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Monitoring on water quality and algae diversity of Kwan Phayao, Phayao Province, Thailand

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The study on water quality from 9 sites around Kwan Phayao, Phayao province, Thailand was conducted during October 2007 – September 2008. The water quality is based on the measurements of physical, chemical and biological parameters. The aims of the study was assessed the water quality and algae diversity of Kwan Phayao. The physical parameters: suspended solid (SS), water depth, water temperature, pH, secchi depth and electrical conductivity (EC) recorded at all sampling sites were between 1.60 – 124.50 mg L^{-1}, 0.35 – 4.00 m, 22.8 – 30.5 °C, 6.1 – 10.0, 0.06 – 1.87 m and 76.20 – 579.00 µS cm^{-1}. The chemical parameters: dissolved oxygen (DO) and biological oxygen demand (BOD) recorded at all sampling sites were between 1.00 – 9.36 mg L-1 and 0.06 – 6.00 mg L^{-1}. The nutrient in Kwan Phayao: ammonia nitrogen (NH_3-N), nitrate nitrogen (NO^-_3-N), orthophosphate phosphorus (PO_4-P) and total phosphorus (TP) recorded at all sampling sites were between 0.000 – 0.783 mg L^{-1}, 0.000 – 0.9810 mg L^{-1}, 0.0000 – 0.1707 mg L^{-1} and 0.0000 – 1.6680 mg L^{-1}. The biological parameter; chlorophyll-a recorded at all sampling sites were between 2.02 – 38.17 mg m^{-3}. Result showed that the algal species consisted of 72 species in winter which belonged to 6 divisions as follows: Cyanophyta 19 species, Chlorophyta 28 species, Crysophyta 15 species, Euglenophyta 5 species, Cryptophyta 3 species and Pyrrophyta 2 species. The variations of physical, chemical and biological parameters were significantly different between months ($P<0.05$): water temperature, secchi depth, electrical conductivity, suspended solid, biological oxygen demand , ammonia nitrogen , total phosphorus, chlorophyll-a and number of algae.

Key words: Water quality; Algae; Kwan Phayao, Thailand

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Introduction

Kwan Phayao is a surface water resource (a lake) in Phayao Province, Thailand. It is the third largest fresh water resource with an area of 20.5 km^2. Water from 11 canals drain into this lake. It maintains an average depth of 1.93 m in the pan basin, and the soaked water area called the Ramsar site which is a significant residence for water birds (Environmental Research Center, 2005). Kwan Phayao consists of the average water volume of 33.84 million m^3. The global position system (GPS) indicates that the lake is between latitude 19° 8.5′ N to 19° 12′ N and longitude 99° 51′ E to 99° 55′ E. At present, Kwan Phayao is a major water resource and fishing lake of Phayao province. The pollution of the lake mostly caused by run-off of urban and agricultural activities should, therefore, be of great concern. The communities normally use water from this lake as raw water for household consumption, and for agricultural purposes.

Phayao province is located in Northern Thailand between latitudes 18°44' N to 19°44' N and longitudes 99°44' E to 100°40' E. The area of Phayao province is approximately 6,335 km^2. Which is 300 - 1,500 m above sea level. Sixty four percent of the population is in the agricultural sector and the main economical plants are rice, corn (for animal feed), soybean, peanuts, shallots, garlic, ginger, lychee, longan and fisheries. The area comprises of rice fields (1,328 km^2), farm plants (577 km^2) and garden plants (320 km^2). Households industries include: longan processing, aquatic animal food processing; receiving raw material from Sapan Pla Bangkok, Ang-Thong and Suksummerai to produce pickled and fermented fish (1,000 - 1,500 kg day^{-1}); and products made from water hyacinth (Secretary Office, 2004).

The area around Kwan Phayao is utilized in many different ways. The north of Ing Canal flows from Nong Leng Sai, Maechai district, collects the drainage from agriculture, floating basket fish farms, livestock, lychee, longan and watermelon gardens. The eastern region is the municipality that releases wastewater from the community. The west area is used for agriculture, food processing (including pickled fish), local liquor, stone mortar making and orchards (longans and lychees). The southern area is protected as a natural resource conservation area and city development is not allowed in this area.

Kwan Phayao is deteriorated by the growth of the surrounding agricultural land, residential and commercial sectors, with a few or no water quality management strategies is placed to bring about improvement. In order to improve water quality and protect the surrounding ecosystem in the future, the development of a reliable and complete database of water quality in Kwan Phayao are needed.

The purpose of this research is to monitor the water quality and algae diversity of Kwan Phayao, Phayao province, Thailand.

Materials and methods

Study Area: Nine sampling sites (Table 1) were selected according to the possible flow patterns derived from the study of Kwan Phayao.

Table 1. Description of nine sampling sites of Kwan Phayao

Site number	Site Description
1	Khun Dej Bridge; the North of Ing river which flows into Kwan Phayao passing most of the agricultural areas.
2	Behind Phayao hospital.
3	Public park; recreation area in the east of Kwan Phayao.
4	Ban San Wieng Mai; agricultural area and pickled fish factories in the west of Kwan Phayao.
5	Mid-point of Kwan Phayao; the deepest spot.
6	Drainagepipes from municipality flowing into the wastewater treatment pond.
7	Ban San Chang Hin; south of Kwan Phayao passing agricultural area.
8	Ban Rong Hai; Mae Tum and Huay Tub Chang canals joined together before flowing into Kwan Phayao passing Mae Tum community and agricultural area of Huay Tub Chang.
9	Fresh Water Fishery Research Center; with a large amount of water hyacinth and other aquatic plants in some seasons at the water gate.

Water quality analysis: Water samples were monthly taken from 9 sites for 12 months from October 2007 to September 2008. Samples were collected at 30 cm depth from the surface: three bottles of 300 mL for determination of dissolved oxygen, three bottles of 300 mL for determination of biochemical oxygen demand and three bottles of 1000 mL for nutrient analysis, determination of suspended solids, chlorophyll-a and number of algae diversity measurement. At sampling site, pH and water temperature were recorded. Light penetration was determined by a Secchi disc, water depth by a measuring line. The water samples were held in ice boxes and immediately transported to the laboratory for analysis of water quality following common protocols. Water samples were filtered through Whatmann Glass Microfibre Filters (GF-C) for measurement of suspended solids. The analysis of dissolved oxygen and biochemical oxygen demand were determined with Azide modification method (Traichaiyaporn, 2000). Ammonia nitrogen by Direct nesslerization method, nitrate nitrogen by Phenoldisulphonic acid method. The orthophosphate phosphorus was determined by the Stannous chloride method and total phosphorus by Sulfuric acid-nitric acid digestion method followed by Stannous chloride method (Traichaiyaporn, 2000 and APHA, AWWA and WPCF, 1998). Chlorophyll-a was detected by the cold acetone method described in APHA, AWWA and WPCF (1998). Materials collected after the filtration of water samples were crushed with mortar and pestle and washed with 90% acetone. Samples were pooled and centrifuged for 5 minutes at 2000 rpm. Samples were refrigerated at 4 C° for 18 hours and subsequently centrifuged as before. The Chlorophyll-a level was calculated after spectrophometer reading at 664, 647 and 630 nm.

Algal analysis: Water samples from Kwan Phayao were transferred to 500 ml cylinder and fixed with 5 mL of Lugol's iodine solution. The preserved samples were left to stand in the dark for 10 days before concentration by decantation; algal concentrations were collected from bottom layer (20-25 mL). The sediment algae was transferred to 50 mL cylinder. Seven days decantation, 10 ml concentrated algae was collected from bottom layer. Concentrated algae was put in a plastic vial adding 2 drops of Lugol's iodine solution and kept in a dark box prior microscopy observation. The fixed algal species were identification in laboratory using compound microscope and texts (Prescott, 1978, and Wongrat, 1995).

Statistical analysis: The statistic method using analysis of variance (ANOVA) to determine if there is any significant difference of all water quality parameters among sampling sites. The comparisons between sites for testing the differences by Duncan's Multiple Range Test (DMRT) for physical, chemical, biological parameter.

Results

Water quality: Water quality of Kwan Phayao of each month and each site of all sampling sites is shown in Table 2. The average range of suspended solid recorded at all sampling sites were between 1.60 – 124.50 mg L^{-1}. The lowest value of suspended solid was 1.60 mg L^{-1} in January at site 7 of San Chang Hin village, south of Kwan Phayao which passing through the agricultural area; the highest value of suspended solid was 124.50 mg L^{-1} in November at site 5 at the mid-point of Kwan Phayao. The statistical analysis showed that the suspended solid of each site in one year observation at Kwan Phayao were significantly different between the sites ($P<0.05$). The deepest point of water resource recorded at all sampling sites were between 0.35 – 4.00 m. The lowest depth was 0.35 m in June at site 6 and the highest depth was 4.00 m in November at water gate site 9. The minimum value, the maximum value and the mean of the deepest point at each site in one year observation of

Kwan Phayao were significantly different between sites ($P<0.05$). The water temperature recorded at all sampling sites, the average range were 22.8 – 30.5 °C. The water temperature in winter from all sampling sites, the average range were between 22.8 – 26.0 °C, the lowest temperature of the water was 22.8 °C in January at site 1; the highest temperature of the water was 30.5 °C in July at sites 1 and 6. The minimum value, the maximum value and the mean of the water temperature at each site in one year observation of Kwan Phayao were recorded and revealed non-significantly different between sites ($P<0.05$). The average range of the sechi depth recorded at all sampling site were between 0.06 – 1.87 m. The lowest of the secchi depth was 0.06 m in February at site 1; in addition, the highest of the secchi depth was 1.87 m in November at site 4. The minimum value, the maximum value and the mean of the secchi depth of each site in one year observation at Kwan Phayao recorded were significantly different between sites ($P<0.05$).

The pH recorded at all sampling sites, average range were between 6.1 – 10.0. The lowest value of the pH was 6.1 in July at site 1 and the highest value of the pH was 10.0 in September at site 9. The minimum, maximum value and the mean pH at each site in one year observation of Kwan Phayao were significantly different between site ($P<0.05$). The average range of the electrical conductivity recorded at all sampling sites were between 76.20 – 579.00 μScm^{-1}. The lowest value of the electrical conductivity was 76.20 μScm^{-1} in September at site 5; the highest value of the electrical conductivity was 579.00 $\mu S\ cm^{-1}$ in November at water gate site 2. The minimum value, the maximum value and the mean of the electrical conductivity were recorded of each site in one year observation at Kwan Phayao were significantly different between the sites ($P<0.05$). The dissolved oxygen recorded at all sampling sites were between 1.00 – 9.36 mg L^{-1}. The lowest value of the dissolved oxygen was 1.00 mg L^{-1} in October at site 2 and the highest value of the dissolved oxygen was 9.36 mg L^{-1} in July at site 5. The minimum value, the maximum value and the mean of the dissolved oxygen at each site in one year observation of Kwan Phayao recorded were significantly different between sites ($P<0.05$). The biochemical oxygen demand recorded at all sampling sites, the average range were between 0.06 – 6.00 mg L^{-1}. The lowest value of the biochemical oxygen demand was 0.06 mg L^{-1} in August at site 1; the highest value of the biochemical oxygen demand was 6.00 mg L^{-1} in October at site 5. The minimum value, the maximum value and the mean of the biochemical oxygen demand at each site in one year observation of Kwan Phayao recorded were non-significantly different between sites ($P<0.05$).

The ammonia nitrogen recorded at all sampling sites were between 0.000 – 0.783 mg L^{-1}. The ammonia nitrogen sample in the winter, the average range were between 0.000 – 0.500 mg L^{-1}, the lowest value of the ammonia nitrogen was 0.000 mg L^{-1} in December at site 3 and site 8; the highest value of the ammonia nitrogen was 0.500 mg L^{-1} in October at site 8. The minimum value, the maximum value and the mean of the ammonia nitrogen at each site in one year observation of Kwan Phayao recorded were non-significantly different between sites ($P<0.05$). The nitrate nitrogen recorded at all sampling sites were between 0.000 – 1.024 mg L^{-1}. The lowest value of the nitrate nitrogen was 0.000 mg L^{-1} in January at site 3, site 4, site 5, site 6 and site 7; the highest value of the nitrate nitrogen was 1.024 mg L^{-1} in September at site 1. The minimum value, the maximum value and the mean of the nitrate nitrogen at each site in one year observation of Kwan Phayao recorded were significantly different between sites ($P<0.05$). The orthophosphate phosphorus recorded at all sampling sites were between 0.0000 – 0.1707 mg L^{-1}. The lowest value of the orthophosphate phosphorus 0.0000 mg L^{-1} in September at site 9; the highest value of the orthophosphate phosphorus was 0.1707 mg L^{-1} in March at site 7. The minimum value, the maximum value and the mean of the orthophosphate phosphorus of each site in one year observation of Kwan Phayao were not significantly different between sites ($P<0.05$). The total phosphorus recorded at all sampling sites were between 0.000 – 1.668 mg L^{-1}. The lowest value of the total phosphorus was 0.000 mg L^{-1} in September at site 9; the highest value of the total phosphorus was 1.668 mg L^{-1} in November at site 3. The minimum value, the maximum value and the mean of the total phosphorus at each site in one year observation of Kwan Phayao recorded were not significantly different between sites ($P<0.05$).

The Chlorophyll-a recorded at all sampling sites were between 2.02 – 38.17 mg m^{-3}, the lowest value of the Chlorophyll-a was 2.02 mg m^{-3} in December at site 6; the highest value of the Chlorophyll-a was 38.17 mg m^{-3} in April at site 5. The minimum value, the maximum value and the mean of the Chlorophyll-a at each site in one year observation of Kwan Phayao recorded were not significantly different between sites ($P<0.05$).

Algae diversity: Algae diversity and algae composition of Kwan Phayao is shown in Table 3. The total number of algal species in the winter consistrd of 72 species, 6 divisions were as follows: division Cyanophyta 19 species (26.39%), division Chlorophyta 28 species (38.89%), division Crysophyta 15 species (20.83%), division Euglenophyta 5 species (6.94%), division Cryptophyta 3 species (4.17%) and division Pyrrophyta 2 species (2.78%). The average numbers of algal species of nine sampling sites recorded from October 2007 to September 2008. The average number of algal species recorded at all sites were between 3.83 – 12.58 species. The average algal species of Kwan Phayao were significantly different between sites ($P<0.05$).

Table 2. The average of water quality all sampling sites of Kwan Phayao

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
SS	42.8083^{c}	34.9500^{c}	17.6833^{a}	13.7667^{a}	33.2833^{bc}	18.9583^{ab}	10.6500^{a}	15.9000^{a}	20.3167^{ab}
Depth	1.9325^{c}	1.9458^{c}	2.3975^{d}	1.2917^{ab}	1.9983^{cd}	1.1767^{a}	1.6883^{bc}	1.3958^{ab}	2.9050^{e}
$Temp_w$	26.21^{a}	26.60^{a}	26.00^{a}	26.46^{a}	26.14^{a}	26.69^{a}	26.56^{a}	26.65^{a}	26.26^{a}
pH	7.36^{a}	7.65^{ab}	8.67^{d}	7.54^{a}	8.50^{cd}	7.84^{abc}	8.31^{bcd}	8.00^{abcd}	8.67^{d}
Transparency	0.28^{a}	0.45^{ab}	0.65^{bc}	1.05^{d}	0.65^{bc}	0.82^{cd}	0.73^{bcd}	0.77^{bcd}	0.65^{bc}
Conductivity	1.8533E2^{abc}	2.9900E2^{e}	2.8825E2^{de}	2..2858E2^{cd}	1.4235E2^{a}	2.1183E2^{bc}	3.5258E2^{e}	3.4550E2^{e}	1.4849E2^{ab}
DO	3.7475^{a}	4.1350^{a}	6.8983^{c}	4.5225^{ab}	6.2233^{bc}	4.9150^{ab}	5.9133^{bc}	6.2850^{bc}	5.9525^{bc}
BOD	1.4758^{a}	2.1600^{ab}	2.0400^{ab}	1.5808^{a}	2.8567^{b}	2.1150^{ab}	2.4692^{ab}	2.0683^{ab}	2.3317^{ab}
NH_3-N	0.1664^{ab}	0.3820^{b}	0.1178^{a}	0.2239^{ab}	0.1587^{ab}	0.2009^{ab}	0.2084^{ab}	0.2748^{ab}	0.2431^{ab}
NO_3-N	0.3914^{c}	0.2904^{abc}	0.1131^{a}	0.3383^{bc}	0.1821^{ab}	0.1686^{ab}	0.1003^{a}	0.1321^{a}	0.1798^{ab}
PO4-P	0.0466^{ab}	0.0404^{ab}	0.0301^{a}	0.0561^{abc}	0.0801^{cd}	0.0807^{cd}	0.0906^{d}	0.6807^{bcd}	0.0572^{abc}
TP	0.3369a	0.2201a	0.2816a	0.2626a	0.3464a	0.2661a	0.3519a	0.2392a	0.3340a
Chlorophyll-a	2.2732^{cd}	2.6858^{d}	1.9914^{bc}	1.1720E1^{a}	1.8040^{abc}	1.2262E1^{a}	1.5620^{ab}	1.5349E1^{ab}	1.8810E1^{bc}

Values represent means the physico-chemical and biological parameters describing the water quality in pond. Values with the same letter superscripts are not significantly different ($P < 0.05$).

Table 3. Diversity of algae of Kwan Phayao at all sampling sites

	Site								
	1	2	3	4	5	6	7	8	9
DIVISION CYANOPHYTA									
Anabaena sp.	+	-	+ + +	+	-	+ + +	-	+ + +	+ + +
Chrocoocuccus sp.	-	+	-	-	-	-	-	-	-
Coelomoron sp.	-	-	-	-	-	-	+	-	-
Cylindrospermopsis sp.	-	+	+ + +	+ +	+ + +	+ + +	+ + +	+ + +	+ + +
Dactylococcopsis sp.	-	-	-	-	+ +	-	-	+ +	-
Lemmermanniella sp.	-	+ +	-	-	-	-	-	+ +	-
Lyngbya sp.	-	-	-	-	+ +	-	-	-	-
Merismopdia sp.1	-	+ +	-	-	-	-	-	-	-
Merismopdia sp.2	++	-	-	++	-	-	+++	-	-
Microsystis sp.	-	-	+++	-	-	+++	-	-	+++
Oscillatoria sp.	-	++	+++	-	+++	+++	-	-	+++
Romeria sp.	-	++	-	-	++	-	-	+++	-
Plectonema sp.	-	-	-	++	-	-	++	-	-
Pseudanabaena sp.	-	-	-	-	-	-	+++	-	-
Raphidiopsis curvata	-	-	-	++	-	-	+++	-	-
Spirulina laissima	-	-	-	-	-	+++	-	-	+++
S. subsalsa	-	-	-	-	-	-	+++	-	-
Synechocystis sp.	-	-	-	++	-	-	++	-	-
Synechococcus sp.	-	-	-	++	-	-	-	-	-
DIVISION CHLOROPHYTA									
Actinastirum sp.	-	-	-	-	++	-	-	-	-
Ankyra sp.	-	-	-	++	-	-	-	++	-
Ankistrodesmus sp.	-	-	+++	+++	+++	+++	+++	+++	+++
Acanthosphaera sp.	-	++	-	-	-	-	-	-	-
Chlorella sp.	-	++	-	++	++	-	++	-	-
Chlorogonium sp.	-	-	-	++	-	-	-	++	-
Closterium sp.	+++	-	+++	-	-	+++	-	-	+++
Cosmarium sp.	-	-	+++	+++	+++	+++	++	+++	+++
Crucigenia sp.	-	-	-	++	-	-	-	-	-
Chodatella sp.	-	-	-	-	++	-	-	-	-

Dictyophaerium sp.	-	-	-	-	++	-	-	-	-
Dimorphococcus sp.	-	-	-	-	-	-	++	-	-
Gloeocystis sp.	-	-	-	-	-	-	++	-	-
Golenkiania sp.	-	-	-	-	++	-	-	-	-
Gonium sp.	-	-	-	-	-	-	++	-	-
Halosphera sp.	-	-	-	++	-	-	-	-	-
Interfilum sp.	-	-	-	-	++	-	-	-	-
Micractinium sp.	-	-	-	-	-	-	++	-	-
Oocystis sp.	-	++	-	-	-	-	-	-	-
Pandorina sp.	+++	-	+++	++	+++	+++	+++	+++	+++
Pediastrum sp.	-	-	+++	-	-	+++	-	-	+++
Platymonas sp.	-	++	-	-	-	-	+++	-	-
Pteronamas sp.	-	++	-	-	-	-	+++	-	-
Scenedesmus sp.1	+++	+++	+++	+++	+++	+++	+++	+++	+++
Scenedesmus sp.2	+++	+++	+++	+++	+++	+++	+++	+++	+++
Spermatozopsis sp.	-	-	-	++	-	-	-	-	-
Starastrum sp.1	+++	+++	+++	+++	+++	+++	+++	+++	+++
Tetraedon sp.	++	++	+++	+++	+++	+++	+++	+++	+++
DIVISION CRYSOPHYTA									
Achnanthes sp.	-	++	-	-	-	-	-	-	-
Cyclotella sp.	-	++	-	-	-	-	-	-	-
Cymbella sp.	-	-	-	-	++	-	-	-	-
Centritractus sp.	-	-	-	-	++	-	-	-	-
Cocconesis sp.	-	-	-	++	-	-	-	-	-
Dinobryon sp.	++	+++	-	+++	+++	++	+++	+++	-
Fragilaria sp.	-	-	-	-	++	-	-	-	-
Gomphonema sp.	-	-	-	+++	-	-	-	-	-
Gyrosigma sp.	-	-	-	-	-	-	-	++	-
Mallomonas sp.	-	++	-	++	-	-	-	-	-
Merosila sp.	-	-	-	-	++	-	-	-	-
Navicula sp.	-	-	-	-	-	-	-	++	-
Nitzschia sp.	-	-	-	-	-	-	++	-	-
Pinnularia sp.	-	-	-	-	-	-	++	-	-
Surirella sp.	-	-	-	++	++	-	-	-	-
Stauroneis sp.	-	-	-	-	++	-	-	-	-
DIVISION EUGLENOPHYTA									
Euglena sp.	-	-	+++	-	-	+++	-	-	+++
Phacus sp.	-	-	+++	-	-	+++	-	-	+++
Trachelomonas sp.	-	-	-	-	++	-	-	++	-
Strombomonas sp.	-	-	-	-	++	-	-	-	-
Lepocinclis sp.	-	-	-	-	-	-	++	-	-
DIVISION CRYPTOPHYTA									
Cryptomonas sp.	-	-	-	-	++	-	-	-	-
Chroomonas sp.	-	-	-	++	-	-	-	-	-
Hemiselmis sp.	-	-	-	-	-	-	++	-	-
DIVISION PYRROPHYTA									
Peridinium sp.	-	-	-	-	++	-	-	-	-
Ceratium sp.	+++	+++	+++	+++	+++	+++	+++	+++	+++

Legend: (-, Not found; +,1 to100 units ml^{-1}; ++, 101 to 1000 units ml^{1}; and +++, greater than 1000 units ml^{-1})

Discussion

The result of this study gave an insight in the physico-chemical and biological factors. The quantity of the suspended solid were 1.60-124.50 mg L^{-1} compared with Channel catfish ponds (Alabama) range from 4 to 340 mg L^{-1}; in Eymir and Mogan lakes (Turkey), the suspended solid were between 7 - 227 mg L^{-1} (Karakoc *et al*., 2003).

Water temperature was between 22.8 - 30.5 ^{o}C which is higher than Pit-lake in Canada during 1992-1998, 0.1-19.4 ^{o}C (Kalin *et al*., 2001); but lower Parana basin in Argentina between 1995-1998, 9.2-2.7 ^{o}C (Izaguirre *et al*., 2001); Lago Bio and Lago Loreto lakes in Equatorial Guines in 2002, 19.3-24.0 ^{o}C (Schabetsberger *et al*., 2004) and in the Eymir and Mogan lakes (Turkey) between 0.0 -12.4 ^{o}C (Karakoc *et al*., 2003). The temperature of Kwan Phayao is closed to Banglang reservior in Yala province during 2000-2001, 26.98 - 30.18 ^{o}C (Ariyadej *et al*., 2004); Chini lake in Malaysia during 2004-2005, 27.28 - 31.39 ^{o}C (Othman *et al*., 2006); in the Three Gorge resevior in China between 2004-2005, 22.0 - 27.0 ^{o}C (Zeng *et al*., 2006); in the Ruvu river system (Tanzania), 14.00-31.1 ^{o}C (Ngoye and Machiwa, 2004) and in the river Pinios (Thessalia-Greece) between 4.1-30.1 ^{o}C (winter-summer) (Bellos and Sawidis, 2005).

The pH value of water in Kwan Phayao was neutral and closes to be basicity condition as well as the general water resources, such as Doi Tao lake, Mae Moh resevior and Banglang resevior are 7.21-9.77, 6.82-8.65 and 6.7-7.2 respectively (Khuantrairong and Traichaiyaporn, 2004; Junshum and Traichaiyaporn, 2005; Ariyadej *et al*., 2004), Turkwel Gorge reservior (Kenya) during 1993-1995, 7.1-8.7 (Kotut *et al*., 1998); in Boeza and Tremor rivers (Spain) 6.6-7.9 (Graido *et al*., 1999); in the two constructed strom water management ponds in Ontario during 1996-1997, 7.9-8.5 (Olding *et al*., 2000); In shallow lake (Japan) in 2000, 6.4-9.6 (Takamura *et al*., 2003); in the river Thame in the Thames basin (England) during 2000-2002, 7.50-8.55 (Neal *et al*., 2006) in Ruvu river system (Tanzania) between 6.95-8.07 (Ngoye and Machiwa, 2004); in the river Pinios (Thessalia-Greece) between 7.01-8.57 (Bellos and Sawidis, 2005). These are different from Chini Lake (Malaysia) between 2004-2005, 6.23-6.63 (Othman *et al*., 2006); and in Sungai Kelantan (Malaysian rivers) were 6.4 (Ahmad *et al*., 2009) which is more acidicity.

The secchi depth was 0.06-1.87 m which close to the small water resources built for agricultural irrigation and attraction points. Chiangmai Moat, 0.19-1.50 m (Rahim, 1994; Thanompongchat, 1995; Vongyara, 1997; Traichaiyaporn *et al*., 2000) and Ang Kaew resevior, 0.05-1.40 m (Kraibut, 1996) the lake Balingo (Kenya) in 1999, 0.7 m (Schagerl and Oduor, 2003) the small man-made reseviors (Zimbabwe) in 2005, 0.2-2.0 m (Basima *et al*., 2006) which are lower than the ordinary reseviors, such as Mae Ngat resevior, 1.35 - 3.96 m (Proongkiat, 1999; Kimpakorn and Traichaiyaporn, 2000; Tularak, 2001; Saeton and Traichaiyaporn, 2002), in the Turkwell Gorge resevior (Kenya) between 1993-1995, 0.28-2.40 m (Kokut *et al*., 1998) shallow lake (Japan) during 2000, 0.17-2.42 m (Takamura *et al*., 2003); the high mountain lakes of the Eastern Alps (Australia and Italy) in 2000, 1.7-16.3 m (Tolotti *et al*., 2003); the lake in Equatorial Guinea in 2002, 0.6-5.5 m (Schabetsberger *et al*., 2004); and the Three-Gorge resevior (China) between 2004-2005, 0.15-4.5 m (Zeng *et al*., 2006).

The electrical conductivity was 76.20-597.00 µs cm^{-1}which is different in minimum and maximum value and similar to Boeza and Tremor rivers (Spain), 18-472 µs cm^{-1} (Graido *et al*., 1999); in high mountain lakes of the Eastern Alps (Australia and Italy) in 2000, 6-254 µs cm^{-1} (Tolotti *et al*., 2003); in Ruvu river system (Tanzania) between 39.8-48,734 µs cm^{-1} (Ngoye and Machiwa, 2004); in the river Pinios (Thessa-Greece) between 138-697 µs cm^{-1} (Bellos and Sawidis, 2005); and in the Eymir and Mogan lakes (Turkey) between 452 - 1971 µs cm^{-1} (Karakoc *et al*., 2003) different from other water resources which the minimum and maximum is not much different which were Mae Ngat Somboonchol dam resevior ranged between 96.33-102.70 µs cm^{-1} was positively correlated with the number of algae (Tularuk, 2001). The conductivity values of Ping river, nad Banglang resevior were 231.439 µs cm^{-1} and 5.83-51.17 µs cm^{-1}, respectively (Proongkiat, 1999; Ariyadej *et al*., 2004). The conductivity values were reported in Turkwel Gorge resevior (Kenya) during 1993-1995,140-200 µs cm^{-1} (Kotut *et al*., 1998); in Lago Biao and Lago Loreto lakes in Equatorial Guinea in 2002, 11.6-95.0 µs cm^{-1} (Schabetsberger *et al*., 2004).

The dissolved oxygen value in water was 1.0-9.36 mg L^{-1} , the amount of dissolved oxygen is lower than the standard value at the first site (1.2 mg L^{-1}), the second site (1.00 mg L^{-1}) and the seventh site (1.40 mg L^{-1}). At the first sampling site , in March, June and July the values were 1.35, 1.52 and 1.22 mg L^{-1}, respectively. These values are lower than the standard of surface water quality (Pollution Control Department, 2001), type 5, (2.0 mg L^{-1}). The first sampling site located at the inlet of the upper Ing river which flowing water all year. Moreover, in rainy season there is the dirt dissolved in the river, which affected the low dissolved oxygen value when compare with the water quality from the other sources, such as dissolved oxygen, 2.80-9.13 mg L^{-1} in the Mae Ngat Somboonchol resevior (Tularak, 2001) in Turkwel Gorge resevior (Kenya) during 1993-1998, 5.7 - 16.4 mg L^{-1} (Kotut *et al*., 1998); pit-lake (Canada) during 1992-1998, 5.7 - 16.4 mg L^{-1} (Kalin *et al*., 2001); in shallow lake (Japan) in 2000, 0.4 - 12.7 mg L^{-1} (Takamura *et al*., 2003); in Ruvu river system (Tanzania) between 6.8 - 16.8 mg L^{-1} (Ngoye and Machiwa , 2004); in the river Pinios (Thessalia-Greece) between 1.9-18.5 mg L^{-1} (Bellos and Sawidis, 2005); in Sungai Kelantan (Malaysian rivers) were 7.2 mg L^{-1} (Ahmad *et al*., 2009) and in the Eymir and Mogan lakes (Turkey) between 4.7 mg L^{-1} - 16.3 mg L^{-1} (Karakoc *et al*., 2003). The amount of biological oxygen demand was 0.06-6.00 mg L^{-1}. This value is higher than the water quality standard type 5 (4.0 mg L^{-1}) in October from the forth (4.20 mg L^{-1}), the fifth (6.00 mg L^{-1}) and the ninth sampling site (5.40 mg L^{-1}).

Ammonia nitrogen ranged 0.000-0.783 mg L^{-1} and nitrate nitrogen ranged 0.000-0.9810 mg L^{-1}. These values are higher than the water quality standard from the surface water type 5 (the ammonia nitrogen is lower than 0.5 mg L^{-1}). The nitrate nitrogen of water of Kwan Phayao was at the level of type 2 of standard surface water which nitrate nitrogen is not more than 5.0 mg L^{-1} (Pollution Control Department, 2001). The sampling sites which contained the ammonia nitrogen higher than the standard value were at the ninth sampling site in January and February 0.613 and 0.548 mg L^{-1}; the forth sampling site, 0.783 mg/L and the seventh sampling site 0.528 mg L^{-1}. These sampling sites are in the communities which many activities are occurred, such as livestocks, agriculture and etc. The amount of nitrogen from the other water sources are as follows: Three Gorge resevior (China) between 2004-2005, 0.100 - 1.490 mg L^{-} (Zeng *et al*., 2006); in Sungai Kelantan (Malaysian rivers) were 0.08 mg L^{-1} (Ahmad *et al*., 2009). Nitrate nitrogen concentrations in Sungai Kelantan (Malaysian rivers) were 0.62 mg L^{-1} (Ahmad *et al*., 2009). Water of Kwan Phayao contained orthophosphate phosphorus 0.0000 - 0.1707 mg L^{-1} and the total phosphorus 0.000 - 1.668 mg L^{-1}. The amount of phosphorus in the other water sources: in the Boeza and Tremor rivers (Spain), 0.00 - 0.62 mg L^{-1} (Graido *et al*., 1999); in Sungai Kelantan (Malaysian rivers) were 36.6 mg L^{-1} (Ahmad *et al*., 2009) and in the Eymir and Mogan Lakes (Turkey) between 0.01 mg L^{-1} - 1.5 mg L^{-1} (Karakoc *et al*., 2003). The amount of chlorophyll- a is 2.02-38.17 mg dm^{-3} when compare with other water sources; the chlorophyll-a concentration in oligotrophic lakes and eutrophic lakes are about 0.30-3.00 mg dm^{-3} and 10.00-500.00 mg dm^{-3}, respectively (Wetzel, 1983). Investigation from the Mae Ngat Somboonchol reservoir in 1999 and 2011 revealed the concentration of chlorophyll-a (0.06 - 0.18 mg dm^{-3} and 0.002 - 0.21 mg dm^{-3}, respectively) had a positive effect on algae in division Chlorophyta, Pyrrophyta and Cryptophyta (Proongkiat, 1999; Tularak, 2001).

There were 72 species of algae in this study which is less than the number of algal species reported in Doi Tao lake which consisted of 162 species in 98 genera of 6 divisions (Khuantrairong and Traichaiyaporn, 2008). When comparing to the study of Promman (2002), the distribution study of toxic algae and water quality in Kwan Phayao for 18 months during April 1999-September 2000. This study was presented 19 species of chlorophyceae, 15 species of zynemaphyceae, 15 species of cyanophyceae, 15 species of euglenophyceae, 6 species of diatomophyceae, 1 species of chrysophyceae and xanthophyceae. The study surveys of phytoplankton in Kwan Phayao (Lucha, 1985) were done during May 1984-April 1985. The study was divided into 3 seasons (rainy season, winter and summer) from 15 stations by phytoplankton net. This study found 216 species as follows; 137 species of chlorophyceae, 30 species of cyanophyceae, 27 species of euglenophyceae, 18 species of chrysophyceae and 4 species of pyrrophyceae.

Conclusion

The assessment on the water pollution of Kwan Phayao caused by run-off, urban and agricultural activities should, therefore, be of great concern. The communities normally use water from Kwan Phayao as raw water for household consumption, while the agricultural the industrial sectors also depend on water supply from Kwan Phayao. In recent years, the solute concentration often exceeded the surface water quality standard. This has been attributed to land use and increased usage of fertilizers.

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