# INFLUENCE OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEDIMENT ON THE DISTIBUTION AND BIOMASS OF SEAGRASSES: KUNG KRABAEN BAY, CHANTHABURI PROVINCE

KAMALAPORN KANONGDECH

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Kamalaporn Kanongdech


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INFLUENCE OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEDIMENT ON THE DISTRIBUTION AND BIOMASS OF SEAGRASSES: KUNG KRABAEN BAY, CHANTHABURI PROVINCE

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## ABSTRACT

The endeavor is to study the relationship of the physical and chemical characteristics of sediment, on the distribution and biomass of seagrasses. This study was carried out in the Kung Krabaen Bay, Chanthaburi Province. Sediment and seagrass samples were collected along four transect lines which were perpendicular to mangroves and parallel to natural canals around the bay, covering the summer and the rainy season during year 2003.

This study found that the physical characteristics of the sediment have related to the distribution of the seagrasses. Specifically, *Halodule pinifolia* can be found in both sandy loam and silt, but *Enhalus acoroides* can be found only in sandy loam. Moreover, the chemical characteristics in this case are the cation exchange capacity, the amount of organic matters, and the amount of potassium of the sediment related to the biomass of seagrasses in some interesting ways. For instance, the cation exchange capacity negatively relates to the biomass of the *H. pinifolia*. Namely, the more the cation-exchange capacity increases, the less the biomass becomes, and vice versa. This is also the case for the amount of organic matters and potassium relate to the biomass of *E. acoroides*. Yet, the high amount of organic matters and nitrogen concentrations found near the rim of the mangrove forests are the result of waste water from the canals around the bay, cause of mild acidity to the sediment, but do not affect the distribution of the two species of seagrasses.

KEY WORDS: *Halodule pinifolia/ Enhalus acoroides*/ biomass of seagrasses

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**การศึกษาความสัมพันธ์ระหว่างคุณสมบัติดินตะกอนทางกายภาพและเคมีต่อการแพร่กระจายและมวลชีวภาพของหญ้าทะเลในบริเวณอ่าวคุ้งกระเบน จังหวัดจันทบุรี (INFLUENCE OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEDIMENT ON THE DISTRIBUTION AND BIOMASS OF SEAGRASSES: KUNG KRABAEN BAY, CHANTHABURI PROVINCE)**

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## บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ของคุณสมบัติดินตะกอนทั้งทางกายภาพและเคมี (texture, color, pH, EC, OM, N, Avai.P, Avai. K, CEC, $H_2S$) กับมวลชีวภาพและการแพร่กระจายของหญ้าทะเลภายในอ่าวคุ้งกระเบน โดยเก็บตัวอย่างดินตะกอนและหญ้าทะเลบริเวณขนานแนวคลองน้ำทิ้งรอบอ่าวและตั้งฉากกับขอบป่าชายเลนในฤดูร้อนและฤดูฝน

ผลการศึกษา พบว่า หญ้าชะเงาฝอยจะพบบริเวณดินที่มีลักษณะแบบร่วนปนทรายและทรายแป้ง ส่วนหญ้าชะเงาพบบริเวณที่มีเนื้อดินแบบร่วนปนทราย ส่วนคุณสมบัติดินตะกอนทางเคมีที่มีความสัมพันธ์กับมวลชีวภาพของหญ้าทะเล ได้แก่ ความสามารถในการแลกเปลี่ยนประจุบวกมีความสัมพันธ์กับมวลชีวภาพของหญ้าชะเงาฝอยในรูปแบบล็อกการิทึ่มเชิงลบซึ่งอธิบายได้ว่าเมื่อมวลชีวภาพมีค่าสูงจะพบค่าความสามารถในการแลกเปลี่ยนประจุบวกในระดับต่ำและในทางกลับกัน เมื่อมวลชีวภาพลดลงก็จะพบความสามารถในการแลกเปลี่ยนประจุบวกมีค่าสูงขึ้น เป็นความสัมพันธ์ในลักษณะเดียวกันกับสารอินทรียรวมและโปแตสเซียมที่เป็นประโยชน์ต่อพืชที่มีความสัมพันธ์แบบคิวบิกเชิงลบและแบบอินเวอร์สกับมวลชีวภาพของหญ้าชะเงา ตามลำดับ นอกจากนี้ยังพบว่าคุณสมบัติของดินตะกอนโดยเฉพาะปริมาณสารอินทรียรวมและไนโตรเจนรวมจะมีปริมาณสูงที่บริเวณติดขอบป่าชายเลนทำให้ดินมีลักษณะเป็นกรดอ่อน ทั้งนี้ส่วนหนึ่งเป็นผลมาจากการพัดพาตะกอนจากแนวคลองน้ำทิ้งรอบอ่าว อย่างไรก็ตาม ปริมาณการสะสมดังกล่าวไม่ส่งผลต่อการแพร่กระจายของหญ้าทะเลทั้งสองชนิด

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# CONTENT


| | | Page |
|---|---|---|
| **ACKNOWLEDGEMENTS** | | **iii** |
| **ABSTRACT** | | **iv** |
| **LIST OF TABLES** | | **ix** |
| **LIST OF FIGURES** | | **xi** |
| **CHAPTER** | | |
| **1** | **INTRODUCTION** | |
| | 1.1 Rationale | 1 |
| | 1.2 Conceptual Study | 2 |
| | 1.3 Hypothesis | 4 |
| | 1.4 Objectives | 4 |
| | 1.5 Scope of Study | 4 |
| | 1.6 Timing | 4 |
| | 1.7 Purpose of Study | 5 |
| **2** | **REVIEW LITTERATURES** | |
| | 2.1 Seagrasses Ecosystem | |
| | 2.1.1 The value of seagrass meadows | 6 |
| | 2.1.2 Environmental factors affecting the seagrasses, growth, and survival | 7 |
| | 2.1.3 The *Enhalus acoroides* and *Halodule pinifolia* information | 8 |
| | 2.1.4 Problems of seagrasses deterioration | 10 |
| | 2.2 Study Site | 11 |
| | 2.3 Sediment Characteristics in the Kung Krabaen Bay | 14 |
| | 2.4 The effects of sediment to seagrasses | 16 |


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# CONTENT (CONT.)


| CHAPTER | | Page |
|---|---|---|
| 3 | **METHODOLOGY** | |
| | 3.1 Tools and equipment | 22 |
| | 3.2 The sample collecting | |
| | 3.2.1 The study site | 22 |
| | 3.2.2 Sample Collecting Methods | 24 |
| | 3.2.3 Sediment and Biomass Analysis in the laboratory | 31 |
| | 3.3 Statistic Analysis | 31 |
| 4 | **RESULTS** | |
| | 4.1 Seagrasses Information | |
| | 4.1.1 The pattern of seagrasses distribution | 33 |
| | 4.1.2 Biomass of seagrasses | 38 |
| | 4.2 Sediment Characteristics Analysis | |
| | 4.2.1 Physical Characteristics | 42 |
| | 4.2.2 Chemical Characteristics | 47 |
| | 4.3 The correlation between the chemical qualities and the biomass of seagrasses | |
| | 4.3.1 The correlation between pH, EC, OM, N, P, K and CEC and the biomass of *Halodule pinifolia* | 78 |
| | 4.3.2 The correlation between pH, EC, OM, N, P, K and CEC and the biomass of *Enhalus acoroides* | 81 |
| | 4.3.3 The correlation between the hydrogen sulfide gas and the biomass of *H. pinifolia* | 87 |
| | 4.3.4 The correlation between the hydrogen sulfide gas and the biomass of *E. acoroides* | 87 |


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# CONTENT (CONT.)


| CHAPTER | | Page |
|---|---|---|
| 5 | **DISSCUSSION, CONCLUSION AND SUGGESTION** | |
| | 5.1 Conclusion | 88 |
| | 5.2 Discussion | |
| | 5.2.1 The distribution of seagrasses | 89 |
| | 5.2.2 The characteristics of sediment | 91 |
| | 5.2.3 The sediment qualities related to *Halodule pinifolia* | 92 |
| | 5.2.4 The sediment qualities related to *Enhalus acoroides* | 93 |
| | 5.2.5 Hydrogen sulfide related to the biomass of *H. pinifolia* and *E. acoroides* | 94 |
| | 5.3 Suggestion | 94 |
| **BIBLIOGRAPHY** | | 96 |
| **APPENDIX** | | 105 |
| **BIOGRAPHY** | | 152 |


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# LIST OF TABLE


| Table | Page |
|---|---|
| 3.1 Parameters of sediment to analyze in the laboratory | 30 |
| 4.1 The averages of biomass of *H. pinifolia* and *E. acoroides* in each transect in the rainy season | 39 |
| 4.2 The texture and color of sediment each transect lines in the Kung Krabaen Bay | 43 |
| 4.3 The texture of the sediment and the species of seagrasses of each transects | 45 |
| 4.4 The pH value of each transect lines in the summer and the rainy season | 48 |
| 4.5 The electrical conductivity of each transect lines in the summer and the rainy season | 52 |
| 4.6 The organic matters of each transect lines in the summer and the rainy season | 56 |
| 4.7 The total nitrogen of each transect lines in the summer and the rainy season | 60 |
| 4.8 The available phosphorus of each transect lines in the summer and the rainy season | 64 |
| 4.9 The available potassium of each transect lines in the summer and the rainy season | 68 |
| 4.10 The cation exchange capacity of each transect lines in the rainy season | 72 |
| 4.11 The average of each parameters and the level of the standard in the 4 transects in the summer and the rainy season | 75 |
| 4.12 The hydrogen sulfide gas in the seagrass beds and non-seagrass beds of each transect in the summer and the rainy season | 76 |
| 4.13 The sediment qualities and the biomass of the *H. pinifolia* | 78 |
| 4.14 The correlation coefficient of 7 chemical parameters correlated to biomass of *H. pinifolia* | 79 |
| 4.15 The sediment qualities and the biomass of the *E. acoroides* | 81 |
| 4.16 The correlation coefficient of 7 chemical parameters correlated to biomass of *E. acoroides* | 82 |


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# LIST OF TABLE (CONT.)


| Table | Page |
|---|---|
| 4.17 The statistics and the equation of correlation patterns between the biomass of *E. acoroides* (Y) and the organic matter (X) | 84 |
| 4.18 The statistics and the equation of correlation patterns between the biomass of *E. acoroides* (Y) and the available potassium (X) | 85 |
| 4.19 The correlation between the biomass of each seagrasses and the chemical qualities of the sediment by conclusion | 86 |


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# LIST OF FIGURES


| Figure | Page |
|---|---|
| 1.1 Conceptual Frame Work | 3 |
| 2.1 *Enhalus acoroides* | 8 |
| 2.2 *Halodule pinifolia* | 9 |
| 2.3 Kung Krabaen Bay, Chanthaburi Province | 11 |
| 2.4 The natural canals around the Kung Krabaen Bay | 13 |
| 2.5 The characteristic of seagrasses distribution in the Kung Krabaen Bay | 14 |
| 3.1 The path way of collecting samples in the Kung Krabaen Bay | 23 |
| 3.2 The diagrams showing the four transect lines and the collecting stations in the summer and the rainy season, covering seagrass bed and non-seagrass bed areas | 27 |
| 3.3 The sediment collecting and fixing with toluene solution in the bag | 28 |
| 3.4 The hydrogen sulfide collecting in the field (a. Pulled the sediment from the PVC, b. Fixed the sediment with Zinc acetate in BOD bottle) | 29 |
| 4.1 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of the Ta Tar Canal (line A) | 34 |
| 4.2 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of the Ta Uoo Canal (line B) | 35 |
| 4.3 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of between the Ta Guy and Mor Suk Canal (line C) | 36 |
| 4.4 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of the Sa Lut Canal (line D) | 37 |
| 4.5 The *H. pinifolia* biomass in each transect lines in the rainy season | 40 |
| 4.6 The biomass of *E. acoroides* in each transects line | 41 |
| 4.7 The biomass of *E. acoroides* between line A, line C, and line D | 41 |
| 4.8 The pH value along the path of each transects in the Kung Krabaen Bay | 49 |


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# LIST OF FIGURES (CONT.)

**Figure** **Page**

in the summer
4.9 The pH value along the path of each transects in the Kung Krabaen Bay in the rainy season 49
4.10 The pH value of line A compared between the summer and the rainy season 50
4.11 The pH value of line B compared between the summer and the rainy season 50
4.12 The pH value of line C compared between the summer and the rainy season 51
4.13 The pH value of line D compared between the summer and the rainy season 51
4.14 The electrical conductivity of each transects in the summer 53
4.15 The electrical conductivity of each transects in the rainy season 53
4.16 The electrical conductivity of line A compared between the summer and the rainy season 54
4.17 The electrical conductivity of line B compared between the summer and the rainy season 54
4.18 The electrical conductivity of line C compared between the summer and the rainy season 55
4.19 The electrical conductivity of line D compared between the summer and the rainy season 55
4.20 The organic matters of each transects in the summer 57
4.21 The organic matters of each transects in the rainy season 57
4.22 The organic matters of line A compared between the summer and the rainy season 58
4.23 The organic matters of line B compared between the summer and the rainy season 58
4.24 The organic matters of line C compared between the summer and the rainy season 59
4.25 The organic matters of line D compared between the summer and the rainy season 59

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# LIST OF FIGURES (CONT.)

**Figure** **Page**

4.26 The total nitrogen of each transects in the summer 61
4.27 The total nitrogen of each transects in the rainy season 61
4.28 The total nitrogen of line A compared between the summer and the rainy season 62
4.29 The total nitrogen of line B compared between the summer and the rainy season 62
4.30 The total nitrogen of line C compared between the summer and the rainy season 63
4.31 The total nitrogen of line D compared between the summer and the rainy season 63
4.32 The available phosphorus of each transects in the summer 65
4.33 The available phosphorus of each transects in the rainy season 65
4.34 The available phosphorus of line A compared between the summer and the rainy season 66
4.35 The available phosphorus of line B compared between the summer and the rainy season 66
4.36 The available phosphorus of line C compared between the summer and the rainy season 67
4.37 The available phosphorus of line D compared between the summer and the rainy season 67
4.38 The available potassium of each transects in the summer 69
4.39 The available potassium of each transects in the rainy season 69
4.40 The available potassium of line A compared between the summer and the rainy season 70
4.41 The available potassium of line B compared between the summer and the rainy season 70
4.42 The available potassium of line C compared between the summer 71

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# LIST OF FIGURES (CONT.)

**Figure** **Page**

and the rainy season
4.43 The available potassium of line D compared between the summer and the rainy season 71
4.44 The cation exchange capacity of each transects in the rainy season 73

4.45 The hydrogen sulfide concentration of each transect lines in the summer 77
4.46 The hydrogen sulfide concentration of each transect lines in the rainy season 77
4.47 The correlation between the cation exchange capacity and the biomass of *H. pinifolia* as be a negative logarithm 80
4.48 The correlation between the organic matters and the biomass of *E. acoroides* as be a negative cubic 83
4.49 The correlation between the available potassium and the biomass of *E. acoroides* as be a positive inverse 85

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# CHAPTER 1
# INTRODUCTION

## 1.1 Rationale

The coastal ecosystem other than the mangrove and coral reef, the seagrass bed meadow is the one of the most abundant marine ecosystem, which provides a very high productivity and amount of economic resources. Seagrasses are a primary producer due to their photosynthesis procedure and become the main food for living organisms (Lewmanomont and Ogawa, 1994, Ogawa and Lewmanomont, 1994, and Rollon and Fortes, 1991), both in the small scale such as epiphytes and in the large scale or marine animals, such as dugong. There is a nutrient circulation within seagrass bed area that is important to phytoplankton and aquatic plants consumption (Boretone, 2000, and Rollon and Fortes, 1991). The nutrients are available from microbial degradation and debris of some dead seagrasses. Moreover, seagrass beds are a very important shelter and hatchery of juvenile fauna (Sudara et al., 1991 and Dolar, 1991). Therefore, this area has an economy value for aquatic animal marketing (Sudara et al., 1991 and Nakrobruh and Boonyubol, 1994). There are many factor requirements for growing seasons of seagrasses and their survival. Those factors are nutrients, characteristics of sediments, salinity, depth, turbidity, wind, temperature, season, and water current (Lewmanomont et al., 2534). These influence different patterns and species of seagrasses distribution in each area (Odgen and Gladfelter, 1983) and affect the capability to grow.

One of the important seagrass bed meadows in Thailand is located in the Kung Krabaen Bay, the east of Thailand. The estuary of the river is approximately 900 meters in width and has an open linkage with the sea water. Thus, there is usually mixed water circulation from the water within the bay and the outer part (Aryuthaka, 2537, Fishery Department, 2540 and Sudara et al., 1991). Around the bay, most of the local people usually do agriculture and fishery activities especially shrimp farming with intensive method (Sangrungreong et al., 1999). Many natural canals exist around the bay, namely Hin canal, Ta Uoo canal, Ta Guy canal, Mor Suk canal, Bang canal, and Salut canal (Warakuldumrongchai, 1997). Four seagrass species distribute within the bay, *Enhalus acoroides*, *Halodule pinifolia*, *Halophila minor* and *H. decipiens*. Some of them locate as

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monospecific area, and some mix. The dominant species distributed most are *Enhalus acoroides* and *Halodule pinifolia* (Aryuthaka, 1994 and Sudara et al., 1992 (a)).

Many potential of seagrass meadows led to the interest to study the relationship between the sediments and seagrass distribution particularly in the Kung Krabaen Bay. The sediment accumulation in the Kung Krabaen bay influences human activities around the main land of the bay via the river runoff from natural canals located in the north, the middle, and the south of the bay. Another source of accumulation of sediment in the seagrass community is a native-sediment existing in the bay. Therefore, the physical and chemical of sediment qualities may be the causes of the differential seagrass distribution.

## 1.2 Conceptual Study

*Enhalus acoroides* and *Halodule pinifolia*, dominant species distributed in the Kung Krabaen Bay, exist in separate locations of the bay. Most area contains the monospecific seagrass covering the large areas while both species mix only in a very tiny area. The different areas that the *E. acoroides* grows have differed from those of *H. pinifolia* because of the accumulation of the sediment. Such sediment comes from the natural canals in the north, the east and the south of the bay, which settle down along some distance near the shore to the estuary of the river. The sediment characteristics, both physical and chemical qualities, may be different between the area close to the influence from human activities in the mainland (mangrove area) and the area farther from the mangrove. This study focuses on the relationship pattern of sediment qualities to seagrasses distribution and biomass, which is the main cause of different. The conceptual framework is shown in Fig. 1.1

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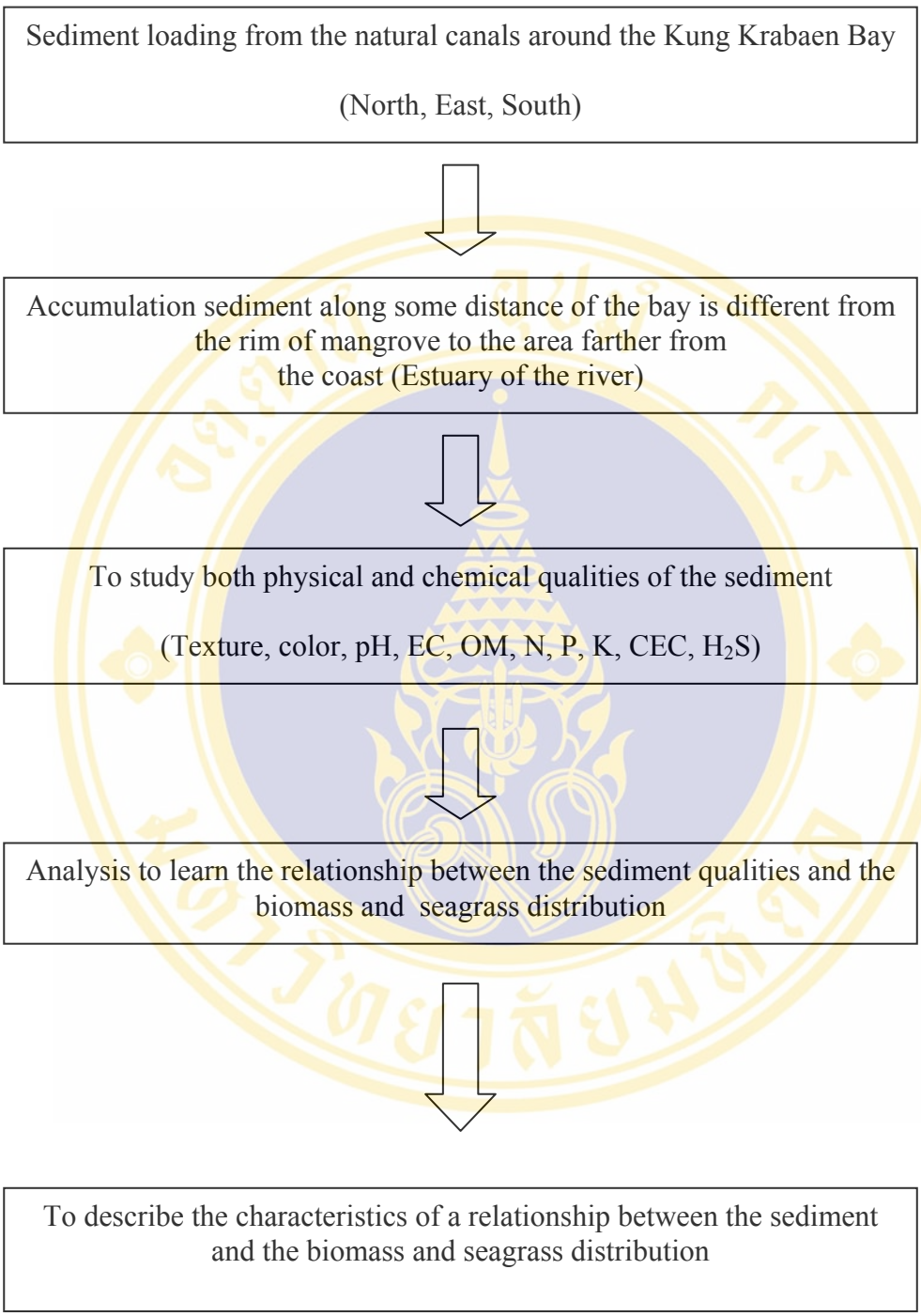


**Fig 1.1 Conceptual Frame Work**

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### 1.3 Hypothesis

The sediment factor qualities related to the distribution of *Halodule pinifolia* differ from those related to *Enhalus acoroides*.

### 1.4 Objectives

1.4.1 To analyze the form of the relation between seagrass biomass (*H. pinifolia and E. acoroides*) and sediment qualities.

1.4.2 To study the variances of sediment quality parameters along the path due to river runoff through the natural canals around the Kung Krabaen Bay.

### 1.5 Scope of study

1.5.1 Study both chemical qualities (pH, EC, OM, N, P, K, CEC, $H_2S$) and physical qualities (texture and color) of the sediment in the seagrass and non-seagrass communities within the Kung Krabaen Bay.

1.5.2 Study site and sample collection stations perpendicular to the rim of the mangrove forest and parallel to the natural canals. There are four sites covering the north, the middle, and the south of the Kung Krabaen Bay.

### 1.6 Timing

The study of sediment qualities related to biomass of seagrasses was carried out for one year in year 2003. The purpose is to cover both the summer and the rainy season due to the differences of rain fall quantities and water currents in the Kung Krabaen Bay. From March to April and from May to the mid of October the bay faces Southwest monsoon. There is a high rainfall level during this time. Whereas from the mid of October to February, the Northeast monsoon affects the weather in this area to become cool and dry.

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The statistic information from the Meteorology Department dated back for ten years (since 1993-2002) reported that the average rainfall level in each month in Thamai district, Chanthaburi province, reaches the highest level in September. The lower average level is in June. Even though there are decreasing rain fall levels from May to September, the levels are higher than some months (The Meteorology Department, npd.).

The season to collect sediment and biomass samples was divided into 2 periods. The first one was in the summer (February to May) and the last was in the rainy season (June to October).

**1.7 Purpose of Study**

1.7.1 To learn the differences in sediment qualities (physical and chemical) of seagrass meadows and non-seagrasses areas, and to acquire the variance along the sample paths in each site (North, East, and South).

1.7.2 To learn which of the sediment qualities related to seagrass biomass (*H. pinifolia* and *E. acoroides*) are the importance parameters affecting the distribution in the Kung Krabaen Bay.

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# CHAPTER 2
# LITTERATURE REVIEW

## 2.1 Seagrass Ecosystems

### 2.1.1 The value of seagrass meadows

The segrass meadow, a marine ecosystem, consists of the seagrasses as the major population. The seagrasses are the flowering aquatic plant with a natural structure similar to grass-land, which adapt to submerge (Fortes, 1994a and Fortes, 1994 b). They are able to grow near the coast in the calm wind and less water currents. The area that is covered with seagrasses is a large place and is mostly under the water which is unlike other marine plants and mangroves. The characteristics and shapes of seagrasses vary among species (Lewmanomont and Ogawa, 1994 and Lewmanomont and Ogawa, 1995). The structure area is very complex in the shallow water environment, as being the habitat of various organisms. The diversity in the community is important to the rule of food chain (Aryuthaka, 2001, Sudara et al., 1991, Sudara et al., 1992b, Rollon and Fortes, 1991, and Nakrobruh and Boonyubol, 1994). In addition, this area is very productive with photosynthesis prosesses, as a primary food source for the marine animals (Lewmanomont and Ogawa, 1994, Ogawa and Lewmanomont, 1994, and Rollon and Fortes, 1991). Nutrient circulation takes place within the seagrass community (Bore, 2000, Rollon and Fortes, 1991), a shelter and hatchery for juvenile fauna (Sudara et al., 1991 and Dolar, 1991). Onate et al.(1991) reported that a very high biomass of seagrasses resulted in the high productivity of invertebrates. Because of the thick area with seagrasses, coverage alone with their roots and rhizome to hold the sediment, the coast erosion can be reduced (Natural resources conservation office, 2000, and Rollon and Fortes, 1991).

Seagrasses in Thailand are distributed both in the Thai Bay and the Andaman Sea (Wilkinson, 1994, Nateekanjanalarp et al., 1991, Lewmanomont and Ogawa, 1994 and Ogawa and Lewmanomont, 1994). The characteristics of the distribution depend on many environmental factors, such as turbidity, water depth, and even the sediment, an important sink of nutrients for the growth of seagrasses (Nateekanjanalarp and Sudara, 1992). The

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Kung Krabaen Bay contains seagrasses in the large area dominated by *Enhalus acoroides* and *Halodule pinifolia* (Aryuthaka, 1994 and Sudara et al., 1992a).

2.1.2 Environmental factors affecting the seagrasses, growth and survival

Many of the environmental factors affect the seagrass communities, such as transparency, sunlight, water temperature, nutrients, salinity, nitrate concentration, phosphorus, and sediment (Nateekanjanalarp and Sudara, 1992, Sudara et al., 1992a, Ogawa and Lewmanomont, 1994 and Lewmanomont and Ogawa, 1994). In the area with fluctuation of salinity, seagrasses are more tolerating, whereas the less salinity-tolerant seagrasses only grow in steady saline water. The study by Lewmanomont et al. (1991) found that various of seagrasses species in Thub Lamu, Thaimung district, Pang Nga province were growing in 15-30 ppt of salinity, while there was 32.9-33.4 ppt in Kung Krabaen Bay (Aryuthaka, 1994). The tropical seagrasses is able to tolerate low salinity better than the temperate species (Larkum et al., 1989).

Nateekanjanalarp and Sudara (1992) reported in the "Species composition and distribution of seagrasses at Koh Samui, Thailand" that the water depth, turbidity and substrate characteristics of the sediment affected the seagrasses distribution in different forms. Seagrasses could be on the coarse sand, coarse sand and mixed with coral fragment, sand missed with clay, and fine clay. The two species of seagrasses in the Kung Krabaen Bay (Aryuthaka, 1994, Sudara et al., 1991, and Sudara et al., 1992a) distributed on substrate which was clay mixed sand and shell fragments. Moreover, there are organic matters deposited 40 centimeter thick.

The temperature, one of an important environmental factor, affects seagrasses survival and tolerance which grow in the shallow water and expose to sunlight during low tide in the day time (Lewmanomont et al., 1991, and Ogawa and Lewmanomont, 1994). Seagrasses are able to grow even in fluctuated temperature, in a wide range from 0 to 40°C. But in Thailand, they can tolerate in 28-32 ° C and less tolerant when the temperature is higher (Larkum et al., 1989). Another important factor to survival is sunlight. Nateekanjanalarp and Sudara (1992) reported that in the rainy season the biomass of seagrasses in the Koh Samui was higher than in the summer. Moreover, Joyner (2004) reported that whenever the sunlight was decreased the growth level of seagrasses was also decreased

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However, the limiting nutrient of seagrasses was accumulated in leaves and roots or rhizomes as nitrogen and phosphorus (Ogawa and Lewmanomont, 1994). In the

summer, Short et al. (1993) found that *Syringodium filiforme* community produced ammonium concentration very rapidly in the sediment. Because the high requirement of seagrasses consumption decreases, that is a reason for high ammonium in the sediment, agreeing with Hillman et al. (1989) who reported that when seagrasses yield high productivity, there are a lot of nutrient requirements. Thus nitrogen and phosphorus become the limiting factors in seagrass communities.

2.1.3 The *Enhalus acoroides* and *Halodule pinifolia* information

*Enhalus acoroides* is namely a tropical eelgrass (Fig. 2.1) (UNEP, 2004). It is a large structure with a 0.7-1.7 cm diameter. The stem is straight from the rhizome which holds the sediment at 30-50 cm deep. There are 2-5 leaves. Flowers and big fruits can found all the year. The reproduction takes place at the water surface in the low tide of low water neap (Lewmanomont, 1991, Lewmanomont and Ogawa, 1994, Lewmanomont et al., 1991, and Lewmanomont and Ogawa, 1995).

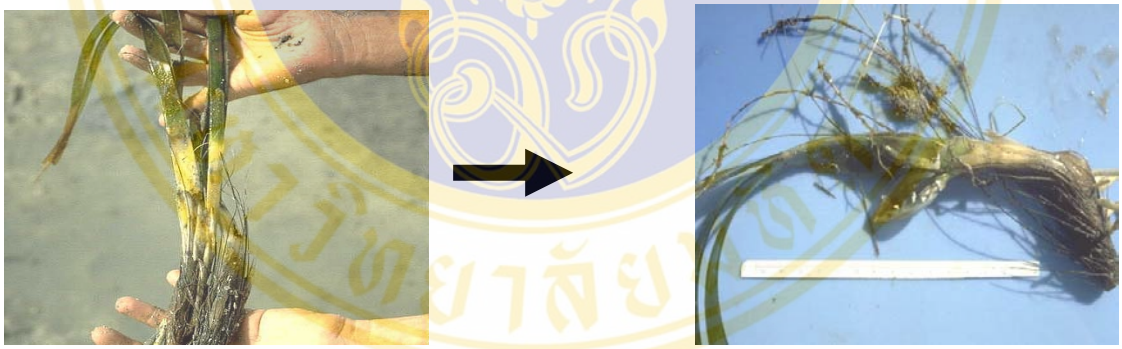

**Fig. 2.1 *Enhalus acoroides***

This species can be found in Chanthaburi, Trad, Surathani, Nakornsrithummarat, Satul, Trang, Krabi, Phang Nga, and Ranong (Sudara et al., 1989, Sudara et al., 1994, Sudara et al., 1991, Lewmanomont and Ogawa, 1994, and Nateekanjanalarp, 1991). The high distribution is in both the marine and the estuary with sandy and clay substrate. Johnstone (1979) and Lewmanomont and Ogawa (1994) reported the *E. acoroides* can found in sediments like clay, clay mixed with sand and coarse sand mixed with coral fragments. It could be in the shallow water or in the canals connected to the sea as a patchy (Nienhuis et al., 1989) and widely spread form. Nateekanjanalarp et al. (1991) reported that they found *E. acoroides* distributed on the coarse sand between the beach and coral reef at a 1-2 meters deep. Nateekanjanalarp and Sudara (1992) also reported in the study of

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this species and seagrass distribution in Samui Island, *E. acoroides* was found at a 0.5-1.0 meter depth. Sometimes in the lowest tide, the *E. acoroides* can emerge over the water surface. The location of this species cannot be too deep also because of reproduction by flowers at the water surface. Its strong rhizome and roots can hold the sediment and protect the coast (Lewmanomont et al., 1991, and Ogawa and Lewmanomont, 1994).

*Halodule pinifolia* is namely a fiber-stand grass (Fig. 2.2) (UNEP, 2004) with a thin vertical stem shape. It is of 0.4-1.0 mm diameter with no flower and fruit. The sediment is usually mud mix with the sand. The distribution is in the shallow part of the coastal area in tidal zones (Lewmanomont et al., 1991, Lewmanomont and Ogawa, 1994, Lewmanomont et al., 1991, and Lewmanomont and Ogawa, 1995).

**Fig. 2.2 *Halodule pinifolia***

The distributions found in Thailand are in Trad, Chanthaburi, Rayong, Prachuabkirikan, Songkla, Phuket, Trang, and Pang Nga (Sudara et al., 1989, Sudara et al, 1994, Sudara et al., 1991, Lewmanomont and Ogawa, 1994, Ogawa and Lewmanomont, 1994, and Nateekanjanalarp, 1991). It usually locates in sand and mud mixes with the sand near the coast (Poomwan, 1993, and Lewmanomont and Ogawa, 1994). Moreover, Nateekanjanalarp et al. (1991) reported that *H. pinifolia* was also distributed in sand and rather turbid areas in tidal zones; it was able to grow at a 3-8 meter deep since only inundated to a 3 meter deep at the lowest tide (Ogawa and Lewmanomont, 1994). Moreover, Hatog (1970) reported in Lewmanomont et al. (1991) that *H. pinifolia* is the pioneer species in the first period, and after other species succeeded in the same area of *H. pinifolia*, it disappeared (Lewmanomont et al., 1991).

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2.1.4 Problems of seagrass deterioration

At present, many seagrass bed areas are decreasing because of rapid industry development, sediment accumulation, pollution, aquaculture or other natural causes such as Typhoon or diseases (Fortes and Sudara, 1994). There have been losses of seagrass bed areas in Thailand of about 20-30%, and that is affecting the fishery activities within the community of seagrass (Poovachiranon et al., 1994a), and Poovachiranon et al., 1994b). Furthermore, a lot of intensive shrimp farming is one of the causes of the seagrass beds loss through wastewater discharge (Satumanaspan et al., 2000). Fish farming, a cause of more sedimentation and less photosynthesis, causes the death of *Posidonia oceanica* (Ruizm et al., 2001). In addition, seagrasses are destroyed by human activities such as people settlement and tourism development (Azkab, 1992). The cause of seagrass deterioration (Natural Resources Conservation Office, 2000, and Sudara et al., 1994) can be partially listed as:

**Natural causes**

1) Monsoon and Typhoon are the cause of turbidity affecting the growth rate and survival

2) Seagrasses are the food for marine animals such as dugongs, sea-turtles, and fishes. Much of consumption on seagrasses is inadequate.

**Human activities**

1) Deforestation is a cause of high sediment accumulation in the river. The river runoff into the seagrass community will reduce seagrasses.

2) The mining activities near the coastal zone are causes of sedimentation in seagrasses community.

3) Coastal fisheries with illegal fishing gear deteriorate seagrasses meadows rapidly. Wastewater drainage from aquaculture farms affects water qualities and seagrass growth rate.

4) Wastewater discharge from factories into seagrass bed areas is high water temperature and contamination causes. The danger is not only upon water quality and seagrasses, but also other living organisms.

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## 2.2 Study Site

The Kung Krabaen Bay has a shape like a ray fish (Fig. 2.3), 5 km long and 3 km wide. The estuary of the river is connected to the sea in the west with a 900 meter wide (Fishery Department, 1997, and Sudara et al., 1991). The Kung Krabaen Bay is small and shallow. The average depth is 1.5-1.8 meters, and the deepest does not exceed 8 meters. The area within the bay is approximately 640 ha. The bay is somewhat closed and has no terrible winds or strong currents of water. Both in the north and south of the bay is a watercourse, whereas in the middle of the bay is shallower than sides. The south coast are covered by with mangrove forest dominated by *Rhysophora spp.* Seagrass distribution in the bay are *Enhalus acoroides* and *Halodule pinifolia* (Sudara et al., 1992b). The substrate of the bay is mud and mud mix with the sand (Department of Fishery, 1993a, Department of Fishery, 1993b, Aryuthaka, 1994, and Sangrungreong and Dumruk, 1998). Sea water runs through the bay via the estuary of the river which is about 600-700 wide. Around the bay is an inundated plain from sediment accumulation. There is only one period of the highest and lowest tides each day (Department of Fishery, 1993a) and Department of Fishery, 1993b).

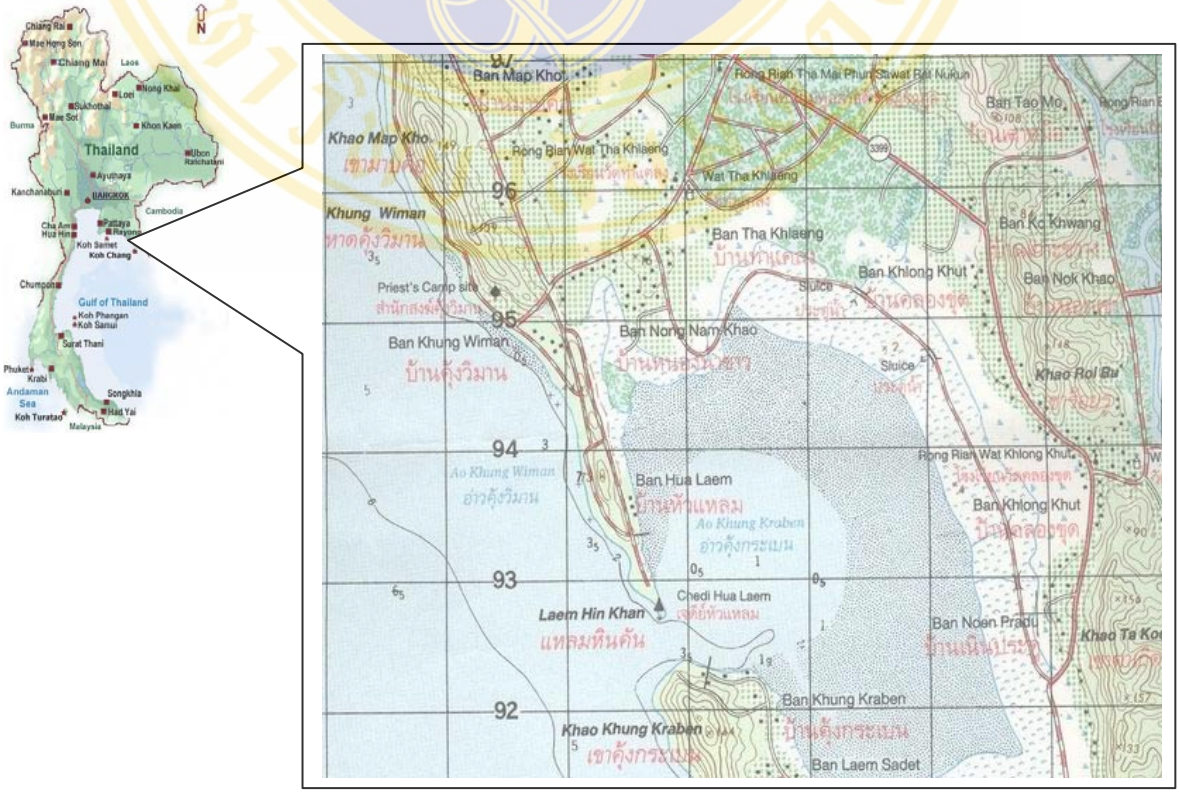


**Fig 2.3 Kung Krabaen Bay, Chanthaburi province, 1: 50,000 (Royal Thai Survey Department, 1998)**

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The area which is connected to the Kung Krabaen Bay, the outer of the Kung Krabaen Bay Royal Development Study Center, is covered with mangrove forest both poor and rich abundance. Most of the area in the east of the Study Center is a paddy field and some shrimp farms. Particularly, the area, which is near the road of the Study Center, consists of a lot of shrimp farms due to the ease to pump seawater into the farms. Before estuary irrigation, the wastewater had been passed through the natural canals (Fig. 2.4) by controlling with the water gates. The natural canals around the Kung Krabaen Bay are Pla Chon Canal, Salut Canal, Bang Canal, Morsuk Canal, Ta Guy Canal, Ta Uoo Canal, and Hin Canal. There are some manmade canals linked to the natural canals to pass new seawater to shrimp farms. Water drainage runs through the manmade canals and then reaches to the Kung Krabaen Bay (Department of Fishery, 1993b). Intensive shrimp farming is a cause of organic matter accumulation in the bay (Sangrungreong and Dumruk, 1998). The study by Boonyaratpalin et al. (2002) reported that the effects of shrimp farming to sediment qualities in the Kung Krabaen Bay after estuary irrigation establishment, the trend of organic matter accumulation was higher. The possible organic matter source was from shrimp farms and mangrove forests, whilst the degradation of organic matter was lower, due to the treatment system of estuary irrigation.

The estuary irrigation of Kung Krabaen bay is the first project of Thailand which consists of water input systems and water treatment. Sea water is taken out of the bay by 8 pumps and via the concrete canal of 8,820 meter long, to the shrimp farms around the bay. After that the seawater will get into the ponds by the law of gravity (Sangrungreong et al., 2000). The water from shrimp farms is treated by sedimentation ponds of the shrimp farmers, run to aerator ponds and settled down the sediment again in aerator canal before letting it into the bay (Kongpung, 2001). This estuary irrigation provides for shrimp farmers the good seawater to shrimp ponds and to drain wastewater via another pathway to decrease contamination. The treatment of the water before reaching the bay is done by a natural system, which is a mangrove forest. Moreover, sedimentation in manmade canals is effective. Thus the sediment accumulation in the bay is not different from before using the estuary irrigation. Sangrungreong et al. (2000) reported that the effects of shrimp farming on the environment, particularly the sediment in the bay, after estuary irrigation was established, was not different from before, in terms of the average of organic matters, organic carbons and C:N ratio. This result is similar to that of Boonyaratpalin et al. (2002) that found that organic matters before and after irrigation was not different, while the pH value and C:N ratio were different. Due to these reports shows that the estuary irrigation system does not decrease effects of organic matter accumulation, whereas some

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parameters such as C:N ratio still difference between before and after using the irrigation. Thus, some sediment accumulation in the Kung Krabaen Bay may effect by wastewater canals, and becomes the cause of relationship between sediment qualities and seagrass distribution.

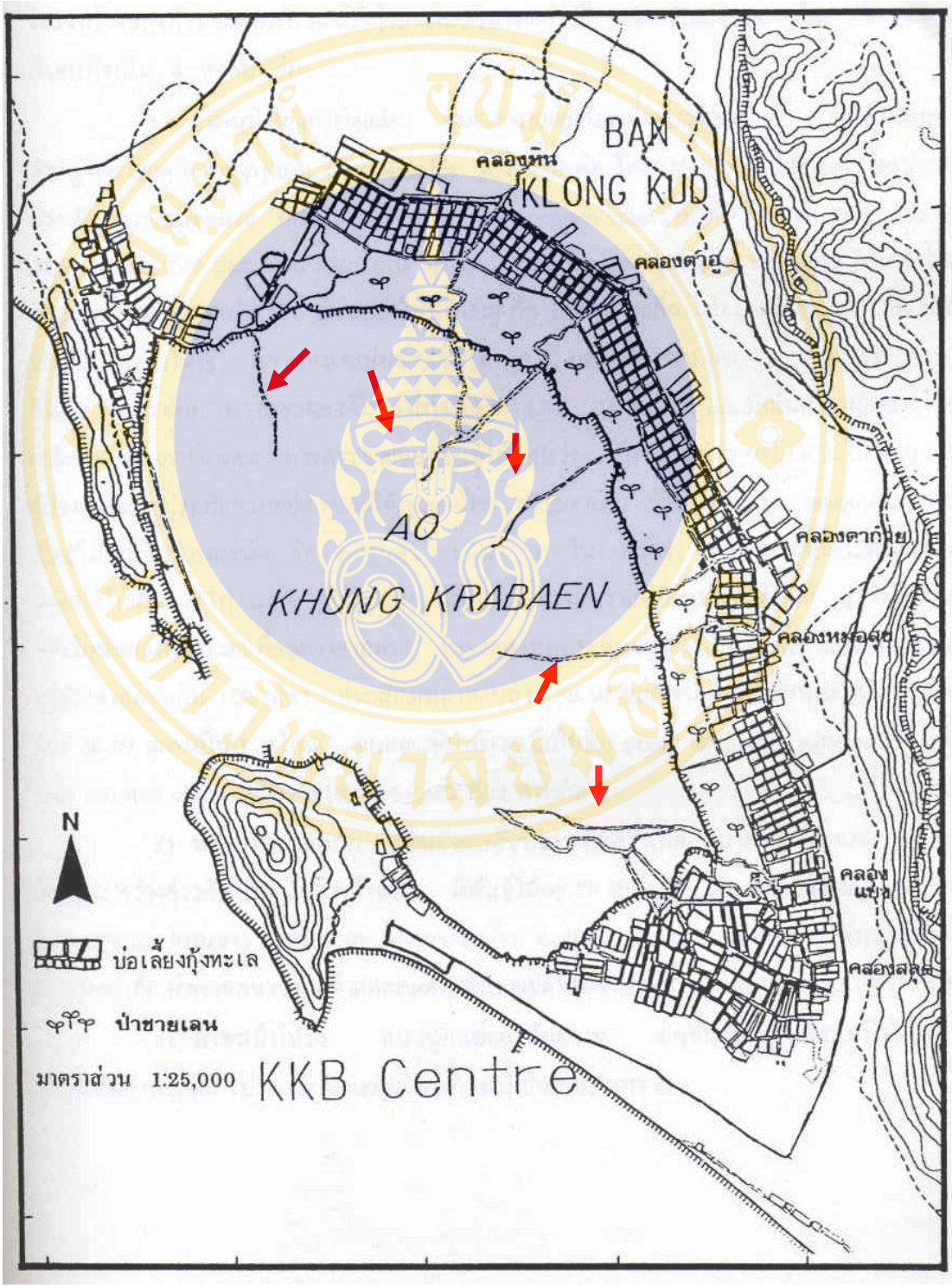


**Fig. 2.4 The natural canals around the Kung Krabaen Bay**

**(Source: Worakuldumrongchai, 1997)**

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The seagrass distribution in the Kung Krabaen Bay is dominated by *Halodule pinifolia* and *Enhalus acoroides* (Aryuthaka, 1994 and Sudara et al., 1992a). *E. acoroides* was found widely spread along the coast in the northwest of the bay, whilst the *H. pinifolia* was found near the north and the east sides of the bay (Sudara et al;, 1992b) as show in Fig. 2.5

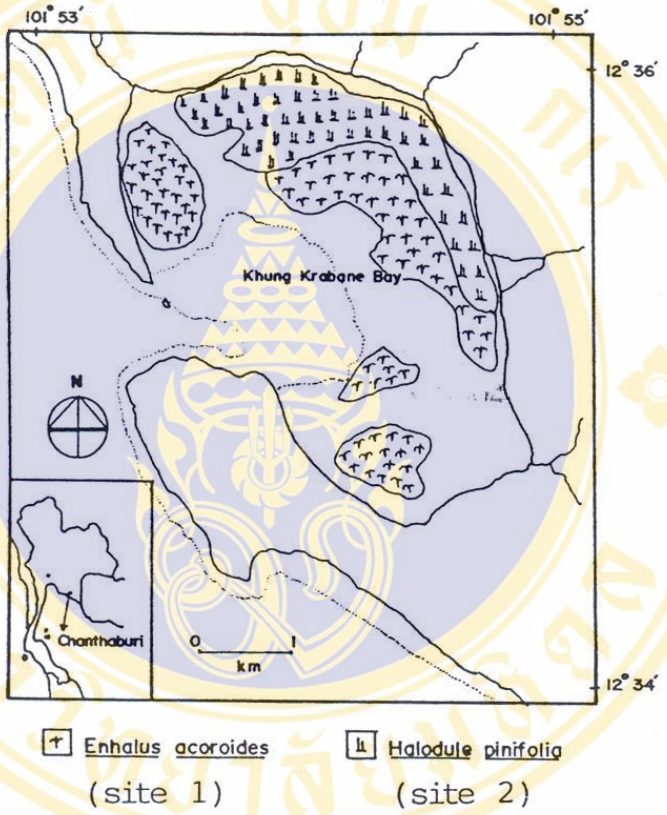


**Fig. 2.5 The characteristic of seagrass distribution in the Kung Krabaen Bay (Source: Sudara et al., 1992b)**

## 2.3 Sediment Characteristics in the Kung Krabaen Bay

Most of the sediment texture is sandy clay loam or clay and mixed with shells. The organic matter accumulation is 40 cm thick. Because of the coastal saline soil is under sea influences, salt composition in the sediment is similar in the seawater. Salt concentration, which depends on the frequency of the tides in a day, rain fall quantities, soil types and soil level steadies, wind, and flora coverage, is different in various areas. The physical qualities of sediment existing very close to the coast are usually clay or mud, or muddy sand. The sediment far from the coast has more sand characteristic. The chemical qualities are usually dominated by sodium chloride ($NaCl_2$) and salty

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(Navanugrah, 1986). Moreover, the coastal area in the east of Thailand is affected by seawater making sediment characteristics sandy, having a low quality of agriculture, being shallow, and consisting of gravels (Keawreonrom, 1990). Thus, the sediment in the Kung Krabaen Bay, Chanthaburi province, is differential because of the sediment origin. Most of sediment characteristic in the Kung Krabaen Bay is sand. The study of physical and chemical qualities of sediment in the Kung Krabaen Bay by Sangrungreong and Dumruk (1998), reported that physical qualities of the sediment along the contour line located in the north (nearly the Ta Tar and Ta Uoo canal) was sandy loam. The south (between Ta Guy and Morsuk canal, and Salut canal) was sandy loam. The sand quantity in texture of the southern sediment is more than in the north. Whereas silt and clay in the south was lower. The reported of study the effect of the estuary irrigation to sediment qualities in the Kung Krabaen Bay found there is high acidity and high concentration of organic matters at the rim of mangrove forest both before and after irrigation establishment. In addition, the nitrogen and phosphorus at the rim of mangrove is higher concentration than the farther area (Sangrungreong, 2000). Aryuthaka (1994) reported in the study of seagrasses in the Kung Krabaen bay that the sediment located at the estuary of the river to the middle of the bay, was very fine sand and some mixed in patchy. The upper part of sediment was muddy and clay with 22-47 %, which was higher mud in northern. However, Sanguansin (1989) reported the sediment of the sea-bottom was different which some was clay missed with sand, sandy clay, and clay or muddy. Along the coast from the out of shore line of Rayong province to Chanthaburi province was clay mixed with sand and more silt-clay at the eastern.

The line of organic matter accumulation and physical qualities, which existed in the north and the south of the Kung Krabaen Bay, were acidity and contained high phosphorus concentration. The available phosphorus concentration was decreasingly and lowest in the middle of the bay as same as acidity. In the north and south of the bay there was a very high concentration of organic matters, total nitrogen, C:N ratio and $BOD_5^{20}$, and was decreased in the middle of the bay, which C:N ratio and $BOD_5^{20}$ were lowest. Whereas the organic matter accumulation in the south of the bay was very low to medium concentration (Sangrungreong and Dumruk, 1998).

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## 2.4 The effects of sediment to seagrasses

The sediment is a substrate for seagrasses to grow up and a habitat for other marine organisms. In the sediment consists of organic matters which are from bacterial degradation and debris. The nutrients are from the sedimentation and organic matters which float from the mangrove source (Bore, 2000). However the degradation in the sediment is a one of cause to add more nutrients and uptake by aquatic plants and seagrasses. Thus, the sediment, physical and chemical characteristics, affects the living organism distribution in different structure.

The physical characteristics of sediment such as the sediment size which contains the particle with an equivalent diameter less than 2.0 mm. There are 3 groups as sand silt and clay that has different size follow the rule of ISSS and USDA system. The triple of those particles are assembled to be different texture depends on percentage of sand, silt and clay (The committee of soil dictionary, 1998). The characteristic of clay, clay mix with sand, and coarse sand mix with coral fractions are usually found the *E. acoroides* and *H. pinifolia* distribution (Johnstone, 1979, and Lewmanomont and Ogawa, 1994).

There are many parameters of chemical characteristics of sediment which are interesting such as;

### 1) The acidity and alkalinity of sediment

Due to the soil reaction in the sediment acidity and alkalinity are able to measure with pH value. The pH value ranges from very acid (pH<3.5) to very alkaline (pH>9). The sediment with pH about 6.6-7.3 is neutral, lower than 6.6 is acid and much more than 7.3 is alkaline (The committee of soil dictionary, 1998 and The institute for the promotion of teaching science and technology, 2004). The suitable pH value for the photosynthesis process in the sea water is 8.2 (Larkum et al., 1989), which contains much necessary organic carbon supply for the process. Sanrungreong et al. (1999) found the sediment in the wastewater canal and the coast of the Kung Krabaen Bay was acidity and was decreased at the farther area. Agreeing with the report of the study of sediment in the Kung Krabaen Bay before and after estuary irrigation establishment which found the rim of mangrove was acidity and had more organic matter accumulation with high level (Sangrunreong, 2000). The differential between acidity and alkalinity characteristics were the result of the microbial degradation, particular the reducing sulfur microbes, to change the form of sulfur (S) in the sediment to the $H_2S$ form (Peter and Sivasoth, 2001).

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**2) Organic matter**

The quantities of organic matters in the seagrass beds depend on texture characteristics such as the sand or the mud. The organic matters consist of the organic carbon and the organic nitrogen. The sediment with a high carbonate concentration has the low organic matter (Kiswara, 1994). The dead of seagrasses and debris are the cause of the high nutrients, which accumulate in the organic matter form, in the seagrass beds (Bore, 2000). The study of Jindanuch (2003) found the flora debris in the mangrove forest (by litter leaves) fall down in the summer higher than in the rainy season. The nutrients in the organic matters are important for seagrasses uptake to grow up. In the *Halodul wrightii* in Florida, USA, the organic carbon was up taken from sediment within 6 hours. The rate of uptake was available at the 40 mm of the upper part of sediment, where the dense of roots and rhizomes were existed. In addition the uptake ratio was available more than in the deeper due to the bacterial activities (Larkum et al., 1989). The organic matters circulation affect the structural habitat of the benthic fauna that Ford et al. (2001), who studied about the effects of the organic matter circulation in the water with the soft substrate, found the too much organic matters in the system affected the juvenile decreasing.

Moreover, the *Halodule wrightii* was released organic carbon from the roots and rhizomes. This organic carbon collaborate the product of bacteria degradation in sediment 20-40 meter deep. The organic carbon released from bacteria was emitted per day about 14 % *Halodule wrightii* emitting and exudation. This exudation of organic carbon also affects the growth of bacteria (Moriarty et al., 1986). Furthermore, the sediment in wastewater canals of the Kung Krabaen Bay consisted of the highest organic matters and was decreased at the farther than the coast (Sangrungreong et al., 1999 and Boonyaratpalin, 2002). The study of Aryuthaka (1994) about the seagrasses in the Kung Krabaen Bay and she found the average of organic matter accumulation in *Enhalus acoroides* bed was 24.3 mg/gdw (0.0243%), whilst the average of organic accumulation in sediment of *Halodule pinifolia* bed was 11.9 mg/gdw (0.0119 %).

**3) Nutrients in the sediment**

The available nutrients in the sediment are the result of the degradation microbial process. In the area with contains the high carbonate concentration is less absorbent nutrients capability (Kiswara, 1994). An essential elementary for growth of plants is nitrogen, phosphorus, potassium, sulfur, magnesium, calcium, manganese, iron, copper,

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zinc and others. The element which plants consumption requires so much and inadequate called limited nutrients. Nitrogen and phosphorus in the sediment are the limiting factor of seagrasses (FRTR, 2004, Short et al., 1993 and Huebert, 1996). In the report of Bulthuis and Woelkerling (1981) had found the nitrogen and phosphorus in the *Herozostera tasmanica* bed, Western Port, Victoria State, Australia, are limiting factors.

The nitrogen that seagrasses uptake for the growth that Boon (1986) reported the mainly nitrogen source was from the ammonium, whereas the nitrate and nitrite were less requirement for seagrasses. He found the ammonium-nitrogen ratio in the seagrass beds was higher than in the non-seagrass beds and coral areas. In the growing season of seagrasses the requirement to fix nitrogen was a high rate about 10-450 mg N $m^{-2}d^{-1}$, whilst had less requirement of nitrate and nitrite. This higher rate of ammonium concentration in the seagrass beds than non-seagrass beds because of the change form process such as the denitrification, the degradation, and dispersion of sediment (Larkum et al., 1989, Boon, 1986, and Dawes, 1998). However the nitrate and nitrite were less concentration than the ammonium in the seagrass beds, but the nitrate was higher than nitrite (Short et al., 1993). Pathong (1999) reported the *E. acoroides* exuded the nitrogen by the nitrate form. The suitable of nitrate concentration to grow to be the seedling was 0.01 mg/l with the 20-25 ppt saline water. Sawatpong (1998) reported the *Halophila ovalis* was able to absorb the ammonium, nitrate, and orthophosphate with the high rate by the density only 2 $kg/m^2$. The exudation ratio was very high at first period and it would be decreased after the time passed.

The study of the nitrogen accumulation in the sediment by Songsangjinda et al., (2000) reported the nitrogen form had settle down as a particle more than had an emission to the surface in the Kung Krabaen Bay. The suspended nitrogen and the sediment circulation were the cause of nitrogen changes by the water mass absorption, and become the high sedimentation at the bottom of the bay. Tunvilai et al. (1993) studied about the total pollutants, which were released from the 0.32 hectares of the intensive shrimp farms, such as ammonia-nitrogen, nitrite-nitrogen, and nitrate-nitrogen. These elements might be the cause of bad water quality in the bay. However Sangrunreong et al. (1999) reported the effect levels of these pollutants to the sediment in the Kung Krabaen Bay was low. Even though some of nitrogen from the shrimp farms was settled down to the bottom of the bay, but the denitrification process at the deeper was the cause of decreasing nitrogen in the sediment by the nitrogen gas releasing. Anyhow the nitrification process was also able to be in the deeper near the rhizomes of seagrasses and the pore of fauna (Larkum et al., 1989). The nitrogen accumulation in the Kung Krabaen Bay, Sangrungreong et al (1999)

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reported, the highest level was upon the water canal. The level of nitrogen concentration was decreased at the wastewater canal, the coast, and the 500 meters and 1,000 meters far from the coast, respectively. Along the deep of sediment at the 0-5 cm. deep in the water canal, the nitrogen concentration was higher than the deeper. This concentration was same at the 500 meters far from the coast. Whilst the mid of the bay there was less different nitrogen concentration between the surface and the deeper.

The studied of the nutrients in the seagrass beds by Bore (2000), which carried out in the Inhaca Island, Mozumbique, focused on the carbon-nitrogen and phosphorus from the litters. He found the both of nutrients were a high level concentration and become the main food of the living organisms. Moreover, Short et al (1993) reported the ammonium concentration at the 15 cm. of the sediment particular in July (growing season of seagrasses) less than in September or January. Anyway the ammonium concentration at the 5-10 cm. and at the 10-15 cm. was low in the summer and high in the winter.

Phosphorus is another limiting factor of marine ecosystem, particular in the seagrass beds which contain the high calcium from shells in the sediment. Phosphorus is usually high concentration at around the roots of seagrasses and less in the deeper part or non-seagrasses area. Phosphorus uptake is good in both leaves and roots or rhizomes. The dissolve phosphorus is available in the upper part of sediment (Larkum et al., 1989 and Dawes, 1989). The studied in *Syringodium filiforme* by Short et al. (1993) who reported the phosphate concentration was very high and more various available than ammonium concentration. In general the phosphate concentration was usually exists at the 5 cm. of the upper part in sediment. The available phosphorus concentration in the Kung Krabaen Bay was high in the water canal and less in the sediment at far from the coast (Sangrungreong et al., 1999).

Potassium in the sediment is an essential element for the growth of plants. However, there is no reported the potassium is a limiting nutrient as same as phosphorus and nitrogen. Nevertheless, the reported about the nutrients in the mangrove forest at the Kung Krabaen Bay that the most of nutrient which available from a high to a low concentration level in the sediment was sodium, magnesium and calcium, respectively. The less which available was potassium concentration. Anyway, the nutrients in the sediment of mangrove forest were still abundant (The Royal of Kung Krabaen Bay Study, npd.). Gimenez et al. (2004) reported the potassium concentration and the leaves of a pomegranate were negative correlation. Moreover, in the growing season of the aquatic angiosperm the potassium and nitrogen uptake was a high concentration and was collected in the top layer of the leave-tissue of plants (Hsun et al., 2000).

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**4) Hydrogen sulfide gas in the sediment**

Even though there is some reports about the toxic of the hydrogen sulfide concentration only 0.1-0.2 ppm is able to danger the benthic organisms (Tanvilai et al., 1994), but some researchers such as Penhale and Wetzel (1982) who studied about the structural and functional adjustment of eelgrass (*Zostera marina* L.) to anoxic condition in the sediment and reported the in situ and laboratory experiment this seagrass was able to protected itself from anoxic condition. The mechanism of their roots was build up more spaces in the roots to explore with the oxygen and scatter easily even in the short time within 24 hours. The studied of transmission of the sulfur gas between the sediment and the aerial by Bodenbender J et al. (1999) with a dynamic chamber technique at the dry sediment of low tide from surface to the 70 cm depp, was found hydrogen sulfide emitted to the atmosphere ranged from 0.07-9.95 μg S $m^{-2}$ $h^{-1}$. This hydrogen sulfide releasing was the lowest value at the fine sand, whilst in the muddy site was the highest emission. In the night time the hydrogen sulfide emission was 10 folds of day time. This rule is obviously in the summer more than in the spring or fall season. However, the hydrogen sulfide emitted to the air still less than the production of the sulfur reduction. There was a report of the seagrasses dead due to too much hydrogen sulfide accumulated in the sediment such as in the *Halodule wrightii* bed or *Thalassia testudinum* bed in the Florida Bay (Dawes, 1998 and Carlson et al., 2004). The sulfate reduction bacteria in the sediment were the one of a cause of the hydrogen sulfide gas accumulation, especially at the 16 cm deep in the sediment. The hydrogen sulfide accumulation in the sediment was able to flux and dissolve in water (Bruchert et al., 2003).

**5) The Cation exchange capacity and the electrical conductivity**

The Cation exchange capacity (CEC) and the electrical conductivity (EC) are the chemical qualities which affect the nutrients absorbent of plants. The half of CEC particles are affected by the organic matter in the sediment (Keowreonrom, 1999). The CEC depends on many factors such as quantities and type of the clay particles. These particles which are the very fine particles contain the higher CEC than the course particles. The organic matter contains the highest CEC when compares with other colloidal. Moreover, the CEC also depends on the pH value (Monjareon and Sanguansupayakorn, 2001). It is a result of a summary of the cation particles which are able to exchange and the sediment

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can hold in. The EC is electrical conductivity of the solution which is extracted from the sediment saturated or the water conductivity (The committee of soil dictionary, 1998).

The physical and chemical qualities of the sediment are correlated with the growth rate and the distribution of seagrasses both direct and non-direct. The direct utility is to provide the nutrients for seagrasses uptake. The indirect utility is to help the sediment hold many nutrients and seagrasses are able to uptake those nutrients easily. In this study the researcher is interested in the study of a relation of physical and chemical qualities of sediment with seagrasses biomass (*H. pinifolia* and *E. acoroides*). The physical qualities are color and texture. The chemical qualities which focus to study are the pH, EC, OM, Total N, avai P, avai K, and CEC. Moreover, another chemical quality is $H_2S$ accumulation in the sediment both on seagrass beds and non-seagrass bed. These results of the study will be the base of data to investigate how much level of the toxic in the sediment in the Kung Krabaen Bay.

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# CHAPTER 3
# METHODOLOGY

This study is a survey study in situ of the Kung Krabaen Bay. The sediment and seagrass samples were collected from the field and analyzed in the laboratory in order to evaluate their physical and chemical characteristics. The details on equipment, methodology, and analyses are described below:

## 3.1 Tools and equipment

1) A satellite map of the Kung Krabaen Bay (LANDSAT 5), 1997, on a scale of 1: 50,000 band 354 (The Royal of Forestry Department, 2000).
2) GPS with UTM (Coordinate system), zone 47P.
3) Instruments for collecting and sampling the sediment and seagrasses in the field.
4) Laboratory equipment for analyses.

## 3.2 The sample collecting

### 3.2.1 The study site

The Kung Krabaen Bay is located in The Royal of the Kung Krabaen Bay Study, Chanthaburi Province. A satellite map, on a scale of 1:50,000 band 354 in 1997 (The Royal of Forestry Department, 2000), displays the bay and the surrounding areas. The land parts of the bay consist of mostly shrimp farms and mangrove forests. Since there is a close and direct connection between the land and the water, the bay becomes the sink for many consequences of human activities.

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**The station of sample collecting**

Due to such characteristics of the bay, the stations to collect the sediment and seagrass samples were chosen to be lines parallel to the natural canals, which were the paths for more sedimentation and a runoff. There were four major collecting sites, which covered the north, the east, and the south sides of the bay. The path way of collecting sample in the Kung Krabaen Bay displays in the Fig. 3.1

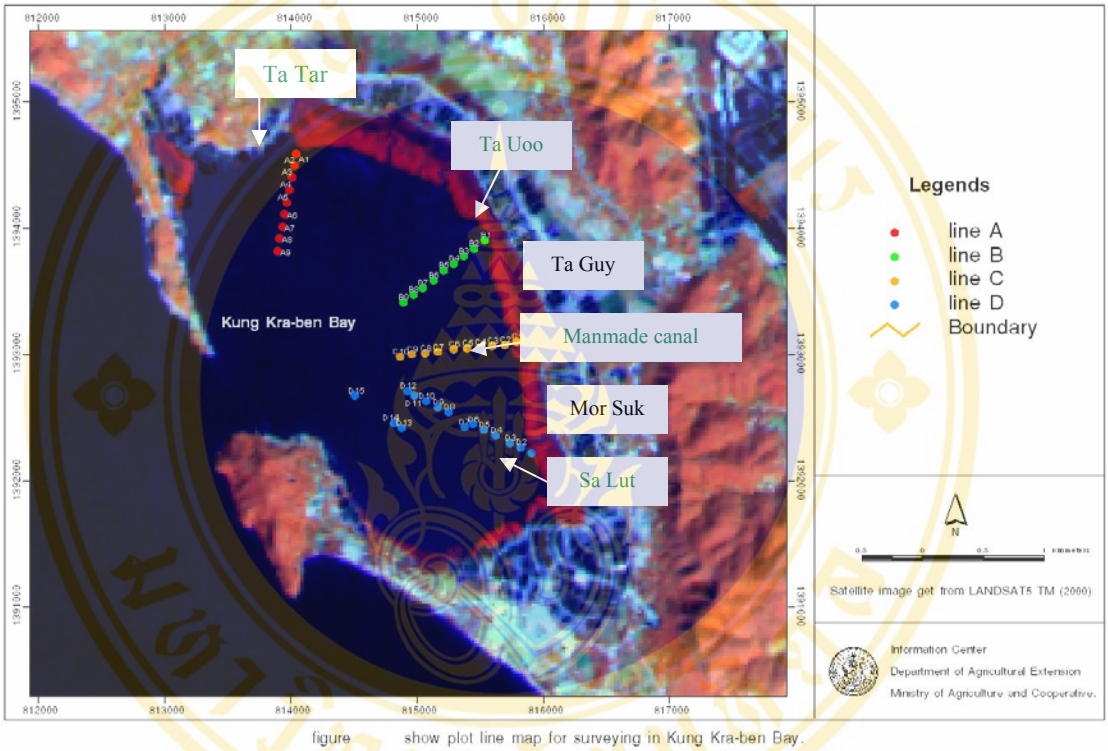


figure show plot line map for surveying in Kung Kra-ben Bay.

**Fig. 3.1 The path way of collecting samples in the Kung Krabaen Bay**

In the Fig. 3.1 the land uses near the sample lines mostly are the shrimp farms around the bay. Moreover there are also the mangrove forests to be a natural filtering in front of the shrimp ponds. However, there are a little bit different characteristics of the land use in each line are shown below:

- The Ta Tar Canal (Line A) located in the north of the bay and closed to the people communities and there were some shrimp farms.
- The Ta Uoo Canal (Line B) located in the east, rather in the upper part near the north location, far from the Ta Tar Canal for about 1.5 km. In the land were the shrimp farms and far from the communities. There were a lot of mangrove forest much more than at the Ta Tar Canal.

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- The location between the Ta Guy and the Mor Suk Canal (Line C), man-made canals located in the southeast of the bay, far from the Ta Uoo Canal for about 800-1,000 meters. The land use was as same as the Ta Uoo Canal.
- The Sa Lut Canal (Line D) located in the south of the bay, far from Line C for about 900-1,000 meters. There were a lot of shrimp farms and communities much more than other canals and less the mangrove forests.

3.2.2 Sample Collecting Methods

In this study the researcher divided the collecting samples to 2 parts. The first was sediment samples and the last was seagrasses. The sediment samples were collected in the summer from 6$^{th}$ to 10$^{th}$ of March, 2003, and in the rainy season from 5$^{th}$ to 9$^{th}$ of October, 2003. The seagrasses were collected only in the rainy season because of the data of biomass in the summer, which carried out by Kumyuang (2003) who studied the correlation between benthos and seagrasses, was not related to the four lines in this study. The seagrasses and the sediment were collected in the same area. The steps in collecting the samples and the details are:

**(1) Transect lines**

The chosen transect lines to collect samples were perpendicular to the rim of the mangrove forest and parallel to the natural canals in the land. The stations are about 100 meters apart and marked with GPS. In each station, three sets of sediment samples and two sets of the seagrass samples were taken. The transect lines ran through both the seagrass and non-seagrass beds. The non-seagrass beds were near the rim of the mangrove forest and the estuary. The seagrass beds consisted of *Halodule pinifolia* and *Enahalus acoroides*. The transect lines were shorter in the summer than in the rainy season, depending on seagrass distribution along the paths. To be precise, the lines, in summer, were 600 meters, and in the rainy season, the lines' lengths vary; line A was 900 meters, line B was 800 meters, line C was 900 meters, and line D was 1,850 meters. The transect lines and the stations were shown in Fig. 3.2

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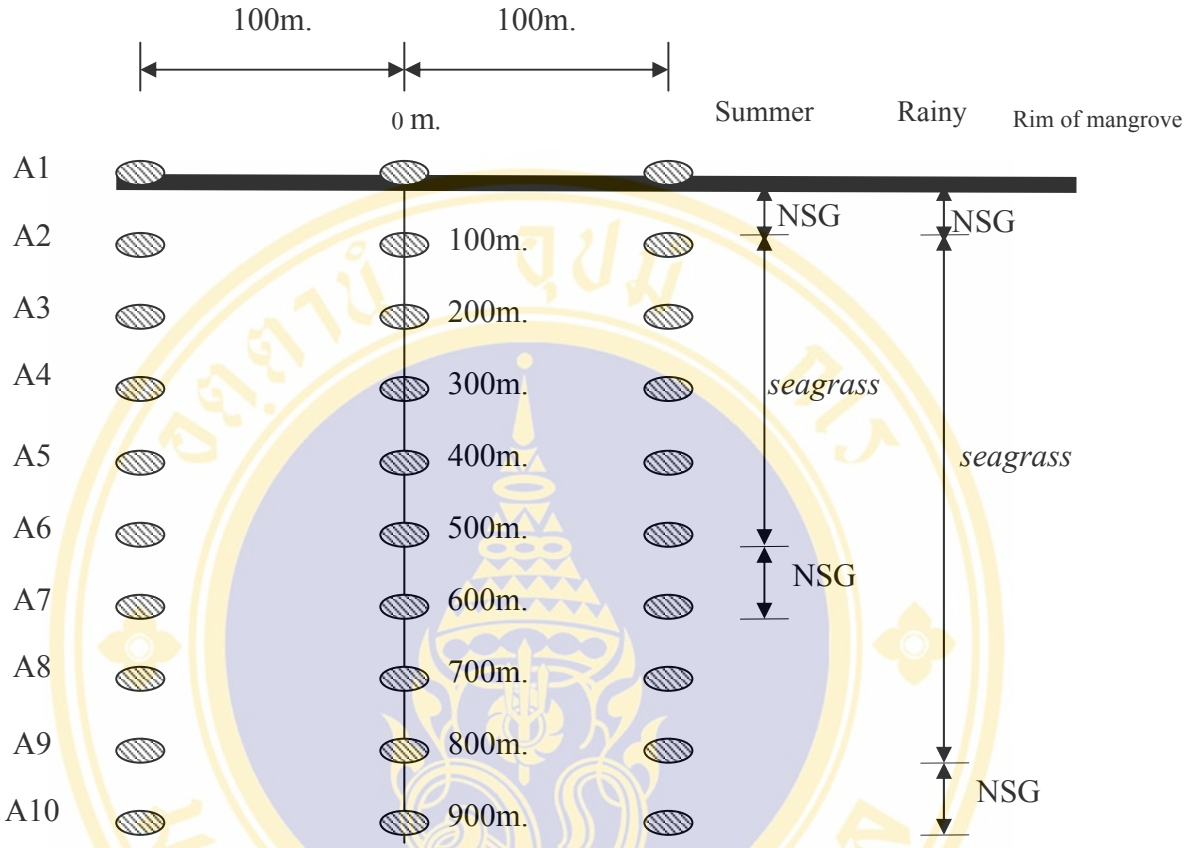
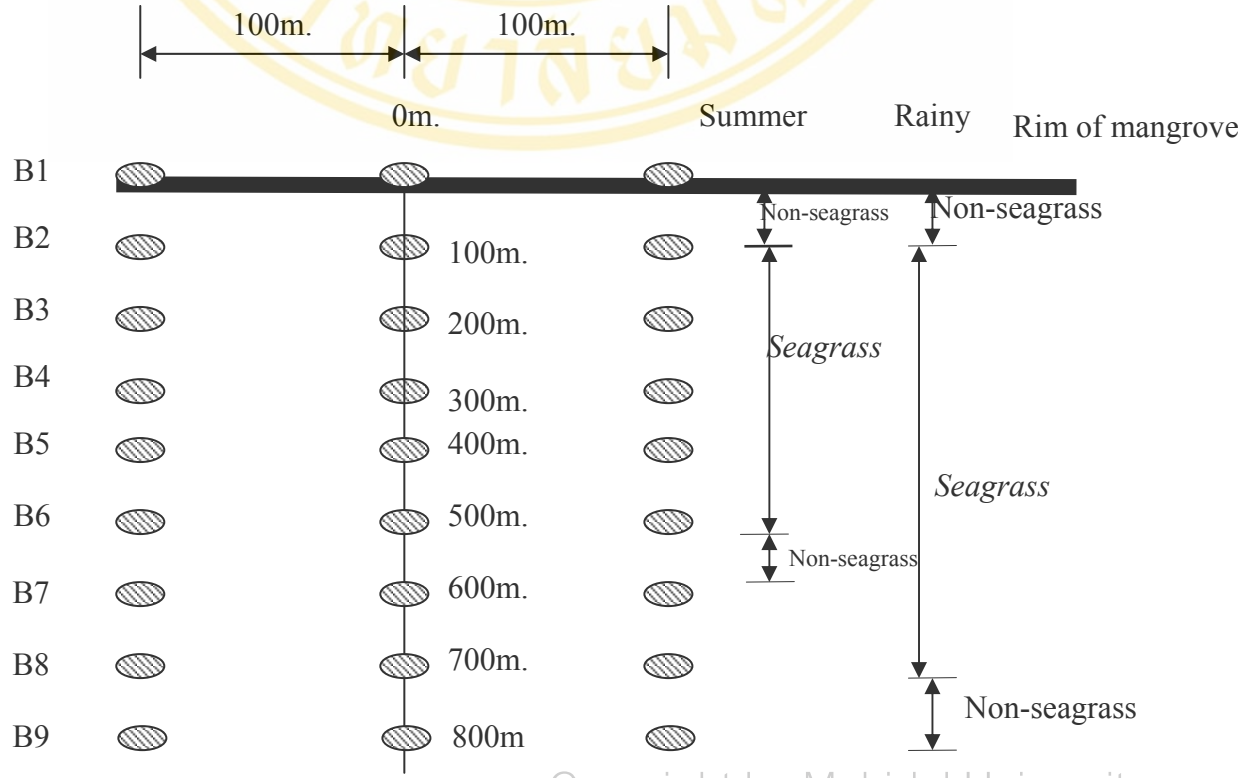
**Ta Tar canal (Line A)**




**Ta Uoo canal (Line B)**

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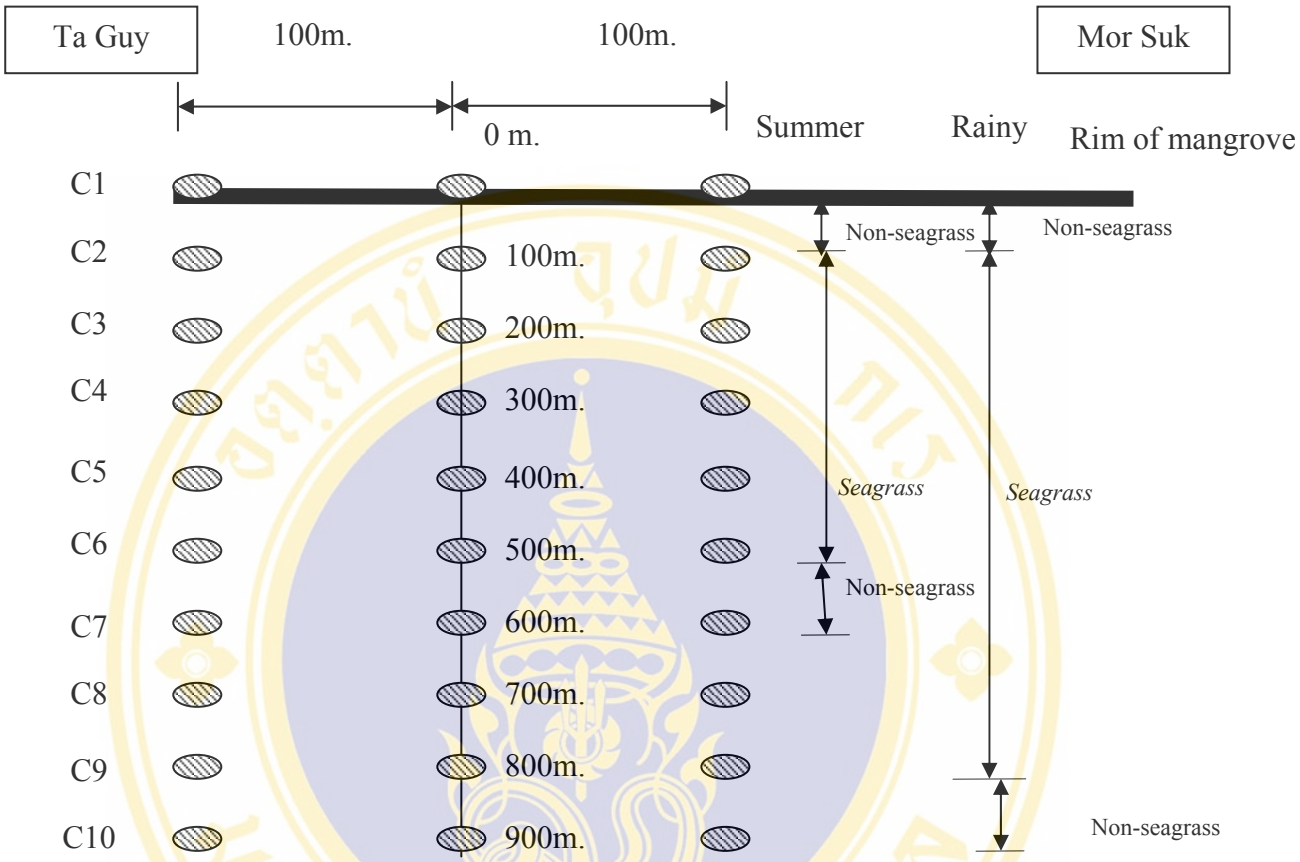
**Between Ta Guy and Mor Suk canal (Line C)**

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**Sa Lut canal (Line D)**

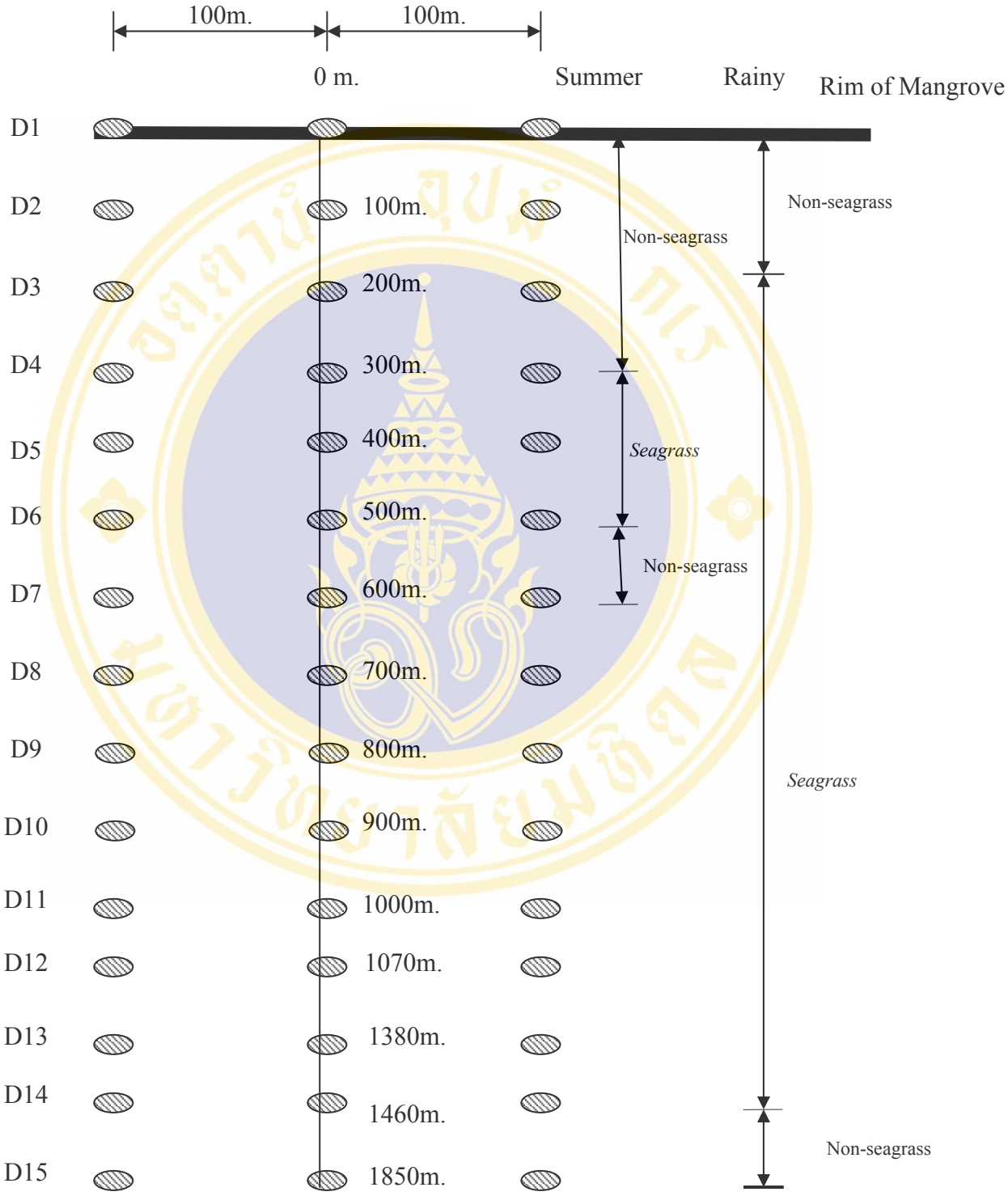


**Fig. 3.2 The diagrams showing the four transect lines and the collecting stations in the summer and the rainy season, covering seagrass bed and non-seagrass bed areas.**

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**(2) Sample Collection method**

**Sediment**

The sediment samples collected from the stations of the transect lines were divided into two parts as;

• The sediment was collected to analyze for two physical parameters (texture and color) and seven chemical parameters (pH, EC, OM, total nitrogen, available phosphorus, available potassium, and the cation exchange capacity.) The sediment samples were retrieved for two kilograms at the 20-30 cm deep from the surface. Then, the samples mixed with a 20 ml toluene solution. Each station was marked, and the samples were sent to the laboratory.

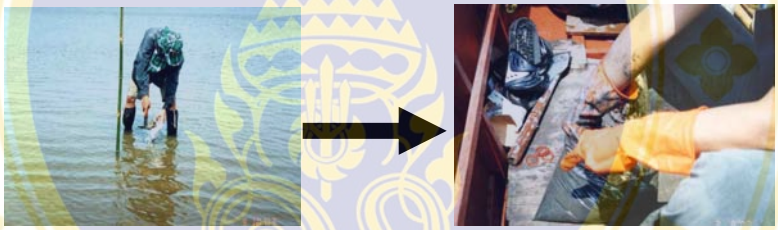

**Fig. 3.3 The sediment collecting and fixing with toluene solution in the bag.**

• The sediment that collected to analyze the hydrogen sulfide gas had done very quickly in the PVC tube. Because hydrogen sulfide could easily change its form by oxidation, the collecting procedures were conducted in a close system. The PVC was used to pull the sediment in the bay at a 30 cm deep and pulled it out from the tube into the vacuum plastic bag. Cut the sediment at the 20 cm in the plastic bag and put it into the BOD bottle which was wrapped with foil and contained the non-oxygen water. Fixed the sediment within the BOD bottle by Zinc acetate solution and took it to analyze in the laboratory by the spectrophotometer at a 670 nm of wavelength.

Even though the sites to collect hydrogen sulfide were as same transect lines as collects the physical and chemical parameters of sediment. However, in each transect line was divided in 3 parts to collect the sediment of hydrogen sulfide were; 1) non-seagrasses beds both located at the rim of mangrove and nearly to the estuary of river, 2) *Halodule pinifolia* area, and 3) *Enhalus acoroides* area. The sediment collecting in each area had to do for 3 times as random method. The method how to collect the sediment to analyze the hydrogen sulfide shows in Fig. 3.4

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a

b

**Fig. 3.4 The hydrogen sulfide collecting in the field (a. Pulled the sediment from the PVC, b. Fixed the sediment with Zinc acetate in BOD bottle)**

There were totally 10 parameters of interest. The physical parameters were texture and color, which were used to explain the general characteristics of sediment in the bay. The chemical parameters were pH, electrical conductivity, organic matters, total nitrogen, available phosphorus, available potassium, cation exchange capacity, and hydrogen sulfide gas. Both physical and chemical characteristics of the sediment in the summer and the rainy season were studied in order to obtain the variance along distances of the transect lines. However, CEC was highly correlated with the absorbent the nutrients capability of sediment, so it was analyzed only in the rainy season in order to explain its relationship to the seagrasses biomass. The methods of sediment analysis of each parameter are shown in table 3.1 (More information in Appendix A):

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**Table 3.1 Parameters of sediment to analyze in the laboratory**

| Parameters to analyze | Chemical quality | Physical quality | Methods | Ref. |
|---|---|---|---|---|
| 1. color | | • | - Using Munsell soil color chart | Munsell soil color chart, 1994 |
| 2. texture | | • | - Hydrometer method | Agriculture Faculty. Kasetsart University, 2004 |
| 3. soil reaction (pH) | • | | - Sediment : $CaCl_2$ 0.01M the ratio is 1: 2. Measure with pH meter | Land Development Department, 2001 |
| 4. electrical conductivity | • | | - sediment: water ratio as 1:5 and ,measure with Electrical-Conductivity Bridge | Land Development Department, 2001 |
| 5. organic matter | • | | - Walkley-Black titration | Land Development Department, 2001 |
| 6. total nitrogen | • | | - Kjeldahl Method | Land Development Department, 2001 |
| 7. available phosphorus | • | | - Extract with Bray II solution and measure with Spectrophotometer | Land Development Department, 2001 |
| 8. available potassium | • | | - Using 1N ammonium acetate, pH 7 and measure with Flame Photometer | Land Development Department, 2001 |
| 9. hydrogen sulfide gas | • | | - Apply Grasshoff method | Grasshoff, 1976 |
| 10. cation exchange capacity | • | | - Analyze by using sodium acetate 1N pH8.2 | Land Development Department, 2001 |

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**Seagrasses**

The seagrasses biomass was collected at the same place which collected the sediment. Each station had to do in 2 times. Using the quadrate as 35 × 35 cm random on seagrass beds. To collect the seagrasses within the quadrate was a 10-30 cm deep. To preserve the seagrasses that was put into the plastic bag with formalin solution. Measure the biomass with the dry weight in the laboratory.

### 3.2.3 Sediment and Biomass Analysis in the laboratory

The sediment collected from the field was dried in the sun and heat in the temperature not over the 110°C and leave it for 12 hours (Keawreonrom, 2004). After that, the sediment was cooled down, to separate the shells and seagrasses fragments from the sediment. Only the sediment was ground and kept in a plastic bag to be analyzed for physical and chemical characteristics (Appendix ).

The preserved seagrass samples from the field were washed the formalin solution by the clean water, and heat it at 60-70 ° C for 24 hours. After the samples were cooler, they were weighed and calculated the gram of biomass ($g/m^2$).

### 3.3 Statistic Analysis

Statistical analysis was taken only in the rainy season, to study the correlation between the biomass of seagrasses and chemical characteristics of the sediment.

1) Seagrasses' biomass was determined for each transects and to compare the discrepancy among the lines by the One-way ANOVA method.

2) Due to the non-linear behavior of the relationship between the sediment quality and the biomass (prove by the scatter plot, Appendix B), this study did not use the stepwise regression. The curvilinear regression was the method to analyze the relationship. The curvilinear regression was the method to analyze the relationship. The independent variables were chemical parameters of sediment as pH, EC, OM, N, P, K and CEC and the dependent variable is the biomass of seagrasses.

Before analyzed by the curvilinear regression, it needed to test the correlation coefficient of the Bivariate correlation. This method did not control effects from other environmental factors. The values of correlation coefficient were Pearson and Kendall's tau_b whose conditions were (Vanishbuncha, 2003);

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- The coefficient of Pearson to test the correlation that was normally distributed information. The hypothesis was the independent variable (X) and a dependent variable (Y) had a linear correlation.

- The coefficient of Kendall's tau_b was not need to test only the normal distribution of information.

3) The analysis of the correlation between the hydrogen sulfide and biomass used only the correlation coefficients of Kendall's tau_b because it required a fewer samples. Due to this, the analysis of the form of correlation, both linear and curvilinear regressions, cannot be performed, so it is not need to test with the curvilinear regression.

On the contrary, the physical characteristics of the sediment were not analyzed using statistics, but instead in terms of descriptions. However, the texture of the sediment will be the indicator of a suitable substrate of seagrasses. Moreover, the chemical characteristics along the distance of the transect lines could not be compared between the summer and the rainy season because the exact station of sample collecting sites was not the completely same every time. The lines studied in the summer are far from the lines studied in the rainy season for about 50-100 meters. In addition, the lines used in the rainy season were longer than those in the summer. Thus in this study, the information on chemical parameters along the distance were explained in terms of the variances in each line and how different they were in the same parameters, different lines, within the same season. (Appendix , Table C-8 to Table C-11).

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# CHAPTER 4
# RESULTS

The study on the sediment characteristics and their influences on the seagrasses distribution were carried out in the Kung Krabaen Bay, Chanthaburi Province. The results of the study are divided to 3 parts:

1) The species and the biomass of the seagrasses and their distribution
2) The physical and chemical characteristics of the sediment along the paths of the transect line
3) The most influential characteristics of the sediment and their effects on the seagrasses' biomass.

## 4.1 Seagrasses Information

The pattern of the seagrasses distribution was recorded for each transects line. All of the four lines were covered by the two dominant species. The routes of seagrass distributions were different in the summer and the rainy season as shown from Fig. 4.1 to 4.4. The record of the biomass of seagrasses in the rainy season is shown in the Table 4.1.

### 4.1.1 The pattern of seagrasses distribution

The dominant species found in the Kung Krabaen bay are *Halodule pinifolia* and *Enhalus acoroides*. Both species distributed along the distances of the transect lines, but separated from each other. *H. pinifolia* grew near the rim of the mangrove forest and covered quite a large area, while *E. acoroides* was adjacent to *H. pinifolia* and spread out as little tufts. The spread of tuft is about 2 meters or much more in some area. Some *E. acoroides* tufts consisted of only 2-3 stems. Although these two species had separated distributions, a mixture of the two could still be found in some transitional zones.

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**Ta Tar Canal (Line A)**

Along the Ta Tar Canal (line A), the distributions of the seagrasses was studied along the length of 0-600 meters in the summer and 0-900 meters in the rainy season. The distance from 0 to 100 meters from the rim of mangrove forest contained no seagrass in both seasons.

In the summer from that 100-300 meters point on, *H. pinifolia* was spread whereas the next to the *H. pinifolia* was found *E. acoroides* from 300-500 meters.

The distribution characteristics in the line A is shown in the Fig. 4.1

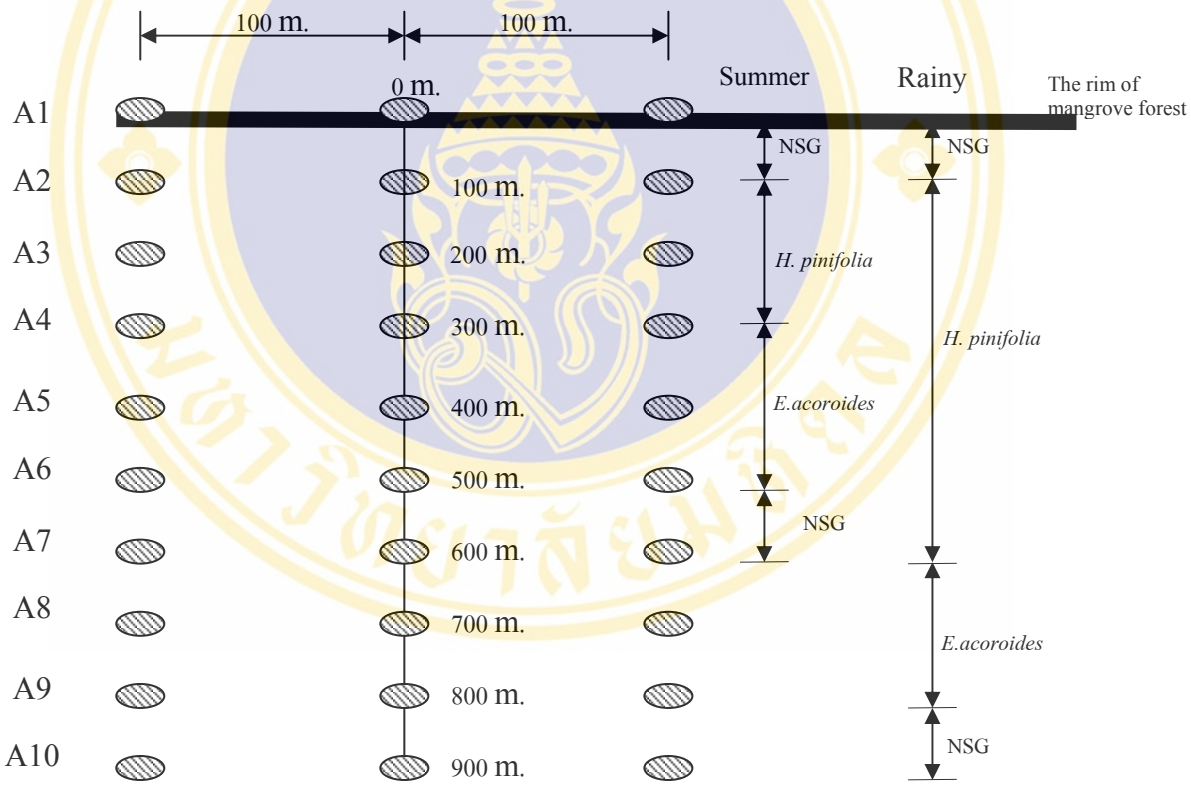


**Fig.4.1 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of the Ta Tar Canal (line A)**

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**Ta Uoo Canal (Line B)**

Along the Ta Uoo Canal (Line B), the distributions of the seagrasses were studied along the distances from 0 to 600 meters in the summer and from 0 to 800 meters in the rainy season. The distance from 0 to 100 meters from the rim of mangrove forest contained no seagrass in both seasons.

In the summer *H. pinifolia* spread from 100-500 meters, but there was no spread of *E. acoroides*.

In the rainy season *H. pinifolia* spread from 100-700 meter, but there was no spread of *E. acoroides* as same as in the summer.

The distribution characteristics in the line B is shown in the Fig. 4.2

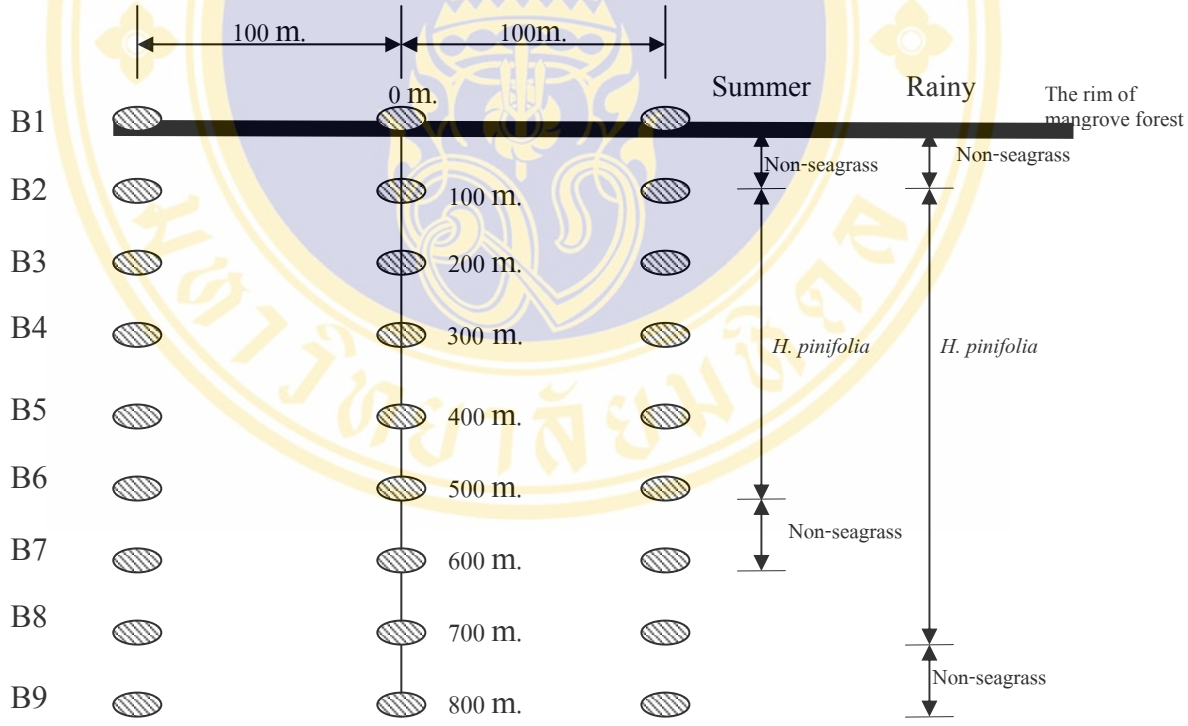


**Fig.4.2 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of the Ta Uoo Canal (line B)**

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**Between Ta Guy and Mor Suk canal (Line C)**

Along the line between the Ta Guy and the Mor Suk Canals (Line C), the distribution of seagrasses was studied along the length of 0-600 meters in the summer and 0-900 meters in the rainy season. In 0-100 meters

In the summer *H. pinifolia* spread from 100-300 meters, from 300-400 meters was mixed between 2 species, and the spread of *E. acoroides* was from 400-500 meters.

In the rainy season there was a mixing of two species at 100-200 meters. Next to the mixing could be found only *H. pinifolia* from 200-400 meters. There was a mixing again at 400-500. There was only *E. acoroides* from 500-600 meters and only *H. pinifolia* from 600-700 meters.

The distribution characteristics in the line C is shown in the Fig. 4.3

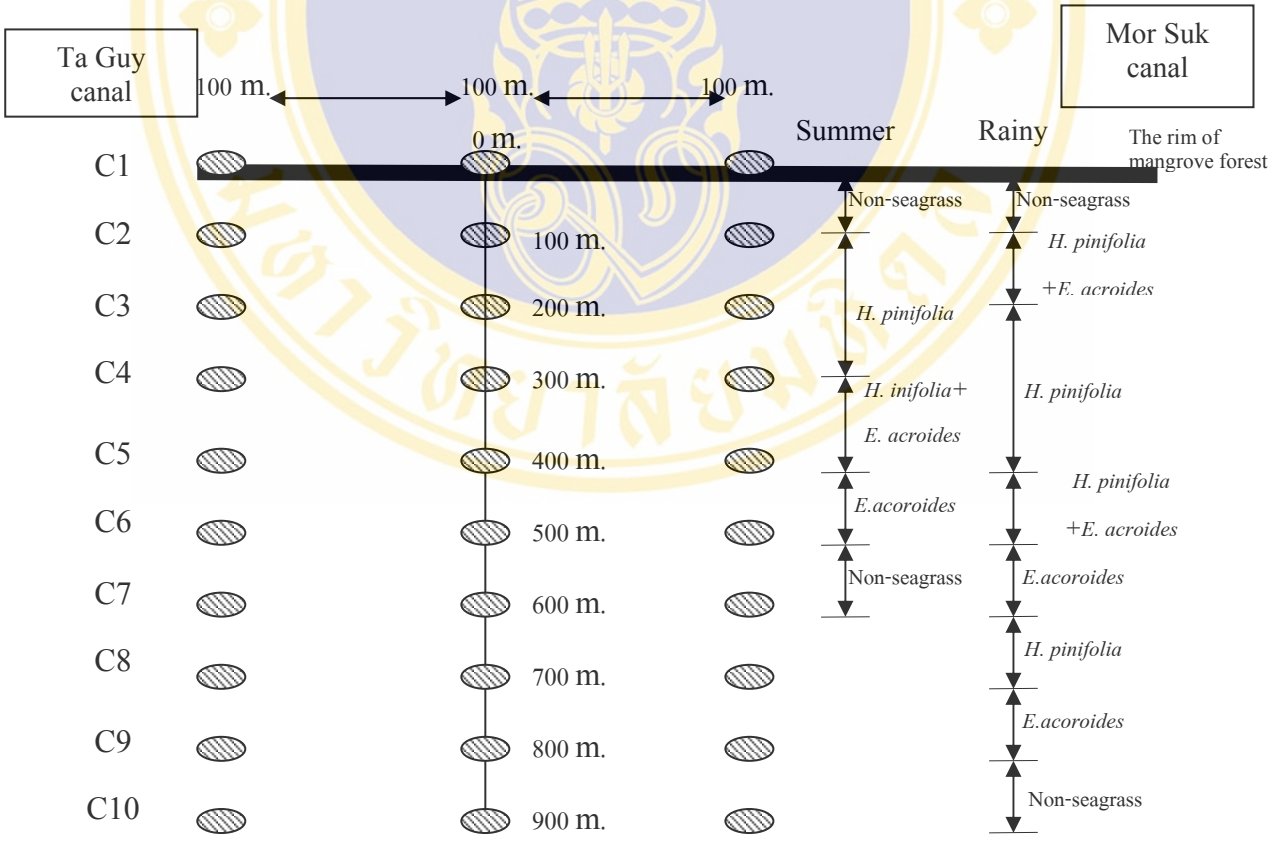


**Fig.4.3 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of between the Ta Guy and Mor Suk Canal (line C)**

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**Sa Lut Canal (Line D)**

Along the Sa Lut canal (Line D), the distribution of seagrasses was studied in 0-600 meters in the summer and 0-1,850 meters in the rainy season. About 0-300 and 0-200 meters from the rim of mangrove forest were the area without seagrass coverage in the summer and the rainy season, respectively.

In the summer *H. pinifolia* spread from 300-400 meters and *E. acoroides* spread from 400-500 meters.

In the rainy season there was only *H. pinifolia* from 200-300 meters. From 300-500 meters there was a mixing of two species. There was only *E. acoroides* spread from 500-600 meters and only *H. pinifolia* from 600-700 meters. There was mixing again from 700-800, and then from 800-1,460 meters only *E. acoroides* spread widely.

The distribution characteristics in the line D is shown in the Fig. 4.4

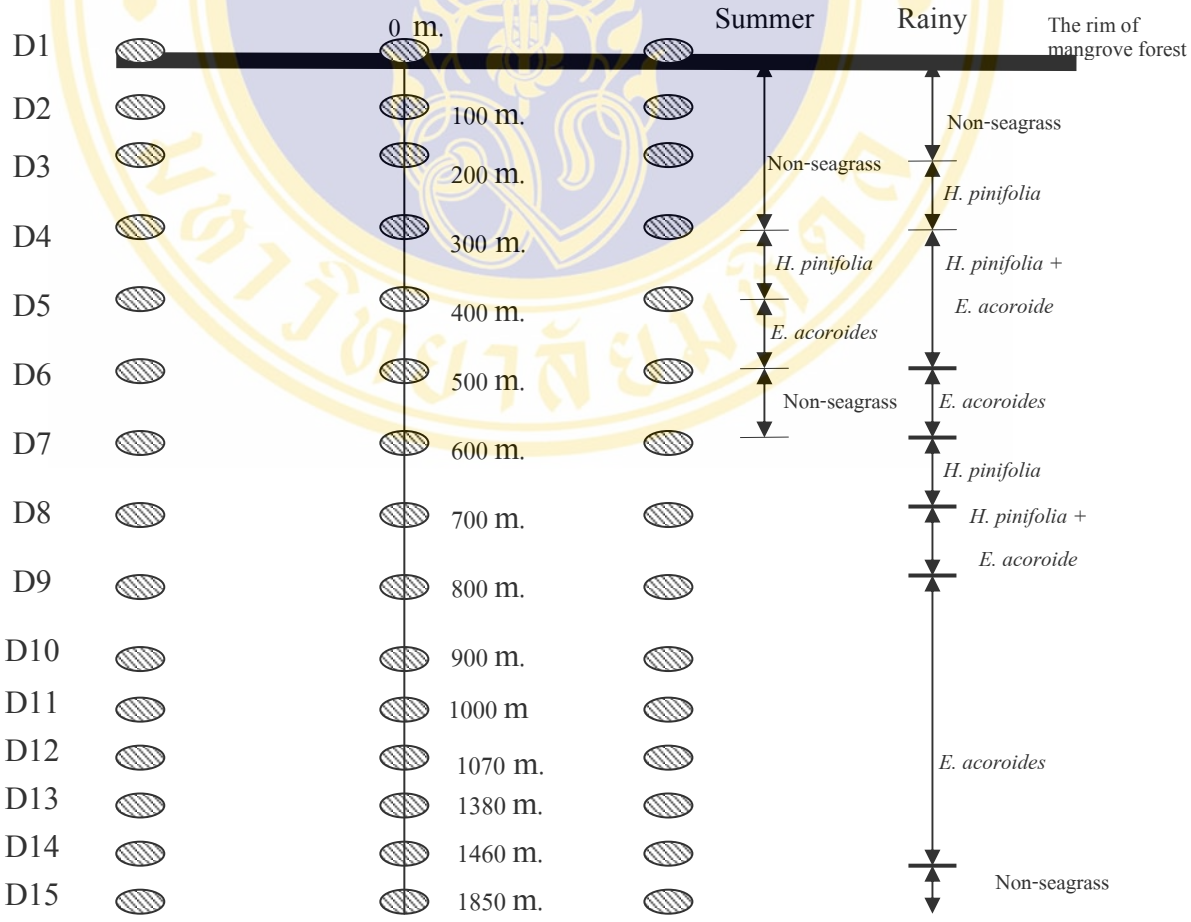


**Fig.4.4 The distribution of the *Halodule pinifolia* and the *Enhalus acoroides* along the path of the Sa Lut Canal (line D)**

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The notice of distribution characteristic was the shorter path of each transects in the summer than in the rainy season. Especially, the Sa Lut Canal (line D) there was longer distribute of *E. acoroides* in the rainy season.

### 4.1.2 Biomass of seagrasses

The statistical analysis by the One way ANOVA;

The biomass of *H. pinifolia* in line A and line C are not significantly different along the routes with the reliability interval 95 % (P value; line A = 0.262, line C=0.058). In case of line B and line D, the differences are greater along the distance with the reliability interval 95 % (P value; line B=0.000, line D=0.014) (Appendix B, Table B-1).

The biomasses of *E. acoroides* in line C and line D are not significantly different along the distance with the reliability interval 95 % (P value; line C=0.115, line D=0.440). One-way ANOVA could not analyze line A because of fewer samples, only 2 numbers. The *E. acoroides* distribution does not occur in line B. The One-way ANOVA test on the biomass of *H. pinifolia* and *E. acoroides* along the distance is shown in Appendix B, Table B-1, and Table B-2.

Because *H. pinifolia* biomass is different along the distance in only 1 or 2 transects, the comparison among transects by total average test is not used in this case. Whereas the difference of biomass of *E. acoroides* among line A, line B and line C are tested with One-way ANOVA. The result is different significantly at reliability interval 95 % (P value=0.040). The highest average is up on line C. (One-way ANOVA test of *E. acoroides* biomass between transect lines is shown in Appendix , Table B-3).

However, the average biomass of *H. pinifolia* in line A, line B, line C and line D is 23.19, 20.51, 13.71 and 9.11 g/m$^2$, respectively. The average biomass of *E. acoroides* is 250.09, 726.70 and 241.97 g/m2 in line A, line C and line D, respectively. The information of biomass as the average value in each transects is shown in Table 4.1 (The raw value data of biomass from the field is shown in Appendix , TableC-1).

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**Table 4.1 The averages of biomass of *H. pinifolia* and *E. acoroides* in each transect in the rainy season.**

| Distances (meters) | Biomass ($g/m^2$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ta Tar canal (Line A) | | Ta Uoo canal (Line B) | | Between Ta Guy Mor Suk canal (Line C) | | Sa Lut canal (Line D) | |
| | *Halodule pinifolia* | *Enhalus acoroides* | *Halodule pinifolia* | *Enhalus acoroides* | *Halodule pinifolia* | *Enhalus acoroides* | *Halodule pinifolia* | *Enhalus acoroides* |
| 0 | - | - | - | - | - | - | - | - |
| 100 | 4.78± 3.63 | - | 10.12± 0.16 | - | - | - | - | - |
| 200 | 15.96± 3.22 | - | 32.04± 5.18 | - | 17.55± 0.00 | 1403.51± 0.00 | - | - |
| 300 | 72.08± 28.08 | - | 28.20± 0.07 | - | 8.86± 1.02 | - | 9.35± 8.20 | - |
| 400 | 34.86± 24.33 | - | 7.02± 4.57 | - | 6.90± 1.67 | - | 0.98± 0.00 | 277.88± 0.00 |
| 500 | 5.96± 0.24 | - | 24.82± 1.31 | - | 15.51± 0.00 | 145.06± 0.00 | 8.57± 0.00 | 198.69± 0.00 |
| 600 | 5.47± 5.06 | - | 40.78± 2.41 | - | - | 712.65± 92.41 | - | 491.06± 314.00 |
| 700 | - | 427.31± 61.92 | 0.61± 0.53 | - | 19.71± 0.86 | - | 19.71± 0.86 | - |
| 800 | - | 72.86± 24.12 | - | - | - | 645.59± 121.18 | 6.94± 0.00 | 68.24± 0.00 |
| 900 | - | - | - | - | - | - | - | 241.67± 43.63 |
| 1,000 | - | - | - | - | - | - | - | 211.22± 80.53 |
| 1,070 | - | - | - | - | - | - | - | 280.33± 81.88 |
| 1,380 | - | - | - | - | - | - | - | 195.55± 23.80 |
| 1,460 | - | - | - | - | - | - | - | 213.06± 123.67 |
| 1,850 | - | - | - | - | - | - | - | - |
| **Average** | 23.19± 10.85 | 250.09± 177.23 | 20.51± 5.58 | - | 13.71± 2.49 | 726.70± 258.71 | 9.11± 3.03 | 241.97± 37.42 |

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***Halodule pinifolia***

The biomass of *H. pinifolia* in line A is lowest at 100 m of 4.78±3.63 g/m$^2$ and highest at 300 m of 72.08±28.08 g/m$^2$. For line B, it becomes lowest at 700 m of 0.61±0.53 g/m$^2$ and highest at 600 m of 40.78±2.41 g/m$^2$. For line C, it is lowest at 400 m of 6.90±1.67 g/m$^2$ and highest at 700 m of 19.71±0.86 g/m$^2$. For line D, it is lowest at 400 m of 0.98±0.00 g/m$^2$ and highest at 700 m of 19.71±0.86 g/m$^2$. The biomass in each transect is shown in the Fig. 4.5.

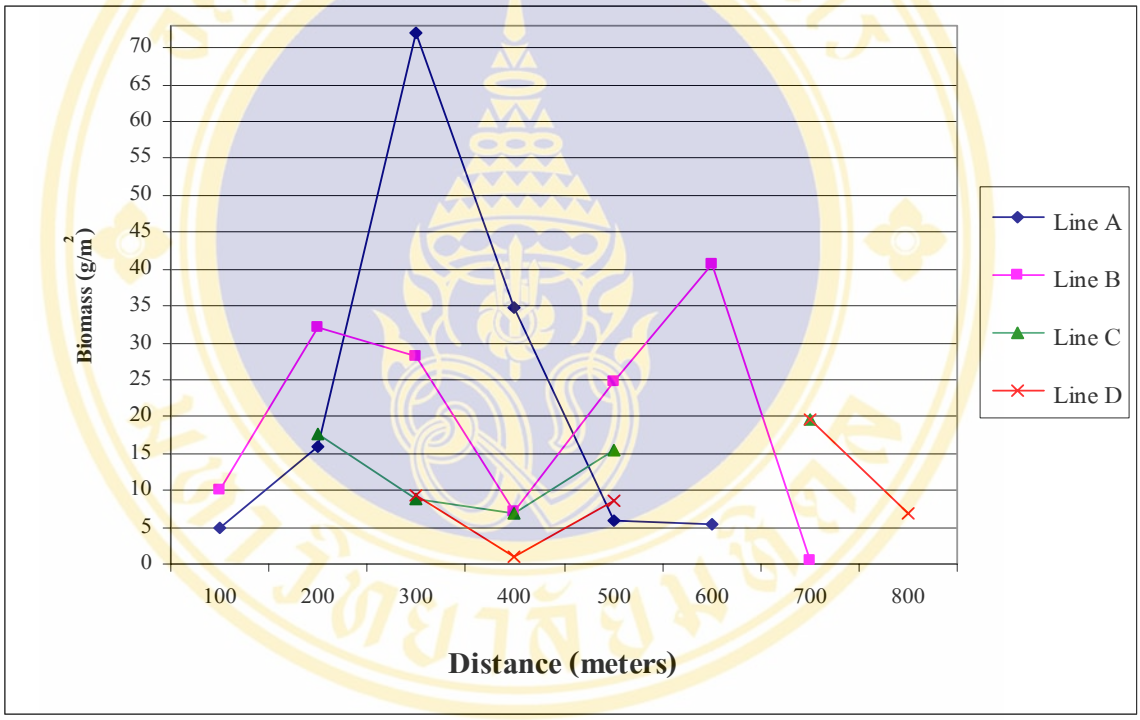


**Fig. 4.5 The *H. pinifolia* biomass in each transect line in the rainy season**

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***Enhalus acoroides***

The biomass of *E. acoroides* in line A is lowest average at 800 m of 72.86±24.12 g/m$^2$ and highest at 700 m of 427.31±61.92 g/m$^2$. For line B, this species does not exist. For line C, it becomes lowest at 500 m of 145.06±0.00 g/m$^2$ and highest at 200 m of 1,403.51 g/m$^2$. For line D, it becomes lowest at 800 m of 68.24±0.00 g/m$^2$ and highest at 600 m of 491.06 g/m$^2$. The biomass of *E. acoroides* of each transect is shown in Fig. 4.6.

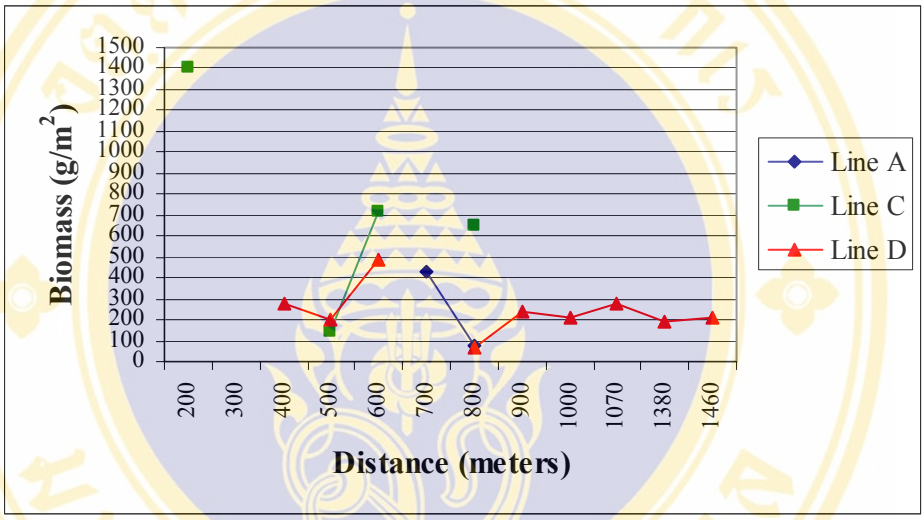


**Fig. 4.6 The biomass of *E. acoroides* in each transects line**

The biomass of *E. acoroides* which is different between three transects is shown in the Fig. 4.7

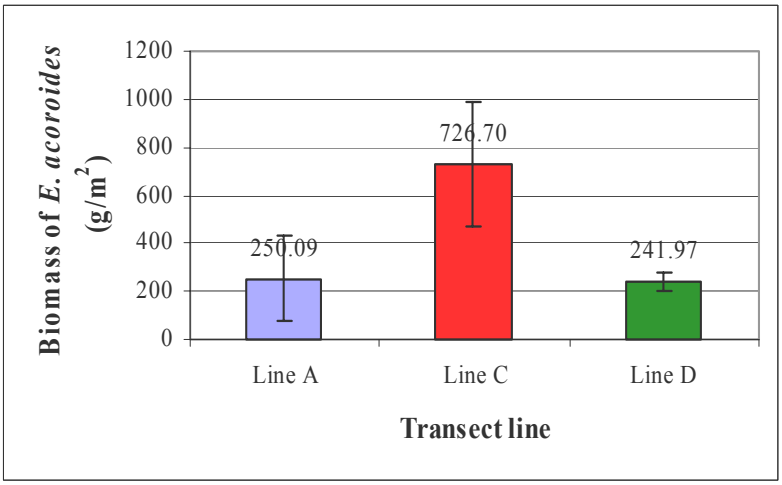


**Fig. 4.7 The biomass of *E. acoroides* between line A, line C, and line D**

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## 4.2 Sediment Characteristics Analysis

The study of sediment characteristics in the Kung Krabaen bay was physically and chemically analyzed. The sediment analysis was carried out in the laboratory on the 4 transects, line A, line B, line C, and line D. The physical qualities used to explain the general characteristics are summarized for the summer and the rainy season. The chemical qualities were determined in 2 parts as:

- To know the variance of chemical parameters (pH, EC, OM, N, avai P, avai K, CEC) along the distance of each line both in the summer and the rainy season
- To know the different values of hydrogen sulfide between seagrass beds and non-seagrass beds both in the summer and in the rainy season.

### 4.2.1 Physical Characteristics

There were two factors of physical characteristics to analyze in this study. These were texture and color. There were 4 kinds of texture that found in the bay which were sandy loam, loamy sand, loam, and silt. In line A was sandy loam, loam, and silt. In line B was sandy loam. Between In line C was sandy loam and loamy sand. In line D was sandy loam, silt, and loamy sand. The colors of the sediment found in the bay were very dark brown, very dark gray, dark olive gray, black, and very dark grayish brown. The texture and color of sediment in each transect lines were shown in the table 4.2

The percentage of sand, silt and clay of texture was shown in Appendix, table C-2.

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**Table 4.2 The texture and color of sediment from each transect lines in the Kung Krabaen Bay**

| Distance (meters) | Ta Tar canal (Line A) | | Ta Uoo canal (Line B) | | Between Ta Guy and Mor Suk canal (Line C) | | Sa Lut canal (Line D) | |
|---|---|---|---|---|---|---|---|---|
| | Texture | Color | Texture | Color | Texture | Color | Texture | Color |
| 0 | sandy loam | very dark brown | sandy loam | very dark grayish brown | sandy loam | very dark gray | sandy loam | very dark gray |
| 100 | sandy loam | very dark gray | sandy loam | very dark gray | loamy sand | very dark gray | silt | very dark grayish brown |
| 200 | sandy loam | dark olive gray | sandy loam | very dark grayish brown | Loamy sand | very dark gray | silt | very dark gray |
| 300 | loam | very dark gray | sandy loam | very dark grayish brown | sandy loam | dark olive gray | silt | very dark gray |
| 400 | silt | dark olive brown | sandy loam | very dark grayish brown | sandy loam | black | silt | very dark gray |
| 500 | silt | dark olive gray | sandy loam | very dark grayish brown | sandy loam | very dark gray | sandy loam | dark olive gray |
| 600 | silt | dark olive gray | sandy loam | very dark grayish brown | sandy loam | black | sandy loam | dark olive gray |
| 700 | silt | black | sandy loam | very dark grayish brown | sandy loam | dark olive gray | sandy loam | dark olive gray |
| 800 | sandy loam | black | sandy loam | very dark grayish brown | sandy loam | dark olive gray | sandy loam | dark olive gray |
| 900 | sandy loam | very dark gray | | | sandy loam | black | sandy loam | dark olive gray |
| 1,000 | | | | | | | sandy loam | dark olive gray |
| 1,070 | | | | | | | sandy loam | very dark gray |
| 1,380 | | | | | | | sandy loam | very dark gray |
| 1,460 | | | | | | | sandy loam | very dark gray |
| 1,850 | | | | | | | Loamy sand | dark olive gray |





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The texture of the sediment in line A, line B, line C, and line D was considered with the seagrasses along the path of each transects shows below;

1) Line A

The texture is a sandy loam which covered both by the *H. pinifolia* and *E. acoroides*.

The loam characteristic is only at the 300 meters which coveres only by the *H. pinifolia.*

The silt characteristic is covered by both *H. pinifolia* and *E. acoroides*.

2) Line B

The texture in this transect is only sandy loam which covers by only the *H. pinifolia*.

3) Line C

The texture is loamy sand which found at the 100-200 meters far from the rim of the mangrove forest. Mostly distribution is the *H. pinifolia*.

The sandy loam characteristic is at 300 meters and near the estuary of the river. At the 300 meters covers by *H. pinifolia* and *E. acoroides*. At near the estuary of the river covers by E. *acoroides* only.

4) Line D

The texture is silt and covered by the *H. pinifolia* only. The sandy loam characteristic is next to the silt area. Both *H. pinifolia* and *E. acoroides* cover this area except the farther near the estuary of the river is only *E. acoroides*.

The characteristics of the texture of sediment and a relationship with the seagrasses are shown in the Table 4.3

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**Table 4.3 The texture of the sediment and the species of seagrasses of each transects**

| Distance (meters) | Ta Tar Canal (Line A) | | Ta Uoo Canal (Line B) | | Between Ta Guy and Mor Suk Canal (Line C) | | Sa Lut Canal (Line D) | |
|---|---|---|---|---|---|---|---|---|
| | **Texture** | **Seagrasses** | **Texture** | **Seagrass** | **Texture** | **Seagrasses** | **Texture** | **Seagrass** |
| **0** | Sandy loam | - | Sandy loam | - | Sandy loam | - | Sandy loam | - |
| **100** | Sandy loam | *H. pinifolia* | Sandy loam | *H. pinifolia* | Loamy sand | *H. pinifolia* | Silt | - |
| **200** | Sandy loam | *H. pinifolia* | Sandy loam | *H. pinifolia* | Loamy sand | *H.+E.* | Silt | - |
| **300** | Loam | *H. pinifolia* | Sandy loam | *H. pinifolia* | Sandy loam | *H. pinifolia* | Silt | *H. pinifolia* |
| **400** | Silt | *E. acoroides* | Sandy loam | *H. pinifolia* | Sandy loam | *H. pinifolia* | Silt | *H. pinifolia* |
| **500** | Silt | *H. pinifolia* | Sandy loam | *H. pinifolia* | Sandy loam | *E. acoroides* | Sandy loam | *E. acoroides* |
| **600** | Silt | *H. pinifolia* | Sandy loam | *H. pinifolia* | Sandy loam | *E. acoroides* | Sandy loam | *E. acoroides* |
| **700** | Silt | *E. acoroides* | Sandy loam | *H. pinifolia* | Sandy loam | *H. pinifolia* | Sandy loam | *H. pinifolia* |
| **800** | Sandy loam | *E. acoroides* | Sandy loam | *H. pinifolia* | Sandy loam | *E. acoroides* | Sandy loam | *H. +E.* |
| **900** | Sandy loam | - | Sandy loam | - | Sandy loam | - | Sandy loam | *E. acoroides* |
| **1,000** | | | | | | | Sandy loam | *E. acoroides* |
| **1,070** | | | | | | | Sandy loam | *E. acoroides* |
| **1,380** | | | | | | | Sandy loam | *E. acoroides* |
| **1,460** | | | | | | | Sandy loam | *E. acoroides* |
| **1,850** | | | | | | | Loamy sand | - |



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The relationship between the percentage of sand, silt, and clay and the seagrasses covering is able to explain below;

The sand texture which covers by *H. pinifolia* has 47, 50, 54, 57, and 76 % of sand and *E. acoroides* has 46, 57, and 76 % of sand.

The silt texture which covers by *H. pinifolia* has 17, 21, 38, 43, 47, and 50 % of silt and *E. acoroides* has 21, 40, 51, and 57 % of silt.

The clay texture which covers by *H. pinifolia* has 3, 5, and 7 % of clay and *E. acoroides* has 1 and 3 % of clay.

According to the percentage of sand, silt, and clay which can found both *H. pinifolia* and *E. acoroides*, there is 57 % of sand, 21 % of silt, and 3% of clay.

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### 4.2.2 Chemical Characteristics

The chemical parameters were studied are pH, EC, OM, N, avai. P, avai. K, CEC, and $H_2S$. The results divided for 2 parts; 1) to determined the variance of each parameter (pH, EC, OM, N, avai. P, avai. K, CEC) along the path of each transect both in the summer and the rainy season. 2) To determined the hydrogen sulfide gas both in the seagrass beds and non-seagrass beds in the summer and the rainy season. The summarize of the results shows of each parameter (The raw data from the field is shown in the Appendix, Table C-3 to Table C-7)

**A. Soil reaction (pH)**

In the summer the total average of the pH value of each line there is 7.73±0.42, 7.69±0.97, 7.94±0.18 and 7.69±0.54 of line A, line B, line C and line D, respectively.

In the rainy season the total average is 7.81±0.28, 8.02±0.12, 8.06±0.70 and 7.98±0.23 of line A, line B, line C and line D, respectively. The data shows in the table 4.4

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**Table 4.4 The pH value of each transect lines in the summer and the rainy season**

| Distance (m) | Summer | | | | Rainy | | | |
|---|---|---|---|---|---|---|---|---|
| | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 0 | 6.86 ± 0.48 | 5.51± 0.27 | 7.55± 0.07 | 6.54± 0.40 | 7.17 ± 0.20 | 8.2± 0.06 | 7.90± 0.09 | 7.90± 0.20 |
| 100 | 7.47 ± 0.06 | 7.75± 0.14 | 7.95± 0.25 | 7.57± 0.11 | 7.53± 0.05 | 7.93± 0.11 | 8.00± 0.03 | 8.00± 0.10 |
| 200 | 7.98 ± 0.02 | 8.09± 0.04 | 7.95± 0.11 | 7.74± 0.04 | 7.76± 0.08 | 7.88± 0.13 | 8.12± 0.03 | 8.12± 0.07 |
| 300 | 7.92 ± 0.06 | 8.14± 0.07 | 8.09± 0.10 | 7.91± 0.09 | 7.85± 0.11 | 7.99± 0.04 | 8.03± 0.03 | 8.03± 0.04 |
| 400 | 8.08 ± 0.01 | 8.10± 0.07 | 8.05± 0.09 | 8.02± 0.02 | 7.84± 0.13 | 7.86± 0.07 | 8.07± 0.07 | 8.07± 0.07 |
| 500 | 7.81 ± 0.09 | 8.08± 0.01 | 8.03± 0.11 | 7.9± 0.04 | 7.88± 0.08 | 7.98± 0.04 | 8.11± 0.05 | 8.11± 0.07 |
| 600 | 7.99 ± 0.04 | 8.14± 0.34 | 7.98± 0.08 | 8.13± 0.06 | 7.81± 0.08 | 8.11± 0.14 | 8.09± 0.15 | 8.09± 0.12 |
| 700 | nd | nd | nd | nd | 7.95± 0.09 | 8.15± 0.12 | 8.11± 0.08 | 8.11± 0.03 |
| 800 | nd | nd | nd | nd | 8.10± 0.04 | 8.04± 0.02 | 8.07± 0.12 | 8.07± 0.09 |
| 900 | nd | nd | nd | nd | 8.22± 0.01 | nd | 8.13± 0.03 | 8.13± 0.04 |
| 1000 | nd | nd | nd | nd | nd | nd | nd | 7.90± 0.06 |
| 1070 | nd | nd | nd | nd | nd | nd | nd | 8.00± 0.12 |
| 1380 | nd | nd | nd | nd | nd | nd | nd | 8.12± 0.06 |
| 1460 | nd | nd | nd | nd | nd | nd | nd | 8.03± 0.07 |
| 1850 | nd | nd | nd | nd | nd | nd | nd | 8.07± 0.04 |
| average | 7.73 ± 0.42 | 7.69± 0.97 | 7.94± 0.18 | 7.69± 0.54 | 7.81± 0.28 | 8.02± 0.12 | 8.06 ± 0.70 | 7.98± 0.23 |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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In the summer the pH was available from 5.51±0.27 to 8.14±0.34 and influenced to the sediment become a moderately acid to a moderately alkaline (Appendix). The 0-200 m along the path there was a different pH value between 4 transects particular at 0 m. The 4 of transects were low pH especially in the line B was lowest. At the 200-600 m of each line was in the vicinity. The pH of each transect lines along the path is shown in Fig. 4.8.

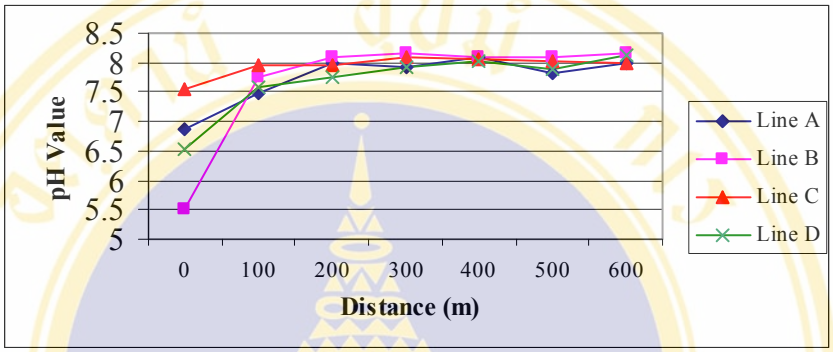


**Fig. 4.8 The pH value along the path of each transects in the Kung Krabaen Bay in the summer**

In the rainy season the average of pH value was available from 7.17±0.20 to 8.22±0.01 and influenced to the sediment become a slightly alkaline to a moderately alkaline (Appendix). The 0-200 m along the path there was a different pH value between 4 transects particular at 0 m. The pH value in the line A and line D was lower than line B and line C. The highest value was available in the line B at the 300 m. The pH of each transect lines along the path is shown in Fig. 4.9.

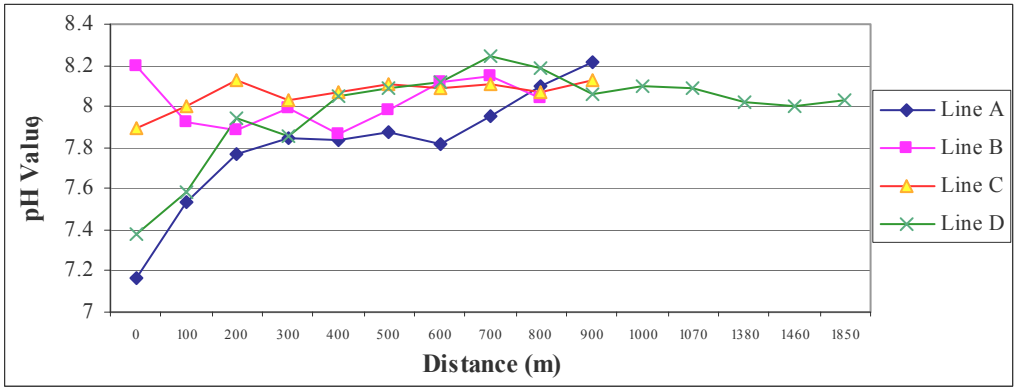


**Fig. 4.9 The pH value along the path of each transects in the Kung Krabaen Bay in the rainy season**

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However the pH value of the sediment in the Kung Krabaen Bay was able to considered separate of each transect line. The comparison was between the summer and the rainy season.

**Ta Tar Canal (Line A)**

The pH value of line A in the summer and the rainy season was the same direction. The 0 meter was lowest value. In the summer the pH was lower than the rainy season and both of the seasons the pH trend was higher at the farther. The comparison is shown in the Fig 4.10.

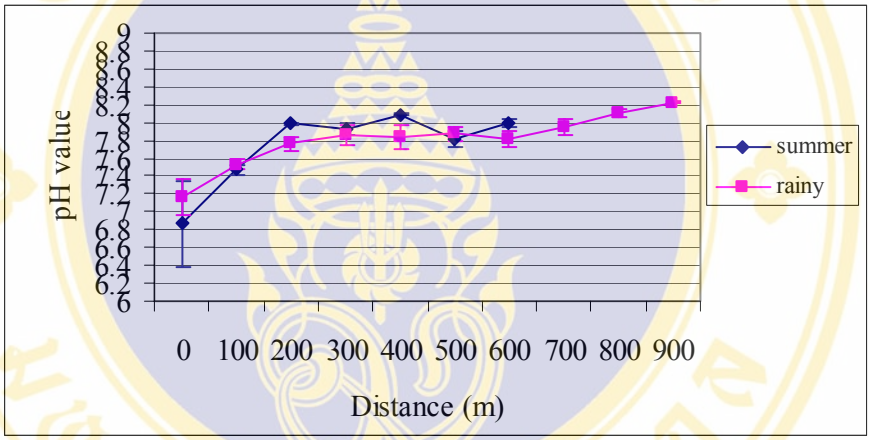


**Fig. 4.10 The pH value of line A compared between the summer and the rainy season**

**Ta Uoo Canal (Line B)**

The pH value of line B at the 0 meter (near the mangrove forest) in the summer was slightly acid. In the rainy season from the 100 meters to the farther the pH value was more alkalinity. The comparison is shown in the Fig 4.11.

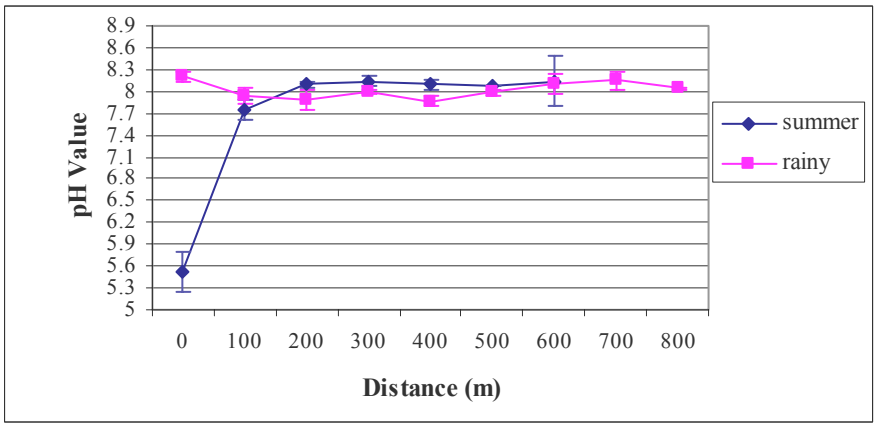


**Fig. 4.11 The pH value of line B compared between the summer and the rainy season**

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**Between TaGuy and Mor Suk (Line C)**

The pH value of line C in the summer and the rainy season was same direction. The trend was higher at the farther area of the rim of the mangrove forest. At the 0 meter the pH was lowest. In the summer was lower than the rainy. The comparison is shown in the Fig 4.12.

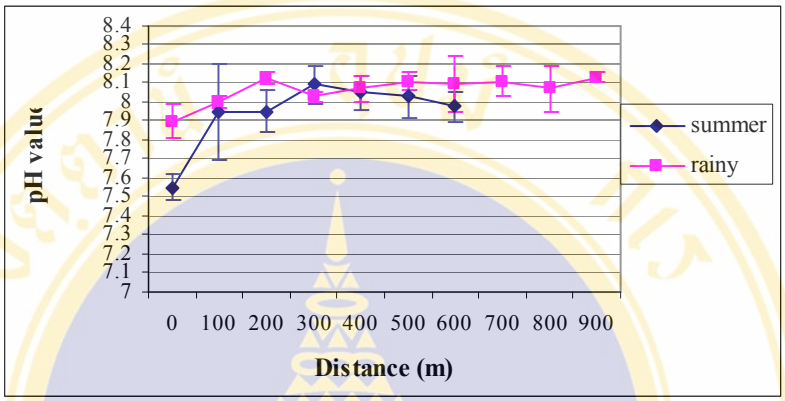


**Fig. 4.12 The pH value of line C compared between the summer and the rainy season**

**Sa Lut Canal (Line D)**

The pH value of line D in the summer and the rainy season was in the vicinity. The trend was higher at the farther area from the mangrove forest to the estuary of the river. At the 0 meter (near the rim of the mangrove) the pH value in the summer was lower than the rainy. The comparison is shown in the Fig 4.13.

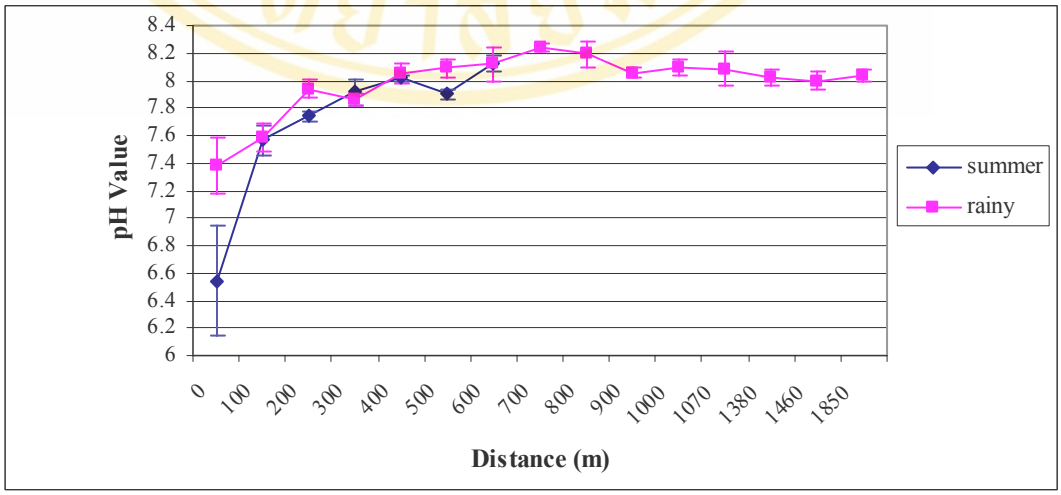


**Fig. 4.13 The pH value of line D compared between the summer and the rainy season**

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**B. Electrical Conductivity (EC: dS/m)**

The total average of electrical conductivity value of each transect line in the summer was 2.94±0.46, 2.95±1.07, 2.67±0.52 and 3.09±0.52 dS/m in line A, line B, line C and line D, respectively.

In the rainy season there was 2.98±0.41, 2.88±0.18, 2.58±0.15 and 2.94±0.24 dS/m, respectively. The data shows in the table 4.5.

**Table 4.5 The electrical conductivity of each transect lines in the summer and the rainy season**

| Distance (m) | EC: dS/m (summer) | | | | EC: dS/m (rainy) | | | |
|---|---|---|---|---|---|---|---|---|
| | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 0 | 2.67±0.58 | 5.23±0.49 | 2.67±0.25 | 3.83±0.16 | 3.32±0.81 | 2.83±0.59 | 2.44±0.49 | 2.98±0.43 |
| 100 | 2.97±0.31 | 3.07±0.12 | 1.77±0.25 | 3.40±0.61 | 3.25±0.22 | 3.14±0.06 | 2.75±0.54 | 3.05±0.38 |
| 200 | 3.20±1.04 | 2.27±0.21 | 2.87±0.25 | 3.25±0.32 | 3.03±0.24 | 2.72±0.29 | 2.29±0.16 | 2.73±0.05 |
| 300 | 3.20±0.26 | 2.80±0.17 | 2.48±0.30 | 2.15±0.37 | 3.29±0.23 | 3.07±0.12 | 2.77±0.17 | 2.93±0.09 |
| 400 | 2.03±0.25 | 2.10±0.10 | 3.40±0.10 | 2.96±0.32 | 3.04±0.42 | 3.13±0.31 | 2.67±0.41 | 3.15±0.19 |
| 500 | 3.30±0.78 | 2.83±0.17 | 2.46±0.06 | 3.10±0.37 | 2.82±0.20 | 2.72±0.31 | 2.67±0.15 | 3.34±0.26 |
| 600 | 3.22±0.08 | 2.33±0.33 | 3.05±0.96 | 2.93±0.45 | 3.37±0.07 | 2.72±0.23 | 2.61±0.28 | 3.33±0.80 |
| 700 | nd | nd | nd | nd | 3.09±0.25 | 2.73±0.10 | 2.64±0.56 | 3.17±0.34 |
| 800 | nd | nd | nd | nd | 2.35±0.22 | 2.83±0.21 | 2.49±0.26 | 2.75±0.13 |
| 900 | nd | nd | nd | nd | 2.19±0.37 | nd | 2.50±0.15 | 2.67±0.16 |
| 1,000 | nd | nd | nd | nd | nd | nd | nd | 2.77±0.25 |
| 1,070 | nd | nd | nd | nd | nd | nd | nd | 2.83±0.08 |
| 1,380 | nd | nd | nd | nd | nd | nd | nd | 3.02±0.26 |
| 1,460 | nd | nd | nd | nd | nd | nd | nd | 2.75±0.22 |
| 1,850 | nd | nd | nd | nd | nd | nd | nd | 2.59±0.18 |
| Average | 2.94±0.46 | 2.95±1.07 | 2.67±0.52 | 3.09±0.52 | 2.98±0.41 | 2.88±0.18 | 2.58±0.15 | 2.94±0.24 |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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The electrical conductivity in the summer was available from 1.77±0.25 to 5.23±0.49 dS/m and influenced to the sediment become a slightly saline to a very slightly saline (Appendix). Between the 4 transect lines was different obviously at the 0-200 meters. The highest value was available at a 0 meter of line B and the lowest value was available of line C at a 100 m. The electrical conductivity of each transect lines along the path is shown in Fig. 4.14.

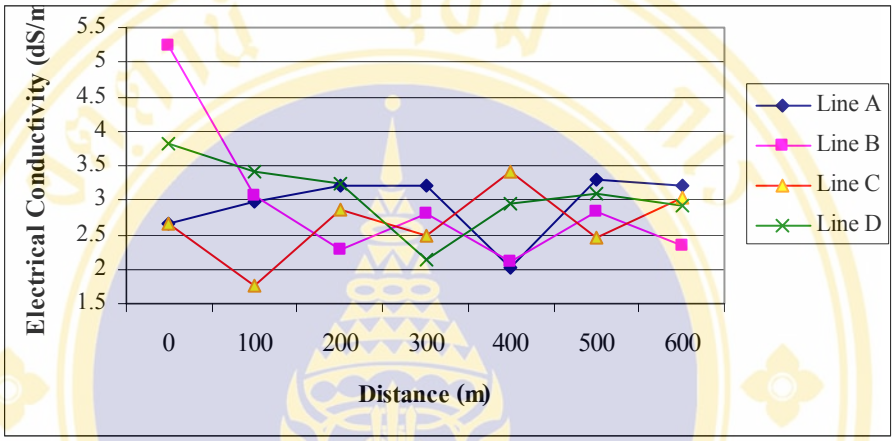


**Fig. 4.14 The electrical conductivity of each transects in the summer**

The electrical conductivity in the rainy season was available from 2.19±0.37 to 3.37±0.07 dS/m and influenced to the sediment become a very slightly saline (Appendix). Since 0 meter to the farther the electrical conductivity was in the same trendy. The trend of the electrical conductivity of line A was lower than the other transects from the 800 meters to the farther. The value of line D was higher than the other transects. The electrical conductivity of each transect lines along the path is shown in Fig. 4.15.

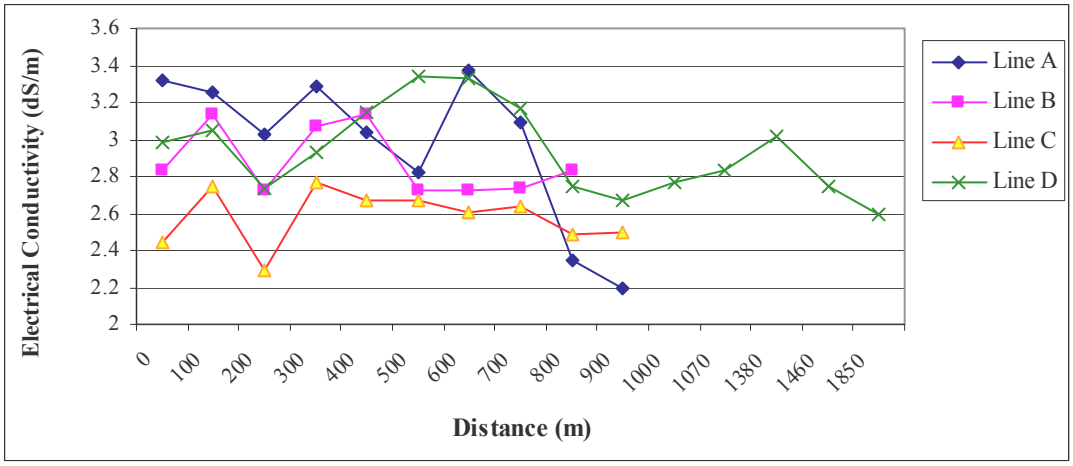


**Fig. 4.15 The electrical conductivity of each transects in the rainy season**

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However the electrical conductivity of the sediment in the Kung Krabaen Bay was able to considered separate of each transect line. The comparison was between the summer and the rainy season.

**Ta Tar Canal (Line A)**

The electrical conductivity of line A in the summer was lower than the rainy season at a 0 meter (near the rim of the mangrove forest). The trend in the summer was higher at the farther, but at the 400 meters was lower than the other distances. In the rainy season the trend was lower at the farther. The comparison is shown in the Fig 4.16.

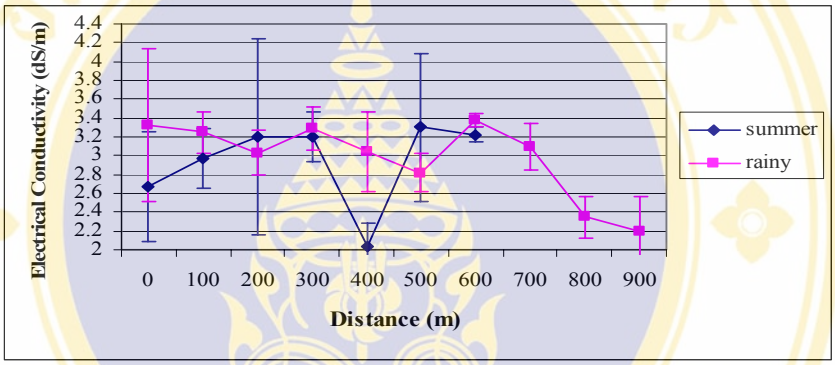


**Fig. 4.16 The electrical conductivity of line A compared between the summer and the rainy season**

**Ta Uoo Canal (Line B)**

The electrical conductivity of line B in the summer and the rainy season was different obviously particular at a 0 meter (near the rim of the mangrove forest). In the summer was higher than the rainy season and decreased when it was far from the mangrove forest. In the rainy season from the rim of the mangrove to the estuary of the river there was not different of the electrical conductivity value. The comparison is shown in the Fig 4.17.

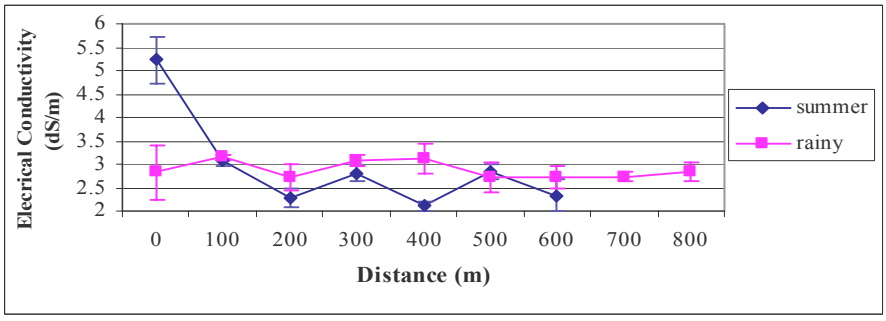


**Fig. 4.17 The electrical conductivity of line B compared between the summer and the rainy season**

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**Between Ta Guy and Mor Suk Canal (Line C)**

The electrical conductivity of line C in the summer was variably more than the rainy season. However the trend in the summer was higher at the farther area whereas in the rainy season the electrical conductivity was in the vicinity. The comparison is shown in the Fig 4.18.

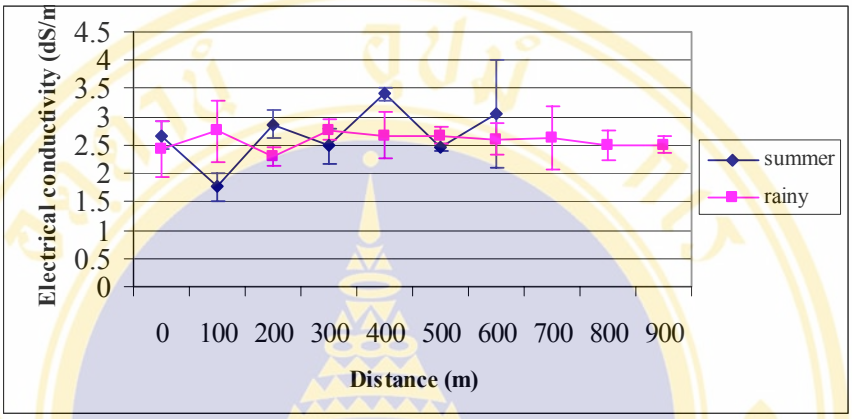


**Fig. 4.18 The electrical conductivity of line C compared between the summer and the rainy season**

**Sa Lut Canal (Line D)**

The electrical conductivity of line D in the summer was higher than the rainy season at the 0-200 meters. In the summer the value at the 300 meters was decreasingly and then increasingly. In the rainy season from the 300 meters to the estuary of the river the electrical conductivity increased and decreased at the farther area. However in the rainy season at the 1,380 meters the value was a little bit higher and then decreasingly. The comparison is shown in the Fig 4.19.

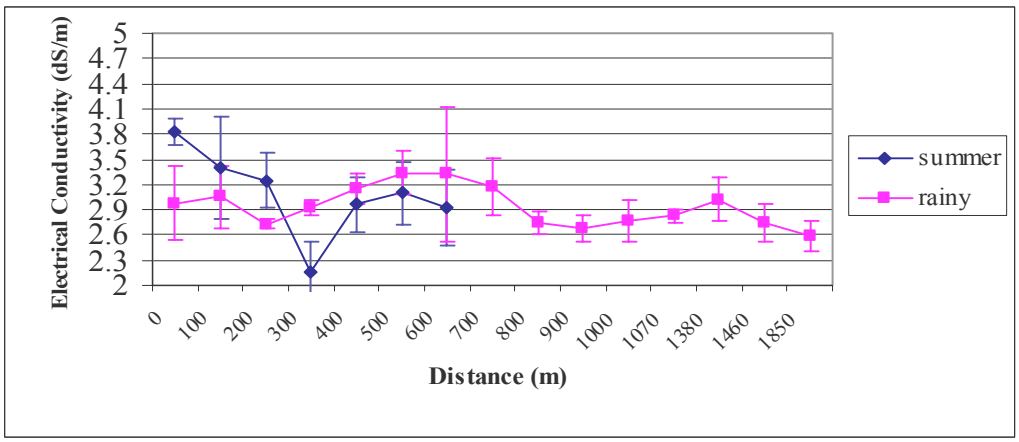


**Fig. 4.19 The electrical conductivity of line D compared between the summer and the rainy season**

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### C. Total organic matter (OM: %)

The total average of the organic matters of each transect line in the summer was available from 2.74±1.28, 1.36±0.75, 2.76±0.63 and 3.71±0.39 % of line A, line B, line C and line D, respectively.

In the rainy season the average was available from 1.77±0.52, 1.27±0.18, 0.58±0.27 and 1.20±0.37 % of line A, line B, line C and line D, respectively. The data shows in the table 4.6.

**Table 4.6 The organic matters of each transect lines in the summer and the rainy season**

| Distance (m) | %OM (Summer) | | | | %OM (Rainy) | | | |
|---|---|---|---|---|---|---|---|---|
| | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 0 | 5.37±0.53 | 5.73±0.25 | 2.48±0.41 | 4.53±0.16 | 3.03±0.81 | 1.68±0.09 | 1.04±0.92 | 1.65±0.70 |
| 100 | 3.32±0.14 | 1.52±0.14 | 1.55±0.05 | 3.82±0.23 | 2.13±0.26 | 1.93±0.01 | 0.57±0.13 | 0.97±0.72 |
| 200 | 2.22±0.04 | 0.49±0.12 | 3.00±0.72 | 3.66±0.09 | 1.65±0.25 | 1.65±0.07 | 0.09±0.04 | 1.20±0.26 |
| 300 | 2.09±0.13 | 0.45±0.15 | 2.56±0.39 | 3.40±0.08 | 1.76±0.22 | 1.59±0.02 | 0.41±0.5 | 1.11±0.11 |
| 400 | 2.07±0.11 | 0.29±0.04 | 3.16±0.21 | 3.48±0.21 | 1.13±0.28 | 1.75±0.02 | 0.70±0.57 | 2.21±2.01 |
| 500 | 2.50±0.30 | 0.33±0.15 | 3.19±0.20 | 3.48±0.08 | 1.58±0.18 | 0.60±0.29 | 0.80±0.66 | 1.20±0.15 |
| 600 | 1.59±0.31 | 0.68±0.06 | 3.40±0.16 | 3.61±0.05 | 1.77±0.13 | 0.85±0.10 | 0.43±0.37 | 1.44±0.43 |
| 700 | nd | nd | nd | nd | 1.82±0.37 | 0.56±0.23 | 0.33±0.45 | 1.22±0.10 |
| 800 | nd | nd | nd | nd | 1.39±0.15 | 0.81±0.02 | 0.63±0.32 | 1.09±0.14 |
| 900 | nd | nd | nd | nd | 1.43±0.09 | nd | 0.79±0.17 | 1.20±0.26 |
| 1000 | nd | nd | nd | nd | nd | nd | nd | 0.90±0.10 |
| 1070 | nd | nd | nd | nd | nd | nd | nd | 0.87±0.20 |
| 1380 | nd | nd | nd | nd | nd | nd | nd | 1.25±0.39 |
| 1460 | nd | nd | nd | nd | nd | nd | nd | 1.03±0.16 |
| 1850 | nd | nd | nd | nd | nd | nd | nd | 0.59±0.07 |
| Average | 2.74±1.28 | 1.36±0.75 | 2.76±0.63 | 3.71±0.39 | 1.77±0.52 | 1.27±0.18 | 0.58±0.27 | 1.20±0.37 |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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In the summer the average of the organic matters of each transect lines was available from 0.29±0.04 to 5.37±0.53 % and influenced to the sediment become a very low level to a very high level (Appendix). At a 0-200 m the trend of the organic matters of 4 transects was decreasingly. At a 200-600 m the average of each line was in the vicinity. Line B was lower level than the other transects, whereas line D was higher level than the others. The organic matters of each transect lines along the path are shown in Fig. 4.20.

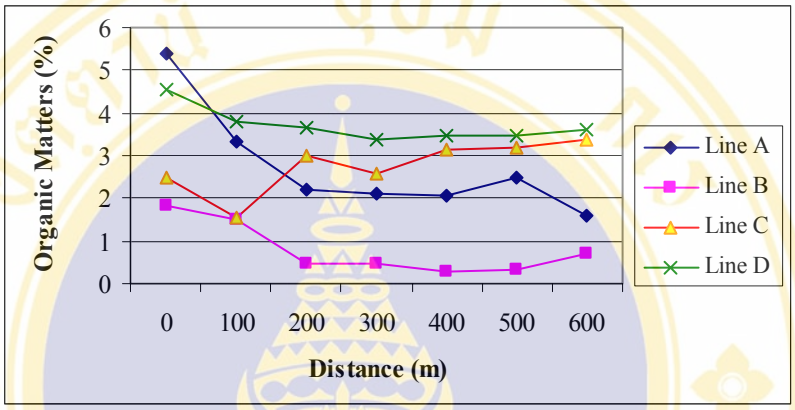


**Fig. 4.20 The organic matters of each transects in the summer**

In the rainy season the average of the organic matters of each transect lines was available from 0.09±0.04 to 3.03±0.81 % and influenced to the sediment become a very low level to a moderately high level (Appendix). It was different obviously between 4 transects at a 0-200 m. The organic matters of each transect lines along the path are shown in Fig. 4.21.

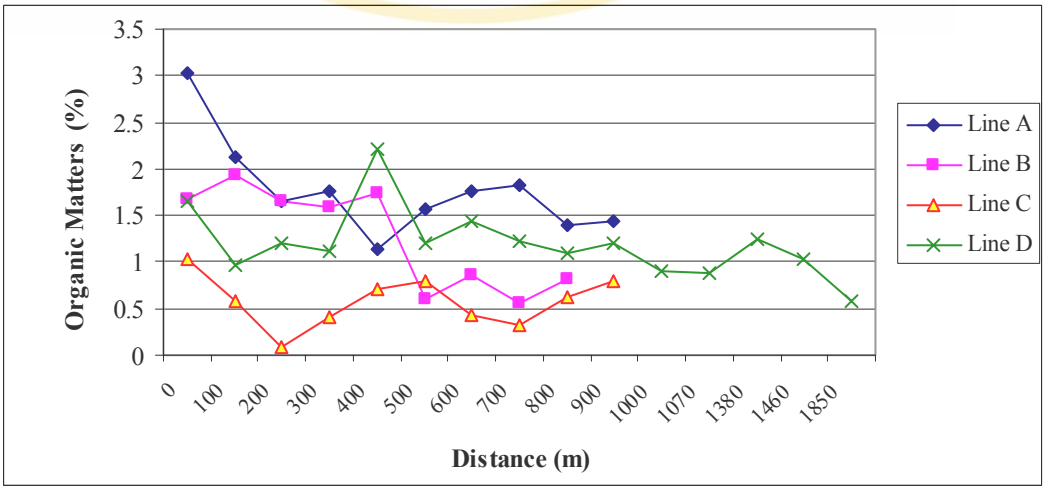


**Fig. 4.21 The organic matters of each transects in the rainy season**

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However the electrical conductivity of the sediment in the Kung Krabaen Bay was able to considered separate of each transect line. The comparison was between the summer and the rainy season.

**Ta Tar Canal (Line A)**

The organic matters in the sediment of line A in the summer and the rainy season were the same trend. The average value at the farther area was higher than the rim of the mangrove forest. In the summer the organic matters were higher than the rainy season. The comparison is shown in the Fig 4.22.

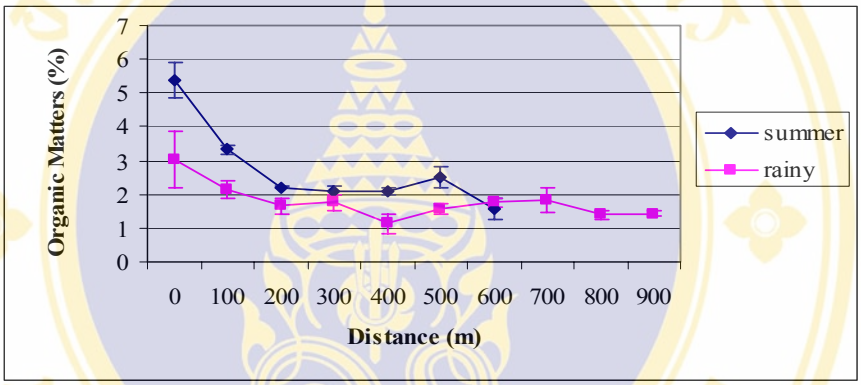


**Fig. 4.22 The organic matters of line A compared between the summer and the rainy season**

**Ta Uoo Canal (Line B)**

The organic matters in the sediment of line B in the summer were decreasingly from the rim of the mangrove forest to the estuary of the river. In the rainy season at the 500 meters (near the estuary of the river) the organic matters was decreasing obviously. The average of the organic matters in the summer was lower than the rainy season. The comparison is shown in the Fig 4.23.

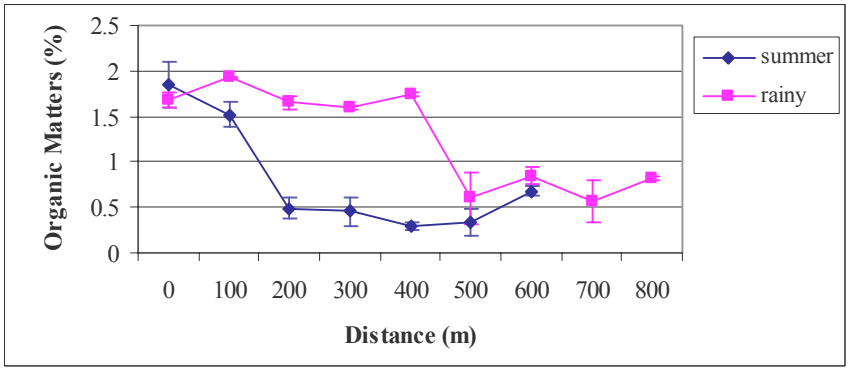


**Fig. 4.23 The organic matters of line B compared between the summer and the rainy season**

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**Between Ta Guy and Mor Suk Canal (Line C)**

The organic matters in the sediment of line C in the summer were higher than the rainy season. The trend in the summer was higher at the farther area. In the rainy season the trend was in the vicinity. The comparison is shown in the Fig 4.24.

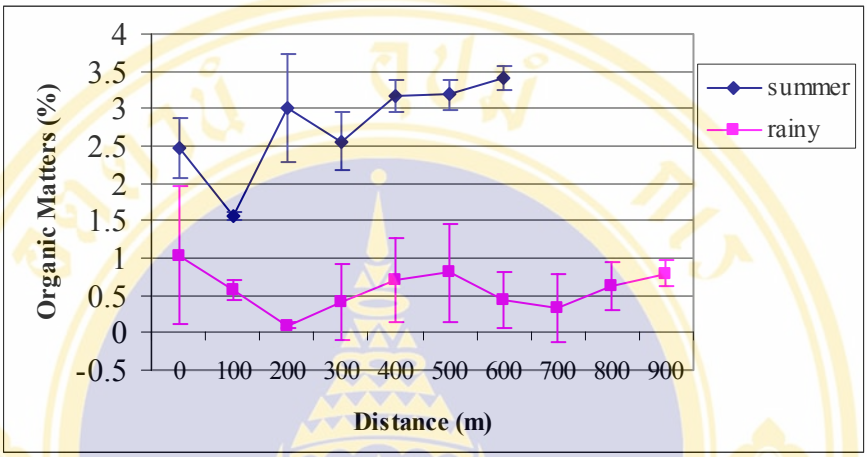


**Fig. 4.24 The organic matters of line C compared between the summer and the rainy season**

**Sa Lut Canal (Line D)**

The organic matters in the sediment of line D in the summer was decreasingly from the rim of the mangrove forest to the estuary of the river. The average was higher than the rainy season. In the rainy season the average was in the vicinity, but at the 400 meters it was increasing obviously. The comparison is shown in the Fig 4.25.

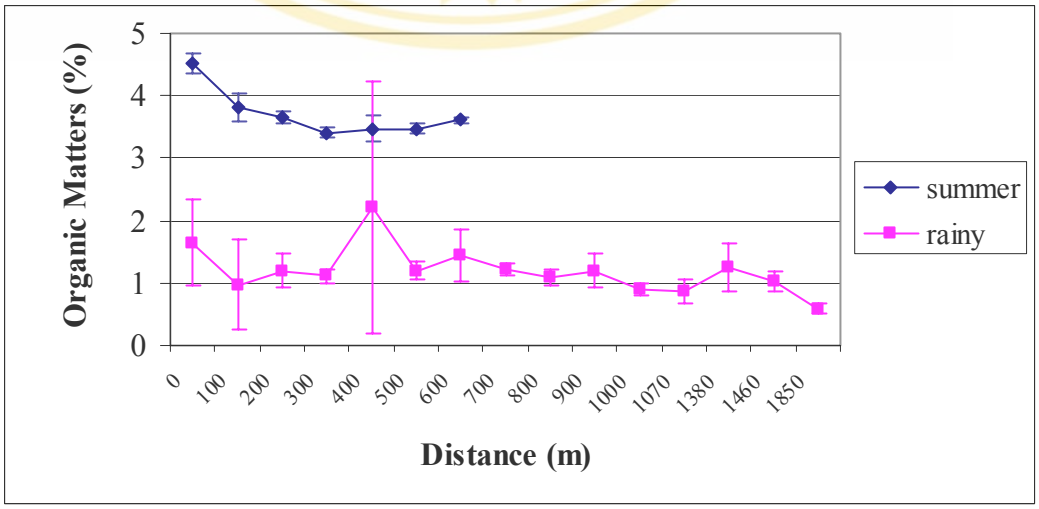


**Fig. 4.25 The organic matters of line C compared between the summer and the rainy season**

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**D. Total nitrogen (N: %)**

The total average of the total nitrogen of each transect lines in the summer was 0.036±0.017, 0.035±0.032, 0.031±0.012 and 0.032±0.005 % of line A, line B, line C, and line D, respectively.

In the rainy season the average was 0.032±0.031, 0.011±0.009, 0.027±0.009, and 0.034±0.020 % of line A, line B, line C and line D, respectively. The data shows in the table 4.7.

**Table 4.7 The total nitrogen of each transect lines in the summer and the rainy season**

| Distance (m) | summer | | | | rainy | | | |
|---|---|---|---|---|---|---|---|---|
| | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 0 | 0.006± 0.002 | 0.099± 0.018 | 0.039± 0.004 | 0.041± 0.005 | 0.095± 0.007 | 0.021± 0.009 | 0.043± 0.027 | 0.057± 0.009 |
| 100 | 0.032± 0.026 | 0.056± 0.030 | 0.009± 0.004 | 0.032± 0.001 | 0.057± 0.003 | 0.014± 0.000 | 0.041± 0.002 | 0.027± 0.001 |
| 200 | 0.051± 0.001 | 0.022± 0.007 | 0.030± 0.010 | 0.032± 0.002 | 0.043± 0.004 | 0.004± 0.001 | 0.023± 0.008 | 0.025± 0.003 |
| 300 | 0.041± 0.001 | 0.009± 0.011 | 0.028± 0.010 | 0.026± 0.000 | 0.039± 0.001 | 0.004± 0.001 | 0.027± 0.003 | 0.037± 0.000 |
| 400 | 0.038± 0.002 | 0.020± 0.002 | 0.048± 0.006 | 0.029± 0.001 | 0.048± 0.003 | 0.003± 0.001 | 0.022± 0.004 | 0.033± 0.001 |
| 500 | 0.055± 0.003 | 0.017± 0.002 | 0.030± 0.004 | 0.031± 0.001 | 0.038± 0.007 | 0.002± 0.001 | 0.020± 0.003 | 0.039± 0.000 |
| 600 | 0.031± 0.002 | 0.023± 0.005 | 0.031± 0.008 | 0.030± 0.001 | 0.002± 0.002 | 0.022± 0.007 | 0.031± 0.001 | 0.038± 0.016 |
| 700 | nd | nd | nd | nd | 0 | 0.020± 0.001 | 0.026± 0.001 | 0.031± 0.000 |
| 800 | nd | nd | nd | nd | 0 | 0.020± 0.001 | 0.020± 0.000 | 0.025± 0.001 |
| 900 | nd | nd | nd | nd | 0 | nd | 0.016± 0.001 | 0.019± 0.000 |
| 1,000 | nd | nd | nd | nd | nd | nd | nd | 0.019± 0.002 |
| 1,070 | nd | nd | nd | nd | nd | nd | nd | 0.022± 0.002 |
| 1,380 | nd | nd | nd | nd | nd | nd | nd | 0.033± 0.003 |
| 1,460 | nd | nd | nd | nd | nd | nd | nd | 0.094± 0.089 |
| 1,850 | nd | nd | nd | nd | nd | nd | nd | 0.013±0. 006 |
| Average | 0.036± 0.017 | 0.035± 0.032 | 0.031± 0.012 | 0.032± 0.005 | 0.032± 0.031 | 0.011± 0.009 | 0.027± 0.009 | 0.034± 0.020 |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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The total average of the total nitrogen in the summer was available from 0.006±0.002 to 0.099±0.018 (less than 0.1%) and influenced to the sediment become a very low level (Appendix). Between the 4 transects at the 0-200 meters the total nitrogen was different, but from the 300 meters to the farther the total nitrogen of line B was lower than others. The total nitrogen of each transect lines along the path are shown in Fig. 4.26.

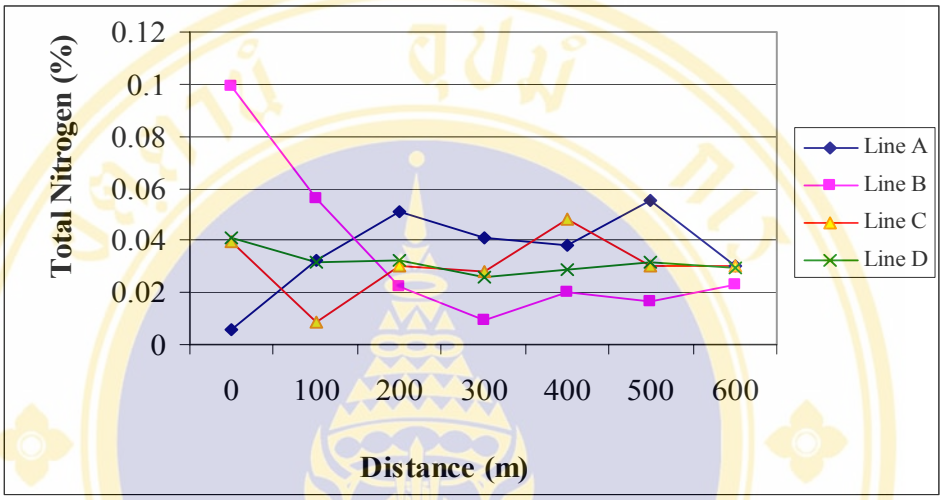


**Fig. 4.26 The total nitrogen of each transects in the summer**

The average of the total nitrogen in the rainy season was available from 0.002±0.002 to 0.095±0.007 % (less than 0.1 %), and influenced to the sediment become a very low level (Appendix). The trend of 4 transects was decreasing when the distance was farther. The highest of average was available in line A, the second was line D, and the lowest was line B. The total nitrogen of each transect lines along the path are shown in Fig. 4.27.

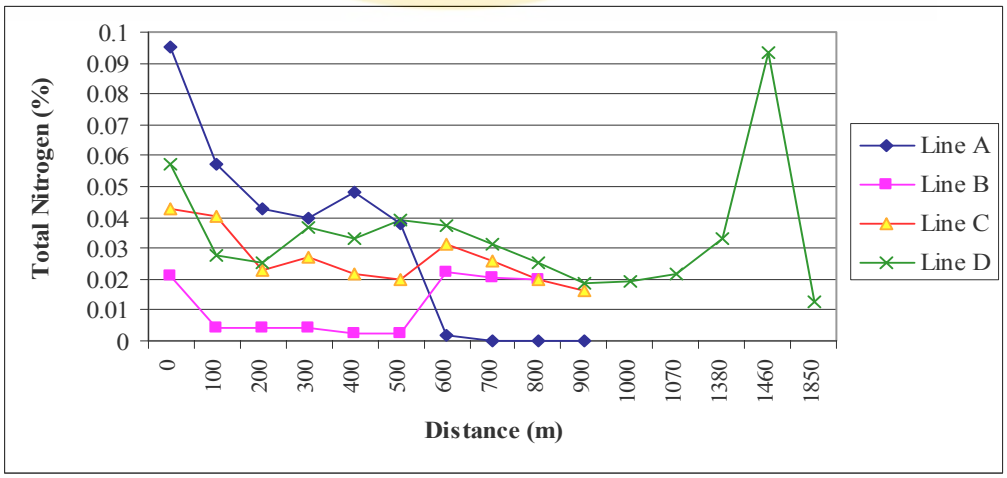


**Fig. 4.27 The total nitrogen of each transects in the rainy season**

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However the total nitrogen in the sediment in the Kung Krabaen Bay was able to considered separate of each transect line. The comparison was between the summer and the rainy season.

**Ta Tar Canal (Line A)**

The total nitrogen in the sediment of line A in at a 0-200 meters was different obviously between the summer and the rainy season. In the summer the average was lower than the rainy season. The trend of the total nitrogen was increasingly in the summer whereas it was decreasingly in the rainy season. At the 200-500 meters in both seasons was in the vicinity and from the 500 meters to the farther the trend was decreasingly. The comparison is shown in the Fig 4.28.

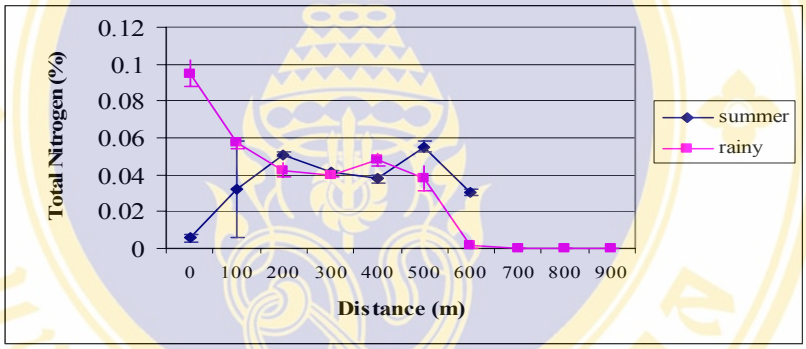


**Fig. 4.28 The total nitrogen of line A compared between the summer and the rainy season**

**Ta Uoo Canal (Line B)**

The total nitrogen in the sediment of line B in the summer was decreasingly from the rim of the mangrove forest to the estuary of the river. In the summer only from a 0 meter to 100 meter the trend was decreasingly, but at the farther area the total nitrogen was in the vicinity. However it was a little bit higher at the 600 meters up. The comparison is shown in the Fig 4.29.

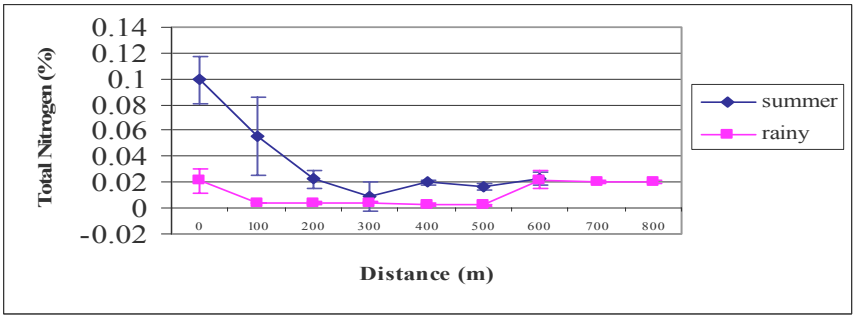


**Fig. 4.29 The total nitrogen of line B compared between the summer and the rainy season**

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**Between Ta Guy and Mor Suk Canal (Line C)**

The total nitrogen in the sediment of line C in the summer and the rainy season was variability from the rim of the mangrove forest to the estuary of the river. At the 0-200 meters in the summer the average was lower than the rainy season. At the 300-600 meters the average was higher in the summer than the rainy season. However in the rainy season the trend of the accumulation was decreasingly. The comparison is shown in the Fig 4.30.

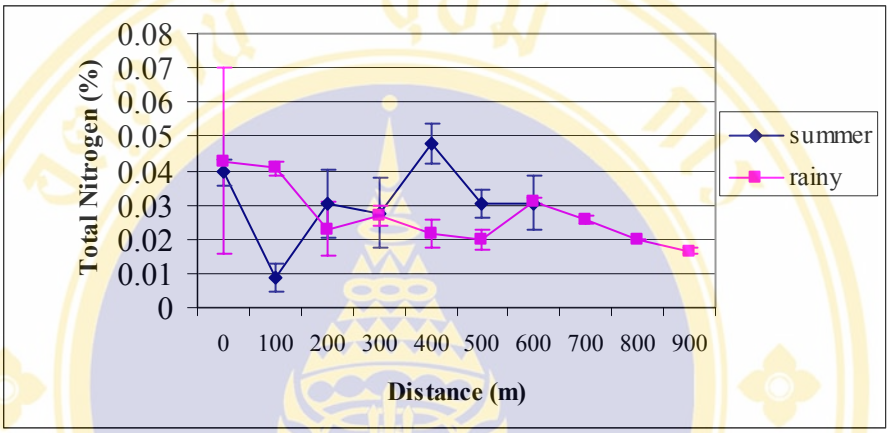


**Fig. 4.30 The total nitrogen of line C compared between the summer and the rainy season**

**Sa Lut Canal (Line D)**

The total nitrogen in the sediment of line D in the summer and the rainy season was in the vicinity from the rim of the mangrove forest to the 600 meters. The trend of accumulation in the summer was decreasingly as same as in the rainy season. However in the rainy season at the 1,460 meters was able to notice that the total nitrogen was higher than the other distances. The comparison is shown in the Fig 4.31.

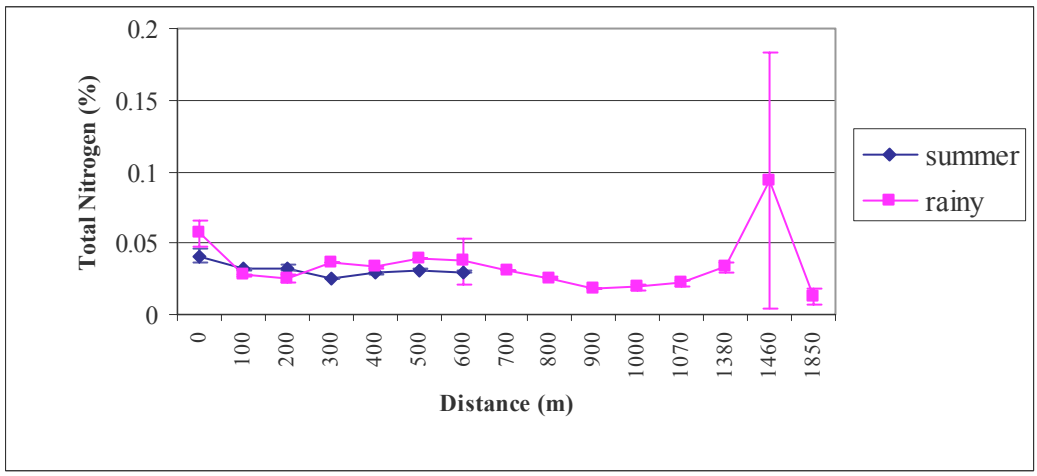


**Fig. 4.31 The total nitrogen of line D compared between the summer and the rainy season**

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**E. Available Phosphorus (Avai p: ppm)**

The total average of the available phosphorus of each transect lines in the summer was 90.93±23.55, 74.24±17.49, 63.35±20.61 and 23.15±7.83 ppm of line A, line B, line C, and line D, respectively. In the rainy season the average was 82.37±17.62, 82.44±14.18, 72.33±11.94, and 64.53±15.72 ppm of line A, line B, line C, and line D, respectively. The data shows in the table 4.8.

**Table 4.8 The available phosphorus of each transect lines in the summer and the rainy season**

| Distance (m) | Summer (ppm) | | | | Rainy (ppm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 0 | 62.33± 23.98 | 84.00± 10.15 | 72.33± 27.40 | 14.44± 5.42 | 63.33± 4.73 | 54.33± 8.50 | 49.00± 14.00 | 68.00± 8.54 |
| 100 | 79.67± 34.93 | 104.00± 6.00 | 26.67± 3.51 | 35.11± 2.80 | 88.00± 14.00 | 80.33± 3.06 | 70.67± 18.15 | 77.33± 4.73 |
| 200 | 59.17± 0.76 | 70.67± 7.64 | 64.67± 22.23 | 23.82± 14.59 | 92.33± 5.69 | 79.67± 8.54 | 62.33± 4.16 | 83.33± 4.62 |
| 300 | 112.67± 12.70 | 56.67± 2.31 | 86.00± 27.18 | 15.67± 4.41 | 82.33± 21.39 | 93.67± 25.58 | 85.00± 6.56 | 97.00± 6.93 |
| 400 | 110.67± 7.23 | 62.00± 7.00 | 79.33± 20.65 | 20.00± 5.17 | 103.33± 18.45 | 94.67± 19.55 | 88.00± 19.05 | 81.33± 6.66 |
| 500 | 100.67± 19.04 | 57.67± 4.51 | 69.00± 10.58 | 21.00± 6.69 | 99.67± 6.66 | 84.33± 9.61 | 79.67± 22.59 | 72.33± 3.21 |
| 600 | 111.33± 6.11 | 84.67± 6.11 | 45.44± 22.34 | 32.00± 4.81 | 102.00± 9.17 | 72.67± 15.50 | 81.00± 13.00 | 63.33± 2.31 |
| 700 | nd | nd | nd | nd | 75.33± 11.15 | 79.33± 7.64 | 62.33± 8.50 | 68.67± 19.14 |
| 800 | nd | nd | nd | nd | 60.00± 12.17 | 103.00± 15.39 | 72.00± 7.55 | 56.00± 6.56 |
| 900 | nd | nd | nd | nd | 57.33± 4.51 | nd | 73.33± 7.37 | 53.33± 15.31 |
| 1000 | nd | nd | nd | nd | nd | nd | nd | 53.00± 2.65 |
| 1070 | nd | nd | nd | nd | nd | nd | nd | 59.00± 7.00 |
| 1380 | nd | nd | nd | nd | nd | nd | nd | 43.33± 8.33 |
| 1460 | nd | nd | nd | nd | nd | nd | nd | 43.00± 4.36 |
| 1850 | nd | nd | nd | nd | nd | nd | nd | 68.00± 6.08 |
| Average | 90.93± 23.55 | 74.24± 17.49 | 63.35± 20.61 | 23.15± 7.83 | 82.37± 17.62 | 82.44± 14.18 | 72.33± 11.94 | 64.53± 15.72 |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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The total average of the available phosphorus in the summer was available from 14.44±5.42 to 112.67±12.70 ppm and influenced to the sediment become a medium to a very high level (Appendix). The trend of line A, line B, and line D was same direction at the 0-200 meters. Along the path the average of line D was the lowest. The total nitrogen of each transect lines along the path are shown in Fig. 4.32.

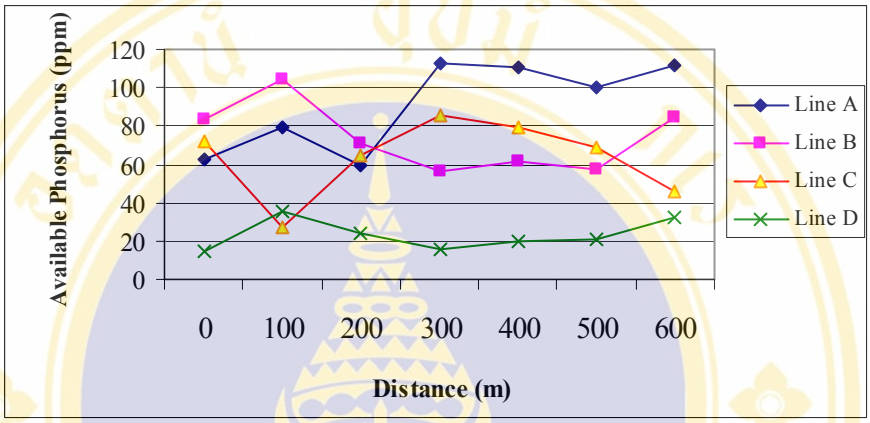


**Fig. 4.32 The available phosphorus of each transects in the summer**

The total average of the available phosphorus in the rainy season was available from 43.00±4.36 to 103.33±18.45 ppm and influenced to the sediment become a medium to a very high level (Appendix). The trend of each line was increasingly at the 0-400 meters and decreasingly from 400 to 700 meters. At the 800 meters the average of line B was higher than the other transects. The total nitrogen of each transect lines along the path are shown in Fig. 4.32.

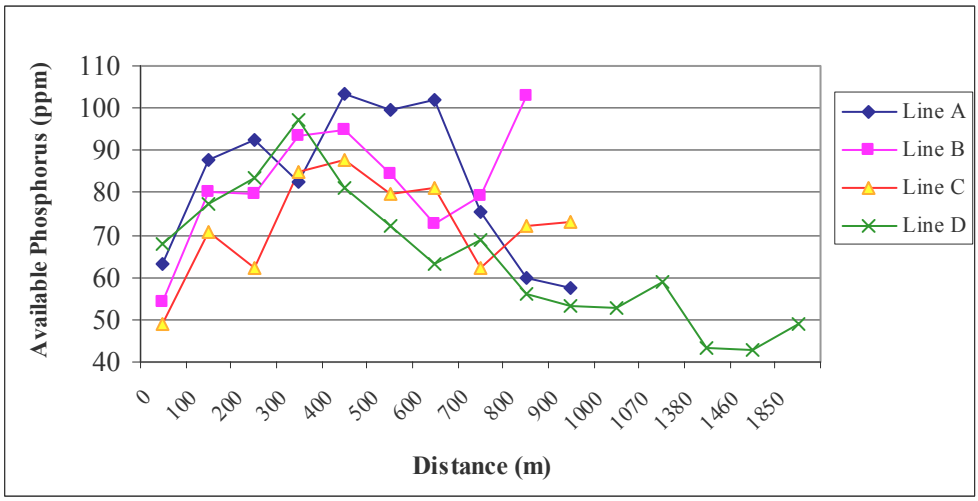


**Fig. 4.33 The available phosphorus of each transects in the rainy season**

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However the available phosphorus in the sediment in the Kung Krabaen Bay was able to considered separate of each transect line. The comparison was between the summer and the rainy season.

**Ta Tar Canal (Line A)**

The available phosphorus in the sediment of line A in the summer was increasingly from the rim of the mangrove forest, but at the 200 meters was low. In the rainy season the average was increasingly up to the 600 meters and then decreasingly. The comparison is shown in the Fig 4.34.

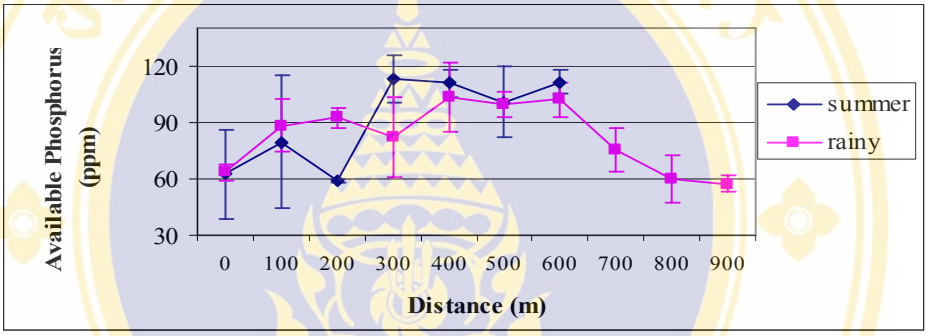


**Fig. 4.34 The available phosphorus of line A compared between the summer and the rainy season**

**Ta Uoo Canal (Line B)**

The available phosphorus in the sediment of line B in the summer and the rainy season at the 0-100 meters was increasingly. In the summer the average was decreasingly from the rim of the mangrove forest to the estuary of the river and higher at the 600 meters. In the rainy season the trend was increasingly at the farther area from the mangrove forest and decreasingly at the 600 meters. Farther than 600 meters the average was higher. The comparison is shown in the Fig 4.35.

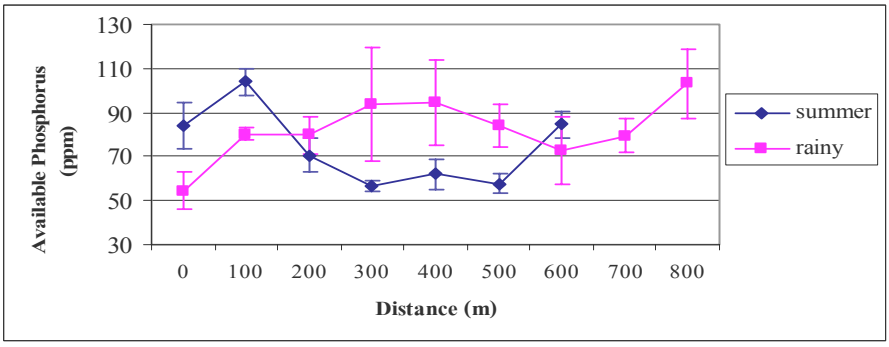


**Fig. 4.35 The available phosphorus of line B compared between the summer and the rainy season**

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**Between Ta Guy and Mor Suk Canal (Line C)**

The available phosphorus in the sediment of line C in the summer was variability more than the rainy season. In the summer at the 100 meters the average was lowest. In the rainy season the trend was increasingly from the rim of the mangrove forest to the estuary of the river. The comparison is shown in the Fig 4.36.

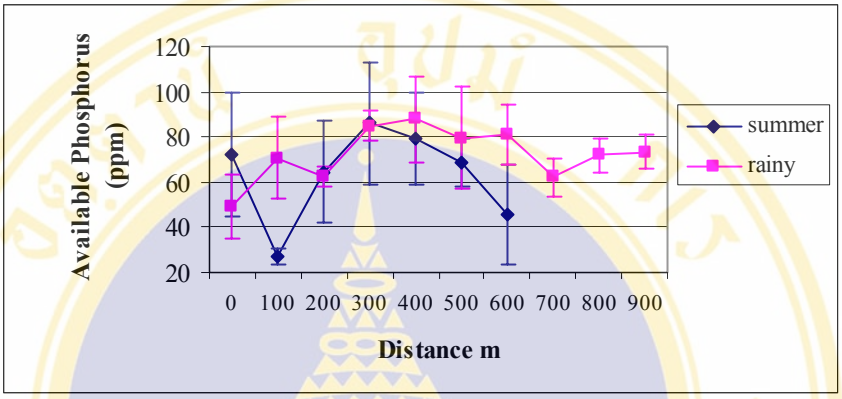


**Fig. 4.36 The available phosphorus of line C compared between the summer and the rainy season**

**Sa Lut Canal (Line D)**

The available phosphorus in the sediment of line D in the summer and the rainy season particular at the 0-600 meters was increasingly and then decreasingly. However at the 600 meters the average was a little bit higher in the summer. At the 700 meters up to the farther area the average was decreasingly in the rainy season. The comparison is shown in the Fig 4.37.

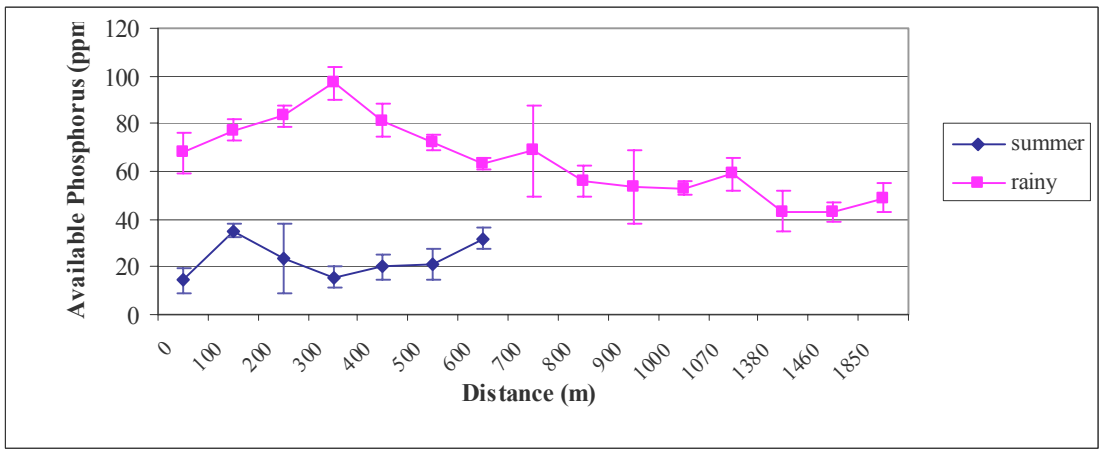


**Fig. 4.37 The available phosphorus of line D compared between the summer and the rainy season**

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**F. Available Potassium (Avai K: ppm)**

The total average of the available potassium of each transect lines in the summer was 94.61±64.06, 86.48±65.87, 59.48±14.86, and 70.80±38.37 ppm of line A, line B, line C and line D, respectively.

In the rainy season the average was 47.39±19.88, 34.32±5.80, 40.08±8.77, and 58.50±12.93 ppm of line A, line B, line C and line D, respectively. The data shows in the table 4.9.

**Table 4.9 The available potassium of each transect lines in the summer and the rainy season**

| Distance (m) | Summer (ppm) | | | | Rainy (ppm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 0 | 230.73± 18.57 | 234.55± 1.49 | 75.56± 1.98 | 137.30± 23.48 | 95.38± 10.92 | 30.28± 7.80 | 52.01± 21.37 | 85.96± 10.23 |
| 100 | 86.42± 49.19 | 79.98± 12.27 | 34.34± 5.19 | 92.18± 1.35 | 61.14± 7.52 | 45.49± 4.53 | 55.39± 0.88 | 54.74± 7.30 |
| 200 | 94.59± 0.59 | 54.35± 5.06 | 65.54± 6.19 | 84.87± 0.30 | 49.48± 7.21 | 38.92± 5.75 | 34.81± 0.35 | 46.06± 6.45 |
| 300 | 43.01± 42.50 | 58.78± 5.52 | 47.56± 0.56 | 74.47± 3.40 | 51.59± 0.29 | 32.88± 6.33 | 47.68± 1.81 | 48.76± 3.39 |
| 400 | 39.66± 40.96 | 55.19± 11.36 | 72.09± 12.54 | 39.16± 2.01 | 39.59± 22.80 | 39.64± 8.69 | 37.26± 6.74 | 40.95± 0.47 |
| 500 | 91.51± 1.65 | 63.89± 7.69 | 53.83± 0.13 | 35.73± 4.38 | 41.10± 10.26 | 27.82± 5.74 | 39.78± 4.23 | 70.61± 27.79 |
| 600 | 76.33± 5.04 | 58.67± 2.55 | 67.45± 17.99 | 31.92± 3.27 | 23.59± 33.61 | 30.13± 6.49 | 39.13± 4.50 | 41.35± 15.89 |
| 700 | nd | nd | nd | nd | 44.30± 7.33 | 30.41± 0.50 | 30.40± 2.05 | 70.59± 5.34 |
| 800 | nd | nd | nd | nd | 33.95± 12.62 | 33.31± 3.64 | 31.25± 0.78 | 63.09± 4.13 |
| 900 | nd | nd | nd | nd | 33.74± 3.20 | nd | 33.11± 5.08 | 53.39± 7.46 |
| 1,000 | nd | nd | nd | nd | nd | nd | nd | 54.58± 3.37 |
| 1,070 | nd | nd | nd | nd | nd | nd | nd | 55.77± 3.74 |
| 1,380 | nd | nd | nd | nd | nd | nd | nd | 75.60± 10.03 |
| 1,460 | nd | nd | nd | nd | nd | nd | nd | 64.42± 12.88 |
| 1,850 | nd | nd | nd | nd | nd | nd | nd | 53.01± 2.43 |
| Average | 94.61± 64.06 | 86.48± 65.87 | 59.48± 14.86 | 70.80± 38.37 | 47.39± 19.88 | 34.32± 5.80 | 40.08± 8.77 | 58.50± 12.93 |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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The average of the available potassium in the sediment in the summer was available from 31.92±3.27 to 234.55±1.49 ppm and influenced to the sediment become a very low to a very high level (Appendix). Each line at 0-200 m the average was different obviously and from the 200 m up to the farther the average was in the vicinity. The available potassium of each transect lines along the path was shown in Fig. 4.38.

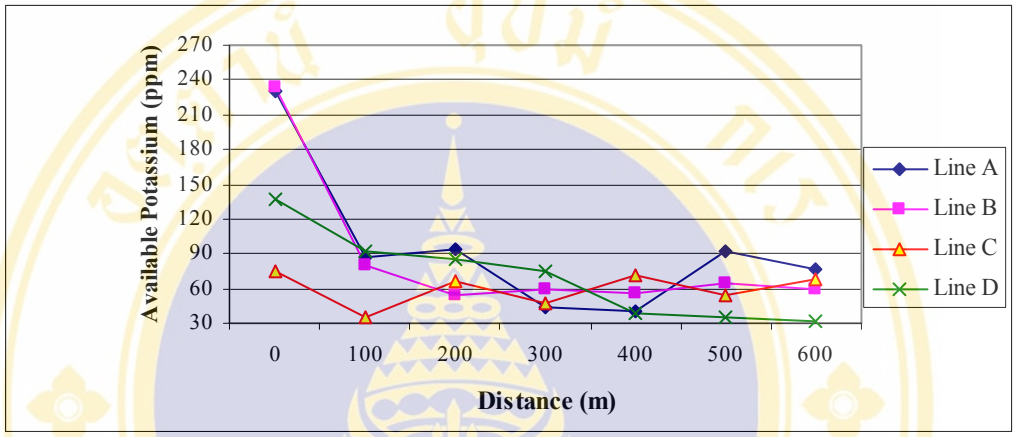


**Fig. 4.38 The available potassium of each transects in the summer**

In the rainy season the average of available potassium of each transect lines was available from 23.59±33.61 to 95.38±10.92 ppm and influenced to the sediment become a very low to a high level (Appendix). At a 0 m of each transects the average was different obviously. In line A and line D the average was higher than line B and line C. At the 300 m the average of line C was a highest level. Line D from the 400 m up to the farther the average was higher than the others. The available potassium of each transect lines along the path was shown in Fig. 4.39.

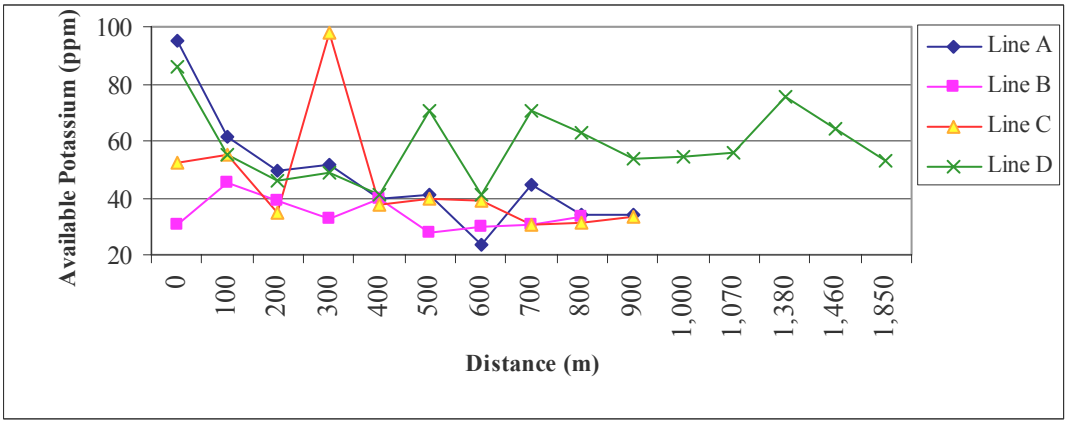


**Fig. 4.39 The available potassium of each transects in the rainy season**

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However the available potassium in the sediment in the Kung Krabaen Bay was able to considered separate of each transect line. The comparison was between the summer and the rainy season.

**Ta Tar Canal (Line A)**

The available potassium in the sediment of line A in the summer and the rainy season was decreasingly from the rim of the mangrove forest to the estuary of the river. The average in the summer was higher than the rainy season particular at the rim of the mangrove forest. The comparison is shown in the Fig 4.40.

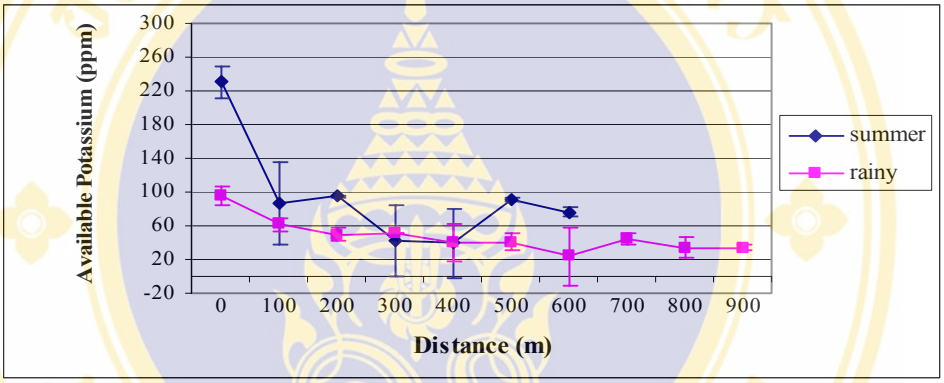


**Fig. 4.40 The available potassium of line A compared between the summer and the rainy season**

**Ta Uoo Canal (Line B)**

The available potassium in the sediment of line B in the summer at the 0-100 meters the average was decreasingly. The rainy season the trend was increasingly. However from the 100 meters up to the farther the trend was in the vicinity between the summer and the rainy season. The comparison is shown in the Fig 4.41.

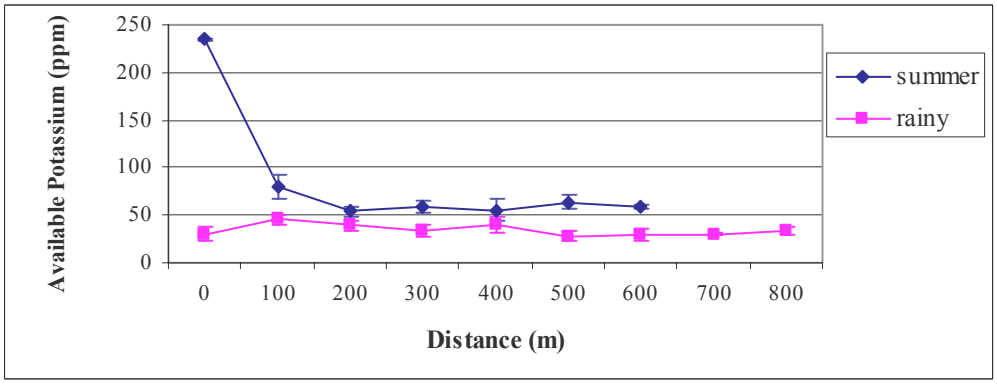


**Fig. 4.41 The available potassium of line B compared between the summer and the rainy season**

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**Between Ta Guy and Mor Suk Canal (Line C)**

The available potassium in the sediment of line C in the summer and the rainy season was variability from the rim of the mangrove forest to the estuary of the river. However the notice of the summer the trend was increasingly whereas in the rainy season was decreasingly. The comparison is shown in the Fig 4.42.

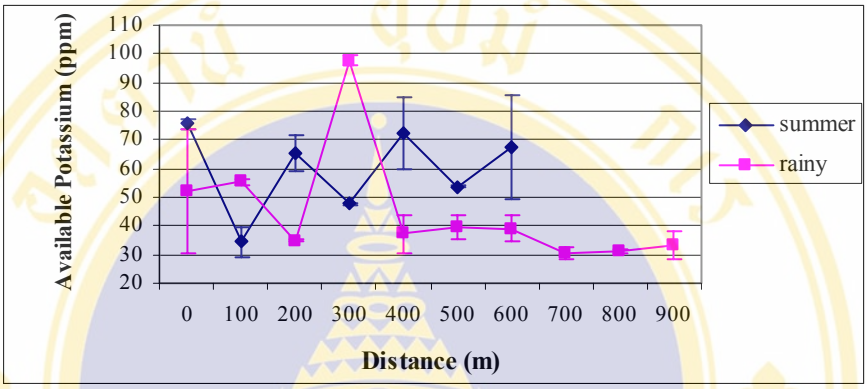


**Fig. 4.42 The available potassium of line C compared between the summer and the rainy season**

**Sa Lut Canal (Line D)**

The available potassium in the sediment of line D in the summer was decreasingly from the rim of the mangrove forest to the estuary of the river. In the rainy season the average was decreasingly at only the 0-400 meters and increasingly at the farther area. The comparison is shown in the Fig 4.43.

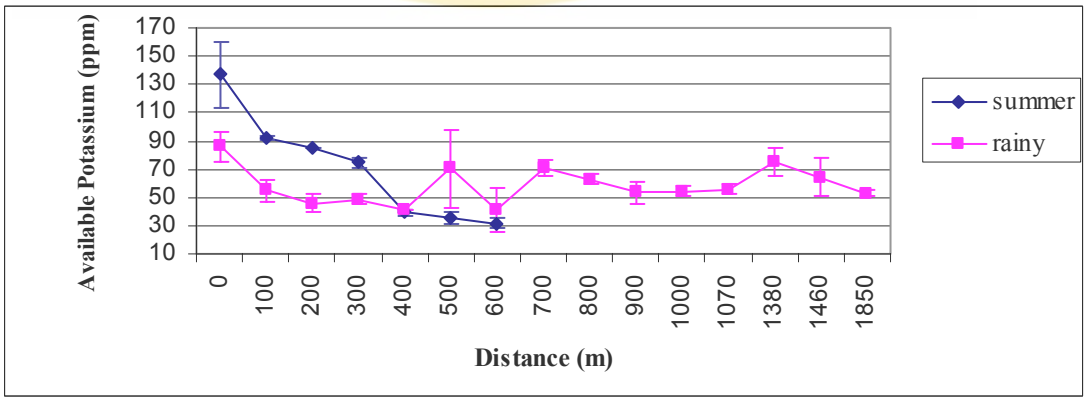


**Fig. 4.43 The available potassium of line D compared between the summer and the rainy season**

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## G. Cation exchange capacity (CEC: meq/100gm.soil)

The cation exchange capacity of the sediment in this case was analyzed only in the rainy season. The lowest of an average was 2.60±0.57 meq/100gm.soil of line B and the highest was 18.60±0.00 meq/100gm.soil of line D. The data shows in the table 4.10.

**Table 4.10 The cation exchange capacity of each transect lines in the rainy season**

| Distance (m) | Line A | | Line B | | Line C | | Line D | |
|---|---|---|---|---|---|---|---|---|
| | CEC (meq/100gm-soil) | Texture | CEC (meq/100gm-soil) | texture | CEC (meq/100gm-soil) | texture | CEC (meq/100gm-soil) | texture |
| 0 | 3.40± 0.00 | Sandy loam | 10.80± 0.28 | Sandy loam | 8.80± 0.28 | Sandy loam | 8.70± 0.14 | Sandy loam |
| 100 | 3.40± 0.00 | Sandy loam | 6.60± 0.00 | Sandy loam | 5.20± 0.57 | Loamy sand | 6.10± 0.14 | Silt |
| 200 | 3.80± 0.00 | Sandy loam | 6.60± 0.00 | Sandy loam | 6.40± 0.00 | Loamy sand | 16.00± 0.00 | Silt |
| 300 | 4.40± 0.28 | Loam | 6.80± 0.28 | Sandy loam | 5.80± 0.28 | Sandy loam | 10.00± 0.28 | Silt |
| 400 | 7.00± 0.00 | Silt | 18.20± 0.28 | Sandy loam | 13.20± 0.00 | Sandy loam | 9.90± 0.42 | Silt |
| 500 | 7.20± 0.28 | Silt | 9.80± 0.00 | Sandy loam | 10.20± 0.00 | Sandy loam | 18.60± 0.00 | Sandy loam |
| 600 | 9.20± 0.28 | Silt | 2.60± 0.57 | Sandy loam | 8.80± 0.28 | Sandy loam | 7.90± 0.14 | Sandy loam |
| 700 | 10.40± 0.28 | Silt | 9.00± 0.57 | Sandy loam | 9.10± 0.14 | Sandy loam | 10.80± 0.00 | Sandy loam |
| 800 | 9.00± 0.00 | Sandy loam | 8.20± 0.00 | Sandy loam | 7.60± 0.28 | Sandy loam | 12.70± 0.14 | Sandy loam |
| 900 | 3.80± 0.00 | Sandy loam | nd | nd | 8.70± 0.14 | Sandy loam | 5.80± 0.28 | Sandy loam |
| 1000 | nd | nd | nd | nd | nd | nd | 7.60± 0.28 | Sandy loam |
| 1070 | nd | nd | nd | nd | nd | nd | 8.70± 0.42 | Sandy loam |
| 1380 | nd | nd | nd | nd | nd | nd | 10.80± 0.00 | Sandy loam |
| 1460 | nd | nd | nd | nd | nd | nd | 13.70± 0.14 | Sandy loam |
| 1850 | nd | nd | nd | nd | nd | nd | 6.70± 0.14 | Loamy sand |
| Average | 6.16± 2.72 | - | 8.73± 4.27 | - | 8.38± 2.33 | - | 10.27± 3.67 | - |

Notice: nd = no data (the area which did not have the sample collection because the characteristic is same as the last station of each transects)

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The average of the cation exchange capacity of the sediment in the rainy season of line A was lower than the other lines. At the 600-800 meters the average of line B was the lowest at the 600 meters whereas at the 200 meters the highest was available in line D. Because of in line D the most of texture characteristic was silt (the particle was very smaller than the other texture of other lines). The cation exchange capacity of each transect lines along the path was shown in Fig. 4.44.

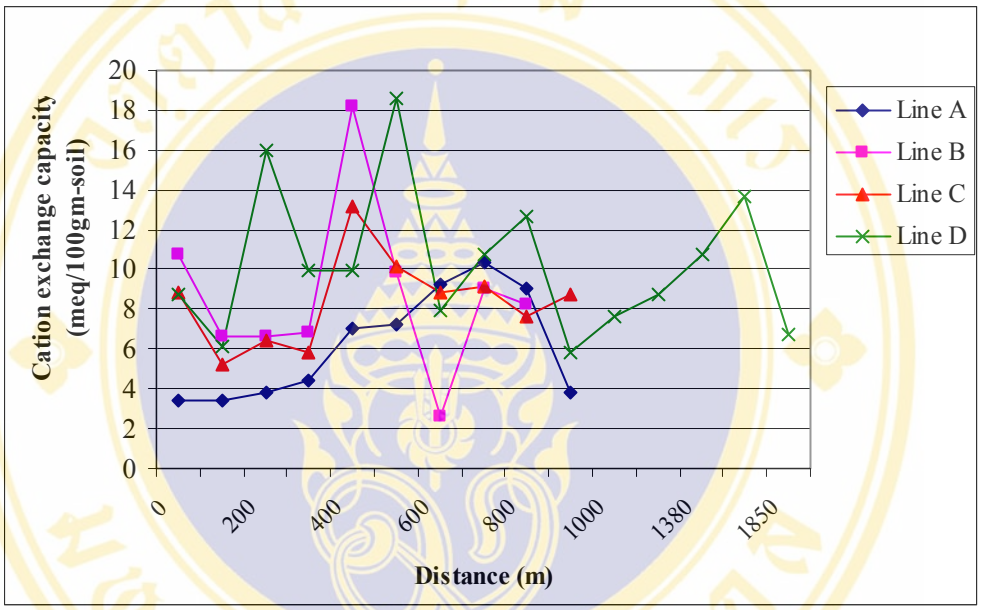


**Fig. 4.44 The cation exchange capacity of each transects in the rainy season**

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**The summarize of the chemical qualities of the sediment of 4 transects in the summer and the rainy season**

The distance along each path of the 4 transects was shorter in the summer than the rainy season. A schedule of each sample station in the summer did not overlap completely with the one in the rainy season. Each schedule which took place in the summer was far from the one in the rainy season about 50-100 meters (Appendix, the Table C-8 to the Table C-11). Such the error of the schedules in this case the analysis of the different between the summer and the rainy season did not do. However the different of the chemical qualities of the sediment between the 4 transects was analyzed in the same season. The level of the different was able to show by the standard of the sediment assessment from the manual of an assessment the environmental of soil resources and land use (Navanugrah, 2002). The summarize was shown below;

The 4 parameters of the sediment from the 7 chemical qualities which studied had a same level were the pH, electrical conductivity, total nitrogen, and available phosphorus. Only 2 parameters were different level between the summer and the rainy season. These parameters were the total organic matters and the available potassium. The average of each parameters and the level of the standard of line A, line B, line C, and line D in the summer and the rainy season were shown in the Table 4.11.

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**Table 4.11 The average of each parameters and the level of the standard in the 4 transects in the summer and the rainy season**

| Sediment Parameter | Line A | | Line B | | Line C | | Line D | | Different |
|---|---|---|---|---|---|---|---|---|---|
| | summer | rainy | summer | rainy | summer | rainy | summer | rainy | |
| pH | 7.73 | 7.81 | 7.69 | 8.02 | 7.94 | 8.06 | 7.69 | 7.98 | In the summer every line was slightly alkaline, In the rainy season most of them were moderately alkaline except the line A |
| | slightly alkaline | slightly alkaline | slightly alkaline | moderately alkaline | slightly alkaline | moderately alkaline | slightly alkaline | moderately alkaline | |
| EC (dS/m) | 2.94 | 2.98 | 2.95 | 2.88 | 2.67 | 2.58 | 3.09 | 2.94 | In the summer and the rainy season the level of each line was the same level |
| | Very slightly saline | Very slightly saline | Very slightly saline | Very slightly saline | Very slightly saline | Very slightly saline | Very slightly saline | Very slightly saline | |
| OM ( %) | 2.74 | 1.77 | 1.36 | 1.27 | 2.76 | 0.58 | 3.71 | 1.20 | In the summer the level was higher than the rainy season except the line B |
| | moderately high | medium | moderately low | moderately low | moderately high | low | high | moderately low | |
| N (%) | 0.036 | 0.032 | 0.035 | 0.011 | 0.031 | 0.027 | 0.032 | 0.034 | In the summer and the rainy season every line had a same level |
| | very low | very low | very low | very low | very low | very low | very low | very low | |
| Avai. P (ppm) | 90.93 | 82.37 | 74.24 | 82.44 | 63.35 | 72.38 | 23.15 | 64.53 | In the summer and the rainy season every line was very high level except the line D |
| | very high | very high | very high | very high | very high | very high | Moderately high | very high | |
| Avai. K (ppm) | 94.61 | 47.39 | 86.48 | 34.32 | 59.48 | 40.08 | 70.80 | 58.50 | In the summer was higher level than the rainy season except the line C. Line A had a high level in the summer whereas in the rainy season had a low level. |
| | high | low | medium | low | low | low | medium | low | |
| CEC (meq/ 100gm.soil) | - | 6.16 | - | 8.73 | - | 8.38 | - | 10.27 | In the rainy season every line had a moderate-ly except the line D |
| | - | moderately low | - | moderately low | - | moderately low | - | medium | |

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## H. Hydrogen sulfide gas in the sediment (ppm)

The result of the hydrogen sulfide concentration in this study divided for 2 area characteristics which were the seagrass beds and the non-seagrass beds. The concentration in the summer was lower than the rainy season. The data shows in the table 4.12

**Table 4.12 The hydrogen sulfide gas in the seagrass beds and the non-seagrass beds of each transect in the summer and the rainy season**

| Community/ transect line | Summer | | | | Rainy | | | |
|---|---|---|---|---|---|---|---|---|
| | LineA (ppm) | LineB (ppm) | LineC (ppm) | LineD (ppm) | LineA (ppm) | LineB (ppm) | LineC (ppm) | LineD (ppm) |
| 1. Non-seagrass (rim of mangrove) | 4.36± 2.19 | 0.78± 0.78 | 0.00 | 0.00 | 0.00 | 28.83± 7.91 | 24.40± 5.32 | 19.14± 5.71 |
| 2. *Halodule pinifolia* | 0.00 | 0.35± 0.33 | 0.00 | 0.00 | 1.50± 1.50 | 20.92± 11.79 | 19.43± 10.13 | 36.87± 10.93 |
| 3. *Enhalus acoroides* | 0.00 | NDi | 0.11± 0.11 | 0.00 | 10.01± 3.65 | NDi | 58.12± 25.11 | 39.13± 13.08 |
| 4.Non-seagrass (estuary of river) | 0.00 | 0.30± 0.09 | 0.00 | 0.00 | 29.21± 13.22 | 13.82± 2.26 | 10.28± 2.23 | 24.12± 12.74 |

Notice: NDi=No Distribution

The concentration of the hydrogen sulfide gas in the sediment within the Kung Krabaen Bay in the summer was average from 0.00-4.36 ppm. The average of line A was the highest level at the non-seagrass beds near the mangrove forest. In line B the concentration was able to found in 4 communities which were near the mangrove forest, *H. pinifolia* area, *E. acoroides*, and near the estuary of the river. In line C the concentration was able to found only at the *E. acoroides* area. In line D there was not found the hydrogen sulfide concentration both non-seagrass beds and seagrass beds. The data shows in Fig 4.45.

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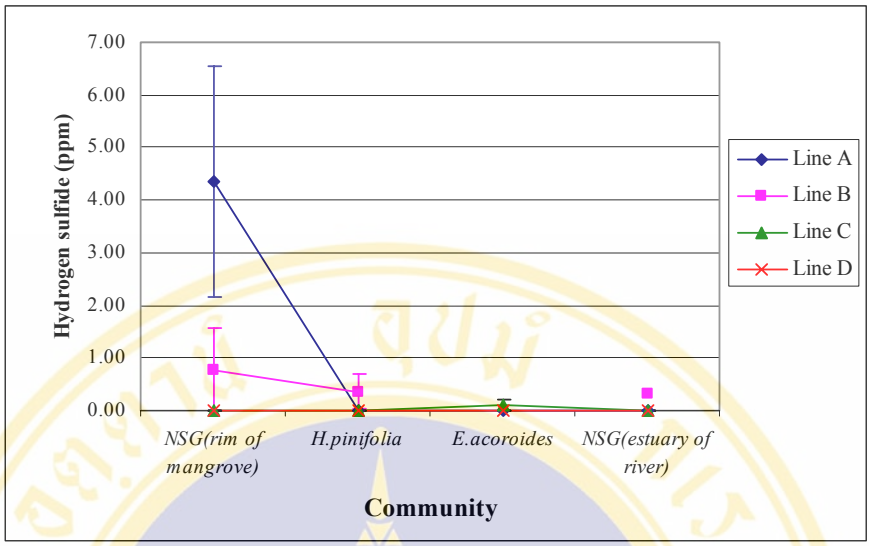


**Fig. 4.45 The hydrogen sulfide concentration of each transect lines in the summer**

The hydrogen sulfide gas concentration in the sediment within the Kung Krabaen Bay in the rainy season was able to found in 4 communities. The non-seagrass beds near the mangrove forest there was a high concentration of the hydrogen sulfide gas. The highest level was available in line B. The lowest level was available in line A. In the *H. pinifolia* area there was the high concentration in line D and the lowest of this area was available in line A. In the *E. acoroides* area there was the high concentration in line C and the lowest of this area was available in line A. The non-seagrass beds near the estuary of the river there was a high concentration in line A and the lowest was available in line C. The hydrogen sulfide gas of each transect lines in the rainy season shows in Fig. 4.46

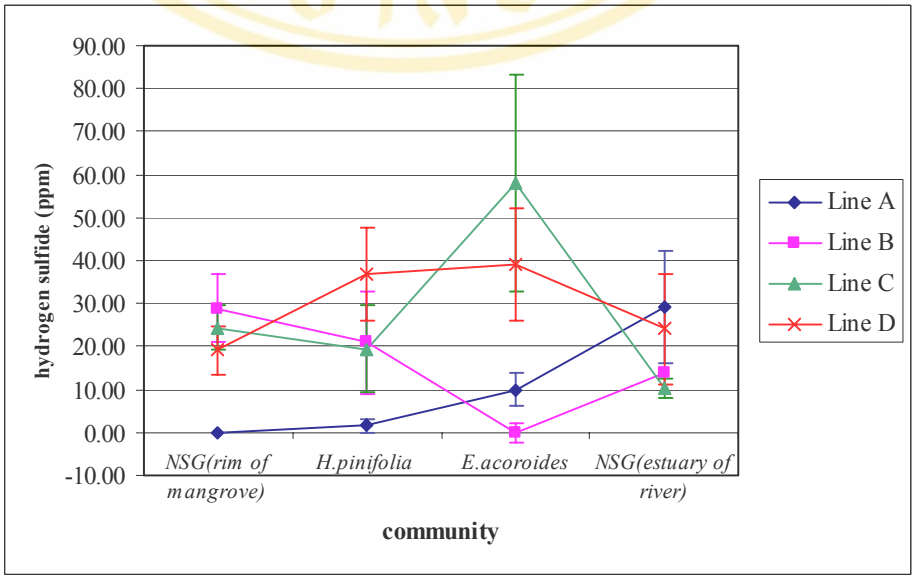


**Fig. 4.46 The hydrogen sulfide concentration of each transect lines in the rainy season**

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### 4.3 The correlation between the chemical qualities and the biomass of the seagrasses

The correlations between the 8 chemical parameters (pH, EC, OM, N, P, K, CEC and $H_2S$) and the biomass of seagrasses by using correlation coefficients are shown as following:

#### 4.3.1 The correlations between pH, EC, OM, N, P, K, and CEC and the biomass of *Halodule pinifolia*

In this study there were only 23 samples of each parameter to analyze the correlation with the biomass of the *H. pinifolia*. The data shows in the Table 4.13.

**Table 4.13 The sediment qualities and the biomass of the *H. pinifolia***

| Number | Sediment Qualities | | | | | | | The biomass of *H. pinifolas* (g/m2) |
|---|---|---|---|---|---|---|---|---|
| | pH | EC (dS/m) | OM (%) | N (%) | Avai. P (ppm) | Avai. K (ppm) | CEC (meq/100gm-soil) | |
| 1 | 7.53 | 3.25 | 2.13 | 0.057 | 88 | 61.14 | 3.4 | 4.78 |
| 2 | 7.76 | 3.03 | 1.65 | 0.043 | 92.33 | 49.48 | 3.8 | 15.96 |
| 3 | 7.85 | 3.29 | 1.76 | 0.039 | 82.33 | 51.59 | 4.4 | 72.08 |
| 4 | 7.84 | 3.04 | 1.13 | 0.048 | 103.33 | 39.59 | 7 | 34.86 |
| 5 | 7.88 | 2.82 | 1.58 | 0.038 | 99.67 | 41.1 | 7.2 | 5.96 |
| 6 | 7.81 | 3.37 | 1.77 | 0.002 | 102 | 23.59 | 9.2 | 5.47 |
| 7 | 7.93 | 3.14 | 1.93 | 0.014 | 80.33 | 45.49 | 6.6 | 10.12 |
| 8 | 7.88 | 2.72 | 1.65 | 0.004 | 79.67 | 38.92 | 6.6 | 32.04 |
| 9 | 7.99 | 3.07 | 1.59 | 0.004 | 93.67 | 32.88 | 6.8 | 28.2 |
| 10 | 7.86 | 3.13 | 1.75 | 0.003 | 94.67 | 39.64 | 18.2 | 7.02 |
| 11 | 7.98 | 2.72 | 0.6 | 0.002 | 84.33 | 27.82 | 9.8 | 24.82 |
| 12 | 8.11 | 2.72 | 0.85 | 0.022 | 72.67 | 30.13 | 2.6 | 40.78 |
| 13 | 8.15 | 2.73 | 0.56 | 0.02 | 79.33 | 30.41 | 9 | 0.61 |
| 14 | 8.12 | 2.29 | 0.09 | 0.023 | 62.33 | 34.81 | 6.4 | 17.55 |
| 15 | 8.03 | 2.77 | 0.41 | 0.027 | 85 | 47.68 | 5.8 | 8.86 |
| 16 | 8.07 | 2.67 | 0.7 | 0.022 | 88 | 37.26 | 13.2 | 6.9 |
| 17 | 8.11 | 2.67 | 0.8 | 0.02 | 79.67 | 39.78 | 10.2 | 15.51 |
| 18 | 8.11 | 2.64 | 0.33 | 0.026 | 62.33 | 30.4 | 9.1 | 19.71 |
| 19 | 8.03 | 2.93 | 1.11 | 0.037 | 97 | 48.76 | 10 | 9.35 |
| 20 | 8.07 | 3.15 | 2.21 | 0.033 | 81.33 | 40.95 | 9.9 | 0.98 |
| 21 | 8.11 | 3.34 | 1.2 | 0.039 | 72.33 | 70.61 | 18.6 | 8.57 |
| 22 | 8.11 | 3.17 | 1.22 | 0.031 | 68.67 | 70.59 | 10.8 | 19.71 |
| 23 | 8.07 | 2.75 | 1.09 | 0.025 | 56 | 63.09 | 12.7 | 6.94 |

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The relationship between the chemical qualities and the biomass of the *H. pinifolia* in this case could found only the cation exchange capacity had a correlation. The correlation was a negative way of a Pearson correlation coefficient (R=-0.428) and was significant at the reliability interval of 95%. However after considered the Kendall's tau_b coefficient there were no parameters had a correlation with the biomass of the *H. pinifolia* and was significant at the reliability interval of 95%. The coefficient of the Pearson and the Kendall's tau_b of each parameter correlated to the biomass of the *H.pinifolia* shows in the Table 4.14 (The table of a correlation between 7 parameters and the biomass of *H. pinifolia* shows in the Appendix, Table B-4).

**Table 4.14 The correlation coefficient of 7 chemical parameters correlated to biomass of *H. pinifolia***

| Parameters of sediment | Biomass of *H. pinifolia* | | | |
|---|---|---|---|---|
| | Pearson Correlation Coefficient [1] | | Kendall's tau_b Correlation Coefficient [2] | |
| | R | Sig ($\alpha < 0.05$) | R | Sig ($\alpha < 0.05$) |
| 1. pH value | - | - | -0.033 | 0.831 |
| 2. EC | - | - | -0.112 | 0.459 |
| 3. OM | - | - | -0.123 | 0.413 |
| 4. Nitrogen | - | - | -0.012 | 0.937 |
| 5. Phosphorus | - | - | -0.195 | 0.195 |
| 6. Potassium | - | - | -0.087 | 0.561 |
| 7. CEC | -0.428 * | 0.041 | - | - |

* Correlated significantly with 95% reliability interval

[1] Data is a normal distribution

[2] Data is not a normal distribution

According to the analysis of a curvilinear regression the CEC had a correlation with the biomass of *H. pinifolia* both of the linear and the logarithm pattern. Both of these correlations were negative. In the other hands there was an inverse correlation pattern which was a positive direction (The test of the Curvilinear Regression of each parameter with the biomass of the *H. pinifolia* shows in the Appendix B, Table B-5). The logarithm pattern was a better correlation to explain the relationship between the CEC and the biomass of the *H. pinifolia* in this case. The level of relationship was about 21.37% ($R^2$ = 0.21367, P value = 0.026, Beta = -0.462), whereas the linear was 18.34% and the inverse was 19.68%. This was significant in 95 % of reliability interval (Appendix, Table B-5). The logarithm equation was shown as;

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$$Y = 48.609\text{-}15.225 \ln (X)$$

When

Y = Biomass of *H. pinifolia*

X = Cation exchange capacity

The graph of the negative logarithm correlation pattern between the cation exchange capacity and the biomass of *H. pinifolia* is shown in Fig. 4.47.

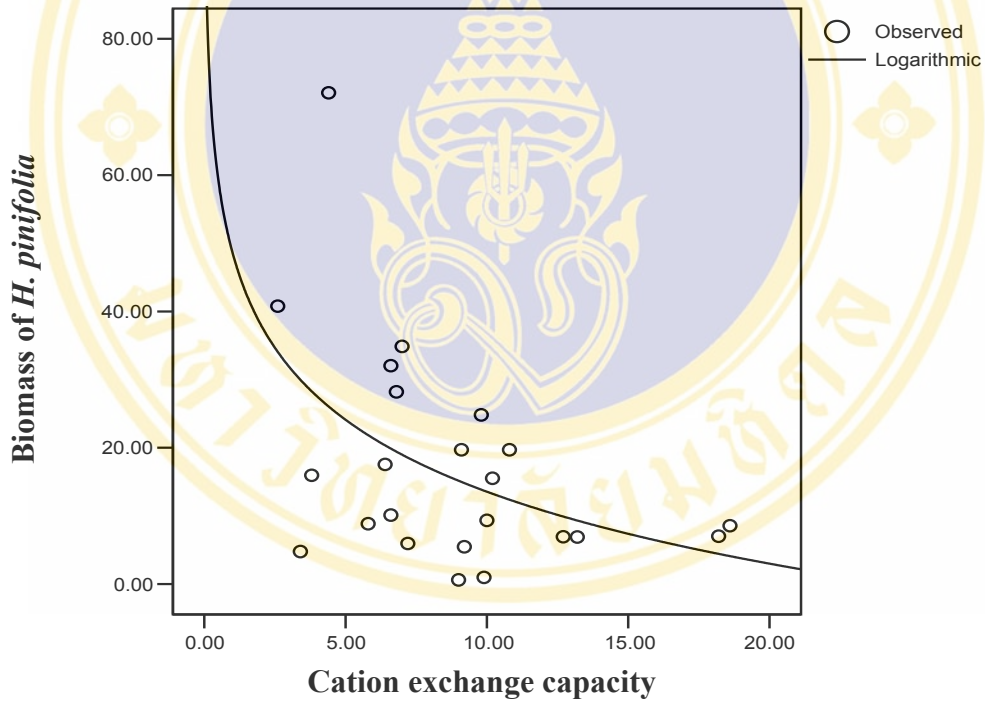


**Fig. 4.47 The correlation between the cation exchange capacity and the biomass of *H. pinifolia* as be a negative logarithm**

The graph explains that when the biomass of *H. pinifolia* decreases the cation exchange capacity increases. Such the measurement of the biomass is decreasing due to the degradation in the sediment. The biomass become the organic matters which is the cause of the cation exchange capacity is increased.

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### 4.3.2 The correlation between pH, EC, OM, N, P, K and CEC and the biomass of *Enhalus acoroides*

In this study there were only 15 samples of each parameter to analyze the correlation with the biomass of the *E. acoroides*. The data shows in the Table 4.15.

**Table 4.15 The sediment qualities and the biomass of the *E. acoroides***

| Number | Sediment Qualities | | | | | | | The biomass of *E. acoroides* (g/m2) |
|---|---|---|---|---|---|---|---|---|
| | pH | EC (dS/m) | OM (%) | N (%) | Avai. P (ppm) | Avai. K (ppm) | CEC (meq/100gm-soil) | |
| 1 | 7.95 | 3.09 | 1.82 | 0 | 75.33 | 44.30 | 10.40 | 427.31 |
| 2 | 8.10 | 2.35 | 1.39 | 0 | 60.00 | 33.95 | 9.00 | 72.86 |
| 3 | 8.12 | 2.29 | 0.09 | 0.023 | 62.33 | 34.81 | 6.40 | 1403.51 |
| 4 | 8.11 | 2.67 | 0.80 | 0.020 | 79.67 | 39.78 | 10.20 | 145.06 |
| 5 | 8.09 | 2.61 | 0.43 | 0.001 | 81.00 | 39.13 | 8.80 | 712.65 |
| 6 | 8.07 | 2.49 | 0.63 | 0.020 | 72.00 | 31.25 | 7.60 | 645.59 |
| 7 | 8.07 | 3.15 | 2.21 | 0.033 | 81.33 | 40.95 | 9.90 | 277.88 |
| 8 | 8.11 | 3.34 | 1.20 | 0.039 | 72.33 | 70.61 | 18.60 | 198.69 |
| 9 | 8.09 | 3.33 | 1.44 | 0.038 | 63.33 | 41.35 | 7.90 | 491.06 |
| 10 | 8.07 | 2.75 | 1.09 | 0.025 | 56.00 | 63.09 | 12.70 | 68.24 |
| 11 | 8.13 | 2.67 | 1.20 | 0.019 | 53.33 | 53.39 | 5.80 | 241.67 |
| 12 | 7.90 | 2.77 | 0.90 | 0.019 | 53.00 | 54.58 | 7.60 | 211.22 |
| 13 | 8.00 | 2.83 | 0.87 | 0.0222 | 59.00 | 55.77 | 8.70 | 280.33 |
| 14 | 8.12 | 3.02 | 1.25 | 0.033 | 43.33 | 75.60 | 10.80 | 195.55 |
| 15 | 8.03 | 2.75 | 1.03 | 0.094 | 43.00 | 64.42 | 13.70 | 213.06 |

The relationship between the chemical qualities and the biomass of the *E. acoroides* in this case could found the organic matters had a correlation. The correlation was a negative way of a Pearson correlation coefficient (R=-0.566) and was significant at the reliability interval of 95%. However after considered the Kendall's tau_b coefficient there were the cation exchange capacity and the available potassium had a negative correlation with the biomass of the *E. acoroides* and was significant at the reliability interval of 95% (R=-0.390, P value=0.042 and R=-0.383, P value=0.047, respectively). The coefficient of the Pearson and the Kendall's tau_b of each parameter correlated to the biomass of the *E. acoroides* shows in the Table 4.16 (The table of a correlation between 7 parameters and the biomass of *E. acoroides* shows in the Appendix, Table B-6).

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**Table 4.16 The correlation coefficient of 7 chemical parameters correlated to biomass of *E. acoroides***

| Parameters of sediment | The biomass of *E. acoroides* | | | |
|---|---|---|---|---|
| | Pearson Correlation Coefficient [1] | | Kendall's tau_b Correlation Coefficient [2] | |
| | R | Sig ($\alpha < 0.05$) | R | Sig ($\alpha < 0.05$) |
| 1. pH value | - | - | - | - |
| 2. EC | - | - | - | - |
| 3. OM | -0.566 * | 0.028 | - | - |
| 4. Nitrogen | - | - | - | - |
| 5. Phosphorus | - | - | - | - |
| 6. Potassium | - | - | -0.390 * | 0.042 |
| 7. CEC | - | - | -0.383 * | 0.047 |

* Correlated significantly with 95% reliability interval

[1] Data is a normal distribution

[2] Data is not a normal distribution

According to the analysis of a curvilinear regression (The test of the Curvilinear Regression of each parameter with the biomass of the *H. pinifolia* shows in the Appendix, Table B-7) the organic matters, the available potassium and the cation exchange capacity had a correlation as below;

**Organic matters**

There are many patterns of a correlation between the organic matter and the biomass of *E. acoroides*. There were linear, logarithm, inverse, quadratic, cubic, power and S curve. However, the correlation coefficients were determined and found the negative linear correlation was 32 % ($R^2$= 0.320, P value = 0.0279, Beta = -0.566). The logarithm is negatively correlated at 69% ($R^2$ = 0.696, P value = 0.0001, Beta = -0.834). The inverse is positively correlated at 76% ($R^2$ = 0.766, P value = 0.0000, Beta = 0.875). The quadratic is negatively correlated at 78% ($R^2$ = 0.784, P value = 0.0001, Beta = -2.698). The cubic is negatively correlated at 88% ($R^2$ = 0.886, P value = 0.0000, Beta = -5.211). The power is negatively correlated at 36 % ($R^2$ = 0.364, P value = 0.0173, Beta = -0.603). The S curve is positively correlated at 37% ($R^2$ = 0.372, P value = 0.0157, Beta = 0.610). The highest correlation is the cubic pattern at 88 %, which has the equation of:

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$$Y = 1741.62-3405.01X+2401.47X^2-521.42X^3$$

When

Y = Biomass of *E. acoroides*

X = Organic matters

The graph of the negative cubic correlation pattern between the organic matters and the biomass of *E. acoroides* is shown in Fig. 4.48.

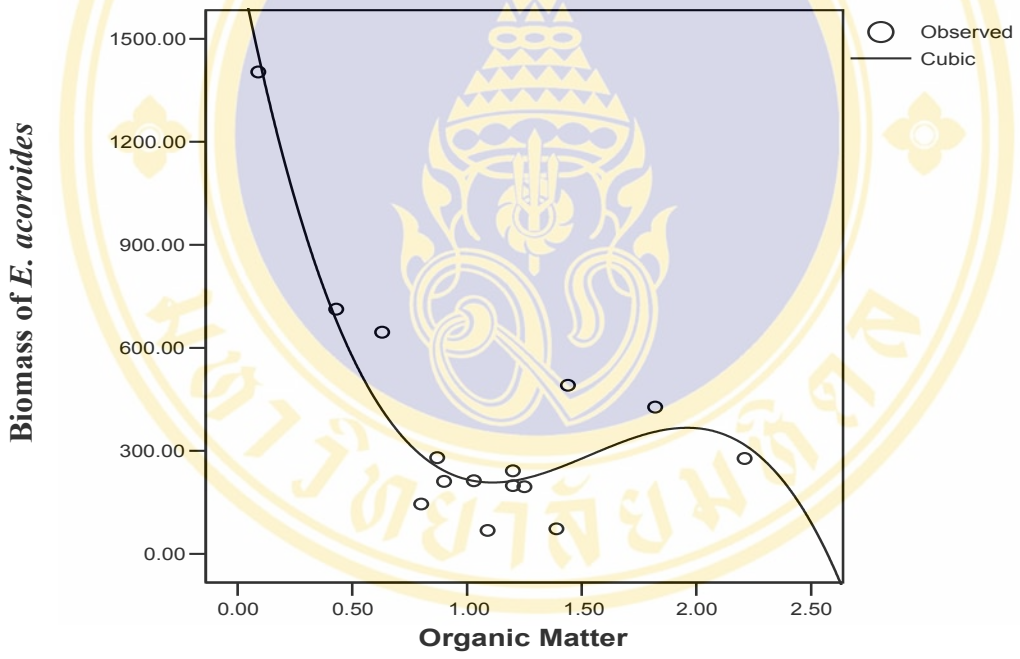


**Fig. 4.48 The correlation between the organic matters and the biomass of *E. acoroides* as be a negative cubic**

The statistic test and an equation of 7 patterns correlation between the organic matters and the biomass of *E. acoroides* shows in the Table 4.17

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**Table 4.17 The statistics and the equation of correlation patterns between the biomass of *E. acoroides* (Y) and the organic matters (X)**

| Correlation Form | Consistent value | | | | Correlation coefficient ($R^2$) | Determine coefficient (Beta) | P value (P value $\alpha < 0.05$) | Equations |
|---|---|---|---|---|---|---|---|---|
| | $b_0$ | $b_1$ | $b_2$ | $b_3$ | | | | |
| 1. Linear | 775.43 | -369.83 | - | - | 0.320 * | -0.566 | 0.0279 | $Y=b_0+b_1X$ |
| 2. Logatithmic | 337.17 | -378.55 | - | - | 0.696 * | -0.835 | 0.0001 | $Y= b_0+b_1 \ln (X)$ |
| 3. Inverse | 180.80 | 113.52 | - | - | 0.766 * | 0.875 | 0.0000 | $Y= b_0+b_1(1/X)$ |
| 4. Quadratic | 1416.05 | -1763.01 | 607.14 | - | 0.784 * | -2.698 | 0.0001 | $Y= b_0+b_1X+b_2X^2$ |
| 5. Power | 255.65 | -0.65 | - | - | 0.364 * | -0.603 | 0.0170 | $Y=b_0(X^{b1})$ |
| 6. S curve | 5.29 | 0.19 | - | - | 0.372 * | 0.610 | 0.0160 | $Y=e_0^{(b0+b1/X)}$ |
| 7. Cubic | 1741.62 | -3405.01 | 2401.47 | -521.42 | 0.886 * | -5.210 ** | 0.0000 | $Y= b_0+b_1X+b_2X^2+b_3X^3$ |

* Correlation Significantly as 95 % of reliability interval

** The most of correlation as 95 % of reliability interval

### Available Potassium

The correlation between the available potassium and the biomass of *E. acoroides* was a logarithm and inverse patterns. The logarithm correlation pattern was the negative way at 27% ($R^2$ = 0.272, P value = 0.0462, Beta = -0.522). The inverse correlation pattern was the positive way at 28 % ($R^2$ = 0.284, P value = 0.0406, Beta = 0.533). Thus, the best correlation here was the inverse type, Significant with 95 % reliability interval. The equation of the inverse was:

$$Y = -298.82 + 30899.43 (1/ X)$$

When

Y = Biomass of *E. acoroides*

X = Available Potassium

The graph of the positive inverse correlation pattern between the available potassium and the biomass of *E. acoroides* is shown in Fig. 4.49.

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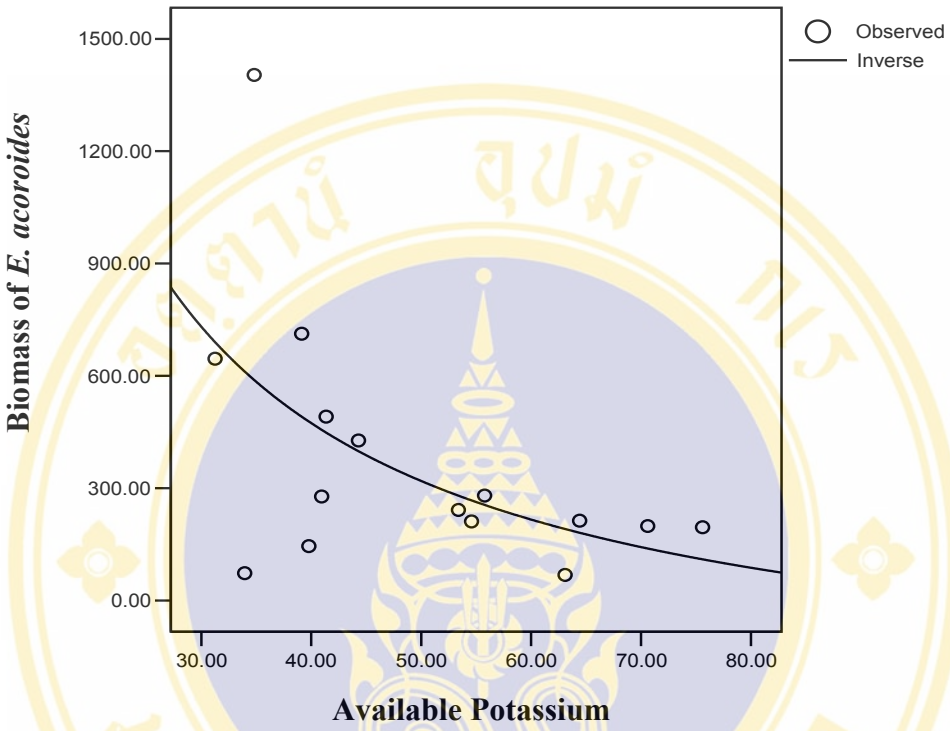


**Fig. 4.49 The correlation between the available potassium and the biomass of *E. acoroides* as be a positive inverse**

The statistic test and an equation of 2 patterns correlation between the available potassium and the biomass of *E. acoroides* shows in the Table 4.18

**Table 4.18 The statistics and the equation of correlation patterns between the biomass of *E. acoroides* (Y) and the available potassium (X)**

| Correlation Form | Consistent value | | | | Correlation coefficient ($R^2$) | Determine coefficient (Beta) | P value (P value $\propto <$ 0.05) | Equations |
|---|---|---|---|---|---|---|---|---|
| | $b_0$ | $b_1$ | $b_2$ | $b_3$ | | | | |
| 1.Logatithmic | 2,837.53 | -637.74 | - | - | 0.272 * | -0.522 | 0.046 | $Y= b_0+b_1 \ln (X)$ |
| 2. Inverse | -298.82 | 30899.43 | - | - | 0.284 * | 0.533 ** | 0.041 | $Y= b_0+b_1(1/X)$ |

* Correlation Significantly as 95 % of reliability interval

** The most of correlation as 95 % of reliability interval

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**Cation exchange capacity**

The correlation between the cation exchange capacity and the biomass of *E. acoroides* was a positive inverse pattern at 25 % ($R^2$ = 0.25495, P value = 0.0549, Beta = 0.505), not significant with 95 % reliability interval. In this case means the cation exchange capacity was not correlated with the biomass of *E. acoroides*.

According to there was more than one parameter correlated to the biomass of *E. acoroides*. These parameters were the organic matters and available potassium. This means there was some correlation with the other environmental factors which could not controlled in the field. The considering of the Kendall's tau_b correlation coefficient shew the organic matters had correlated to the electrical conductivity in a positive way at 48% (R=0.483, P value=0.013) with 95 % of reliability interval. The available potassium had correlated to the electrical conductivity in a positive way at 45% (R = 0.452, P value = 0.020), had correlated to the available phosphorus in a negative way at 54% (R = -0.543, P value = 0.005) and had correlated to the cation exchange capacity in a positive way at 42% (R = 0.421, P value = 0.029) with 95 % of reliability interval. Thus, in this studied could explained the organic matters and the available potassium correlated to the biomass of *E. acoroides* due to the co-effect of the electrical conductivity, the available phosphorus, and the cation exchange capacity.

However in this case was able to conclude that only the cation exchange capacity had a correlation with the biomass of *H. pinifolia* whereas the organic matters and the available potassium had a correlation with the biomass of *E. coroides*. The correlation by conclusion shows in the Table 4.19 and the correlation between the factors shows in the Appendix, Table B-6.

**Table 4.19 The correlation between the biomass of each seagrasses and the chemical qualities of the sediment by conclusion**

| Seagrasses | Sediment Qualities | Correlation Pattern |
|---|---|---|
| *H. pinifolia* | CEC | Negative Logarithm |
| *E. acoroides* | OM | Negative Cubic |
| | K | Positive Inverse |

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### 4.3.3 The correlation between the hydrogen sulfide gas and the biomass of *H. pinifolia*

The correlation between the hydrogen sulfide gas and the biomass of *H. pinifolia* in the sediment analyzed by the Kendall's tau_b correlation coefficient due to the abnormal distribution of data. It had no correlation with 95 % of reliability interval (R=-0.667, P value=0.174). However the concentration of this gas in line A was the lowest with the highest biomass. The highest concentration of this gas was available in line D with the lowest biomass.

### 4.3.4 The correlation between the hydrogen sulfide gas and the biomass of *E. acoroides*

The correlation between the hydrogen sulfide gas and the biomass of *E. acoroides* in the sediment analyzed by the Kendall's tau_b correlation coefficient due to the abnormal distribution of data. It had no correlation with 95 % of reliability interval (R=-0.333, P value=0.602). However the concentration of this gas in line A was the lowest and in line C was the highest. The highest biomass of *E. acoroides* was available in line C whereas in line A and line D was in the vicinity.

Summarize of the correlation between the sediment and the seagrasses in the Kung Krabaen Bay was able to know only the pattern of each correlation. The *H. pinifolia* correlated to the cation exchange capacity only whereas the *E. acoroides* correlated to the organic matters ant the available potassium. Moreover there was some effect from the other chemical qualities such as the electrical and the available phosphorus interfere between the correlations of *E. acoroides*. The entire correlation pattern was curvilinear pattern. Anyway there was no correlation between the hydrogen sulfide gas in the sediment and the biomass of both two species of seagrasses in this study.

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# CHAPTER 5
# CONCLUSION DISSCUSION AND SUGGESTION

The study of physical and chemical qualities of sediment that related to the biomass of seagrasses was carried out in the Kung Krabaen Bay, Chanthaburi province. The ten parameters to studied were texture, color, pH, electrical conductivity, organic matter, total nitrogen, available phosphorus, available potassium, cation exchange capacity and hydrogen sulfide. Some of those parameters have a relation to the biomass of seagrasses in term of curvilinear form. There is different of parameters which have a relation to the biomass between the *H. pinifolia* and *E. acoroides*.

## 5.1 Conclusion

The study of a correlation between the sediment qualities and biomass of seagrasses in the rainy season within the Kung Krabaen Bay, there was the cation exchange capacity correlated to *H. pinifolia* in the negative way. While the organic matter correlated to *E. acoroides* in the negative way and the available potassium was in the positive way. The correlation types were logarithm, cubic and inverse, respectively. Hydrogen sulfide no had a correlation with both species.

The characteristics of the distribution of the *H. pinifolia* and the *E. acoroides* were separated the area covering obviously. *H. pinifolia* was widely spread near the mangrove forest whereas *E. acoroides* which was covering like a patch next to *H. pinifolia*. In the rainy season the distribution of seagrasses in the Kung Krabaen Bay was spread longer than in the summer.

The sediment characteristics, were found in the Kung Krabaen Bay, were loamy sand, sandy loam, loam, and silt. The texture which mostly found the *H. pinifolia* was the sandy loam whereas the silt, loamy sand and loam were found in the tiny area. The *E. acoroides* was mostly found in the sandy loam and in the silt of some area. The chemical characteristics (pH, EC, OM, N, P, K, and CEC) were variously along the path. Both in the summer and the rainy season the organic matters, the total nitrogen, and the available potassium were high concentration at the rim of the mangrove forest and were low at near the estuary of the river. The pH value was opposite way of those three parameters. The

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electrical conductivity, the available phosphorus, and the cation exchange capacity were variously and had non-direction.

## 5.2 Discussion

### 5.2.1 The distribution of seagrasses

According to the results in the summer and the rainy season within the Kung Krabaen Bay the dominant species of seagrasses distributed were *Halodule pinifolia* and *Enahalus acoroides*. These two species were found in the east of Thailand (Sudara et al, 1989, Sudara et al, 1994, Sudara et al, 1991 and Nateekanjanalarp, 1991). This results was as same as a report of Aryuthaka (1994), Sudara et al (1991), Sudara et al. (1992a) and Sawatpong (1998) who reported that the *H. pinifolia* and *E. acoroides* were the dominant species and their distribution covered the north and the east of the Kung Krabaen Bay. The area which both species were able to growth was in the mid-littoral zone (Aryuthaka, 2001). Each of the sample paths in this study the seagrasses distributed in the rainy season longer than the summer, agreeing with with Lewmanomont et al. (1991) who reported that on June and August, the beginning of the rainy season, the seagrasses were highest abundant. Furthermore to confirm with Azkab (1991) who reported that the biomass of *E. acoroides* of Indonesia in the rainy season (September) was higher than the summer (April). Besides, Nateekanjanalarp and Sudara (1992) reported in the study of species and distribution of seagrasses in the Sa Mui Island that the average of density and biomass of seagrasses were higher in the rainy season than the summer. One of the reasons of longer distribution in the rainy season depended on the environmental factors particular the time period to face with the sun light and turbidity in the bay (Ogawa and Lewmanomont, 1994). Moreover, Rollon et al. (2003) who studied the distribution of *E. acoroides* with the seeds in Philippines reported that the good condition to grow was shallow area, clear water and enough sunlight. The highest abundant season of *E. acoroides* in Philippines was up on August to October which was the same time period in this study.

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***Halodule pinifolia***

The distribution of *H. pinifolia* of each transect was abundant in the wide area near the mangrove forest and existed at 0-1.2 meters deep of the lowest tide. Each of transect (Line A, Line B, Line C, and Line D) the *H. pinifolia* began distributed at the 100 meters far from the rim of the mangrove excepted the Line D was found at the 200 meters in the summer and 300 meters in the rainy season. The substrate of *H. pinifolia* mostly be the sandy loam, loamy sand, silt, and loam which agreed with Lewmanomont et al. (1991) and Lewmanomont and Ogawa (1994) who reported that the *H. pinifolia* was able to grow in the sand or sandy loam from the undulated coast to the lower of the lowest tide area. However Poomwan (1993) reported *H. pinifolia* was able to distribute on the very fine sand and fine sand at the undulated area up to the 2 meters deep.

***Enhalus acoroides***

*E. acoroides* in the Kung Krabaen Bay was existed like a patch next to the *H. pinifolia*. It was at about 0.3-1.5 meters deep of the lowest tide. It was similar to the report of Nateekanjanalarp (1991) who reported that *E. acoroides* was able to grow at a 1-2 meter deep in the Gulf of Thailand. In this study the *E. acoroides* was separated from the *H. pinifolia* obviously. In the general this seagrass was spread in the wide area isolated except some areas was able to mix with others (Kiswara, 1992, Nienhuis et al., 1989, Fortes, 1994, Lewmanomont et al., 1991, Lewmanomont et al., 1995, and Pathong, 1999). The substrate that *E. acoroides* was able to grow in the Kung Krabaen Bay was a loamy sand which settled in the line A, line C, and line D. Some of the researchers reported that sometimes this species was able to found in the mud area (Loo et al., 1994, Fortes, 1994, Johnstone, 1979, and Kiswara, 1992). Some area was existed by the mud mix with the sand and the sand mix with the fragment of corals (Lewmanomonta et al., 1995 and Lewmanomont and Ogawa, 1994) or some area was the fine sand such as in the Thub La Mu Bay, Phang Nga Province (Poomwan, 1993). However in this study there was no distribution of *E acoroides* in the line B.

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### 5.2.2 The characteristics of sediment

The two physical and 8 chemical characteristics of sediment in term of the texture, color, pH, electrical conductivity, organic matter, total nitrogen, available phosphorus, available potassium, cation exchange capacity, and hydrogen sulfide, respectively were investigated along the path of 4 transect lines. The only hydrogen sulfide which was investigated in each community (non-seagrass and seagrass area) of 4 transects. These characteristics were analyzed both in the summer and the rainy season.

The texture and the color of the sediment were summarized of the characteristics of the sediment in the Kung Krabaen Bay in this case. There were four majors of the sediment which found in the bay. They were sandy loam which found in all 4 transects, loamy sand which found only in the line C and the line D, loam which found only in the line A, and silt which found only in the line A and the line D. Most of them were dark grayish brown and black color. The sediment usually mixed with the fragment of shells, agreeing with Sangrungreong and Dumruk (1998) reported in the study of sediment qualities along the contour line in the Kung Krabaen Bay. Moreover he found the sandy loam characteristic in the north of the bay (near the line A and line B), as same as found in the south of the bay (near the line C and line D).

In term of the chemical characteristics of the sediment;

The pH value both in the summer and the rainy season, particularly near the rim of the mangrove forest, was mild acidity more than at the area near the estuary of the river. The organic matters were the opposite result of the pH value agreeing with Boonyaratpalin et al. (2002) who reported the farther area from the mangrove the organic matters was decreased. The organic matters were a result from degradation of microbial and made the sediment be an acid (McCauley et al., 2003). This reason agreed with Peter and Sivasothi (2001) who reported that in natural the sediment in the mangrove forest was always acidity due to the Sulfate-reduction bacteria. A little acid characteristic of the sediment of the mangrove forest confirm with Sangrungreong et al., (2000), who studied the effect to the sediment qualities in the Kung Krabaen Bay before and after the marine irrigation established, reported the acidity and a high concentration of organic maters were obviously at the rim of the mangrove. Furthermore this study there was the highest concentration of organic matters in line D and the lowest in line B. Because of near the line D consisted of a lot of local people communities and shrimp farms, whereas there was less mangrove forest.

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The total nitrogen and the available potassium both in the summer and the rainy season, particular at near the rim of the mangrove forest were high and low at the estuary of the river. This result agreed with Sangrungreong et al. (2000) reported the nitrogen at the wastewater canal (near the mangrove forest) was higher concentration than the farther.

The electrical conductivity and the cation exchange capacity were variously and had non-direction in the rainy season whereas the available phosphorus was variously in the summer.

Hydrogen sulfide concentration in the summer and the rainy season was different. In some area such as line D in the summer there was not found the hydrogen sulfide concentration both non-seagrass and seagrass beds. In line A the high concentration existed at near the rim of the mangrove due to much of organic matters accumulation. In line B and line C there was the trend of hydrogen sulfide concentration as same as in line A. In the rainy season there was a higher concentration than the summer. Both non-seagrass and seagrass bed of 4 transects also contained the high level. Because of the hydrogen sulfide emission to the air and into the water was easily, the concentration in the sediment become low in the summer. This reason confirmed with Bruchert et al. (2003) who reported the upwelling near the coast of Namibia made the sulfide become the hydrogen sulfide and fluxing between surface of sediment and water due to the oxidation process. Moreover Bodenbender et al. (1999) reported the sulfur was emitted between the surfaces of sediment to the aerial in term of hydrogen sulfide form about 70 %. This emission rate was very high in the summer.

### 5.2.3 The sediment qualities related to *Halodule pinifolia*

The substrate of the sediment, which the *H. pinifolia* was able to grow in the Kung Krabaen Bay, mostly was sandy loam and silt. Exceptional in line B the sediment was only sandy loam. In line A, line C, and line D the substrate was loamy sand and silt.

The chemical characteristics such as pH, electrical conductivity, organic matters, total nitrogen, available phosphorus, available potassium, and cation exchange capacity, there was only the cation exchange capacity related to the biomass of *H. pinifolia*. The relation was the negative logarithm. This relation shew while the biomass of *H. pinifolia* was high, the CEC was low. However at the low biomass was decreased but the CEC was higher. Such because of the degradation of the biomass become to be the organic matters in the sediment. The organic matters, which were increased, were the cause of higher CEC (NSW Department of Primary Industries, 2002 and Griffin, 2004).

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### 5.2.4 The sediment qualities related to *Enhalus acoroides*

The substrate of the sediment, which the *E. pinifolia* was able to grow in the Kung Krabaen Bay, mostly was sandy loam.

The chemical characteristics such as pH, electrical conductivity, organic matters, total nitrogen, available phosphorus, available potassium, and cation exchange capacity there was only 2 factors related to the biomass of *E. acoroides*;

1) The organic matters were a negative cubic related to the biomass of *E. acoroides*. In the first period of the graph line the biomass of the *E. acoroides* was decreasing rapidly whereas the organic matters were increased. The biomass was one pf the cause to increase the organic matters in the sediment, agreed with Logan and Longmore (2004) who reported the accumulation of the leaves fall become the organic matters in the sediment. Moreover Onate-Pacalioga (1994) reported the litter fall and degradation in seagrass beds of the Bais Bay, Philippines was about a 7,000 g.dw/day$^{-1}$. These litter fall become the organic matters about a 77,500 g. dw/day$^{-1}$.

2) The available potassium was a positive inverse relation with the biomass of *E. acoroides*. While the biomass was high, the available potassium was low and when the biomass was decreased the available potassium was increased. This relation was able to explain that the *E. acoroides* take up the potassium so that the biomass was high. After that the available potassium do not need for the *E. acoroides* so that it was high concentration in the sediment. This result was similar to the study of Gimenez et al. (2004) which was about the relationship between the available potassium and the leaves of a pomegranate plant in Spain. He found the high level of the leaves while there was low concentration of the available potassium.

However in this study the available potassium become the limiting factor of the *E. acoroides*. Even though in many reports there was only phosphorus and nitrogen were a limiting factor in the seagrass beds (Short et al., 1993, and Bulthuis and Woelkerling, 1981)

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### 5.2.5 Hydrogen sulfide related to the biomass of *H. pinifolia* and *E. acoroides*

In this study the hydrogen sulfide had no correlation with the biomass both of *H. pinifolia* and *E. acoroides*. That meant the hydrogen sulfide gas had no toxic to the seagrasses, however it had no a benefit as well. Such because of the seagrasses might have a special structure within themselves to protect the hydrogen sulfide gas by the bigger pore of oxygen path. This was agreed with Penhale et al. (1982) who studied the structural and functional within the roots of *Zostera marina* L. to the anoxia condition, he found more spaces to the oxygen diffusion and releasing it around the roots. At the same time Fry et al. (1982) reported there was sulfur absorbent on the leaves and roots of seagrasses to decrease the toxic of the hydrogen sulfide.

## 5.3 Suggestion

This study was carried out in the field, thus some environmental factors could not controlled. Not only had the sediment characteristics had a relation with the biomass of seagrasses, but also the other environmental factors. Moreover the natural of tidal in the Kung Krabaen Bay affected the sample collecting, particular the hydrogen sulfide gas. The planning of this collecting sample must do very rapidly to decrease the oxidation. By this reason, the number of hydrogen sulfide samples was less and could not analyze the type of relationship. In the next time to study about the hydrogen sulfide gas should have the perfect plan and an efficiency instrument. Moreover the structural and functional within the leaves and roots of the seagrasses, *H. pinifolia* and *E. acoroides* still need the proof to confirm the rule of decreasing anoxia condition.

The idea leaded to study the sediment qualities which parallel to the wastewater canals in the Kung Krabaen Bay because of the effects of the sediment accumulation. Particularly the hydrogen sulfide piled up in the sediment both in the non-seagrass and seagrass beds. However there was no effect of the hydrogen sulfide gas that means the wastewater canal does not a major problem. Furthermore the organic matters and the total nitrogen accumulation were still being a little effect of wastewater canals particular at the rim of the mangrove forest. In this area, mangrove forest still shows the less acidity characteristic of the sediment. By the conclusion the concentration of each parameter, which was decreasingly along the path at the farther, does not affect to the distribution of the seagrasses in the Kung Krabaen Bay.

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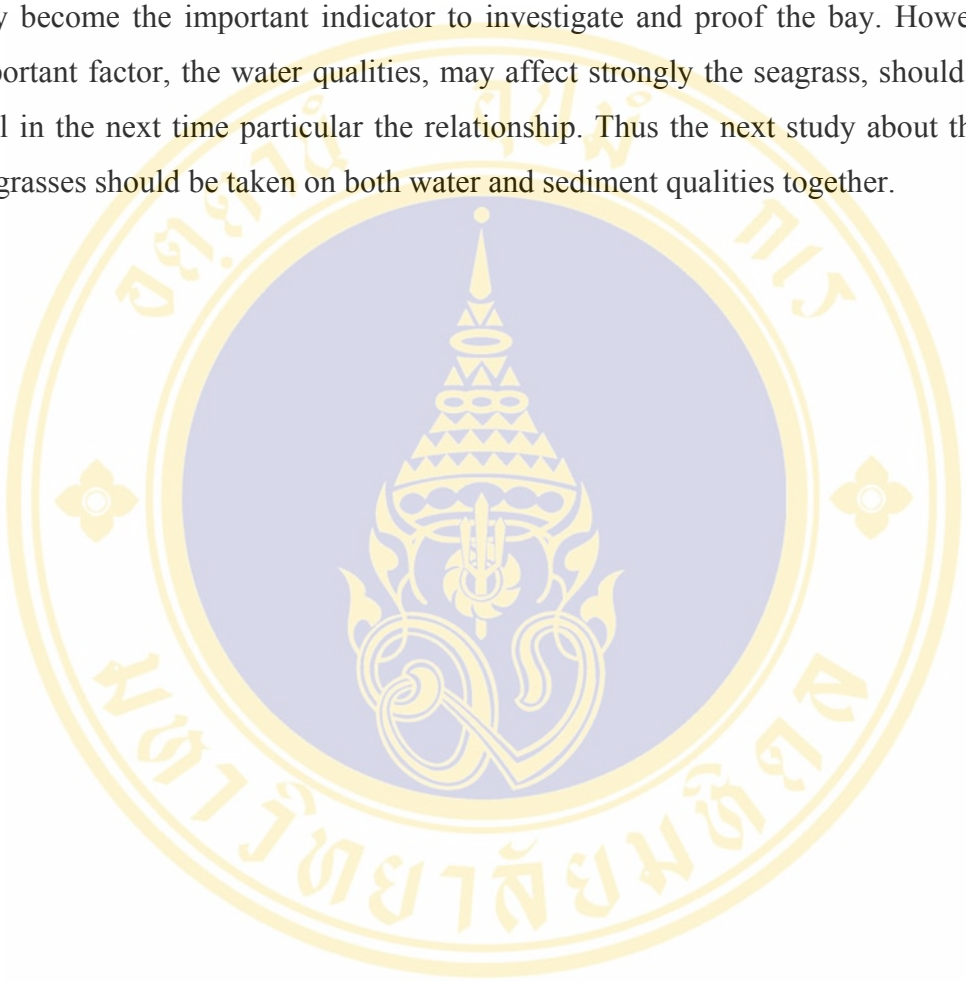
The results of this study such as the texture of the sediment and the type of a relationship between the biomass of seagrasses and the sediment can be the data base to restore the seagrass beds in the future. Some of sedimentary factors such as the organic matters, nutrients, and hydrogen sulfide gas which accumulate in the Kung Krabaen Bay may become the important indicator to investigate and proof the bay. However the one important factor, the water qualities, may affect strongly the seagrass, should be study as well in the next time particular the relationship. Thus the next study about the effects of seagrasses should be taken on both water and sediment qualities together.



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# Appendix

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# Sediment Analysis

**สีของดิน**

เทียบสีด้วยสมุดเทียบสีดินของ Munsel

**เนื้อดิน**

**อุปกรณ์**

1. เครื่องชั่ง
2. Hydrometer
3. Thermometer
4. กรวยกรอง Funnel
5. กระดาษกรองเบอร์ 42
6. Wishing bottle
7. Beaker 600 ml
8. Hot Plate
9. Stirring rod
10. Sedimentation Cylinder
11. กระจกนาฬิกา
12. Dispersion cup
13. Mechanic stirrer

**สารเคมี**

1. ไฮโดรเจนเปอร์ออกไซด์ ($H_2O_2$) เข้มข้น 30%

2. สารละลายแคลกอน (Calgon Solution) ความเข้มข้น 5% เตรียมโดยใช้โซเดียมเฮกซาเมตาฟอสเฟท (Sodium hex phosphate) 50 กรัม ละลายในน้ำกลั่นจำนวนหนึ่งอย่าให้ถึง 1000 มล. นำไปปรับสารละลายให้มี pH 8.3-8.5 ด้วยโซเดียมคาร์บอเนต (Sodium Carbonate) แล้วเติมน้ำกลั่นลงไปจนได้สารละลายครบ 1000 มล.

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**วิธีการวิเคราะห์**

1. ชั่งตัวอย่างดินที่ร่อนผ่านตะแกรงขนาด 2 มม. จำนวน 60 กรัม ใส่ใน Beaker เติมน้ำ 100 มล. แล้วเติมสารละลาย $H_2O_2$ ลงใน Beaker การเติมให้เติมทีละน้อยๆ ประมาณ 5-10 มล. ทุกครั้งที่เติมต้องรอให้ปฏิกิริยาสงบเงียบเสียก่อน เร่งปฏิกิริยาให้เร็วขึ้นได้โดยอุ่นบน Hot Plate เมื่อดินไม่ทำปฏิกิริยาอีกแล้ว ตั้งทิ้งไว้ 1 ชม. เพื่อไล่ $H_2O_2$ ที่เกินพอออกไปทิ้งให้เย็น

2. ถ่ายดินจาก Beaker ลงในกรวยซึ่งรองด้วยกระดาษ เบอร์ 42 ให้หมด แล้วชะดินในกรวยกรองด้วยน้ำกลั่นครั้งละ 50 มล. จนครบ 200 มล.

3. นำดินในกรวยกรองใส่ลงใน Beaker นำไปอบที่อุณหภูมิ 105-110 องศาเซลเซียส เป็นเวลา 15-24 ชม. นำไปทำให้เย็นใน desiccator

4. ชั่งน้ำหนักของดินที่ได้นี้ 40 กรัม ลงใน Dispersion cup ถ้าเป็นดินเนื้อหยาบใช้ดินปราศจากอินทรียวัตถุ 100 กรัม เติมสารละลายแคลกอน 5% ลงไป 100 มล. เติมน้ำกลั่น 100 มล. ตั้งทิ้งไว้ 10 นาที นำไปกวนด้วยเครื่องกวน (mechanical stirrer) เป็นเวลา 5 นาที

5. ถ่ายตัวอย่างดินที่กวนแล้วลงใน Sedimentation cylinder ฉีดน้ำล้างไล่ดินลงใน Sedimentation cylinder ให้หมด เติมน้ำกลั่นลงไป 100-200 มล. หย่อน Hydrometer ลงไป แล้วเติมน้ำกลั่นลงไปจนถึงขีดล่างของ Sedimentation cylinder ถ้าใช้ดิน 100 กรัม ให้เติมน้ำกลั่นจนถึงขีดบนของ Sedimentation cylinder

6. ยก Hydrometer ออก ใช้จุกยางปิด Sedimentation cylinder ให้แน่นใช้มือหนึ่งจับปาก Sedimentation cylinder ตรงจุกยากอีกมือหนึ่งจับก้นของ Sedimentation cylinder กระดกก้นของ Sedimentation cylinder ขึ้นลงหลายๆครั้ง เพื่อเขย่าให้อนุภาคของดินกระจายอย่างสม่ำเสมอ แล้ววางลงเปิดจุกยางเริ่มจับเวลา

7. เมื่อถึงวินาทีที่ 20 หย่อน Hydrometer ลงไปในสารแขวนลอย อ่านค่าเมื่อครบ 40 วินาที พอดี นับตั้งแต่วาง Sedimentation cylinder ลงบนโต๊ะ วัดอุณหภูมิของสารแขวนลอยตรงที่ระดับศูนย์กลางของปริมาตรของกระเปาะ Hydrometer จดค่าไว้ และปฏิบัติซ้ำอีกครั้ง เมื่อได้เวลาอีก 20 วินาที จะครบ 2 ชม. อ่านค่าเมื่อได้เวลา 2 ชม. พอดี

8. เติมสารละลายแคลกอน 5% จำนวน 100 มล. ลงใน Sedimentation อีกใบหนึ่งแล้วปฏิบัติเช่นเดียวกับข้อ 7 จดค่าที่ได้ในข้อ 7 และ 8 ไว้ นำไปคำนวณ

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**การคำนวณ**

1. ค่าที่อ่านได้จากก้านของ Hydrometer คือจำนวนกรัมของอนุภาคแข็งที่แขวนลอยอยู่รอบๆ กระเปาะของ Hydrometer ขณะที่อ่านต่อ 1000 มล. ของสารแขวนลอย ดังนั้น ค่าที่อ่านได้ในข้อ 7 จึงเป็นค่าจำนวนกรัมของอนุภาคดินและอนุภาคของแคลกอน และค่าที่ได้ในข้อ 8 จึงเป็นจำนวนกรัมของอนุภาคของแคลกอนอย่างเดียว เมื่อหักค่าข้อ 8ออกจากข้อ 7 จะได้ค่าจำนวนกรัมของอนุภาคดินแต่เพียงอย่างเดียว ก่อนจะนำไปหักออกให้นำค่าข้อ 8 ปรับเป็นค่าที่น่าจะได้เมื่ออุณหภูมิของสารละลายแคลกอนในข้อ 8 นั้นเท่ากันกับอุณหภูมิของสารแขวนลอยของดินในแต่ละกรณีในข้อ 7 ก่อน แล้วจึงใช้ค่าที่ปรับแล้วนี้แทนค่าที่อ่านได้โดยตรงจากสารละลาย จึงจะได้ผลต่างที่ถูกต้อง

*ปรับค่าด้วยสูตร*

$Rc = A + 0.50 (T-B)$ สำหรับสารละลาย Calgon_____(1)

เมื่อ Rc = ค่าที่ควรอ่านได้จาก Hydrometer ในข้อง 8 (g/l) ถ้าอุณหภูมิของสารละลาย Calgon เท่ากับ T °C

A = ค่าที่อ่านได้จาก Hydrometer ในข้อ 8 (g/l)

T = อุณหภูมิของสารแขวนลอยของดิน (ในข้อ 7 แล้วแต่กรณี) เป็น °C

B = อุณหภูมิของสารละลาย Calgon ข้อ 8 เป็น °C

2. เมื่อนำค่า Rc ที่ได้ไปหักออกจากค่าที่อ่านได้จาก Hydrometer ในข้อ 7 ในแต่ละกรณีแล้ว จะได้ค่า R's แต่ละกรณีมาเป็นค่าที่แสดงจำนวนกรัมของอนุภาคดินต่อลิตร

3. ค่า R's ที่ได้จากในแต่ละกรณีนั้นจะเป็นค่าที่ถูกต้องต่อเมื่ออุณหภูมิของสารแขวนลอยของดิน ในแต่ละกรณีในข้อ 7 มีอุณหภูมิที่ระบุไว้บนก้าน Hydrometer หากอุณหภูมิไม่เท่ากันต้องปรับค่า R's ให้เป็นค่าที่ถูกต้อง (Rs) โดยใช้สูตร

$Rs = R's + 0.36(T-L)$ สำหรับแขวนลอยดิน_____(2)

Rs = จำนวนกรัมที่ถูกต้องของอนุภาคของดินต่อลิตรของสารแขวนลอยดิน

R's = จำนวนกรัมของอนุภาคของดินที่อ่านได้จาก Hydrometer ของสารแขวนลอยดินต่อลิตร

T = อุณหภูมิของสารแขวนลอยของดิน เป็น°C

L = อุณหภูมิที่ระบุไว้บนก้าน Hydrometer เป็น °C

4. คำนวณเปอร์เซ็นต์โดยน้ำหนักของ Sand Silt Clay ในส่วนที่เป็นอนินทรียสารของตัวอย่างดินที่ใช้ในการวิเคราะห์นี้ โดยถือว่าขณะที่อ่านค่าเมื่อ 40 วินาทีนั้น ไม่มีอนุในส่วน

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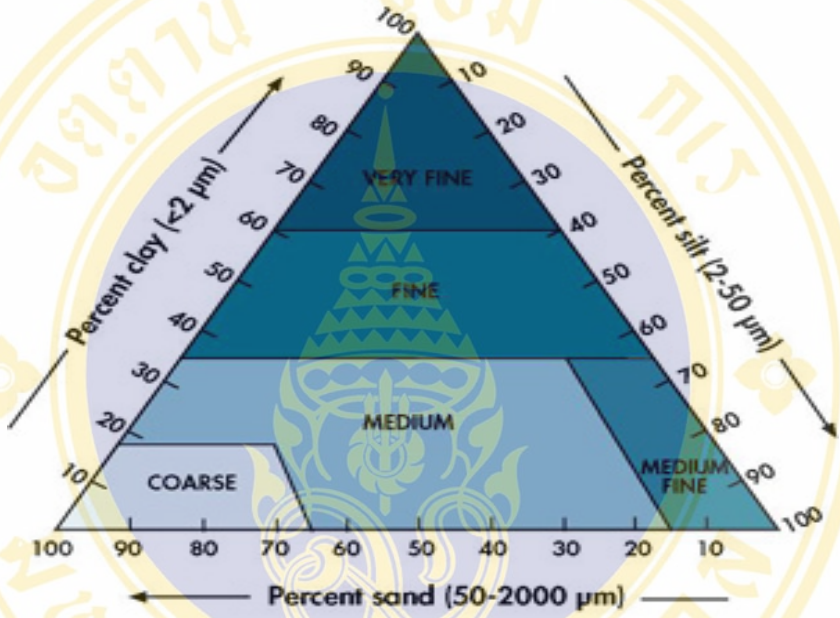
ที่เป็นอนินทรียสารของตัวอย่างดินที่ใช้ในการวิเคราะห์นี้ โดยถือว่าขณะที่อ่านค่าเมื่อ 40 วินาทีนั้น ไม่มีอนุภาคจำพวก Sand อยู่รอบกระเปาะ Hydrometer เลย และขณะที่อ่านค่าเมื่อ 2 ชม. ไม่มีอนุภาค Sand และ Silt อยู่รอบกระเปาะ Hydrometer เลย

5. ใช้ไดอะแกรมสามเหลี่ยมพิจารณาประเภทของเนื้อดิน




**ปฏิกิริยาของดิน (pH)**

**อุปกรณ์**

1. บีกเกอร์ขนาด 50 มล.
2. แท่งแก้ว
3. กระบอกตวง ขนาด 10 มล.
4. เครื่องวัด pH

**สารเคมี**

1. สารละลายแคลเซียมคลอไรด์ ($CaCl_2$), 0.01M โดยละลายแคลเซียมคลอไรด์ ($CaCl_2$) 1.4703 กรัม ในน้ำกลั่นทำให้มีปริมาตร 1 ลิตร

2. สารละลายบัฟเฟอร์มาตรฐาน โดยใช้สารละลายบัฟเฟอร์มาตรฐาน pH 4 และสารละลายบัฟเฟอร์มาตรฐาน pH 7 สำหรับปรับเครื่องวัด pH

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**วิธีวิเคราะห์**

1. ชั่งตัวอย่างดิน 10 กรัม ใส่ลงในบีกเกอร์ขนาด 50 มิลลิลิตร

2. เติมสารละลายแคลเซียมคลอไรด์ ($CaCl_2$) 0.01 M ลงไปในตัวอย่างดิน 20 มิลลิลิตรแทนน้ำกลั่น

3. นำสารละลายดินไปวัด pH ด้วยเครื่องวัด pH โดยใช้สารละลายบัฟเฟอร์มาตรฐาน pH 7 และ pH 4 ปรับเครื่องวัด pH ก่อน

**ค่าการนำไฟฟ้า (Electrical Conductivity; EC)**

วิธี ดิน: น้ำ อัตราส่วน 1: 5

**อุปกรณ์**

1. ขวดแก้วก้นแบน Erlenmeyer flask) ขนาด 125 มิลลิลิตร
2. กรวย
3. กระดาษกรองเบอร์ 5
4. ขวดกรอง (Filtering flask) ขนาด 500 มิลลิลิตร
5. บีกเกอร์ขนาด 50 มิลลิลิตร
6. เทอร์โมมิเตอร์
7. เครื่องวัดค่าการนำไฟฟ้า (Conductivity meter)

**สารเคมี**

1. สารละลายมาตรฐานโพแทสเซียมคลอไรด์ (KCl) 0.01 N โดยละลายโพแทสเซียมคลอไรด์ (KCl) 0.7456 กรัมที่อบแห้ง ในน้ำกลั่น แล้วทำให้มีปริมาตร 1 ลิตร ใช้ปรับ Conductivity meter หรือใช้สารละลาย Calibration Standard 12.9 mS/cm 7230 ppm NaCl 0.1000 M ± 0.0005 M KCl ในการปรับเครื่อง (ใช้เฉพาะกับ Orion Conductivity Cell)
2. น้ำกลั่น

**วิธีการ**

1. ชั่งดิน 10 กรัมใส่ในขวดแก้วก้นแบนขนาด 125 มิลลิลิตร
2. เติมน้ำกลั่น 50 มิลลิลิตร เขย่าให้เข้ากันเป็นเวลา 2 ชั่วโมง กรอง หรือเขย่า 30 นาที ทิ้งค้างคืน รุ่งขึ้น กรอง (ถ้าเป็นดินเหนียวทิ้งค้างคืนแล้วกรอง)

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3. ได้สารละลายดิน 1: 5 นำไปวัดค่าการนำไฟฟ้า (EC) ด้วยเครื่องวัดค่าการนำไฟฟ้า (Conductivity meter)

4. วิธีวัดค่าการนำไฟฟ้า

- อุ่นเครื่องวัดค่าการนำไฟฟ้า เป็นเวลา 15 นาทีที่อุณหภูมิ 25 °C
- ปรับเครื่อง โดยใช้ Calibration Standard 12.9 mS/cm 7230 ppm NaCl, 0.1000 M. ± 0.0005 M KCl ในการปรับเครื่อง ซึ่งเครื่องจะอ่านได้ประมาณ 12.88 mS/cm.
- วัดอุณหภูมิของสารละลายดินที่สกัดได้ที่อุณหภูมิ 25 °C
- วัดค่าการนำไฟฟ้าของสารละลาย ด้วยเครื่องวัดค่าการนำไฟฟ้า ค่าที่อ่านได้จากเครื่องมีหน่วยเป็นมิลลิซีเมนต่อเซนติเมตร (mS/cm) ที่ 25 °C

**ปริมาณสารอินทรียรวม (Organic Matter)**

**อุปกรณ์**

1. ขวดแก้วก้นแบน (Erlenmeyer flask) ขนาด 250 มล.
2. ปิเปต ขนาด 10 มล.
3. กระบอกตวงขนาด 25 และ 50 มล.
4. บิวเรตขนาด 50 มล.

**สารเคมี**

1. สารละลายโพแทสเซียมไดโครเมท (Potassium dichromate) 1N โดยนำโพแทสเซียมไดโครเมท ( $K_2Cr_2O_7$) อบที่ 105 ° C 98.0 กรัม ละลายในน้ำกลั่น ทำให้มีปริมาตร 2 ลิตร
2. สารละลายเฟอรัสแอมโมเนียมซัลเฟต (Ferrous Ammonium Sulphate) 0.5 N โดยนำสารละลายเฟอรัสแอมโมเนียมซัลเฟต $[Fe(NH_4)_2(SO_4)_2.6H_2O]$ 400 กรัม ละลายในน้ำกลั่นพอสมควร เติมกรดซัลฟูริกเข้มข้นลงไป 50 มล. ทำให้มีปริมาตร 2 ลิตร
3. สารละลายออร์โทฟีแนนโทรลีน อินดิเคเตอร์ (0.025 M) โดยนำเฟอรัสซัลเฟต ($FeSo_4.7H_2O$) 0.7 กรัม และออร์โท-ฟีแนนโทรลีน (O-phenanthroline) 1.48 กรัม ละลายในน้ำกลั่น ทำให้มีปริมาตร 100 มล.
4. กรดซัลฟูริกเข้มข้น (conc. $H_2SO_4$)

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**วิธีการ**

1. ชั่งตัวอย่างดิน 1 กรัมใส่ในขวดแก้วก้นแบนขนาด 250 มล.
2. ปิเปต สารละลายโพแทสเซียมไดโครเมท 1 10 มล.
3. เติมกรดซัลฟูริกเข้มข้น 15 มล. เขย่าขวดแก้วเบาๆ เป็นเวลา 1-2 นาที ตั้งทิ้งไว้เป็นเวลา 30 นาที
4. เติมน้ำกลั่น ประมาณ 50 มล. ทิ้งไว้ให้เย็น
5. หยดอินดิเคเตอร์ ออร์โธฟีแนนโทรลีน 5 หยด
6. ติเตรทด้วยสารละลายเฟอร์รัสแอมโมเนียมซัลเฟต 0.5 เพื่อหาปริมาณโพแทสเซียมได โครเมทที่เหลือจากปฏิกิริยาจนกระทั่งสีของสารละลายดินเปลี่ยนจากสีเขียวเป็นสีน้ำตาลแดงที่จุดยุติ
7. บันทึกปริมาณโพแทสเซียมไดโครเมท และเฟอร์รัสแอมโมเนียมซัลเฟตที่ใช้
8. ทำ blank เช่นเดียวกันกับวิธีวิเคราะห์ดิน
9. คำนวณปริมาณอินทรียคาร์บอนและอินทรียวัตถุ

**การคำนวณ**

$$\% \text{ organic carbon} = \frac{(B-T)N}{B} \times \frac{100}{77} \times \frac{3}{10^3} \times \frac{100}{X} \times 10$$

$$\%\text{organic matter} = \%\text{organic carbon} \times 1.724$$

$$\text{หรือ } \%\text{organic matter} = \frac{(B-T)N}{B} \times \frac{100}{77} \times \frac{100}{58} \times \frac{3}{10^3} \times \frac{100}{X} \times 10$$

เมื่อ N = ความเข้มข้นของโพแทสเซียมไดโครเมท (นอร์มอล)

B = ปริมาตรของสารละลายเฟอร์รัสแอมโมเนียมซัลเฟตที่ติเตรทกับ blank (มิลลิลิตร)

T = ปริมาตรของสารละลายเฟอร์รัสแอมโมเนียมซัลเฟตที่ติเตรทกับตัวอย่างดิน(มิลลิลิตร)

X = น้ำหนักดิน (กรัม)

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**ไนโตรเจนรวม**

**อุปกรณ์**

1. micro-kjeldahl tube ขนาด 100 มล.
2. เครื่องกลั่นไนโตรเจน
3. เตาย่อย (Digestion system)
4. ขวดแก้วก้นแบน (Erlenmeyer flask) ขนาด 250 มล.
5. buret ชนิด 2 ตำแหน่ง ขนาด 10 มล.
6. pipette ขนาด 15, 25 มล.

**สารเคมี**

1. กรดซัลฟูริกเข้มข้น (conc. $H_2SO_4$)
2. โซเดียมไฮดรอกไซด์เข้มข้น 40 เปอร์เซ็นต์ (NaOH solution)
3. เกลือผสมชนิดเม็ด (kjeltabs)
4. กรดบอริก 4 เปอร์เซ็นต์ (Boric acid solution)
5. อินดิเคเตอร์ (mixed indicator) โดยละลาย 0.3 กรัมของโบรโมครีซอลกรีน (Bromocresol green) และ 0.2 กรัมเมททิลเรด (Methyl res) ใน 400 มล. ของเอทิลแอลกอฮอล์ 90 เปอร์เซ็นต์ สีของอินดิเคเตอร์จะเปลี่ยนเป็นสีแดงในสภาพของสารละลายกรด และจะเป็นสำน้ำเงินในสภาพสารละลายด่าง
6. สารละลายกรดไฮโดรคลอริกมาตรฐาน (0.1 N HCl) โดย ตวงกรดไฮโดรคลอริกมาตรฐาน (HCl) 9 มล. ลงในน้ำกลั่น ปรับปริมาตรเป็น 1 ลิตรด้วยน้ำกลั่น หาความเข้มข้นที่แน่นอนของกรดไฮโดรคลอริกมาตรฐาน (HCl) โดยเทียบมาตรฐาน (Standardize) ติเตรทกับโพแทสเซียมไฮโดรเจนพทาเลต (Potassium hydrogen phthalate; KHP) โดยใช้ฟีนอลพทาลีน (phenolphthalein) เป็นอินดิเคเตอร์ (indicator)

**วิธีการ**

1. ชั่งดิน 0.5-2 กรัมใส่ลงใน micro-kjeldahl tube
2. เติมเกลือ kjeltab 2 เม็ด และเติมกรดซัลฟูริกเข้มข้น 15 มล.
3. นำไปย่อยด้วยเตาย่อย (Digestion System) จนสารละลายสีขาวขุ่น
4. นำตัวอย่างในข้อ 3 มาเข้าเครื่องกลั่น Kjeltec System กำหนดให้เติมน้ำกลั่น 50 มล. และ NaOH 40% 25 มล. กลั่นประมาณ 4 นาที

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5. เติมกรดบอริก 4% 25 มล. ลงในขวดแก้วก้นแบน ขนาด 250 มล. หยด mixed indicator ประมาณ 6-7 หยด สารละลายจะมีสีม่วงแดง นำไปรองรับการกลั่นจากข้อ 4 สารละลายนี้จะเปลี่ยนจากสีม่วงแดงเป็นสีเขียว และรองรับจนได้สารละลายในขวดแก้วก้นแบนประมาณ 150 มล.

6. ติเตรทสารละลายที่ได้จากการกลั่นในข้อ 5 กับกรดไฮโดรคลอริกมาตรฐาน (HCl) 0.1 N จนสีของสารละลายเปลี่ยนจากสีเขียวเป็นสีม่วงแดง

7. กลั่น blank และติเตรท เช่นเดียวกับตัวอย่างดินอย่างน้อย 2 ตัวอย่าง

**การคำนวณ**

สมมติความเข้มข้นของกรดไฮโดรคลอริกมาตรฐาน = X นอร์มอล

จำนวนปริมาตรกรดไฮโดรคลอริกมาตรฐานที่ใช้ = Y มิลลิลิตร

ดิน A กรัม มีปริมาณไนโตรเจน = XY มิลลิกรัมสมมูล

ดิน 100 กรัม มีปริมาณไนโตรเจน $= XY \times \frac{100}{A} \times 0.014$ กรัม

$= 1.4 \frac{XY}{A}$ เปอร์เซนต์

**ฟอสฟอรัส**

**อุปกรณ์**

1. เครื่องชั่งละเอียด 4 ตำแหน่ง
2. ขวดแก้วก้นแบน (Erlenmeyer flask) ขนาด 50 มล.
3. หลอดแก้ว (test tube)
4. กระดาษกรองเบอร์ 5 ขนาด 11 ซม.
5. ปิเปต
6. เครื่องทำสารละลายเจือจาง (Auto dilutor)
7. ขวดปริมาตร (Volumetric flask) ขนาด 50 มล. และ 1 ลิตร
8. บีกเกอร์ขนาด 2 ลิตร
9. สารเคมีชนิดต่างๆ
10. เครื่อง Spectrophotometer

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**สารเคมี**

1. น้ำยาสกัด Bray II (0.03 N NH4F, 0.1 N HCl) โดยการละลายแอมโมเนียมฟลูออไรด์ (ammonium fiuoride, $NH_4F$) 11.10 กรัม ในน้ำกลั่น 8 ลิตร เติมกรดไฮโดรคลอริกเข้มข้น (conc. HCl) ลงไป 86 มล. แล้วปรับให้มีปริมาตร 10 ลิตร ปรับ pH ให้อยู่ระหว่าง 1.5-1.6

2. Stock solution (Reagent A: Sulfuric-molybdate-tartrate solution) โดยละลายแอมโมเนียมโมลิบเดต (ammonium molybdate, $[(NH_4)_6Mo_7O_{24}.4H_2O]$) 50 กรัมใส่ในบีกเกอร์ขนาด 2 ลิตร เติมน้ำกลั่น 200 มล. คนให้ละลาย ละลายแอนติโมนีโพแทสเซียมตาร์เตรท (antimony potassium tartrate, $KSbO.C_4H_4O_6$) 1.213 กรัม ในน้ำกลั่น 50 มล. (ถ้าไม่ละลายนำไปอุ่นแต่ต้องไม่เกิน 60 ° C) เมื่อละลายเข้ากันดีแล้ว เทใส่ในบีกเกอร์ที่ใส่แอมโมเนียมโมลิบเดต คนให้เข้ากันอีกครั้ง ค่อยๆเติมกรดซัลฟูริกเข้มข้น (conc. $H_2SO_4$) 700 มล. ทิ้งไว้ให้เย็น เทลงในขวด Volumetric flask ขนาด 1 ลิตร แล้วทำให้มีปริมาตร 1 ลิตรด้วยน้ำกลั่น เทเก็บไว้ในขวด polyethylene หรือ ขวด pyrex สีน้ำตาลและเก็บไว้ในที่มืดและเย็น น้ำยานี้ทิ้งไว้ได้นาน 6 เดือน

3. น้ำยา develop สี (Working solution, Reagent B) โดยละลาย ascorbic acid 1.76 กรัม ในน้ำกลั่นประมาณ 1,600 มล. เติมสารละลายข้อ 2 ลงไป 40 มล. ทำให้มีปริมาตร 2 ลิตรด้วยน้ำกลั่น ตั้งทิ้งไว้ให้เย็นประมาณ 2 ชั่วโมง จึงนำมาใช้ สารละลายน้ำเก็บได้ไม่เกิน 24 ชั่วโมง ดังนั้น จึงต้องเตรียมใหม่ทุกครั้ง

4. สารละลายมาตรฐานฟอสฟอรัส 50 ppm P โดยละลายโพแทสเซียมไดwไฮโดรเจนฟอสเฟต (Potassium dihydrogen phosphate, $KH_2PO_4$ ที่อบแห้งที่ 40 ° C นาน 2 ชั่วโมง) 0.2195 กรัม ในน้ำกลั่นพอสมควร ปรับสภาพให้เป็นกรดด้วยกรดซัลฟูริก 1-2 หยด แล้วทำให้มีปริมาตร 1 ลิตร

5. นำสารละลายมาตรฐาน ข้อ 4 มาทำ Standard set ให้มีความเข้มข้น 0, 2, 4, 6, 8, 10 และ 15 ppmP ด้วยน้ำยาสกัด

**วิธีการ**

1. ชั่งตัวอย่างดิน 1.0 กรัมใส่ในขวดแก้วก้นแบน (Erlenmeyer flask) ขนาด 50 มล.

2. เติมน้ำยาสกัด Bray II 10 มล. เขย่า 1 นาที กรองด้วยกระดาษกรอง No. 5 ขนาด 11 ซม.

3. ปิเปตสารละลายที่สกัดได้ในข้อ 2 อัตราส่วน 1 ส่วนต่อ working solution 16 ส่วน (เท่ากับ 17 เท่า โดยใช้ Auto-dilutor) ลงในหลอดแก้ว ทิ้งไว้ครึ่งชั่วโมง นำไปอ่านค่าความเข้มข้น (concentration) ด้วยเครื่อง Spectrophotometer ที่ช่วงคลื่น 882 นาโนเมตร

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4. ทำ blank และชุดของสารละลายมาตรฐาน (standard set) เช่นเดียวกับข้อ 3

**การคำนวณ**

$$\text{ฟอสฟอรัส} = \frac{B \times DF(\text{sample}) \times X}{A \times DF(\text{standard})} \quad \text{ppm}$$

เมื่อ

A = น้ำหนักของตัวอย่างดิน (กรัม)

B = น้ำยาสกัด (มิลลิลิตร)

X = ค่าที่อ่านได้ เมื่อวัดค่าเทียบกับ standard set

DF = อัตราส่วนการเจือจาง (dilution factor)

ดังนั้น ถ้าไม่มีการทำเจือจาง

$$\text{ฟอสฟอรัส} = \frac{B \times X}{A} \quad \text{ppm}$$

**โพแทสเซียมที่เป็นประโยชน์ต่อพืช**

**อุปกรณ์**

1. ขวดแก้วก้นแบน (Erlenmeyer flask) ขนาด 50 มล.
2. กระดาษกรอง เบอร์ 5
3. ปิเปต
4. บิวเรตขนาด 250 มล.
5. หลอดแก้ว
6. เครื่องชั่ง
7. เครื่องเขย่า
8. เครื่องทำสารละลายเจือจาง (Auto dilutor)
9. เครื่อง Flame photometer

**สารเคมี**

1. สารละลายแอมโมเนียมอะซิเตท (ammonium acetate solution) 1 N pH 7.0 โดยผสม 57 มล.ของกรดน้ำส้ม (glacial acetic) และ 68 มล. ของแอมโมเนียมไฮดรอกไซด์ (conc.

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$NH_4OH$) ในน้ำกลั่น ให้มีปริมาตรเกือบ 1 ลิตร ปรับ pH ของสารละลายให้มีค่าเท่ากับ 7 ด้วยการใช้กรดอะซิติก หรือด่างแอมโมเนียมไฮดรอกไซด์ เป็นตัวปรับ จากนั้นเติมน้ำกลั่นให้เท่ากับ 1 ลิตร

2. สารละลายโพแทสเซียมมาตรฐาน 1,000 ppm โดยละลาย 1.907 กรัมของโพแทสเซียมคลอไรด์ (KCl) ที่อบแห้งที่อุณหภูมิ 100 $\pm$ 5 ° C ในน้ำกลั่นทำให้มีปริมาตร 1 ลิตร และเตรียมสารละลายโพแทสเซียม 100 ppm จากสารละลายโพแทสเซียมมาตรฐาน 1,000 ppm

3. สารละลายมาตรฐานโพแทสเซียม 100 ppm โดยปิเปตสารละลายข้อ 2 มา 10 มล. ปรับปริมาตรเป็น 100 มล. ด้วยน้ำกลั่น

4. Standard set ของโพแทสเซียม โดยทำสารละลายข้อ 3 ให้มีความเข้มข้น 0, 5, 10, 15 และ 20 ppmK ด้วยสารละลายสกัด

5. สร้างกราฟมาตรฐานเพื่อใช้ในการปรับเครื่อง

**วิธีการ**

1. ชั่งดิน 2.5 กรัมใส่ในขวดแก้วก้นแบนขนาด 50 มล.
2. เติมสารละลายสกัดจากสารเคมีข้อ 1. มา 25 มล.
3. เขย่า 30 นาที ด้วยเครื่องเขย่า
4. กรองผ่านกระดาษกรองเบอร์ 5 ขนาดเส้นผ่าศูนย์กลาง 12.50 ซม.
5. ใช้สารละลายมาตรฐานจากสารเคมีข้อ 4. มา 10 ppm เป็นตัวปรับเครื่องที่ความยาวคลื่น 383 นาโนเมตร
6. สารละลายที่กรองได้จากข้อ2. นำมาวัดปริมาณโพแทสเซียม ด้วยเครื่อง Flame photometer ถ้ามีความเข้มข้นมากต้องเจือจางด้วยสารละลายสกัดจากสารเคมีข้อ 2.

**การคำนวณ**

$$\text{โพแทสเซียมที่เป็นประโยชน์ต่อพืช (avai.K)} = \frac{D \times C \times B}{A} \quad \text{ppm}$$

เมื่อ

A = น้ำหนักของตัวอย่างดิน (กรัม)

B = ปริมาตรของสารละลายแอมโมเนียมอะซิเตทที่ใช้สกัด (มิลลิลิตร)

C = อัตราส่วนการเจือจาง (Dilution factor) (เท่า)

D = ความเข้มข้นของโพแทสเซียมเมื่อเทียบกับความเข้มข้นมาตรฐาน (ppm)

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**ความสามารถในการแลกเปลี่ยนประจุ (วิธี โซเดียมอะซิเตท 1N pH 8.2)**

**อุปกรณ์**

1. ขวดแก้วก้นแบน (Erlenmeyer flask) ขนาด 125 และ 500 มล.
2. กรวย (Buchner funnel)
3. ขวดแก้วกรอง (filtering flask) ขนาด 500 มล.
4. กระดาษกรองเบอร์ 42
5. ขวดปริมาตรขนาด 100 มล.
6. ขวดกลั่น (Kjeldahl flask)
7. บิวเรตขนาด 50 มล.

**สารเคมี**

1. สารละลายโซเดียมอะซิเตท (NaOAc 1N pH 8.2 โดยละลายโซเดียมอะซิเตท (Sodium acetate: $NaC_2H_3O_2.2H_2O$) 136 กรัม ในน้ำกลั่น 1 ลิตร วัด pH 8.2 ด้วยกรดอะซิติกหรือแอมโมเนียมไฮดรอกไซด์

**วิธีการ**

1. ชั่งดิน 5 กรัม ใส่ใน sample tube ที่รองข้างล่างของหลอด้วย filter pulp หนัก 1 กรัม แล้วนำไปติดตั้งบนเครื่อง Mechanical Vacuum Extractor จากนั้นใส่ tared extraction syring ด้านล่างของ sample tube พร้อม punger
2. เติมสารละลายโซเดียมอะซิเตท 1N pH 8.2 จนถึงขีด 20 มล. และตั้งทิ้งไว้ 20 นาที หรือทิ้งค้างคืน
3. กรองด้วย Mechanical Vacuum Extractor โดยตั้งเวลาให้เครื่องชะละลายตัวอย่างดินด้วย NaOAc ที่หมายเลข 3 เปิดเครื่องสกัดจน NaOAc ที่ใส่ลงไปอยู่เหนือตัวอย่างดินประมาณ 1.0 ซม. ปิดเครื่อง เติม Na4OAc ลงไปใน sample tube จนถึงขีด 20 มิลลิลิตร ใส่ extractant reservoir tube ลงบน sample tube เติม NaOAc ลงไปใน extractant reservoir tube จนถึงขีด 35 มิลลิลิตร แล้วจงเปิดเครื่องชะละลายตัวอย่างดิน เครื่องจะทำงานและปิดเอง
4. เมื่อเครื่องสกัดหยุด ดึง plunger ของ tared extraction syring ลง แล้วทิ้งสารละลายใน tared extraction syring จากนั้นชะละลายตัวอย่างดินด้วย NaOAc อีกครั้ง ดำเนินการเช่นเดียวกันกับครั้งแรก

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5. เติมเอธิลแอลกอฮอล์ 95% 45 มิลลิลิตร เพื่อชะละลาย NaOAc ที่เหลือออกจากดิน ทำเช่นเดียวกันกับการชะละลายตัวอย่างดินด้วย $NH_4OAc$ ต้องเปลี่ยน reservoir tube ใหม่สำหรับใส่เอธิลแอลกอฮอล์ ตั้งเวลาในการชะละลายไปที่หมายเลข 1 ชะล้าง 2 ครั้ง สารละลายที่ได้นำไปทิ้ง

6. เปลี่ยน reservoir tube และ tared estraction syring ใหม่ แล้วชะละลายตัวอย่างดินด้วย $NH_4OAc$ 1N pH 7 40 มิลลิลิตร โดยทำเช่นเดียวกันกับการชะละลายตัวอย่างดินด้วย NaOAc ทำเช่นนี้ 2 ครั้ง

7. สารละลายที่ได้ ใส่ในขวดปริมาตร 100 มิลลิลิตร ทำให้มีปริมาตร 100 มิลลิลิตร ด้วย $NH_4OAc$ สำหรับนำไปวัด Ca, Mg, Na และ K

8. นำตัวอย่างดินไปกลั่นไล่ $NH_4^+$ และติเตรทสารละลายที่ได้ หาค่า CEC

9. ทำ blank และติเตรทเช่นเดียวกันกับตัวอย่างดิน

**การคำนวณ**

$$CEC = \frac{(A-B)N \times 100}{X} \quad cmol/kg$$

เมื่อ

A = ปริมาตรของกรดไฮโดรคลอริกมาตรฐานที่ใช้ติเตรทกับตัวอย่างดิน (มิลลิลิตร)

B = ปริมาตรของกรดไฮโดรคลอริกมาตรฐานที่ใช้ติเตรทกับ blank (มิลลิลิตร)

N = ความเข้มข้นของกรดไฮโดรคลอริกมาตรฐาน (นอร์มอล)

X = น้ำหนักเป็นกรัมของตัวอย่างดิน

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**ไฮโดรเจนซัลไฟด์**

**อุปกรณ์**

1. ขวดบีโอดี
2. ปิเปต
3. กระบอกตวงขนาด 100 มล.
4. หลอดทดลอง
5. จุกยางปิดหลอดทดลอง

**สารเคมี**

1. N, N-dimethyl-P-Phenylene diamine dihydrochloride, (CH3)2 N.C6H4.NH2.2HCl. (NPD) โดยชั่ง 1.0 กรัมของ NPD ละลายใน 500 มล. ของ 50% v/v HCl (6M HCl) สารละลายนี้สามารถเก็บรักษาได้หลายเดือน
2. Ferric Chloride Solution, FeCl3 โดยละลาย FeCl3 8.0กรัม ใน 500 มล. 6M HCl สารละลายนี้จะมีอายุการใช้งานนาน
3. Zinc acetate solution โดย ละลาย Zinc acetate dehydrate 10.44 กรัม ในน้ำกลั่นที่ปราศจากออกซิเจน (oxygen free distilled water) 1,000 มล. แล้วเติม gelatin 2 กรัม
4. Oxygen free distilled water โดยการต้มน้ำกลั่นประมาณ 30-60 นาที โดยผ่านแก๊ส Nitrogen ขณะต้ม ทิ้งให้เย็นที่อุณหภูมิห้อง โดยผ่านแก๊ส Nitrogen ต่อเนื่องขณะทิ้งให้เย็น ควรเตรียมก่อนการใช้งาน หรือเตรียมสารละลาย เพราะน้ำกลั่นที่ปราศจากออกซิเจนจะเก็บรักษายาก
5. Sulphide stock solution โดย ล้าง Sodium sulphide stock solution ในน้ำกลั่นที่ปราศจากออกซิเจนให้ได้ปริมาตร 500 มล. แล้วเติม 5 มล. Zinc acetate gelatine solution สารละลายนี้มีอายุการใช้งานประมาณ 4-5 ชั่วโมง และควรเขย่าก่อนใช้งาน สารละลายนี้มีความเข้มข้น 5 μ g H2S-S/ml

**วิธีการ**

1. เก็บรักษาน้ำตัวอย่างที่เก็บด้วยขวดบีโอดี (ปริมาตรประมาณ 250 มล.)ในภาคสนามด้วย Zinc acetate solution 2.5 มล. แล้วเก็บไว้ในที่มืด
2. ตวงน้ำตัวอย่าง 100 มล. แล้วเติมสารละลาย NPD และ FeCl3 อย่างละ 1 มล. ทิ้งไว้ประมาณ 1 ชม. และควรเขย่าหลังจากเติมสารละลาย

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3. วัดด้วยเครื่อง Spectrophotometer มี photo cell ขนาด 1-10 ซม. ที่ wavelength 670 nm. โดยใช้น้ำตัวอย่างเป็น reference solution

**การคำนวณ**

ความเข้มข้น H2S มีหน่วยเป็น mg/l ให้ค่าที่วัดไฮโดรเจนซัลไฟด์ได้ เป็น A mg/l

ดูปริมาตรของขวด BOD = 300 ml

ดินเปียกที่ใส่ในขวด BOD n g มี H2S = y mg

ถ้าเป็นดินเปียก/ดินแห้ง(g) = y* ***สูตร***/n g

= z mg/ gดินแห้ง

note (ตัวอย่าง): ดินที่อบแห้ง (สมมติ) 1.5 g จากดินเปียก 3.2 g (สมมติ)

ดินที่อบแห้ง 1 g จากดินเปียก 3.2/1.5*1 g

***สูตร*** = *นน.ดินเปียก*1 /ดินแห้ง*

ให้ Z = H2S mg/ g ดินแห้ง

A = H2S ที่วัดได้ (mg/l)

Y = นน. ดินแห้ง (g)

เพราะฉะนั้น Z = A * 300/1000(Y) mg/ g ดินแห้ง

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## The standard of sediment quality assessment in environment (Navanukrah, 2002)

**เนื้อดินตะกอน (Texture of soil sediment)**

ได้แก่ เนื้อดินที่เกิดจากการผสมของอนุภาคดินของดินทราย ทรายแป้ง และดินเหนียวในสัดส่วนต่างๆกัน จำแนกได้เป็น

| สัญลักษณ์เนื้อดินตะกอน | เนื้อดินตะกอน(Texture) |
|---|---|
| S | ทราย (Sand) |
| SL | ดินร่วนปนทราย (Sandy Loam) |
| LS | ดินทรายปนดินร่วน (Loamy Sand) |
| SCL | ดินร่วนเหนียวปนทราย (Sandy Clay Loam) |
| L | ดินร่วน (Loam) |
| CL | ดินร่วนปนดินเหนียว (Clay Loam) |
| SiC | ดินเหนียวปนทรายแป้ง (Silty Clay) |
| SC | ดินเหนียวปนทราย (Sandy Clay) |
| C | ดินเหนียว (Clay) |
| Si | ดินทรายแป้ง (Silt) |
| SiL | ดินร่วนปนทรายแป้ง (Silt Loam) |
| SiCL | ดินร่วนปนทรายแป้ง (Silty Clay Loam) |

**ปฏิกิริยาของดินตะกอน (pH)**

ค่าแสดงความเป็นกรดเป็นด่างของดิน มีค่า Permissible Value 1-14 จำแนกเป็นค่าพิสัยได้ 10 ระดับ ดังนี้

| ค่า pH | คำบรรยาย |
|---|---|
| < 4.5 | กรดแก่จัดมาก (Extremly Acid) |
| 4.5-5.0 | กรดจัดมาก (Very Strongly Acid) |
| 5.1-5.4 | กรดจัด (Strongly Acid) |
| 5.5-6.0 | กรดปานกลาง (Moderately Acid) |

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| ค่า pH | คำบรรยาย |
|---|---|
| 6.1-6.5 | กรดอ่อน (Slightly Acid) |
| 6.6-7.3 | กลาง (Neutral) |
| 7.4-7.8 | ด่างอ่อน (Slightly Alkaline) |
| 7.9-8.4 | ด่างปานกลาง (Moderately Alkaline) |
| 8.5-9.0 | ด่างจัด (Stongly Alkaline) |
| >9.0 | ด่างจัดมาก (Very Strongly Alkaline) |

**ปริมาณสารอินทรียรวมในดิน (Organic Matter)**

โดยประมาณมีค่า Permissible Value < 0.5->4.5 จำแนกเป็นค่าพิสัยได้ 10 ระดับดังนี้

| อินทรียวัตถุ (%) | ระดับ |
|---|---|
| < 0.5 | ต่ำมาก (Very Low) |
| 0.5-1.0 | ต่ำ (Low) |
| 1.0-1.5 | ค่อนข้างต่ำ (Moderately Low) |
| 1.5-2.5 | ปานกลาง (Medium) |
| 2.5-3.5 | ค่อนข้างสูง (Moderately High) |
| 3.5-4.5 | สูง (High) |
| > 4.5 | สูงมาก (Very High) |

**ปริมาณไนโตรเจน (Nitrogen)**

เป็นปริมาณร้อยละของไนโตรเจนที่ตรวจพบในดินตะกอน แบ่งเป็นระดับต่างๆได้ ดังนี้

| ไนโตรเจนร้อยละ | ระดับ |
|---|---|
| < 0.1 | ต่ำมาก (Very Low) |
| 0.1-0.2 | ต่ำ (Low) |
| 0.2-0.5 | ปานกลาง (Medium) |
| 0.5-0.75 | สูง (High) |
| > 0.75 | สูงมาก (Very High) |

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**ความสามารถในการแลกเปลี่ยนประจุ (Cation Exchange Capacity: CEC)**

คือ ประสิทธิภาพของดินในการดูดซับธาตุหรือสารประกอบในดิน โดยทั่วไปอนุภาคดินเหนียวและอินทรียวัตถุสามารถดูดซับและแลกเปลี่ยนประจุต่างๆในดินได้ดี ระดับและปริมาณความสามารถในการแลกเปลี่ยนจำแนกไว้ดังนี้

| ปริมาณ CEC(me/100gm.soil) | ระดับ |
|---|---|
| < 3 | ต่ำมาก (Very Low) |
| 3-5 | ต่ำ (Low) |
| 5-10 | ค่อนข้างต่ำ (Moderately Low) |
| 10-15 | ปานกลาง (Medium) |
| 15-20 | ค่อนข้างสูง (Moderately High) |
| 20-30 | สูง (High) |
| >30 | สูงมาก (Very High) |

**ปริมาณฟอสฟอรัสที่เป็นประโยชน์ต่อพืช (Available Phosphosous: Available-P($P_2O_5$))**

ปริมาณฟอสฟอรัสที่เป็นประโยชน์ต่อพืช (Available Phosphorous) ที่ได้จากการสกัดโดยน้ำยา Bray II มีค่า Permissible Value < 3->45 จำแนกเป็นค่าพิสัยได้ 7 ระดับ ดังนี้

| ปริมาณ $P_2O_5$ (ppm) | ระดับ |
|---|---|
| < 3 | ต่ำมาก (Very Low) |
| 3-6 | ต่ำ (Low) |
| 6.10 | ค่อนข้างต่ำ (Moderately Low) |
| 10-15 | ปานกลาง (Medium) |
| 15-25 | ค่อนข้างสูง (Moderately High) |
| 25-45 | สูง (High) |
| > 45 | สูงมาก (Very High) |

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**ปริมาณโปแตสเซียมที่เป็นประโยชน์ต่อพืช (Available Potassium (Available-K ($K_2O_5$))**

คือ ปริมาณโปแตสเซียมที่เป็นประโยชน์ต่อพืช (Available Potassium) มีค่า Permissible Value < 30-20 จำแนกเป็นค่าพิสัยได้ 5 ระดับ ดังนี้

| ปริมาณ $K_2O_5$(ppm) | ระดับ |
|---|---|
| <30 | ต่ำมาก (Very Low) |
| 30-60 | ต่ำ (Low) |
| 60-90 | ปานกลาง (Medium) |
| 90-120 | สูง (High) |
| >120 | สูงมาก (Very High) |

**ค่าการนำไฟฟ้า (Electricity Conductivity at Saturation Extract: ECe)**

| ปริมาณ (ECe (dS/m) at 25 °C) | ระดับ |
|---|---|
| 2-4 | Very Slightly Saline |
| 4-8 | Slightly Saline |
| 8-16 | Moderately Saline |
| > 16 | Strongly Saline |

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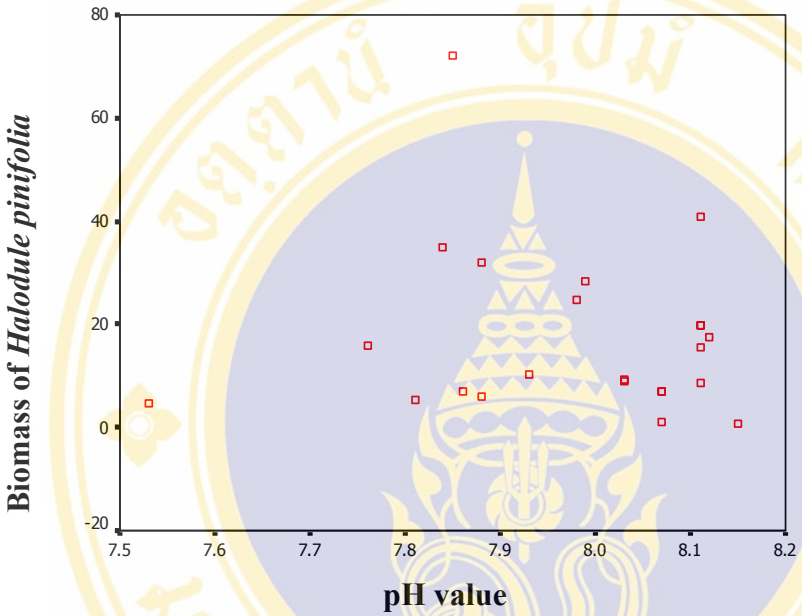
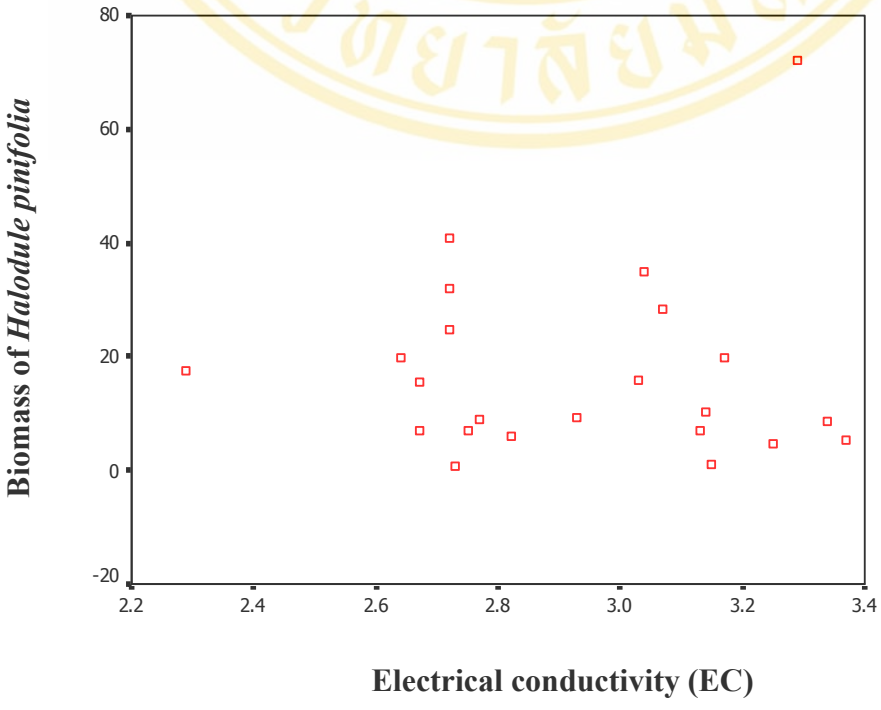
**Fig. B-1 Scatter Plot of relationship between chemical parameters of sediment and seagrasses biomass**

***Halodule pinifolia***

**1. Soil reaction (pH)**




**2. Electrical Conductivity (EC)**

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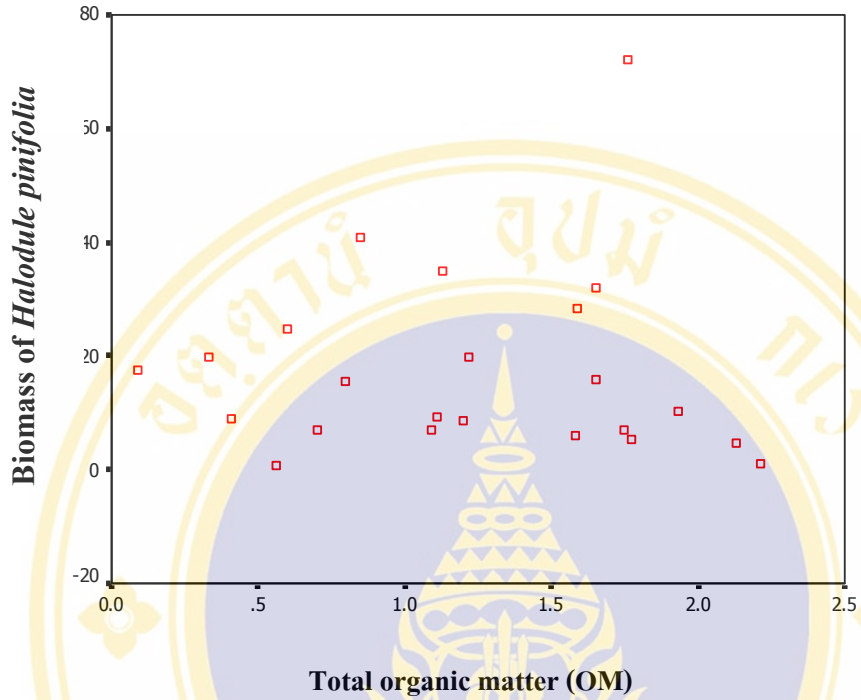
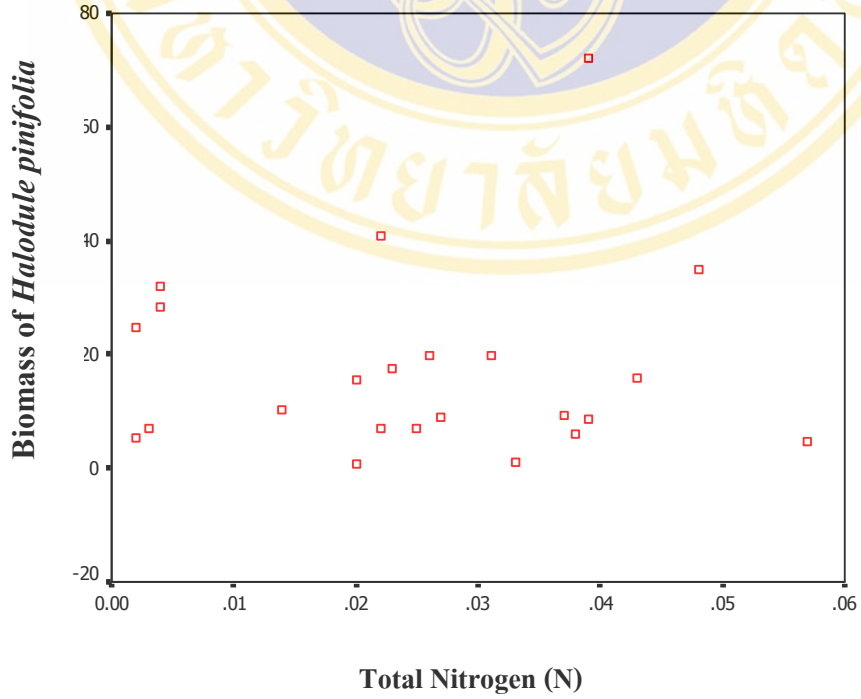
### 3. Total Organic matter (OM)




### 4. Total Nitrogen (N)

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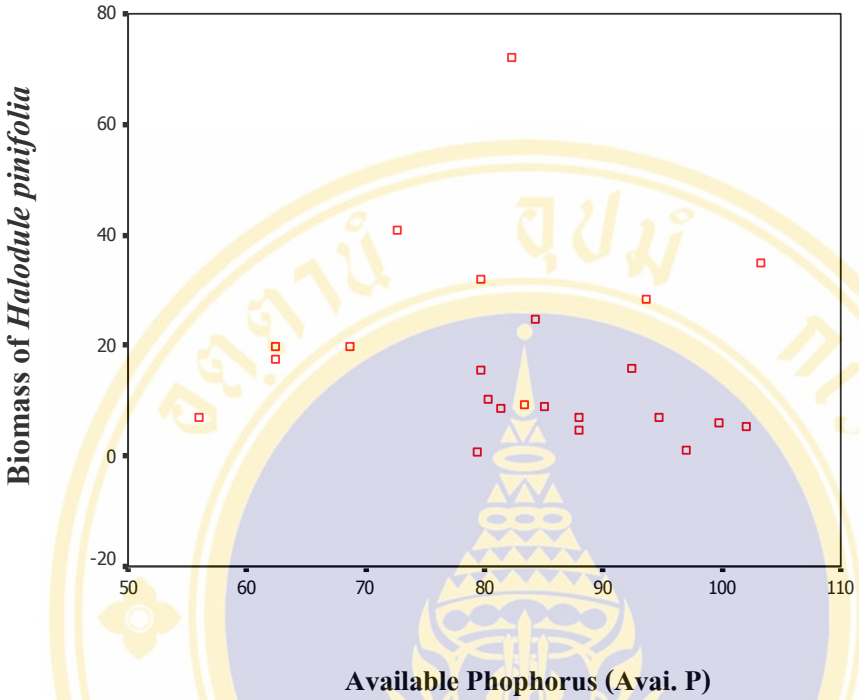
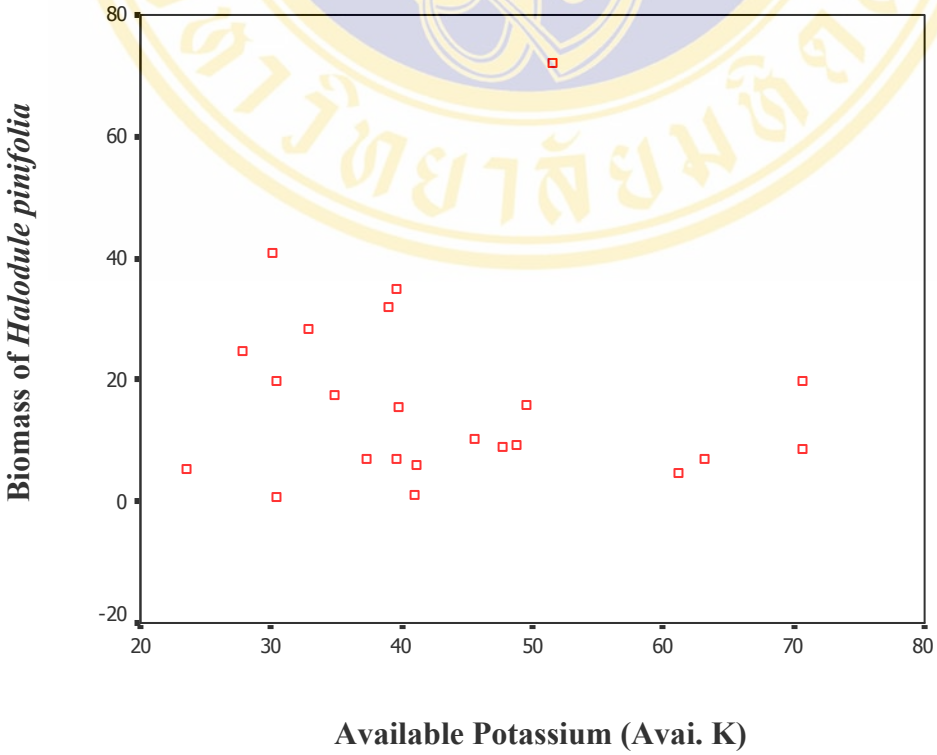
## 5. Available Phosphorus (Avai. P)




## 6. Available Potassium (Avai. K)

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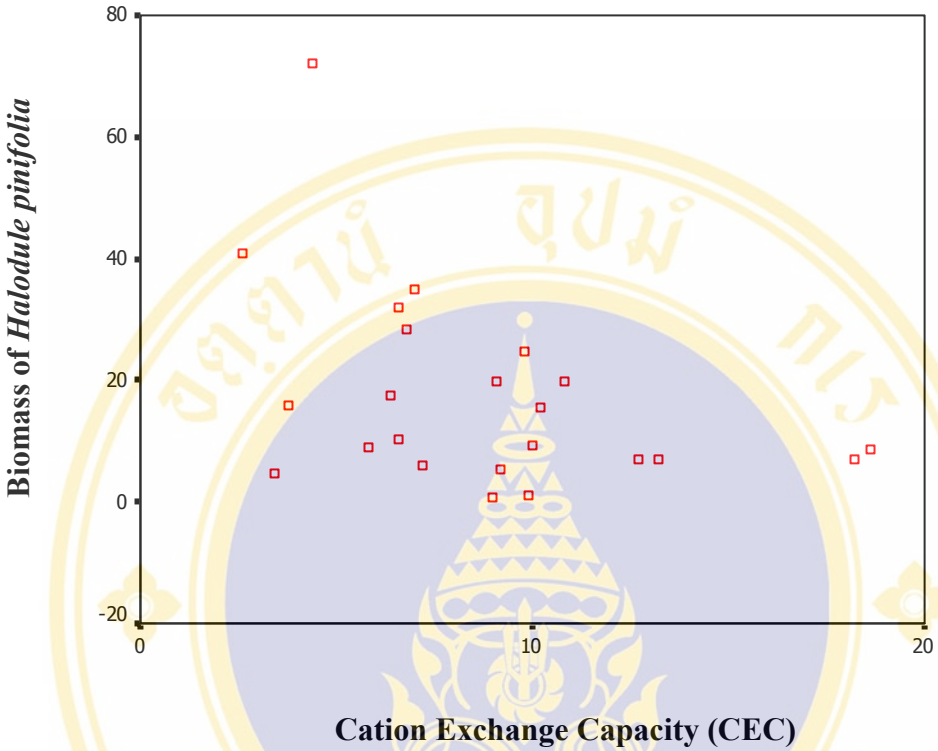
## 7. Cation Exchange Capacity (CEC)

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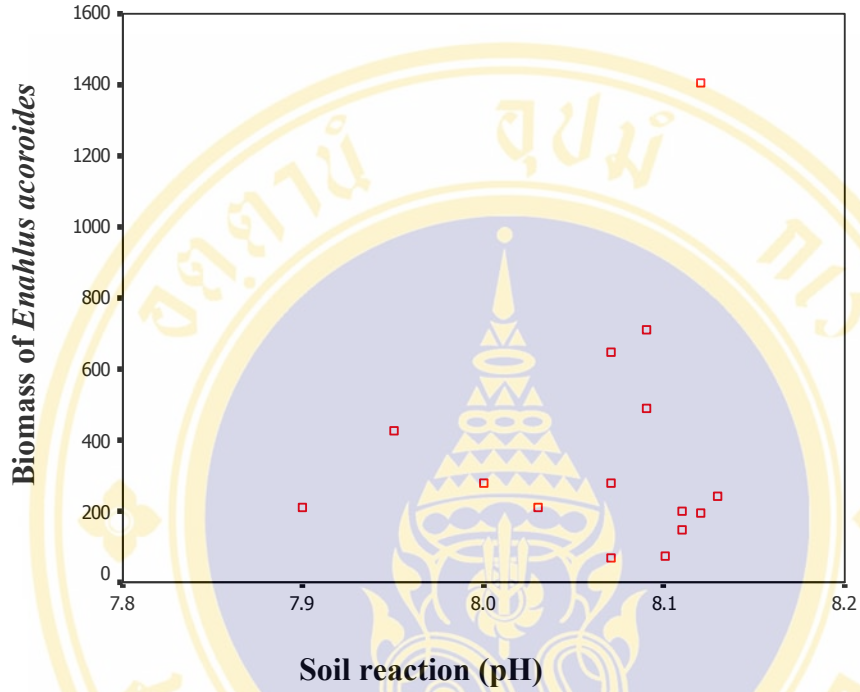
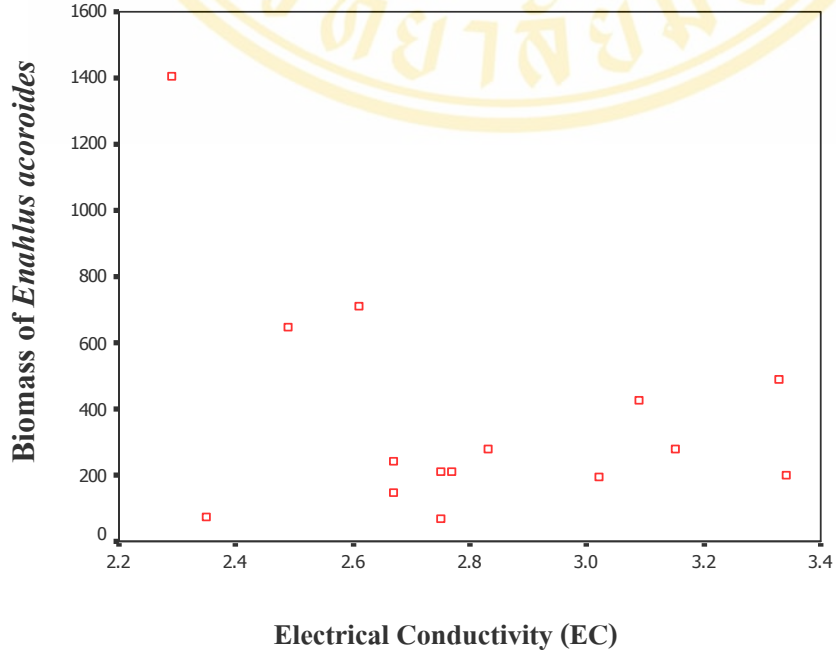
## *Enhalus acoroides*

### 1. Soil reaction (pH)




### 2. Electrical Conductivity (EC)

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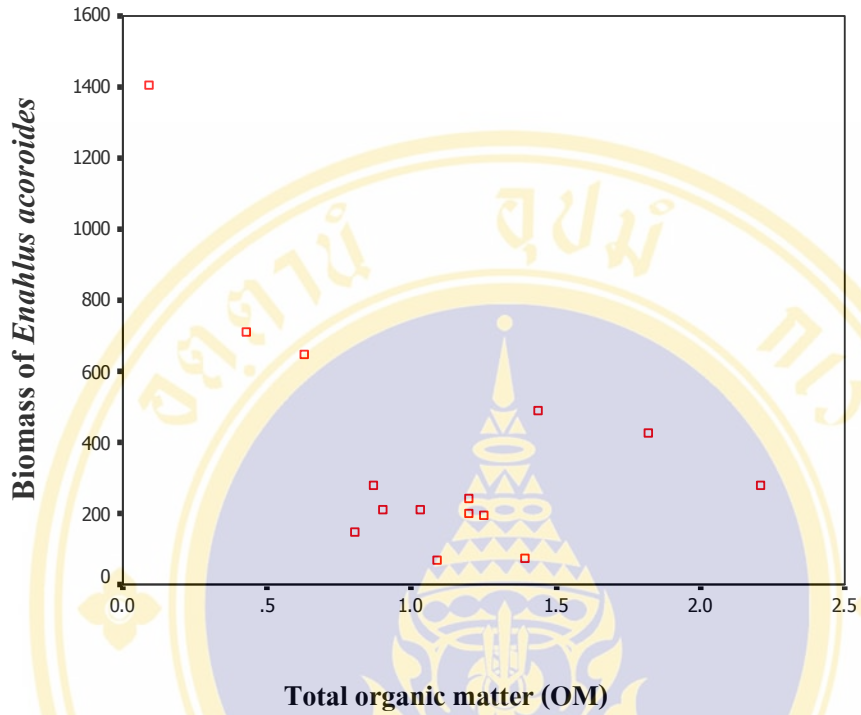
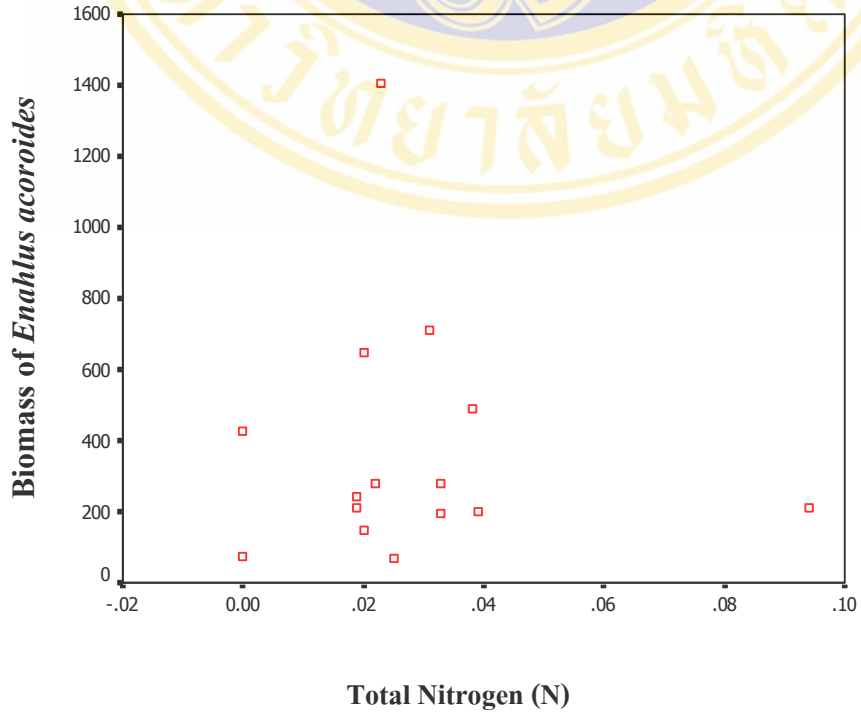
### 3. Total Organic matter (OM)




### 4. Total Nitrogen (N)

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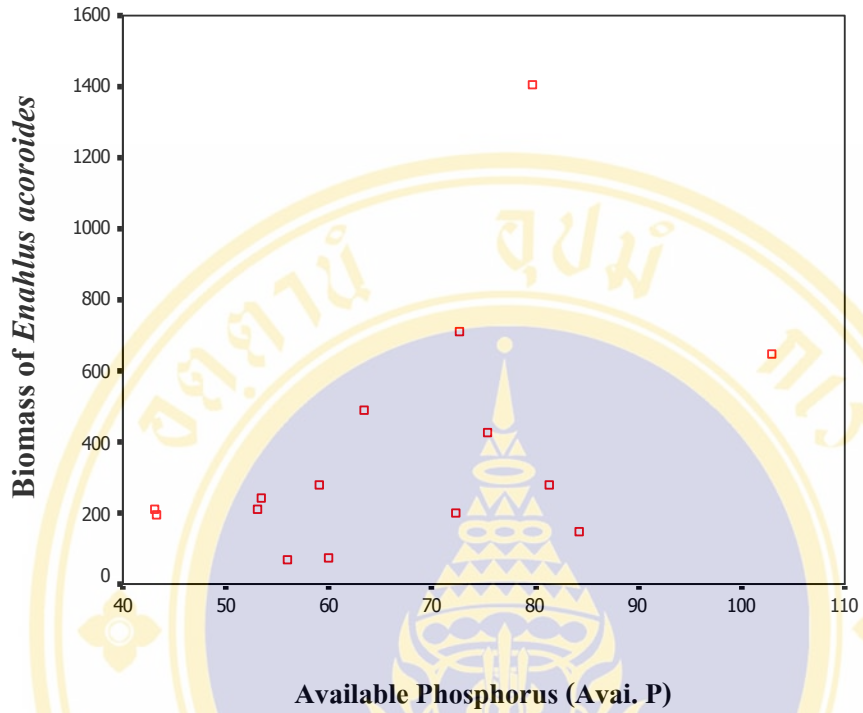
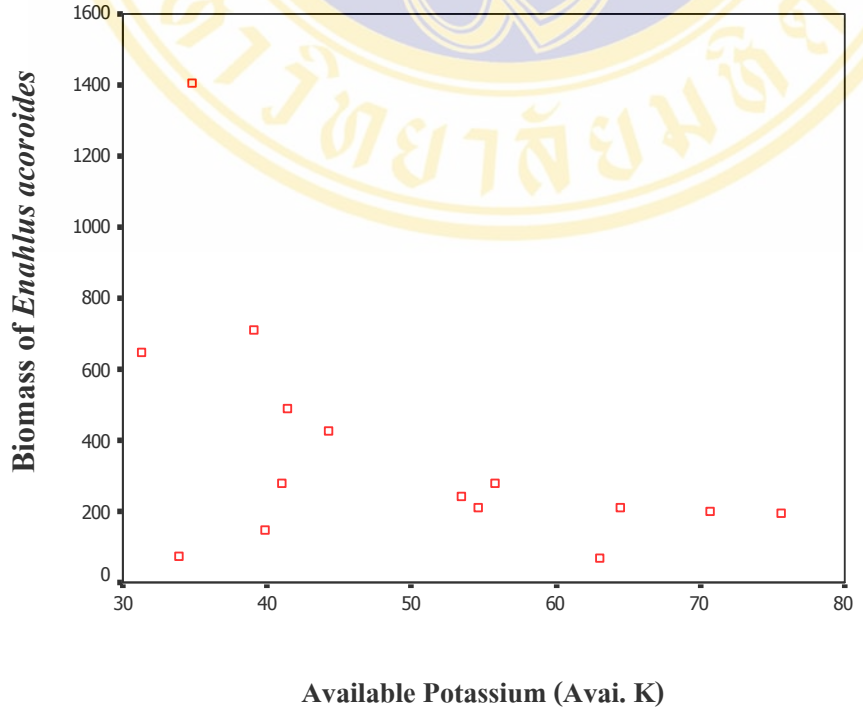
## 5. Available Phosphorus (Avai. P)




## 6. Availble Potassium (Avai. K)

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## 7. Cation Exchange Capacity (CEC)

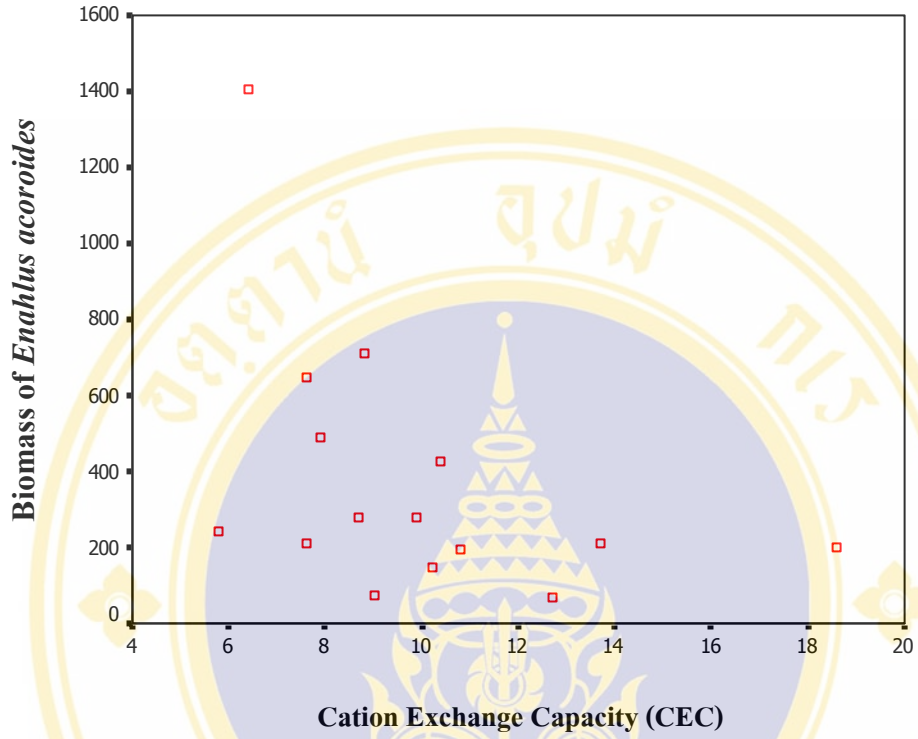


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**Table B-1 Variance test value of biomass of *Halodule pinifolia* along distance with One-way ANOVA**

| One-way ANOVA | | P Value ($\alpha < 0.05$) | | | |
|---|---|---|---|---|---|
| | | Ta Tar (Line A) | Ta Uoo (Line B) | Between Ta Guy and Mor Suk (Line C) | Sa Lut (Line D) |
| Sum of squares | Between | 7057.626 | 2614.370 | 222.070 | 456.626 |
| groups | | 2859.255 | 111.167 | 283.455 | 197.371 |
| | Within | 9916.88 | 2725.537 | 505.525 | 653.997 |
| groups | | 5 | 6 | 4 | 4 |
| | Total | 6 | 7 | 5 | 5 |
| df | Between | 11 | 13 | 9 | 9 |
| groups | | 1411.525 | 435.728 | 55.518 | 114.156 |
| | Within | 476.543 | 15.881 | 56.691 | 39.474 |
| groups | | 2.962 | 27.437 | 0.979 | 2.892 |
| | Total | 0.109 | 0.000 | 0.494 | 0.137 |
| Mean Square | Between | | | | |
| groups | | | | | |
| | Within | 1.556 | 1055.360 | 12.014 | 49.996 |
| groups | | 0.413 | 0.000 | 0.058 | 0.014 |
| F | | 2.962 | 27.437 | 0.979 | 2.892 |
| Sig. | | 0.262 | 0.017 | 0.557 | 0.278 |
| **Robust Tests of Equality of Means** | | | | | |
| Welch | Statistic | | | | |
| | Sig. | | | | |
| Brown-Forsythe | Statistic | | | | |
| | Sig. | | | | |

* significant at 95 % reliability interval

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**Table B-2 Variance test value of biomass of *Enhalus acoroides* along distance with One-way ANOVA**

| One-way ANOVA | | P Value (∝ < 0.05) | | | |
|---|---|---|---|---|---|
| | | Ta Tar (Line A) | Ta Uoo (Line B) | Between Ta Guy and Mor Suk (Line C) | Sa Lut (Line D) |
| Sum of squares | Between | - | - | 570924.8 | 266729.5 |
| groups | | - | - | 1041891 | 319776.9 |
| | Within | - | - | 1612816 | 586506.4 |
| groups | | - | - | 3 | 8 |
| | Total | - | - | 4 | 9 |
| df | Between | - | - | 7 | 17 |
| groups | | - | - | 190308.277 | 33341.191 |
| | Within | - | - | 260472.83 | 35530.763 |
| groups | | - | - | 0.731 | 0.938 |
| | Total | - | - | 0.585 | 0.530 |
| Mean Square | Between | | | | |
| groups | | | | | |
| | Within | - | - | 7.326 | 1.286 |
| groups | | - | - | 0.115 | 0.440 |
| F | | - | - | 0.731 | 0.938 |
| Sig. | | - | - | 0.664 | 0.598 |
| **Robust Tests of Equality of Means** | | | | | |
| Welch | Statistic | | | | |
| | Sig. | | | | |
| Brown-Forsythe | Statistic | | | | |
| | Sig. | | | | |

* significant at 95 % reliability interval

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**Table B-3 Different test of biomass of *Enhalus acoroides* between transect with One-way ANOVA**

| Method test | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **One-way ANOVA** | | | | | |
| Between Groups | 685158.5 | 2 | 342579.269 | 4.252 | 0.040 |
| Within Group | 966768.9 | 12 | 80564.073 | | |
| Total | 1651927 | 14 | | | |
| **Robust Tests of Equality of Means** | | | | | |
| Welch | | | | | 0.424 |
| Brown-Forsythe | | | | | 0.179 |

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**Table B-4 Correlation Coefficient of 7 parameters and biomass of *Halodule pinifolia* and among sediment parameters**

## Pearson Correlation Coefficient

**Correlations**

| | | pH Value | Electrical conductivity | Organic Matter | Total nitrogen | Available phosphorous | Available potassium | Cation exchange capacity | Biomass of H. pinifolia |
|---|---|---|---|---|---|---|---|---|---|
| pH Value | Pearson Correlation | 1 | -.503* | -.659** | -.267 | -.545** | -.098 | .362 | -.090 |
| | Sig. (2-tailed) | . | .015 | .001 | .217 | .007 | .656 | .090 | .683 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Electrical conductivity | Pearson Correlation | -.503* | 1 | .778** | .221 | .512* | .411 | .137 | .042 |
| | Sig. (2-tailed) | .015 | . | .000 | .311 | .012 | .052 | .533 | .849 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Organic Matter | Pearson Correlation | -.659** | .778** | 1 | .129 | .540** | .259 | -.075 | -.001 |
| | Sig. (2-tailed) | .001 | .000 | . | .558 | .008 | .233 | .734 | .996 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Total nitrogen | Pearson Correlation | -.267 | .221 | .129 | 1 | .054 | .582** | -.244 | .030 |
| | Sig. (2-tailed) | .217 | .311 | .558 | . | .807 | .004 | .262 | .890 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Available phosphorous | Pearson Correlation | -.545** | .512* | .540** | .054 | 1 | -.244 | -.034 | -.101 |
| | Sig. (2-tailed) | .007 | .012 | .008 | .807 | . | .262 | .877 | .646 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Available potassium | Pearson Correlation | -.098 | .411 | .259 | .582** | -.244 | 1 | .226 | -.071 |
| | Sig. (2-tailed) | .656 | .052 | .233 | .004 | .262 | . | .301 | .746 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Cation exchange capacity | Pearson Correlation | .362 | .137 | -.075 | -.244 | -.034 | .226 | 1 | -.428* |
| | Sig. (2-tailed) | .090 | .533 | .734 | .262 | .877 | .301 | . | .041 |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| Biomass of H. pinifolia | Pearson Correlation | -.090 | .042 | -.001 | .030 | -.101 | -.071 | -.428* | 1 |
| | Sig. (2-tailed) | .683 | .849 | .996 | .890 | .646 | .746 | .041 | . |
| | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

## Kendall's tau_b Correlation Coefficient

**Correlations**

| | | | pH Value | Electrical conductivity | Organic Matter | Total nitrogen | Available phosphorous | Available potassium | Cation exchange capacity | Biomass of H. pinifolia |
|---|---|---|---|---|---|---|---|---|---|---|
| Kendall's tau_b | pH Value | Correlation Coefficie | 1.000 | -.378* | -.510** | -.128 | -.480** | -.090 | .257 | -.033 |
| | | Sig. (2-tailed) | . | .014 | .001 | .408 | .002 | .558 | .093 | .831 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Electrical conductivity | Correlation Coefficie | -.378* | 1.000 | .615** | .225 | .329* | .371* | .016 | -.112 |
| | | Sig. (2-tailed) | .014 | . | .000 | .138 | .030 | .014 | .916 | .459 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Organic Matter | Correlation Coefficie | -.510** | .615** | 1.000 | .108 | .339* | .230 | -.091 | -.123 |
| | | Sig. (2-tailed) | .001 | .000 | . | .475 | .025 | .125 | .543 | .413 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Total nitrogen | Correlation Coefficie | -.128 | .225 | .108 | 1.000 | .044 | .479** | -.180 | -.012 |
| | | Sig. (2-tailed) | .408 | .138 | .475 | . | .771 | .001 | .234 | .937 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Available phosphorous | Correlation Coefficie | -.480** | .329* | .339* | .044 | 1.000 | -.048 | -.028 | -.195 |
| | | Sig. (2-tailed) | .002 | .030 | .025 | .771 | . | .751 | .853 | .195 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Available potassium | Correlation Coefficie | -.090 | .371* | .230 | .479** | -.048 | 1.000 | .024 | -.087 |
| | | Sig. (2-tailed) | .558 | .014 | .125 | .001 | .751 | . | .874 | .561 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Cation exchange capac | Correlation Coefficie | .257 | .016 | -.091 | -.180 | -.028 | .024 | 1.000 | -.234 |
| | | Sig. (2-tailed) | .093 | .916 | .543 | .234 | .853 | .874 | . | .119 |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Biomass of H. pinifolia | Correlation Coefficie | -.033 | -.112 | -.123 | -.012 | -.195 | -.087 | -.234 | 1.000 |
| | | Sig. (2-tailed) | .831 | .459 | .413 | .937 | .195 | .561 | .119 | . |
| | | N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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**Table B-5 Curvilinear test of *Haludule pinifolia* and sediment parameters**

| Parameters | Form of curve | $R^2$ | Adjust $R^2$ | Standard Error | Beta | Sig. ($\propto$ < 0.05) |
|---|---|---|---|---|---|---|
| 1. pH | Linear | 0.00812 | -0.03912 | 16.5846 | -0.090 | 0.683 |
| | Logarithmic | 0.00746 | -0.03981 | 16.5901 | -0.086 | 0.695 |
| | Inverse | 0.00681 | -0.04048 | 16.5955 | 0.083 | 0.708 |
| | Quadratic | 0.09280 | 0.00208 | 16.2525 | 22.989, 23.081 | 0.378 |
| | Cubic | 0.09246 | 0.00171 | 16.25559 | 11.500, -11.593 | 0.379 |
| | Power | 0.00979 | -0.03737 | 1.12774 | 0.902 | 0.640 |
| | Compound | 0.01064 | -0.03647 | 1.12726 | -0.099 | 0.653 |
| | S curve | 0.00896 | -0.03824 | 1.12822 | 0.095 | 0.668 |
| | Growth | 0.01064 | -0.03647 | 1.12726 | -0.103 | 0.640 |
| | Exponential | 0.01064 | -0.03647 | 1.12726 | -0.103 | 0.640 |
| 2. EC | Linear | 0.00177 | -0.04576 | 16.6371 | 0.042095 | 0.8488 |
| | Logarithmic | 0.00154 | -0.04601 | 16.63957 | 0.039191 | 0.8591 |
| | Inverse | 0.00130 | -0.04626 | 16.64156 | -0.03601 | 0.8704 |
| | Quadratic | 0.00422 | -0.09536 | 17.02755 | -0.87604, 0.919477 | 0.9586 |
| | Cubic | 0.00420 | -0.09538 | 17.02773 | -0.43042, 0.475077 | 0.9588 |
| | Power | 0.00653 | -0.04078 | 1.12961 | 0.922395 | 0.7141 |
| | Compound | 0.00705 | -0.04023 | 1.12930 | -0.08398 | 0.7032 |
| | S curve | 0.00762 | -0.03964 | 1.12898 | 0.087276 | 0.6921 |
| | Growth | 0.00653 | -0.04078 | 1.12960 | -0.08078 | 0.7141 |
| | Exponential | 0.00653 | -0.04078 | 1.12960 | -0.08078 | 0.7141 |
| 3. OM | Linear | 0.0000 | -0.04762 | 16.65235 | -0.00119 | 0.9957 |
| | Logarithmic | 0.00081 | -0.04677 | 16.64559 | 0.02851 | 0.8972 |
| | Inverse | 0.00026 | -0.04735 | 16.65022 | -0.01603 | 0.9421 |
| | Quadratic | 0.04282 | -0.05289 | 16.69424 | 0.857053, -0.88283 | 0.6455 |
| | Cubic | 0.10740 | -0.03353 | 16.54005 | -1.58658 5.175387 | 0.5292 |

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| Parameters | Form of curve | $R^2$ | Adjust $R^2$ | Standard Error | Beta | Sig. ($\propto$ < 0.05) |
|---|---|---|---|---|---|---|
| | | | | | -3.73560 | |
| | Power | 0.00773 | 1.12891 | 1.12891 | -0.08791 | 0.6900 |
| | Compound | 0.01758 | 1.12330 | 1.12330 | 0.875833 | 0.5465 |
| | S curve | 0.00752 | 1.12903 | 1.12903 | 0.086733 | 0.6939 |
| | Growth | 0.01758 | 1.12330 | 1.12330 | -0.13258 | 0.5465 |
| | Exponential | 0.01758 | 1.12330 | 1.12330 | -0.13258 | 0.5465 |
| 4. Nitrogen | Linear | 0.00093 | -0.04665 | 16.64465 | 0.030431 | 0.8904 |
| | Logarithmic | 0.0000 | -0.04762 | 16.65236 | 0.000963 | 0.9965 |
| | Inverse | 0.00001 | -0.04761 | 16.65230 | -0.00281 | 0.9898 |
| | Quadratic | 0.00267 | -0.09706 | 17.04078 | -0.09460, 0.13183 | 0.9736 |
| | Cubic | 0.05728 | -0.09157 | 16.99809 | -1.84936, 4.51808, -2.78811 | 0.7652 |
| | Power | 0.00911 | -0.03807 | 1.12813 | 0.945939 | 0.6648 |
| | Compound | 0.00309 | -0.04438 | 1.13155 | -0.09547 | 0.8011 |
| | S curve | 0.00765 | -0.03960 | 1.12896 | 0.087469 | 0.6915 |
| | Growth | 0.00309 | -0.04438 | 1.13155 | -0.05557 | 0.8011 |
| | Exponential | 0.00309 | -0.04438 | 1.13155 | -0.05557 | 0.8011 |
| 5. Phosphorus | Linear | 0.01025 | -0.03688 | 16.56677 | -0.10126 | 0.6457 |
| | Logarithmic | 0.00721 | -0.04007 | 16.59226 | -0.08488 | 0.7002 |
| | Inverse | 0.00429 | -0.04312 | 16.61658 | 0.065523 | 0.7664 |
| | Quadratic | 0.03099 | -0.06591 | 16.79713 | 1.477291, -1.58510 | 0.7299 |
| | Cubic | 0.02723 | -0.07004 | 16.82964 | 0.627881, -0.74069 | 0.7587 |
| | Power | 0.03093 | -0.01521 | 1.11564 | -0.17587 | 0.4221 |
| | Compound | 0.03411 | -0.01189 | 1.11381 | 0.831374 | 0.3989 |
| | S curve | 0.02665 | -0.01970 | 1.11810 | 0.163255 | 0.4567 |
| | Growth | 0.03411 | -0.01189 | 1.11381 | -0.18467 | 0.3989 |
| | Exponential | 0.03411 | -0.01189 | 1.11381 | -0.18467 | 0.3989 |
| 6. Potassium | Linear | 0.00510 | -0.04228 | 16.60986 | -0.07141 | 0.7461 |
| | Logarithmic | 0.00297 | -0.04451 | 16.62762 | -0.05449 | 0.8049 |

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| Parameters | Form of curve | $R^2$ | Adjust $R^2$ | Standard Error | Beta | Sig. ($\propto$ < 0.05) |
|---|---|---|---|---|---|---|
| | Inverse | 0.00115 | -0.04641 | 16.64275 | 0.03397 | 0.8777 |
| | Quadratic | 0.01414 | -0.08445 | 16.94252 | 0.580631, -0.65893 | 0.8673 |
| | Cubic | 0.01414 | -0.14152 | 17.38264 | 0.639660, -0.78742, 0.070611 | 0.9642 |
| | Power | 0.00023 | -0.04737 | 1.13317 | 0.015289 | 0.9448 |
| | Compound | 0.00005 | -0.04757 | 1.13328 | 1.00690 | 0.9751 |
| | S curve | 0.00068 | -0.04692 | 1.13292 | -0.0261 | 0.9058 |
| | Growth | 0.00005 | -0.04757 | 1.13328 | 0.00689 | 0.9751 |
| | Exponential | 0.00005 | -0.04757 | 1.13328 | 0.00689 | 0.9751 |
| 7. CEC | Linear | 0.18341 | 0.14453 | 15.04796 | -0.42827 | 0.0415 |
| | Logarithmic | 0.21367 | 0.17623 | 14.76651 | -0.46224 | 0.0264 |
| | Inverse | 0.19678 | 0.15853 | 14.92431 | 0.44359 | 0.0340 |
| | Quadratic | 0.22521 | 0.14773 | 15.01973 | -1.22663, 0.82413 | 0.0780 |
| | Cubic | 0.22699 | 0.10494 | 15.39220 | -0.60039, -0.68455, 0.916277 | 0.1707 |
| | Power | 0.11867 | 0.07670 | 1.06394 | 0.734968 | 0.1529 |
| | Compound | 0.09482 | 0.05172 | 1.07824 | -0.34448 | 0.1075 |
| | S curve | 0.11356 | 0.07135 | 1.06702 | 0.336986 | 0.1159 |
| | Growth | 0.09482 | 0.05172 | 1.07824 | -0.30793 | 0.1529 |
| | Exponential | 0.09482 | 0.05172 | 1.07824 | -0.30792 | 0.1529 |

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**Table B-6 Correlation Coefficient of 7 parameters and biomass of *Enhalus acoroides* and among sediment parameters**

## Pearson Correlation Coefficient

**Correlations**

| | | pH Value | Electrical conductivity | Organic Matter | Total nitrogen | Available phosphorous | Available potassium | Cation exchange capacity | Biomass of E. acoroides |
|---|---|---|---|---|---|---|---|---|---|
| pH Value | Pearson Correlation | 1 | -.138 | -.157 | .081 | .144 | -.064 | .051 | .163 |
| | Sig. (2-tailed) | . | .624 | .577 | .774 | .610 | .820 | .856 | .560 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Electrical conductivity | Pearson Correlation | -.138 | 1 | .653** | .227 | -.145 | .468 | .499 | -.357 |
| | Sig. (2-tailed) | .624 | . | .008 | .416 | .606 | .079 | .058 | .191 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Organic Matter | Pearson Correlation | -.157 | .653** | 1 | -.067 | -.148 | .150 | .240 | -.566* |
| | Sig. (2-tailed) | .577 | .008 | . | .813 | .598 | .593 | .388 | .028 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Total nitrogen | Pearson Correlation | .081 | .227 | -.067 | 1 | -.356 | .448 | .438 | -.059 |
| | Sig. (2-tailed) | .774 | .416 | .813 | . | .193 | .094 | .103 | .834 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Available phosphorous | Pearson Correlation | .144 | -.145 | -.148 | -.356 | 1 | -.698** | -.146 | .462 |
| | Sig. (2-tailed) | .610 | .606 | .598 | .193 | . | .004 | .604 | .083 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Available potassium | Pearson Correlation | -.064 | .468 | .150 | .448 | -.698** | 1 | .622* | -.501 |
| | Sig. (2-tailed) | .820 | .079 | .593 | .094 | .004 | . | .013 | .057 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Cation exchange capaci | Pearson Correlation | .051 | .499 | .240 | .438 | -.146 | .622* | 1 | -.433 |
| | Sig. (2-tailed) | .856 | .058 | .388 | .103 | .604 | .013 | . | .107 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Biomass of E. acoroides | Pearson Correlation | .163 | -.357 | -.566* | -.059 | .462 | -.501 | -.433 | 1 |
| | Sig. (2-tailed) | .560 | .191 | .028 | .834 | .083 | .057 | .107 | . |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

## Kendall's tau_b Correlation Coefficient

**Correlations**

| | | | pH Value | Electrical conductivity | Organic Matter | Total nitrogen | Available phosphorous | Available potassium | Cation exchange capacity | Biomass of E. acoroides |
|---|---|---|---|---|---|---|---|---|---|---|
| Kendall's tau_b | pH Value | Correlation Coefficie | 1.000 | -.188 | -.079 | .090 | .049 | -.049 | -.059 | -.010 |
| | | Sig. (2-tailed) | . | .342 | .689 | .652 | .803 | .803 | .764 | .960 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Electrical conductivity | Correlation Coefficie | -.188 | 1.000 | .483* | .343 | -.106 | .452* | .309 | -.067 |
| | | Sig. (2-tailed) | .342 | . | .013 | .081 | .585 | .020 | .112 | .728 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Organic Matter | Correlation Coefficie | -.079 | .483* | 1.000 | -.020 | -.077 | .211 | .202 | -.249 |
| | | Sig. (2-tailed) | .689 | .013 | . | .921 | .692 | .276 | .298 | .198 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Total nitrogen | Correlation Coefficie | .090 | .343 | -.020 | 1.000 | -.146 | .359 | .332 | .049 |
| | | Sig. (2-tailed) | .652 | .081 | .921 | . | .456 | .066 | .090 | .804 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Available phosphorous | Correlation Coefficie | .049 | -.106 | -.077 | -.146 | 1.000 | -.543** | -.115 | .314 |
| | | Sig. (2-tailed) | .803 | .585 | .692 | .456 | . | .005 | .552 | .102 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Available potassium | Correlation Coefficie | -.049 | .452* | .211 | .359 | -.543** | 1.000 | .421* | -.390* |
| | | Sig. (2-tailed) | .803 | .020 | .276 | .066 | .005 | . | .029 | .042 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Cation exchange capac | Correlation Coefficie | -.059 | .309 | .202 | .332 | -.115 | .421* | 1.000 | -.383* |
| | | Sig. (2-tailed) | .764 | .112 | .298 | .090 | .552 | .029 | . | .047 |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Biomass of E. acoroide | Correlation Coefficie | -.010 | -.067 | -.249 | .049 | .314 | -.390* | -.383* | 1.000 |
| | | Sig. (2-tailed) | .960 | .728 | .198 | .804 | .102 | .042 | .047 | . |
| | | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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**Table B-7 Curvilinear test of *Enhalus acoroides* and sediment parameters**

| Parameters | Form of curve | $R^2$ | Adjust $R^2$ | Standard Error | Beta | Sig. ($\propto$ < 0.05) |
|---|---|---|---|---|---|---|
| 1. pH | Linear | 0.02673 | -0.04814 | 351.67441 | 0.663489 | 0.5604 |
| | Logarithmic | 0.02664 | -0.04824 | 351.69071 | 0.163213 | 0.5611 |
| | Inverse | 0.02655 | -0.04833 | 351.70703 | -0.16293 | 0.5618 |
| | Quadratic | 0.02682 | -0.04804 | 351.65814 | 0.163767 | 0.5598 |
| | Cubic | 0.02691 | -0.04794 | 351.64190 | 0.164038 | 0.5591 |
| | Power | 0.00013 | -0.07679 | 0.84618 | 0.011198 | 0.9683 |
| | Compound | 0.00013 | -0.07679 | 0.84618 | 1.011313 | 0.9684 |
| | S curve | 0.00012 | -0.07679 | 0.84618 | -0.01115 | 0.9685 |
| | Growth | 0.00013 | -0.07679 | 0.84618 | 0.011249 | 0.9683 |
| | Exponential | 0.00013 | -0.07679 | 0.84618 | 0.011249 | 0.9683 |
| 2. EC | Linear | 0.12780 | 0.06071 | 332.91395 | -0.35749 | 0.1908 |
| | Logarithmic | 0.14923 | 0.08379 | 328.79796 | -0.38631 | 0.1549 |
| | Inverse | 0.17203 | 0.10834 | 324.36338 | 0.414762 | 0.1242 |
| | Quadratic | 0.36265 | 0.25643 | 296.20510 | -8.73773, 8.394248 | 0.0670 |
| | Cubic | 0.36265 | 0.25643 | 296.20510 | -8.7377, 8.394248 | 0.0670 |
| | Power | 0.00999 | -0.06616 | 0.84199 | -0.09997 | 0.7230 |
| | Compound | 0.00655 | -0.06987 | 0.84346 | 0.922268 | 0.7744 |
| | S curve | 0.01421 | -0.06162 | 0.84020 | 0.119203 | 0.6722 |
| | Growth | 0.00655 | -0.06987 | 0.84346 | -0.08092 | 0.7744 |
| | Exponential | 0.00655 | -0.06987 | 0.84346 | -0.08092 | 0.7744 |
| 3. OM | Linear | 0.32034 | 0.26806 | 293.88009 | -0.56598 | 0.0279 |
| | Logarithmic | 0.69645 | 0.67310 | 196.40033 | -0.83453 | 0.0001 |
| | Inverse | 0.76557 | 0.74754 | 172.59556 | 0.87496 | 0.0000 |
| | Quadratic | 0.78403 | 0.74804 | 172.42507 | -2.69810, 2.238217 | 0.0001 |
| | Cubic | 0.88600 | 0.85491 | 130.84276 | -5.21100, 8.853016, -4.30156 | 0.0000 |
| | Power | 0.36359 | 0.31463 | 0.67509 | -0.60298 | 0.0173 |

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| Parameters | Form of curve | $R^2$ | Adjust $R^2$ | Standard Error | Beta | Sig. ($\propto$ < 0.05) |
|---|---|---|---|---|---|---|
| | Compound | 0.15607 | 0.09115 | 0.77740 | 0.673644 | 0.1450 |
| | S curve | 0.37246 | 0.32418 | 0.67037 | 0.610291 | 0.0157 |
| | Growth | 0.15607 | 0.09115 | 0.77740 | -0.39505 | 0.1450 |
| | Exponential | 0.15607 | 0.09115 | 0.77740 | -0.39505 | 0.1450 |
| 4. Nitrogen | Linear | 0.00350 | -0.07316 | 355.84676 | -0.05913 | 0.8342 |
| | Logarithmic | - | - | - | - | - |
| | Inverse | - | - | - | - | - |
| | Quadratic | 0.03645 | -0.12415 | 364.20233 | 0.419423, -0.51183 | 0.8003 |
| | Cubic | 0.05588 | -0.20160 | 376.54057 | 1.324632, -4.03136, 2.695978’ | 0.8825 |
| | Power | - | - | - | - | - |
| | Compound | 0.00136 | -0.07545 | 0.84566 | 1.037613 | 0.8961 |
| | S curve | - | - | - | - | - |
| | Growth | 0.00136 | -0.07545 | 0.84566 | 0.036922 | 0.8961 |
| | Exponential | 0.00136 | -0.07545 | 0.84566 | 0.036922 | 0.8961 |
| 5. Phosphorus | Linear | 0.21328 | 0.15276 | 316.18027 | 0.461819 | 0.0831 |
| | Logarithmic | 0.21334 | 0.15283 | 316.16777 | 0.461886 | 0.0830 |
| | Inverse | 0.20208 | 0.14070 | 318.42273 | -0.44953 | 0.0927 |
| | Quadratic | 0.21707 | 0.08658 | 328.29718 | 0.909570, -0.451963 | 0.2303 |
| | Cubic | 0.23865 | 0.03101 | 338.13590 | -5.81773, 13.25481, -7.103062 | 0.3724 |
| | Power | 0.21359 | 0.15310 | 0.75044 | 0.462162 | 0.0828 |
| | Compound | 0.22415 | 0.16447 | 0.74538 | 1.605517 | 0.0747 |
| | S curve | 0.19249 | 0.13037 | 0.76044 | -0.43873 | 0.1018 |
| | Growth | 0.22415 | 0.16447 | 0.74538 | 0.473446 | 0.0747 |
| | Exponential | 0.22415 | 0.16447 | 0.74538 | 0.473446 | 0.0747 |
| 6. Potassium | Linear | 0.25136 | 0.19377 | 308.43328 | -0.50135 | 0.0589 |
| | Logarithmic | 0.27200 | 0.21600 | 304.15162 | -0.52153 | 0.0462 |
| | Inverse | 0.28439 | 0.22934 | 301.55229 | 0.533280 | 0.0406 |

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| Parameters | Form of curve | $R^2$ | Adjust $R^2$ | Standard Error | Beta | Sig. ($\propto$ < 0.05) |
|---|---|---|---|---|---|---|
| | Quadratic | 0.29640 | 0.17914 | 311.21978 | -2.41170, 1.922100 | 0.1213 |
| | Cubic | 0.29660 | 0.17937 | 311.17513 | -1.47969, 1.001195 | 0.1211 |
| | Power | 0.19333 | 0.13128 | 0.76004 | -0.43969 | 0.1010 |
| | Compound | 0.18898 | 0.12659 | 0.76209 | 0.647450 | 0.1054 |
| | S curve | 0.19055 | 0.12829 | 0.76135 | 0.436523 | 0.1038 |
| | Growth | 0.18898 | 0.12659 | 0.76209 | -0.434714 | 0.1054 |
| | Exponential | 0.18898 | 0.12659 | 0.76209 | -0.434714 | 0.1054 |
| 7. CEC | Linear | 0.18755 | 0.12505 | 321.30851 | -0.433070 | 0.1069 |
| | Logarithmic | 0.23220 | 0.17314 | 312.35475 | -0.48187 | 0.0689 |
| | Inverse | 0.25495 | 0.19764 | 307.69172 | 0.504928 | 0.0549 |
| | Quadratic | 0.28536 | 0.16625 | 313.65337 | -2.17376, 1.768569 | 0.1332 |
| | Cubic | 0.28551 | 0.09065 | 327.56429 | -1.79006, 0.929909, 0.466138 | 0.2775 |
| | Power | 0.21654 | 0.15627 | 0.74903 | -0.465339 | 0.0805 |
| | Compound | 0.17763 | 0.11437 | 0.76740 | 0.656088 | 0.1177 |
| | S curve | 0.23101 | 0.17186 | 0.74208 | 0.480635 | 0.0697 |
| | Growth | 0.17763 | 0.11437 | 0.76740 | -0.421460 | 0.1177 |
| | Exponential | 0.17763 | 0.11437 | 0.76740 | -0.421460 | 0.1177 |

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## 1. Biomass of seagrasses

**Table C-1. Biomass of seagrasses in each station of each transect lines, Kung Krabaen Bay in rainy season ($g/m^2$)**

| Distance (m) | Station | Ta Tar (Line A) | | Ta Uoo (Line B) | | Between Ta Guy and Mor Suk (Line C) | | Sa Lut (Line D) | |
|---|---|---|---|---|---|---|---|---|---|
| | | *H. pinifolia* | *E. acoroides* | *H. pinifolia* | *E. acoroides* | *H. pinifolia* | *E. acoroides* | *H. pinifolia* | *E. acoroides* |
| 0 | 1/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1/2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100 | 2/1 | 1.14 | 0 | 10.29 | 0 | 0 | 0 | 0 | 0 |
| | 2/2 | 8.41 | 0 | 9.96 | 0 | 0 | 0 | 0 | 0 |
| 200 | 3/1 | 19.18 | 0 | 26.86 | 0 | 0 | 1,403.51 | 0 | 0 |
| | 3/2 | 12.73 | 0 | 37.22 | 0 | 17.55 | 0 | 0 | 0 |
| 300 | 4/1 | 44.00 | 0 | 28.16 | 0 | 7.84 | 0 | 1.14 | 0 |
| | 4/2 | 100.16 | 0 | 28.24 | 0 | 9.88 | 0 | 17.55 | 0 |
| 400 | 5/1 | 59.18 | 0 | 11.59 | 0 | 5.22 | 0 | 0 | 0 |
| | 5/2 | 10.53 | 0 | 2.45 | 0 | 8.57 | 0 | 0.98 | 0 |
| 500 | 6/1 | 6.20 | 0 | 26.12 | 0 | 15.51 | 0 | 0 | 198.69 |
| | 6/2 | 5.71 | 0 | 23.51 | 0 | 0 | 145.06 | 8.57 | 0 |
| 600 | 7/1 | 10.53 | 0 | 38.37 | 0 | 0 | 620.24 | 0 | 177.06 |
| | 7/2 | 0.41 | 0 | 43.18 | 0 | 0 | 805.06 | 0 | 805.06 |
| 700 | 8/1 | 0 | 489.22 | 0.08 | 0 | 18.86 | 0 | 0 | 0 |
| | 8/2 | 0 | 365.39 | 1.14 | 0 | 20.57 | 0 | 0 | 0 |
| 800 | 9/1 | 0 | 48.73 | 0 | 0 | 0 | 524.41 | 0 | 0 |
| | 9/2 | 0 | 96.98 | 0 | 0 | 0 | 766.78 | 6.94 | 0 |
| 900 | 10/1 | 0 | 0 | - | - | 0 | 0 | 0 | 285.31 |
| | 10/2 | 0 | 0 | - | - | 0 | 0 | 0 | 198.04 |
| 1,000 | 11/1 | - | - | - | - | - | - | 0 | 130.69 |
| | 11/2 | - | - | - | - | - | - | 0 | 291.76 |
| 1,070 | 12/1 | - | - | - | - | - | - | 0 | 362.20 |
| | 12/2 | - | - | - | - | - | - | 0 | 198.45 |
| 1,380 | 13/1 | - | - | - | - | - | - | 0 | 171.76 |
| | 13/2 | - | - | - | - | - | - | 0 | 219.35 |
| 1,460 | 14/1 | - | - | - | - | - | - | 0 | 89.39 |
| | 14/2 | - | - | - | - | - | - | 0 | 336.73 |
| 1,850 | 15/1 | - | - | - | - | - | - | 0 | 0 |
| | 15/2 | - | - | - | - | - | - | 0 | 0 |

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## 2. Sediment Quality

### 2.1 Physical quality

**Table C-2. Texture as percent of sand silt and clay of each transect**

| Distance (m) | Ta Tar (Line A) | | | | Ta Uoo (Line B) | | | | Between Ta Guy and Mor Suk (Line C) | | | | Sa Lut (Line D) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Sand | % Silt | % Clay | Texture | % Sand | % Silt | % Clay | Texture | % Sand | % Silt | % Clay | Texture | % Sand | % Silt | % Clay | Texture |
| **0** | 72 | 21 | 7 | Sandy loam | 62 | 33 | 5 | Sandy loam | 74 | 21 | 5 | 74 | 47 | 48 | 5 | Sandy loam |
| **100** | 56 | 37 | 7 | Sandy loam | 46 | 49 | 5 | Sandy loam | 80 | 17 | 3 | 80 | 47 | 50 | 3 | Silt |
| **200** | 54 | 39 | 7 | Sandy loam | 50 | 47 | 3 | Sandy loam | 76 | 21 | 3 | 76 | 47 | 50 | 3 | Silt |
| **300** | 50 | 43 | 7 | Loam | 72 | 25 | 3 | Sandy loam | 63 | 34 | 3 | 63 | 47 | 50 | 3 | Silt |
| **400** | 40 | 57 | 3 | Silt | 52 | 45 | 3 | Sandy loam | 59 | 38 | 3 | 59 | 47 | 50 | 3 | Silt |
| **500** | 36 | 59 | 5 | Silt | 54 | 43 | 3 | Sandy loam | 57 | 40 | 3 | 57 | 53 | 44 | 3 | Sandy loam |
| **600** | 42 | 55 | 3 | Silt | 50 | 47 | 3 | Sandy loam | 51 | 46 | 3 | 51 | 57 | 40 | 3 | Sandy loam |
| **700** | 46 | 51 | 3 | Silt | 54 | 43 | 3 | Sandy loam | 61 | 36 | 3 | 61 | 57 | 40 | 3 | Sandy loam |
| **800** | 54 | 43 | 3 | Sandy loam | 52 | 45 | 3 | Sandy loam | 57 | 42 | 1 | 57 | 59 | 38 | 3 | Sandy loam |
| **900** | 72 | 25 | 3 | Sandy loam | | | | | 53 | 44 | 3 | 53 | 57 | 40 | 3 | Sandy loam |
| **1,000** | | | | | | | | | | | | | 57 | 42 | 1 | Sandy loam |
| **1,070** | | | | | | | | | | | | | 55 | 44 | 1 | Sandy loam |
| **1,380** | | | | | | | | | | | | | 63 | 34 | 3 | Sandy loam |
| **1,460** | | | | | | | | | | | | | 67 | 30 | 3 | Sandy loam |
| **1,850** | | | | | | | | | | | | | 79 | 20 | 1 | Loamy sand |

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## 2.2 Chemical Quality

### Table C-3. Chemical quality in summer and rainy of Ta Tar canal (Line A)

| Distance (m) | Station | Chemical quality | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | summer | | | | | | rainy | | | | | |
| | | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) |
| 0 | 1/1 | 6.54 | 3.00 | 5.56 | 0.004 | 49.50 | 243.87 | 7.07 | 3.20 | 3.21 | 0.100 | 58.00 | 87.66 |
| | 1/2 | 7.42 | 2.00 | 4.77 | 0.007 | 47.50 | 217.60 | 7.40 | 4.18 | 3.73 | 0.090 | 67.00 | 103.10 |
| | 1/3 | 6.63 | 3.00 | 5.78 | - | 90.00 | - | 7.04 | 2.57 | 2.14 | - | 65.00 | - |
| 100 | 2/1 | 7.43 | 2.90 | 3.18 | 0.014 | 120.00 | 51.63 | 7.57 | 3.08 | 1.88 | 0.055 | 102.00 | 55.82 |
| | 2/2 | 7.43 | 2.70 | 3.32 | 0.050 | 59.50 | 121.20 | 7.54 | 3.16 | 2.10 | 0.059 | 74.00 | 66.46 |
| | 2/3 | 7.55 | 3.30 | 3.47 | - | 59.50 | - | 7.48 | 3.50 | 2.40 | - | 88.00 | - |
| 200 | 3/1 | 8.00 | 3.70 | 2.24 | 0.052 | 60.00 | 95.00 | 7.84 | 2.99 | 1.59 | 0.045 | 86.00 | 54.58 |
| | 3/2 | 7.98 | 3.90 | 2.24 | 0.050 | 59.00 | 94.18 | 7.77 | 2.82 | 1.44 | 0.040 | 97.00 | 44.38 |
| | 3/3 | 7.97 | 2.00 | 2.17 | - | 58.50 | - | 7.68 | 3.29 | 1.92 | - | 94.00 | - |
| 300 | 4/1 | 7.98 | 3.50 | 2.17 | 0.040 | 120.00 | 12.95 | 7.86 | 3.21 | 1.73 | 0.040 | 71.00 | 51.79 |
| | 4/2 | 7.87 | 3.00 | 1.95 | 0.042 | 98.00 | 73.06 | 7.95 | 3.55 | 1.99 | 0.039 | 69.00 | 51.38 |
| | 4/3 | 7.92 | 3.10 | 2.17 | - | 120.00 | - | 7.74 | 3.11 | 1.55 | - | 107.00 | - |
| 400 | 5/1 | 8.08 | 2.00 | 1.95 | 0.039 | 106.00 | 10.70 | 7.72 | 2.69 | 1.29 | 0.040 | 108.00 | 23.47 |
| | 5/2 | 8.09 | 1.80 | 2.17 | 0.036 | 119.00 | 68.72 | 7.98 | 3.51 | 1.29 | 0.050 | 83.00 | 55.71 |
| | 5/3 | 8.08 | 2.30 | 2.09 | - | 107.00 | - | 7.81 | 2.92 | 0.81 | - | 119.00 | - |
| 500 | 6/1 | 7.81 | 2.40 | 2.60 | 0.053 | 119.00 | 62.67 | 7.79 | 2.60 | 1.37 | 0.046 | 98.00 | 33.84 |
| | 6/2 | 7.72 | 3.80 | 2.74 | 0.057 | 102.00 | 90.34 | 7.91 | 2.88 | 1.70 | 0.043 | 94.00 | 48.35 |
| | 6/3 | 7.89 | 3.70 | 2.17 | - | 81.00 | - | 7.93 | 2.99 | 1.66 | - | 107.00 | - |
| 600 | 7/1 | 8.03 | 3.15 | 1.23 | 0.032 | 118.00 | 72.77 | 7.88 | 3.43 | 1.81 | 0.033 | 100.00 | -0.17 |
| | 7/2 | 7.95 | 3.30 | 1.81 | 0.029 | 106.00 | 79.89 | 7.72 | 3.30 | 1.88 | 0.003 | 94.00 | 47.36 |
| | 7/3 | 8.00 | 3.20 | 1.73 | - | 110.00 | - | 7.84 | 3.38 | 1.62 | - | 112.00 | - |
| 700 | 8/1 | | | | | | | 7.87 | 2.90 | 1.59 | 0.000 | 71.00 | 39.12 |
| | 8/2 | | | | | | | 8.04 | 3.00 | 2.25 | 0.000 | 67.00 | 49.48 |
| | 8/3 | | | | | | | 7.94 | 3.38 | 1.62 | - | 88.00 | - |
| 800 | 9/1 | | | | | | | 8.14 | 2.53 | 1.37 | 0.000 | 52.00 | 42.87 |
| | 9/2 | | | | | | | 8.06 | 2.10 | 1.25 | 0.000 | 74.00 | 25.02 |
| | 9/3 | | | | | | | 8.11 | 2.42 | 1.55 | - | 54.00 | - |
| 900 | 10/1 | | | | | | | 8.22 | 2.29 | 1.33 | 0.000 | 62.00 | 31.48 |
| | 10/2 | | | | | | | 8.23 | 2.50 | 1.48 | 0.000 | 57.00 | 36.00 |
| | 10/3 | | | | | | | 8.21 | 1.78 | 1.48 | - | 53.00 | - |

### Table C-4. Chemical quality in summer and rainy of Ta Uoo canal (Line B)

| Distance (m) | Station | Chemical quality | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | summer | | | | | | rainy | | | | | |
| | | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) |
| 0 | 1/1 | 5.21 | 5.80 | 2.69 | 0.087 | 75.00 | 233.50 | 8.16 | 2.21 | 1.51 | 0.015 | 46.00 | 26.40 |
| | 1/2 | 5.74 | 5.00 | 1.66 | 0.112 | 95.00 | 235.60 | 8.27 | 2.91 | 1.73 | 0.027 | 63.00 | 34.16 |
| | 1/3 | 5.59 | 4.90 | 1.19 | - | 82.00 | - | 8.17 | 3.38 | 1.81 | - | 54.00 | - |
| 100 | 2/1 | 7.81 | 3.00 | 1.37 | 0.034 | 98.00 | 71.30 | 7.87 | 3.09 | 1.96 | 0.004 | 81.00 | 42.00 |
| | 2/2 | 7.59 | 3.00 | 1.81 | 0.077 | 104.00 | 88.65 | 8.05 | 3.11 | 1.92 | 0.003 | 83.00 | 48.97 |
| | 2/3 | 7.86 | 3.20 | 1.37 | - | 110.00 | - | 7.86 | 3.21 | 1.92 | - | 77.00 | - |
| 200 | 3/1 | 8.06 | 2.10 | 0.37 | 0.022 | 64.00 | 50.70 | 7.90 | 2.61 | 1.51 | 0.004 | 95.00 | 40.47 |
| | 3/2 | 8.13 | 2.50 | 0.37 | 0.023 | 69.00 | 57.92 | 8.00 | 3.05 | 1.66 | 0.004 | 78.00 | 37.36 |
| | 3/3 | 8.08 | 2.20 | 0.72 | - | 79.00 | - | 7.74 | 2.50 | 1.77 | - | 85.00 | - |
| 300 | 4/1 | 8.21 | 2.60 | 0.37 | 0.001 | 58.00 | 54.88 | 7.98 | 3.00 | 1.55 | 0.004 | 76.00 | 29.33 |
| | 4/2 | 8.07 | 2.90 | 0.74 | 0.017 | 58.00 | 62.68 | 7.96 | 3.01 | 1.59 | 0.005 | 123.00 | 36.42 |
| | 4/3 | 8.15 | 2.90 | 0.25 | - | 54.00 | - | 8.04 | 3.21 | 1.62 | - | 82.00 | - |
| 400 | 5/1 | 8.12 | 2.20 | 0.37 | 0.021 | 65.00 | 63.22 | 7.94 | 3.48 | 1.77 | 0.003 | 115.00 | 41.96 |
| | 5/2 | 8.15 | 2.10 | 0.25 | 0.018 | 54.00 | 47.16 | 7.84 | 2.90 | 1.70 | 0.002 | 76.00 | 37.31 |
| | 5/3 | 8.02 | 2.00 | 0.25 | - | 67.00 | - | 7.81 | 3.01 | 1.77 | - | 93.00 | - |
| 500 | 6/1 | 8.07 | 3.00 | 0.25 | 0.018 | 53.00 | 69.32 | 8.01 | 2.38 | 0.79 | 0.002 | 74.00 | 25.14 |
| | 6/2 | 8.09 | 2.50 | 0.62 | 0.015 | 58.00 | 58.45 | 7.99 | 2.79 | 0.98 | 0.003 | 86.00 | 30.49 |
| | 6/3 | 8.07 | 3.00 | 0.12 | - | 62.00 | - | 7.94 | 2.99 | 0.04 | - | 93.00 | - |
| 600 | 7/1 | 7.94 | 2.00 | 0.74 | 0.026 | 86.00 | 56.86 | 8.25 | 2.70 | 0.66 | 0.017 | 57.00 | 36.61 |
| | 7/2 | 8.53 | 2.00 | 0.62 | 0.020 | 78.00 | 60.47 | 7.98 | 2.96 | 0.92 | 0.027 | 88.00 | 23.64 |
| | 7/3 | 7.96 | 3.00 | 0.67 | - | 90.00 | - | 8.11 | 2.51 | 0.98 | - | 73.00 | - |
| 700 | 8/1 | | | | | | | 8.12 | 2.80 | 0.72 | 0.020 | 86.00 | 30.69 |
| | 8/2 | | | | | | | 8.28 | 2.61 | 0.85 | 0.021 | 71.00 | 30.12 |
| | 8/3 | | | | | | | 8.04 | 2.78 | 0.11 | - | 81.00 | - |
| 800 | 9/1 | | | | | | | 8.04 | 2.92 | 0.85 | 0.021 | 116.00 | 29.71 |
| | 9/2 | | | | | | | 8.06 | 2.99 | 0.79 | 0.020 | 107.00 | 36.90 |
| | 9/3 | | | | | | | 8.02 | 2.59 | 0.79 | - | 86.00 | - |

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## Table C-5. Chemical quality in summer and rainy of between Ta Guy and Mor Suk (Line C)

| Distance (m) | Station | Chemical quality | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | summer | | | | | | rainy | | | | | |
| | | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) |
| 0 | 1/1 | 7.61 | 2.30 | 2.13 | 0.042 | 104.00 | 74.16 | 7.97 | 2.22 | 0.15 | 0.024 | 49.00 | 36.90 |
| | 1/2 | 7.57 | 2.50 | 2.37 | 0.037 | 55.00 | 76.96 | 7.80 | 3.01 | 1.99 | 0.062 | 63.00 | 67.12 |
| | 1/3 | 7.47 | 2.00 | 2.92 | - | 58.00 | - | 7.92 | 2.10 | 0.98 | - | 35.00 | - |
| 100 | 2/1 | 7.70 | 1.50 | 1.58 | 0.008 | 27.00 | 30.67 | 7.97 | 3.02 | 0.70 | 0.042 | 78.00 | 56.01 |
| | 2/2 | 7.95 | 2.00 | 1.50 | 0.009 | 30.00 | 38.01 | 8.02 | 3.10 | 0.55 | 0.039 | 84.00 | 54.77 |
| | 2/3 | 8.20 | 1.80 | 1.58 | - | 23.00 | - | 8.02 | 2.12 | 0.44 | - | 50.00 | - |
| 200 | 3/1 | 8.07 | 2.90 | 2.21 | 0.024 | 39.00 | 61.16 | 8.10 | 2.43 | 0.11 | 0.024 | 67.00 | 34.56 |
| | 3/2 | 7.86 | 2.61 | 3.64 | 0.037 | 77.00 | 69.92 | 8.15 | 2.11 | 0.11 | 0.022 | 61.00 | 35.06 |
| | 3/3 | 7.92 | 3.10 | 3.16 | - | 78.00 | - | 8.12 | 2.32 | 0.04 | - | 59.00 | - |
| 300 | 4/1 | 8.15 | 2.40 | 2.37 | 0.035 | 56.00 | 47.95 | 8.04 | 2.58 | 0.04 | 0.025 | 92.00 | 46.40 |
| | 4/2 | 8.15 | 2.22 | 2.29 | 0.021 | 109.00 | 47.16 | 7.99 | 2.81 | 0.22 | 0.029 | 79.00 | 48.96 |
| | 4/3 | 7.97 | 2.81 | 3.00 | - | 93.00 | - | 8.05 | 2.91 | 0.98 | - | 84.00 | - |
| 400 | 5/1 | 8.08 | 3.40 | 3.08 | 0.052 | 103.00 | 63.22 | 8.05 | 2.80 | 0.85 | 0.019 | 77.00 | 32.49 |
| | 5/2 | 8.12 | 3.30 | 3.00 | 0.044 | 70.00 | 80.96 | 8.01 | 3.01 | 0.18 | 0.024 | 77.00 | 42.02 |
| | 5/3 | 7.95 | 3.49 | 3.40 | - | 65.00 | - | 8.15 | 2.21 | 0.07 | - | 110.00 | - |
| 500 | 6/1 | 7.92 | 2.49 | 3.40 | 0.033 | 77.00 | 53.92 | 8.08 | 2.51 | 0.05 | 0.022 | 101.00 | 36.79 |
| | 6/2 | 8.04 | 2.50 | 3.16 | 0.027 | 73.00 | 53.74 | 8.17 | 2.71 | 1.25 | 0.018 | 56.00 | 42.47 |
| | 6/3 | 8.13 | 2.40 | 3.00 | - | 57.00 | - | 8.08 | 2.80 | 1.11 | - | 82.00 | - |
| 600 | 7/1 | 7.89 | 4.15 | 3.56 | 0.036 | 70.00 | 80.17 | 7.96 | 2.51 | 0.15 | 0.032 | 88.00 | 35.95 |
| | 7/2 | 8.05 | 2.50 | 3.40 | 0.025 | 26.33 | 54.73 | 8.07 | 2.92 | 0.30 | 0.030 | 89.00 | 42.31 |
| | 7/3 | 7.99 | 2.49 | 3.24 | - | 40.00 | - | 8.25 | 2.39 | 0.85 | - | 66.00 | - |
| 700 | 8/1 | | | | | | | 8.02 | 2.35 | 0.04 | 0.025 | 72.00 | 28.95 |
| | 8/2 | | | | | | | 8.14 | 2.28 | 0.85 | 0.026 | 59.00 | 31.85 |
| | 8/3 | | | | | | | 8.16 | 3.28 | 0.11 | - | 56.00 | - |
| 800 | 9/1 | | | | | | | 8.20 | 2.32 | 0.26 | 0.020 | 64.00 | 30.70 |
| | 9/2 | | | | | | | 8.03 | 2.35 | 0.85 | 0.020 | 73.00 | 31.80 |
| | 9/3 | | | | | | | 7.98 | 2.79 | 0.79 | - | 79.00 | - |
| 900 | 10/1 | | | | | | | 8.10 | 2.36 | 0.66 | 0.016 | 76.00 | 29.51 |
| | 10/2 | | | | | | | 8.14 | 2.49 | 0.72 | 0.017 | 65.00 | 36.70 |
| | 10/3 | | | | | | | 8.15 | 2.65 | 0.98 | - | 79.00 | - |

## Table C-6. Chemical quality in summer and rainy of Sa Lut (Line D)

| Distance (m) | Station | Chemical quality | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | summer | | | | | | rainy | | | | | |
| | | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) |
| 0 | 1/1 | 6.18 | 3.68 | 4.66 | 0.045 | 8.33 | 153.90 | 7.58 | 3.38 | 2.33 | 0.063 | 76.00 | 93.19 |
| | 1/2 | 6.97 | 3.80 | 4.35 | 0.038 | 16.33 | 120.70 | 7.19 | 2.52 | 1.70 | 0.051 | 59.00 | 78.72 |
| | 1/3 | 6.48 | 4.00 | 4.58 | - | 18.67 | - | 7.38 | 3.03 | 0.92 | - | 69.00 | - |
| 100 | 2/1 | 7.67 | 3.80 | 3.56 | 0.031 | 33.33 | 91.22 | 7.61 | 2.62 | 0.15 | 0.028 | 72.00 | 49.57 |
| | 2/2 | 7.57 | 3.70 | 3.95 | 0.032 | 33.67 | 93.13 | 7.48 | 3.32 | 1.25 | 0.027 | 81.00 | 59.90 |
| | 2/3 | 7.46 | 2.70 | 3.95 | - | 38.33 | - | 7.66 | 3.21 | 1.51 | - | 79.00 | - |
| 200 | 3/1 | 7.79 | 3.35 | 3.71 | 0.031 | 40.00 | 84.65 | 8.02 | 2.69 | 1.44 | 0.023 | 78.00 | 41.50 |
| | 3/2 | 7.72 | 3.50 | 3.56 | 0.034 | 19.80 | 85.08 | 7.89 | 2.78 | 1.25 | 0.027 | 86.00 | 50.62 |
| | 3/3 | 7.71 | 2.89 | 3.71 | - | 11.67 | - | 7.91 | 2.72 | 0.92 | - | 86.00 | - |
| 300 | 4/1 | 8.02 | 2.58 | 3.48 | 0.026 | 12.33 | 72.06 | 7.90 | 3.01 | 1.05 | 0.037 | 101.00 | 51.16 |
| | 4/2 | 7.88 | 1.96 | 3.32 | 0.026 | 14.00 | 76.87 | 7.82 | 2.84 | 1.25 | 0.037 | 89.00 | 46.36 |
| | 4/3 | 7.84 | 1.91 | 3.40 | - | 20.67 | - | 7.86 | 2.95 | 1.05 | - | 101.00 | - |
| 400 | 5/1 | 8.04 | 3.18 | 3.40 | 0.030 | 15.00 | 37.74 | 8.12 | 3.10 | 1.11 | 0.032 | 83.00 | 41.28 |
| | 5/2 | 8.01 | 2.60 | 3.71 | 0.028 | 19.67 | 40.58 | 8.04 | 2.99 | 4.52 | 0.034 | 74.00 | 40.62 |
| | 5/3 | 8.01 | 3.11 | 3.32 | - | 25.33 | - | 7.98 | 3.36 | 0.98 | - | 87.00 | - |
| 500 | 6/1 | 7.94 | 3.51 | 3.56 | 0.032 | 24.00 | 38.82 | 8.15 | 3.17 | 1.11 | 0.039 | 70.00 | 90.26 |
| | 6/2 | 7.89 | 2.79 | 3.40 | 0.031 | 13.33 | 32.63 | 8.11 | 3.64 | 1.38 | 0.039 | 71.00 | 50.96 |
| | 6/3 | 7.87 | 3.00 | 3.48 | - | 25.67 | - | 8.01 | 3.20 | 1.11 | - | 76.00 | - |
| 600 | 7/1 | 8.19 | 3.20 | 3.56 | 0.030 | 30.67 | 34.23 | 8.19 | 2.61 | 1.05 | 0.026 | 66.00 | 30.11 |
| | 7/2 | 8.08 | 2.41 | 3.64 | 0.029 | 28.00 | 29.61 | 7.98 | 3.19 | 1.90 | 0.049 | 62.00 | 52.58 |
| | 7/3 | 8.11 | 3.18 | 3.64 | - | 37.33 | - | 8.18 | 4.20 | 1.38 | - | 62.00 | - |
| 700 | 8/1 | | | | | | | 8.26 | 3.50 | 1.25 | 0.031 | 89.00 | 74.36 |
| | 8/2 | | | | | | | 8.20 | 2.82 | 1.11 | 0.031 | 66.00 | 66.81 |
| | 8/3 | | | | | | | 8.26 | 3.19 | 1.31 | - | 51.00 | - |
| 800 | 9/1 | | | | | | | 8.20 | 2.85 | 0.98 | 0.026 | 55.00 | 60.17 |
| | 9/2 | | | | | | | 8.27 | 2.61 | 1.05 | 0.025 | 50.00 | 66.01 |
| | 9/3 | | | | | | | 8.10 | 2.80 | 1.25 | - | 63.00 | - |
| 900 | 10/1 | | | | | | | 8.10 | 2.78 | 1.44 | 0.019 | 36.00 | 58.66 |

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| Distance (m) | Station | Chemical quality | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | summer | | | | | | rainy | | | | | |
| | | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) | pH | EC (dS/m) | OM (%) | N (%) | P (ppm) | K (ppm) |
| | 10/2 | | | | | | | 8.04 | 2.49 | 1.25 | 0.018 | 65.00 | 48.11 |
| | 10/3 | | | | | | | 8.03 | 2.75 | 0.92 | - | 59.00 | - |
| 1,000 | 11/1 | | | | | | | 8.11 | 2.79 | 0.79 | 0.021 | 52.00 | 56.96 |
| | 11/2 | | | | | | | 8.15 | 2.51 | 0.92 | 0.018 | 51.00 | 52.19 |
| | 11/3 | | | | | | | 8.04 | 3.00 | 0.98 | - | 56.00 | - |
| 1,070 | 12/1 | | | | | | | 8.01 | 2.79 | 1.05 | 0.020 | 66.00 | 58.41 |
| | 12/2 | | | | | | | 8.02 | 2.78 | 0.92 | 0.024 | 59.00 | 53.12 |
| | 12/3 | | | | | | | 8.23 | 2.93 | 0.66 | - | 52.00 | - |
| 1,380 | 13/1 | | | | | | | 7.96 | 2.92 | 1.25 | 0.031 | 34.00 | 68.50 |
| | 13/2 | | | | | | | 8.01 | 3.32 | 1.64 | 0.035 | 46.00 | 82.69 |
| | 13/3 | | | | | | | 8.08 | 2.83 | 0.85 | - | 50.00 | - |
| 1,460 | 14/1 | | | | | | | 8.07 | 2.99 | 1.18 | 0.157 | 38.00 | 73.53 |
| | 14/2 | | | | | | | 7.99 | 2.72 | 1.05 | 0.030 | 46.00 | 55.31 |
| | 14/3 | | | | | | | 7.94 | 2.55 | 0.85 | - | 45.00 | - |

**Table C-7. Hydrogen sulfide in summer and rainy**

| Community | station | $H_2S$ (ppm) : summer | | | | $H_2S$ (ppm) : rainy | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Line A | Line B | Line C | Line D | Line A | Line B | Line C | Line D |
| 1. rim of mangrove | 1/1 | 0 | 0 | 0 | 0 | 0 | 14.89 | 21.24 | 8.00 |
| | 1/2 | 6.21 | 0 | 0 | 0 | 0 | 42.28 | 17.19 | 9.88 |
| | 1/3 | 6.86 | 2.33 | 0 | 0 | 0 | 29.33 | 34.78 | 29.55 |
| 2. *Halodule pinifolia* | 2/1 | 0 | 1.02 | 0 | 0 | 0 | 21.97 | 35.52 | 58.44 |
| | 2/2 | 0 | 0 | 0 | 0 | 4.49 | 0 | 22.04 | 29.23 |
| | 2/3 | 0 | 0.03 | 0 | 0 | 0 | 40.79 | 0.73 | 22.95 |
| 3. *Enhalus acoroides* | 3/1 | 0 | | 0 | 0 | 6.92 | | 108.33 | 58.85 |
| | 3/2 | 0 | - | 0 | 0 | 17.28 | - | 31.97 | 44.16 |
| | 3/3 | 0 | | 0.34 | 0 | 5.84 | | 34.05 | 14.39 |
| 4. estuary of river | 4/1 | 0 | 0.48 | 0 | 0 | 9.04 | 17.06 | 11.84 | 47.17 |
| | 4/2 | 0 | 0.21 | 0 | 0 | 24.50 | 9.47 | 13.13 | 22.01 |
| | 4/3 | 0 | 0.21 | 0 | 0 | 54.10 | 14.93 | 5.89 | 3.18 |

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**3. Station point: UTM (Coordinate system), Zone 47P**

**Ta Tar (Line A)**

**Table C-8 Station point in summer and rainy of Ta Tar canal (line A)**

| Distance (m) | Station | Summer point | | rainy point | |
|---|---|---|---|---|---|
| | | E | N | E | N |
| 0 | A1 | 0814376 | 1394715 | 0814386 | 1394690 |
| 100 | A2 | 0814365 | 1394629 | 0814367 | 1394592 |
| 200 | A3 | 0814349 | 1394521 | 0814349 | 1394492 |
| 300 | A4 | 0814334 | 1394421 | 0814330 | 1394389 |
| 400 | A5 | 0814319 | 1394322 | 0814311 | 1394289 |
| 500 | A6 | 0814305 | 1394220 | 0814289 | 1394189 |
| 600 | A7 | 0814291 | 1394118 | 0814271 | 1394089 |
| 700 | A8 | - | - | 0814249 | 1393989 |
| 800 | A9 | - | - | 0814233 | 1393890 |
| 900 | A10 | - | - | 0814213 | 1393783 |

**Ta Uoo (Line B)**

**Table C-9 Station point in summer and rainy of Ta Uoo canal (line B)**

| Distance (m) | Station | Summer point | | rainy point | |
|---|---|---|---|---|---|
| | | E | N | E | N |
| 0 | B1 | 0815971 | 1394086 | 0815937 | 1393979 |
| 100 | B2 | 0815835 | 1394012 | 0815843 | 1393912 |
| 200 | B3 | 0815834 | 1394013 | 0815762 | 1393847 |
| 300 | B4 | 0815695 | 1393860 | 0815679 | 1393786 |
| 400 | B5 | 0815629 | 1393783 | 0815596 | 1393728 |
| 500 | B6 | 0815559 | 1393700 | 0815513 | 1393647 |
| 600 | B7 | 0815491 | 1393629 | 0815462 | 1393587 |
| 700 | B8 | - | - | 0815347 | 1393529 |
| 800 | B9 | - | - | 0815267 | 1393466 |

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**Between Ta Guy and Mor Suk canal (Line C)**

**Table C-10 Station point in summer and rainy of between Ta Guy and Mor Suk (line C)**

| Distance (m) | Station | Summer point | | rainy point | |
|---|---|---|---|---|---|
| | | E | N | E | N |
| 0 | C1 | 0816238 | 1392901 | 0816199 | 1393142 |
| 100 | C2 | 0816152 | 1392870 | 0816101 | 1393114 |
| 200 | C3 | 0816056 | 1392873 | 0815997 | 1393113 |
| 300 | C4 | 0815963 | 1392843 | 0815891 | 1393099 |
| 400 | C5 | 0815858 | 1392839 | 0815789 | 1393088 |
| 500 | C6 | 0815753 | 1392823 | 0815682 | 1393081 |
| 600 | C7 | 0815655 | 1392814 | 0815547 | 1393058 |
| 700 | C8 | - | - | 0815442 | 1393047 |
| 800 | C9 | - | - | 0815335 | 1393038 |
| 900 | C10 | - | - | 0815237 | 1393023 |

**Sa Lut canal (Line D)**

**Table C-11 Station point in summer and rainy of Sa Lut canal (line D)**

| Distance (m) | Station | Summer point | | rainy point | |
|---|---|---|---|---|---|
| | | E | N | E | N |
| 0 | D1 | 0816319 | 1392179 | 0816320 | 1392226 |
| 100 | D2 | 0816225 | 1392236 | 0816227 | 1392274 |
| 200 | D3 | 0816140 | 1392284 | 0816139 | 1392313 |
| 300 | D4 | 0816049 | 1392328 | 0816021 | 1392376 |
| 400 | D5 | 0815947 | 1392361 | 0815927 | 1392421 |
| 500 | D6 | 0815853 | 1392413 | 0815840 | 1392466 |
| 600 | D7 | 0815773 | 1392483 | 0815770 | 1392443 |
| 700 | D8 | - | - | 0815641 | 1392565 |
| 800 | D9 | - | - | 0815549 | 1392610 |
| 900 | D10 | - | - | 0815453 | 1392658 |
| 1000 | D11 | - | - | 0815356 | 1392704 |
| 1070 | D12 | - | - | 0815297 | 1392737 |
| 1380 | D13 | - | - | 0815250 | 1392432 |
| 1460 | D14 | - | - | 0815187 | 1392477 |
| 1850 | D15 | - | - | 0814867 | 1392700 |

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# BIOGRAPHY

| | |
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