TABLE OF CONTENTS

	Page	
Acknowledgements	iii	
Abstract (Thai)	v	
Abstract (English)	vii	
Table of contents	S ix 3	
List of Tables	xii	
List of Figures	xiii	
Abbreviations and Symbols	xx	
Chapter 1 Introduction	1	
1.1 Objectives	3	
Chapter 2 Literature reviews	4	
2.1 Cyanobacteria and their roles in biosphere	4	
2.2 Hypersaline environments	8 111	
2.3 Halophilism and halotolerance	13 13 14 15	
2.4 Cyanobacteria and their adaptation in high salt concentrations	15	
2.5 Diversity of cyanobacteria in hypersaline environments	17	

TABLE OF CONTENTS (continue)

	Page
Chapter 3 Materials and Methods	24
3.1 Sampling	24
3.2 Soil physic-chemical analysis	29
3.3 Evaluation of cyanobacterial morphotypes	31
3.4 Isolation and cultivation procedure	32
3.5 Ecophysiology studies	32
3.5.1 Growth dependence under salinity gradients	32
3.5.2 Crossed gradient experiments	33
3.6 The intensive studies of <i>Oxynema</i>	36
3.6.1 Study of phylogenetic position	37
3.6.2 Ultrastructure studies	40
Chapter 4 Results	42
4.1 Description of studied sites	42
4.2 Soil physico-chemical properties	48
4.3 Evaluation of cyanobacterial morphotypes	61
4.3.1 Taxonomic part	63

TABLE OF CONTENTS (continue)

	Page
4.4 Isolation and cultivation of cyanobacteria	106
4.5 Ecophysiology studies	106
4.5.1 Growth dependence under salinity gradients	106
4.5.2 Crossed gradients experiments	112
4.6 Oxynema genus novum	114
Chapter 5 Discussions	136
Chapter 6 Conclusion	146
References	149
Appendices	170
Curriculum vitae	191

LIST OF TABLES

Table		Page
1	Main ionic compositions in northern and southern arm of the Great	11
	Salt Lake between 1975-1977.	
2	Geographic positions and some characteristic of each area.	26
3	Textures and composition of soil samples from 4 study sites	51
	during February-May and October-December 2009.	
5024	Diversity and abundance of cyanobacterial species from natural	64
	and cultures (from soils) found in Phetchaburi, Samut Songkhram	
	and Sakon Nakhon solar salterns during evaporization periods	
	with different salinities.	
5	Diversity and abundance of other algal species from Natural found	66
	in Phetchaburi, Samut Songkhram and Sakhon Nakon solar	
	salterns during evaporization periods with different salinities.	
6	Main characteristics of cyanobacterial morphotypes found in	108
	cultures.	
7	Morphology of other species in <i>Phormidium</i> group I according to	119
	Komárek and Anagnostidis (2005) and other similar species with	
	Oxynema thaianum.	

	LIST OF FIGURES	
Figur		Page
1	Schematic drawing of a building of typical microbial mat formed	7
	by cyanobacteria.	
2	Schematic diagram shows the procedures of sea salt productions.	13
3	Some compatible solute structures were found in cyanobacteria.	16
302 4	Map of Thailand and showing of 6 studied saltern areas.	27
205 5	The areas of 6 studied locations in different part of Thailand.	28
6	All instruments used in growth dependence under salinity	34
	gradients experiments.	
7	The crossed gradients unit of temperature and light.	35
8	Model of the settle of 42 serological plates on the crossed	36
	gradients unit of temperature and light.	
9	The highest, lowest and average mean temperature of	44
	Phetchaburi areas between the years 2006-2010.	
10	Rain-days of Phetchaburi province between the year 2008-2010.	45
11	Total rainfalls of Phetchaburi province between the year 2008-	45
	2010.	
12	Monthly rainfalls of Phetchaburi province between the year 2008-	46
	2009.	
V/1913	Percent of relative humidity of Phetchaburi province between the	46
	the year 2008-2010.	

Figure		Page
14	Some species of plants and bird found surrounding the study areas	47
	of Phetchaburi solar salterns.	
15	The natural characteristics of cyanobacteria presented at Petchaburi	50
	and Samut Songkhram areas.	
16	Moisture content values of soil samples of 14 sampling sites from	51
	4 studied areas during February-May (PPA, SSA, CPA and SNA)	
	and October-December (PPB and SSB) 2009.	
17	The pH values of soil samples of 14 sampling sites from 4 studied	52
	areas during February-May (PPA, SSA, CPA and SNA) and	
	October-December (PPB and SSB) 2009.	
18	Salinity level of soil samples of 14 sampling sites from 4 studied	53
	areas during February-May (PPA, SSA, CPA and SNA) and	
	October-December (PPB and SSB) 2009.	
19	The electrical conductivity (EC) of 14 sampling sites from 4 studied	54
	areas during February-May (PPA, SSA, CPA and SNA) and	
	October-December (PPB and SSB) 2009.	
20	The organic matters (OM) values of 14 sampling sites from 4	54
	studied areas during February-May (PPA, SSA, CPA and SNA)	
	and October-December (PPB and SSB) 2009.	
21	Ammonium nitrogen (NH4 ⁺ -N) values of 14 sampling sites from 4	55
	studied areas during February-May (PPA, SSA, CPA and SNA)	
	and October-December (PPB and SSB) 2009.	
22	Nitrate nitrogen (NO3 ⁻ -N) values of 14 sampling sites from 4	55
	studied areas during February-May (PPA, SSA, CPA and SNA)	
	and October-December (PPB and SSB) 2009.	

Figure	e o 9104	Page
23	Phosphorus values (P) of 14 sampling sites from 4 studied areas	57
	during February-May (PPA, SSA, CPA and SNA) and October-	
	December (PPB and SSB) 2009.	
24	Potassium values (K) of 14 sampling sites from 4 studied areas	57
	during February-May (PPA, SSA, CPA and SNA) and October-	
	December (PPB and SSB) 2009.	
25	Sulfur values (S) of 14 sampling sites from 4 studied areas	58
	during February-May (PPA, SSA, CPA and SNA) and October-	
	December (PPB and SSB) 2009.	
26	Manganese values (Mn) of 14 sampling sites from 4 studied areas	58
	during February-May (PPA, SSA, CPA and SNA) and October-	
	December (PPB and SSB) 2009.	
27	Irons (Fe) values of 14 sampling sites from 4 studied areas during	59
	February-May (PPA, SSA, CPA and SNA) and October- December	
	(PPB and SSB) 2009.	
28	Sodium ion (Na ⁺) values of 14 sampling sites from 4 studied areas	59
	during February-May (PPA, SSA, CPA and SNA) and October-	
	December (PPB and SSB) 2009.	
29	Calcium ion (Ca ²⁺) values of 14 sampling sites from 4 studied areas	60
	during February-May (PPA, SSA, CPA and SNA) and October-	
30	Magnesium ion (Mg ²⁺) values of 14 sampling sites from 4 studied	60
	areas during February-May (PPA, SSA, CPA and SNA) and	
	October- December (PPB and SSB) 2009.	

Figure		Page
31	Chloride ion (Cl ⁻) values of 14 sampling sites from 4 studied areas	61
	during February-May (PPA, SSA, CPA and SNA) and	
	October- December (PPB and SSB) 2009.	
32	Light microscopy photographs of cyanobacteria found in this study:	84
	Aphanocapsa salina, Aphanothece halophytica, Cyanosarcina sp1	
	Chroococcus spp., Cyanobium sp.and Pseudocapsa sp.	
23	Light microscopy photographs of cyanobacteria found in this study:	85
	Coleofasciculus chthonoplastes	
34	Light microscopy photographs of cyanobacteria found in this study:	86
	Geitlerinema lacus-solaris, Geitlerinema, and Halomicronema sp.	
35	Light microscopy photographs of cyanobacteria found in this study:	87
	Gloeocapsa sp., Halothece spp. and Leptolyngbya sp.1	
36	Light microscopy photographs of cyanobacteria found in this study:	88
	Johannesbaptistia pellucida.	
37	Light microscopy photographs of cyanobacteria found in this study:	89
	Komvophoron cf. skujae	
38	Light microscopy photographs of cyanobacteria found in this study:	90
	Leptolyngbya spp.and komvophoron sp.	
39	Light microscopy photographs of cyanobacteria found in this study:	91
	Merismopedia sp. and lyngbya spp.	
40	Light microscopy photographs of cyanobacteria found in this study:	92
	Nostoc spp.	
41	Light microscopy photographs of cyanobacteria found in this study:	93
	Oxynema thaianum.	

Figure		Page
42	Light microscopy photographs of cyanobacteria found in this study:	94
	Psudanabaena sp. and Spirulina subsalsa	
43	Light microscopy photographs of cyanobacteria found in this study:	95
	Xenococcus schousboei, Tricocoleus sp. and Tyconema sp.	
44	Light microscopy photographs of cyanobacteria found in this study:	96
	Wollea sp.	
45	Illustration of coccoid cyanobacteria found in this study:	97
	Aphanocapsa salina., Aphanothece halophytica., Chroococcus spp.,	
	Pseudocapsa sp.and Cyanosarcina spp.	
46	Illustration of coccoid cyanobacteria found in this study:	98
	Halothece spp., Cyanobium sp., Gloeocapsa sp. and Merismopedia sp.	
47	Illustration of coccoid cyanobacteria found in this study:	99
	Xenococcus schousboei and Johannesbaptistia pellucida.	
48	Illustration of filamentous cyanobacteria found in this study:	101
	Geitlerinema spp., Coleofasciculus chthonoplastes and	
	Halomicronema sp.	
49	Illustration of filamentous cyanobacteria found in this study:	100
	Komvophoron spp., Pseudanabaena sp.and Leptolyngbya sp.1	
50	Illustration of filamentous cyanobacteria found in this study:	102
	Lyngbya spp. and Leptolyngbya spp.	
51	Illustration of filamentous cyanobacteria found in this study:	103
	Oxynema thaianum.	
52	Illustration of filamentous cyanobacteria found in this study:	104
	Tricocoleus sp., Spirulina subsalsa and Tyconema sp.	
	LIST OF FIGURES (continue)	

Figure		Page
53	Illustration of heterocytous cyanobacteria found in this study	105
	Wollea sp. and Nostoc spp.	
54	The growth of <i>Leptolyngbya</i> sp.1 strain isolated from this study,	109
	cultured in various concentrations of salt.	
55	The growth of <i>Nostoc</i> sp.1 strain isolated from this study, cultured	109
	in various concentrations of salt.	
56	The growth of Wollea sp. strain isolated from this study, cultured	110
	in various concentration of salt.	
57	The growth of Oxynema thaianum strain isolated from this study,	110
	cultured in various concentrations of salt.	
58	The growth of <i>Nostoc</i> sp.2 strain isolated from this study, cultured	111
	in various concentration of salt.	
59	Morphological changing of some selected strains growing under	113
	gradients of salt concentrations (Nostoc sp.1 and Wollea sp.).	
60	Morphological changing of some selected strains growing under	114
	gradients of salt concentrations (Nostoc sp.2).	
61	Growth rates of <i>Nostoc</i> sp.1 strain in crossed gradients of temperature and light.	115
62	Growth rates of <i>Nostoc</i> sp.2 strain in crossed gradients of	116
	Temperature and light.	
63	Illustration of other species in <i>Phormidium</i> group I and	124
	others similar species with Oxynema thaianum (I).	
64	Illustration of other species in <i>Phormidium</i> group I and	125
	others similar species with Oxynema thaianum (II).	
	LIST OF FIGURES (continue)	

Figure		Page
65	Photos from the type specimens of Oxynema lloydianum and	126
	Oxynema acuminatum.	
66	Position of the Oxynema thaianum strain CCALA 960 in	131
	phylogenetic tree.	
67	Ultrastructure (SEM) of filaments of Oxynema thaianum	133
	(strain CCALA 960).	
68	Ultrastructure (TEM) of filaments of Oxynema thaianum	134
	(strain CCALA 960).	
69	Transmission electron micrographs of Microcoleus cthonoplastes	135
	(after Hernández-Mariné, 1996).	

ลิ<mark>ปสิทธิ์มหาวิทยาลัยเชียงใหม่</mark> Copyright[©] by Chiang Mai University All rights reserved

ABBREVIATIONS AND SYMBOLS

bp base pair

°C degree celsius

comb. nov. combinatio nova (latin word) = new combination

cf. confer (latin word) = compare

DNA deoxyribonucleic acid

dNTPs deoxynucleotide triphosphate

etc. et cetera (latin word) = and other things

et latin word = and

et al. et alibi (latin word) = and others

ex latin word = from

f. forma (latin word) = form

g gram

g/l gram per litre

g/ml gram per milliliter

gen. nov. genus novum (latin word) = new genus

i.e. id est (latin word) = that is

in (latin word) = in

in vitro latin word = in an artificial environment outside the living

organism

km² square kilometre

M molar

mM millimolar

mm millimetre

m² square metre

mg/l milligram per litre

nm nanometer

OD optical density

PCR Polymerase Chain Reactions

ppm part per million

ppt part per thousand

rpm revolution per minute

RNA ribonucleic acid

rRNA ribosomal ribonucleic acid

SDS sodium dodecyl sulfate

sensu latin word = perception, opinion, thought, sense, view

signification, meaning

spec. nov. or sp. nov. species nova (latin word) = new species

Γm melting temperature

ul microliter

μm micrometer

μmol.m⁻².s⁻¹ micro photon mole

The code of sampling site of each study areas in different periods of investigation.

Site names	Code
Sakon Nakhon Saltern in Sakon Nakhon province	SN
Udon Thani Saltern in Udon Thani province	UT
Phetchaburi Saltern in Phetchaburi province	PP
Chantaburi Saltern in Chantaburi province	CP
Samut Songkhram Saltern in Samut Songkhram province	SS
Natural hypersaline area in Nakhon Ratchasima province	NR
Phetchaburi saltern pond no.1 in evaporation step during February-May 2009	PP ₁ A
Phetchaburi saltern pond no.2 in evaporation step during February-May 2009	PP ₂ A
Phetchaburi saltern pond no.3 in evaporation step during February-May 2009	PP ₃ A
Phetchaburi saltern pond no.4 in evaporation step during February-May 2009	PP ₄ A
Phetchaburi saltern pond no.1 in evaporation step during October- December 2009	PP ₁ B
Phetchaburi saltern pond no.2 in evaporation step during October- December 2009	PP ₂ B
Phetchaburi saltern pond no.3 in evaporation step during October- December 2009	PP ₃ B
Phetchaburi saltern pond no.4 in evaporation step during October- December 2009	PP ₄ B
Samut Songkhram pond no.1 in evaporation step during February-May 2009	SS_1A

The code of sampling site of each study areas in different periods of investigation.

Site names	Code
Samut Songkhram pond no.2 in evaporation step during February-May 2009	SS ₂ A
Samut Songkhram pond no.3 in evaporation step during February-May 2009	SS ₃ A
Samut Songkhram pond no.4 in evaporation step during February-May 2009	SS ₄ A
Samut Songkhram pond no.1 in evaporation step during October-December	SS_1B
2009	
Samut Songkhram pond no.2 in evaporation step during October-December	SS_2E
2009	
Samut Songkhram pond no.3 in evaporation step during October-December	SS_3E
2009	
Samut Songkhram pond no.4 in evaporation step during October-December	SS ₄ I
2009	
Chanthaburi pond no.1 in evaporation step during February-May 2009	CP_1A
Chanthaburi pond no.1 in evaporation step during October-December 2009	CP_1E
Sakon Nakhon pond no.1 in evaporation step during February-May 2009	SN_1A
Sakon Nakhon pond no.1 in evaporation step during October-December	SN_1E
2009	

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved