CHAPTER II

LITERATURE REVIEW

The shrimp ponds in the mangrove forests are operating as intensive and semi-intensive shrimp culture(Menasveta, 1991) The aquaculture development not only decrease the mangrove area but also has the direct impact on the environmental quality as summarized in Figure II-1.

Kongsangchai(1990) has concluded the impacts of shrimp culture on the mangrove ecosystem in three ways:

1. Loss of mangrove area. In all part of shrimp farm, the forest clearance , water digging and dike around shrimp ponds induce weathering and soil erosion to the nearby forests. This impact is more pronounced if the selected area is near the seashore.

2. Decrease in productivity. The work of Tantipukanont and Paphavasit (1991) shows clearly that the abundance and species diversity zooplankton in the disturbed mangrove due to shrimp farm was lower than the nearby natural forest. This affect not only the fisheries but also the aquaculture. Thus the natural shrimp larvae are also decreasing due to the mangrove destruction.

3. The dike around shrimp pond obstructs the tides and water circulation to nearby mangroves. These will adversely affect

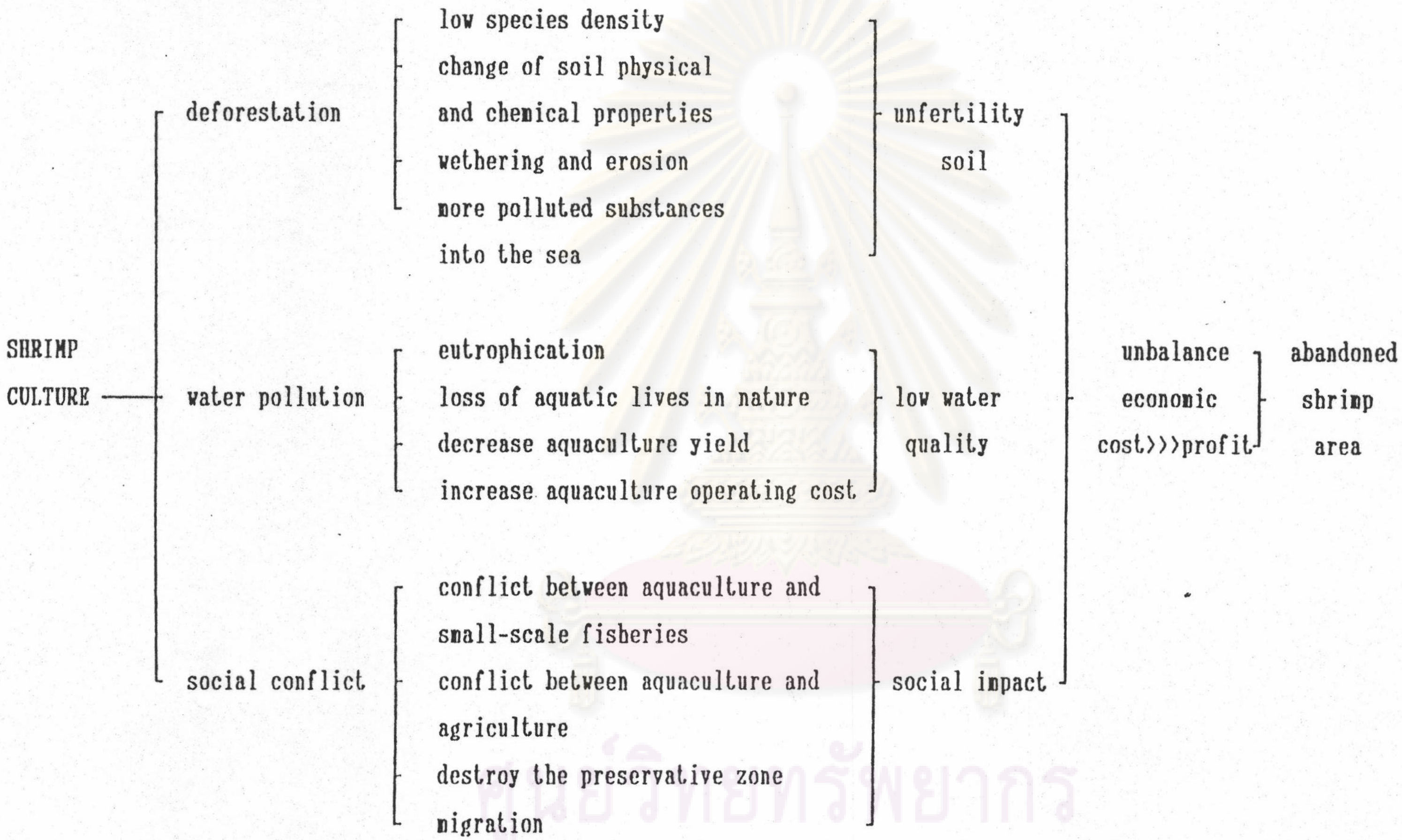

Figure-II-1 Environmental impact due to shrimp culture(Adapted from Chantadisai and Apinant,1987; Chantadisai,1990; Kongsangchai,1990 and Menasveta,1991) the growth and survival of mangrove seedling.

The physico-chemical disruption occurs in the area due to shrimp farming.

1. Loss of soil nutrients.

After the mangrove forests have been cleared, the top soil erosion is more rapid. The mud layer becomes thinner. From the work of Miyawaki et. al.(1985) shows that after four to five years of shrimp pond construction, the natural nutrients will be diminished and the farm will be abandoned.

2. Decreasing of soil nutrients.

Gajaseni(1982) showed that the rate of litter composition in abandoned shrimp farm was much lower than in the natural mangrove, there was no or few sources of nutrient. Suwansri,Gajaseni and Ajchariyavanich(1988) also revealed the similar results. They conducted a comparison study on nitrate and phosphate budgets by input-output approach between a natural mangrove and a disturbed mangrove ecosystem. They found that there was a significant difference (at 0.05) of higher nitrate input over output in the natural mangrove ecosystem. The outputs of nitrate and phosphate from disturbed mangrove ecosystem were significantly higher than the input(0.05). Nitrate and phosphate resevoirs in soil were significantly higher(at 0.05) in natural mangrove ecosystem over the disturbed mangrove ecosystem. Narongrit(1992)studied on impact of shrimp farming on mangrove properties, Changwat Suratthani. She found that the concentration of macronutrients (nitrogen, phosphorus, potassium, sodium, magnesium and calcium) in shrimp pond were lower than the natural mangroves.

3. <u>High acidity soil</u>.

The pH value of soil in shrimp pond is lower than the natural mangrove soil(Chantadisai and Apinan,1987; Narongrit,1992) Bhodipuk (1988) revealed the sulfuric acid that was the cause of acid soil resulting three sources:

3.1 Oxidation reaction of oxygen and hydrogen sulfide

$$H_2S + 2O_2 \longrightarrow H_2SO_4$$

3.2 Oxidation reaction of oxygen and sulfur

$$2S_2 + 3O_2 + 2H_2O \longrightarrow 2H_2SO_4$$

3.3 Oxidation reaction of oxygen and jarosite(pyrite)

$$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 2FeSO_4 + 2H_2SO_4$$

4. <u>High elasticity soil</u>.

The high elasticity soil is soft and sticky soil when wet but crack on the surface and hard when dry. Narongrit(1992) found that on the soil surface(5-10 centimeters) of shrimp pond, there was more clay particles than natural soil mangrove and clay particles will increase after draining water into the pond. The sodium soil with high clay particles will give the elasticity soil.(Board of Department of Soil Science,1987)

5. Accumulation of toxic substances in soil.

Athisuk et.al.(1986) studied pesticide residues in shrimp tissue and environmental samples in shrimp farm area in Changwat Samutprakarn. They found organochlorine compound in the sediment of shrimp pond for example DDT, Deldrin,Chloden and Eldrin but organophosphorus were not found. Moordee(1991) also reported on some chemical residued for shrimp pest and some insecticide contaminates in the soil of shrimp ponds.

6. The obstructed dike.

The dike will obstruct tide, so the natural inundation over the shrimp pond is not possible except the drainage of sea water through small canal. This dike not only obstruct the tide but also prevent the nutrients from run-off.

Because the recovery of disturbed mangrove in nature is approximtely 20 years, so the rehabilitation of disturbed mangrove was attempted for many reasons. Rabinowitz(1975) conducted the planting experiments in mangrove swamps of Panama.

Four mangrove genera (*Rhizophora, Avicennia, Laguncalaria* and *Pelliciera)*were planted as propagules in stands of each genus. This experiment was design to test the hypothesis that the habitat separation among mangroves is controlled by physiological preference. The result of his study reject his hypothesis because their habitat division is not controlled by physiological preference but tidal sorting of propagules is proposed as a mechanism for the control of zonation.

Sidhu(1975) studied on the culture and growth of 14 mangrove species in genera *Acanthus, Aegialitis, Avicennia, Brugiera, Carapa, Ceriops, Excoecaria, Heritiera* and *Rhizophora at* Alhabud , India in washed river-sand flooded with distilled water and salt solution of several concentrations. His study shows no dormancy was observed except in seeds of *Carapa* and *Heritiera*. All other species exhibited strong viviparous. The growth experiments showed that none of the selected mangrove species survived in sand with no nutrients. The yellowing of leaves of all species due to absence of sodium chloride and ammonium nitrate in the salt solution while the green color was restored when the salt solution contains that two compounds. *R. mucronata* and *C. candolleana* grew best in soils flooded with salt solution of full-strength seawater whereas *R. conjugata, C. roxburghiana* and *B. parviflora* grew best in soil flooded with water having 50% of seawater salt concentration.

Motohiko (1992) has successfully planted mangroves on the desert along the sea shore of Saudi Arabian in his attemt to turn the desert green.

In Thailand, these project were carried out under the co-operations of several organizations after the Cabinet issued the resolution on December 1987 that the reforestation on disturbed mangrove area such as the preservation area, after mining area and the new mud flat area must be carried out in order to revive the mangrove ecosystem and to hinder the exploitation of mangrove woods.

Soonhaue(1978) studied the distribution, growth and survival of mangrove seedling at Amphoe Klung, Changwat Chantaburi. The rate of height growth and survival of seedling planted under forest canopy in one year period of *R. apiculata, R. mucronata* and *B. gymnorrhiza* were 38, 28 and 39 centimeters respectively. Growth was high in period after planting in October and decreased in February or March and then increased again in July and September. Rate of mortality for three species were 81%, 18% and 80% respectively. The high mortality rate is due to violent tide, limited light and the crab attacks on seedling.

Aksornkoae(1982) studied on the productivity and enery relationships of mangrove plantations of *R. apiculata* in Thailand. From this investigation, a suitable cutting rotation of mangrove plantation should be 14 or 15 years but if this should be less, 10 years for example, sivilculture treatment such as intermediate cutting will be needed to increase plantation growth. Prop-root and branches are also suitable for making charcoal and prop-root will give higher quality charcoal than branches.

Srisawasdi(1982) studied on a comparison of growth development of five mangrove species planted on an abandoned mining area in Phang-Nga. *R. mucronata, R. apiculata, C. tagal, B. gymnorrhiza* and *B. parviflora* were the selected mangrove species planted at 1.5x1.5 meter spacing. From the information obtained on productivity and mortality rate during the first sixth months, the two Rhizophoras are the best suitable species for planting on denuded mining area. *C. tagal* can be used although the growth was not as good but the mortality rate is very low.

Aksornkoae et.al.(1986) reported on the productivity and mortality of mangrove area for coastal zone development at Amphoe Takuapa, Changwat Phangnga. The productivity (diameter, total heigh and total dry weight) in such area was lower than the productivity of natural mangrove. Their recommendations on this topic were first, the area has to be leveled down until the area can be flooded by seawater before planting. Secondly, the *R. apiculata* is suitable to be planted on an abandoned mining area in term of economic and ecological benefits but *A. alba* and *Brugiera sp.* is suitable in term of ecological protection. Lastly, *Rhizophora* planting should be tried by using seedling from nursery in stead of seedling collected from trees. The planting should be carried out immediately. These may give higher productivity and less mortality rate.

Wechakit(1987) carried out on the growth and survival study of private mangrove plantation (*R. apiculata*) at Amphoe Amphawa,Changwat Samutsongkram. The ages of these mangrove were between 1-15 year-old. The average height of increment of the plantation was 0.82 m./yr.. The annual height increment was highest in a 11 year-old stand(1.56 m./yr.) and the lowest in a 1-year-old plantation (0.45 m./yr.). The average diameter increment was 0.46 m./yr.. The total biomass and the total volume of plantation were greatest in a 14 year-old plantation and the rate of survival of plantation decrease with ages increase. From this research, the suitable spacing is 1x1 or 1.5x1.5 meters was recommended and the mangrove plantation should be cut the multi-stem to increasing the space between the plant at 5 year-old plantation.

The rate of germination of *R. apiculata* which cut into two and three pieces was studied by Charoensuabsakul(1988). The result from this research revealed that all the pieces can germinate and the rate of survival is high to 94%. The two pieces cut propagules will germinate faster than the three pieces cut propagules.

Bhodthipaks and Prayuneyong(1988) studied on propagation techniques of *A. alba* and *C. decandra* by bare root planting root cutting stump planting and direct transplanting from the natural mangroves. Due to *R. apiculata* plantation on harded mud are found dead in patches. The *A. alba* and *C. decandra* in term of bare root planting, root cutting, stump planting and direct transplanting from natural mangrove were on trials to replacement the dead *Rhizophora*. The result shows that the last method gives 90% and 3.3% survival for *A. alba* and *C. decandra* respectively while other means of prapagation failed.

Kongsangdow, Kooha and Komasatit (1988) reported on the revival of mangrove forest by pioneer species at Amphoe Muang, Changwat Samutsakhon. After five-year experiment (1982-1987), *A. alba* is the best pioneer species for the revival of disturbed mangrove forest because of high growth and survival rate. The pioneer species can grow in the upper zone of the disturbed mangrove area which the soil is harder but the rate of survival is lower. For the soft clay area near the coastal area no species can survive because they could not tolerate currents and waves.

Teratanatorn(1988) studied on the growth and survival of mangrove species planted on the area after mining at Amphoe Takua Pa Changwat Phang-nga. *R. apiculata, R. mucronata, B. cylindrica, B. parviflora* and *C. Tagal* are the selected species. From the results of this one-year investigation, the two *Rhizophoras* should be suitable for planting on this area compared with the other three mangrove species. He also recommended that the propagules should be planted in the nursery before because the nutrients in this area were limiting and the unsuitable environmental condition may affect the establishment of the propagules.

The eco-physicological study of plant density effect of experimental mangrove stands of *Kandelia candel* and *R. apiculata* by Patanaponpaiboon(1989) concluded that after two and a half years planting at 25, 44.4, 100 and 400 plants per square metre in vinyl house under greenhouse, the effect of plant density was pronounced on the ecological processes such as leaf longivity, flushing and falling, whereas the physiological process, the rate of photosynthesis were less affected by plant density.

Tanapermpool(1989) studied on productivity of *Rhizophora apiculata* Blume plantation in Changwat Pattani. His result was similar to Wechakit (1987) that the total volume and total biomass increment was greatest in a 14 years old plantation but the annual height and diameter increment was highest in a 14 years old stand.

Bamroongrugsa(1991) who studied on mangrove plantation carried out on the new mud flat area which is caused by the river precipitation around Pattani Bay. Pods of *R. apiculata* and six-month-old seedling of the rest four species: *A. marina, E. Agallocha, C. tagal and B. parviflora* were used for planting. After one year data, the highest survival rate was 65% belongs to *A. marina* but *R. apiculata* grew more rapidly than other species. The main cause of mortality of mangrove seedling were drought and heat of the ground during dry season. But from the observation *A. marina* could grow well at the upper tidal zone which is dry while *R. apiculata* grew rapidly in the intertidal zone. He recommended that the drainage from nearby shrimp pond will help the seedling survival in the dry season.

Srisawasdi(1991) carried out the planting experiment of three mangrove species on mud flats in Changwat Nakhonsri-thammarat. After two years of planting, *R. mucronata* has the higher rate of survival and growth than *R. apiculata* and *C. tagal*. The growth and survival rate of *R. apiculata* was also better than *C. tagal*.

Toepakngam, Aksornkoae and Hikagi(1991) carried out the mangrove forestation on saline soil in north-east Thailand. *X. granatum, E. agallocha, Heriteira littoralis* and *Melaleuca leucadrendron* were grown on salt affected area at Ban Nonglub Amphoe Muang, Khonkaen. There was soil improvement with organic matters as rice husk and farm manure. The result shows that the four species establish and grow well. After one year, *E. Agallocha* and *M. leucadrendron* grow after five times more than its transplanting height while *X. granatum* and *H. littralis* were two times taller than its respective starting height.

Mangrove community is very complex. Each mangrove species needs different environmental factors. But the factors that mostly influence the survival and growth of mangrove plants are:

1. <u>Tide</u>.

Tides affact the survival of mangrove species especially the time of establishment of seedling(Clarke and Hannon,1969; Chapman,1976) The *Avicennia sp.* seedling that germinate in waterlog area will have high mortality but this condition would not affacted them if they can split 2-4 leaves(Clark and Hannon, 1970). Egler(1948) found that *R. mangle* cannot grow if they are under the water that six feet higher than the top of stem everyday. The tides will also control salinity thus affecting photosynthesis. *R. apiculata* grow well on the area that flood by normal high tide (Banijbatana, 1957; Dinghou, 1958; Steenis, 1958; Chapman, 1970; Berry, 1972; Sasekumar, 1973; Klankamsorn and Jaruppat, 1982) while *C. tagal* can grow well on the area that flood by spring tide(Banijbatana,1957; Chapman,1970; Berry, 1972; Sasekumar, 1973; Klankamsorn and Jaruppat, 1982) Watson(1928) found that *B. gymnorrhiza* can grow on the area that flood by spring tide too.

2. <u>Salinity</u>.

Mangrove does not use the salt from the seawater but it is the limiting factor for another terrestial forests distribution(Aksornkoae,1989: Patanaponpaiboon,1991). Each species will tolerate to different salinity range. *Avicennia sp.* tolerate to salinity in wide range because they can grow in the near freshwater up to the 30 ppt.(MacNae,1968). Clarke and Hannon(1970) showed that optimal salinity for *A. marina* is 20-40 ppt. and they would grow slowly if the salinity was higher. Macnae(1968) found that *C. tagal* can tolerate in seawater salinity over 30ppt. Chapman(1976) found that *A. marina* and *L. racemosa* which grow at 90 ppt. would be dwarfish as same as *C. tagal* which grow at 60 ppt. would be dwarfish too. The suitable salinity for family Rhizophoraceae that *C. tagal* and *R. mucronata* normally grow at 20 ppt. Watson(1928) found that *R. apiculata* distributed near mouth of estaurine that salinity below 15 ppt.. de Haan(1931) also confirmed that the suitable range of salinity tolerance of *R. apiculata* was 1-30 ppt. while *B. gymnorrhiza* can grow well in water salinity between 10-30 ppt.. Macnae(1968) and Ubolcholaket(1986) also confirmed that *B. gymnorrhiza* can tolerate the range of salinity from 10-25 ppt.

3. <u>Light and Temperature</u>.

These two factors directly affect the photosynthesis. Chapman(1944) quoted by Chapman(1976) found that *Avicennia sp.* need light very much especially *A. germinan* cannot grow if they are under the shade of tree. MacNae(1963) has pointed that *Avicennia* seedling die under the shade of their parent and also that even old trees die when they are overtopped by the *Rhizophora* and *Brugiera* trees, for the development of which they have acted as shading nurse. Banus and Kolehmainen(1975) found that light also affected the floating, rooting and growth of red mangrove(*R. stylosa*) seedling. The result from his work showed that in sun light, the seedling assumed the vertical floating position within 10-30 days. The first leaf-pair formed at 40-50 days, the percent with leaf versus time was constant among several batches and did not depend upon the rooted seed being planted in mud. In the shade,about one-half of seedling remained floating horizontally for several months. Seedling that floated for several months formed secondary roots which accumulated algae and sediments. Shade delayed leaf formation to over 3 months. Seedlings grew well in the lagoon and in mud-filled plastic trays with gently flowing seawater in the laboratory. However, their growth habits were different. Soonhuae (1978) studied on some mangrove species planted under the shade of trees. He found that in one year, *R. apiculata, R. mucronata B. gymnorrhiza* planted under sun light were growing better than that planted under the shade. The work of Smith(1987) also confirmed this. He found that the relative growth of *R. stylosa, A. marina* and *C. tagal* were greatest in the high versus low intertidal and in gaps versus under the canopy but *B. gymnorrhiza* growth was not significantly different between gap and canopy or high and low intertidal. Aksornkoae(1989) concluded that the optimal light intensity for the growth of mangrove plant is between 3,000-3,800 kilocalories per squaremeters per day.

4. Soil properties.

The trend of alteration of soil properties would corresponded to the mangrove species zone (Clarke and Hannon,1969). The structure, composition, mineral and aeration of soil are one of the limiting factors for plant growth so if the soil condition is changed, the mangrove species will change too. (Aksornkoae et. al. 1979).

By nature, *R. mucronata* likes deep and soft sandy clay which inundation while *R. apiculata* can grow in the harder clay or black soil. (Pattanaponpaiboon, 1991) *R. apiculata* can also grow in soft clay (Walsh,1974; Dinghou,1958; Steenis,1958), black soil with sand and humus (Dinghou,1958; Steenis,1958; Macnae,1968), and new settled silt (Jordan,1964). Besides these, *R. apiculata* was found on silty clay loam (Sukseleung,1981), silty clay (Panichsuko,1984), silt loam(Aksornkoae et.al.,1986), clay soil (Wechakit,1987), and sandy clay loam (Teratanatorn,1988). *Avicennia sp.* can grow in the sand or clay (Macnae, 1968; Chapman, 1977; Aksornkoae, 1989 and Pattanaponpaiboon; 1991). Macnae and Kalk (1962) founded *B. gymnorrhiza* can grow in dry soil with underground water is near soil surface while Thom(1967) found *B. gymnorrhiza* can grow on wet soil. Moreover, *B. gymnorrhiza* can also grow on sand soil (Heatheway,1953; Moul,1957; Gledhill,1963). Macnae and Kalk(1962) found that *C. tagal* can grow well on dry soil while Thom(1967) found that it can grow on drainage soil. *C. tagal* was also found on silty clay (Srisawasdi,1985), on clay (Teratanatorn,1988), and on silty loam (Srisawasdi,1991).

For soil pH, *R. apiculata* can grow on the soil that has pH from 5.6-6.6 (Hesse,1961 and Giglioli and Thornton,1965) while Tomlinson(1957) found that it can grow on low pH soil. Besides these, *R. apiculata* can grow on the high acid soil to neutral soil (2.75-7.5)(Kongsangchai,1974;Pornpattimakorn,1979;Sukseleung,1981; Srisawasdi, 1983; Panichsuko, 1984; Aksornkoae et. al.,1986; Wechakit,1987; Teratanatorn,1988). *B. gymnorrhiza* can grow on soil pH 3.9-3.95 (Kongsangchai,1974). Srisawasdi(1985) found *C. tagal* can grow on soil pH 4.2 while Teraranatorn(1988) found it grow on soil pH 2.2

For soil nutrients in natural mangrove, nitrogen, phosphorus and potassium are the limiting factors. Nakasuka (1982) studied on the preliminary studies on viviparous seed and early growth of *R. stylosa* in Okinawa, he found that the seed that cultured in nutrient solution and tapwater showed the different growths. Bud break, shoot and root elongation were better in nutrient solution than in tapwater. Hesse(1961) found that ammonia and nitrate concentration in soil under *R. apiculata* were 1 and 2 ppm.(part per million) respectively. Phosphorus in soil under *R. apiculata* was 5.25-5.75 ppm.(Kongsangchai,1974), 37-58 ppm. (Srisawasdi,1983), 8-11 ppm.(Panichsuko,1984), 8-16ppm.(Aksornkoae et. al.,1986),51 ppm.(Wechakit,1987),11.7 ppm.(Teratanatorn,1988). Kongsangchai(1974) found phosphorus concentration in soil under *B. gymnorrhiza* was 5.7 - 5.88 ppm.. Srisawasdi(1985) found phosphorus concentration under *C. tagal* was 15.6 ppm. while Teratanatorn(1988) found phosphorus concentration was 13.3 ppm. Potassium concentration in soil under *R. apiculata* was 135.75-262 ppm.(Kongsangchai,1974), 484-703 ppm.(Suksileung,1981), 768-

800 ppm.(Srisawasdi,1983), 136-137 ppm.(Panichsuko,1984), 902 ppm. (Aksornkoae et. al.,1986), 765 ppm.(Wechakit,1987), 67.3 ppm. (Teratanatorn,1988). Kongsangchai(1974) found potassium concentration in soil under *B. gymnorrhiza* was 139.75-159 ppm.. Srisawasdi(1985) found potassium concentration under *C. tagal* was 902 ppm. while Teratanatorn(1988) found only 13.3 ppm.. For calcium concentration in soil under *R. apiculata* was 987-1480 ppm.(Suksileung,1981), 110-196 ppm.(Panichsuko,1984), 1520 ppm. (Wechkit,1987), and 131 ppm.(Teratanatorn,1988). while potassium concentration for *C. tagal* was 121 ppm.(Teratanatorn,1988). For magnesium concentration in soil under *R. apiculata* was 2115-3105 ppm.(Suksileung,1981), 248-1110 ppm.(Panichsuko,1984), 2340 ppm. (Wechkit,1987), and1237 ppm.(Teratanatorn,1988) while magnesium concentration for *C. tagal* was 1237 ppm..

From the study reviewed, it is cleared that the attempt on the reforestation of mangrove species on abandoned shrimp farm was limited. Therefore, the suitable conditions for mangrove planting in such area was not evidenced. However several research papers have recommended that the preparation of planting site and mangrove seedling prior to the planting on the abandoned shrimp pond are as follows:

1. Dike destruction

Due to the fact that the dike obstruct tide from the sea and nutrients in runoff from the land so the destruction of dike is very crucial. If this is not possible, a small canal will be used in order to drain the seawater into the pond(Havanond and Rattanavirakul, 1991)

2 <u>Clearance of floor surface</u>.

The floor surface should be cleared especially *Sueda maritima* that is the only one shrub that can grow on the abandoned shrimp pond. This plant species will disturb mangrove seedling by competing with the mangrove seedlings using nutrients in the soil.

3 <u>Recommended mangrove species</u>.

Miyawaki et. al.(1985);Havanond and Rattanavirakul(1991) advised the pioneer species that may grow on the area like this are *R. apiculata, R. mucronata, C. tagal, B. perviflora* and *B. cylindrica* because of low nutrient and abnormal soil conditions.

4 <u>The new propagules</u>.

The new propagules should be planted as soon as collected from the parent trees. However, if the storage of propagules is neccessary, Havanond and Tanapermpool(1991) recommended that the pioneer species that should grow on the area like this are *R. apiculata , R. mucronata, B. gymnorrhiza, B. perviflora* and *B. cylindrica*. These five species, the propagules can be stored in nurseries for two months prior planting. This will not affect the survival rate.