IMPACT OF SHRIMP FARMING ON THE ENVIRONMENT IN SAPHALE REGION OF MAHARASHTRA

Thesis Submitted in Partial Fulfilment of
the Requirement for the Degree of
Doctor of Philosophy
in
Inland Aquaculture

BY

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SEPTEMBER 2000

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SEPTEMBER 2000

Dedicated to

the fond memory of (Late) Dr. N.K. Thakur

and

to my parents with gratitude, respect and love

केन्द्रीय मत्स्य शिक्षा संस्थान
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CERTIFICATE

Certified that the thesis entitled "**IMPACT OF SHRIMP FARMING ON THE ENVIRONMENT IN SAPHALE REGION OF MAHARASHTRA**" is a record of independent bonafide research work carried out by **Mr. Sukham Munilkumar** during the period of study from October 1996 to September 2000 under our supervision and guidance for the degree of Doctor of Philosophy (Inland Aquaculture) and that the thesis has not previously formed the basis for the award of any other Degree, Diploma, Associateship, Fellowship or any other similar title.

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DECLARATION

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Chapter 1
INTRODUCTION

Even though world catch of fish shows an increasing trend reaching 98 million tonnes in 1996, chronic over-fishing continues to threaten the productivity and viability of aquatic ecosystems worldwide. It is projected that by the end of this century, there will no longer be an increase in capture fisheries output on an average.

In the present scenario of continuing decline in wild fish stocks, the importance of aquaculture as a food-producing activity is gaining ground. The world now holds about 6.0 billion people adding approximately 100 millions each year. The current rate of increase in world population is calling into question the capacity of humanity to continue and ensure supply of food for all into the next century. Human population is estimated to reach 6.261×10^6 by the end of 2000 and 8.500×10^6 in 2025 (UN, 1992). At the same time, agricultural production has stagnated over the last two years after a period of impressive growth through the 1970s and 1980s. The issue of food security has now become crucial in planning for future generations and the fisheries sector, along with other agricultural activities, is being examined to determine the sustainable contribution it can make to future food supply (Welcomme, 1996).

Fish farming known as aquaculture is one of the fastest growing sectors in world food production (Williams, 1996). From 6.9 million tonnes in 1984, farmed fish production got more than tripled, reaching 23.1 million tonnes in 1996 (McGinn, 1998). Between 1990 and 1995, world aquaculture production expanded at an average annual rate of 11% (FAO, 1995). World aquaculture production increased from 13.48 million tonnes in 1987 to 34.12 million tonnes in 1996 (FAO, 1998).

An estimated 30% of shrimp, 40% of salmon and mollusks (oysters, clams, scallops and mussels) and 65% of freshwater fish consumed today have lived in captivity for most of their lives (FAO, 1995). Worldwide, one out of every five fish eaten today was raised in a farm (Holmes, 1996).

Shrimp farming first became profitable during the 1970s and has since mushroomed into a widespread enterprise throughout the tropical world. About 1.2 million hectares of shrimp ponds are in Thailand, Indonesia, China, India and other Asian countries. Western white shrimp (*Penaeus vannamei*) and the giant tiger shrimp of Asia (*P. monodon*), respectively, comprise 22 and 58% of the shrimp grown in shallow ponds (Boyd and Clay, 1998). Giant tiger prawns, were valued at US$ 3.5 billion in 1995, making this the most valuable aquaculture commodity even though only 500,000 t were cultivated (FAO, 1995). Driven by the high profits and export market, shrimp farming now spans 50 countries and is expanding rapidly (Gujja and Finger-Stich, 1996).

Traditional shrimp ponds are characterised by the harvesting of low impoundments where natural stocking of wild seed takes place under tidal influence along with different species of fishes. The most significant contribution towards the evolution of modern shrimp farming was made by M. Fujinaga of Japan who did the pioneering work for hatchery technology related to spawning and larval rearing of 'kuruma' prawn (*P. japonicus)* in the 1930s. The availability of shrimp seed as commercial hatcheries were established throughout the region in the 1970s and 1980s coupled with the marketing of formulated feeds, and the active support of governments and private sector set the stage for the industry to take-off in the 1980s (Primavera, 1994).

The culture of shrimp is basically a two-step process composed of a broodstock-hatchery phase for producing seed or post-larvae and a grow-out phase, usually in earthen ponds, for rearing of juveniles to marketable size.

When these activities are highly developed, specialisation includes producers/manufacturers of farm equipment, algal feeds, formulated feeds, spawners, nauplii, farm services, etc. With the development of a shrimp-farming industry worldwide, there has been a concerted effort to enhance the production level that involves higher usage of inputs. Due to intensification, the positive aspects of shrimp culture are also accompanied by some realised and potential adverse environmental impacts. These include destruction of mangroves for construction of shrimp farms; the eutrophicating effects of shrimp pond wastes on estuarine and coastal waters; land subsidence due to continuous usage of ground water, salinisation of aquaculture land, etc. As a result of these problems, protests are taking place in India, Bangladesh, Thailand, Malaysia, the Philippines, Ecuador, Taiwan, etc. There have been many campaigns against shrimp farming with environmental groups calling for a complete ban on shrimp farming other than using the traditional methods (Masood, 1997).

In India, social groups like PREPARE and LAFTI have campaigned against shrimp farming activities in the states like Tamil Nadu, Andhra Pradesh, Orissa, etc. Allegations on shrimp farming in India regarding its pollutional nature are listed as follows (Thakur *et al.,* 1997):

(1) Shrimp farming results in loss of mangrove ecosystem.

(2) Agricultural land being converted into commercial shrimp farms causes unemployment to the landless labourers and also loss of cultivable land.

(3) Indiscriminate catch of shrimp seed from natural waters depletes its availability, causing considerable damage to its fishery in coastal waters.

(4) Shrimp farms constructed well above the ground level cause salinisation of soil and ground water in the surrounding fields.

(5) The wastewater discharged from shrimp farms causes considerable damage to the aquatic environment.

(6) Due to the accumulation of pollutants from shrimp farms, waterborne diseases spread.

According to environmentalists, Tamil Nadu's shrimp export revenue of US$ 868 million in 1994 came at the expense of US$ 138 million in jobs lost and environmental destruction. Therefore, the argument is that shrimp farming is a scheme where the rich get richer while creating a negative impact in the overall national economy and in a country where not all of the people can afford to eat well, aquaculture is replacing locally-produced, traditional forms of agricultural produce with produce for export that most Indians cannot afford. The Hon'ble Supreme Court of India in December 1996, ordered the closure of all semi-intensive and intensive shrimp farms within 500 m of the high-tide line and banned shrimp farming activities except the traditional ones. The landmark decision focused attention on its socio-economic costs.

Though much of the potential environmental concerns are of a speculative nature and are not supported by scientific evidence (Pillay, 1992), there is awareness that the enormous yields of modern farming have come at a high environmental and social cost, a cost we are learning to acknowledge. In the Saphale region of Palghar Taluka (Thane District, Maharashtra), shrimp farming is being carried out from the beginning of the 1990s. But, no organised research on the impact of shrimp farming on the environment has so far been conducted in this region. The present study is, therefore, undertaken to assess the impacts brought about by shrimp farming on the environment and in turn, improved eco-friendly farming practices are to be suggested which will be economically viable, environmentally sound and socially acceptable.

review of literature

Chapter 2
REVIEW OF LITERATURE

The demand for shrimp the world over, especially in Japan, the United States and Europe, has resulted in increased production of farmed shrimp at the phenomenal rate of 20 - 30% per year in the last two decades (Primavera, 1994). Farmers in India and China have cultured shrimp in tidal impoundments on an extensive basis. This traditional method of shrimp culture is characterised by natural recruitment, with little or no fertilisation and feeding, and low production costs. Yields were also low, typically 50 to 500 kg/ha in a year (Chamberlain, 1991). To meet the increasing demand, a lot of farming techniques have been evolved involving huge usage of inputs. Over the last 60 years, techniques have been developed to raise shrimp intensively in ponds (Weidner, 1992). These recent aquaculture developments are occurring at a time of increasing awareness of environmental issues, particularly since the 1992 Earth Summit (UN, 1992). In Asia, deterioration in water quality, habitat destruction and loss of biodiversity are being widely reported (ESCAP, 1990) as results of coastal aquaculture. Between 1990 and 1995, the number of shrimp farms in Southeast Asia got tripled (Weber, 1996). This development is not without problems, however. Shrimp ponds were abandoned in the late 1980s after several years of intensive production as the environmental stress triggered diseases and environmental damage (Holmes, 1996).

In the recent past, there had been reports of ecological damages inflicted by shrimp farms (Saclauso, 1989; GESAMP, 1991; Boyd and Musig, 1992; Shiva, 1995; Stevenson and Burbridge, 1997). In India, a strong community movement gained momentum along the east coast, especially in Tamil Nadu and Andhra Pradesh, against the shrimp farming practices. Subsequently, the Honb'le Supreme Court intervened in December 1994 and based on the report of the National Environmental Engineering Research

Institute (NEERI), Nagpur, in line with the Environmental Protection Act, gave several directives in May 1995 regarding coastal aquaculture practices.

It has now become clearer that a balance between shrimp farming and the environment is certainly essential for its sustainability. Even the Government of India is paying greater attention to the incorporation of environmental issues into the national aquaculture development programmes (FAO/NACA, 1994; MOF/NACA, 1994). The Food and Agricultural Organisation's Technical Consultation on Policies for Sustainable Shrimp Culture held in Bangkok in December 1997 (FAO, 1998) sought the progress in implementing the Code of Conduct for Responsible Fisheries in relation to shrimp culture activities to the Committee on Fisheries.

Phillips *et al.* (1993) described the long history of extensive shrimp farming in Asia. The systems rely on the natural food within the pond and tidal fluctuations for water exchange. Silas (1987) reported that the traditional *bheries* of West Bengal, are constructed in naturally inundated land in the Sundarbans after clearing mangroves and natural stocking takes place through tidal movement. Shrimp has traditionally been grown in low-density monoculture, in polyculture with fish or in rotation culture with rice in the *bheries* of West Bengal and *pokkalies* of Kerala (Alagarswami, 1995; Shiva and Karir, 1997).

Wickins (1986) reported a gradual increase in production from less than 0.5 t/ha to more than 15.0 t/ha in Taiwan during a decade. Subsequently, Liao (1990) described the development of extensive culture methods to semi-intensive or intensive culture methods, which involved greater inputs of feed or fertilisers, supplementary stocking and water quality management. This trend started in the early 1970s in Taiwan and then, gradually spread to other parts of Asia in the late 1970s and early 1980s as hatchery and grow-out technologies developed.

Other than land-based commercial shrimp ponds, there have been some attempts in cages (Walford and Lam, 1987), pens (Angell, 1989), tanks and raceways (Fast, 1992). Reddy *et al.* (1998) described the characteristics of shrimp culture methods based on land elevation, pond area, water depth, stocking density, water exchange rate, aeration, feed and feeding frequency, level of water quality management and production levels.

Shrimp farming is an economic activity, which is characterised by a great dependence on environmental conditions. There have been several reviews on the relationship between shrimp farming and the environment (Chua *et al.,* 1989; Lin, 1989; Liao, 1990; GESAMP, 1991; Primavera, 1991, 1992, 1993, 1995, 1997, 1998; Macintosh and Phillips, 1992; Csavas, 1993; Phillips *et al.,* 1993; Baird and Quarto, 1994; FAO/NACA, 1995; Clay 1996; Gujja and Finger-Stich, 1996; Barraclough and Finger-Stich, 1996; Patil and Krishnan, 1998; Boyd and Clay, 1998; Kongkeo, 1999).

Construction of channels for water supply and drainage and pumping of brackish water away from the seafront inland resulted in hydrological changes, siltation and saltwater intrusion (Cholik and Poernomo, 1987; Mahmood, 1987). Srinivas (1998) stated that the sediment accumulation from shellfish farming may result in the abandonment of beds or the transfer of beds towards the sea and in bio-deposits if not flushed out, increasing the organic mud which could lead to elevation of sea-bed by as much as 30 to 50 cm/yr. Large-scale land subsidence has taken place in Taiwan (Chen, 1990) and the Philippines (Primavera, 1991) due to abstraction of groundwater for freshwater supply.

Mangroves are important in coastal protection and their removal may cause coastal erosion (Carter, 1959), changes in the pattern of sedimentation and shoreline configuration (Snedaker and Getter, 1985). Mangroves are important in nutrients cycling, as a source of organic matter to increase coastal productivity and as breeding grounds, nursery areas or general habitats for many commercially important fishes, crustaceans and mollusks (Leh and Sesekumar, 1980; Macintosh, 1982; Christensen, 1987; Mathes and Kapetsky, 1988). There are evidences that removal of mangroves leads to a decline in fisheries production (Kapetsky, 1986) and other socio-economic as well as ecological problems (Dixon, 1989; Primavera, 1991).

The expansion of shrimp farming has led to the destruction of mangroves, even though shrimp farming is often unfairly blamed and is just one of the many coastal activities leading to the loss of the mangroves (Csavas, 1990, 1993). The reduction in mangrove areas from 7500 ha in 1967 to only 973 ha in 1988 in the Chokaria Sunderbans (Bangladesh) due to shrimp farming has been reported by Choudhury *et al.* (1994) and from 3650 ha in 1983 to 2000 ha in 1994 in Puttlan District (Sri Lanka) by Liyanage (1995). DeWalt *et al.* (1996) stated that most of the 21,600 ha of shrimp ponds in Ecuador and more than a-third of the 11,515 ha of shrimp ponds in Honduras were developed in mangroves (Alvarez *et al.,* 1989; Stonich, 1995). Menasveta (1996) reported a loss of 203,765 ha of mangrove areas to Thailand of which 32% were converted in shrimp farms. Tuan (1997) also reported a total loss of 10,200 ha of mangrove areas to shrimp farming activities in Vietnam. Nandakumar and Salim (1997) reported a marked reduction of wetlands, in general, and mangroves, in particular, in the coastal stretch from Payyannur to Valapattnam in Kerala (India).

Many workers have reported impacts on biodiversity due to wild seed by-catch. For every single *P. mondon* seed, up to 24 penaeid post-larvae in the Philippines (Motoh, 1981), 47 - 99 prawn and fish fry in Tamil Nadu, India (Ramamurthy, 1982), 10 fish and shrimp larvae in the Sunderbans, India (Silas, 1987), 66 - 157 crustacean larvae and fish fry in rivers and estuaries of West Bengal, India (Banergee and Singh, 1993), 475 juvenile shrimp in Malaysia (Chong *et al.,* 1990) and 15 - 22 shrimp along with 21 - 32 fishes and 39 - 46 zooplankton in the littoral waters of Bangladesh (Deb *et al.,* 1994) were discarded. Deb *et al.* (1994) further reported that given a yearly collection of one billion *P. monodon* seed in southeast Bangladesh, the amount of by-catch destroyed is staggering and could have major consequences on marine food chain. DeWalt *et al.* (1996) also reported that in Honduras, perhaps 15 to 20 billion fry of species other than *P. vannamei* and *P. stylirostris* are discarded for the supply of the estimated 3.3 million post-larvae for shrimp farming.

Introduction of exotic species can lead to habitat changes, disruption of host communities by competitors and genetic interactions with native population (Welcomme, 1988; Sindermann, 1993). Colorni *et al.* (1987) reported that viral diseases affecting cultured penaeid shrimp in Israel were caused by transfer of non-native *P. monodon* and *P. stylirostris.* According to Lightner (1992), penaeid species imported for their desirable characteristics and their transportation between geographical regions have caused the spreading of five of the six known penaeid prawn viruses in other regions. Mass mortalities that caused the 1993 collapse of endemic *P. chinensis* in China might have been due to the introduction of viruses through imported *P. monodon, P. japonicus* and *P. vannamei* (Anon, 1993).

Phillips *et al.* (1993) gave the ranges of wastewater quality recorded at an estuarine shrimp farm in Thailand during the 5-month grow-out period. Primavera (1993) estimated that only 16.7% (by dry weight) of the total amount of feed is converted into shrimp biomass and the rest is leached or otherwise not consumed, egested as faeces or eliminated as metabolites. According to Boyd and Clay (1998), up to 30% of the feed is never consumed even in the best regulated feeding system. Briggs and Funge-Smith (1994) analysed the inputs and outputs of nitrogen and phosphorous in intensive shrimp ponds. Briggs (1994) stated that oxygen demand of sediments, originated from waste feed and faecal waste, is greater than that of all the shrimp in the pond.

The discharge of nutrients from shrimp ponds may contribute to eutrophication with increased primary productivity and possible phytoplankton bloom (Phillips, 1995). On the other hand, an assessment of the contribution of shrimp pond effluents to the overall nutrient load in coastal areas in the upper Gulf of Thailand and the Bohai Sea in China indicates that shrimp farms can hardly be blamed for coastal eutrophication (FAO/NACA, 1994).

Boyd (1978) and Bergheim *et al.* (1984) reported high 'shock' loads of solids, biochemical oxygen demand, and nitrogen and phosphorus loads that are several times higher than at other times during tank cleaning. There is concern that coastal environments are being subjected to hyper-nutrification and eutrophication as a result of shrimp farming (SEAFDEC, 1989), but so far, impacts have not been quantified (Chua *et al.,* 1989).

Shrimp pond wastes consist of solid matter, mainly a mixture of left-over food, faeces, phytoplankton and colonising bacteria, and dissolved matter such as ammonia, urea, carbon dioxide and phosphorus (Spaargaren *et al.,* 1982; Dall and Smith, 1986; Mohanty *et al.,* 1989; Wajsbrot *et al.,* 1989). Boyd (1989) described that wastewater includes amino acids, proteins, fats, carbohydrates, fibre, minerals and bacteria.

Waste production exceeding the assimilative capacity of the local water bodies has been correlated with the major crash of shrimp farming in Taiwan and in the Upper Gulf of Thailand, and disease outbreaks in the Philippines, Indonesia and China (Lin 1989; Liao, 1992; FAO/NACA, 1994). Jayasinghe (1994) put the blame on pollution of the main water supply canal (the Dutch canal) by pond wastewater as the root cause of shrimp mortalities on the west coast of Sri Lanka.

Chen and Sheng (1992) noticed deterioration in water quality due to pond effluents in Shandong and Habei in China. Macintosh and Phillips (1992) showed that total nitrogen, phosphorus, nitrite, silicate, orthophosphate, dissolved oxygen and biochemical oxygen demand increased, and further, visibility decreased in intensive Thai ponds throughout the grow-out period. Although the pollution potential of shrimp pond effluents is minimal compared to domestic or industrial waste waters (Macintosh and Phillips, 1992), problems arise because of the large volume of water discharged from intensive farms compounded by high concentration of farm units in areas with limited water supply and inadequate flushing (Primavera, 1994).

Satapornvanit (1993) described the quality of influent and effluent waters of nine shrimp ponds in Thailand. Karthikeyan and Srimurali (1995) examined the role of environmental impact analysis statement and management of a proposed shrimp farm at Nellore in Andhra Pradesh (India). Deiva and Rahman (1997) examined the impact of shrimp farm effluents on mangroves and evaluated the performance of biological effluent treatment methods on the banks of River Karaiyar at Muthupet Estuary, Tamil Nadu (India). Kumaresan *et al.* (1997) found that the hydrological parameters measured in a pond on the banks of Vellar Estuary, Tamil Nadu, were within normal ranges and were comparable to those in the adjacent estuary. Padmavathi *et al.* (1997) studied the impact of nitrogen and phosphorus on pond fertility and the effluent quality of shrimp farms in Tuticorin, Tamil Nadu.

In a survey undertaken in the coastal areas of Andhra Pradesh and Tamil Nadu (CIFE/CIBA, 1997), it was observed that at certain places, the intake water was already charged with higher levels of organic load than the discharged water from shrimp farms. Paul Raj *et al.* (1998) found no evidence of any significant increase in total suspended solids, biochemical oxygen demand, chemical oxygen demand and eutrophication of creeks and estuaries due to the higher nutrient shedding through farm effluents.

According to Primavera (1998), chemicals used in shrimp farming may be classified as therapeutants, disinfectants, water and soil treatment compounds, algicides and pesticides, plankton growth inducers (fertilisers and minerals), and feed additives. Poernomo and Singh (1982) reported that long-term liming could harden pond sediments and make them less suitable for shrimp culture. Phillips *et al.* (1993) speculated that organic and inorganic fertilisation might contribute to the nutrient load in receiving waters although such effects have not been quantified.

Baticados *et al.* (1986) reported the use of chlorinated hydrocarbons such as dichloro-diphenyle-trichloroethane, endrin, aldrin and organotins as molluscicides in some Southeast Asian countries. Apud *et al.* (1989) discouraged the use of these compounds as these pose a threat to shrimp health, product quality, human health and the wider environment.

The prophylactic use of antibiotics at low doses to prevent the occurrence of disease has become widespread in the Philippines and other tropical countries (Brown, 1989; Baticados and Paclibare, 1992). Nash (1990) reported that the widespread use of oxytetracycline in Taiwan, Thailand and the Philippines has resulted in the development of resistant strains of *Vibrio* spp. which have made treatment of *vibrio* infections extremely difficult. Saitanu *et al.* (1994) detected oxytetracycline and oxolinic acid residues above permissible levels in 8.4% of 1461 *P. monodon* sampled from the Thai domestic market. Srisomboon and Poomchatra (1995) reported the detection of anti-microbial residue in 30 shipments of cultured shrimp from Thailand by the Japanese Quarantine Station.

The abstraction of fresh water from underground aquifers for intensive shrimp farming in Taiwan, the Philippines and Thailand has resulted in saltwater intrusion and salinisation of freshwater aquifers (Primavera, 1991; Liao, 1992). On the other hand, the discharge of salt water from shrimp farms located behind mangroves caused salinisation in adjoining rice and other agricultural lands (Primavera, 1993; Dierberg and Kiattisim, 1996).

Parthasarathy (1995) reported that many drinking water sources in villages adjacent to shrimp farms have turned saline due to the indiscriminate pumping of ground water by shrimp farms in Tamil Nadu. Pundarikanthan (1998) investigated 14 villages in the coastal areas of Nagapattinam Quaid-E-Milleth District of Tamil Nadu and found that eight villages are free from potable groundwater salinisation. Ravichandran *et al.* (1998) reported that soil salinity beyond 50 m from the farm site decreases rapidly and drinking water wells beyond 200 m of shrimp farms do not show any effect of salinisation in the sandy areas of Nellore District, Andhra Pradesh.

Sharmila *et al.* (1996) studied the bacterial flora in a semi-intensive culture farm of *P. indicus* and their environment in Pattinamaruthur (Tuticorin). The mean total viable counts ranged from 1.80 to 4.50 x 10^3 CFU/ml in rearing water and 1.82 to 4.72 x 10^6/g in sediment. Tookwinas (1998) reported a total bacterial plate count of 19,003 $\pm$ 15.4 CFU/ml in the bay and 23,801 $\pm$ 17.33 CFU/ml in the discharge canal waters at Kung Krabaen Bay, Eastern Thailand. Dalmin *et al.* (1998) expressed that the environmental parameters did not seem to play a vital role in all types of bacterial loads in water and sediment. Prabhu *et al.* (1999) studied the bacterial population in water and sediment in relation to probiotic application in shrimp ponds. Otta *et al.* (1999) investigated the bacterial flora associated with shrimp culture ponds in India and the total bacterial count ranged from 1.5 x 10^3 to 3.6 x 10^5 CFU/ml.

Kumaresan *et al.* (1997) while studying soil and water quality management in a modified extensive shrimp farm with special reference to iron and copper, found the iron and copper concentrations in the pond to be higher than the optimum level.

Paul Raj *et al.* (1997) also studied total iron, copper, chromium, manganese, zinc, cadmium, and lead in water and sediment as a part of environmental impact assessment in the shrimp farming areas of

Nagapattinam Quaid-E-Milleth District, Tamil Nadu. Carbonell *et al.* (1998) reported that levels of iron, zinc, copper, manganese, chromium, cadmium, lead and mercury in sediments from shrimp farm areas located in Nicaragua and Honduras were lower than reported in other investigations (Establier *et al.*, 1985; Prudente *et al.*, 1994; McGee *et al.*, 1995).

There have been protests against the plans to convert paddy fields to shrimp farms in Andhra Pradesh in India and Kerpan in Malaysia (Rajagopal, 1995; Seabrook, 1995). There were social unrest and agitations against shrimp farming leading to killings in Bangladesh, Honduras and India (Khor, 1995; Stonich, 1995; Alauddin and Hamid, 1996; DeWalt *et al.*, 1996). In Andhra Pradesh, shrimp farming supports 70,000 odd farmers (Angell, 1998). But there have been allegations and apprehensions regarding conversion of farmlands alleging soil salinisation, health hazards, displacement of employment and damage to marine fisheries (Thakur *et al.*, 1997; Paul Raj *et al.*, 1998). Vivekanandan and Kurien (1998) reported that the socio-economic problems arise from issues like land alienation and displacement of coastal communities from open access public lands used by them for fish drying, net drying, grazing, subsistence cultivation, etc. Skladany (1992) claimed that intensive shrimp farming in coastal Southeast Asia has denied the use of these areas to local residents for traditional activities such as fishing, gathering construction material, food collection, fuel gathering and hunting. In India, huge corporate shrimp farms block access to fishing grounds and beaches for landing boats and drying nets (Rajagopal, 1995; Patil and Krishnan, 1998).

Shrimp ponds may cover extensive coastal areas which have often required the conversion of rice fields, salt pans, coconut and sugar cane plantations, abandoned lands and mangrove forests (Aitken, 1990; Chong, 1990). Reports on land conversion for shrimp farms in Asia and Latin America are widely published (Choudhury *et al.*, 1994; Alauddin and Tisdell, 1996; Clay, 1996; Shiva and Karir, 1997).

There has been an increase in land price in Thailand from US$ 50 - 75/ha in 1985 to US$ 50,000 - 75,000/ha in 1991 (Boromthanarat, 1995). Paul Raj *et al.* (1998) reported a 10-time increment in land price in Nagapattinam Quaid-E-Milleth District of Tamil Nadu.

In most of intensive shrimp farming systems, the concept of shrimp farmer does not exist as these are set up by business houses or outsiders who provide the capital (Goss *et al.,* 1998) and actual work of tending the farms is done by the technicians and labourers (Alauddin and Hamid, 1996). The employment of local people is often limited to low-paying unskilled jobs, and the technical and managerial positions are mainly held by outsiders (Primavera, 1998). Hariati *et al.* (1995), Gujja and Finger-Stich (1996) and Stevenson and Burbridge (1997) estimated the life span, rate and area of abandonment of shrimp farms. CIFE/CIBA (1997) and Paul Raj *et al.* (1998) also studied the socio-economic aspects of shrimp farming in coastal areas of Andhra Pradesh and Tamil Nadu indicating increase in employment opportunity.

Murthy (1997) described the impact of the Supreme Court judgement on shrimp culture in India .Das and Singh (1998) highlighted the details of various acts of the government and their legal implications, which have direct bearings on shrimp farming in India. Chidambaram (1998) gave the opinion on the role of the Ministry of Environment, Government of India, in amending the Coastal Regulatory Zone (CRZ) Notification dated 19.02.1991. Issac (1998) described the effects of the Hon'ble Supreme Court's judgement of 11.12.1996 on shrimp farming activities in India. Stephen (1998) discussed the legal factor and Sakthivel (1998) suggested amendments to the CRZ Notification with respect to the Water (Prevention and Control of Pollution) Act, 1994.

material and methods

Chapter 3
MATERIAL AND METHODS

3. 1. LOCATION

Saphale Region is located in Palghar Taluka of Thane District, Maharashtra. It is situated on the western side of the district facing the Arabian Sea at 19° 55" latitude North and 72° 06" longitude East (Fig. 1). This region lies around 70 km away from Mumbai in the north along the Western Railway. The region experiences typical tropical climate characterised by an oppressive summer, dampness in the atmosphere and heavy southwest monsoon. Cold season extends from December to February followed by summer from March to June. The pre-monsoon period is from February to May and the monsoon lasts from the middle of June till September, while the post-monsoon period is during October to January.

On an average, the region receives 270 cm of rainfall annually: 94% of the total rainfall is received during the southwest monsoon with a peak in July. The mean temperature ranges from 22 to 30°C. There is a steady increase in ambient temperature from February reaching a peak in May. Mean temperature in May is around 33°C, which may go up to 40°C. The lowest temperature is encountered in the month of January with an average of 16 ± 2°C.

Relative humidity is high reading up to 80% during the monsoon, but is low during November to March. During May and throughout the southwest monsoon, the wind blows from the southwest and northwest directions. During other periods, it blows from the northeast direction in the mornings and from the northwest in the afternoons (Padmakumar, 1983).

3. 2. ABOUT THE SHRIMP FARMS

Presently, around 500 ha in Saphale region have been allocated for shrimp farming activities through Konkan Vikas Mandal (Government of

Maharashtra). Out of these, 150 ha of the water-spread area are being utilised for shrimp farming by different private entrepreneurs and commercial organizations (Plate IA). The total number of farms in this area is five. Shakti Aquaculture Farm Ltd has around 75 ha of water-spread area, while Ruia Aquaculture Ltd has 25 ha, King's Prawn Farm Ltd has around 15 ha, Pancham Aquafarms Ltd around 40 ha and the farm of Mr. Vijayakar has 5 ha water-spread area.

The village Vedi is located near the King's Prawn Farm, which also gets engaged in salt manufacturing. Khardi - Para and Dongra villages are in the vicinity of Shakti Aquaculture Farm, while Datiwada fishing village is situated near the mouth of Vaitarna Creek, which is the source of water to these shrimp farms along a stretch of 5 km. Datiwada village is located at a distance of 500 m from Ruia Aquaculture Ltd. These aquafarms were developed during the year 1991.

3. 3. SAMPLING STATIONS

The following stations were selected on the Vaitarna Creek stretch with a purpose to collect the samples (Fig 2.).

3. 3. 1. Station I (D):

It is situated near the jetty at Datiwada fishing village (Plate IB). This is the place where Vaitarna Creek meets the Arabian Sea. On the other side of this waterbody, lies Arnala, another small fish landing centre towards Virar (Vasai Taluka).

3. 3. 2. Station II (R1):

It is located near one of the inlet points at Ruia Aquaculture Farm (Plate IIA). It is about 1.0 km inside the creek, which supplies water to Ruia Aquaculture Farm.

3. 3. 3. Station III (R2):

It is situated near one of the outlet channels at Ruia Aquaculture Farm, which is 800 m away from Station I (Plate IIB). This is the place where the wastewater discharge from Ruia Aquaculture Farm falls into the creek.

3. 3. 4. Station IV (S1):

This station is near one of the intake points of water by Shakti Aquaculture Farm and is 2.0 km away from Station II (Plate IIIA).

3. 3. 5. Station V (S2):

This station receives the wastewater discharge from Shakti Aquaculture Farm and is 1.5 km away from Station III on a branch of the creek (Plate IIIB).

3. 3. 6. Station VI (K1):

This is located near the inlet of King's Prawn Farm (Plate IVA). It is the end point of one of the tributaries of the creek, which terminates in a reservoir tank. The salt manufacturing unit near this farm also uses this water. This is 1.5 km upstream of Station IV on the main creek.

3. 3. 7. Station VII (K2):

This station receives the wastewater discharge from King's Prawn Farm. It is located on a branch of the main creek and is 1.0 km away from Station IV (Plate IVB).

3. 4. SOIL AND HYDROLOGICAL PARAMETERS

The soil and water samples were collected to study the seasonal variations in soil and water quality over a period of 13 months. Sampling was done on a monthly basis from January 1998 to January 1999 during high tide.

Water samples were analysed using standard methods. Temperature was noted with a mercury thermometer; salinity was noted by a refractometer

(Atago); pH was measured by a hand-held pH meter (E Merck 325); dissolved oxygen was determined by membrane electrode method using an oxygen meter (Yellow Spring Instruments; 55 system); total alkalinity, hardness and total suspended solids were estimated by standard methods (APHA, 1992).

Ammonium-nitrogen (NH_4-N), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) were determined using a spectrophotometer (Merck; SQ 200) with Spectroquant test kits; biochemical oxygen demand (3 d; 27°C) and chemical oxygen demand were measured according to Sawyer and McCarthy (1967). Heavy metals like iron, zinc, copper and manganese were measured with a spectrophotometer (Merck; SQ 200) and using Spectroquant test kits. Samples for phytoplankton were collected in 250-ml plastic bottles and preserved with 1 - 2 ml of Lugol's solution and after concentrating the sample, quantitative estimations were done using a haemocytometer. 200 l of water was filtered through bolting silk net no. 17 and preserved with 5% formalin for the zooplankton population estimation. The water samples collected aseptically in sterilised glass bottles were brought to the laboratory and inoculation was done for total plate count (TPC) using TCBS Agar (Himedia; M189) following Malik (1992). Soil samples were analysed for pH by a hand-held pH meter (Takemura; OM-13) and organic carbon following Piper (1966).

3. 5. STATISTICAL ANALYSIS OF DATA

Statistical analysis was performed to test the significance of the differences between means using 't' test (Snedekor and Cochran, 1961) and performing one way Analysis of Variance (ANOVA).

3.6. SOCIO-ECONOMIC AND LEGAL ASPECTS

A questionnaire was developed (modified from Gupta *et al.*, 1992) which covered occupational status, economic motivation and different perceptions about the shrimp-farming activities. Simple random-sampling technique was adopted to select the respondents. The three neighbouring villages, *viz.,* Vedi, Khardi - Para and Datiwada, were selected and interviews were conducted to assess the socio-economic impact of shrimp farming. The Fisheries Department was also contacted to discuss the legal implications and shrimp farming activities in the region.

results

Chapter 4
RESULTS

4. 1. AMBIENT TEMPERATURE

The ambient temperature recorded at the time of sample collection varied from 21.9°C at station I to 32.4°C at Station VII. The lowest temperature was recorded at all the stations in January 1998, while the highest was observed in May 1999 (Tables 1 – 7; Fig. 3). As the sampling was done on a single day and progressed till the afternoon, the temperature showed an increasing trend.

The differences between the means of temperature at different stations were not statistically significant at 5% level ($F = 0.4057$).

4. 2. WATER TEMPERATURE

The water temperature at all the stations varied from 20.4 to 30.5°C (Tables 1 – 7; Fig. 4) (both at Station I). The maximum temperature was recorded in May, while the minimum was noted during January 1998. At all the stations, the maximum temperature range (25.8 - 30.5°C) was recorded starting from April to October, while the minimum temperature ranging from 22.8 to 24.6°C was observed during November-January. The monthly mean temperature ranged from 25.4 to 26.32°C.

The mean values of water temperature at all the stations do not show any statistically significant difference at 5% level ($F = 0.1312$).

4. 3. SALINITY

Salinity values varied from 1 to 42‰ (Tables 1- 7; Fig. 5). The lower range of 1 - 16‰ was observed during July to October and the higher range of 25 - 42‰ was noted during November-January at all the stations. The overall trend showed a near-freshwater condition during the monsoon months

(June-September). There was an increase in salinity starting with October, which peaked in May when the evaporation rate was the highest.

The differences in the mean salinity values at all the stations are not statistically significant at 5% level ($F = 0.0101$) and hence, the water may be presumed to be having similar salinity conditions.

4. 4. HYDROGEN ION CONCENTRATION

The pH at all the stations was on the alkaline side with values ranging from 7.48 at Station IV in August to 8.69 at Station V (Tables 1 – 7; Fig. 6) in February. The overall minimum range of 7.48 - 8.24 was observed during August – September and an increasing trend was observed thereafter. The higher pH values were recorded during June and February at all the stations.

4. 5. TOTAL ALKALINITY

Total alkalinity at all the stations ranged from 112 to 220 mg/l (Tables 1 – 7; Fig. 7). The lowest value was recorded at Station I in May, while the highest was at Station V in November. The mean value of Total alkalinity at Station IV (157 mg/l) was the highest. A statistical analysis of the differences in mean values indicates that the stations do not differ from each other significantly at 5% level ($F = 0.8487$).

4. 6. DISSOLVED OXYGEN

The dissolved oxygen concentration in all the water samples ranged from 4.47 mg/l at Station I to 7.96 mg/l at Station IV (Tables 1 – 7; Fig. 8). The mean values ranged from 6.07-7.12 mg/ml. The minimum dissolved oxygen content was seen during June at all the stations. There was an increasing trend in the oxygen content from Station I to Station VII at all times. The mean values of dissolved oxygen at Station VI and Station VII were above 7.0 mg/l, while the values at the other stations were in the range of 6.0 - 6.8 mg/l. But the analysis of means of dissolved oxygen contents do not indicate any significant difference between the stations at 5% level (F = 1.8232).

4. 7. TOTAL SUSPENDED SOLIDS

The total suspended solids (TSS) showed an increasing trend as one progressed from Station I to Station VII at all the times (Tables 1 – 7; Fig. 9). The TSS ranged from 20.5 mg/l in January 1998 at Station I to 100.4 mg/l in September at Station VII. The increase in TSS at all the stations was seen from June onwards till September when monsoon was active. The mean TSS value ranged from 41.98 at Station I to 62.37 mg/l at Station VII.

Analysis of variance to test the significant differences between the mean values at all the stations reveals that they are significantly different at 5% level of significance (F = 2.975). But there was no significant difference between Station II (41.86 mg/l) and Station III (46.48 mg/l), between Station IV (51.38 mg/l) and Station V (56.83 mg/l), and between Station VI (60.12 mg/l) and Station VII (62.37 mg/l). But Station I is significantly different from other stations.

4. 8. AMMONIUM NITROGEN

Nitrogen in the form of ammonium-nitrogen in the water samples varied from 0.28 mg/l at Station VI in March to 0.61 mg/l at the same station in November (Tables 1-7; Fig. 10). The mean values ranged from 0.43 mg/l at Station VI to 0.49 mg/l at Station I and Station V.

The monthly mean value at Station V was the highest, but the differences in means between the stations are insignificant at 5% level (F=1.1050).

4. 9. NITRITE-NITROGEN

The range of nitrite-nitrogen content in water samples was 0.173 mg/l at Station III and Station IV simultaneously in June as the minimum and 0.341

mg/l at Station II in November as the maximum (Tables 1 – 7; Fig. 11). There was a constant increasing trend before the monsoon till May and again from October till December.

The analysis of variance of mean values for nitrite-nitrogen at all the stations shows that they are not statistically different at 5% level ($F = 0.1514$).

4. 10. NITRATE-NITROGEN

Nitrate-nitrogen content in the water samples varied from 0.75 mg/l at Station VI in August to 1.92 mg/l at Station V in April (Tables 1 – 7; Fig. 12). Higher concentrations were seen during the initial stages of the study period but showed a decreasing trend at later stages. There was no wide variation amongst the stations at any time.

The overall nitrate-nitrogen load was seen to be higher at Station I. The differences in means between all the stations are insignificant at the 5% level ($F = 0.3266$).

4. 11. PHOSPHATE- PHOSPHORUS

The phosphate-phosphorus content in water samples ranged from 0.01 mg/l at Station IV in January 1998 to 0.16 mg/l at Station III and Station IV, simultaneously, in April (Tables 1 – 7; Fig.13). The overall highest concentration was observed during the month of April.

The monthly mean values of phosphate-phosphorus at all the stations are apparently different; yet it is not significantly different as the differences in means between all the stations are insignificant at 5% level ($F = 2.1026$).

4. 12. BIOCHEMICAL OXYGEN DEMAND

The biochemical oxygen demand (BOD) was observed to be increasing before decreasing during July-October, (Tables 1 – 7; Fig. 14).

The minimum value recorded was 2.50 mg/l at Station I and Station II in August and September, respectively. The maximum value was observed in April at Station V as 11.22 mg/l.

Analysis of variance to test any significant difference between the mean BOD values, reveals that there is no significant difference between the stations at 5% level ($F = 0.1020$).

4. 13. CHEMICAL OXYGEN DEMAND

The chemical oxygen demand (COD) of water samples ranged from 19 mg/l at Station VI in July to 55 mg/l at Station V in January 1998 (Tables 1-7; Fig. 15). Higher COD contents were seen during the pre-monsoon and post-monsoon periods. The highest concentrations were observed during January-March.

The analysis of variance of mean values of COD at all the stations reveals that they are not significantly different at 5% level ($F = 0.6644$).

4. 14. PHYTOPLANKTON

The phytoplankton population varied from 7.0 x 10^3/l at Station VI in August to 324.0 x 10^3/l at Station IV in October (Tables 1 – 7; Fig. 16). Phytoplankton population was high during the months of January-March. Their population was low during April-August before reaching a peak in October.

The analysis of variance of means at all the stations reveals that there is no significant difference between the stations at 5% level ($F = 0.3592$).

4. 15. ZOOPLANKTON

Zooplankton population varied from 40/m^3 at Station III in June to 2450/m^3 at Station V in November (Tables 1 – 7; Fig. 17). The mean population ranged from 411.15/m^3 (Station VI) to 828.77/m^3 (Station V). A peak was seen in February only to fall in March and to rise again in April. The population was observed to undergo alternate rise and fall.

Apparently, differences between the mean zooplankton population at all the stations can be seen, the one at Station V (828.77/m^3) being the highest. But these means are not statistically different at 5% level (F = 1.1823).

4. 16. TOTAL PLATE COUNT

The total plate count (TPC) of aerobic heterotrophic bacteria in water samples varied from 0.290 x 10^3 CFU/ml at Station IV in March to 8.100 x 10^6 CFU/ml at station IV in October (Tables 1 –7; Fig. 18). The mean count at all the stations ranged from 0.688 x 10^6 CFU/ml at Station VI to 0.846 x 10^6 CFU/ml at Station III. Higher counts were observed during the months of May-June and August-October. Lower counts were noted during the winter months.

Even though the difference in mean counts at all the stations seems to vary, it is not significant statistically at 5% level (F = 0.0624).

4. 17. IRON

Iron concentration at all the stations varied from 0.11 mg/l at Station I and VI in February and August respectively to 0.26 mg/l at Station V in May (Tables 1 – 7; Fig. 19).

There was an increasing trend in iron concentration at all the stations peaking in June before decreasing again in July-August. There was generally a rise in September again and gradually decreased till January 1999.

Analysis of variance of mean values shows that the stations are significantly different at 5% level (F = 2.4500). Station IV and Station V are similar, but differ significantly from others. There was no difference between Station I and Station VI either.

4. 18. ZINC

The zinc concentration in water samples at all the stations ranged from 0.12 mg/l at stations I and VI in September to 0.27 mg/l at Station V and Station VII in May and April, respectively (Tables 1 – 7; Fig. 20).

Analysis of variance of means of zinc concentration shows that Station V is significantly different from the rest of the stations at 5% ($F = 2.6916$). But other Stations are not different from each other significantly.

4. 19. COPPER

The copper concentrations at all the stations varied from a minimum of 0.03 mg/l to a maximum of 0.20 mg/l (Tables 1 – 7; Fig. 21). The range of the monthly mean values was 0.072 mg/l at Station I as the minimum and 0.136 mg/l at Station V as the maximum. The maximum concentrations at all the stations were observed in May and there was no marked deference in January in both the years.

Analysis of variance of mean values shows highly significant differences between stations ($F = 4.1502$). Station IV and Station V are distinctly different from other stations at 5% level.

4. 20. MANGANESE

The concentrations of manganese varied from 0.01 to 0.07 mg/l (Tables 1-7; Fig. 22), while the monthly mean ranged from 0.028 mg/l at Station I to 0.05 mg/l at Station V.

There was no marked change in manganese concentration over the months. But statistically, the mean of manganese concentrations at all the stations show significant differences between stations at 5% level ($F = 3.9826$).

4. 21. SOIL pH

The soil pH values were from near-neutral to slightly-alkaline with values ranging from 6.7 at Station V in August to 7.9 at Station I and Station III in June and August, respectively (Tables 1 – 7; Fig. 23).

4. 22. SOIL ORGANIC CARBON

Organic carbon content of soil varied from a minimum of 0.32% at Station I, IV and VI in September to 0.60% at Station V in April (Tables 1 – 7; Fig. 24). The range of the mean values varied from 0.40% at Station I to 0.50%, at Station V. At all the stations, there were no significant variations. The maximum values were mostly observed in April, while the minimum values were seen in September.

There is a significant difference between the stations at 5% level ($F = 2.7425$). Station V is different from others even though Station II, Station III, Station IV and Station VII are similar.

4. 23. THE WELL WATER

4. 23. 1. Salinity

The lowest salinity value of 1‰ was observed during the monsoon period of June-August (Table 8). During the last four months of the study period starting from October, the well water showed a salinity value of 3‰, which was also observed in March. Salinity of 2‰ was observed during the rest of the months.

4. 23. 2. Hardness

The maximum hardness value of 220 mg/l was seen in January, while the minimum value of 130 mg/l was recorded in May (Table 8). The mean hardness value was 183.38 mg/l. Higher range of 190 mg/l and above were seen in January-April 1998 and from October 1998 to January 1999.

4. 24. SOCIO-ECONOMIC SURVEY

Eighty-one per cent of the villagers did not perceive shrimp farming as the cause of water-borne diseases (Table 9). Regarding fish catches from the nearby inshore areas, 98% of the villagers could not find any relation with the shrimp farming activity, even though they feel that the catches had dwindled over the last few years. Rise in the cost of land had been attributed to shrimp farming by 70% of the people: 74% of the villagers disagreed that shrimp farming leads to destruction of mangroves and wildlife in the area.

Regarding the salinisation of ground water in the area, 53% of villages in Khardi-Para blamed the shrimp farms. But, overall 35% of the villagers did not think that shrimp farms caused salinisation: 46% of them could not give any opinion.

Twenty-six per cent of the villagers claimed that some portion of the agricultural land had been converted into shrimp farms, but 51% of them said otherwise. Fifty per cent of the villagers in Datiwada where the main occupation is fishing, claimed that water flow and sedimentation pattern have been altered in the creek; 51% of all the villagers could not say anything regarding this aspect.

Regarding local employment, 61% of the villagers in the three villages agreed that shrimp farms give employment. The economic motivation was quite high: 51% of the villagers felt that shrimp farming is one way of enhancing income. The overall impression of shrimp farming and community welfare is such that as 54% of the villagers had no idea and 23% of the villagers said that shrimp farming is good for the community.

discussion

Chapter 5
DISCUSSION

5. 1. LAND USE PATTERN

Shrimp ponds may cover extensive coastal areas which have often required the conversion of rice fields, salt pans, coconut and sugarcane plantations, abandoned lands and mangrove forests (Aitken, 1990; Chong, 1990), although there is no doubt that sustained areas of virgin mangrove swamps have been cleared for shrimp pond construction (Terchunian, 1986). It is important to recognise that mangrove ecosystems have also been utilised for other purposes such as forestry, agriculture, pond fish culture, etc. (Neal, 1984; FAO 1985; Andriawan and Jhamtani, 1989; Soemodihardjo and Soerianegara, 1989; Zamora, 1989). The removal of mangroves has implication on the sustainability of various coastal activities (Phillips, 1998) and also socio-economic impacts (Bailey, 1988). In Saphale area, the shrimp farms have been constructed on lands adjacent to the creek, leased out by the Konkan Vikas Mandal under the Kolambi Shetti Prakalp. In this area, except for mangrove species of *Avecennia*: *Rhizophora, Sonnetata* and certain dwarf shrubs, there is no significant mangrove cover. Ponds reclaimed from mangrove swamps exhibit typically acid sulphate soil (Pedini, 1981; Simpson and Pedini, 1985, 1987). But the soil samples taken near the outlets and insets of the ponds in Saphale reveal a pH range of 6.7 - 7.9 which is fairly neutral to alkaline in nature. This shows that the farms have not been constructed in mangrove acid sulphate areas. As these shrimp farms need proper drainage system for easy dewatering and drying as and when required, these are located away from the coastal wetlands.

Conversion of productive agricultural lands to aquafarms is a very common phenomenon in many states of India because of the high returns from aquaculture as compared to agriculture. Most of the shrimp farms in India are constructed on the coastal wetlands, which are under private holdings and are not suitable for any worthwhile agricultural activities. All these lands are put under agricultural category in revenue records (Reddy and Sukham, 1999). This is one reason why records everywhere show conversion of agricultural lands into shrimp farms as there is no mention of aquacultural category. In Saphale region, the conversion of agricultural land has not taken place as the farms have come up mostly on government lands, which are leased out.

5. 2. WATER USE PATTERN

Even though shrimp farming is being practised using full-strength sea water (Kongkeo, 1990) of above 40‰ (Al-Thobaiti and James, 1996), the shrimp farming technology for *P. monodon* developed in Taiwan was based on salinity of 15 - 25‰ (Chiang and Kuo, 1988) and is widely practised in creek-based shrimp farms.

Abstraction of ground water for freshwater supply of shrimp ponds may result in salinisation of the freshwater aquifers and had been implicated in land subsidence in Taiwan (Liao, 1989). Some shrimp farms in Nellore (Andhra Pradesh) and Tamil Nadu made use of the ground water for reducing the high-saline condition in ponds due to evaporation (CIFE/CIBA, 1997). But the shrimp farms in Saphale do not utilise ground water at all for any purpose. Therefore, the fear about the salinisation of freshwater aquifers is unfounded.

5. 3. WILD TRY BY-CATCH AND DECLINE IN FISHERY

Use of shrimp seed caught from the wild as stocking material and its impact on biodiversity due to discarding/destruction of by-catch have been discussed widely (Motoh, 1981; Ramamurthy, 1982; Silas, 1987; Chong *et al.*, 1990; Deb *et al.*, 1994; DeWalt *et al.*, 1996). In the present-day farming practices, the Saphale shrimp farms rely exclusively on hatchery- produced seeds.

5. 4. INTRODUCTION OF DISEASE THROUGH TRANSLOCATION

The practice of transporting penaeid stocks between facilities and different geographic regions has resulted in the introduction of five of the six known penaeid shrimp viruses to regions where these might not have previously existed (Lightner *et al.,* 1992). In this regard, this might have happened here in Saphale also where most of the shrimp seed was transported from the east coast of India where disease problem is very common.

5. 5. USE OF CHEMICALS

In many shrimp farming regions, the prophylactic use of antibiotics to guard against possible infection by the bacteria *Vibrio* spp. (Alderman and Michel, 1992) has led to the development of resistant strains. The main environmental concerns from the use of antibiotics are the possible development of resistance to antibiotics by human pathogens such as *Vibrio* spp. and the increased difficulty in treating diseases of aquaculture stock due to the development of resistant strains of pathogens (Karunasagar *et al.,* 1994). Oxytetracycline and benzalkonium chloride are widely used in Saphale shrimp farms, especially during the disease outbreaks. But their fate on the environment is to be investigated further.

5.6. WATER QUALITY

The general extensive shrimp culture systems with low stocking densities and little or no fertilisation or supplementary feeding do not generate significant amounts of waste (Phillips, 1998). Increasing inputs of fertilisers and supplementary feeds enhance the potential for nutrients, organic matter and other wastes to affect the quality of the effluent. Supplementary feed is the most important input contributing to the discharge of nutrients from more intensive culture systems and up to 30% of the feed is never consumed (Boyd and Clay, 1998). Fertilisers, such as triple super phosphate, urea, cow dung and chicken manure (Apud *et al.,* 1989; Chamberlain, 1991) which are used to promote growth of shrimp food organisms may contribute to the nutrient load and can be expected in effluents during harvesting, draining and cleaning of ponds, because of the additional discharge of material previously bound to sediment particulate matter (Barg, 1992).

5.6.1. Temperature

Temperature variations influence the lives of organisms especially in the intertidal zones. Thermal properties of water constitute an important factor in the maintenance of conditions that make the aquatic environment suitable for life (Reid, 1961). During the period of investigation, the water temperature varied from 20.4 to 30.5°C when all the stations are considered together (Tables 1 -7; Fig. 4). Phillips *et al.* (1993) reported a range of 22 - 31°C in effluent water from intensive shrimp farms in Thailand. All the stations at Saphale farms exhibit almost similar water temperature characteristics and the discharge from shrimp farms did not affect the water temperature. The water temperature values were influenced by ambient temperature which ranged from 21.9 to 32.4°C.

5.6.2. Salinity

Salinity influences the distribution of marine and brackishwater organisms. It also indicates the physical process involved in the movement of water mass. Low salinity in seawater due to heavy run off and flood during the southwest monsoon is a characteristic feature of the west coast of India. Wide variations in salinity from 1 to 42‰ (Tables 1-7; Fig.5) are due to the heavy monsoon run off during and excessive evaporation in June, which saw the maximum air temperature. Salinity between stations did not show any significant variation indicating that the discharge from farms do not influence the overall salinity of the creek. Salinity range of 10 - 38‰ was reported from Thailand in effluent water from shrimp ponds (Phillips *et al.,* 1993).

5.6.3. Hydrogen Ion Concentration

Hydrogen ion concentration is governed by the buffering action of carbonic acid and is an important factor in maintaining the bicarbonate and carbonate system and to a lesser extent by the boric acid-borate system (Martin, 1970). It is also reported to play an important role in the formation of algal blooms (King, 1982). Although observed changes of pH have little effect on most organisms, pH values below 5 or much above 9 are found to be harmful (Moore, 1958).

A pH range of 6.6 - 8.8 from intake and outlet points was reported (CIFE/CIBA, 1997) in Andhra Pradesh and Tamil Nadu. Phillips *et al.* (1993) observed a pH range of 7.5 - 8.9 in shrimp farm effluent water in Thailand. Paul Raj *et al.* (1997) recorded a pH range of 6.8 - 8.2 at inlets and outlets of creek/estuary-based shrimp farms of Nagapattinam Quaid-E-Milleth District, Tamil Nadu during 12 - 28 September, 1995.

The observed values of pH (Tables 1-7; Fig. 6) reveals normal range of fluctuations in an ideal range of 7.48 - 8.69 which agrees with the above observations. There seems to be an increase in the pH values at outlets at Station III, Station V and Station VII while the farming activities were going on. But the variations were not significant among the stations. The values were on the higher alkaline side, except during the month of August and September. Lower values in these months may be due to the heavy monsoon and the low intensity of farming activities. Values of more than 8.0 may be because of the regular liming practices in shrimp ponds and their subsequent discharges.

5.6.4. Total Alkalinity

The total alkalinity in the Saphale farms (112 - 220 mg/l) seems to correspond with that in the farms of Tamil Nadu where Paul Raj *et al.* (1997) reported a range of 90.74 - 172.22 mg/l. The alkalinity of water indicates the measure of its capacity to neutralise the acids caused by the salts of week acids. The range of alkalinity (Tables 1-7; Fig. 7) was well within the ideal range for shrimp farming.

5.6. 5. Dissolved Oxygen

Dissolved oxygen is one of most important parameters in water quality assessment. It is essential for all forms of life except for one or two groups of bacteria. In saline water, solubility of oxygen is low which further decreases with the increase in temperature. Dissolved oxygen levels are often employed as indications of primary water quality since their impact on the ecosystem is readily felt.

The dissolved oxygen concentrations in Saphale farms ranged from 4.47 to 7.96 mg/l (Tables 1-7; Fig. 8). Paul Raj *et al.* (1997) reported a range of 3.1 - 8.8 mg/l in the shrimp farming area of Tamil Nadu. Joseph *et al.* (1998) found the range to be 4.4-5.2 mg/l in Adyar, Ennore estuaries and Kandaleru creek. The increasing trend in the dissolved oxygen content on proceeding from Station I to Station VII may be due to the difference in sampling time as the whole sampling procedure was carried out the same day starting at Station I and ending at Station VII. The observed values do not indicate abnormal water quality. The lower dissolved oxygen content during May and June can be attributed to higher water temperature.

5.6.6. Total Suspended Solids (TSS)

Total suspended solids indicate the load of non-filterable solids. It is mainly contributed by silt load and organic detritus, which take time to settle down at the bottom. The TSS ranged from 20.5 to 100.4 mg/l. CIFE/CIBA (1997) reported a range of 3.0 – 173.0 mg/l in Andhra Pradesh and Tamil Nadu. TSS range recorded by Paul Raj *et al.* (1997) was 35.6 - 118.4 mg/l at inlet and outlet of shrimp farms in Tamil Nadu during September 1995. Joseph *et al.* (1998) found the range to be 30.0-61.0 mg/l in Adyar, Ennore estuaries and Kandaleru creek. In the present study, several variations were observed even through there were no significant differences amongst the stations (Tables 1-7; Fig. 9). The increase in TSS from June to September can be attributed to high silt load and the agitation of water column during monsoon rains. Even when there were hectic farming activities during

January-April and November-January, there was no significant increase in TSS. During the harvest period in April, there was a slight increase in the TSS value at all the stations. Even then, these values are well within the normal limits. Excess amounts of TSS can cause stress, gill clogging, gill damage, etc.

5.6.7. Ammonium-Nitrogen

NH_4-N is traditionally taken as an indicator of water contamination with faecal matter and putrefaction products. Although the NH_4-N content is of no toxicological significance as such, even small quantities in water may indicate unhygienic conditions, for instance by increased numbers of faecal bacteria, germs, etc.

Funge-Smith and Briggs (1996) found that the NH_4-N content during normal shrimp farming operation was 0.06 ± 2.75 mg/l at the time of harvesting. The present investigation revealed a range of 0.28 - 0.61 mg/l (Tables 1-7; Fig. 10) and the optimum value for shrimp farm is 0.40 mg/l (Treece, 2000).

5.6.8. Nitrite-Nitrogen

NO_2-N is an intermediate product in the bacterial oxidation of ammonia to nitrate. It is directly toxic to aquatic organisms if it exceeds the limit of 0.5 mg/l. The present study reveals a range from 0.173 to 0.337 mg/l (Tables 1-7; Fig. 11), which is well within the safe limits. In creek/estuary-based shrimp farms of Nagapattinam Quaid-E-Milleth District (Tamil Nadu), Paul Raj *et al.* (1997) reported a range of 0.050 - 0.200 mg/l, while Tookwinas (1998) recorded a range of 0.004 ± 0.002 – 0.014 ± 0.005 mg/l in the shrimp-farming area at Kung Krabaen Bay (Thailand) during 1989 - 1994. During harvesting, the water quality of shrimp farm effluents was found to be 0.10 ± 0.01 mg/l by Funge-Smith and Briggs (1994).

5.6.9. Nitrate-Nitrogen

It is the end product of nitrification. Nitrate is not toxic to fish unless present at very high levels of more than 100 mg/l (Poxton, 1991), though tolerance levels may vary according to species. It is critical for the primary production of algae. Paul Raj *et al.* (1997) reported a high range of 10 - 20 mg/l at the farm inlets and outlets in Tamil Nadu. CIFE/CIBA (1997) observed a range of 0.07 - 1.5 mg/l in the shrimp farms of Andhra Pradesh and a range of 0.008 - 0.031 mg/l in those of Tamil Nadu. The present study also showed a relatively high range of 0.75 - 1.92 mg/l (Tables 1-7; Fig. 12). The highest values were observed at outlets during the harvesting season. The flushing of the bottom sediment during the draining of ponds may be responsible for these higher values.

5.6.10. Phosphate-Phosphorus

Phosphate is an essential plant nutrient that decides the biological productivity (Boyd, 1989). The present investigation reveals a PO_4-P range of 0.01 - 0.16 mg/l (Tables 1-7; Fig. 13), the outlets having higher values indicating the additive potential of the shrimp farms. CIFE/CIBA (1997) report indicates a range of 0.01-0.54 mg/l in Andhra Pradesh, while in Tamil Nadu, it was 0.095 - 0.125 mg/l. Paul Raj *et al.* (1997) reported a range of below detectable levels to 0.25 mg/l. These farms have not been implicated for eutrophication of the creek or estuaries where these are located.

5.6.11. Biochemical Oxygen Demand

Biochemical oxygen demand quantifies the amount of oxygen required by microorganisms to degrade organic substances present in water. It gives an indirect measure of the total amount of biodegradable organic matter in the water. Although BOD is not a measure of the amount of oxygen required to completely oxidise all organic matter, it is nevertheless a measure of the volume of oxygen necessary to restore the balance between oxidation and microbial activities (Reid, 1961), and hence, considered a versatile index of the amount of organic loading.

The range of BOD was 6 - 42 mg/l in the inlets and outlets of shrimp farms in Andhra Pradesh, while in Tamil Nadu, it was 0.8 - 6.6 mg/l at inlets and outlets (CIFE/CIBA, 1997). Paul Raj *et al.* (1997) reported a range of 1.6 - 22.6 mg/l at the inlets and outlets of creek/estuary-based farms in Tamil Nadu. The range recorded in the present study was a minimum of 2.50 mg/l and a maximum of 11.22 mg/l (Tables 1-7; Fig. 14). There was an increasing trend in pre-monsoon when the harvesting was going on. Even then, the maximum value of 11.22 mg/l at Station IV near the outlet in April did not go beyond the permissible limit of 20 mg/l. Lower values at all the stations were observed from July to October mainly because of monsoon rains. Station I, which is at the mouth of the creek indicates lower values as compared to the other stations and the stations situated at the outlet show slightly higher values. But, the variations are not significant. Higher values were observed during April when the harvesting was carried out. It indicates that especially during the harvesting period, BOD tends to go up even though the normal discharge during water exchange do not show any significant increase in organic load.

5.6.12. Chemical Oxygen Demand

The COD indicates a measure of the pollutional strength of water (Owsley, 2000). It is based on the fact that all the carbonaceous organic matter can be oxidised to carbon dioxide and water regardless of the biological assimilability of the substance by strong oxidising agents in the acidic range.

The study done by CIFE/CIBA (1997) showed a range of 15 - 68 mg/l at inlet and 6 - 70 mg/l at outlets of the shrimp farms in Andhra Pradesh, while in the farms in Tamil Nadu, it was 3.0 - 50.0 mg/l at inlets and 3.0 - 59.0 mg/l at outlets. The present investigation shows a range of 19 - 55 mg/l (Tables 1-7; Fig. 15) against the admissible level of 75 mg/l (MOA, 1995). The range was much less than the range of 54.4 - 103.6 mg/l reported from the farm outlets in Tamil Nadu by Paul Raj *et al.* (1997). The lower values were seen during August and September due to heavy monsoon run-off. There was no significant difference between the stations, which reflects the low influence of farming waste discharge on the overall water quality of the creek.

5.6.13. Phytoplankton

Padmakumar (1983) reported that the phytoplankton cell count ranged from 0.04 x 10^5 – 19.44x10^5cell/l with diatoms as the dominant group in an estuary in Bombay. The phytoplankton population of Saphale at 5 – 324 x 10^3/l (Tables 1-7; Fig. 16) has not shown any excessive bloom due to eutrophication. There was no distinct correlation between the phytoplankton growth and the nutrient discharge.

5.6.14. Zooplankton

The zooplankton population density varies from 20/m^3 to 24,425/m^3 having copepods as the dominant group in mangrove swamps near Juhu beach in Mumbai (Padmakumar, 1983). Paul Raj *et al.* (1997) observed zooplankton population at inlets and outlets as 107 - 682/m^3 with the water of the estuary having 17 - 467/m^3. The range in zooplankton population at Saphale which was 40 - 2450/m^3 (Tables 1-7; Fig. 17), seems to reflect more of the estuarine population in nature with distinct peaks in June and October which might have resulted at the onset of monsoon from the release of nutrients from the farms. Phytoplankton growth is not related with zooplankton growth except during the peaks.

5.6.15. Total Plate Count

A total viable count of 0.60 - 1.90 x 10^3 CFU/ml was encountered in the source water in a Tuticorin shrimp farm (Sharmila *et al.*, 1996). Otta *et al.* (1999) found the creek water in the east coast of India to have a bacterial level of 3.1 x 10^3 CFU/ml. While the shrimp ponds in India showed a total bacterial count in the range of 10^3 - 10^5 CFU/ml, the total bacterial plate count at shrimp farms in Kung Krabaen Bay, (Thailand) during 1989 to 1994 showed a range of 19,003 ± 15.4 to 23,801 ± 17.33 CFU/ml (Tookwinas, 1998). Paul Raj *et al.* (1997) found the total bacterial count at outlets to be 26 - 370 x 10^3 CFU/ml. The range (1.10 x 10^3 to 8.10 x 10^6 CFU/ml) encountered at Saphale (Tables 1-7; Fig. 18) has been quite wide with fluctuations throughout the year. Higher counts were encountered when disease outbreaks were reported.

5.6.16. Heavy Metals

Heavy metals occur naturally in the aquatic environment as a result of weathering and land drainage, and the use of various pesticides and fungicides that contain metals has added large quantities of heavy metals to the aquatic environment (Treece, 2000). Excessive additions of heavy metals could have an adverse effect on aquatic animals as well as on the human population that uses these animals as food.

5.6.16.1. Iron

Dissolved iron is not toxic to shrimp, but when it precipitates it can cause problems. It should be below 0.01 mg/l to be in the optimum range for shrimp culture and below 1.0 mg/l for any kind of shrimp production to occur (Treece, 2000). Fujimura (1989) reported that the water samples from hatchery in Sabah (Malaysia) contain 0.23 mg/l of iron and those from Guam, 0.3 mg/l. Total iron concentration at the inlet and outlet water at Saphale shrimp farms showed a range of 0.11 - 0.26 mg/l (Tables 1-7; Fig. 19). These values conform to the values reported by Paul Raj *et al.* (1997), which are in the range of 0.001 - 1.030 mg/l. Very high ranges have been reported from the shrimp farms at the Vellar Estuary by Kumaresan *et al.* (1997).

5.6.16.2. Zinc

Estuarine waters at Adyar and Ennore was found to have 0.11-0.16 ppm zinc level (Joseph *et al.*, 1998). Fujimura (1989) reported zinc levels in hatchery water from Sabah (Malaysia) at 0.06 mg/l. Zinc in water has been shown to cause a decrease in the rate of oxygen consumption of freshwater shrimp (Chinnayra, 1971). The range of zinc concentration (0.022 - 0.300 mg/l) reported by Paul Raj *et al.* (1997) is similar to that (0.12 - 0.27 mg/l) recorded at Saphale (Tables 1-7; Fig. 20).

5.6.16.3. Copper

Joseph *et al.* (1998) reported 0.08 ppm and 0.15 ppm of copper at Ennore and Adyar estuaries, respectively. Fujimura (1989) reported 0.03 mg/l of copper in the hatchery water from Sabah (Malaysia). Copper occurs as a natural or native metal in various mineral forms. Oxides and sulphates of copper are used as pesticides, algicides and fungicides. The toxicity of copper to aquatic life is dependent on the alkalinity of water as copper ion is complexed by anions present and at lower alkalinity levels, copper is generally more toxic to aquatic life (Treece, 2000). The copper concentrations of 0.03 to 0.20 mg/l observed in the farms at Saphale (Table 1-7; Fig. 21) more or less follow the pattern observed by Paul Raj *et al.* (1997) in the estuary-based farms in Tamil Nadu.

The heavy metal concentration at outlets, were seen to be higher than at inlets (Tables 1-7) and the higher values were observed when the culture period was at its maximum. This phenomenon corroborates the findings in case of iron and copper by Kumaresan *et al.* (1997) at Parangipettai, Tamil Nadu.

5.6.16.4. Manganese

This metal is a required nutrient for aquatic animals, but can be toxic to aquatic animals at relatively higher concentrations. The manganese concentrations at Saphale farms (Tables 1-7; Fig. 22) are much less as compared to those reported from many parts of the world (Treece, 2000). Paul Raj *et al.* (1997) reported concentrations up to 0.10 mg/l in the Tamil Nadu farms.

5.6.17. Soil pH

Soil pH showed a range of 8.88 ± 0.02 to 9.00 ± 0.02 under pond conditions (Sharmila *et al.,* 1996) at a shrimp farm in Tamil Nadu. The present study shows that the soil pH range at Saphale farms (Tables 1-7; Fig. 23) falls within the optimum of 6.5 - 7.5 (Joseph *et al.,* 1998).

5.6.18. Soil Organic Carbon

The total organic carbon percentage in sediment increased significantly ($P < 0.01$) from an initial level of 0.24 ± 0.04 to 0.49 ± 0.04 during culture period (Sharmila *et al.,* 1996). The range shown in Saphale (Tables 1-7; Fig. 24) is quite comparable to the range of 0.06 - 0.45% reported by Paul Raj *et al.* (1997) and falls within the optimum range of 0.5 - 2.5% (Joseph *et al.,* 1998).

5.6.19. WELL WATER

The well water quality at Saphale (Table 8) indicates saline condition having salinity up to 3‰ with a low hardness range as compared to the range reported by Paul Raj *et al.* (1997) of 238 - 813 mg/l at well, bore well and hand pumps in Tamil Nadu. Salinisation of coastal aquifers has occurred in many places where there is no shrimp farming or similar activities. Besides the coastal agro-ecological zones, there are large tracks of salt affected areas in the hot, semi-arid eco-region states of Haryana, Rajasthan and Uttar Pradesh (Joseph *et al.*, 1998). The present situation in Saphale cannot be attributed to shrimp farming activities, which do not discharge salt water to inland areas nor do they abstract ground water.

5.7. LEGAL ASPECTS

In the absence of legislation for conversion of agricultural or coastal land for aquaculture and without any regulation for treatment of waste water released from the aquaculture farms, there have been a virtual boom in the aquaculture activity, until encountering legal and viral disease problems, which have brought almost all the activity to a stand-still (Pandian, 1998).

In 1994, when the Indian shrimp industry had just started to bloom with production of around 62,000 t from 82,540 ha, a socio-political movement against the industry was launched by the veteran social leader Mr. S. Jagannathan, Chairman, Gram Swaraj Movement, a voluntary organization, in Tanjore District of Tamil Nadu (Issac, 1998). The Hon'ble Supreme Court accepted the civil writ petition bearing No. 561 of 1994 on the basis of numerous hearings and issued a number of interim orders. The first interim order dated 12 December 1994 directed the states not to permit the setting up of any industry or construction of any type within 500 m from the seawater at the maximum high tide.

In the second interim order of 27 March 1995, the Court directed NEERI to visit the coastal areas and give its report keeping in view the notification dated 19 February 1991 under clause (d) of sub-rule (3) of rule (5) of the Ministry of the Environment Protection Act, 1986 (James, 1998). On 9 May 1995, based on the NEERI reports, the Court directed that no part of agricultural land and salt farms be converted to commercial aquaculture farms, no ground water be drawn for aquaculture purpose, or any of the industries whether already existing or in the process of being set up be established and no further farms be set up. The Court had also directed the state governments to provide free access through aquaculture units to sea-coast to the fishermen/tourists and fresh water for drinking, wherever necessary.

On 11 December 1996 the Hon'ble Supreme Court passed a landmark judgement on the above writ petition under Article 32 of the Constitution of India (Singh and Ahmad, 1996). The salient features of the judgement include constitution of an authority by the Central Government to regulate aquaculture activities and to ensure strict adherence to the regulations under the Coastal Regulation Zone (CRZ) Notification. As per the judgement, all aquaculture farms within the CRZ were to be demolished by 31 March 1997, traditional and improved traditional method of aquaculture are to be permitted; agriculture lands, salt pans, mangroves and wet lands are not to be used for aquaculture, no aquaculture industry to be permitted within 1000 m of Chilka Lake and Pulicat Lake, aquaculture industry other than traditional and improved traditional may be constructed outside the CRZ and outside 1000 m of Chilka and Pulicat lakes, those already in operation to get authorised from the Authority before 30 April 1997, aquaculture industry which is not to be allowed, loss to ecology and environment, and compensation to affected people have to be assessed by the Authority, and workmen in employment for more than one year to be compensated in addition to six years wages and gratuity which was to be paid before 31 May 1997. In response to the judgement, the shrimp farming industry, the Central Government and the state governments sought a review and the ruling on the review is yet to be delivered.

Meanwhile, the Ministry of Agriculture, Government of India, got an Aquaculture Authority Bill passed in the Rajya Sabha and the legal implication remains status quo till date. The Second NEERI Report dated 10 July 1995 on Maharashtra State as a whole does not mention any of the shrimp farms in Saphale and states that shrimp farming activity in the west coast of India is mostly confined to the traditional extensive type of farming.

At present, all the farms in Saphale region are registered with the Aquaculture Authority and have obtained permission from the Maharashtra Pollution Control Board and these farms have been offered subsidies for construction of Effluent Treatment Plants (ETP).

5.8. SOCIO-ECONOMIC IMPACT

5.8.1. Impact on health of the local population

Pillay (1992) threw lights on the possible impact of aquaculture on human health including the transmission of water-borne diseases. Not a single case of shrimp farming creating health problem has been encountered

(CIFE/CIBA, 1997). In the present survey, 81% of the local villages confirmed this (Table 9). There is no other report on this by other workers.

5. 8. 2 Impact on land use pattern

Shrimp farming, which utilises public resources renders public goods become private property controlled by private interests producing for international markets (Clay, 1996). Intensive shrimp farming in coastal Southeast Asia has denied the use of these areas to local residents for traditional activities such as fishing, gathering construction material, food collection, fuel gathering and hunting (Skladany, 1992). Reports of land conversion to shrimp farms in Asia and Latin America are many (Choudhury *et al.,* 1994; Alauddin and Tisdell, 1996).

There has been an increase in land price in the villages: 70% of the villagers cited shrimp farming as the reason for the hike in land price (Table 9). But interestingly, most of the existing farms have come up on the government land, which has been leased out for 25 years through Konkan Vikas Mandal. Even though 26% of villagers claimed that land conversion into shrimp farms has occurred, 51% of them said otherwise. It can very well be understood that some of these villagers might have been using some of the mudflats for cultivation of rice without any ownership of the available land. Even now, vast tracks of land, which are lying fallow, could be seen around the farms. No agricultural activity has been observed during the 13 months of the study.

Paul Raj *et al.* (1997) reported a 10-time increment in land price in Nagapattinam Quaid-E-Milleth District, Tamil Nadu. Before the commencement of shrimp farming, the land value was only Rs.18,000 - 20,000 per hectare which had increased to about Rs.180,000. In Vedi, Khardi-Para and Datiwada villages, the land price has risen up from Rs.15,000 to Rs.60,000 per hectare after the commencement of shrimp farming in the area. Land price in Thailand also increased from US$ 50 - 75 per hectare in 1985 to US$ 50,000 - 75,000 per hectare in 1991 (Boromthanarat, 1995) leading to buying out of small farmers and land owners by big shrimp farmers and companies. Ruia Aquaculture Ltd is reported to have purchased some portion of the land at the rate of Rs.25,000 per hectare in 1995.

5.8.3. Impact on mangrove eco-system

Mangroves are considered to be the most productive areas rich in nutrients, and serve as nursery and feeding ground for many of the commercially important species of finfish and shellfish. As these shrimp farms have proper drainage systems for easy dewatering and drying, as and when required, these are located away from the mud flats and mangroves. These farms receive water by pumping from the surrounding creek, Ahali/Dubhari Phata which is a branch of Vaitarna Creek, rather than tidal waters. Thus, these farms cannot be assumed as to have been constructed on coastal wetlands. In the survey, 74% of the villagers have said that shrimp farms are not connected with the destruction of mangroves and wild life (Table 9).

5.8.4. Impact on local fisheries

Collection of wild seed for shrimp farming and the by-catch destruction have been reported by many authors (Motoh, 1981; Ramamurthy, 1982; Silas, 1987; Banergee and Singh, 1993; FAO/NACA, 1995). Given the huge collection of wild seed and the quantity of by-catch destroyed, it could have major consequences on the marine food chain (Deb *et al.,* 1994). General feeling among the fishermen community at Datiwada is that marine fish catches are gradually declining, but the fishermen cannot find any relation between dwindling catches and shrimp farming (Table 9) as wild seed collection is non-existent in this part and the shrimp farms exclusively use hatchery-produced seed.

5.8.5. Impact on soil quality

A rise in the groundwater level may reduce the safe bearing capacity of soil and lowering of the ground water over an area may result in differential settlement of structures. Abstraction of large quantities of water from groundwater sources would cause salinisation of agricultural lands and land subsidence (Nair, 1998). No shrimp farm in Saphale Region uses ground water for lowering the salinity in the ponds (hypersaline conditions are common in this area during the pre-monsoon period). Even the drinking water is procured through water tankers from inland areas. In Khardi-Para village, 53% of the villagers feel that salinisation of the well water is due to Shakti Aquaculture Farms (Table 9). The saline condition of the well (Table 8) indicates that the salinisation problem does exist, but it cannot be attributed to Shakti Aquaculture Farms, which is 1.5 km away from the village. The problem of salt intrusion has been reported not only from the coastal areas in recent years but in inland areas also (Joseph *et al.*, 1998). Except the villagers of Khardi-Para, none else has implicated shrimp farms for salinisation of ground water. Wells like Malya Talao, which is around 500 m from the creek at Datiwada and Dongra are still of fresh water in nature.

5.8.6. Impact on accessibility to fishing grounds

In India, huge corporate shrimp farms block access to fishing grounds and to beaches for landing of boats and drying fishermen's nets (Rajagopal, 1995; Patil and Krishnan, 1998). In Saphale Region, Datiwada, which is a fishing village has its proper landing centre and the villages of Vedi and Khardi-Para are not fishermen's villages either. Thus, the above statement does not hold true here. But the villagers (37%) say that because of the construction of farms, the water flow and sedimentation patterns in the creek have altered (Table 9). This has led to shallowing of the creek at the mouth hampering the berthing of fishing boats at Datiwada during low tide.

5.8.7. Employment opportunities and income generation

Regarding the local employment opportunities, the villagers (61%) agreed that shrimp farms provide employment to local community (Table 9), mainly as farm hands. The average labour requirement per hectare of paddy cultivation is about 180 labour-days per crop, whereas in shrimp farming, it is about 600 labour-days (Paul Raj *et al.,* 1997) and employment opportunity has increased due to shrimp farming.

CIFE/CIBA (1997) reported that the local labourers had to go to far-flung areas for earning their livelihood, at about Rs.20 - 25 per day, but now, the local people are able to get jobs near their villages in the shrimp farms with daily wages of Rs.75 - 150 in Andhra Pradesh and Rs.40 - 60 in Tamil Nadu. Many of them have benefited by securing regular employment as feed boys, pump operators, watchmen, etc. at a salary range of Rs.1200 - 1500 per month with free food and accommodation.

Labourers on daily wages earn Rs.25 - 40 per day depending on the nature of work. Around 150 workers are being employed in these shrimp farms. The number of people employed came down due to the limited farming activities because of the disease problem. But, most of the skilled labourers employed in these farms are from other states like West Bengal, Andhra Pradesh and Tamil Nadu.

The establishment of aquafarms has created subsidiary occupations like catering, transportation, handling of construction material, etc. (Paul Raj *et al.,* 1997). Similar spurt in activities could be seen in Saphale also, where subsidiary services like grocery supply, drinking water supply, construction material supply, etc. have provided employment to many. This apart, a number of ancillary industries such as shrimp hatcheries, feed mills, ice plants, etc. have provided employment opportunities indirectly.

5. 8. 8. Economic motivation

Even though villagers of Khardi-Para are a little unhappy with shrimp farming when asked whether they are ready to do farming themselves, 40% replied in the affirmative (Table 9). Overall, 51% of the villagers in these three villages agree that shrimp farming can enhance income. The reasons cited for not going for shrimp farming were lack of technical knowledge and financial support.

Twenty-three per cent of the villagers feel that shrimp farming is good for the community, while 23% of them said that it is not good for the community: 54% of the villagers could not see any relation between community welfare and shrimp farming (Table 9). It has been found that majority of the villagers do not have a fairly good idea of shrimp farming. They felt that it is only for those who have money.

summary and conclusion

Chapter 6
SUMMARY AND CONCLUSION

The study was carried out during January 1998 - January 1999 in Saphale, Palghar Taluka of Thane District in Maharashtra, to assess the physical, chemical and biological parameters of Vaitarna Creek bordering the shrimp farms of King's Prawn Ltd, Shakti Aquaculture Farm Ltd and Ruia Aquaculture Ltd. A survey was also conducted in the neighbouring villages of Vedi, Khardi-Para and Datiwada to evaluate the socio-economic impacts of shrimp farming.

For carrying out the study, seven stations, namely, Station I (near the jetty at Datiwada fishing village), Station II (near the inlet point of Ruia Aquaculture Farm), Station III (near the outlet channel at Ruia Aquaculture Farm), Station IV (near one of the intake point of Shakti Aquaculture Farm), Station V (outlet point of Shakti Aquaculture Farm), Station VI (inlet point of King's Prawn Farm) and Station VII (outlet point of King's Prawn Farm) were selected.

Shrimp farming is being carried out in earthen ponds constructed on the land leased out by the Konkan Vikas Mandal under the "Kolambi Shetti Prakalp" scheme. There is no significant mangrove cover and it was observed that salt manufacturing and agriculture were the activities carried out near the shrimp farms. No significant fishing activities were observed in these creeks during the study.

The construction of shrimp farms has reportedly altered the shoreline configuration and water flow pattern leading to sedimentation and siltation in the creek. This caused the creek to become shallow making the entry of boats difficult during the low tide.

Salinity values ranged from 1‰ during monsoon to 42‰ during summer. Wide ranges had been recorded in the water quality parameters at all the seven sampling stations during the study period (Tables 1-7). A significant increase in organic nutrient load has been observed during harvesting, draining and cleaning of ponds.

Overuse of antibiotics such as oxytetracycline, furazolidone and streptomycin could be very dangerous due to the potential generation of drug-resistant shrimp pathogens and the transfer of drug resistance to human pathogens. Excessive use of copper sulphate as an algicide, biodegradable pesticides such as tea seed cake (saponin), organopesticides and mollucicides such as chlorinated hydrocarbon are of particular concern due to their toxicity and persistence and their potential health hazards. Prolonged use of disinfectants and water quality conditioners such as bleaching powder, benzalkonium chloride, zeolites and various commercial water probiotics may cause ecological imbalance.

The observations made during the study are:

1. Except nitrate, the physico-chemical parameters at the seven sampling stations did not show any significant increase over the study period. The reason may be the limited farming activities due to disease outbreaks.

2. Marginally high values were recorded at the outlet points for most of the parameters, but these do not differ significantly ($P > 0.05$).

3. Increases in total suspended solids were due to the influence of surface run off and the churning action during monsoon.

4. BOD and COD showed higher values when the dissolved organic carbon levels were higher, but the influence of monsoon is significant in lowering these values considerably.

5. Since the nutrient loading was not in excess, plankton blooms could not be seen except the seasonal fluctuations, especially before and after the monsoon.

6. The concentration of heavy metals in different water samples was below the lethal concentrations.

7. The soil conditions were alkaline in nature and rich in organic carbon, which is suitable for shrimp farming.

8. Socio-economic impacts:

   a) No relation was found between shrimp farming and human health problems.

   b) There has been an increase in land prices due to shrimp farming; land price has risen up from Rs.15,000 to Rs.60,000 per hectare.

   c) There was no significant relation between shrimp farming and fishing, which is done in the in-shore areas of Arabian Sea. There were no significant fishing activities in the creeks near the shrimp farms.

   d) Around 150 workers were being engaged, getting Rs.25 - 40 per day depending on the nature of their work in the shrimp farms. Subsidiary occupations like catering, transportation and supply of construction materials, have come to existence in these areas.

   e) There was some social unrest at Khardi-Para Village, which was mainly due to the villagers' contention that their lands have been forcibly taken over by Shakti Aquaculture Farms Ltd. Those were the unregistered government lands, which were utilized by the villagers for cultivation. When the government leased out those lands, this social problem started.

f) There was a very strong economic motivation, especially among the educated villagers to take up shrimp farming. They see shrimp farming as a good opportunity for income generation.

RECOMMENDATIONS

In view of the present investigations and the author's findings, the following recommendations are made in connection with the improved eco-friendly shrimp farming practices:

1. To ensure optimum sustainable use of coastal resources, coastal aquaculture development must be preceded by assessment of the potentials and limitations. Involvement of other coastal resource users should be made certain in all decision making processes concerning shrimp farming development plans.

2. The process of environmental impact assessment should be incorporated in shrimp farming activities to identify the potential impact on the environment and mitigation measures.

3. Reduction in wastewater generation involves proper site selection, pond design and good farming practices like water quality management and use of efficient feeds. Since most of the nutrient load comes from feeds, improved water-stable quality pelletised feeds need be developed.

4. Biological treatment ponds to treat wastewater should be incorporated in the farm lay-out.

5. Use of chemicals and antibiotics should be limited, and drugs used should be water stable and not used for human being.

6. Establishment of withdrawal time and permissible residue levels of drugs and chemotherapeutants at an early date is a must.

7. Restriction on quantity of feed used should be considered to restrict wastewater generation and nutrient loading in the ecosystem.

8. Mutual understanding and technical linkages are to be developed between the farmers, so that there is no misunderstanding and clash of interests in the use of common resources.

9. Species other than tiger prawn should also be cultured and an integrated farming approach may be adopted.

10. Smaller units of shrimp farms should be encouraged.

11. To reduce the biological oxygen demand and turbidity of wastewater, sediment basins to settle suspended solids should be constructed to receive the wastewater before discharge.

12. Mangroves can be planted on levees and fringe areas of shrimp ponds to act as nutrient sinks for surplus nutrient discharged from shrimp ponds. They will also reduce soil erosion.

13. If the water-spread area for culture practices exceeds 5 ha, the aquafarming unit should construct raw water and wastewater treatment systems to meet the wastewater quality criteria.

14. Sedimentation in the water supply creek is partly a result of solid waste discharge from the shrimp farms, which hampers navigation in the creek: restriction in water supply and reduction in depth should be rectified by dredging.

15. The State can establish model demonstration farms to promote sustainable shrimp farming operations.

16. Demarcation of shrimp farming zones should form a part of the integrated coastal zone management programmes and should clearly identify suitable sites for shrimp farming activities.

17. As shrimp farming requires close proximity to waterfronts; Coastal Regulation Zone Rules have to be modified to avoid inward salinisation of soil and water.

18. Certification of hatcheries should be done to maintain uniform quality of seed and to assure seed to be free of diseases.

19. Certification of feed manufacturers and feeds should be done ensure environment-friendly quality feeds.

20. Use of chemicals and drugs in the industry should be controlled to prevent adverse impact on the bacterial flora and human health conditions.

21. The impact of the industry on environment should be regularly monitored in order to take corrective measures, if needed.

22. Wastewater quality from shrimp farms should be regulated and standards set.

23. The concept of eco-tourism can be developed in conjunction with the shrimp farming activity. As the coastal farms are always located at

naturally aesthetic locations, people can be attracted to spend leisure time experiencing and indulging in farming activities.

24. Government should consider leasing out land to small and marginal farmers rather than entrepreneurs.

25. The idea of satellite farming as well as coastal farming estates can be developed.

26. Fishermen at Datiwada, even though at the moment are ignorant about shrimp farming, (educated ones) have shown interest in the farming activities, as they do not see much future in traditional fishing which is a more risky business. Therefore, they can be motivated and supported to take up sustainable low intensity shrimp farming.

KEY ISSUES AND FUTURE DIRECTION OF RESEARCH

The lack of understanding of the interactions between shrimp farming and the environment in more precise and quantified terms is an important issue. Future research should be multidisciplinary in approach focused on problem solving and planning of any aquaculture development, rather than the traditional production-oriented research, which tends to ignore the interactions of technology with the surrounding social and ecological environment (FAO/NACA, 1997). Future areas of research identified through this study are:

1. Assessment and management of water quality and quantity,
2. Quantitative assessment of environmental impacts,
3. Wastewater management,
4. Social conflicts and their management,
5. Social cost accounting and cost-benefit analysis, and
6. International trade agreements, government policies, legislation and management tools.

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tables, figures & plates

Table 1: Physico-chemical and biological variables at Station I

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	21.9	25.8	25.5	26.6	31.2	29.4	29.2	27.9	28.2	27.3	23.5	22.6	23.8
Water Temperature (°C)	20.4	24.8	24.6	25.8	30.5	28.6	28.2	27.4	27.2	26.2	22.8	21.8	22.4
Salinity (‰)	28	32	32	34	35	37	2	5	5	16	29	28	29
Water pH	8.54	8.19	8.21	8.24	8.51	8.59	8.52	8.10	8.24	8.52	8.02	8.17	8.25
Total Alkalinity (mg/l)	164	176	132	124	112	122	116	114	124	148	174	162	158
Dissolved Oxygen (mg/l)	6.45	6.70	6.25	6.43	4.98	4.47	6.90	6.23	6.64	5.62	5.44	6.57	6.21
Total Suspended Solids (mg/l)	20.5	33.0	21.4	30.8	25.2	54.4	59.8	60.4	62.2	31.8	37.0	20.6	23.4
Ammonium-Nitrogen (mg/l)	0.40	0.45	0.48	0.50	0.53	0.38	0.37	0.46	0.51	0.54	0.61	0.60	0.52
Nitrite-Nitrogen (mg/l)	0.281	0.282	0.288	0.279	0.238	0.194	0.262	0.278	0.219	0.242	0.345	0.261	0.249
Nitrate-Nitrogen (mg/l)	1.26	1.52	1.38	1.64	1.47	1.21	0.95	0.97	0.92	0.96	0.97	0.89	0.81
Phosphate-Phosphorus (mg/l)	0.10	0.10	0.11	0.11	0.06	0.13	0.07	0.05	0.06	0.06	0.05	0.05	0.07
Biochemical Oxygen Demand (mg/l)	7.56	7.80	8.78	9.74	8.42	7.56	3.50	2.50	2.54	3.86	5.94	6.28	6.78
Chemical Oxygen Demand (mg/l)	40	44	40	36	30	25	20	25	25	30	36	40	46
Phytoplankton (no. x 10^3/l)	110	101	136	31	54	67	85	42	208	234	32	68	121
Zooplankton (no./m^3)	250	210	70	380	170	365	2325	470	940	870	420	1420	190
Total Plate Count (CFU x 10^3/ ml)	2.10	4.30	4.40	24.0	5200	370	2.70	160	480	3200	27.0	3.60	1.10
Iron (mg/l)	0.17	0.11	0.12	0.14	0.17	0.24	0.15	0.13	0.18	0.16	0.12	0.13	0.14
Zinc (mg/l)	0.18	0.18	0.20	0.20	0.23	0.21	0.16	0.14	0.12	0.15	0.15	0.16	0.19
Copper (mg/l)	0.07	0.09	0.12	0.12	0.13	0.08	0.05	0.03	0.04	0.04	0.05	0.07	0.05
Manganese (mg/l)	0.03	0.02	0.03	0.03	0.03	0.04	0.02	0.01	0.01	0.03	0.03	0.04	0.04
Soil pH	7.6	7.4	7.5	7.5	7.7	7.9	7.8	7.3	7.6	7.8	7.4	7.4	7.5
Soil Organic Carbon (%)	0.42	0.45	0.41	0.40	0.43	0.42	0.40	0.35	0.32	0.33	0.42	0.44	0.46

Table 2: Physico-chemical and biological variables at Station II

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	22.2	26.2	25.9	26.9	31.6	30.2	29.4	28.4	29.5	27.9	23.8	23.2	24.2
Water Temperature (°C)	21.6	24.8	25.2	25.8	29.8	29.4	28.8	27.6	28.4	27.2	22.8	22.4	23.2
Salinity (‰)	29	30	33	35	39	40	3	5	5	17	28	30	29
Water pH	8.52	8.24	8.15	8.32	8.49	8.34	8.47	7.88	7.98	8.63	8.14	8.25	8.37
Total Alkalinity (mg/l)	152	160	140	136	136	116	112	116	136	152	178	174	180
Dissolved Oxygen (mg/l)	6.70	6.29	6.32	6.51	5.12	4.56	7.20	7.87	7.43	6.78	6.89	7.82	7.35
Total Suspended Solids (mg/l)	31.4	34.6	23.8	41.0	28.4	67.2	62.4	62.8	64.4	40.2	40.8	24.2	23.4
Ammonium-Nitrogen (mg/l)	0.47	0.40	0.42	0.48	0.43	0.38	0.37	0.46	0.52	0.58	0.53	0.58	0.42
Nitrite-Nitrogen (mg/l)	0.294	0.286	0.280	0.282	0.240	0.176	0.232	0.260	0.220	0.248	0.341	0.274	0.248
Nitrate-Nitrogen (mg/l)	1.11	1.27	1.42	1.53	1.32	1.16	0.94	0.82	0.94	0.89	0.85	0.87	0.78
Phosphate-Phosphorus (mg/l)	0.09	0.05	0.08	0.15	0.06	0.07	0.07	0.05	0.05	0.04	0.05	0.05	0.07
Biochemical Oxygen Demand (mg/l)	8.22	7.80	8.98	9.82	8.46	7.46	3.66	2.56	2.50	3.58	6.38	6.36	6.62
Chemical Oxygen Demand (mg/l)	35	43	40	32	32	25	21	24	27	30	20	27	43
Phytoplankton (no. x 10^3/l)	107	84	123	14	34	34	15	9	101	215	35	44	114
Zooplankton (no./m^3)	170	312	123	492	113	197	789	310	520	1128	650	782	325
Total Plate Count (CFU x 10^3/ ml)	1.60	2.90	37.0	3.90	25.0	1500	1.70	420	910	7400	25.0	3.90	1.60
Iron (mg/l)	0.17	0.14	0.12	0.15	0.19	0.22	0.16	0.14	0.21	0.17	0.13	0.14	0.12
Zinc (mg/l)	0.16	0.17	0.18	0.20	0.21	0.20	0.16	0.15	0.13	0.17	0.15	0.18	0.19
Copper (mg/l)	0.08	0.10	0.12	0.12	0.12	0.09	0.06	0.03	0.04	0.05	0.05	0.06	0.05
Manganese (mg/l)	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.02	0.02	0.04	0.04	0.04	0.04
Soil pH	7.8	7.5	7.3	7.7	7.8	7.7	7.8	7.1	7.1	7.7	7.6	7.7	7.7
Soil Organic Carbon (%)	0.45	0.43	0.45	0.48	0.47	0.41	0.39	0.36	0.34	0.49	0.48	0.51	0.48

Table 3: Physico-chemical and biological variables at Station III

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	22.2	26.3	26.7	27.0	31.8	30.4	29.4	28.5	29.5	28.2	23.8	23.2	24.2
Water Temperature (°C)	21.8	24.6	25.4	26.2	29.6	28.8	28.6	27.8	28.2	27.8	21.8	22.6	23.4
Salinity (‰)	28	31	34	35	40	42	5	5	1	18	28	30	28
Water pH	8.65	8.33	8.23	8.51	8.23	8.21	8.32	7.54	7.79	8.48	8.17	8.10	8.43
Total Alkalinity (mg/l)	176	194	165	128	120	128	122	120	142	160	182	168	148
Dissolved Oxygen (mg/l)	6.08	6.73	6.29	6.80	5.21	4.79	7.51	7.63	7.67	6.82	6.98	7.29	7.44
Total Suspended Solids (mg/l)	32.2	36.2	37.6	42.8	38.6	67.4	66.4	72.4	74.6	40.8	42.2	26.2	26.8
Ammonium-Nitrogen (mg/l)	0.40	0.44	0.46	0.50	0.50	0.42	0.37	0.47	0.52	0.58	0.52	0.52	0.48
Nitrite-Nitrogen (mg/l)	0.271	0.278	0.241	0.291	0.268	0.173	0.238	0.268	0.234	0.254	0.273	0.275	0.241
Nitrate-Nitrogen (mg/l)	1.30	1.29	1.51	1.65	1.42	1.12	0.95	0.82	0.96	0.91	0.87	0.85	0.79
Phosphate-Phosphorus (mg/l)	0.11	0.04	0.08	0.16	0.05	0.06	0.10	0.07	0.06	0.03	0.04	0.04	0.05
Biochemical Oxygen Demand (mg/l)	8.56	7.86	8.98	9.88	8.50	7.50	4.28	2.60	2.52	3.42	6.60	6.78	7.12
Chemical Oxygen Demand (mg/l)	37	42	45	30	37	27	30	27	32	30	25	33	46
Phytoplankton (no. x 10^3/l)	94	62	223	13	66	45	13	12	5	194	5	67	123
Zooplankton (no./m^3)	275	530	475	1725	60	40	325	370	920	1376	213	1125	425
Total Plate Count (CFU x 10^3/ ml)	2.70	7.70	18.0	6.30	280	4800	1.60	930	250	4900	54.0	3.70	6.80
Iron (mg/l)	0.18	0.14	0.13	0.16	0.20	0.26	0.17	0.13	0.20	0.17	0.14	0.16	0.12
Zinc (mg/l)	0.17	0.16	0.17	0.18	0.19	0.19	0.16	0.15	0.14	0.17	0.16	0.18	0.21
Copper (mg/l)	0.11	0.13	0.14	0.11	0.13	0.09	0.06	0.04	0.03	0.07	0.05	0.09	0.05
Manganese (mg/l)	0.03	0.03	0.01	0.02	0.03	0.04	0.01	0.02	0.03	0.04	0.05	0.06	0.06
Soil pH	7.5	7.5	7.3	7.4	7.3	7.2	7.4	7.9	6.9	7.3	7.2	7.1	7.4
Soil Organic Carbon (%)	0.47	0.46	0.48	0.51	0.48	0.42	0.39	0.37	0.36	0.43	0.49	0.52	0.51

Table 4: Physico-chemical and biochemical variables Station IV

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	22.6	26.6	26.4	28.5	32.0	30.8	29.8	29.1	30.2	28.6	24.1	23.8	24.3
Water Temperature (°C)	21.6	24.8	24.8	27.4	29.8	29.2	28.8	27.2	27.8	27.4	21.6	22.4	22.8
Salinity (‰)	29	30	32	36	39	41	4	5	2	18	27	29	29
Water pH	8.54	8.54	8.41	8.25	8.45	8.42	8.45	7.48	8.12	8.64	8.21	8.08	8.22
Total Alkalinity (mg/l)	174	176	170	142	152	146	136	128	138	146	198	186	172
Dissolved Oxygen (mg/l)	6.12	6.82	6.57	6.87	5.33	4.68	7.65	7.57	7.89	7.12	7.96	7.34	7.48
Total Suspended Solids (mg/l)	41.0	37.2	38.2	45.6	40.2	70.2	75.8	76.2	83.4	55.8	51.2	24.4	28.8
Ammonium-Nitrogen (mg/l)	0.40	0.40	0.48	0.48	0.41	0.38	0.37	0.46	0.51	0.51	0.53	0.56	0.44
Nitrite-Nitrogen (mg/l)	0.239	0.281	0.270	0.320	0.277	0.173	0.280	0.266	0.212	0.262	0.276	0.280	0.265
Nitrate-Nitrogen (mg/l)	1.27	1.34	1.68	1.48	1.31	0.96	0.98	0.84	0.91	0.87	0.90	0.87	0.81
Phosphate-Phosphorus (mg/l)	0.01	0.03	0.08	0.16	0.06	0.06	0.10	0.02	0.02	0.04	0.04	0.04	0.05
Biochemical Oxygen Demand (mg/l)	8.30	8.42	9.48	10.38	8.58	8.42	4.76	2.74	2.78	3.84	7.04	7.12	7.32
Chemical Oxygen Demand (mg/l)	43	40	35	32	30	25	24	28	20	36	20	27	40
Phytoplankton (no. x 10^3/l)	78	124	314	46	27	62	37	29	82	324	82	74	72
Zooplankton (no./m^3)	121	792	162	321	85	148	428	530	1248	310	360	805	271
Total Plate Count (CFU x 10^3/ ml)	1.90	6.80	29.0	2.80	230	4100	1.80	850	370	8100	19.0	2.80	1.70
Iron (mg/l)	0.16	0.16	0.18	0.19	0.24	0.25	0.19	0.17	0.14	0.13	0.15	0.16	0.14
Zinc (mg/l)	0.19	0.18	0.19	0.19	0.20	0.21	0.18	0.15	0.14	0.18	0.18	0.19	0.19
Copper (mg/l)	0.12	0.14	0.15	0.13	0.16	0.07	0.08	0.08	0.08	0.05	0.09	0.11	0.09
Manganese (mg/l)	0.02	0.03	0.05	0.04	0.05	0.04	0.01	0.04	0.02	0.05	0.05	0.02	0.03
Soil pH	7.7	7.6	7.7	7.4	7.8	7.7	7.8	6.8	7.6	7.7	7.3	7.1	7.3
Soil Organic Carbon (%)	0.48	0.47	0.52	0.54	0.49	0.43	0.41	0.38	0.32	0.41	0.45	0.49	0.53

Table 5: Physico-chemical and biological variables at Station V

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	23.0	26.6	26.2	27.6	32.0	30.8	30.0	29.2	30.4	28.8	24.2	24.4	24.8
Water Temperature (°C)	22.4	23.4	24.2	26.4	30.5	29.2	28.4	27.4	28.2	28.2	22.8	23.4	22.8
Salinity (‰)	30	32	33	35	40	41	6	7	1	19	25	28	28
Water pH	8.60	8.69	8.03	8.37	8.55	8.53	8.23	7.62	8.21	8.53	8.10	8.25	8.53
Total Alkalinity (mg/l)	162	152	174	160	138	126	124	120	150	168	220	184	166
Dissolved Oxygen (mg/l)	6.22	6.68	6.51	6.92	5.25	4.78	7.43	7.62	7.35	7.34	7.46	7.41	7.57
Total Suspended Solids (mg/l)	46.0	37.8	41.4	46.0	46.8	75.6	84.6	85.8	92.8	62.4	59.8	27.4	32.4
Ammonium-Nitrogen (mg/l)	0.41	0.47	0.56	0.59	0.47	0.42	0.37	0.48	0.50	0.56	0.55	0.58	0.46
Nitrite-Nitrogen (mg/l)	0.240	0.265	0.285	0.337	0.265	0.192	0.244	0.292	0.182	0.238	0.311	0.305	0.279
Nitrate-Nitrogen (mg/l)	1.33	1.31	1.75	1.92	1.65	1.27	1.16	0.86	0.87	0.92	0.95	0.94	0.88
Phosphate-Phosphorus (mg/l)	0.03	0.05	0.09	0.13	0.04	0.07	0.08	0.03	0.09	0.03	0..05	0.04	0.04
Biochemical Oxygen Demand (mg/l)	8.76	9.74	10.36	11.22	8.58	8.64	4.82	2.82	2.64	3.12	5.06	5.68	6.80
Chemical Oxygen Demand (mg/l)	55	38	40	35	35	30	25	30	21	37	20	25	42
Phytoplankton (no. x 10^3/l)	205	85	278	34	23	26	24	51	94	247	73	105	102
Zooplankton (no./m^3)	180	1320	147	425	180	230	1250	420	2417	460	2450	945	350
Total Plate Count (CFU x 10^3/ ml)	1.80	21.0	37.0	240	2600	1900	2.30	110	170	4100	170	4.40	2.50
Iron (mg/l)	0.14	0.15	0.19	0.22	0.26	0.22	0.20	0.19	0.17	0.15	0.16	0.17	0.16
Zinc (mg/l)	0.22	0.22	0.25	0.25	0.27	0.23	0.20	0.17	0.15	0.17	0.18	0.19	0.20
Copper (mg/l)	0.16	0.18	0.19	0.19	0.20	0.09	0.09	0.09	0.08	0.06	0.14	0.15	0.15
Manganese (mg/l)	0.04	0.04	0.06	0.06	0.07	0.05	0.04	0.04	0.03	0.02	0.06	0.04	0.05
Soil pH	7.5	7.8	7.2	7.5	7.6	7.8	7.3	6.7	7.5	7.8	7.1	7.3	7.6
Soil Organic Carbon (%)	0.57	0.53	0.57	0.60	0.51	0.47	0.43	0.39	0.38	0.45	0.48	0.52	0.59

Table 6: Physico-chemical and biological variables at Station VI

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	23.0	26.8	26.8	27.6	32.2	31.0	30.4	29.2	30.6	29.2	24.2	24.6	24.6
Water Temperature (°C)	22.4	24.2	24.8	26.8	30.5	29.4	28.8	27.8	28.0	29.0	23.3	23.2	23.0
Salinity (‰)	30	30	34	35	38	40	6	6	1	15	25	28	29
Water pH	8.52	8.42	8.12	8.42	8.38	8.27	8.11	7.87	8.13	8.57	8.24	8.32	8.44
Total Alkalinity (mg/l)	166	168	180	176	160	130	130	118	120	115	192	180	174
Dissolved Oxygen (mg/l)	6.40	7.32	6.58	7.24	5.32	4.91	7.87	7.86	7.45	7.42	7.55	7.82	7.73
Total Suspended Solids (mg/l)	52.0	40.2	42.4	48.2	44.4	83.2	82.8	93.2	97.8	69.4	65.2	30.4	32.4
Ammonium-Nitrogen (mg/l)	0.40	0.39	0.28	0.32	0.39	0.40	0.38	0.46	0.51	0.56	0.54	0.54	0.47
Nitrite-Nitrogen (mg/l)	0.224	0.276	0.272	0.325	0.216	0.198	0.238	0.251	0.185	0.230	0.256	0.298	0.220
Nitrate-Nitrogen (mg/l)	1.25	1.24	1.64	1.65	1.40	1.13	1.10	0.75	0.95	0.92	0.92	0.90	0.82
Phosphate-Phosphorus (mg/l)	0.04	0.04	0.08	0.11	0.03	0.03	0.07	0.03	0.08	0.04	0.05	0.03	0.06
Biochemical Oxygen Demand (mg/l)	7.74	8.28	8.76	9.24	8.38	8.38	4.96	2.70	2.58	4.00	7.04	6.86	6.62
Chemical Oxygen Demand (mg/l)	40	45	38	30	30	25	19	25	30	34	20	35	40
Phytoplankton (no. x 10^3/l)	141	78	224	31	13	32	13	07	33	287	42	34	97
Zooplankton (no./m^3)	67	573	157	135	410	158	702	360	918	430	228	795	412
Total Plate Count (CFU x 10^3/ ml)	2.30	38.0	72.0	41.0	290	2300	4.90	370	840	4600	380	4.70	1.80
Iron (mg/l)	0.13	0.12	0.13	0.14	0.17	0.19	0.16	0.11	0.15	0.14	0.14	0.12	0.14
Zinc (mg/l)	0.21	0.22	0.21	0.20	0.19	0.17	0.16	0.15	0.12	0.17	0.16	0.18	0.20
Copper (mg/l)	0.12	0.12	0.13	0.13	0.13	0.07	0.05	0.05	0.03	0.04	0.10	0.11	0.07
Manganese (mg/l)	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.02	0.01	0.01	0.02	0.03	0.03
Soil pH	7.6	7.5	7.3	7.6	7.4	7.4	7.3	6.9	7.3	7.7	7.4	7.5	7.5
Soil Organic Carbon (%)	0.48	0.50	0.52	0.52	0.45	0.44	0.41	0.34	0.32	0.33	0.36	0.40	0.48

Table 7: Physico-chemical variables and biological at Station VII

Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
Ambient Temperature (°C)	23.2	26.9	26.8	27.7	32.4	31.2	30.6	29.3	30.6	29.4	24.4	24.8	24.7
Water Temperature (°C)	22.2	24.8	25.4	26.8	30.4	29.2	29.2	27.8	28.2	28.6	23.4	23.0	23.2
Salinity (‰)	30	32	34	35	40	42	4	6	2	16	25	28	29
Water pH	8.63	8.51	8.20	8.53	8.56	8.59	8.20	7.89	8.07	8.38	8.15	8.25	8.51
Total Alkalinity (mg/l)	160	172	196	180	142	128	112	110	116	138	178	192	182
Dissolved Oxygen (mg/l)	7.30	7.29	6.81	7.20	5.29	5.14	7.85	7.74	7.62	7.58	7.85	7.90	6.95
Total Suspended Solids (mg/l)	54.0	42.4	42.6	49.8	46.2	85.4	85.6	95.6	100.4	72.4	68.4	31.2	36.8
Ammonium-Nitrogen (mg/l)	0.38	0.40	0.30	0.30	0.40	0.42	0.39	0.48	0.52	0.58	0.55	0.54	0.48
Nitrite-Nitrogen (mg/l)	0.228	0.280	0.229	0.320	0.221	0.290	0.238	0.249	0.188	0.225	0.275	0.266	0.213
Nitrate-Nitrogen (mg/l)	1.28	1.29	1.52	1.63	1.49	1.17	1.14	0.77	0.98	0.93	0.88	0.82	0.80
Phosphate-Phosphorus (mg/l)	0.05	0.05	0.07	0.09	0.04	0.04	0.03	0.04	0.06	0.05	0.04	0.03	0.06
Biochemical Oxygen Demand (mg/l)	7.80	8.38	8.94	9.28	8.36	8.40	4.74	2.72	2.60	4.20	6.16	6.12	6.28
Chemical Oxygen Demand (mg/l)	42	44	43	32	35	30	20	31	32	40	28	43	42
Phytoplankton (no. x 10^3/l)	123	84	371	17	19	41	21	09	71	305	23	105	123
Zooplankton (no./m^3)	75	620	180	315	617	210	925	382	670	220	120	1050	746
Total Plate Count (CFU x 10^3/ ml)	1.90	3.40	66.0	2.80	390	2100	4.20	630	260	6700	240	5.80	2.90
Iron (mg/l)	0.14	0.13	0.15	0.17	0.18	0.21	0.18	0.15	0.17	0.16	0.15	0.16	0.14
Zinc (mg/l)	0.20	0.22	0.21	0.27	0.22	0.20	0.18	0.15	0.13	0.16	0.17	0.18	0.20
Copper (mg/l)	0.12	0.13	0.15	0.15	0.16	0.08	0.07	0.06	0.03	0.04	0.12	0.10	0.06
Manganese (mg/l)	0.02	0.03	0.04	0.04	0.05	0.04	0.04	0.03	0.01	0.02	0.03	0.03	0.03
Soil pH	7.7	7.4	7.1	7.6	7.6	7.7	7.3	6.9	7.2	7.5	7.4	7.5	7.7
Soil Organic Carbon (%)	0.52	0.54	0.55	0.56	0.47	0.45	0.42	0.37	0.34	0.35	0.37	0.42	0.46

Table. 8. Salinity and Hardness of a village well water

Month	Salinity (‰)	Hardness (mg/l) as $CaCO_3$
January 1998	2	220
February	2	100
March	3	196
April	2	190
May	2	130
June	1	190
July	1	160
August	1	166
September	2	178
October	3	192
November	3	200
December	3	190
January 1999	3	210

Table 9: Villagers' opinion regarding shrimp farming in Saphale

		Datiwada n = 16 (%)		Khardi Para n = 15 (%)		Vedi n = 12 (%)		All n = 43 (%)	
1	Health problem due to shrimp farming								
	Yes	0	(0)	0	(0)	0	(0)	0	(0)
	No	10	(62)	13	(87)	12	(100)	35	(81)
	Can't say	6	(38)	2	(13)	0	(0)	8	(19)
2	Fish catches have dwindled due to shrimp farming								
	Yes	0	(0)	0	(0)	0	(0)	0	(0)
	No	1	(6)	0	(0)	0	(0)	1	(2)
	Can't say	15	(94)	15	(100)	12	(100)	42	(98)
3	Rise in land cost due to shrimp farming								
	Yes	8	(50)	13	(87)	9	(75)	30	(70)
	No	0	(0)	0	(0)	0	(0)	0	(0)
	Can't say	8	(50)	2	(13)	3	(25)	13	(30)
4	Shrimp farming leads to destruction of mangrove and wild life								
	Yes	0	(0)	0	(0)	0	(0)	0	(0)
	No	12	(75)	11	(73)	9	(75)	32	(74)
	Can't say	4	(25)	4	(27)	3	(25)	11	(26)
5	Shrimp farms have caused salinisation of ground water								
	Yes	0	(0)	8	(53)	0	(0)	8	(19)
	No	9	(56)	0	(0)	6	(50)	15	(35)
	Can't say	7	(44)	7	(47)	6	(50)	20	(46)
6	Any Agriculture land conversion into shrimp farms has occurred								
	Yes	0	(0)	8	(53)	3	(25)	11	(26)
	No	12	(75)	3	(20)	7	(58)	22	(51)
	Can't say	4	(25)	4	(27)	2	(17)	10	(23)
7	Shrimp farms have altered water flow and sedimentation patterns in the creek								
	Yes	8	(50)	4	(27)	4	(33)	16	(37)
	No	0	(0)	1	(7)	4	(33)	5	(12)
	Can't say	8	(50)	10	(66)	4	(34)	22	(51)

Contd…2

Table 9 (Contd. 2)

		Datiwada n = 16 (%)		Khardi Para n = 15 (%)		Vedi n = 12 (%)		All n = 43 (%)	
8	Shrimp farming provides local employment								
	Yes	9	(56)	7	(47)	10	(84)	26	(61)
	No	3	(19)	6	(40)	1	(8)	10	(23)
	Can't say	4	(25)	2	(3)	1	(8)	7	(16)
9	Economic motivation (one can do shrimp farming to enhance income)								
	Yes	9	(56)	6	(40)	8	(67)	22	(51)
	No	0	(0)	2	(13)	0	(0)	2	(5)
	Can't say	7	(44)	7	(47)	4	(33)	19	(44)
10	Shrimp farming is good for the community								
	Yes	9	(56)	0	(0)	1	(8)	10	(23)
	No	0	(0)	10	(67)	0	(0)	10	(23)
	Can't say	7	(44)	5	(33)	11	(92)	23	(54)

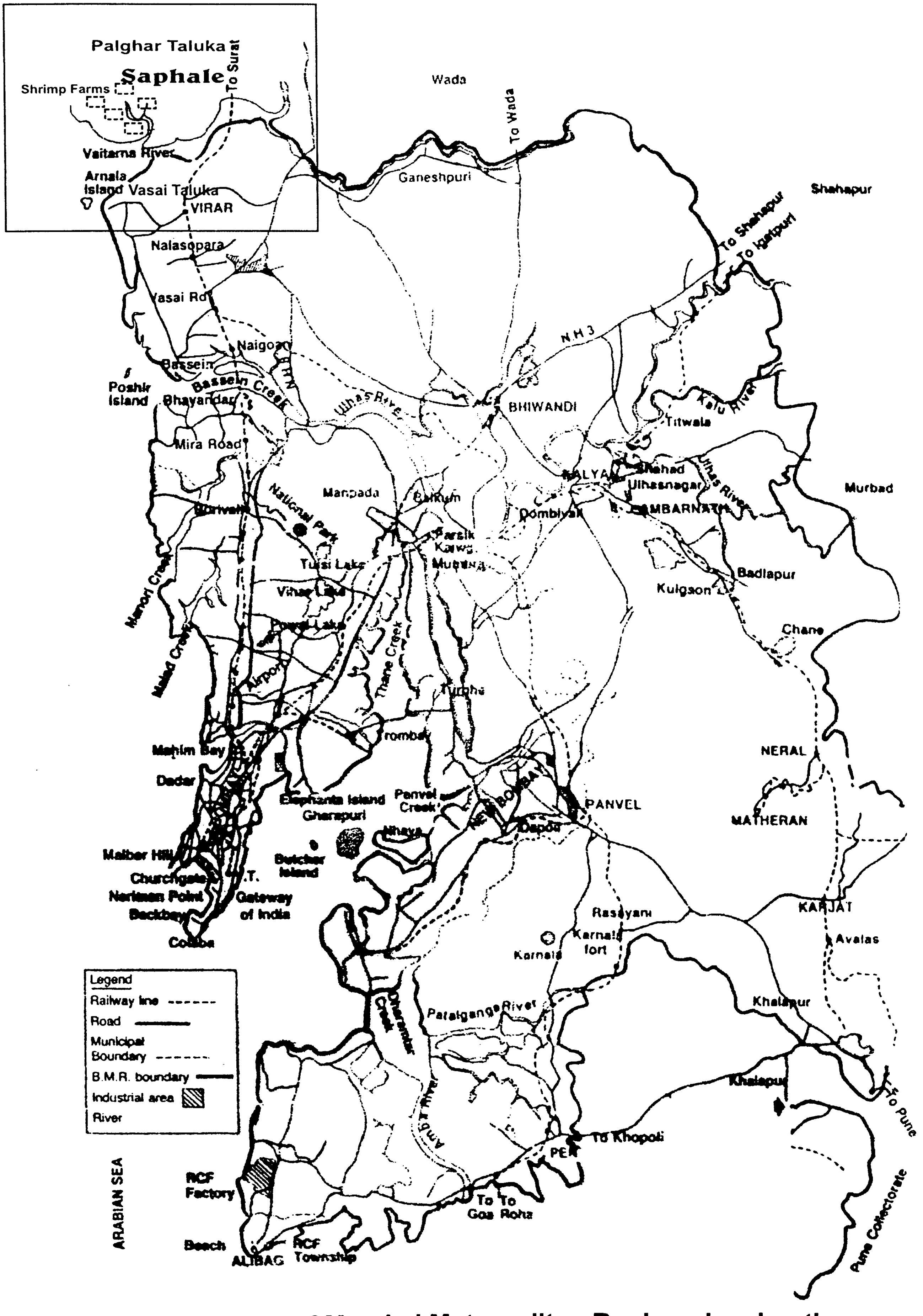

Fig. 1: Map of Mumbai Metropolitan Region showing the location of the shrimp farms in Saphale (Dist. Thane)

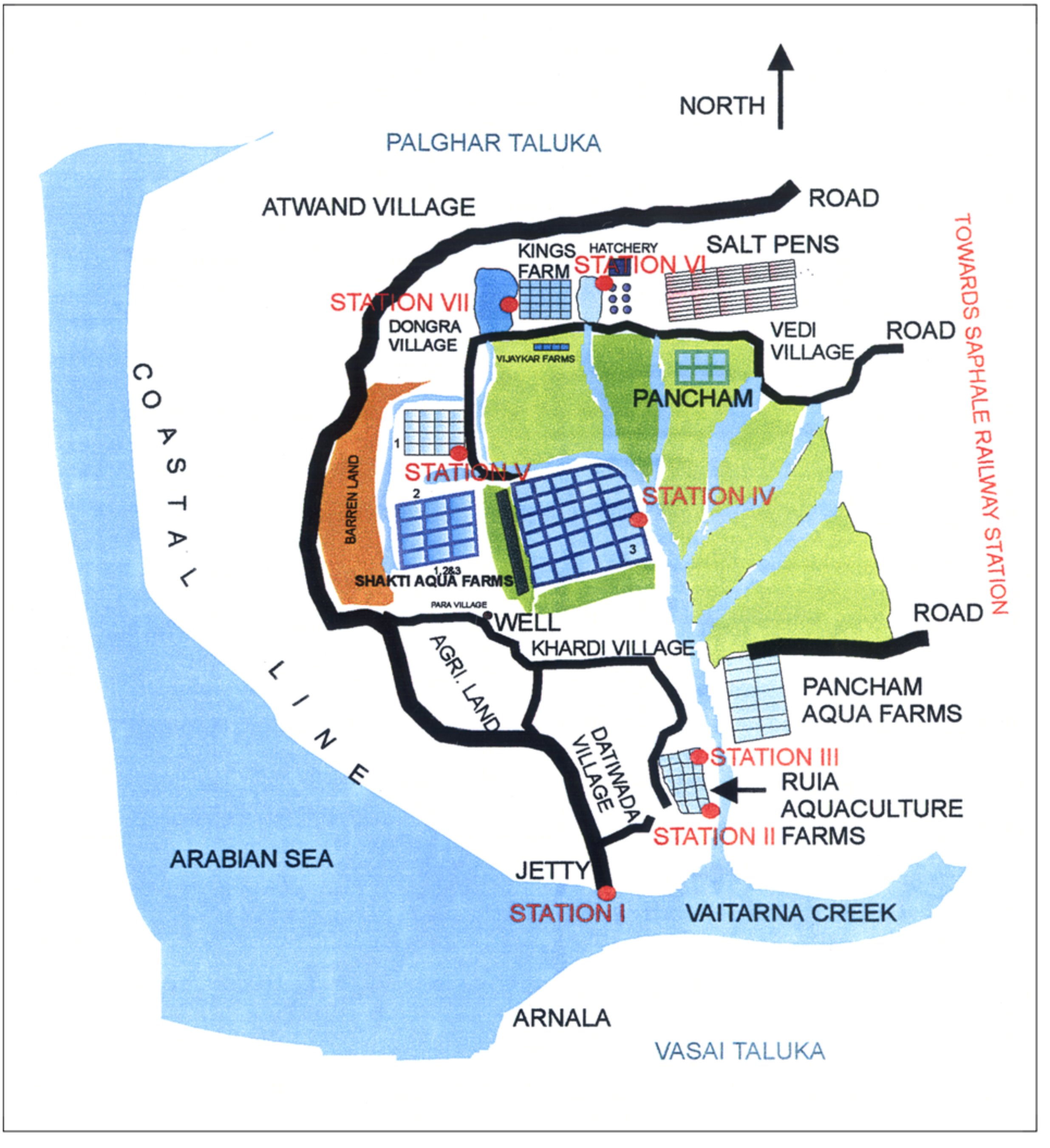

Fig.2. MAP OF THE STUDY AREA

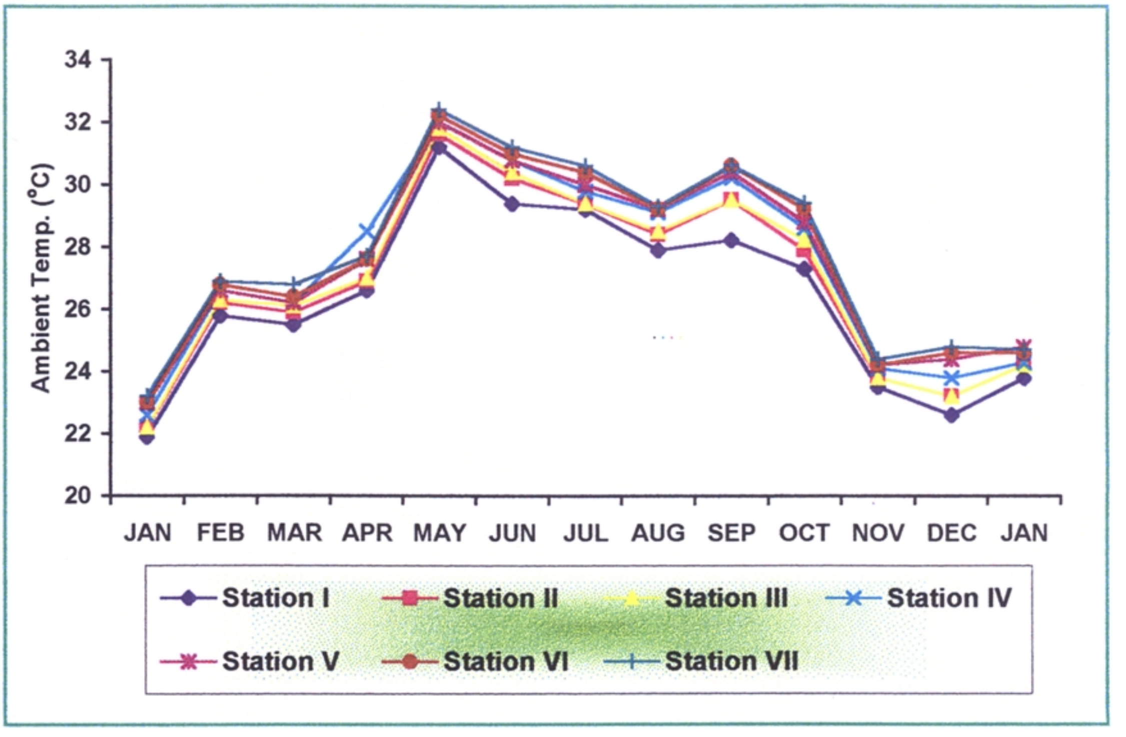

Fig. 3: **Ambient temperature at the sampling stations**

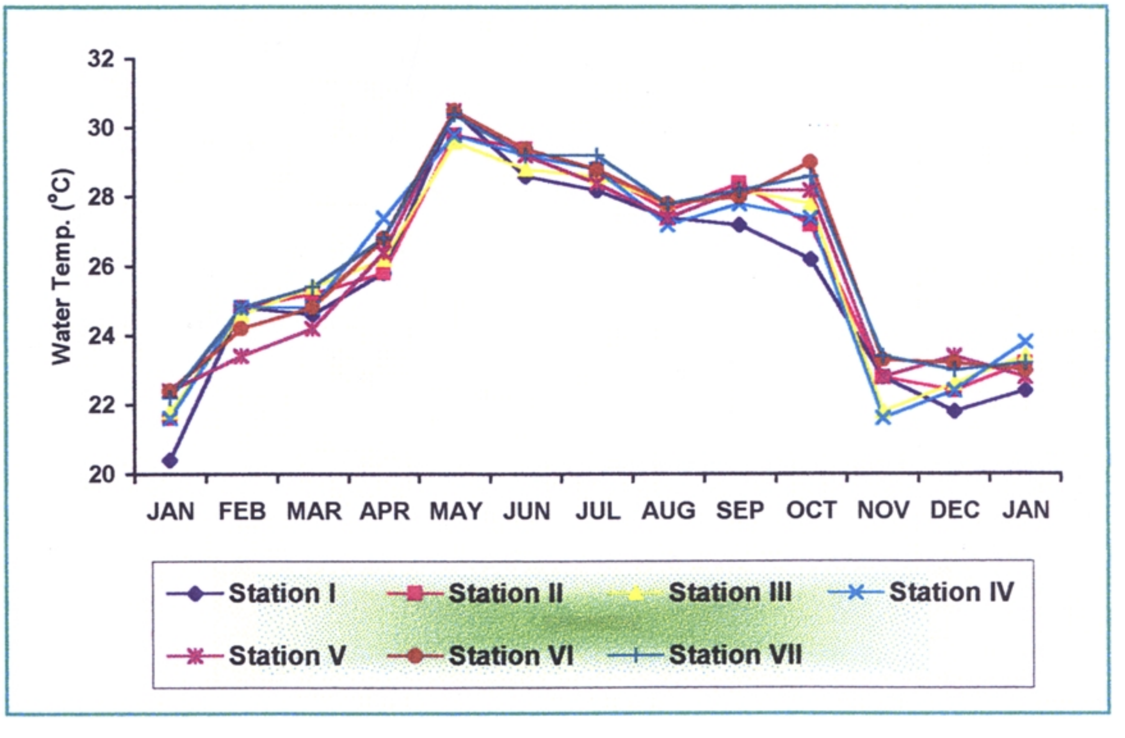

Fig. 4: **Water temperature at the sampling stations**

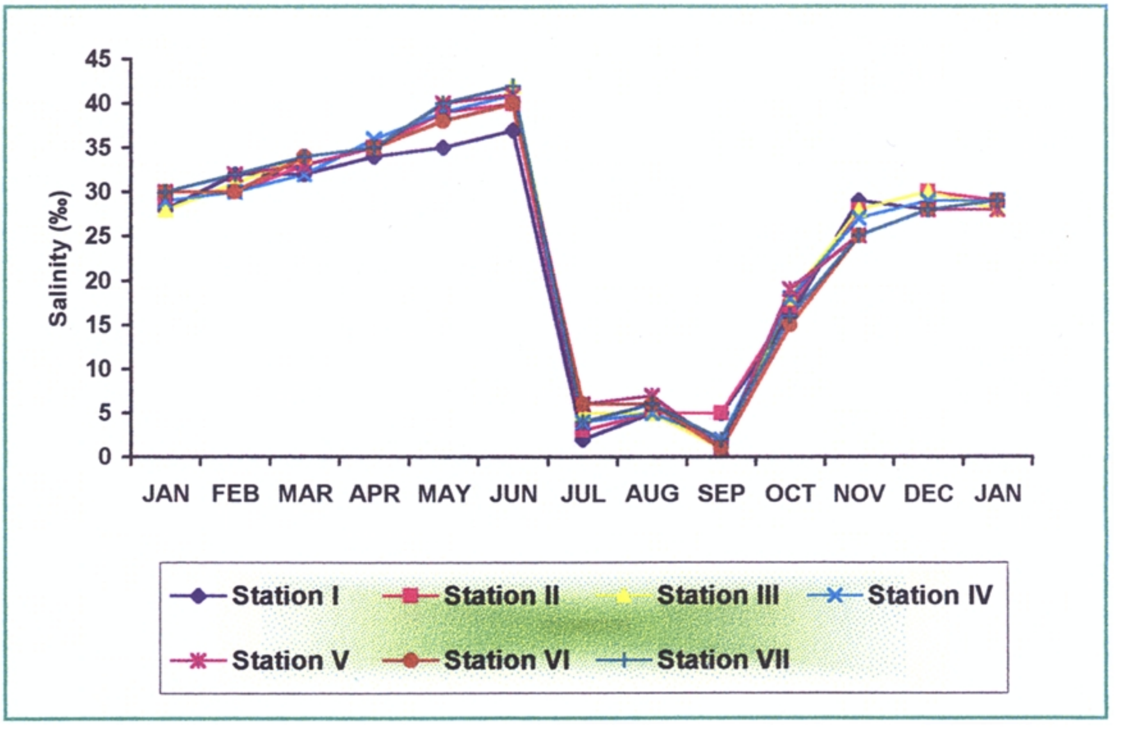

Fig. 5: **Salinity at the sampling stations**

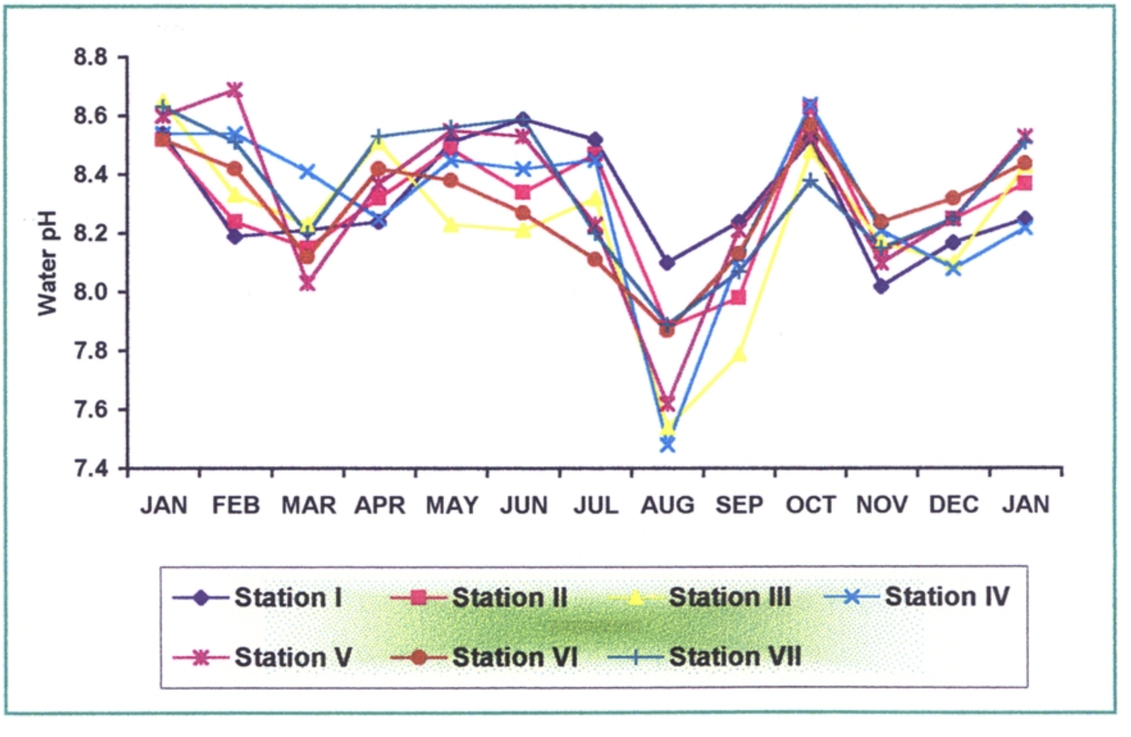

Fig. 6: **Water pH at the sampling stations**

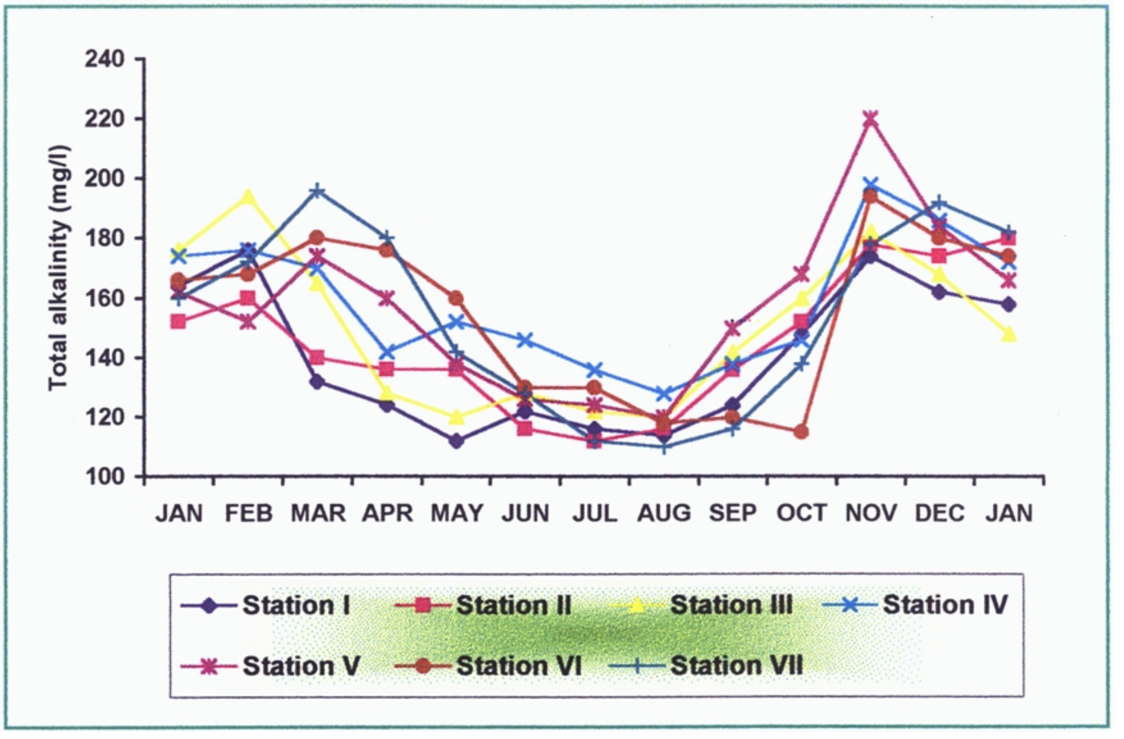

Fig. 7: Total alkalinity at the sampling stations

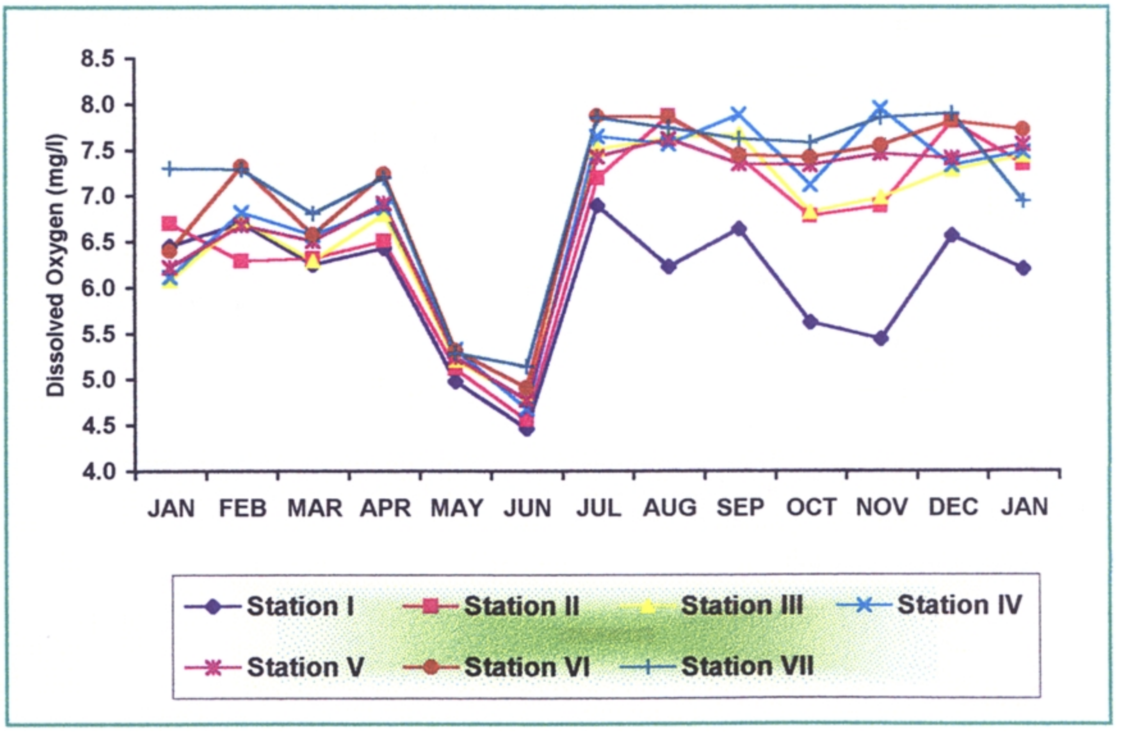

Fig. 8: Dissolved Oxygen at the sampling stations

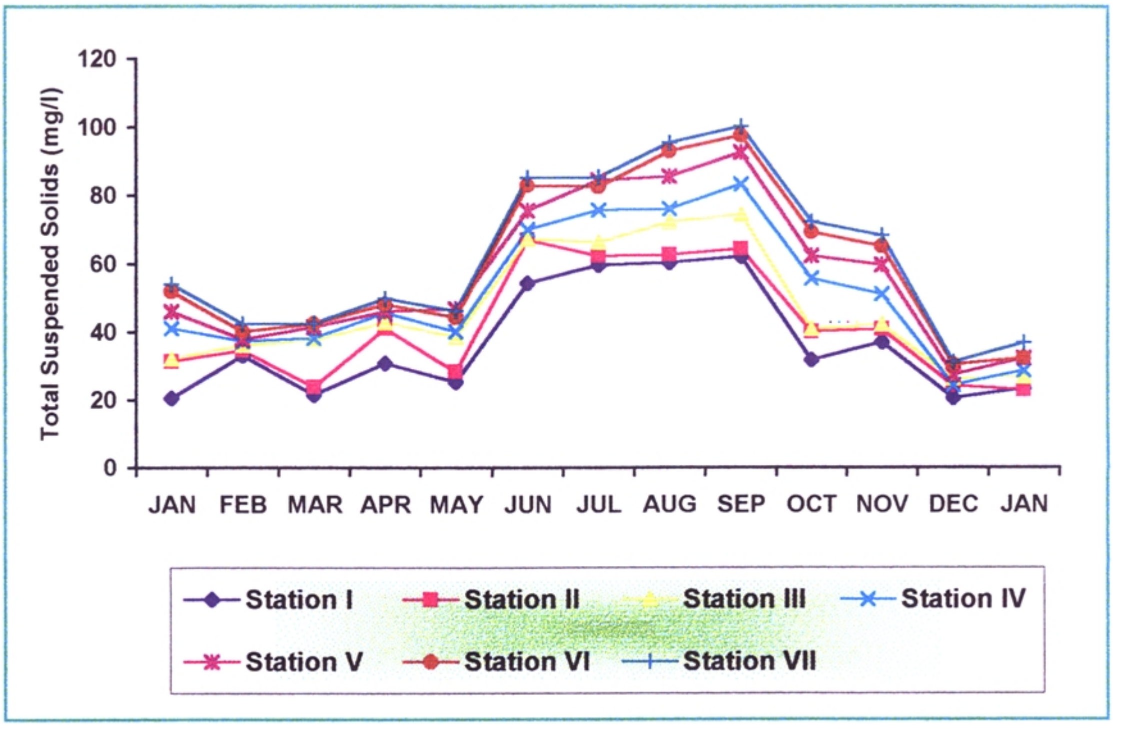

Fig. 9: Total Suspended Solids at the sampling stations

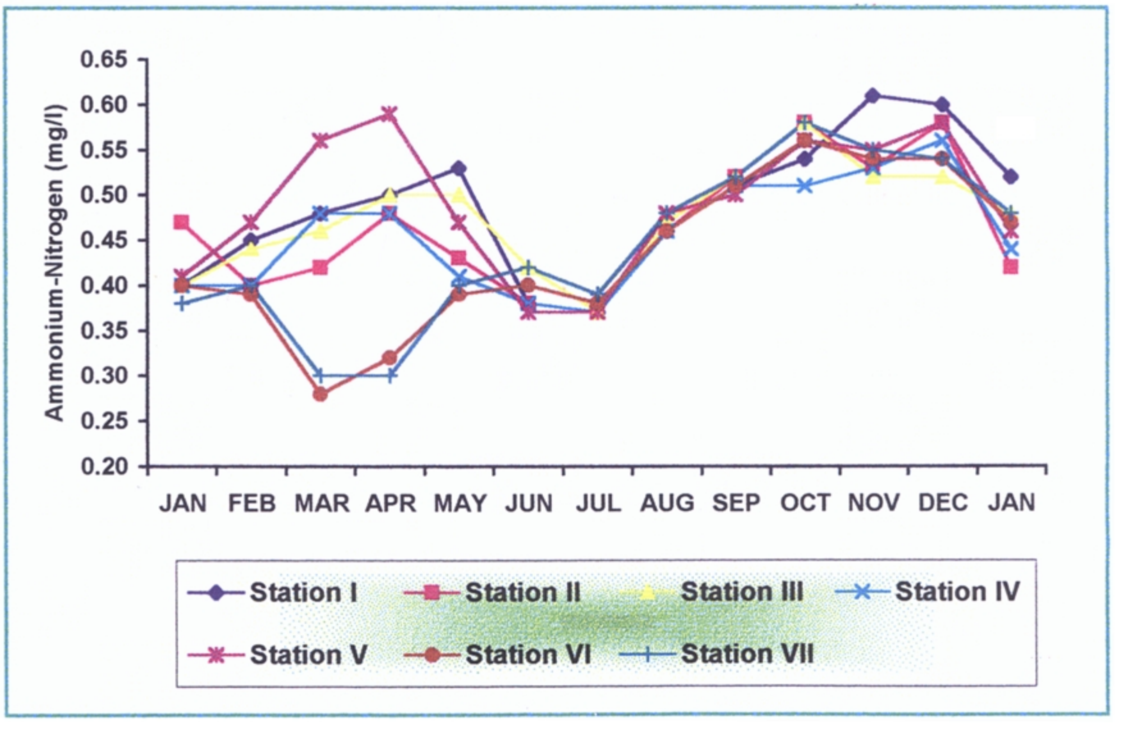

Fig. 10: Ammonium-Nitrogen at the sampling stations

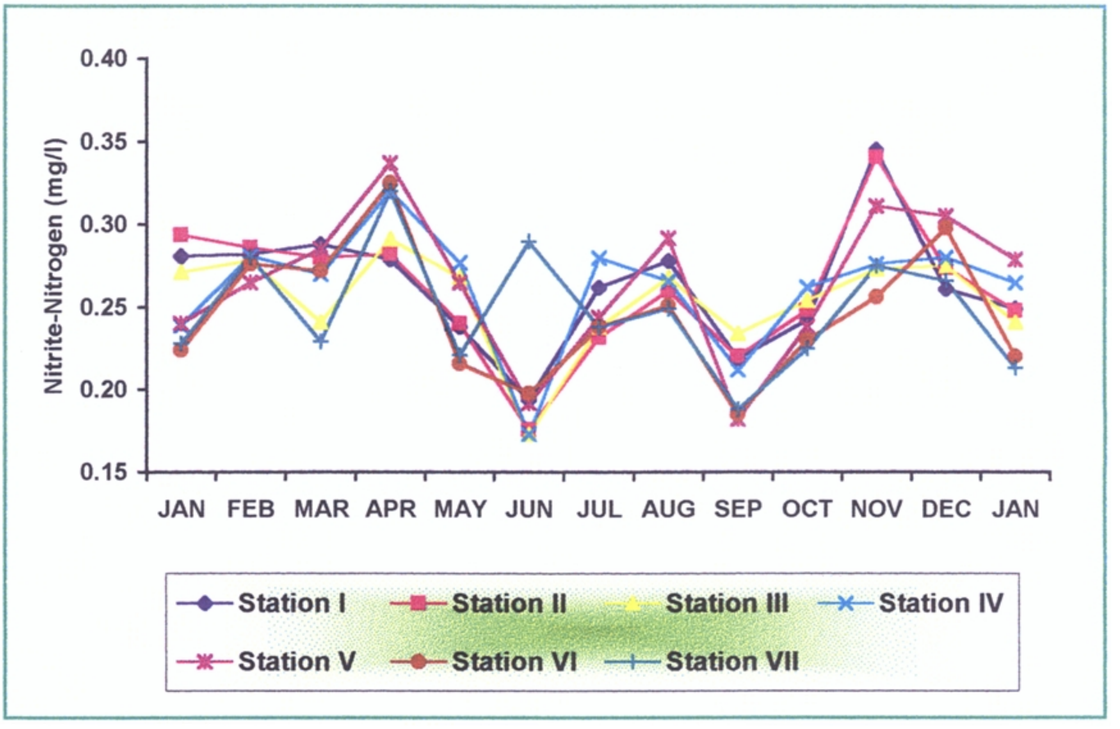

Fig. 11: Nitrite-Nitrogen at the sampling stations

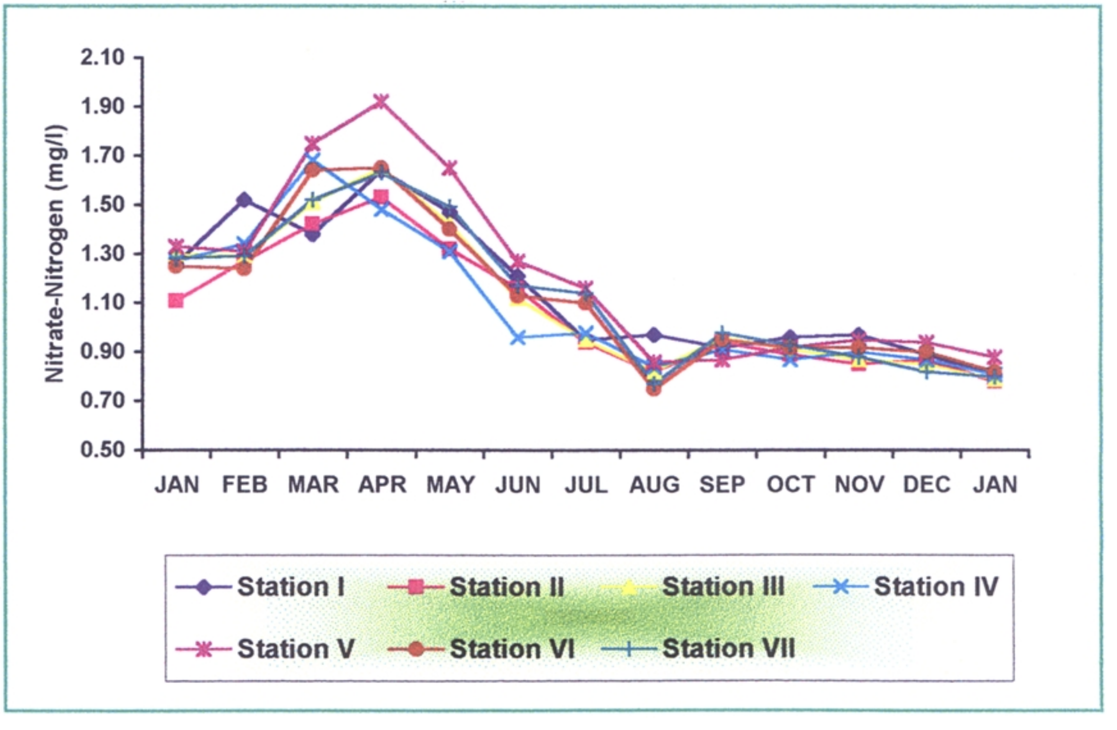

Fig. 12: Nitrate-Nitrogen at the sampling stations

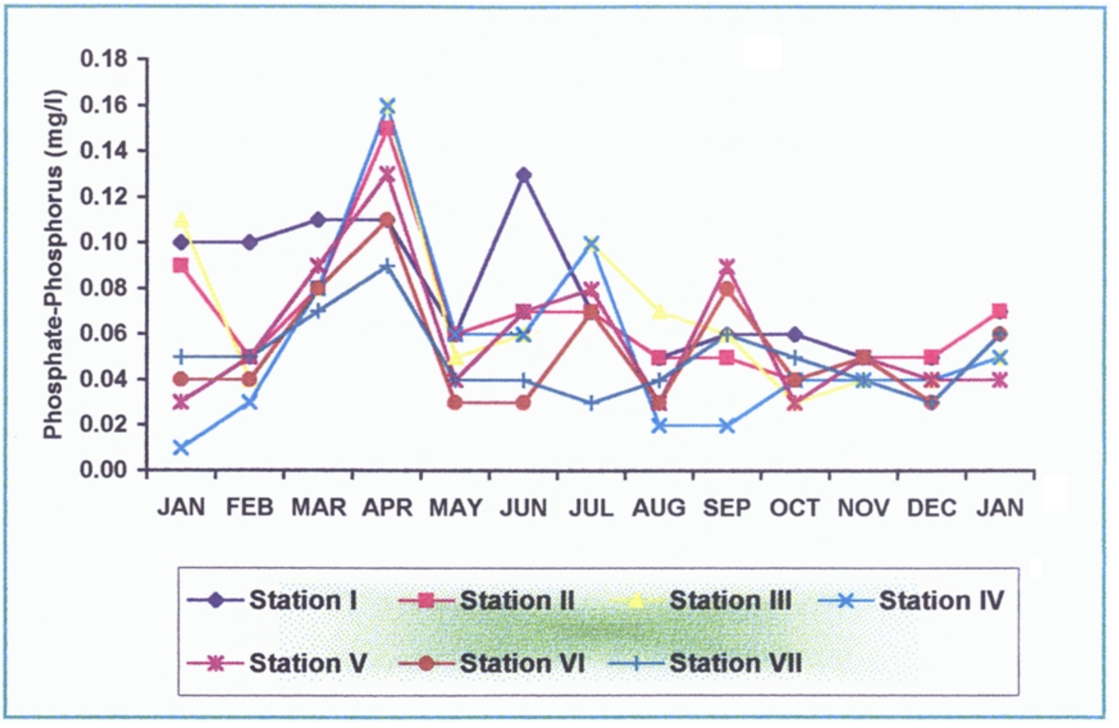

Fig. 13: Phosphate-Phosphorus at the sampling stations

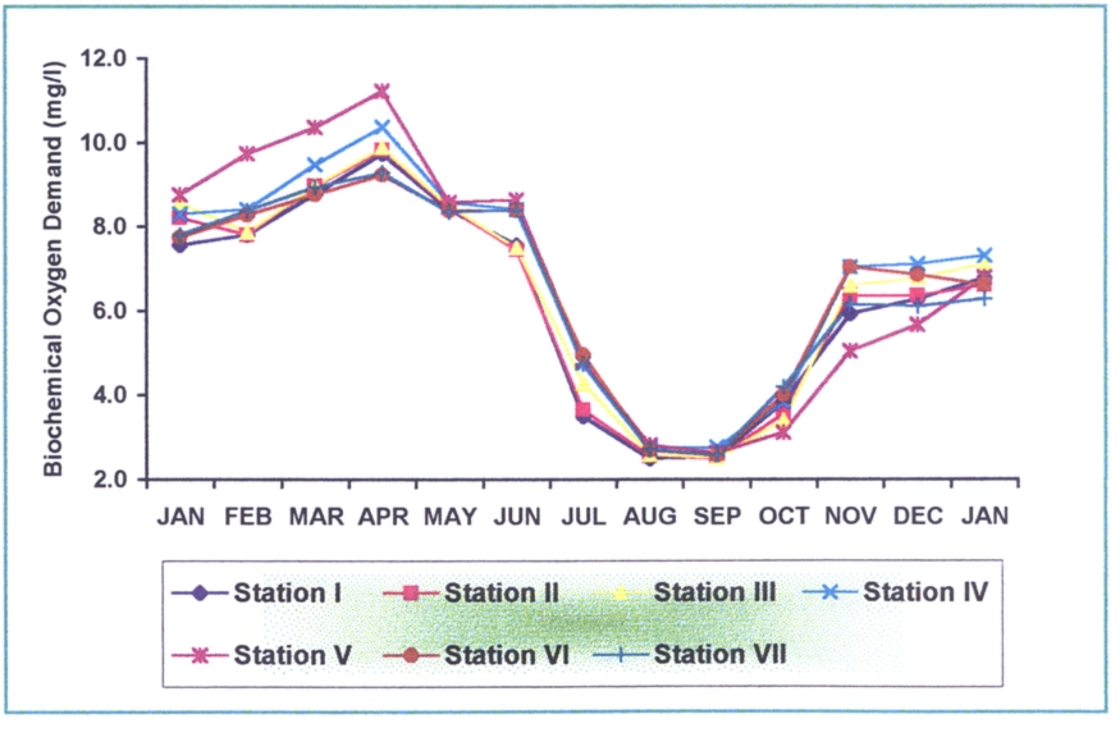

Fig. 14: Biochemical Oxygen Demand at the sampling stations

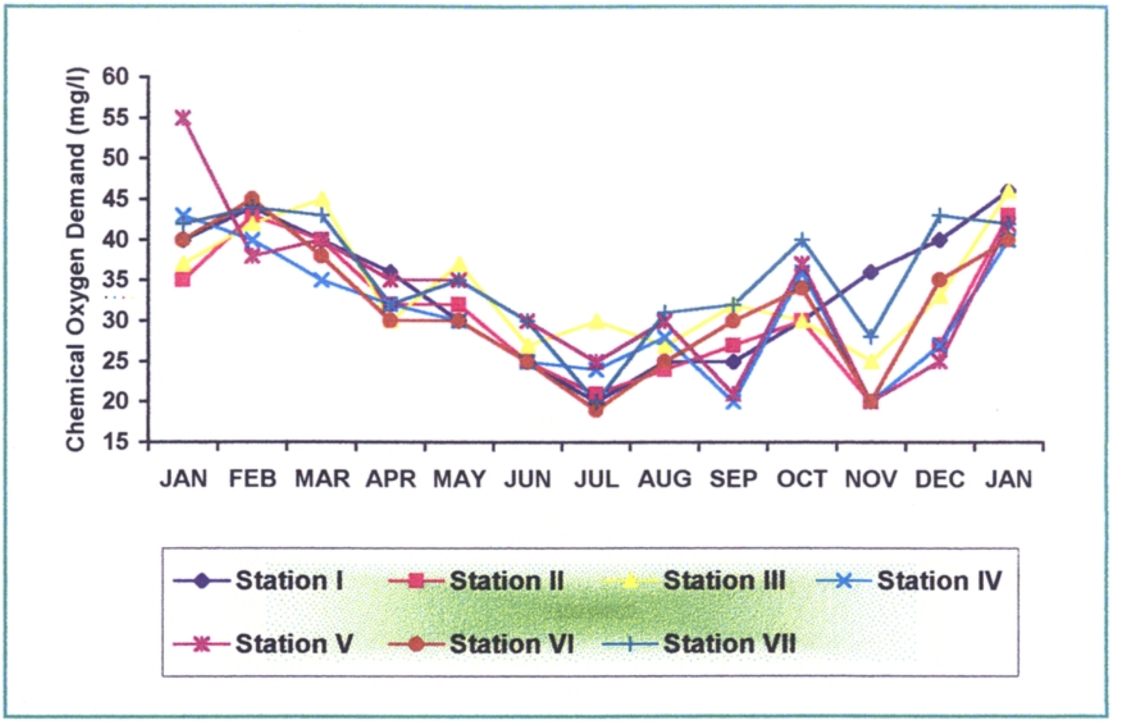

Fig. 15: Chemical Oxygen Demand at the sampling stations

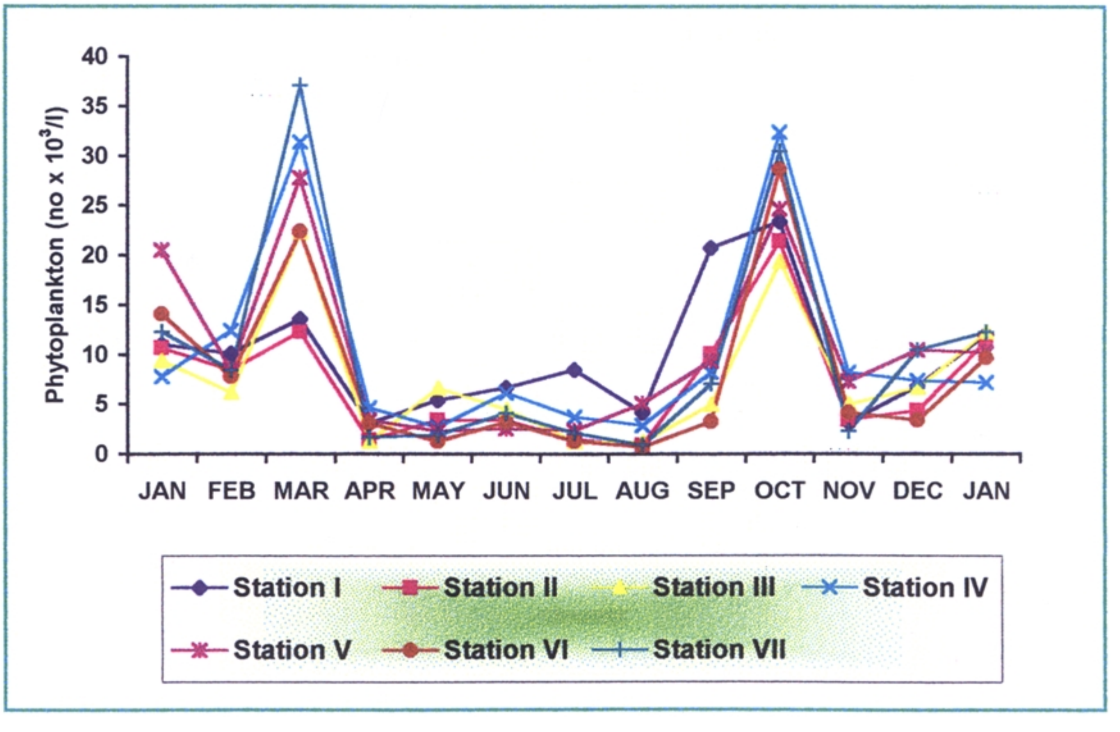

Fig. 16: Phytoplankton population at the sampling stations

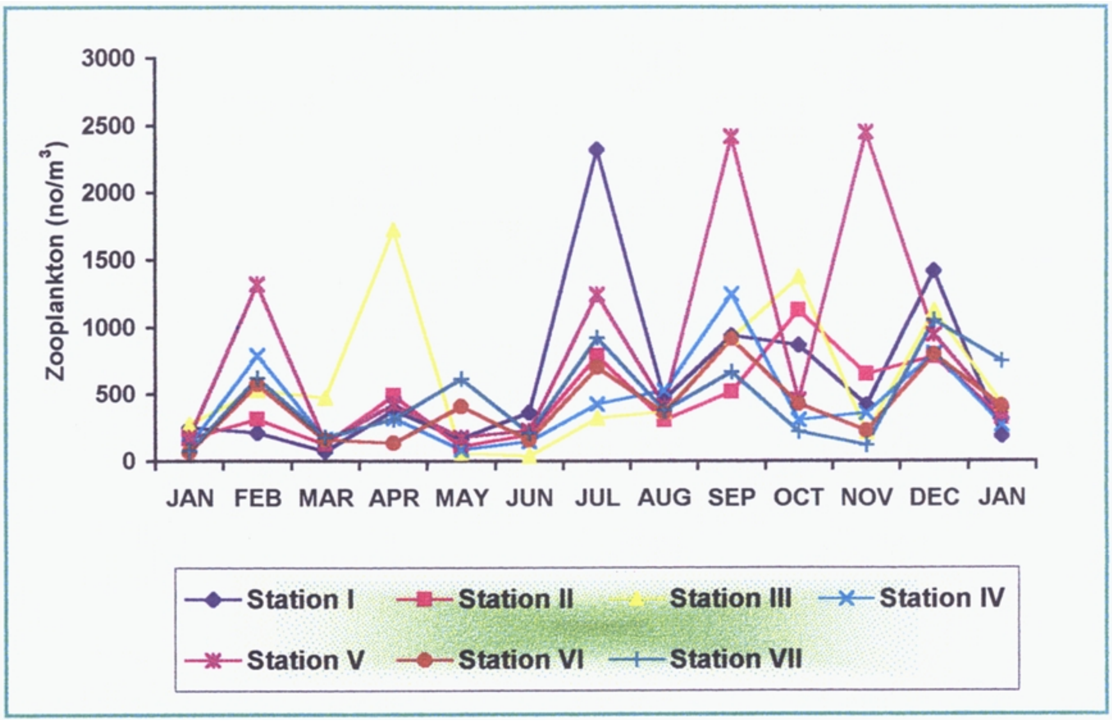

Fig. 17: Zooplankton population at the sampling stations

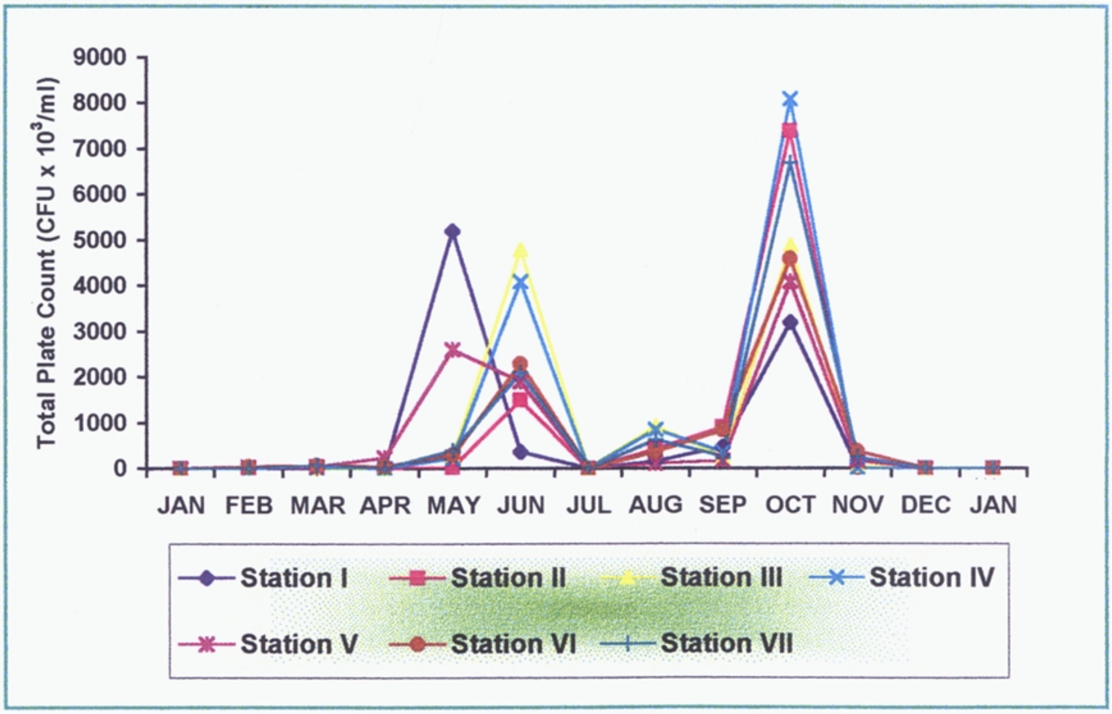

Fig. 18: Total Plate Count at the sampling stations

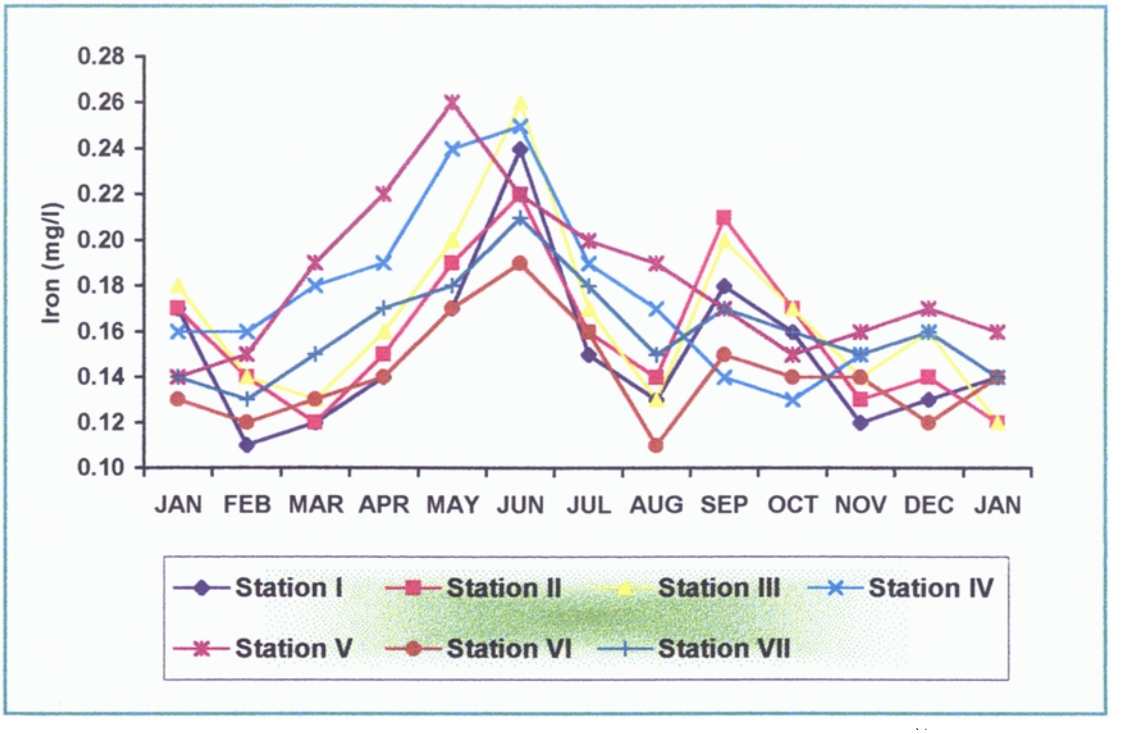

Fig. 19: Iron concentration at the sampling stations

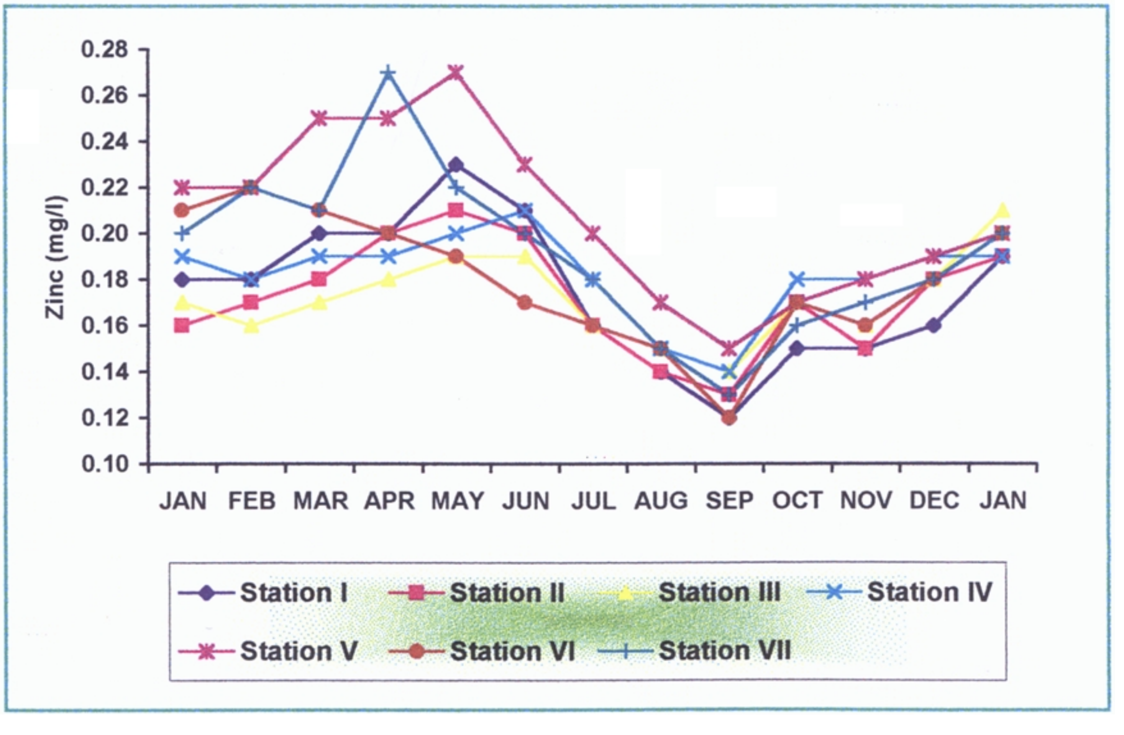

Fig. 20: Zinc concentration at the sampling stations

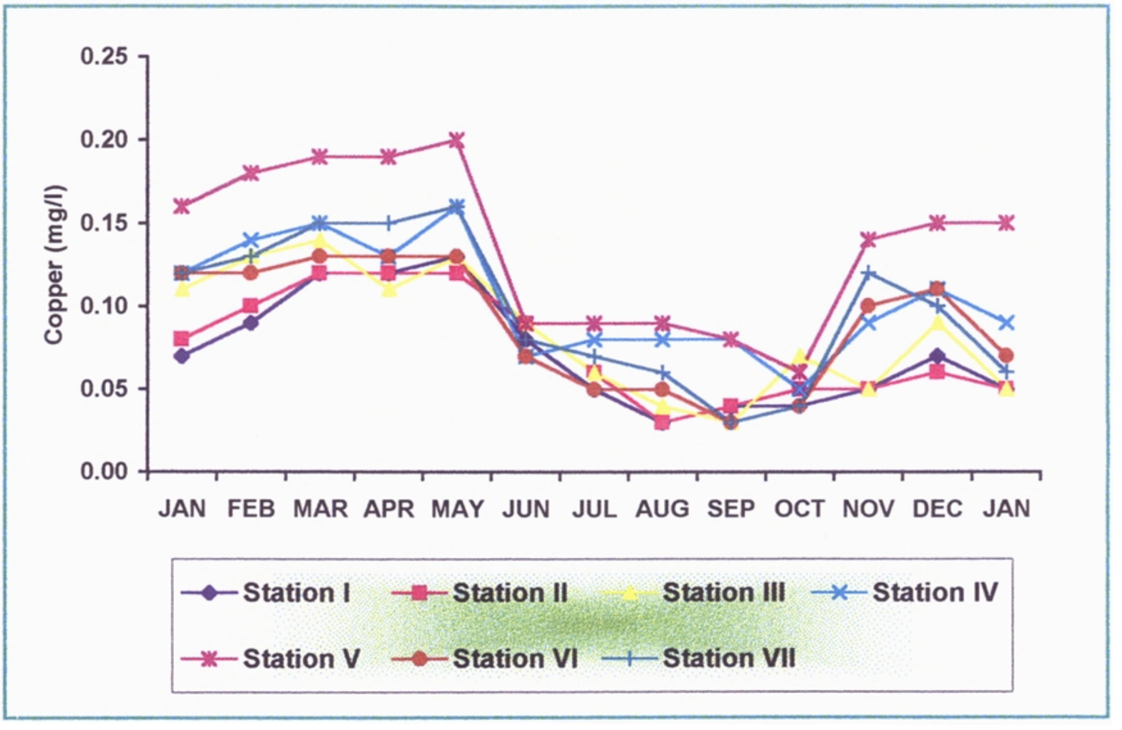

Fig. 21: Copper concentration at the sampling stations

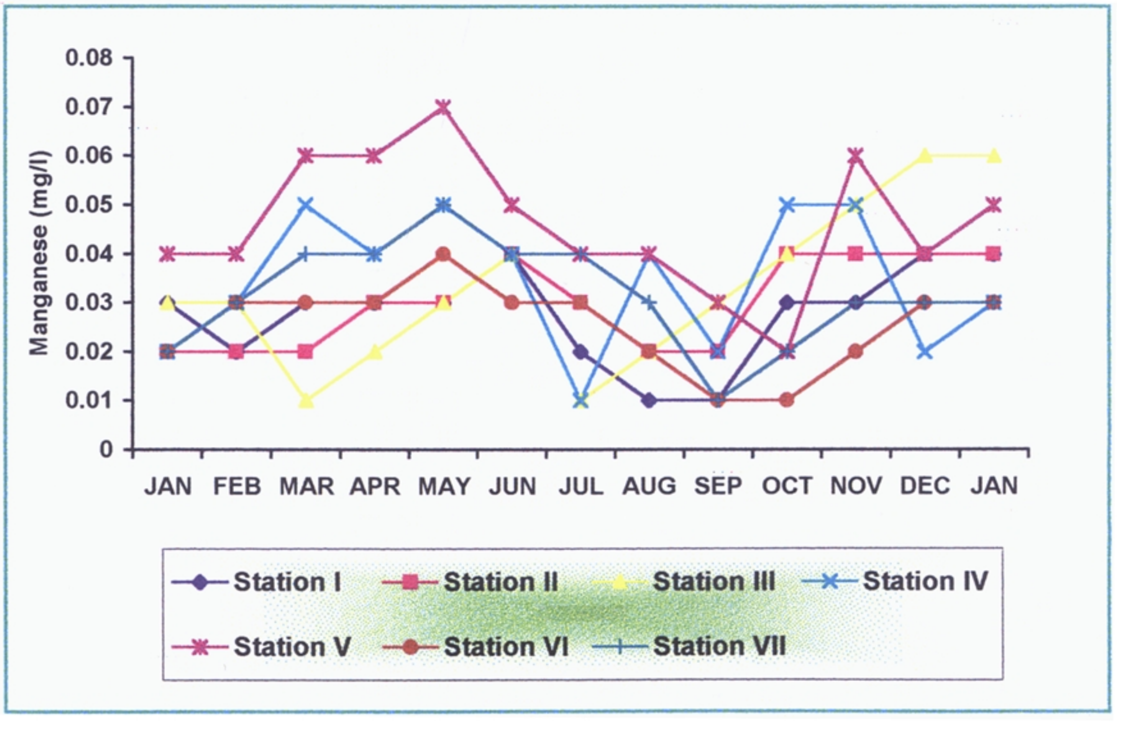

Fig. 22: Manganese concentration at the sampling stations

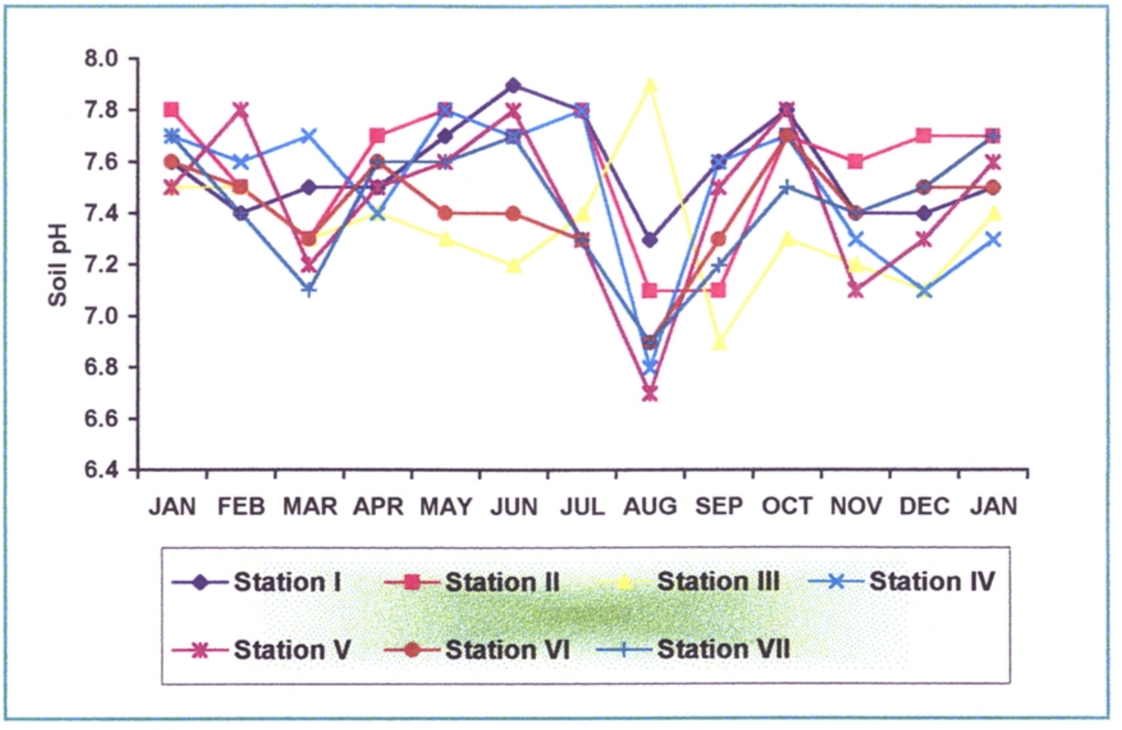

Fig. 23: Soil pH at the sampling stations

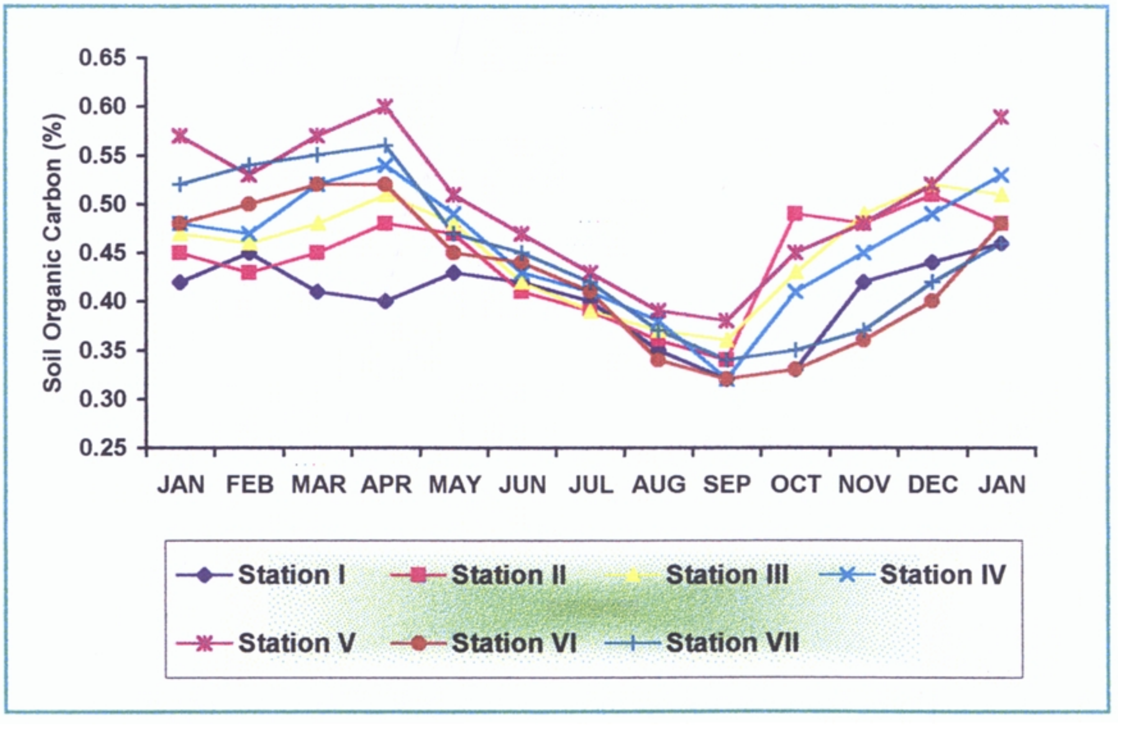

Fig. 24: Soil Organic Carbon at the sampling stations

PLATE I

PLATE IA: A VIEW OF THE STUDY AREA

PLATE IB: SHOWING THE SAMPLING STATION I(D)

PLATE II

PLATE IIA: SHOWING THE SAMPLING STATION II(R1)

PLATE IIB: SHOWING THE SAMPLING STATION III(R2)

PLATE III

PLATE IIIA: SHOWING THE SAMPLING STATION IV(S1)

PLATE IIIB: SHOWING THE SAMPLING STATION V(S2)

PLATE IV

PLATE IVA: SHOWING THE SAMPLING STATION VI(K1)

PLATE IVB: SHOWING THE SAMPLING STATION VII(K2)

PLATE V

PLATE VA: SHOWING A COMMUNITY WELL AT KHARDI-PARA

PLATE VB: FISH DRYING AT DATIWADA FISHING VILLAGE

PLATE VI

PLATE VIA: SALT PANS AT VEDI GAON

PLATE VIB: AN INTERVIEW WITH A RESPONDENT AT VEDI

ANNEXURE I

SOCIO-ECONOMIC IMPACT

LIST OF VARIABLES

Variable No.	Variable Name	Code
V1	Gender	1 = Male 2 = Female
V2	Age (yr)	As recorded
V3	Village	1 = Datiwada 2 = Khardi-Para 3 = Vedi
V4	Qualification	1 = Illiterate 2 = Up to primary school 3 = Up to high school 4 = Up to junior college 5 = Up to degree college
V5	Occupation	1 = Fishing 2 = Farming 3 = Others
V6	Any health problem due to shrimp farming	1 = Yes 2 = No 3 = Can't say
V7	Fish catches have dwindled due to shrimp farming	1 = Yes 2 = No 3 = Can't say
V8	Rise in land cost due to shrimp farming	1 = Yes 2 = No 3 = Can't say
V9	Shrimp farming leads to destruction of mangrove and wildlife	1 = Yes 2 = No 3 = Can't say
V10	Shrimp farms have caused salinisation of ground water	1 = Yes 2 = No 3 = Can't say
V11	Any agriculture land conversion in shrimp farms	1 = Yes 2 = No 3 = Can't say

Variable No.	Variable Name	Code
V12	Shrimp farm have altered water flow and sedimentation pattern on the creek	1 = Yes 2 = No 3 = Can't say
V13	Shrimp farming provides employment local community	1 = Yes 2 = No 3 = Can't say
V14	Economic motivation (one can do shrimp farming to increase income)	1 = Agree 2 = Disagree 3 = Can't say
V15	Shrimp farming is good for the community	1 = Agree 2 = Disagree 3 = Can't say

ANNEXURE II

OPINION OF VILLAGERS REGARDING SHRIMP FARMING IN SAPHALE

DATA

Sr. No.	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
1	1	30	1	2	3	2	3	3	2	3	2	3	1	3	3
2	1	28	1	2	1	3	3	3	3	3	3	3	3	3	3
3	1	40	1	2	1	2	3	1	2	3	2	1	1	1	1
4	1	25	1	5	1	2	3	1	2	2	2	1	1	1	1
5	1	28	1	2	1	2	3	1	2	2	2	1	1	1	1
6	1	30	1	2	3	3	3	3	3	3	3	3	3	3	3
7	1	27	1	2	3	3	3	3	3	3	3	3	3	3	3
8	1	32	1	3	3	2	2	1	2	2	2	1	1	1	1
9	2	35	1	1	3	3	3	3	3	3	3	3	3	3	3
10	1	41	1	3	1	2	3	3	2	2	2	1	1	1	1
11	2	34	1	1	1	2	3	1	2	2	2	1	2	1	1
12	1	27	1	4	1	2	3	1	2	2	2	1	2	1	1
13	1	42	1	1	1	2	3	1	2	2	2	3	2	1	1
14	2	51	1	1	3	3	3	3	2	2	2	3	1	3	3
15	2	42	1	1	3	3	3	3	2	2	2	3	1	3	3
16	1	37	1	2	1	2	3	1	2	3	2	1	1	1	1
17	2	42	2	1	3	2	3	1	2	3	2	3	1	1	3
18	1	35	2	1	2	2	3	1	2	1	1	3	3	3	2
19	1	32	2	2	1	2	3	1	2	1	1	3	2	2	2
20	1	45	2	1	2	3	3	1	2	1	1	3	2	2	2

Sr. No.	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
21	1	22	2	2	2	3	3	1	2	1	1	3	1	3	2
22	2	37	2	2	2	2	3	1	3	3	3	3	1	3	3
23	1	24	2	3	3	2	3	3	2	3	1	1	2	3	3
24	1	47	2	1	2	2	3	1	2	1	1	1	1	1	2
25	1	31	2	4	2	2	3	1	2	3	3	3	2	1	3
26	2	41	2	1	2	3	3	1	3	3	2	2	1	3	2
27	1	37	2	2	2	2	3	1	3	1	3	3	2	1	2
28	2	44	2	1	2	3	3	1	3	3	3	3	1	3	2
29	1	35	2	1	2	2	3	1	2	1	2	1	2	3	2
30	1	33	2	2	2	2	3	1	2	1	1	1	3	1	2
31	2	39	2	1	2	2	3	3	2	3	1	3	1	1	3
32	1	20	3	5	3	2	3	1	2	3	3	3	1	3	3
33	1	35	3	3	2	2	3	1	2	2	2	3	1	1	1
34	1	66	3	5	3	2	3	1	2	2	2	1	1	1	3
35	2	40	3	1	2	2	3	3	2	3	2	2	1	3	3
36	2	37	3	1	3	2	3	1	3	2	1	3	1	3	3
37	1	24	3	4	3	2	3	3	2	2	3	2	1	1	3
38	1	51	3	3	2	2	3	1	2	3	2	1	1	1	3
39	2	38	3	1	2	2	3	3	2	2	1	2	1	3	3
40	1	35	3	3	3	2	3	1	2	2	2	1	1	1	3
41	1	29	3	4	3	2	3	1	2	3	2	2	2	3	3
42	1	48	3	2	2	2	3	1	3	3	2	1	1	1	3
43	1	42	3	2	2	2	3	1	3	3	1	3	3	1	3

ANNEXURE III

ESTIMATED QUANTUM OF WATER TAKEN AND WASTE WATER DISCHARGED DURING THE PERIOD OF STUDY (x 10^3 m^3)

	R1 (inlet)	R2 (outlet)	S1 (inlet)	S2 (outlet)	K1 (inlet)	K2 (outlet)
January 1998	--	--	240.0	240.0	--	--
February	--	--	480.0	480.0	--	--
March	--	--	300.0	300.0	150.0	--
April	--	--	180.0	600.0	50.0	--
May	--	--	600.0	--	25.0	25.0
June	--	--	100.0	--	25.0	30.0
July	50.0	--	--	--	--	30.0
August	50.0	--	60.0	450.0	--	150.0
September	50.0	12.0	350.0	--	--	--
October	150.0	25.0	100.0	--	--	--
November	90.0	30.0 66.0	50.0	100.0	--	--
December	--	100.0 150.0	50.0	350.0	--	--
January 1999	--	--	50.0	20.0	--	--
Total	390.0	383.0	2560.0	2540.0	250.0	235.0

ANNEXURE IV

FARMING ACTIVITIES DURING THE STUDY PERIOD

Shakti Aquaculture Farm

January 1998	74 DOC. All the ponds stocked and farming activities in full swing
February	105 DOC. All the farming activities in progress without any problem
March	130 DOC. Time for harvesting; procedure for harvesting already started;. liming to harden shell and water exchange
April	140-150 DOC. Harvested with 30/35 count (30 g)
May	Intake of water for stocking, liming, chlorination
June	Stocking done in D section ponds, some yet to be done; some ponds being exposed to sun; shrimps in C ponds only
July	40 DOC. in D section ponds; no exchange of water; 35‰ in ponds 104 DOC in C ponds. It was 2-3 ‰ in ponds just after rain
August	C + D ponds harvested at 10-15 g due to disease at 60-70 DOC; few ponds (7 no.) remaining; around 15 tonnes harvested; heavy rainfall
September	Water intake on 17th; 5-15‰ range, no farming activities
October	Stocking of the ponds going on; no significant farming activity
November	5-10 DOC at D section;10-15 DOC at C ponds
December	Disease outbreak; ponds drained out; drying in the sun

*DOC –Days of culture

King's Farm

January	All the ponds in C section drained out due to disease. 2 ponds harvested, 5 ponds of 60 DOC in D section.
February	No activity
March	Intake of water and fertilization of ponds timing

April	Stocking commences
May	Stocking still going on. Some ponds are already 10DOC
June	20-40 DOC, water exchange upto 20-30% once in each pond and volume of water made up later on.
July	50-70 DOC. Raining 3-4 days prior to sampling day
August	Harvested at 15-20 gm ranges at around 100 DOC, due to disease outbreak. Around 20 tonnes of shrimp were harvested at 15 gm individual wt.
September	No activity. All ponds are empty
October	No activity
November	No activity
December	No activity. Ponds are drained out
January	No activity

Ruia Aquafarm

January	All the ponds are lying vacant
February	----
March	----
April	----
May	----
Jun	Construction and repairing of canals and ponds for stocking
July	Intake of water (5-15 ‰) for water culture before stocking, very turbid water
August	Stocking going on in 3 ponds already stocked
September	Only 6 ponds with seed, Heavy rain previous day 37 DOC
October	Stocking fan 25 ponds started, water intake for 15 ponds
November	Harvesting was done in 3 ponds. 25 ponds stocked and DOC is 19-26 days
December	10 ponds harvested at 40-60 DOC. Rest have been drained out due to disease
January	All the ponds drained out (disease). No activity

ANNEXURE V

Salient details regarding various parameters of shrimp farming practices in Saphale, Thane Dist., Maharashtra

Sl. No.	Parameters	Saphale, Thane
1	Percentage of	
	a) Corporate farms	
	b) Private farms	95.0
2	Size of farms	
	a) Total area (ha)	5-120
	b) Water spread area (ha)	4-75
	c) Size of individual Pond (ha)	0.6-1.25
	d) distance of farms from the sea	1-15 km.
3	Land holding on which farm exists (in percent)	
	a) Private land	25
	b) Govt. land	75
4	Location of the farm (in percent)	
	a) Sea-based	Nil
	b) Creek/canal based	100
5	Year of farm construction	1990-94
6	Number of farms which are fenced	1
7	Species cultured	*P. monodon* 100%
8	Level of operation (in percent)	
	a) Extensive	5
	b) Modified extensive	95
	c) Semi-intensive	Nil
9	Source of seed	
	a) Natural	Nil
	b) Hatchery	100%

Sl. No.	Parameters	Saphale, Thane
10	Rate of stocking (PL-20) (per ha) a) Extensive b) Modified extensive	 25000 60000-80000
11	Nos. of ponds in which aerators are being used (in percent)	90
12	Feed used (in percent) a) Imported b) Local c) Both	 100% -- --
13	FCR a) Imported b) Indian	 1:1.5 --
14	Use of drugs	Vit. C powder with feed. Benzalkonium chloride, Oxytetracycline when disease occurs.
15	Culture duration	120 to 150 days
16	Average production a) Extensive b) Modified extensive	 500-1000 1200-1500
17	Nos. of staff employed a) Technical b) Supporting	 1 person/10 ha 10 persons/10 ha
18	Any problem experienced a) Disease outbreak b) Water quality deterioration c) Social unrest	 2 crops out of 3 crops per year Not significant Some villagers at Khardi-Para