the 4th week. In the pond applied with piggery waste, the value decreased suddenly during the 4th week. Again higher concentration was recorded during the 8th week in all ponds except in the control pond.

The average iron concentration in the muscle of prawn in ponds applied with poultry dropping, cowdung, piggery waste and control pond were 10.00, 8.97, 8.55 and 8.28 ppm respectively, anova of which showed no significant difference (P>0.05). Correlation analysis also indicated no significant relationship between iron content in muscle and growth rate of prawns.

Table 42: Concentration of Zn, Cr and Fe (ppm) recorded in the tissue of prawns collected from ponds applied with organic manures.

Treatment Weeks	Poultry dropping A	Control B	Cowdung C	Piggery D
Zinc				
0	43.78	43.78	43.78	43.78
4	38.78	39.01	36.39	39.68
6	44.11	41.26	41.24	37.23
8	37.66	37.43	38.03	37.67
9	43.39	39.73	41.68	42.06
Mean	41.52 *A	40.24 A	40.22 *A	40.08 A
Correlation r value	-0.204 NS	-0.708 NS	-0.509 NS	-0.813 NS
Copper				
0	28.69	28.69	28.69	28.69
4	37.38	23.46	35.74	22.48
6	39.13	32.96	34.22	26.99
8	24.86	26.89	24.64	24.37
9	26.23	25.43	23.73	31.24
Mean	31.25 *A	27.48 A	29.40 *A	26.75 A
Correlation r value	-0.164 NS	0.086 NS	-0.113 NS	-0.230 NS
Iron				
0	7.86	7.86	7.86	7.86
4	12.45	10.27	8.93	4.12
6	9.64	6.30	12.48	9.77
8	13.65	7.09	10.29	12.48
9	6.40	9.88	5.30	8.53
Mean	10.00 *A	8.28 A	8.97 *A	8.55 A
Correlation r value	0.138 NS	-0.246 NS	0.257 NS	0.221 NS

* Any two means having a common letter are not significantly different.

Fig. 35 Zn, Cu and Fe conc. recorded in tissue of prawns from manured ponds

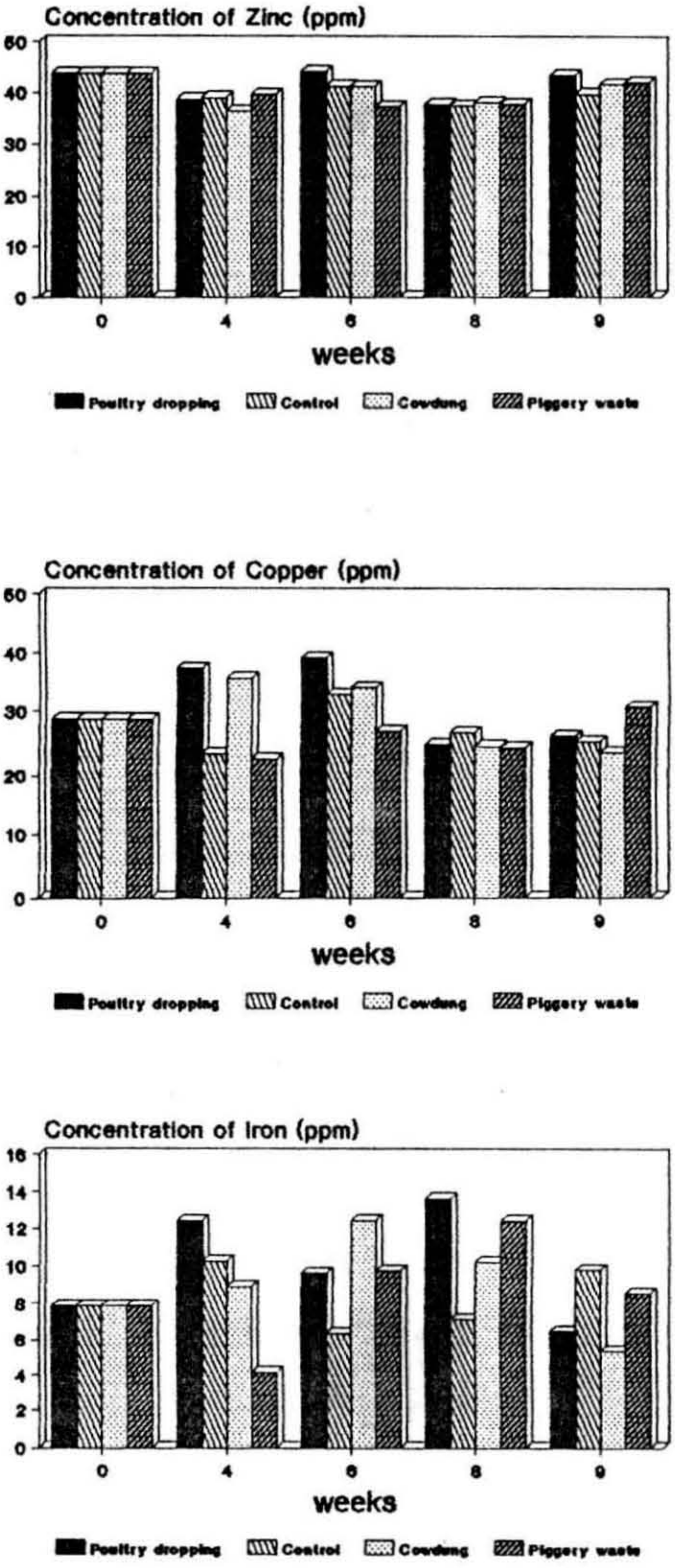


Table 43: Analysis of variance of various parameters recorded in Chapter III.

				F Value	
Source	D.F	S.S	M.SS	Calculated	Tabled
Water Zinc (table 40)					
Treatment	3	122.92	40.975	0.755	3.24
Error	16	869.76	54.360		
Total	19	992.69			
Copper (table 40)					
Treatment	3	127.42	42.47	1.208	3.24
Error	16	562.36	35.14		
Total	19	689.78			
Iron (table 40)					
Treatment	3	59.58	19.86	0.185	3.24
Error	16	1715	107.18		
Total	19	1774.58			
Sediment Zinc (table 41)					
Treatment	3	546.36	182.12	5.171	4.77
Error	16	563.44	35.215		
Total	19	1109.80			
Copper (table 41)					
Treatment	3	47.13	15.710	2.375	3.24
Error	16	105.82	6.614		
Total	19	152.95			

Source	D.F.	S.S	M.SS	F Value Calculated	F Value Tabled
Iron (table 41)					
Treatment	3	144.81	48.27	0.421	3.24
Error	16	1833.35	114.58		
Total	19	1978.16			
Tissue Zinc (table 42)					
Treatment	3	6.111	2.037	0.257	
Error	16	126.63	7.914		
Total	19	132.74			
Copper (table 42)					
Treatment	3	61.43	20.477	0.837	3.24
Error	16	391.05	24.440		
Total	19	452.48			
Iron (table 42)					
Treatment	3	8.55	2.85	0.397	3.24
Error	16	114.83	7.17		
Total	19	123.38			

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4. DISCUSSION

The importance of trace elements in the growth and development of crustaceans has been stressed upon by many workers (Martin, 1974; Rainbow, 1985; and Qazim <u>et</u> <u>al</u>., 1988). Among the different trace elements, zinc is the most important one (Waldichuk, 1974). In Cochin estuarine waters, Sankaranarayan and Stephen (1978) and Rajendran and Kurien (1986) reported a zinc concentration of 0.69 to 9.0 and 9.4 ppb respectively. In culture ponds near to Cochin estuary also, Joshi (1990) and Anikumari (1992) reported zinc concentration of 4.16 to 14.72 and 5.3 to 7.10 ppb. The concentration of 6.41, 12.73 ppb observed in the present study agrees with that recorded by the above said authors.

A comparison of the average concentration of zinc in different ponds in the present study shows slightly higher average values of 12.72 ppb in pond applied with piggery waste when compared with the values of 9.96, 7.25 and 6.40 ppb in the ponds applied with poultry dropping, cowdung and in control pond respectively. This may be due to the releasing of zinc from the pond sediment to the water since low zinc concentration in sediment was also noticed in this pond. The excess zinc in water in the pond applied with piggery waste may also be due to its release to the water favoured by low organic carbon which binds trace metals, as has also been opined by

Murthy and Veerayya (1981). In all the ponds there were drastic changes in the concentration of zinc and this may be on account of utilization.

According to Chattopadhyay and Saha (1980), importance of copper in aquaculture lies in its being involved with respiration of primary fish food organisms and also with their utilization of iron in the formation of chlorophyll during photosynthesis. In the present study, no significant difference in copper concentration in water was found between ponds applied with different organic manures. However, the least value of 1.10 ppb and the highest value of 7.27 ppb were recorded in the pond applied with poultry manure and control pond respectively. This may be on account of absorption of copper from water by the abundant growth of phytoplankton in the pond applied with poultry manure. This utilization is further evidenced by the low concentration of copper in this pond compared to other ponds. The high concentrations of copper in control pond and pond applied with piggery waste may be due to the release of copper from the sediment, a reason equally applicable to high zinc concentration in this pond. Kanwar and Randhawa (1974) described the availability of copper in the soil to depend upon a number of factors such as pH, organic carbon, calcium carbonate and soil texture. According to Rajendran and Kurian (1986), the copper content in Cochin estuarine water is very low of the order of 0.1 to 1.2 ppb. On the other hand, Sankaranarayan and Stephen (1978), Joshi (1990) and Anikumari (1992) recorded higher concentration of 0.9 to 13.7; 3.44 to 12.64 and 2.75 to 12.25 ppb respectively. The copper concentration observed in different ponds in the present study ranging between 0.56 and 22.46 ppb shows wider fluctuations.

Iron concentration in water in different ponds in the present investigation did not show much variation among different ponds, the average concentration recorded varying between 10.25 and 14.92 ppb. Chattopadhyay and Saha (1980) observed positive correlation between iron content in water and salinity, electrical conductivity of water. On the other hand a negative correlation between iron concentration and water salinity was observed in the present study. However Joshi (1990) has recorded low concentration ranging between 1.12 and 5.85 ppb in brackishwater ponds of Vypeen island, where no manuring was done. Thus it may be concluded that the highest values observed in the present study may be due to the effect of fertilization.

An evaluation of the zinc concentration in the sediment from ponds applied with different organic manures showed significant difference. The highest concentration of 29.71 ppm was observed in pond applied with cowdung. This may be due to the slow release of zinc from the sediment to water probably because of the reduced conditions in the bottom of this pond which inhibit the release of zinc in to the water (Lu and Chen 1971). Concurrently the low concentration in ponds applied with poultry and piggery waste may be on account of its release in to the water body as the bottom of these ponds are not in much reduced state.

In the present study, the average zinc concentration in the sediment in different ponds ranged between 16.34 and 29.71 ppm. This value is hgiher than the value of 0.5 - 3.21 ppm reported by Rajendran and Kurian (1986) in the adjacent cochin backwaters. On the other hand, very high values of 32.08 to 92.8 and 42 to 81 ppm have been reported by Joshi (1990) and Anikumari (1992) respectively in brackishwater ponds near to Cochin estuarine system. Theie study was in deeper ponds and since reduced conditions persist in deeper ponds, zinc release into water was inhibited showing higher values in the sediment.

Anikumari (1992) recorded 0 to 13.45 ppm copper concentration in brackishwater ponds near to Cochin estuarine system. On the other hand, Joshi (1990) recorded a concentration of 32.08 - 92.8 ppm in brackishwater ponds of the same area. The values of 7.51 - 10.83 ppm obtained in the present study were almost similar with that of the first author.

Iron content in sediment also did not show any significant difference among the different ponds. However pond C showed higher values. The values of 11.53 and 19.10 ppm in the present study is higher than the values of 0.72 - 6.08 ppm obtained by Joshi (1990) in the same area. According to Lu and Chen (1971), with reducing conditions, the release of iron in to water is enhanced. The ponds where Joshi (1990) studied, were deeper and the reducing conditions there might have enhanced the release of iron in to the water and hence low concentration in sediment.

The concentration of zinc in the muscle of prawns obtained from different ponds did not show variation and the average values ranged between 40.09 and 41.52 ppm (dry weight). A concentration of 16.07 ppm (wet weight) was reported by Darmono and Denton (1990) in P. monodon obtined from culture ponds. Matkar et al., (1981) also found out a zinc concentration of 11.15 ppm (wet weight). On the other hand, Anikumari (1992) reported a lower concentration of 6.66 - 18.31 ppm (dry weight). The concentration obtained in the present study is higher than the values obtained by Anikumari (1992) and almost similar to the values reported by other authors as they reported values in wet weight against the values given in the present study in dry weight basis.

Copper concentration in the muscle did not show much variation in the present study. The average concentration ranged between 26.75 and 31.25 ppm. Darmono and Denton (1990) reported a concentration of 7.23 ppm wetweight in the muscle of cultured P. monodon, while Zingde et al., (1976) observed the copper concentration of 21 to 48 ppm in the muscle of P. monodon obtained from Goan waters. On the other hand, Anikumari (1992) reported a very low concentration of 1.49 to 9.95 ppm (dry weight) in P. Indicus. The concentration obtained in the present study seems to be in accordance with that observed by the above said authors except Anikumari (1992).

Matkar et al., (1981) reported a very high concentration of 15 ppm (wet weight) in the muscle of Aselius indicus from marine waters off Bombay. Darmono and Denton (1990) observed an iron concentration of 2.07 ppm wet weight in P. monodon collected from cultured ponds. The average concentration of 8.28 to 10.00 ppm (dry weight) observed in the present study agrees more with the observations made by Darmono and Denton (1990).

Compared to water and sediment, the content of each trace metal in the muscle of prawns does not vary much among different ponds in the present study and the reason may be attributed to the body regulation of trace elements in the prawns (Bryan, 1968).

The quantity of manure applied was 670.52 kg poultry dropping in pond A, 2000 kg cowdung in pond C and 913.38 kg piggery waste in pond D. According to table 39, the quantity of zinc applied by the manuring was 9.25 kg, 7.2 kg and 9.77 kg per ha in pond applied with poultry dropping, cowdung and piggery waste respectively. The quantity of copper supplied was 7.3 kg, 10.80 kg and 9.04 kg per ha respectively. Evincing comparatively high quantity provided, the iron content in ponds applied with poultry dropping, cowdung and piggery waste was 13.67 kg, 15.6 kg and 15.98 kg, per ha respectively.

In accordance with high quantity of 9.77 kg applied, the zinc concentration in the water of the pond applied with piggery waste showed correspondingly higher average value of 12.72 ppb. In other ponds the concentration of zinc applied with cowdung and poultry manure was 7.2 and 9.25 kg/ha respectively. Correspondingly zinc concentration in water also showed comparatively low values of 7.25 and 9.96 ppb respectively. However, in the sediment, the concentration of zinc was found to be higher in pond applied with cowdung (29.71 ppm) compared to other ponds, which may probably be due to the binding action of the sediment under reduced lower dissolved oxygen concentration resulting in the accumulation of zinc in the mud as has also been reported by Lu and Chen (1971). Nevertheless, in the muscle of the prawns cultured in these ponds, the zinc concentration indicated a narrow range between 40.08 and 41.52 ppm, thus showing indication of body regulation within the tissues irrespective of the variation of zinc concentration observed in the environment.

Copper concentration in the water of the pond applied with piggery waste showed maximum concentration of 7.05 ppb compared to the low concentration of 3.63 and 1.01 ppb in ponds applied with cowdung and piggery waste. A comparison of the copper concentration in water, sediment and tissue in ponds applied with different organic manures indicated certain interesting features. In the pond applied with cowdung, the copper concentration in water was 3.63 ppb with the concentration in the sediment amounting to 8.85 ppm. In the tissue, a concentration of 29.40 ppm was noticed. In the pond applied with poultry dropping on the other hand, where the sediment showed 6.80 ppm, water showed the least concentration of 1.10 ppb with higher concentration of 31.28 ppm in the tissue, thereby indicating absorption and accumulation from the water to the tissue. In the pond applied with piggery waste, however, tissue showed a lower concentration of 26.75 ppm with higher values of 7.05 ppb in water and 7.51 ppm in the sediment, thus indicating lower rate of accumulation in the tissue.

Iron concentration in the pond applied with cowdung, poultry dropping and piggery waste were 14.92 ppb, 13.22 ppb and 10.25 ppb respectively in the water, while in the sediment, the values were 19.10 ppm, 15.43 ppm and 11.53 ppm respectively. A comparison of Iron content in the manures such as cowdung (15.60 kg), poultry dropping (13.67 kg) and piggery waste (15.98 kg) and its concentration in water and sediment indicated higher rate of accumulation in sediment in ponds applied with cowdung and poultry dropping. In the tissue, the higher concentration of 10.00 ppm was noticed in the prawns cultured with poultry manure. Here it is probable that the iron concentration from the sediment is released in to the water and then to tissues which is reflected by the comparatively low concentration in the sediment and water and higher concentration in the muscle of prawns.

The zinc and copper concentration is the tissue of prawns in the present study were 40.08 to 41.52 and 26.76 to 31.25 ppm respectively. These levels were below the maximum levels of 450 ppm zinc and 35 ppm copper (dry wt.) set by the Australian National Health and Medical Research Council for human consumption (Darmono and Denton, 1990).

An evaluation of the impact of the concentration of trace elements in different manures under study indicates that poultry manure haivng zinc, copper and iron concentrations of 1.38, 1.09 and 2.04% respectively showed better production in terms of primary productivity along with better growth and survival of prawns. In ponds applied with piggery waste and cowdung having zinc, copper and iron concentrations of 0.36, 0.54, 0.78% and 1.07, 0.99, 1.75% respectively, where productivity was moderate. Here it is probable that poultry manure with the desired levels of micronutrients have enabled steady and slow release of nutrients enabling rich productivity and encouraging yield.

SUMMARY

SUMMARY

The investigation on the Ecological and Productivity Studies of the Prawn Farms in Central Kerala is described under 3 chapters.

CHAPTER 1

1 The Chapter 1 deals with the ecology and productivity of some semi-intensive prawn farms at Poyya and Chellanam lying at the northern and middle portions of the Cochin estuarine system, from where 3 ponds each were selected for study. The major water, soil and biological parameters along with the growth rate, survival rate and production of stocked prawns were evaluated.

2 Among 3 ponds at Poyya, two belonged to State Fisheries Department having an area of 0.4 ha and 0.2 ha and pond 3 belonged to a Private Ltd. Company with an area of 0.7 ha and stocked with post larvae of P. indicus at a density of 2,19,000, 2,33,000 and 2,14,000/ ha respectively. At Chellanam, 3 ponds having an area of 0.5, 0.6 and 0.8 ha were stocked with P. indicus at a density of 1,41,900, 2,31,666 and 1,03,000/ha.

3 Temperature was not significantly different among different ponds. Growth showed positive correlation with temperature in all ponds except in pond 3 at Poyya.

4 Salinity was significantly high in all ponds at Poyya compared to the ponds at Chellanam.

5 Dissolved oxygen concentration was significantly high in ponds 1 and 2 at Poyya compared to the ponds at Chellanam. In all ponds at Poyya, growth showed significant relationship with dissolved oxygen concentration, while no significant relationship was observed at Chellanam.

6 pH values were significantly high in ponds at Chellanam compared to the ponds at Poyya. In pond 3, a negative correlation was obtained between growth and water pH.

7 Total alkalinity was found to be significantly high in ponds at Chellanam, in accordance with high pH values, while it was low in ponds at Poyya. In ponds at Poyya, the average alkalinity values were 86.41 to 107.18 ppm, while the values were 141.97 to 157.02 ppm in ponds at Chellanam.

8 In all the ponds, the total hardness was found decreasing towards the end of the culture period. Ponds at Poyya showed higher values when compared to the ponds at Chellanam. Ponds 3 and 4 showed significant negative correlation between growth and total hardness.

9 Regionwise, no difference in nitrate value was observed. However, the value in pond 1 at Poyya is significantly different from that of other ponds except pond 5 at Chellanam. No significant relationship was observed between nitrate concentration and growth of prawns in both at Poyya and Chellanam.

10 Phosphate concentration was not significantly different among different ponds, however slightly higher values were noticed in ponds at Chellanam. Correlation analysis indicated no significant relationship between growth and phosphate concentration.

11 It is obvious that there exists a remarkable variation in nitrite concentration among the different ponds, with lower values noticable at Chellanam.

12 Ammonia concentration was low in ponds at Chellanam with the highest value noticed in pond 3 at Poyya. There exists a significant relationship between ammonia concentration and growth in ponds 1 and 3.

13 Primary productivity values were generally high in ponds at Chellanam. In ponds 2 and 3 at Poyya and 5 and 6 at Chellanam, primary productivity was found significantly influencing the growth of prawns.

14 Phytoplankton concentration is found to be significantly high in ponds at Chellanam. In ponds 2 at Poyya and 5 and 6 at Chellanam, growth showed positive correlation with phytoplankton concentration.

15 The highest (2.20 ml/M^3) and the lowest(0.30 ml/M^3) zooplankton concentration were observed in pond 2 and 3 at Poyya respectively. However, no significant correlation was obtained in any of the pond between growth and zooplankton concentration.

16 The soil pH was comparatively high in ponds at Chellanam. There was increase and decrease in soil pH towards the end of the culture period in ponds at Poyya and Chellanam respectively, a case usually noticed in brackishwater ponds. In pond 2, soil pH was found significantly influencing the growth.

17 Organic carbon content was significantly high in ponds at Poyya (3.02 to 3.33%). The average organic carbon content was 0.79 to 1.13% in ponds at Chellanam.

18 Ponds 1 and 2 at Poyya have very high gravel content.

19 Benthos concentration was nil d ng many weeks in ponds at Poyya. Significantly very high benthos concentration was observed in ponds at Chellanam.

20 Survival rate observed (10.09 to 37.13%) was very low at Poyya when compared to the 61.30% to 79.79% observed in ponds at Chellanam. Yield per hectare was also higher in ponds at Chellanam compared to the ponds at Poyya.

21 This study clearly indicates that the ponds at Chellanam lying at the middle portion of the Cochin estuarine system having moderate water pH, salinity, alkalinity, hardness, soil pH, organic carbon are more productive compared to the ponds at Poyya lying at the northern end of Cochin estuarine system. Ponds at Poyya recorded low water and soil pH, total alkalinity and high ammonia and organic carbon.

22 Similar studies if taken up will enable identifying various grades of productive ponds, so that necessary steps can be evolved so as to improve the under productive ponds.

CHAPTER 2

23 In Chapter 2, the influence of organic manures on the ecology and productivity of brackishwater shrimp ponds was evaluated. This study was conducted in four small brackishwater ponds at Narakkal which are designated as A, B, C and D. The quantity of manure applied was 2000 kg cowdung in pond C, 670.52 kg poultry dropping in pond A and 913.38 kg piggery waste in pond D, while pond B was kept as control. The quantity of each manure was adjusted in such a way that each manure provided the same quantity of phosphorus in the pond to which it was applied, but with variable quantity of nitrogen and organic carbon.

24 Temperature did not vary significantly among different ponds. However, a gradual increase and subsequent reduction were noticed during the middle and end of the experiment respectively in all ponds.

25 The salinity also showed higher values during the middle period of culture and decreased during the end due to the monsoon rain. Anova of salinity at different ponds did not show any significant difference.

26 Dissolved oxygen was determined at 4 times of the day viz. 00.00, 06.00, 12.00 and 18.00 hrs. Dissolved oxygen at 00.00, 06.00 and 12.00 hrs did not show any significant variation among different ponds. On the other hand, dissolved oxygen at 18.00 hrs was found significantly high in pond applied with piggery waste and poultry dropping. Dissolved oxygen of less than 2 ppm at 06.00 hrs was observed thrice in pond applied with cowdung, compared to the pond applied with poultry dropping where dissolved oxygen was not reduced to below 2 ppm.

27 pH, total alkalinity and total hardness values were not found to be significantly different among various ponds applied with organic manures, showing that manures can not influence these parameters significantly. All these values were found decreasing during the 2nd half of the experiment.

28 Concentration of nitrate nitrogen was not statistically different among different ponds, although comparatively higher concentration was noticed in ponds applied with organic manures. In pond C applied with cowdung, nitrate nitrogen was found to have significant influence on the growth of prawns.

29 Phosphate concentration was found to be significantly higher in pond applied with cowdung compared to all other ponds indicating that manure can increase the phosphate concentration. However correlation analysis did not show any significant relationship between phosphate concentration and growth in any pond.

30 The pond applied with piggery waste showed significantly higher nitrite concentration and in pond applied with cowdung, nitrite concentration was found positively influencing the growth of prawns.

31 Ammonia concentration was not significantly different among different ponds.

32 Primary productivity values were generally higher in ponds applied with poultry dropping. The productivity in pond applied with piggery waste was found to be significantly different from the values in control pond.

33 The phytoplankton concentration of 5.09 ml/M^3 observed in pond applied with poultry dropping was statistically significant with the values obtained in control pond (3.32 ml/M^3). On the other hand, higher zooplankton concentration of 3.10 ml/M^3 was observed in pond applied with piggery waste followed by poultry dropping,

which was statistically different with the concentration in pond applied with cowdung and also in the control pond.

34 Statistically higher heterotrophic activity of water was noticed in pond applied with piggery waste. A negative and positive relationship was observed between growth and heterotrophic activity in control pond and the pond applied with cowdung.

35 Soil pH was not significantly different among different ponds and a negative correlation was observed between soil pH and growth in ponds applied with poultry dropping, cowdung and control pond.

36 Significantly high organic carbon content was noticed in pond applied with cowdung (2.62%) compared to 1.01, and 1.63% organic carbon in ponds applied with piggery waste and poultry dropping respectively. In pond applied with poultry .dropping and cowdung a negative correlation was obtained between growth and organic carbon content.

37 Significantly high total nitrogen was observed in pond applied with cowdung. However no relationship between growth of prawns and total nitrogen was observed in any of the ponds. On the other hand, higher C/N ratio

was observed in pond applied with poultry dropping. A negative correlation was obtained between C/N ratio and growth in pond applied with cowdung.

38 The significantly highest total phosphorus was observed in pond applied with cowdung and the lowest in pond with piggery waste.

39 Heterotrophic activity was found to be significantly high in ponds applied with poultry dropping and piggery waste, while respiration rate of mud did not vary significantly among different ponds.

40 Significantly highest benthos concentration was observed in pond with poultry dropping. In pond with piggery waste, a negative correlation was obtained between growth of prawns and benthos concentration.

41 Only in pond with poultry dropping, a steady growth of prawns was observed. Highest survival and production were obtained in pond applied with poultry dropping. The lowest survival rate and production were observed in pond with cowdung.

42 Among the different manures used poultry by virtue of its high nutrientconcentration resulting in higher primary productivity, phytoplankton, zooplankton and benthos have yielded better growth, survival and production of prawns.

CHAPTER III

43 In Chapter III, the concentrations of trace elements in ponds applied with different organic manures described in Chapter II were evaluated.

44 Comparatively higher concentration of zinc in water is recorded in ponds applied with piggery waste and poultry dropping. On the other hand, the concentration of copper was lowest in pond applied with poultry dropping. The concentration of iron was highest in pond applied with cowdung and the least in pond with piggery waste. However no statistical significant difference was observed between trace elements concentrations in water at different ponds applied with organic manures.

45 In sediment, the significantly higher zinc concentration was observed in pond with cowdung. Copper and iron concentration were also comparatively higher in pond with cowdung.

46 The concentrations of zinc, copper and iron in the tissue of prawns collected from different ponds with organic manures showed almost similar values due to the body regulation.

47 Poultry manure having higher concentration of 1.38% zinc, 1.09% copper and 2.04% iron is a better manure for fertilizing brackishwater ponds.

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