APPENDIXES

APPENDIX A

RESEARCH DATA

Cell count, distribution of *Pediastrum* and data of each parameter in some freshwater resources of Thailand (Table12)

Table 7 Cell count and distribution of *Pediastrum* at 68 sampling sites

Sites	CHR1	CHM1	CHM2	CHM3	PHY1	PHY2	PHR1	UTD1	SKT1	PSL1	NKS1	NKS2	PHC1	PCB1	PCB2	SRB1	PTT1	SMP1	PNS1
Palter	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangucoro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paran	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paranru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pargen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. asym	0	0	0	0	0	0	0	0	0	0	0	0	0	375	0	0	0	0	0
Pbira	0	0	0	375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250
Pbiema	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125
Pbigla	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250
Pbiwae	0	0	0	375	0	0	0	0	0	0	500	375	0	0	0	0	0	0	0
Pbbory	0	0	0	375	0	0	0	0	0	0	0	0	0	0	375	0	0	0	0
Pbbrev	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbcari	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbcorn	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbfor	0	0	0	125	0	0	0	0	125	0	0	0	125	0	0	0	0	0	0
Pblong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbper	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbpseu	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbrau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pcla	375	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0
Pclara	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0
Pddup	0	1125	250	4250	0	0	375	3125	0	500	0	375	2500	0	0	875	0	0	250
Pdas	375	0	0	0	0	250	0	375	0	0	0	0	250	0	0	0	0	0	0
Pdcla	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcoha	125	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0
Pdcornu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcoro	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdgenu	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0
Pdgracil	0	250	0	1750	0	0	0	16750	0	375	0	0	0	0	0	0	0	0	0
Pdpunc	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	ANT1	SBR1	SPB1	UTT1	UTT2	NPT1	NPT2	LOE1	UDT1	NKI1	NPN1	NPN2	SKN1	MDH1	YST1	RET1	RET2	KLS1	KKN1
Palter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangucoro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paran	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0
Paranru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pargen	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. asym	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbira	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbiema	0	0	0	0	0	0	0	250	0	0	0	125	0	0	0	0	0	0	0
Pbigla	0	125	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0
Pbiwae	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	750	375	0
Pbbory	0	0	0	0	0	0	0	0	0	0	0	875	0	0	0	0	0	0	0
Pbbrev	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbcari	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbcorn	125	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbfor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pblong	0	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0
Pbper	0	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0
Pbpseu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbrau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	0
Pcla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pclara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pddup	1500	375	375	750	0	375	0	0	0	0	0	0	0	0	0	0	0	1125	0
Pdas	0	0	500	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcoha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcornu	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcoro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdgenu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdgracil	0	0	0	0	625	0	0	0	0	0	250	0	0	0	0	0	0	0	0
Pdpunc	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	KKN2	NRS1	NRS2	SUR1	SUR2	SSK1	SSK2	UBR1	CCS1	CBR1	RYN1	RYN2	CTB1	SKO1	TAK1	KCN1	KCN2	KCN3	RBR1
Palter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangucoro	125	0	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0
Paran	0	0	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0
Paranru	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0
Pargen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. asym	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbira	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbiema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbigla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbiwae	0	0	500	0	0	0	0	0	0	0	375	0	0	0	0	375	250	0	0
Pbbory	0	0	500	0	0	0	0	0	0	0	500	0	0	0	0	0	0	0	0
Pbbrev	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbcari	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0
Pbcorn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbfor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pblong	0	0	375	0	0	0	0	0	0	0	375	0	0	0	0	0	0	0	0
Pbper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbpseu	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pbrau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pcla	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0
Pclara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pddup	0	0	0	1625	625	500	0	1375	875	0	0	2125	625	0	500	0	0	0	0
Pdas	0	0	0	250	0	0	0	0	250	0	375	500	0	0	0	0	250	0	0
Pdcla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcoha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcornu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdcoro	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0
Pdgenu	0	0	0	0	0	0	0	0	0	0	0	0	375	0	0	0	0	0	0
Pdgracil	0	0	0	375	0	0	0	375	250	0	0	0	375	0	0	0	0	0	0
Pdpunc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	CHP1	SRT1	SRT2	SRT3	NST1	NST2	NST3	PTL1	SKA1	STN1
Palter	0	0	0	0	0	0	0	0	0	0
Pangu	0	0	0	0	0	125	0	0	125	0
Pangucoro	0	0	0	0	0	0	0	0	0	0
Paran	0	0	0	0	0	0	0	250	0	0
Paranru	0	0	0	0	0	0	0	0	0	0
Pargen	0	0	0	0	0	0	0	0	0	0
P. asym	0	0	0	0	0	0	0	0	0	0
Pbira	0	0	0	0	0	0	0	250	375	0
Pbiema	0	0	0	0	0	0	0	0	0	0
Pbigla	0	0	0	0	0	0	0	250	375	0
Pbiwae	0	0	0	0	0	0	0	0	0	0
Pbbory	0	375	0	0	0	0	0	0	0	0
Pbbrev	0	0	0	0	0	0	0	0	0	0
Pbcari	0	0	0	0	0	0	0	0	0	0
Pbcorn	250	125	0	0	0	0	0	0	0	0
Pbfor	0	0	0	0	0	0	0	0	0	0
Pblong	0	0	0	0	0	0	0	0	0	0
Pbper	0	0	0	0	0	0	0	0	0	0
Pbpseu	0	0	0	0	0	0	0	0	0	0
Pbrau	0	0	0	0	0	0	0	0	0	375
Pcla	0	0	0	0	0	0	0	0	0	0
Pclara	125	0	0	0	0	0	0	0	0	0
Pddup	0	375	0	0	500	0	0	500	875	375
Pdas	0	0	0	0	250	0	0	375	0	0
Pdcla	250	0	0	0	0	0	0	0	0	0
Pdcoha	0	0	0	0	0	0	0	0	0	0
Pdcornu	0	125	0	0	0	0	0	0	0	125
Pdcoro	0	0	0	0	0	0	0	250	0	0
Pdgenu	0	0	0	0	0	0	0	0	0	0
Pdgracil	0	375	0	0	0	0	0	375	0	0
Pdpunc	0	0	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	CHR1	CHM1	CHM2	CHM3	PHY1	PHY2	PHR1	UTD1	SKT1	PSL1	NKS1	NKS2	PHC1	PCB1	PCB2	SRB1	PTT1	SMP1	PNS1
Pdreti	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0
Pdrotu	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdrugu	0	0	0	1125	0	0	0	17500	0	0	0	0	0	0	0	0	0	0	0
Pemarg	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pkawra	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plong	0	0	0	875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250
Pmuti	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0
Pobtus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Porbi	0	0	0	0	0	125	0	0	125	0	0	0	0	0	0	0	0	0	0
Ppertu	125	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ppri	0	0	0	375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pssim	375	250	0	0	0	375	0	0	750	375	750	1625	0	0	375	250	1750	0	0
Pscla	0	0	0	0	0	0	0	0	125	0	0	0	0	125	0	125	0	0	0
Psduo	0	0	0	125	0	250	0	0	0	0	0	0	0	0	250	0	125	0	0
Psechi	0	0	0	2375	250	0	0	0	0	0	250	0	0	0	250	0	375	0	0
Psgra	0	0	0	125	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0
Pspseu	0	0	0	1250	0	0	0	0	250	0	0	375	0	0	0	0	250	0	0
Psradi	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psstur	0	0	0	1500	0	375	0	0	0	0	250	250	0	375	0	0	0	0	0
Psub	0	0	0	875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptetras	250	375	250	4500	0	0	0	0	0	0	0	0	500	0	0	0	0	0	0
Pteapi	0	0	0	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteex	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptetetra	0	0	0	625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psculp	125	0	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0
Psp1	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psp2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psp3	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	ANT1	SBR1	SPB1	UTT1	UTT2	NPT1	NPT2	LOE1	UDT1	NKI1	NPN1	NPN2	SKN1	MDH1	YST1	RET1	RET2	KLS1	KKN1
Pdreti	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdrotu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdrugu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pemarg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pkawra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plong	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pmuti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pobtus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Porbi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ppertu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ppri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pssim	0	500	625	750	0	375	500	500	0	0	0	0	0	250	500	0	250	1250	0
Pscla	0	0	0	250	0	0	0	250	625	0	0	0	0	0	0	0	0	0	0
Psduo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psechi	0	0	1875	375	0	0	0	250	0	375	0	0	0	0	0	0	500	625	0
Psgra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pspseu	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	375
Psradi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250	0	0	0
Psstur	0	0	0	0	0	0	0	0	0	375	0	0	0	0	0	0	0	0	0
Psub	250	0	0	0	0	0	0	375	0	0	0	0	0	0	0	0	0	0	0
Ptetras	0	0	375	500	375	0	0	500	375	0	0	4750	0	250	0	0	375	375	0
Pteapi	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0
Pteex	0	0	250	375	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptetetra	0	0	0	0	125	0	0	250	0	0	250	0	0	0	0	0	0	0	0
Psculp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250	0	0
Psp2	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	0
Psp3	0	0	0	0	0	0	0	125	0	0	250	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	KKN2	NRS1	NRS2	SUR1	SUR2	SSK1	SSK2	UBR1	CCS1	CBR1	RYN1	RYN2	CTB1	SKO1	TAK1	KCN1	KCN2	KCN3	RBR1
Pdreti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdrotu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pdrugu	0	0	0	250	0	0	0	0	0	0	625	0	625	0	0	0	0	0	0
Pemarg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinper	0	0	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0
Pkawra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plong	0	0	0	0	0	375	0	0	0	0	0	0	0	0	0	0	0	0	0
Pmuti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pobtus	0	0	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0
Porbi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ppertu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ppri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pssim	0	375	2250	0	0	0	500	0	1375	0	0	0	2500	625	0	0	0	0	0
Pscla	0	250	0	0	0	0	0	0	0	0	0	0	375	0	0	250	375	0	750
Psduo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psechi	625	0	0	0	0	0	375	0	375	0	0	0	0	0	0	1000	1500	0	750
Psgra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pspseu	0	0	0	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0
Psradi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psstur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psub	0	0	0	0	0	0	0	0	0	0	500	0	0	0	375	0	0	0	0
Ptetras	500	0	1250	0	500	625	500	250	875	375	375	0	0	0	500	0	0	625	0
Pteapi	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0
Pteex	0	0	0	0	0	0	0	375	0	0	0	0	0	0	0	0	0	0	0
Ptetetra	0	0	0	0	250	375	0	0	0	375	0	0	0	0	375	0	0	0	0
Psculp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psp1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psp2	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0
Psp3	0	0	0	0	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0

Table 7 (continued)

Sites	PBR1	CHP1	SRT1	SRT2	SRT3	NST1	NST2	NST3	PTL1	SKA1	STN1
Pdreti	0	0	0	0	0	0	0	0	0	0	0
Pdrotu	0	0	0	0	0	0	0	0	0	0	0
Pdrugu	0	0	0	0	0	0	0	0	0	0	0
Pemarg	0	0	0	0	0	0	0	0	125	0	0
Pinte	0	0	0	250	0	0	250	0	0	0	0
Pinper	0	0	125	0	0	0	0	0	0	0	0
Pkawra	0	0	0	0	0	0	0	0	0	250	0
Plong	0	0	0	0	0	0	0	0	0	0	0
Pmuti	0	0	0	0	0	0	125	0	0	0	0
Pobtus	0	0	250	0	0	0	0	0	0	0	0
Porbi	0	0	0	0	0	0	0	0	0	0	0
Ppertu	0	0	0	0	0	0	0	0	0	0	0
Ppri	0	0	0	0	0	0	0	0	0	0	0
Pssim	0	0	0	11250	625	0	0	500	0	0	0
Pscla	0	0	0	5625	0	0	0	0	0	0	0
Psduo	0	0	0	0	0	0	0	0	0	0	0
Psechi	1500	0	0	2875	625	375	0	0	0	0	0
Psgra	0	0	0	0	0	0	0	0	0	0	0
Pspseu	0	0	0	2375	0	0	0	375	0	0	0
Psradi	0	0	0	0	0	0	0	0	0	0	0
Psstur	0	0	0	1500	0	0	0	0	0	0	0
Psub	0	0	0	0	0	0	0	0	0	250	0
Ptetras	0	0	625	0	0	375	500	0	1000	625	375
Pteapi	0	0	0	0	0	0	0	0	0	0	0
Pteex	0	0	0	0	0	250	0	0	250	250	0
Ptetetra	0	0	250	0	0	0	0	0	250	0	0
Psculp	0	0	0	0	0	0	0	0	0	0	0
Psp1	0	0	0	0	0	0	0	0	0	0	0
Psp2	0	0	0	250	0	0	0	0	0	0	0
Psp3	0	0	0	0	0	0	0	0	0	0	0

Table 8 Some physical and chemical parameters and water quality of the sampling site

Site Name	W T	A T	secchi	cond	pH	Alk	Turbid	DO	BOD	SRP	NO_3	NH_4	Chlo *a*	PC-score
CHR1	29.5	33.5	36	253.5	7.49	119	50	6.7	6.4	0.10	0.70	1.38	120.4	Meso-eutrophic
CHM1	33.5	30.0	20	224.0	7.77	117	59	6.3	5.1	0.04	0.90	0.02	48.7	mesotrophic
CHM2	30.5	33.0	40	164.0	9.73	121	61	10.6	9.5	0.03	0.65	0.29	119.4	mesotrophic
CHM3	29.8	34.3	101	230.0	8.04	109	19	5.7	3.0	0.17	1.25	0.65	34.8	Meso-eutrophic
PHY1	30.5	28.5	30	257.5	8.47	139	41	7.7	2.7	0.05	0.45	0.05	44.4	mesotrophic
PHY2	29.0	28.5	29	474.5	7.99	256	94	6.8	6.6	0.25	1.00	3.87	26.6	Meso-eutrophic
PHR1	34.6	35.0	45	411.0	7.63	223	24	9.0	5.0	0.03	0.65	0.06	47.7	mesotrophic
UTD1	31.5	35.0	18	324.0	8.00	166	89	6.0	5.9	0.95	1.20	0.46	637.0	eutophic
SKT1	30.4	29.5	23	317.5	7.82	135	80	7.6	0.3	0.03	0.55	0.07	230.7	mesotrophic
PSL1	34.4	30.5	25	242.5	9.00	74	74	14.0	11.5	0.05	nd	0.22	73.2	Meso-eutrophic
NKS1	34.2	31.5	55	232.0	7.42	107	35	11.3	2.6	0.03	0.05	0.04	59.0	mesotrophic
NKS2	30.6	31.5	40	583.5	7.54	291	29	7.8	2.5	0.05	0.00	0.09	42.1	mesotrophic
PHC1	31.6	30.5	10	484.5	7.66	155	302	6.5	6.4	0.99	0.55	0.17	383.4	Meso-eutrophic
PCB1	32.0	33.0	42	237.5	8.57	99	102	8.2	7.2	0.05	0.40	0.01	30.5	mesotrophic
PCB2	33.3	29.0	70	263.5	8.32	104	107	7.0	0.4	0.01	0.40	0.10	13.8	mesotrophic
SRB1	30.4	30.0	20	202.5	8.00	53	75	6.5	5.7	2.06	0.20	1.08	58.6	Meso-eutrophic
PTT1	30.7	28.2	33	1118.0	7.13	51	44	8.5	6.1	0.02	nd	0.30	15.7	mesotrophic
SMP1	28.9	26.0	35	1195.0	7.28	117	27	8.1	4.3	1.42	0.45	5.22	39.3	hypereutrophic
PNS1	29.7	29.0	50	398.0	7.52	279	196	6.5	nd	0.07	0.20	0.20	22.4	Meso-eutrophic

Table 8 (continued)

Site Name	W T	A T	secchi	cond	pH	Alk	Turbid	DO	BOD	SRP	NO_3	NH_4	Chlo *a*	PC-score
ANT1	29.0	30.0	15	505.0	7.79	242	247	8.8	nd	0.04	0.13	0.29	120.8	Meso-eutrophic
SBR1	30.0	31.8	32	205.5	8.10	248	199	9.5	8.9	0.01	0.20	0.15	104.7	Meso-eutrophic
SPB1	32.6	34.5	45	681.0	8.42	180	36	10.7	7.0	0.11	0.25	0.12	95.2	Meso-eutrophic
UTT1	31.4	28.0	43	400.5	8.36	119	44	9.0	5.8	0.02	0.20	0.44	34.1	mesotrophic
UTT2	30.5	26.8	40	335.5	8.24	122	34	5.5	3.9	0.14	0.55	0.06	31.8	mesotrophic
NPT1	30.4	31.0	25	599.0	8.67	81	57	11.0	7.1	0.09	0.75	0.08	97.0	meso-eutrophic
NPT2	30.9	31.0	45	1010.0	8.71	189	37	11.8	11.2	1.58	0.35	0.24	197.8	eutophic
LOE1	22.8	17.0	49	138.0	8.13	52	35	7.4	4.8	0.46	0.45	0.23	101.2	meso-eutrophic
UDT1	23.2	19.0	32	320.0	8.08	78	113	5.6	4.7	0.02	1.90	0.02	73.3	mesotrophic
NKI1	22.5	25.5	25	190.0	8.12	75	64	8.2	6.5	0.06	0.80	0.27	25.2	mesotrophic
NPN1	20.3	21.0	62	55.0	7.56	13	81	9.1	6.2	0.00	0.10	0.04	17.0	oligo-mesotrophic
NPN2	21.1	21.5	30	115.7	6.73	9	102	6.6	4.9	0.00	0.00	0.01	51.9	oligo-mesotrophic
SKN1	20.8	26.5	23	587.5	8.31	107	130	11.0	0.0	1.46	0.00	5.69	215.6	hypereutrophic
MDH1	20.8	19.0	5	220.0	9.04	73	126	11.2	9.0	0.00	0.01	0.03	42.4	mesotrophic
YST1	20.7	24.0	35	329.0	7.76	90	27	5.1	3.3	0.01	0.00	0.26	9.5	mesotrophic
RET1	23.3	31.0	58	215.5	7.88	36	32	8.9	5.9	0.01	0.00	0.18	6.9	mesotrophic
RET2	24.2	27.5	17	479.5	9.00	107	92	12.2	9.3	0.01	0.00	0.82	138.9	meso-eutrophic
KLS1	24.3	27.0	96	205.5	7.43	76	14	8.2	6.1	0.00	0.00	0.04	2.7	oligo-mesotrophic

Table 8 (continued)

Site Name	W T	A T	secchi	cond	pH	Alk	Turbid	DO	BOD	SRP	NO_3	NH_4	Chlo *a*	PC-score
KKN1	23.7	24.0	32	765.5	8.66	91	80	9.8	8.1	0.05	0.00	0.26	105.8	meso-eutrophic
KKN2	24.3	29.5	40	246.5	8.33	106	70	8.5	6.7	0.04	0.00	0.03	19.5	oligo-mesotrophic
NRS1	30.7	31.5	16	781.0	9.34	254	87	22.0	17.7	0.13	0.60	0.19	200.5	meso-eutrophic
NRS2	29.5	29.0	16	881.0	8.65	269	98	11.9	11.5	0.01	0.50	0.13	293.2	meso-eutrophic
SUR1	31.9	32.0	22	445.0	9.64	136	111	18.5	17.0	3.00	0.05	2.14	16.4	meso-eutrophic
SUR2	32.0	35.5	42	372.5	9.05	127	45	13.5	10.3	0.08	nd	0.06	447.7	meso-eutrophic
SSK1	27.6	24.0	61	102.7	7.21	27	21	5.3	0.8	0.05	nd	0.06	80.8	oligo-mesotrophic
SSK2	28.0	27.0	56	254.0	8.23	91	29	7.2	2.5	0.05	0.00	0.00	37.5	oligo-mesotrophic
UBR1	28.9	26.0	55	287.0	9.56	107	30	10.1	5.9	0.10	nd	0.03	32.1	meso-eutrophic
CCS1	31.1	30.0	32	997.5	7.67	150	72	3.0	0.0	0.01	0.45	0.01	63.8	meso-eutrophic
CBR1	32.7	33.5	12	1142.0	10.29	181	163	21.0	18.7	0.29	0.55	0.03	161.7	meso-eutrophic
RYN1	32.9	32.0	10	1863.5	8.95	140	262	9.0	0.0	0.06	0.60	0.07	212.5	meso-eutrophic
RYN2	31.3	32.0	20	717.5	8.34	96	323	11.5	6.5	0.61	0.30	2.24	72.8	eutophic
CTB1	32.0	31.0	27	319.5	9.58	89	130	9.0	8.6	0.00	0.50	0.01	16.3	mesotrophic
SKO1	30.6	27.0	45	488.0	7.73	25	46	3.9	2.0	0.02	nd	0.05	33.5	mesotrophic
TAK1	32.0	31.8	35	387.5	8.02	126	59	3.6	nd	0.35	0.60	0.99	182.0	eutophic
KCN1	32.7	30.5	48	236.0	8.41	87	15	15.6	13.9	0.05	0.20	0.04	34.1	meso-eutrophic
KCN2	32.5	34.0	120	185.0	8.44	89	7	7.6	4.0	0.03	0.55	0.04	11.6	mesotrophic

Table 8 (continued)

Site Name	W T	A T	secchi	cond	pH	Alk	Turbid	DO	BOD	SRP	NO_3	NH_4	Chlo *a*	PC-score
KCN3	34.2	30.5	45	209.0	8.41	109	37	12.3	9.2	0.08	0.65	0.02	53.2	meso-eutrophic
RBR1	32.6	29.5	35	270.0	8.74	80	16	14.0	7.9	0.09	nd	nd	55.2	meso-eutrophic
PBR1	27.0	32.0	38	541.5	7.31	57	29	3.4	3.2	0.22	0.45	0.14	9.4	meso-eutrophic
CHP1	30.7	33.1	49	231.0	8.26	121	56	8.0	4.0	0.01	0.00	0.04	72.4	mesotrophic
SRT1	33.0	27.0	24	120.2	9.59	58	65	10.0	6.7	0.00	0.00	0.07	131.8	mesotrophic
SRT2	31.4	31.0	24	347.0	7.82	93	116	6.2	5.7	0.02	0.40	0.14	136.1	meso-eutrophic
SRT3	34.5	37.0	110	194.7	5.12	104	99	8.0	1.4	0.04	0.75	0.07	6.7	mesotrophic
NST1	32.5	30.5	32	85.4	5.66	37	52	5.6	0.7	0.16	0.50	0.15	32.9	mesotrophic
NST2	32.5	33.0	40	30.8	6.30	19	32	8.0	0.7	0.02	0.60	0.03	22.2	oligo-mesotrophic
NST3	33.7	35.0	60	324.5	5.94	150	30	7.0	5.7	0.03	0.70	0.10	15.1	mesotrophic
PTL1	31.0	30.0	15	163.3	6.70	52	128	10.7	10.4	0.14	0.50	0.18	184.3	meso-eutrophic
SKA1	30.5	30.0	72	62.9	5.55	34	36	8.0	6.6	0.03	0.00	0.08	15.1	oligo-mesotrophic
STN1	31.5	26.0	190	122.5	6.04	21	44	7.7	0.4	0.03	0.00	0.00	13.9	oligo-mesotrophic

APPENDIX B

WATER QUALITY ASSESSMENT

Classification of water quality

Classification of trophic state by using water characteristic and dominant phytoplankton according to the criteria of Lorraine and Vollenweider (1981), Wetzel (2001) (Tables 9-11), and Peerapornpisal *et al*. (2007).

Table 9 Assessment of water quality by considering amount of total phosphorus, total nitrogen, chlorophyll a and Secchi depth (Lorraine and Vollenweider, 1981)

Variable (Annual Mean Values)		**Oligotrophic**	**Mesotrophic**	**Eutrophic**	**Hypereutrophic**
Total phosphorus	Mean	8.0	26.7	84.4	
mg.m^{-3}	x + 1 s.d.	4.85 – 13.3	14.5 – 49	38 – 189	
	x + 2 s.d.	2.9 – 22.1	7.9 – 90.8	16.8 – 424	
	Range	3.0 – 17.7	10.9 – 95.6	16.2 – 386	750 – 1200
	n	21	19 (21)	71 (72)	2
Total nitrogen	Mean	661	753	1875	
mg.m^{-3}	x + 1 s.d.	371 – 1180	485 – 1170	861 – 4081	
	x + 2 s.d.	208 – 2103	313 – 1816	395 – 8913	
	Range	307 – 1630	361 – 1387	393 – 6100	100 – 150
	n	11	8	37 (38)	2
Chlorophyll *a*	Mean	4.2	16.1	42.6	
mg.m^{-3}	x + 1 s.d.	2.6 – 7.6	8.9 – 29	16.9 – 107	
	x + 2 s.d.	1.5 – 13	4.9.– 52.5	6.7 – 270	
	Range	1.3 – 10.6	4.9 – 19.5	9.5 – 275	
	n				
Secchi Depth	mean	9.9	4.2	2.45	
m	x + 1 s.d.	5.9 – 16.5	2.7 – 7.4	1.5 – 4.0	
	x + 2 s.d.	3.6 – 27.5	14 – 13	0.9 – 6.7	
	Range	5.4 – 28.3	1.5 – 8.1	0.8 – 7.0	0.4-0.5
	n	13	20	70	(72) 2

Table 10 Classification of trophic state by using water characteristic and dominant phytoplankton (Wetzel, 2001)

General Lake Trophy	Water Characteristics	Dominant Algae	Other Commonly Occurring Algae
Oligotrophic	Slightly acidic; very salnity	Desmids *Staurodesmus*, *Staurastrum*	*Sphaerocystis*, *Gloeocystis*, *Rhizosolenia*, *Tabellaria*
Oligotrophic	Neutral to slightly alkaline; Nutrient-poor lakes	Diatoms, especially, *Cymbella* and *Tabellaria*	Some *Asterionella* spp., some *Melosira* spp., *Dinobryon*
Oligotrophic	Neutral to slight alkaline; nutrient-poor lakes or more productive lakes at seasons of nutrient reduction	Chrysophycean algae, especially *Dinobryon*. Some *Mallomonas*	Other Chrysophyceans, e.g. *Synura*, *Uroglena*: diatom *Tabellaria*
Oligotrophic	Neutral to slight alkaline; nutrient-poor lakes	Chlorococcal *Oocystis* or Chrysophycean *Botryococcus*	Oligotrophic diatoms
Oligotrophic	Neutral to slight alkaline; generally nutrient poor; common in shallow Arctic lakes	Dinoflagellates, especially some *Peridinium* and *Ceratium* spp.	Small chrysophytes cryptophytes, and diatoms
Mesotrophic or Eutrophic	Neutral to slightly alkaline; annual dominants or in eutrophic lakes at certain seasons	Dinoflagellates, some *Peridinium* and *Ceratium* spp.	*Glenodinium* and many other algae
Eutrophic	Usually alkaline lakes with nutrient enrichment	Diatoms much of year, especially *Asterionella* spp., *Fragilaria crotonensis*, *Synedra*, *Ctephanodiscus*, and *Melosira granulata*	Many other algae, especially green and blue-greens during warmer periods of year; desmids of dissolved organic matter is fairly high
Eutrophic	Usually alkaline; nutrient enriched; common in warmer periods of temperature lakes or perennially in enriched tropical lakes	Blue-green algae, especially *Anacystis* (=*Microcystis*), *Aphanizomenon*, *Anabaena*	Other blue-green; euglenophytes if organically enriched or polluted

Table 11 Surface water quality standards of Thailand

Parameter	Units	Statistics	Standard Value for Class[1)] Class1	Class2	Class3	Class4	Class5	Methods for Examination
1. Colour,Odour and Taste	–	–	n	n’	n’	n’	–	–
2. Temperature	C°	–	n	n’	n’	n’	–	Thermometer
3. pH	–	–	n	5-9	5-9	5-9	–	Electrometric pH Meter
4. Dissolved Oxygen (DO)[2/]	mg/l	P20	n	6.0	4.0	2.0	–	Azide Modification
5. BOD (5 days, 20°C)	mg/l	P80	n	1.5	2.0	4.0	–	Azide Modification at 20°C , 5 days
6. Total Coliform Bacteria	MPN/100 ml	P80	n	5,000	20,000	–	–	Multiple Tube Fermentation Technique
7. Fecal Coliform Bateria	MPN/100 ml	P80	n	1,000	4,000	–	–	Multiple Tube Fermentation Technique
8. NO_3 -N	mg/l	–	n		5.0		–	Cadmium Reduction
9. NH_3 -N	mg/l	–	n		0.5		–	Distillation Nesslerization
10.Phenols	mg/l	–	n		0.005		–	Distillation,4-Amino antipyrene
11.Copper (Cu)	mg/l	–	n		0.1		–	Atomic Absorption -Direct Aspiration
12.Nickle (Ni)	mg/l	–	n		0.1		–	Atomic Absorption -Direct Aspiration
13.Manganese (Mn)	mg/l	–	n		1.0		–	Atomic Absorption -Direct Aspiration
14.Zinc (Zn)	mg/l	–	n		1.0		–	Atomic Absorption -Direct Aspiration
15.Cadmium (Cd)	mg/l	–	n		0.005* 0.05**		–	Atomic Absorption -Direct Aspiration
16.Chromium Hexavalent	mg/l	–	n		0.05		–	Atomic Absorption -Direct Aspiration
17.Lead (Pb)	mg/l	–	n		0.05		–	Atomic Absorption -Direct Aspiration
18.Total Mercury (Total Hg)	mg/l	–	n		0.002		–	Atomic Absorption-Cold Vapour Technique
19.Arsenic (As)	mg/l	–	n		0.01		–	Atomic Absorption -Direct Aspiration
20.Cyanide (Cyanide)	mg/l	–	n		0.005		–	Pyridine-Barbituric Acid
21.Radioactivity - Alpha - Beta	Becquerel/l	–	n		0.1 1.0		–	Gas-Chromatography
22.Total Organochlorine Pesticides	mg/l	–	n		0.05		–	Gas-Chromatography
23.DDT	µg/l	–	n		1.0		–	Gas-Chromatography
24.Alpha-BHC	µg/l	–	n		0.02		–	Gas-Chromatography
25.Dieldrin	µg/l	–	n		0.1		–	Gas-Chromatography
26.Aldrin	µg/l	–	n		0.1		–	Gas-Chromatography
27.Heptachlor & Heptachlorepoxide	µg/l	–	n		0.2		–	Gas-Chromatography
28.Endrin	µg/l	–	n		None		–	Gas-Chromatography

Classification and Objective	
Classification	Objectives/Condition and Beneficial Usage
Class 1	Extra clean fresh surface water resources used for : (1) conservation not necessary pass through water treatment process require only ordinar process for pathogenic destruction (2) ecosystem conservation where basic organisms can breed naturally
Class 2	Very clean fresh surface water resources used for : (1) consumption which requires ordinary water treatment process before use (2) aquatic organism of conservation (3) fisheries (4) recreation
Class 3	Medium clean fresh surface water resources used for : (1) consumption, but passing through an ordinary treatment process before using (2) agriculture
Class 4	Fairly clean fresh surface water resources used for : (1) consumption, but requires special water treatment process before using (2) industry
Class 5	The sources which are not classification in class 1-4 and used for navigation.

Remark: 1) DO value is minimum value

P = Percentile value

n = naturally

n' = naturally but changing not more than 3° C

* = when water hardness not more than 100 mg/l as $CaCO_3$

** = when water hardness more than 100 mg/l as $CaCO_3$

Based on Standard Methods for the Examination of Water and Wastewater recommended by APHA : American Public Health Association, AWWA : American Water Works Association and WPCF : Water Pollution Control Federation

Source: Notification of the National Environmental Board, No. 8, B.E. 2537 (1994), issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992) , published in the Royal Government Gazette, Vol. 111, Part 16, dated February 24, B.E.2537 (1994).

APPENDIX C

The Evaluation Water Quality by AARL-PC score

The trophic status of water was evaluated from the main parameters (conductivity, DO, BOD, ammonia nitrogen, nitrate nitrogen and soluble reactive phosphorus) by the Applied Algal Research Laboratory - Physical and Chemical Score (AARL PC Score) (Tables 10) according to Lorraine and Vollenweider (1981), Wetzel (1983), Peerapornpisal *et al*. (2004) and Pollution control Department (2010). The calculation of trophic status AARL PC score are showed in Table 12 which the summary of the score in 7 parameters (Table 12) are used in classification

Table 12 Water quality scores followed physical and chemical parameters

Dissolved Oxygen (DO)

dissolved oxygen (mg.l^{-1})	score
> 9	0.1
8-9	0.2
7-8	0.3
6-7	0.4
5-6	0.5
4-5	0.6
3-4	0.7
2-3	0.8
1-2	0.9
<1 and >9 in the afternoon sampling	1.0

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (mg.l^{-1})	score
< 0.3	0.1
0.3-0.8	0.2
0.8-1.5	0.3
1.5-3	0.4
3-5	0.5
5-8	0.6
8-15	0.7
15-30	0.8
30-50	0.9
> 50	1.0

Conductivity

conductivity (μS.cm^{-1})	score
< 10	0.1
10-30	0.2
30-50	0.3
50-70	0.4
70-90	0.5
90-120	0.6
120-180	0.7
180-250	0.8
250-500	0.9
> 500	1.0

Nitrate Nitrogen

nitrate nitrogen (mg.l^{-1})	score
< 0.05	0.1
0.05-0.1	0.2
0.1-0.3	0.3
0.3-0.8	0.4
0.8-1.5	0.5
1.5-3.0	0.6
3.0-10.0	0.7
10.0-20.0	0.8
20.0-40.0	0.9
> 40.0	1.0

Ammonia Nitrogen

ammonia nitrogen (mg.l^{-1})	score
< 0.01	0.1
0.01-0.03	0.2
0.03-0.06	0.3
0.06-0.10	0.4
0.10-0.20	0.5
0.20-0.40	0.6
0.40-0.60	0.7
0.60-1.0	0.8
1.0-5.0	0.9
> 5.0	1.0

Soluble Reactive Phosphorus

soluble reactive phosphorus ($mg.l^{-1}$)	score
< 0.01	0.1
0.01-0.04	0.2
0.04-0.08	0.3
0.08-0.15	0.4
0.15-0.25	0.5
0.25-0.35	0.6
0.35-0.50	0.7
0.50-1.25	0.8
1.25-2.5	0.9
> 2.5	1.0

Chlorophyll *a*

chlorophyll *a* ($\mu g.l^{-1}$)	score
< 0.5	0.1
0.5-1.0	0.2
1.0-2.0	0.3
2.0-5.0	0.4
5.0-25.0	0.5
25.0-50.0	0.6
50.0-100.0	0.7
100.0-250.0	0.8
250.0-500.0	0.9
> 500.0	1.0

Table 13 Water quality scores followed trophic level and general water quality

7 parameters

score	water quality by trophic level	general water quality
< 1.2	ultraoligotrophic status	very clean
1.2-2.0	oligotrophic status	clean
2.1-2.9	oligotrophic-mesotrophic status	clean-moderate
3.0-3.8	mesotrophic status	moderate
3.9-4.7	mesotrophic-eutrophic status	moderate-polluted
4.8-5.6	eutrophic status	polluted
>5.6	hypereutrophic status	very polluted

6 parameters

score	water quality by trophic level	general water quality
< 0.1	ultraoligotrophic status	very clean
0.1-1.2	oligotrophic status	clean
1.3-2.4	oligotrophic-mesotrophic status	clean-moderate
2.5-3.6	mesotrophic status	moderate
3.7-4.8	mesotrophic-eutrophic status	moderate-polluted
4.9-6.0	eutrophic status	polluted
> 6.0	hypereutrophic status	very polluted

5 parameters

score	water quality by trophic level	general water quality
< 0.1	ultraoligotrophic status	very clean
0.1-1.0	oligotrophic status	clean
1.1-2.0	oligotrophic-mesotrophic status	clean-moderate
2.1-3.0	mesotrophic status	moderate
3.1-4.0	mesotrophic-eutrophic status	moderate-polluted
4.1-5.0	eutrophic status	polluted
> 5.0	hypereutrophic status	very polluted

To calculate the AARL PC score, the summary of scores in each parameter (Table 9) was compared with the standard water quality score in (Table10). The example is shown in Table11.

Table 14 Calculation the trophic status from AARL PC score

parameters	level	AARL PC score
DO ($mg.l^{-1}$)	6.8	0.4
BOD ($mg.l^{-1}$)	0.4	0.2
conductivity ($\mu S.cm^{-1}$)	91	0.6
NO_3-N ($mg.l^{-1}$)	0.25	0.3
NH_3-N ($mg.l^{-1}$)	0.48	0.7
SRP ($mg.l^{-1}$)	0.19	0.5
Chlorophyll *a* ($\mu g.l^{-1}$)	7.8	0.5
Total score		3.2
Trophic status		mesotrophic status

APPENDIX D

CULTURE MEDIA

Jaworski' s Medium (JM) (Thompson *et al*., 1988)

Preparation of 9 chemical stock solution about:

1. $Ca(NO_3).4H_2O$	2.000 g
2. KH_2PO_4	1.240 g
3. $MgSO_4.7H_2O$	5.000 g
4. $NaHCO_3$	0.225 g
5. EDTA FeNa	0.225 g
EDTA Na_2	0.225 g
6. H_3BO_3	0.248 g
$MnCl_2.4H_2O$	0.139 g
$(NH_4)_6Mo_7O_{24}.4H_2O$	0.100 g
7. Cyanocobalamin (Vitamin B12)	0.004 g
Thiamine HCL (Vitamin B1)	0.004 g
Biotin	0.004 g
8. $NaNO_3$	8.000 g
9. $Na_2HPO_4.12H_2O$	3.600 g

Each chemical dissolved in 100 ml distillate water, then, 1 ml of each solution was pipette to volumetric flask and adjust to 1 Liter. Finally, adjustment of pH to 7-8.

Bold' s Basal Medium (Modified) (Stein, 1973)

This medium is highly enriched and is used for many of the green algae. Reference: Stein, J. (ED.) Handbook of Phycological methods. Culture methods and growth measurements. Cambridge University Press. 448 pp.

STOCK	STOCK SOLUTION	ml/Liter
1. KH2PO4	8.75 g/500 ml	10 ml
2. CaCl2.2H2O	1.25 g/500 ml	10 ml
3. MgSO4.7H2O	3.75 g/500 ml	10 ml
4. NaNO3	12.5 g/500 ml	10 ml
5. K2HPO4	3.75 g/500 ml	10 ml
6. NaCl	1.25 g/500 ml	10 ml
7. Na2EDTA. 2H2O	10 g/L	1 ml
KOH	6.2 g/L	
8. FeSO4.7H2O	4.98 g/L	1 ml
H2SO4 (concentrated)	1 ml/L	
9. Trace Metal Solution	See below	1 ml
10. H3BO3	5.75 g/500 ml	0.7 ml

Adjust the pH to 6.8. OPTIONS: For 10% BBM, use 100 ml of 100% BBM/Liter of distilled water. The addition of 5 ml of soil extract is also beneficial to some algae.

Trace Metal Solution:

Substance	g/Liter
1. H_3BO_3	2.86 g
2. $MnC_{l2}.4H_2O$	1.81 g
3. $ZnSO_4.7H_2O$	0.222 g
4. $Na_2MoO_4.2H_2O$	0.390 g
5. $CuSO_4.5H_2O$	0.079 g
6. $Co(NO_3)_2.6H_2O$	0.0494 g

Dissolve each of the above substances separately prior to adding the next on the list.

Algal medium (Stein, 1973)

Compositions:

1. $NaNO_3$	1.000 g
2. KH_4Cl	50 mg
3. $CaCl_2$	58 mg
4. $MgSO_4$	0.513 g
5. K_2HPO_4	0.250 g
6. $FeCl_3$	3 mg

Dissolve each of the above substances in 1 Liter distilled water.

APPENDIX E

PUBLICATION

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Diversity of *Pediastrum* spp. in Some Water Resources of Thailand

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Abstract

Pediastrum spp., the most beautiful phytoplankton, are green algae belonging to Division Chlorophyta, Class Chlorophyceae, Order Chlorococcales, Family Hydrodictyaceae. Their dominant characteristics are coenobia disc shape or stellate, flat and single layer cell, chloroplast parietal with single pyrenoid. There have been few previous studies on *Pediastrum* spp. in Thailand. This research aims to study the diversity of *Pediastrum* spp. in some water resources of Thailand. Species identification was carried out based on cell morphological characteristics including The number and shape of the cells in coenobium, perforations between the cells and length of the processes on the peripheral cells and cell wall ultrastructure which are recognizable under light microscope and scanning electron microscope. Twelve taxa from a total of 42 taxa of *Pediastrum* (from 20 sites) are new records of Thailand. Three species namely *Pediastrum simplex* Meyen, *Pediastrum duplex* Meyen and *Pediastrum tetras* (Ehrenberg) Ralfs were found in all water samples which were meso-eutrophic water quality.

Background

Pediastrum spp. are green algae in the freshwater habitats, for example, permanent or semi-permanent lakes, pools, ponds and ditches [1]. The published scientific data from brackish and salty water are limited [2].

They have been found in many water bodies of trophic status, especially in meso-eutrophic and eutrophic waters with high nutrient content, especially nitrogen and phosphorus [3, 1]. The major taxonomic characteristics for identification to the species of *Pediastrum* are (1) number and shape of the cells in coenobium, (2) perforations between the cells, (3) length of the processes on the peripheral cells [1].

The number of *Pediastrum* species worldwide is recorded at about 406 species. A checklist of the algae in Thailand has been recorded at about 40 species [4] which is very few when compared with the checklist around the world. This research aims at studying the diversity of *Pediastrum* spp. in some water resources of Thailand.

Materials and Methods

Sampling sites

1. The specimens were collected from 20 sites as in lakes, reservoirs, ponds, ditches and pools located throughout Thailand.
2. The limnological data such as latitude, longitude and utilization of sampling site such as forest, agricultural and community of each sampling site were recorded.

Water sampling procedure

Water samples were collected using polyethylene bottles which were kept in a cool box (5-7°C). Physico-chemical analysis was done according to altitude, ordination, temperature, light intensity, transparency, turbidity, conductivity, pH, alkalinity, dissolved oxygen (DO), chlorophyll *a,* and nutrient content, especially nitrate nitrogen, ammonium nitrogen and soluble reactive phosphorus (SRP) [5].

Investigation of Pediastrum spp.

Pediastrum spp. were collected by filtering 10 liters of water with a 10 μm pore size plankton net. The samples were preserved with Lugol's solution and the fresh samples were kept in a cool box for isolation and cultivation [6].

Pediastrum spp. identification and counting

The *Pediastrum* spp. were observed under 40 and 100X light microscope and then photographed using an Olympus Normaski microscope and scanning electron microscope (SEM). The samples were first rinsed with distilled water, laid on cover glasses and air dried at 30-40 ◦C and then affixed to aluminium stubs with carbon tape. Finally, the stubs were coated with gold and photographed by SEM [7]. The samples were identified according as previously described [3,7-10].

Pediastrum spp. were counted under light microscope.

Results and Discussion

Twelve taxa from a total of 42 taxa of *Pediastrum* (from 20 sites) which were new a record of Thailand [Fig.1,:(A)-(L)]. All taxa were documented using light microscope based on cell morphology and cell wall ultrastructure for identification to the species of *Pediastrum,* which were (1) number and shape of the cells in coenobium, (2) perforations between the cells and (3) length of the processes on the peripheral cells [1]. However, visibility was not possible through light microscope it was clearly necessary to use a scanning electron microscope to study details of the cell wall which are important components for identification. So, all the taxa were documented using scanning electron microscope for identification to species of *Pediastrum* [Fig.2,:(A)-(L)].

Three species, namely *Pediastrum simplex* Meyen, *Pediastrum duplex* Meyen and *Pediastrum tetras* (Ehrenberg) Ralfs were identified using light microscope [Fig. 3:(A)-(C)] and were documented using SEM [Fig. 4:(A)-(C)]. They were found in all samples with meso-eutrophic water quality and they have a tendency to be used for assessment of meso-eutrophic water.

Pediastrum spp. were found in difference trophic status such as oligo-mesotrophic, mesotrophic, meso-eutrophic and eutrophic water due to different activities along the reservoir. Distribution of the most abundant *Pediastrum* spp. were in meso-eutrophic which was slightly alkaline (pH 8.0). Conductivity value was 350 $\mu S.cm^{-1}$, DO and BOD values were 8.7 $mg.L^{-1}$ and 5.8 $mg.L^{-1}$ respectively. Concentration of nitrate nitrogen, ammonium nitrogen and soluble reactive phosphorus were 0.39 $mg.L^{-1}$, 0.28 $mg.L^{-1}$ and 0.24 $mg.L^{-1}$ respectively.

New species recorded in Thailand are described as follows:

Pediastrum alternans Nygaard

Coenobia are circular in outline without perforations or with very small, irregular hole at the outer side of the inner cell (deep incisions of the outer cell). Coenobia are composed of 8-32 cells. Cells are irregularly polygonal within the coenobium. Marginal cells have U-like incision on the outer side. Cell wall ultrastructure is fine wavy or net-like sculpture. Diameter of Coenobia is 70-130 µm, cells 12-22 µm wide, 15-28 µm long [Fig.1,2:(A)]. They are found in mesotrophic water.

Pediastrum asymmetricum Hegewald

Coenobia are circular in outline with large perforations in young stages and smaller in old stages. Coenobia are usually composed of 8 or 16 celled. Marginal cells are elongated and paired creating opening between cells. Eight-celled have one inner cell and 7 marginal cells, so one marginal cell is not paired but all cells keep their asymmetric form. Cell wall ultrastructure is densely regularly granular. Marginal cells are 5-11 µm wide, 15-20 µm long. cells 4-8 µm wide, 8-14 µm long [Fig.1,2:(B)]. They are found in meso-eutrophic water.

Pediastrum biradiatum var. grabrum Raciborski

Coenobia are circular in outline with perforations which are usually smaller than the cell diameter. They are composed of 8-32 cells, inner cells are X- shaped, marginal cells with concave sides. The middle is divided into two secondary conical lobes each. Diameter of Coenobia is 50-82 µm, marginal cells are 8-24 µm wide, 11-30 µm long. Inner cells are 8-21 µm wide, 10-26 µm long [Fig.1,2:(C)]. They are found in mesotrophic and meso-eutrophic water.

Pediastrum biwae Negoro

Coenobia are always with perforations. The diameter of perforations is larger than the diameter of the cell. Lobes of marginal cells are narrow and the two neighbouring always arcuate one to another. Cell wall ultrastructure is smooth or slightly punctuate. Diameter of Coenobia is 60-130 µm, cells 7-20 µm wide, 10-35 µm long [Fig.1,2:(D)]. They are found in oligo-mesotrophic water.

Pediastrum boryanum var. longicone Reinsch

Coenobia are usually irregular in outline without perforations or with very few small perforations. Coenobia are composed of 4-64 cells. Marginal cells have V- shaped incision and deep. Process is long or sometimes slightly curved at the end and sometimes slightly widened. Cell wall ultrastructure is scarcely and distinctly granular. Diameter of Coenobia is 80-248 µm, cells 2-10 µm wide, 4-15 µm long They are found in mesotrophic water.

Pediastrum boryanum var. perforatum (Raciborski) Nitardy

Coenobia are circular in outline without perforations or small perforations. They are composed of 4-32 cells. Incisions are wide and V-shaped. Process is long. Cell wall ultrastructure is very distinctly granular. Diameter of Coenobia is 100-120 µm, cells 8-21 µm wide, 8-26 µm long [Fig.1,2:(F)]. They are found in meso-eutrophic water.

Pediastrum boryanum var. pseudoglabrum Parra

Coenobia are circular in outline without perforations. They are composed of 4-32 cells. Marginal cells have V- shaped incision. Cell wall ultrastructure is very finely granular. Diameter of Coenobia is 20-96 µm, marginal cells 8-11 µm wide, 8-14 µm long [Fig.1.2:(G)]. They are found in mesotrophic water.

Pediastrum duplex var. asperum A. Braun

Coenobia are circular in outline. Perforations in coenobia are always smaller than the cell diameter. Coenobia are composed of 16-64 cells. Cell wall ultrastructure is irregularly net-like sculpture. Diameter of Coenobia is 90 µm, cells 8-18 µm wide, 8-19 µm long. They are found in eutrophic water. [Fig.1,2:(H)].

Pediastrum duplex var. coronatrum Raciborski

Coenobia are circular in the outline with a small lens – shaped perforations in front and another at the back. Marginal cells are usually longer than wide and in lateral contact along one-third of the length. Processes of marginal cells ending are short spines. Coenobia are composed of 16-32-64 cells. Cell wall ultrastructure varies from net-like to warty. Diameter of coenobia is 120-214µm, marginal cells 21-25 µm wide, 25-25 µm long [Fig.1,2:(I)]. They are found in meso-eutrophic water.

Pediastrum simplex var. pseudoglabrum Parra

Coenobia are circular in the outline with perforations. Diameter of the perforations is usually larger than the cell diameter. Cell wall ultrastructure is smooth. Diameter of Coenobia is 80 µm, marginal cells 10-17 µm wide, 11-20 µm long [Fig.1,2:(J)]. They are found in mesotrophic water.

Pediastrum subgranulatum Raciborski

Coenobia are circular in outline which are composed of 8-16-64 cells with regularly disposed perforations (perforations are always of smaller diameter than the cell diameter). Marginal cells have two long prominent radial conical lobes usually longer than the cell body. Cell wall ultrastructure varies from irregularly, densely and distinctly granular. Diameter of Coenobia is 120 µm, marginal cells 5.5-28.5 µm wide, 5-25 µm long, inner cells 4-20 µm wide, 5-25 µm long [Fig.1,2:(K)]. They are found in meso-eutrophic water quality.

Pediastrum tetras var. aqiculatum Fritsch

Coenobia are circular or rectangular in outline and composed of 4-32 cells. Coenobia are lack of perforations. Marginal cells have narrow incisions and are trapezoidal in shape. Marginal cell are divided into two lobes and less deeply concave, each lobe truncated. Cell wall ultrastructure varies from irregularly net-like to warty. Diameter of coenobia is 80 µm, cells 6-18 µm wide, 8-19 µm long [Fig.1,2:(L)]. They are found in mesotrophic and meso-eutrophic water.

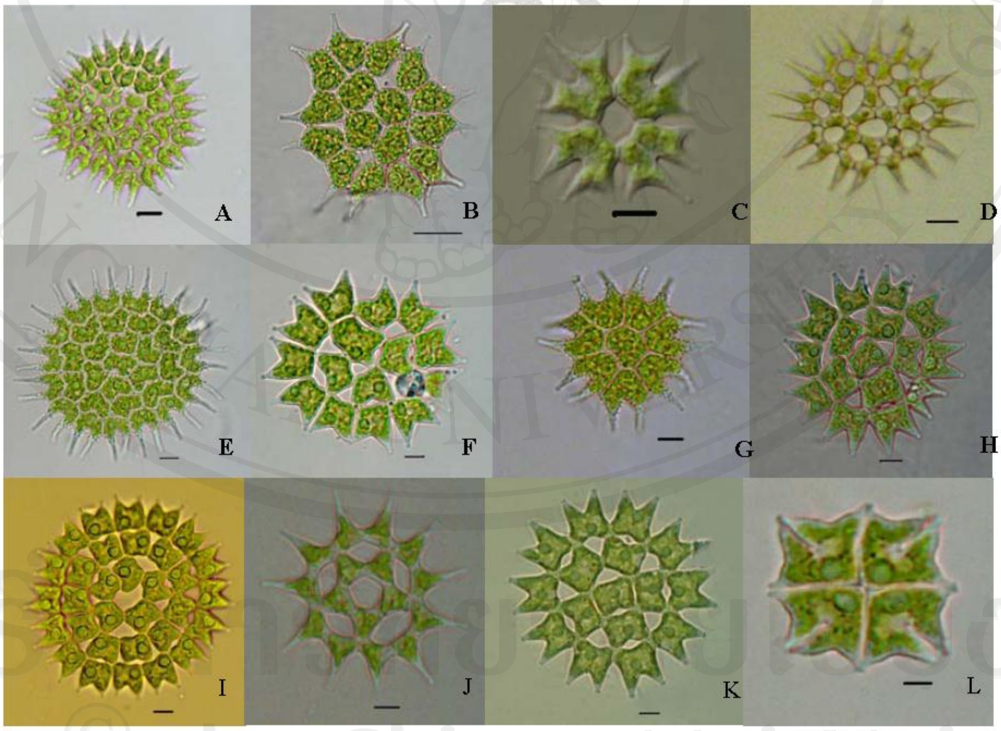

Figure 1 Light micrographs of *Pediastrum* spp. new record of Thailand A. *Pediastrum alternans* Nygaard, B. *Pediastrum asymmetricum* Hegewald and C. *Pediastrum biradiatum var. grabrum* Raciborski D. *Pediastrum biwae* Negoro E. *Pediastrum boryanum* var. *longicone* Reinsch, F. *Pediastrum boryanum* var. *perforatum* (Raciborski) Nitardy, G. *Pediastrum boryanum* var. *pseudoglabrum* Parra, H. *Pediastrum duplex* var. *asperum* A. Braun, I. *Pediastrum duplex* var. *coronatrum* Raciborski, J. *Pediastrum simplex* var. *pseudoglabrum* Parra, K. *Pediastrum subgranulatum* Raciborski and L. Pediastrum tetras var. *aqiculatum* Fritsch (scale bar = 10 µm)

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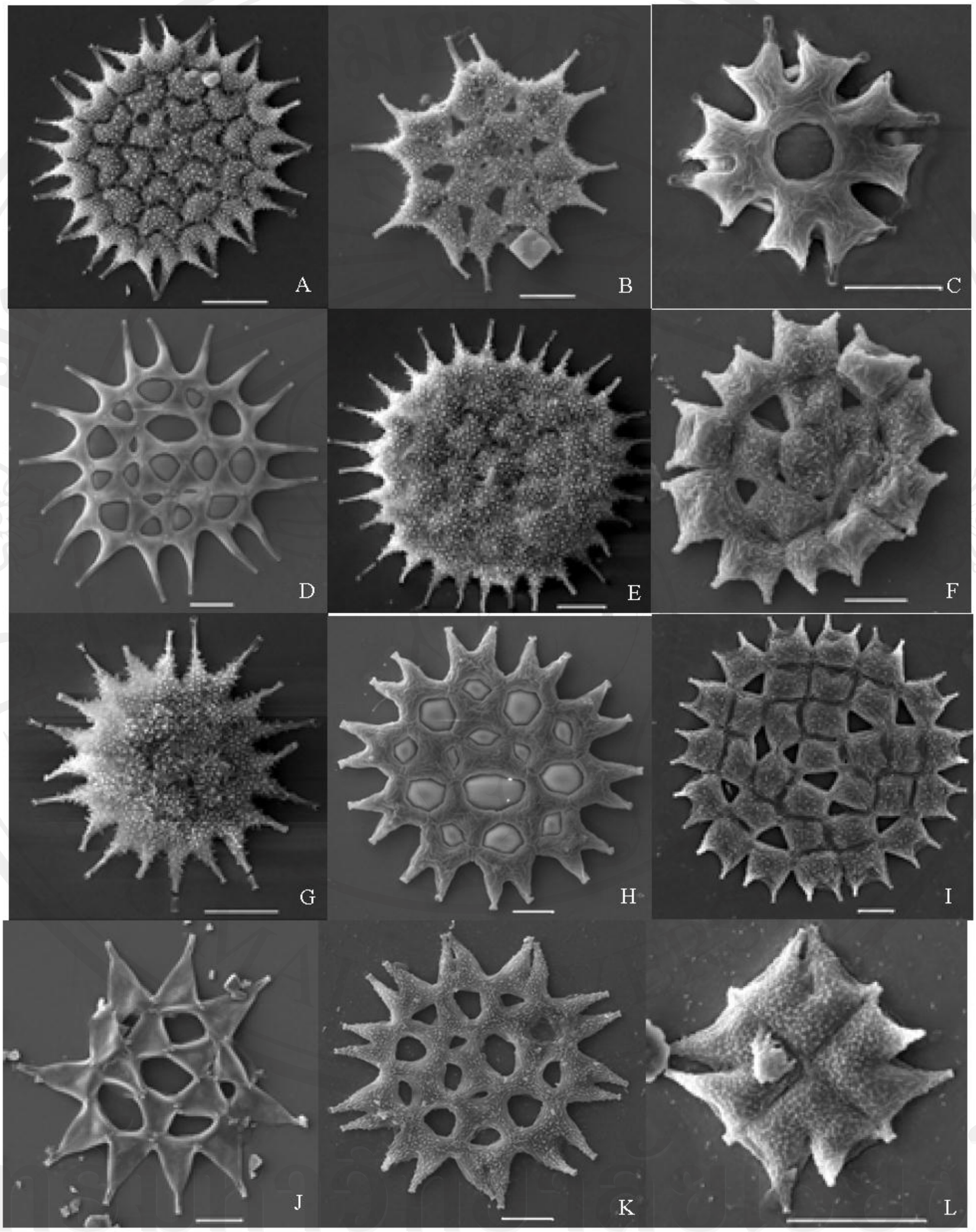

Figure 2 Scanning electron microscope of *Pediastrum* spp. new record of Thailand A. *Pediastrum alternans* Nygaard, B. *Pediastrum asymmetricum* Hegewald and C. *Pediastrum biradiatum var. grabrum* Raciborski
D. *Pediastrum biwae* Negoro E. *Pediastrum boryanum* var. *longicone* Reinsch,
F. *Pediastrum boryanum* var. *perforatum* (Raciborski) Nitardy, G. *Pediastrum boryanum* var. *pseudoglabrum* Parra, H. *Pediastrum duplex* var. *asperum* A. Braun, I. *Pediastrum duplex* var. *coronatrum* Raciborski,
J. *Pediastrum simplex* var. *pseudoglabrum* Parra, K. *Pediastrum subgranulatum* Raciborski and
L. *Pediastrum tetras* var. *aqiculatum* Fritsch (scale bar = 10 µm)

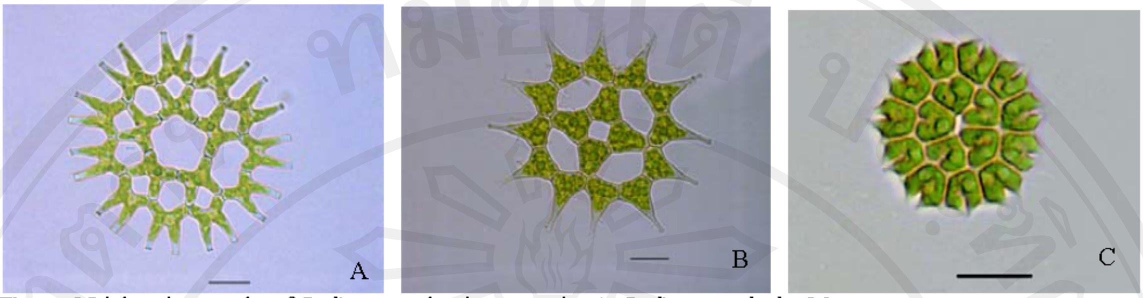

Figure 3 Light micrographs of *Pediastrum* dominant species A. *Pediastrum duplex* Meyen, B. *Pediastrum simplex* Meyen and C. *Pediastrum tetras* (Ehrenberg) Ralfs (scale bar = 10 µm)

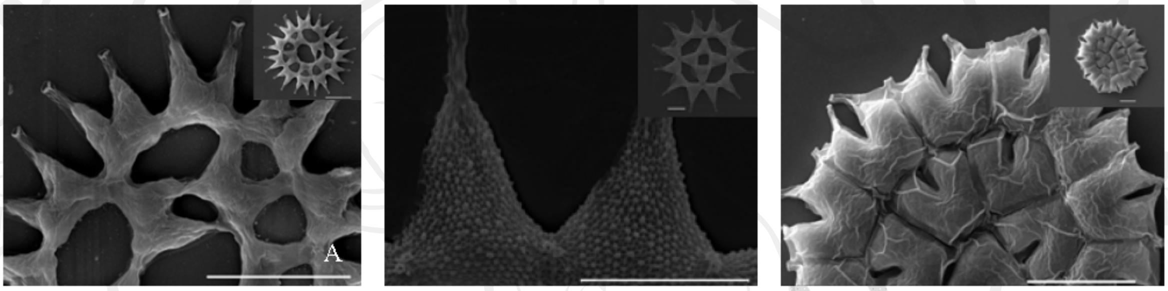

Figure 4 Scanning electron micrographs of *Pediastrum* dominant species. A. *Pediastrum duplex* Meyen, B. *Pediastrum simplex* Meyen and C. *Pediastrum tetras* (Ehrenberg) Ralfs (scale bar = 10 µm)

Conclusion

Light microscope and SEM are very important for *Pediastrum* spp. identification. SEM, with high magnification can indicate fine details of the cells which are very useful for identification to species. In this study, 42 taxa of *Pediastrum* from 20 sites were found and 12 taxa were new records of Thailand. Three species, namely *Pediastrum simplex* Meyen, *Pediastrum duplex* Meyen and *Pediastrum tetras* (Ehrenberg) Ralfs were found in all samples which were in meso-eutrophic water and tended to assess the meso-eutrophic status of water quality.

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Field of Specialization

- Assessment of water quality by using phytoplankton as biological indicators
- Biodiversity of fresh water algae in lentic ecosystems
- Water quality monitoring
- Cultivation of Freshwater algae

Publications:

Tippawan Prasertsin and Yuwadee Peerapornpisal. 2012. Diversity of *Pediastrum* spp. in some water resources of Thailand. Journal of the Microscopy Society of Thailand. 5(1-2):33-37.

Prasertsin, T., Pekkoh, J., Pathom- aree, W. and Y. Peerapornpisal. 2012. Diversity, new and rare taxa of *Pediastrum* spp. in some freshwater resources in Thailand. Chiang Mai Journal of Science (in press).

Abstract:

Prasertsin, T., Akihiro T. and Y. Peerapornpisal. 2013. Diversity of *Pediastrum* spp. and indication of water quality in some water resources of Thailand. The 6th National Conference on Algae and Plankton, 28-30 March 2013, Chiang Mai Province, Thailand. p.103.

Prasertsin, T. and Y. Peerapornpisal. 2012. Diversity of *Pediastrum* spp. in some water resources of Thailand. The 29th Microscopy Society of Thailand Annual Conference, 30 January - 1 February 2012, Cha-am Province, Thailand. p.78.

Prasertsin, T. and Y. Peerapornpisal. 2011. Diversity of *Pediastrum* spp. and water quality in various water resources of Chiang Mai province. The 5th National Conference on Algae and Plankton, 16-18 March 2011, Songkhla Province, Thailand. p. 69.

Award:

The first prize in oral presentation: Excellent

Entitle: Diversity of *Pediastrum* spp. and indication of water quality in some water resources of Thailand

Session: Biodiversity of phytoplankton and water quality

Conference: The 6th National Conference on Algae and Plankton

28-30 March, 2013, Empress International Convention Centre at the Empress Hotel, Chiang Mai, Thailand