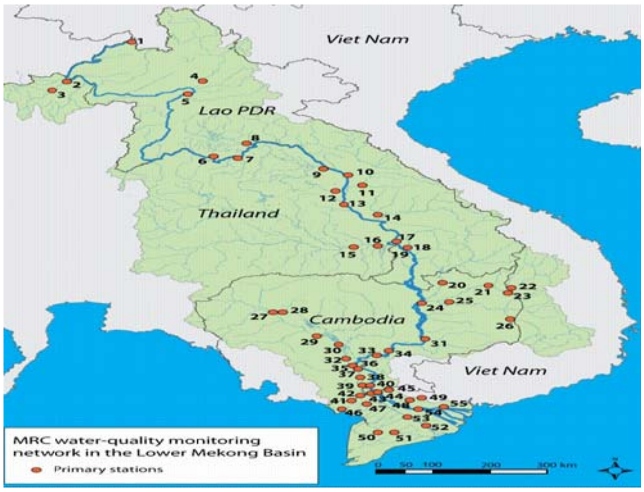
Annual Report

on

Water Quality Data Assessment

Thailand – 2013



Thailand National Mekong Committee

Department of Water Resources

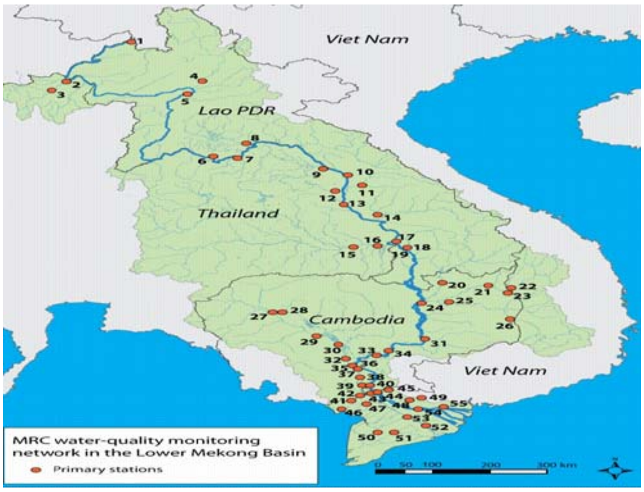
Ministry of Natural Resources and Environment

Annual Report

on

Water Quality Data Assessment

Thailand – 2013



Research and Water Quality Analysis Division,

Bureau of Research Development and Hydrology,

Thailand National Mekong Committee, Department of Water Resources,

Ministry of Natural Resources and Environment.

Contents

List of figures

List of tables

Chapter 1
Introduction

1.1 The Mekong River Basin

The Mekong River is the longest river in South East Asia, the twelfth longest and the tenth largest discharge in the world (Dai and Trenberth, 2002). It has originated on the Tibetan Plateau and flows southward through China, Myanmar, the Lao PDR, Thailand, Cambodia and Viet Nam, where it discharges into the South China Sea. The catchment of the river, which covers an area of 795,000 km^2, is functionally divided into two basins; the Upper Mekong Basin, at where the Lanchang River flows southwards through China, and the Lower Mekong Basin, which includes parts of the Lao PDR, Thailand, Cambodia and Viet Nam (Figure 1.1 a). The river forms the border between the Lao PDR and Myanmar in the transition zone between the upper and lower basins. The Mekong River Basin Diagnostic Study (MRC, 1997) and the State of the Basin Report (MRC, 2003) provide further information on the basin, its water-related resources, and its inhabitants.

The hydrology of the Mekong system is dominated by the annual monsoon cycle, such that the discharge during the wet season (from June to November) may be up to twenty times greater than during the dry season (December to May). Geography also plays an important role in the annual variation of discharge, as the contribution to the flow coming from the Upper Mekong Basin varies according to the season. For example, at Kratie (in Cambodia) the so-called 'Yunnan Component' compromises 40% of the dry season flow, but only 15% of the wet season flow (MRC, 2005). In contrast, 50% of the sediment discharged into the South China Sea from the Mekong comes from China (MRC, 2004).

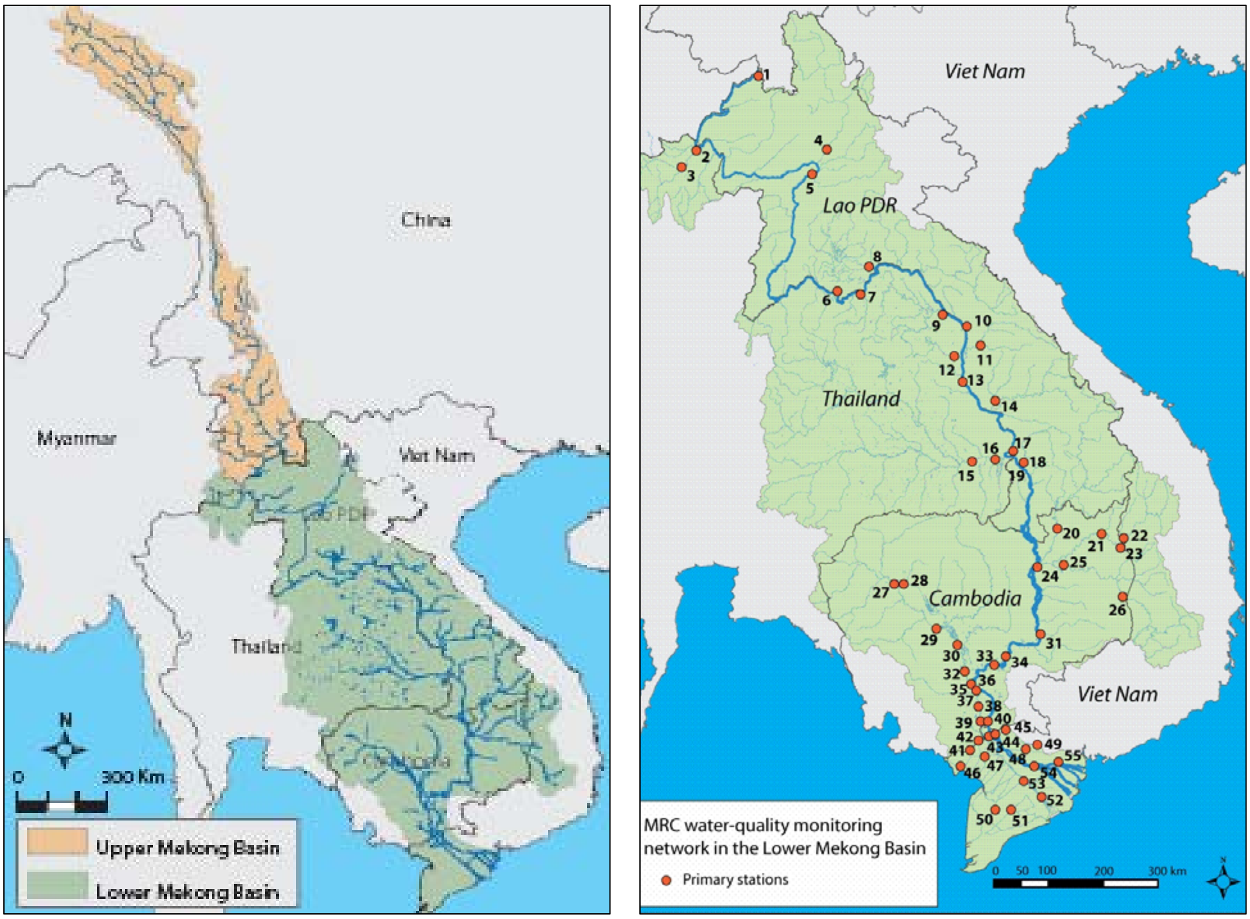
The livelihoods of most of the 60 million people who live in the Lower Mekong Basin (LMB) depend to some extent on the water resources of the Mekong River. These livelihoods rely on the environmental health of the Mekong River and its tributaries remaining in good condition. Water quality is a key factor in determining environmental health. Under the guidance of the Mekong River Commission, the four lower riparian countries (the Lao PDR, Thailand, Cambodia and Viet Nam) have monitored the water quality of the LMB since 1985 (monitoring of the Cambodian component began in 1993).

The condition of the River, which at present has a good/acceptable water quality, must be maintained to promote the sustainable development of the Mekong River Basin. The purpose of MRC water quality monitoring programme are to provide timely data and/or information on the status and changes in water quality of the Mekong River Basin, which are used by relevant stakeholders. Water quality monitoring of the River also help to recognize changes in the condition of the river's environment in sufficient time to take remedial action.

Water Quality Monitoring Network at the Lower Mekong Basin is a complementary task to the Environmental Programme. It is funded by SIDA through the Mekong River Commission cooperated with each National Mekong Committee (NMC) of four countries: Cambodia, the Lao PDR, Thailand and Viet Nam. Water quality monitoring programme has initially implemented in the Lao PDR, Thailand and Viet Nam since 1985, then later in Cambodia since 1993. (MRCS, 2003)

The monitoring stations are divided into two types, primary and secondary station. Primary stations are located in the Mekong River for monitoring water quality of the transboundary flow or water quality problems of general characteristics basin wide to meet the Water Utilization Program (WUP) and Basin Development Plan (BDP) targets. Secondary stations are located in the Mekong River tributaries for monitoring water quality to resolve problems for country level or local level which mainly focus on national or local interest.

The programme monitors 87 permanent stations of Water Quality Monitoring Network (WQMN), which 55 are primary stations and 32 are secondary stations on the main steam and important tributaries of the Mekong River, respectively (Figure 1.1 b).



(a) The Mekong River Basin (b) MRC-WQMN sampling sites

Figure 1.1 The Mekong River Basin and MRC-WQMN sampling sites

1.2 Overview of the Mekong River and Tributaries in Thailand

The Lower Mekong Basin (LMB) has total area around 606,000 km^2, which about 188,645 km^2 is located in Thailand. The LMB is divided into 10 sub-areas (SA) based on the hydrological conditions and country territory. The Mekong Basin's part in Thailand includes SA-2T (covering Kok river and Mekong river basins in the North), SA-3T (covering Mekong River basin in the Northeast), SA-5T (covering Chi river and Mun river Basins), and SA-9T (covering Tonle Sap basin).

Chiang Rai Sub-area (SA-2T) covers a total area of 18,859 km^2; consist of Kok river and Ing river basins located in Chiang Rai and Phayao provinces, and Mekong River Basin (MRB) Part 1. The Mekong River meanders along the Thai-Lao territory. This SA covers areas of the three province, Chiang Mai province, Chiang Rai province; and Phayao province.

SA-2T is dominated by tropical monsoon or tropical savanna climate. The rainy season occurs during May-October, which is influenced by the southwest monsoon from the Andaman Sea as well as typhoons and depressions from the South China Sea. Rains scatter widely over the whole area with a peak in August. Winter lasts from October to February. The area is subject to the influence of the Northeast monsoon, which brings cold and dry weather from China, thus causing low temperatures over the area. The summer is between February and mid-May with maximum mean temperature in April,

Nong Khai/Songkhram Sub-area (SA-3T) the total area is 46,460 km^2. It is narrow and elongated shape along the Mekong River. Upland is the general topographical feature of this area, with elevation range between 100 and 200 m MSL. The catchment is bounded to the west and east by high ridges, which dip northwards and eastwards to the Mekong River. This SA extends over eight northeastern provinces in the Mekong River Basin, i.e. Udon Thani, Sakon Nakhon, Loei, Nong Bua Lamphu, Nong Khai, Nakhon Phnom, Mukdahan, and Amnat Charoen.

The climate of the Mekong River Basin 2 is primarily influenced by the Southwest and Northeast monsoons. It is also subjected to depressions from the South China Sea each year. Consequently, heavy rains are observed during the wet season. There are three seasons in the area, i.e. rainy season, summer, and winter.

Mun/Chi Sub-area (SA-5T) in Thailand's part is divided into 2 main river basins, namely, Chi and Mun river basins, covering a total area of 119,177 km^2. They are under the jurisdiction of 15 provinces, namely, Ubon Ratchathani, Nakhon Ratchasima, Chaiyaphum, Maha Sarakham, Loei, Yasothon, Khon Kaen, Kalasin, Roi Et, Si Sa Ket, Udon hani, Nong Bua Lamphu, Buri Ram, Surin, and Amnat Charoen. High ridges form the western boundary of the area, i.e. Phetchabun range with elevation of 1,400 m MSL. Chi River originates from these mountainous areas. PhuPhan range forms the northeastern boundary with elevation of about 600 m MSL,stretching from Udon Thani to Ubon Ratchathani. This range is the source of Lam Pao and Yang rivers. On the south are Banthat and Dong Rak mountain ranges with elevation of 300-1,350 m MSL, which are the sources of Mun River. The central part of the SA is a low ridge, dipping southwards to Mun River. The area near the confluence of Mun and Chi rivers is low-lying land.

The climate in SA-5T2 is divided into 2 river basins, namely, Chi and Mun, because this SA covers a very large area. The collected data were divided based on the boundaries of river basins in Thailand.

1.3 Objective of the report

This annual country report on Water Quality Data Assessment provides an overview of water quality parameters and the changes of key environmental stressors that may impact on the rivers aquatic life. It provides a summary of water quality monitoring data during the period from January to December of 2013. The data are taken from 8 sampling sites in the Mekong River and its tributaries flow through Thailand.

Chapter 2
Methodology

2.1 Sampling plan

2.1.1 Sampling station

In 2013, the sampling stations in Thailand cover 8 stations, which categorized as 3 primary stations along Mekong River and 5 secondary stations in 4 tributaries as shown in Figure 2.1 and detailed in Table 2.1.

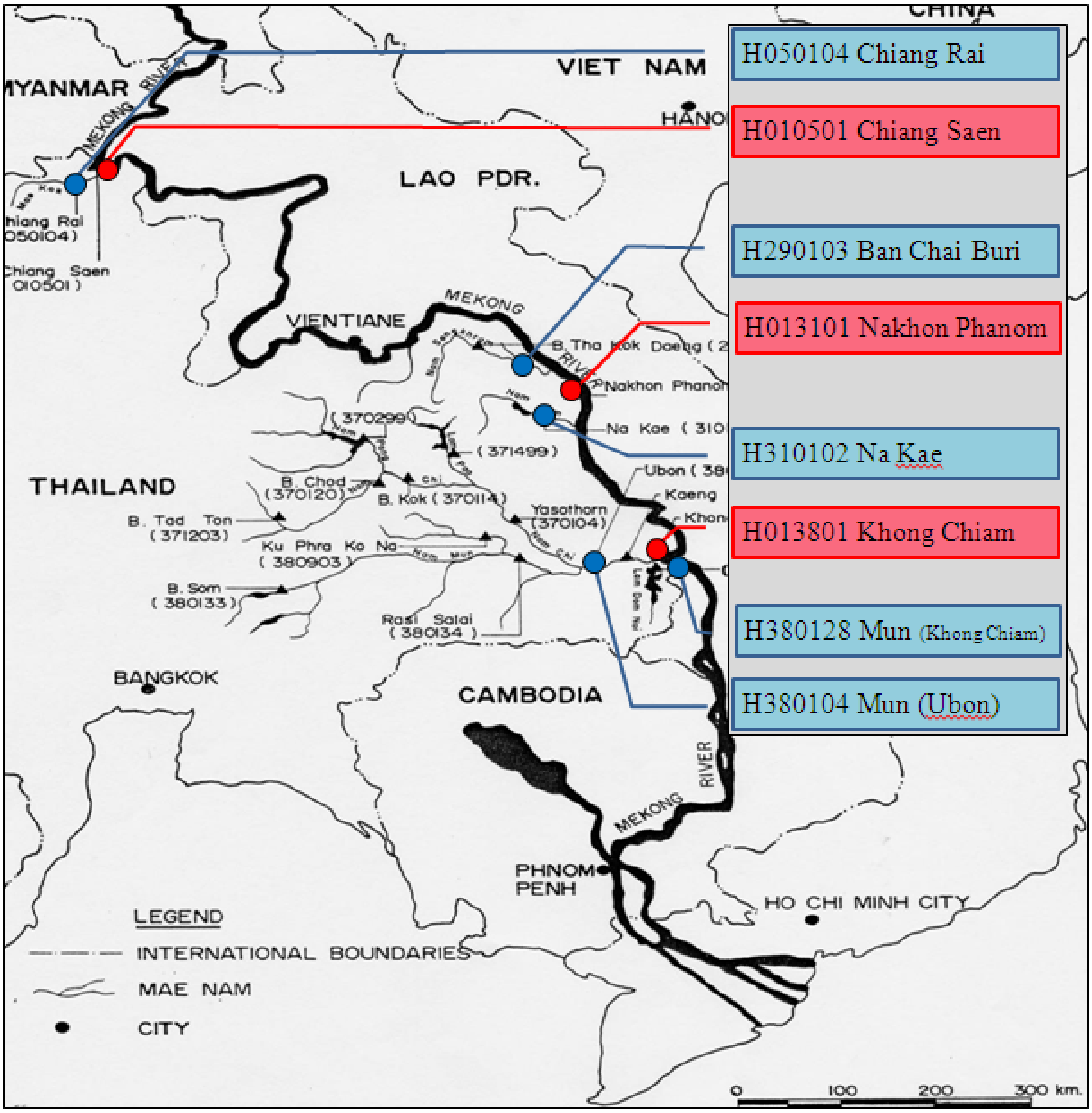


Figure 2.1 The MRC-WQMN sampling sites of Thailand in 2013

Table 2.1 List of the water quality sampling sites

Station Code	Station Name	Station Location		River Name
		Latitude (N)	Longitude (E)	
H010501	Chiang Saen	20° 10′ 24″	100° 05′ 00″	Mekong (mainstream)
H013101	Nakhon Phanom	17° 23′ 54″	104° 48′ 12″	Mekong (mainstream)
H013801	Khong Chiam	15° 19′ 06″	105° 30′ 00″	Mekong (mainstream)
H050104	Chaing Rai	19° 55′ 06″	99° 51′ 00″	Mae Kok
H290103	Ban Chai Buri	17° 38′ 24″	104° 27′ 36″	Nam Songkhram
H310102	Na Kae	16° 55′ 42″	104° 41′ 18″	Nam Kam
H380104	Ubon	15° 14′ 48″	104° 57′ 24″	Nam Mun
H380128	Mun	15° 19′ 12″	105° 30′ 36″	Nam Mun

2.1.2 Sampling techniques

The Mekong River and its tributaries are generally well mixed, therefore the monitoring involves sampling on monthly basis by means of a simple surface grab technique from the edge of the river in a location where it is apparent that water is free flowing and well mixed. Water sample are taken at 30-50 cm depth below the surface.

Water sampling, sample preservation and transportation had been performed following the Standard Methods for the Examination of Water and Wastewater 20th Edition 1060 Collection and Preservation of Sample (Clesceri *et al*., 1998) and acceptable method in the guideline of WQMN as previously agreed between the laboratories and the MRCs. After preserving, all water samples were quickly transported to the laboratory of Research and Water Quality Analysis Division at Nonthaburi Province.

2.1.3 Sampling frequency and duration

The water monitoring were conducted from January through December, one sampling event every months. Monitoring samples were started in January and completed in the December. Thus, each site was monitored a total of twelve times during the year. Each sampling event was taken approximately in the middle of the month between the date 13th and 18th of each month.

2.2 Parameters and analytical methods

List of monitoring parameters are categorized in 5 indicating grouped as follows with analytical methods presented in Table 2.2

(1) Basic parameters: Temperature, pH, EC, TSS
(2) Main ions: Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, Alkalinity, SO_4^{2-}, Cl^{-}
(3) Nutrients: NH_4^{+}-N, $NO_{2\&3}^{-}$-N, Total-N, Total-P
(4) Organic matters: DO, COD
(5) Microbiology: Faecal coliform

Table 2.2 List of parameters and analytical methods

No.	Parameters	Unit	Method Use	Recommended Methods
1	Temperature	^{o}C	Electrometric	2550-Temp/SM
2	pH	-	Electrometric	4500-H+/SM
3	Conductivity (EC)	ms/m	Electrometric	2510-Ec/SM
4	TSS	mg/l	Dried at 103 – 105 ^{0}C	2540-D-TSS-SM
5	Ca^{2+}	meq/l	EDTA Titration	3500-Ca-B/SM
6	Mg^{2+}	meq/l	EDTA Titration	3500-Mg-B/SM
7	Na^{+}	meq/l	Ion Chromatography	3500-Na-B/SM
8	K^{+}	meq/l	Ion Chromatography	3500-K-B/SM
9	Alkalinity	meq/l	Titration	2320-A/SM
10	SO_4^{2-}	meq/l	Turbidity	4500- SO4 –E/SM
11	Cl^{-}	meq/l	Argentometric	4500-Cl/SM
12	$NO_{2\&3}^{-}$	mg/l	Cd reduction	4500-NO2-3/SM
13	Total-N	mg/l	Digestion with $K_2S_2O_8$	4500-N/SM
14	NH_4^{+}	mg/l	Indophenols blue	4500-NH4/SM
15	Total-P	mg/l	Digestion with $K_2S_2O_8$	4500-P/SM
16	DO	mg/l	Winkler	4500-O/SM
17	COD	mg/l	Permanganate Oxidation	-
18	Faecal Coliform	MPN in 100 ml	Multiple Tube	9221-Faecal Coliform group/SM

2.3 Data assessment methodology

2.3.1 Data reporting

Current status and trend of water quality are reported in terms of temporal variation and spatial variation. For current status, temporal variations at each station for each parameter were employed by box plot. Spatial variations in Mekong River and 4 tributaries at each year from 1985 to 2013 for each parameter were also employed by box plot. Changes in water quality for both temporal and spatial variations in 2013 and 2012 were tested by independent t-test, paired-sample t-test and analysis of variance.

2.3.2 Group of parameter

(1) Basic parameters: Temperature, pH, EC, TSS
(2) Nutrients: NH_4^+-N, $NO_{2\&3}^-$-N, Total-N, Total-P
(3) Organic matters: DO, COD

2.3.3 Water quality indices

Another way for evaluation the water body adequacy and impact is considered by water quality indices (WQI). The WQI is one of the most widely used of all existing water quality procedures. Water Quality indices were related to water quality in some physicochemical properties. They have scales which reflect in term of protection of aquatic life, human impact on water quality and a range of potential water use. In order to amalgamate water chemistry data various indices are frequently used. There are three main WQI accepted at the RTAG meeting in July 2006 (Wilanders, 2007).

(1) WQI_{al} for the protection of aquatic life
(2) WQI_{hi} for human impact on water quality
(3) WQI_{ag} for agriculture use which is divided into three categories as following;
    (3.1) general irrigation
    (3.2) irrigation of paddy rice
    (3.3) livestock and poultry

Guideline values to developed WQI in 2013 are picking from the Procedures for Water Quality approved in 2012, although these guidelines have not been officially approved by the MRC Joint Committee. The guidelines have been finalized by the Technical Body on Water Quality, a regional working group established to develop the guidelines, and have been used by the member countries to assess the Mekong River water. Details of water quality indices and guideline values are in Appendix B.

2.3.4 QA/QC program

1) Collection, Storage and Preservation of Samples

The program includes training course in sampling method, sample preservation techniques and site data collection to field technician at the Hydrological Center, Water Resources Regional Office. The 4 centers including Chiang Rai, Mukdaharn, Ubon Ratchatani and Khong Chiam are responsible for river water sampling on monthly basis. River water is sampled from the 30 cm under water surface and the midstream of water river body. Two types of water sample are collected as type A and B with the difference in preservation technique. Each type of sample is collected in two plastic bottles. One liter of water sample is collected in each bottle for most physical and chemical analyses. Only type B sample is preserved by adding 1.5 ml of concentrated sulfuric acid to pH less than 2. The sample used for Dissolved Oxygen measurement are taken in 2 BOD bottles and added with the oxygen fixing reagent at the sampling site. In addition, the collections of field blank and duplicate sample are generally assigned to all hydrological centers. The samples used for Fecal Coliform Bacteria analysis are separately collected in two 125-mL glass bottles. All of water samples are kept in cool box with control temperature less than 4 °C and immediately sent to Research and Water Quality Analysis Division.

2) Sample Analysis

Because of biological activity, adsorption to the wall of container and change in sensitive parameters involving sample stability, all of samples are immediately analyzed to complete within 2 weeks in laboratory to reduce the elapsed time between sample collection and analysis. Two types of control charts commonly used in the laboratory are as X-chart and R-chart. The synthesized control samples of EC, pH, NH_4^+, $NO_{2\&3}^-$, Total-N, Total-P and COD are analyzed at the same time with sample analysis. The derived data was used as the values plotted in X-chart to determine the reliable of the analysis while the range of duplicate data obtained by measurement in Dissolved Oxygen, TSS and Fecal Coliform Bacteria analysis are used in R-chart. The checking correctness of analyses by ion-balance is applied to each water sample for which relatively complete analyses are made.

Chapter 3
Results and Discussions

3.1 Water quality parameters in Mekong River and tributaries

The water quality in Mekong River and tributaries in 2013 from Chiang Saen, Nakhon Phanom and Khong Chiam, Thailand were conducted at 3 primary sampling stations along Mekong River. The four tributaries river consist of Kok River, Song Khram River, Kam River and Mun River, which alternating with primary stations, were conducted from 5 sampling stations. The water quality parameters results were displayed in this section with box-and-whisker plot. The plot showed information of lower extreme, lower quartile, median, upper quartile and upper extreme, also outliner and extreme outlier.

The sequences of stations to display are sequenced by location to reach from Mekong River upstream to downstream. The upstream station before station in Thailand is located in the Lao PDR. The first station in Thailand is Chiang Rai station, which discharged in Mekong River with Chiang Saen station as downstream monitoring station. Next, Song Khram River discharged into Mekong River with Nakorn Phanom station as downstream monitoring station. Then, Kam River discharged into Mekong River with Khong Chiam as downstream monitoring station. Finally, Mun River discharged into Mekong River with downstream monitoring station located in Pakse, the Lao PDR.

The water quality analysis data in the past from 1985 to present also showed yearly variation with box plot in Mekong River and 4 tributaries; Kok River, Song Khram River, Kam River and Mun River. The variations in average water quality parameter show the trend of changes both locations and time series.

Note that in Song Kram River and Mun River, the monitoring station between 1985 and 2003 and the monitoring station between 2004 to present were located in difference location. However, the box plot of variation in average water quality parameter values of these two tributaries should be plotted based on data collecting year, thus the difference in sampling locations were neglect.

3.1.1 Basic parameters

1) pH

The average observed pH values at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 6.34, 6.44 and 6.50, respectively. These average pH values were higher than average pH values of the all Mekong mainstream stations in 2012 only 0.10, these different were not statistically significant both paired-sample t-test and independent-sample t-test with 95% confidence level, so pH values in Mekong River in this year were stable after confidentially lower than previous year of pH values were occurred around 1.1 since 2010.

The average observed pH values at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 6.64, 6.64, 6.69, 6.61 and 6.66, respectively. The difference between average values in 2012 and 2013 with 95% confidence were not statistical significance at all stations.

The box plot of pH values in Figure 3.1 show the variation in pH at individual station. The monitoring stations in Mekong River had similar pH variation to the tributaries, but with lower median than all tributaries.

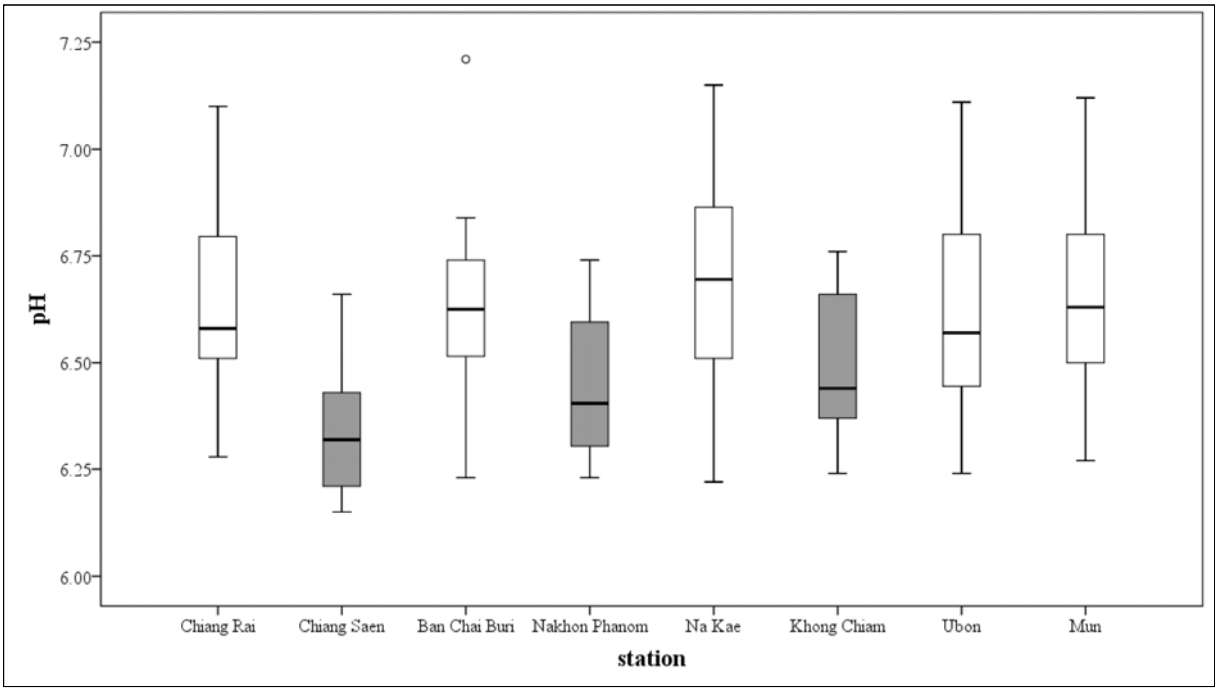


Figure 3.1 The observed pH at monitoring stations in 2013

The variation of pH values along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.2. These plot figures out the Mekong River had relatively low variation than Song Khram River and Mun River, which had the highest variation. Moreover, the change of median in pH at each year seems to be related in all streams. In 2012, Mekong River shows the lowest pH value since 1985 and others tributaries also have lower pH values than previous year. In this year, the pH values were stable after continually decreasing since year 2009 and clearly change in the last 2 year. Then pH values in tributaries also increasingly.

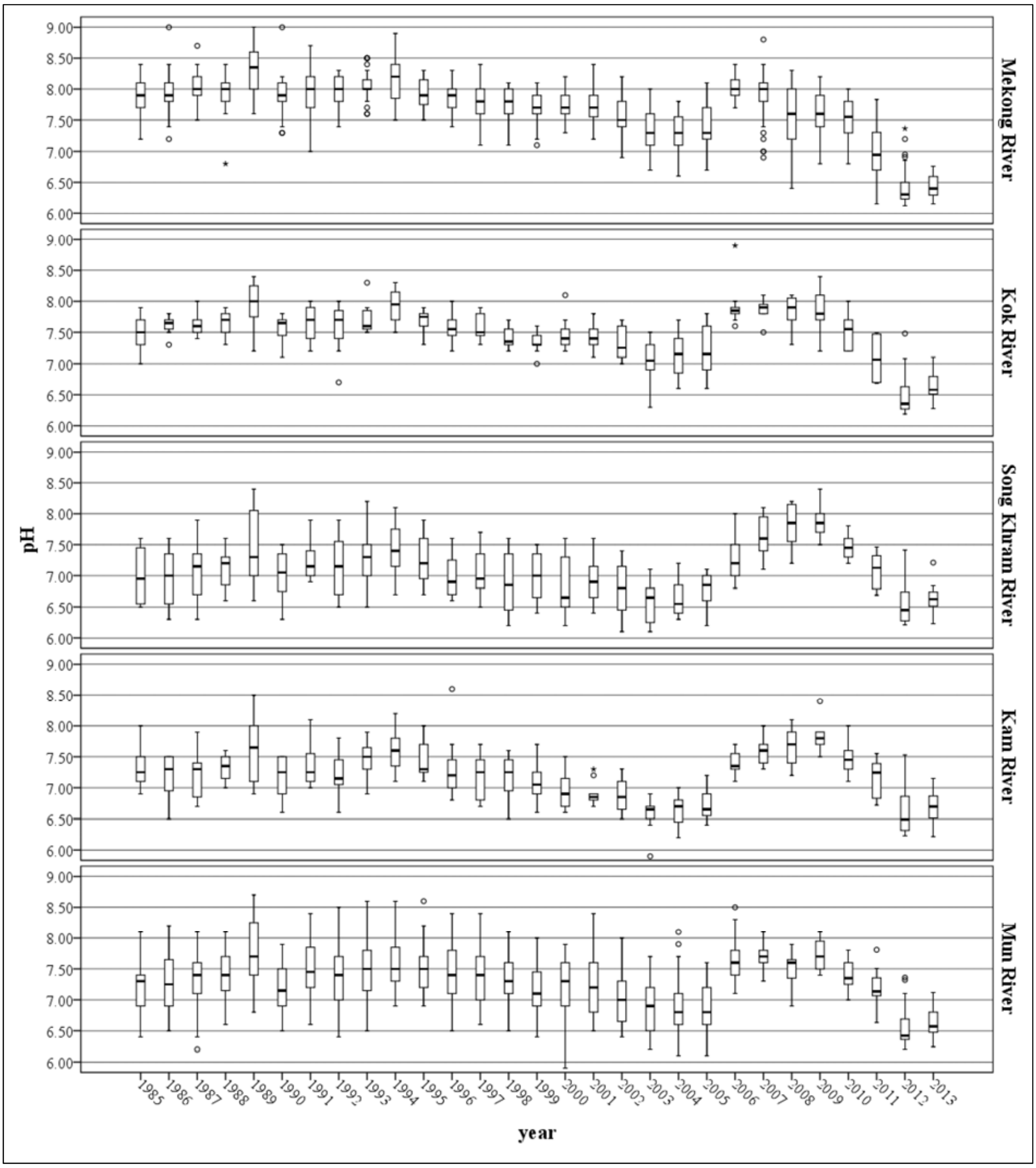


Figure 3.2 The variation of pH in Mekong River and tributaries from 1985 to 2013

2) Electrical conductivity (EC)

The average observed EC values at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 24.48, 20.15 and 18.48 mS/m, respectively. These average EC values were higher than the all Mekong mainstream stations in 2012 just around 0.8 mS/m, and these were not statistically significant differences in EC values for each station observed in 2012 with 95% confidence.

The average observed EC values at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 11.41, 29.35, 12.23, 31.29 and 15.31 mS/m, respectively. The difference between average values in 2012 and 2013 with 95% confidence were only statistical significance at Ubon station with 8 mS/m increasing. Variation of EC values for each station shows in Figure 3.3

The EC value in Song Khram River at Ban Chai Buri was found much extremely higher than others stations in momentary time period, especially in dry season (February to May). Song Khram river origins in Sakon Nakhon province and flow through the severely salt affected area in Ban Dung district, Udon Thani province. Ban Dung district has more than 30% widespread of rock salt farming area. In 2013, the high EC values in Song Khram River at Ban Chai Buri station were 64.30, 26.90, 23.40 and 80.40 mS/m from February to May, respectively, and also show the highly concentration of chloride and sodium ion, which mainly compound of rock salt, compared to others stations (Table C3).

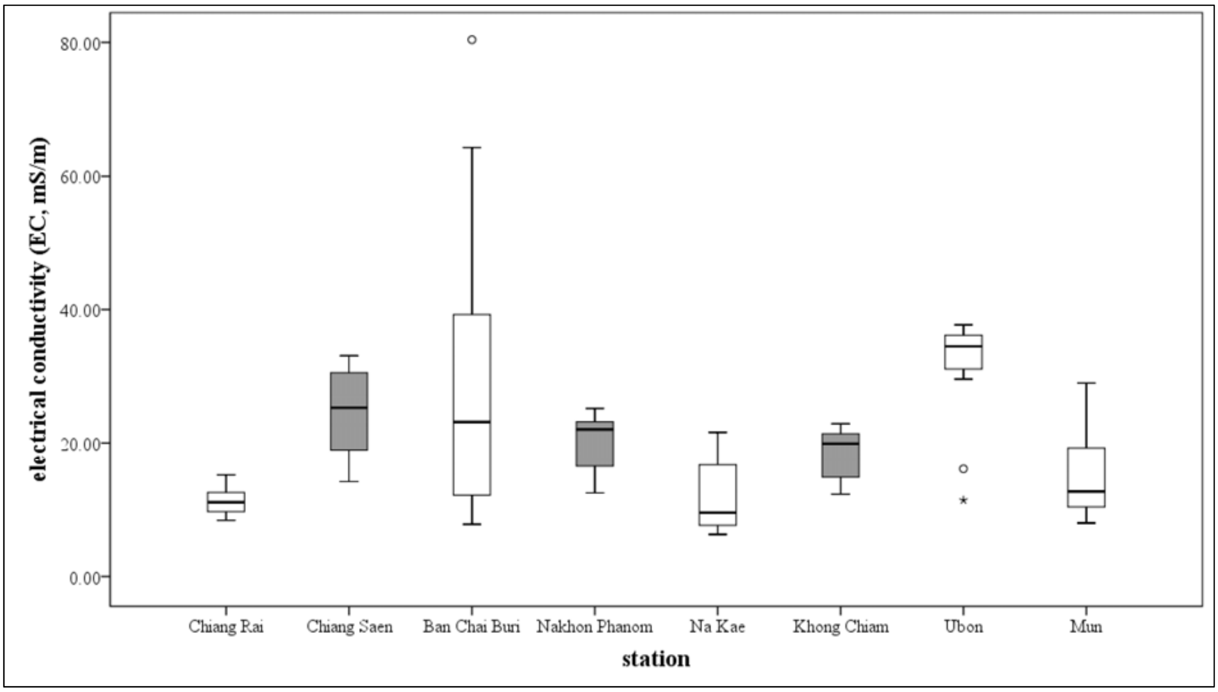


Figure 3.3 The observed EC at monitoring stations in 2013

The variation of EC values along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.4. These plot figures out the Mekong River, Kok River and Kam River (since 2001) had quite stable in EC values. While the EC values in Song Khram River showed the highly variation, because of this river had affected from salinized water discharge from rock salt farming in Ban Dung district, especially in dry season. However, the highest EC from Song Khram River seems not affecting the EC value in Mekong River all the record years since 1985.

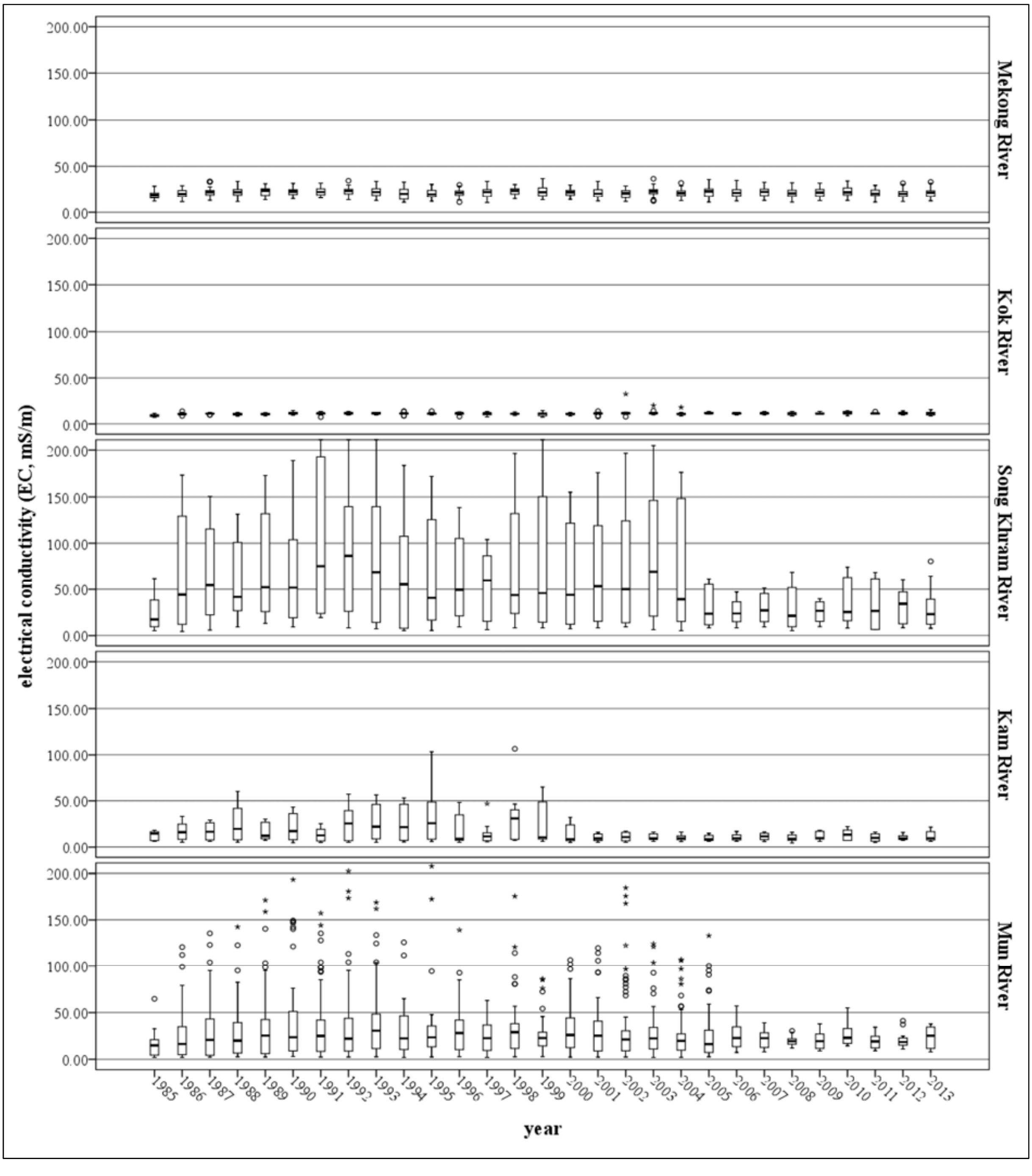


Figure 3.4 The variation of EC in Mekong River and tributaries from 1985 to 2013

3) Total Suspended Solids (TSS)

The average observed TSS concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 121, 97 and 96 mg/l, respectively. These average TSS concentrations were lower than average TSS concentrations of Mekong mainstream stations in 2012 only 8 mg/l, but these were not statistically significant differences in TSS concentrations for each station observed in 2012 with 95% confidence.

The average observed TSS concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 175, 13, 14, 13 and 12 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were only statistical significance at Ubon station with 15 mg/l decreasing.

The box plot of TSS concentrations (Figure 3.5) shows the variation of TSS at individual station. The monitoring stations in Mekong River had very relative high TSS variation and median than the tributaries, except Kok River (Chiang Rai sampling station) that also had more variation. However, the median at Chiang Saen station also lower than Chiang Rai station, so the tributaries should not be effected the TSS concentration in Mekong River. The TSS concentration at upstream station in Mekong River before discharge of Kok River necessary to determine the effect of Kok River to TSS of Mekong River in this part.

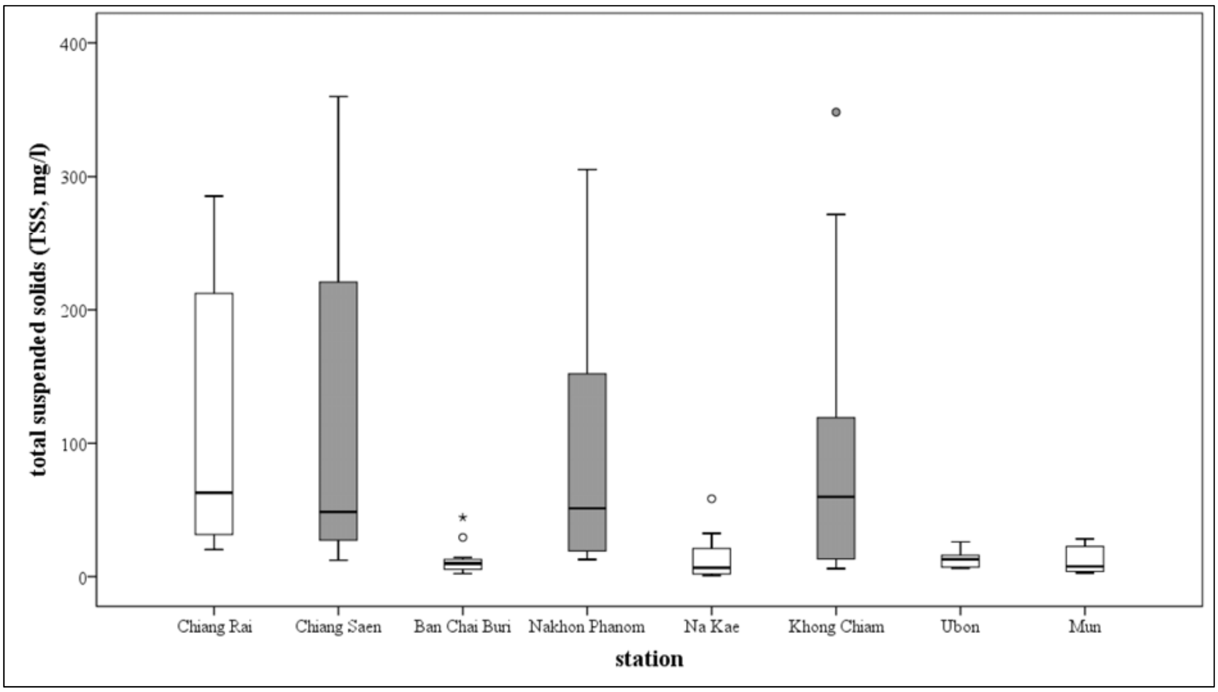


Figure 3.5 The observed TSS at monitoring stations in 2013

The variation of TSS concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.6. These plot figures out the Mekong River and Kok River had highly variation in TSS concentrations; especially Mekong River also had much extreme concentration frequently. While the TSS values in the three rest tributaries show the stable with very low concentration and variation.

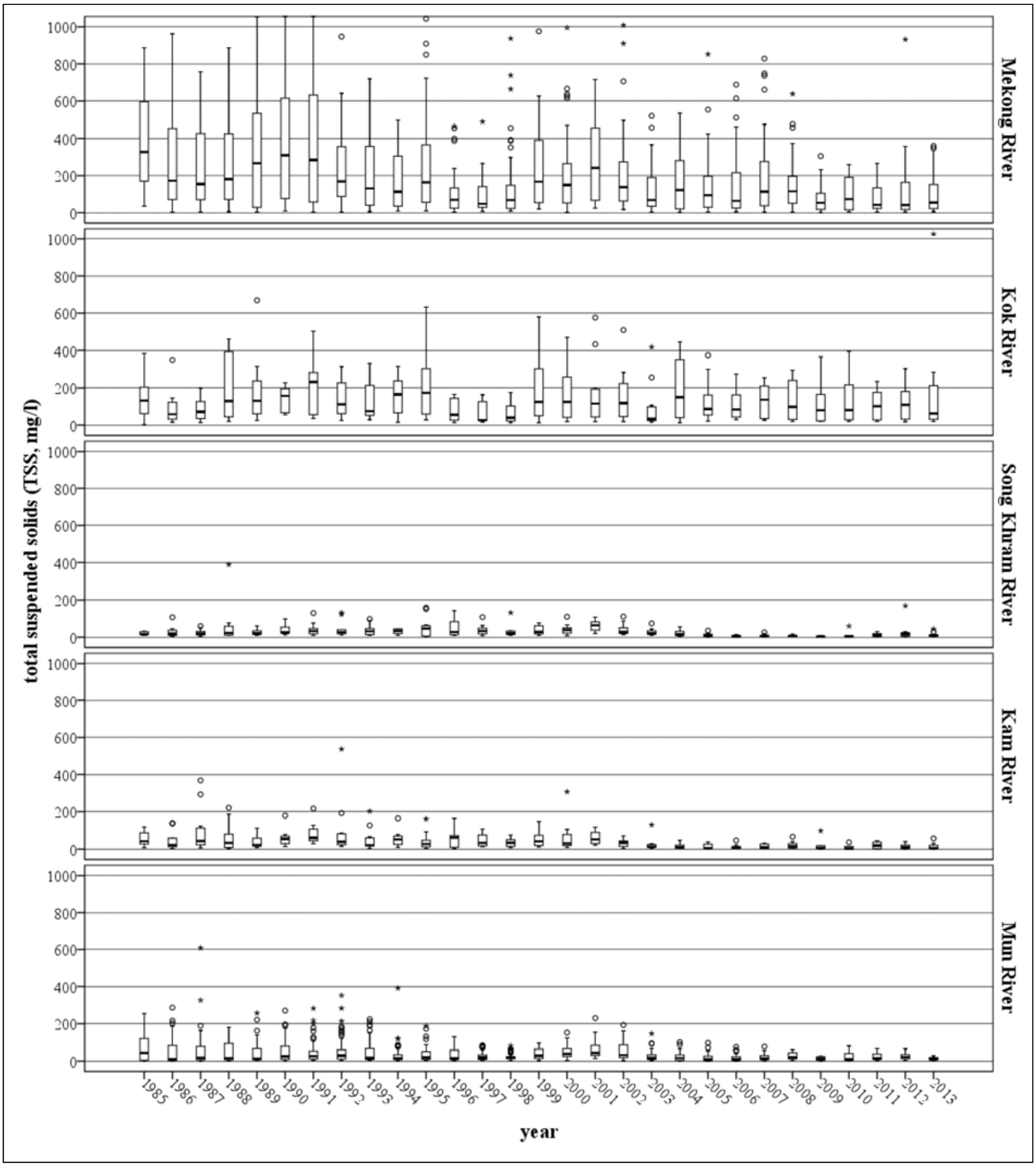


Figure 3.6 The variation of TSS in Mekong River and tributaries from 1985 to 2013

3.1.2 Nutrient

1) Ammonium nitrogen (NH_4^+-N)

The average observed NH_4^+-N concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.070, 0.063 and 0.067 mg/l, respectively. These average NH_4^+-N concentrations were higher than average NH_4^+-N concentrations of all Mekong mainstream stations in 2012 around 0.028 mg/l, but these were not statistically significant differences in NH_4^+-N concentrations for each stations observed in 2012 with 95% confidence.

The average observed NH_4^+-N concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.061, 0.078, 0.050, 0.060 and 0.043 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were not statistical significance at all stations.

The box plot of NH_4^+-N concentrations (Figure 3.7) shows the variation of NH_4^+-N at individual station. The monitoring stations in Mekong River had quite stable in variation range and mean, although the NH_4^+-N discharge from Song Khram River at Ban Chai Buri had higher concentration.

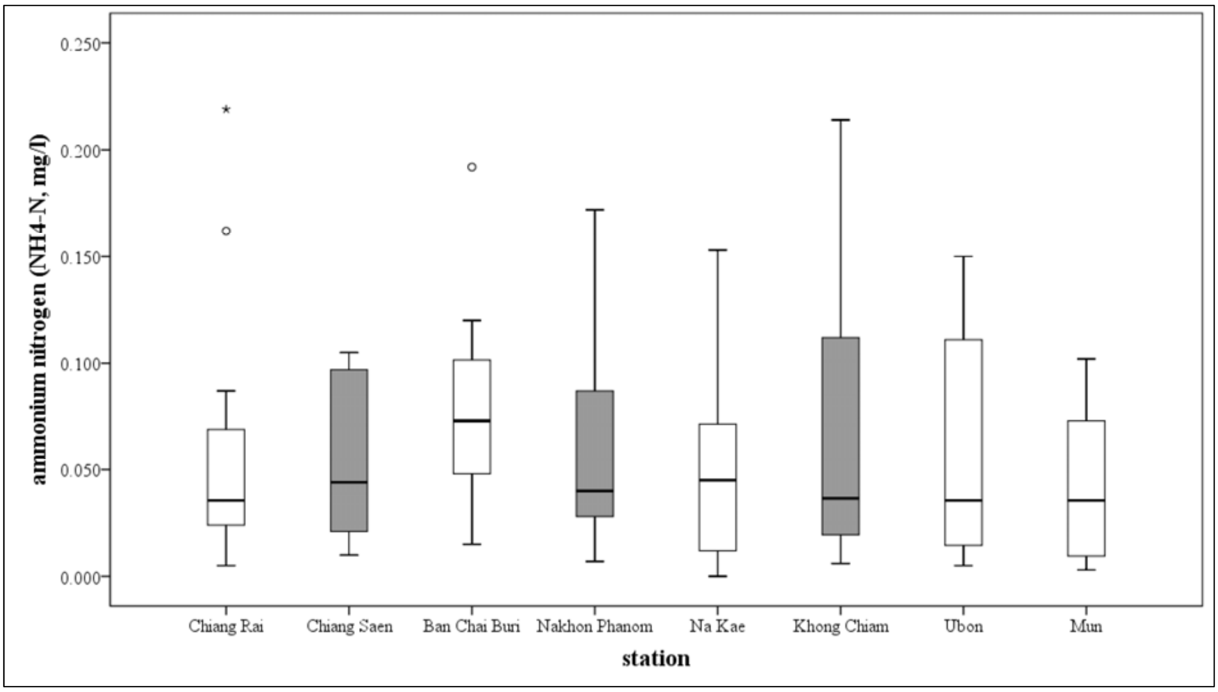


Figure 3.7 The observed NH_4^+-N at monitoring stations in 2013

The variation of NH_4^+-N concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.8. These plot figures out the Mekong River and all four tributaries had much variation in NH_4^+-N concentrations with correlated in variation. In 2013, Mekong River and all tributaries seem to have higher variation and mean concentration compare to the past four years.

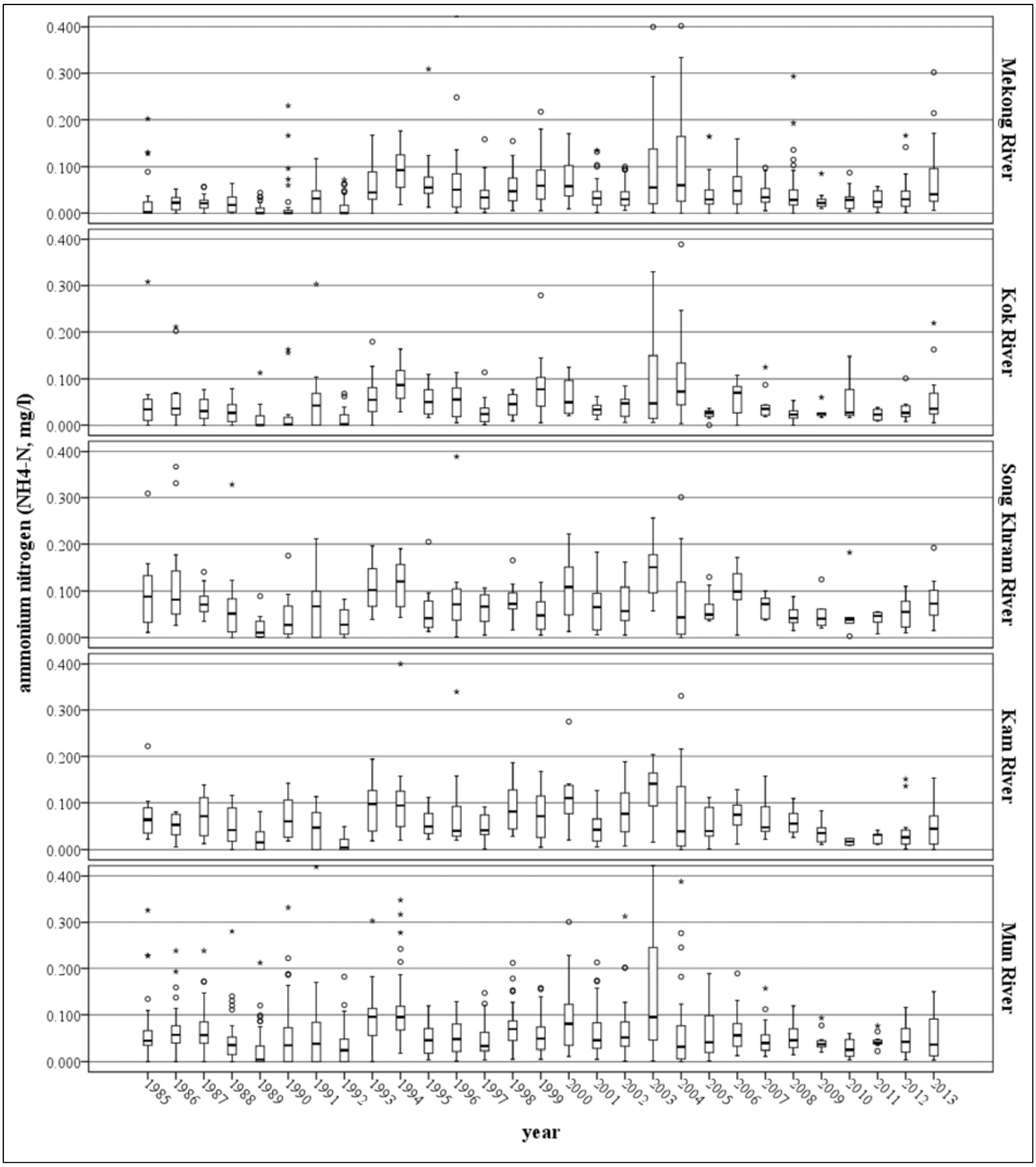


Figure 3.8 The variation of NH_4^+-N in Mekong River and tributaries from 1985 to 2013

2) Nitrite and nitrate nitrogen ($NO^{-}_{2\&3}$-N)

The average observed $NO^{-}_{2\&3}$-N concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.362, 0.245 and 0.239 mg/l, respectively. These average $NO^{-}_{2\&3}$-N concentrations were pretty higher than average $NO^{-}_{2\&3}$-N concentrations of all Mekong mainstream stations in 2012 around 0.039 mg/l, but these were not statistically significant differences in $NO^{-}_{2\&3}$-N concentrations for each stations observed in 2012 with 95% confidence.

The average observed $NO^{-}_{2\&3}$-N concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.251, 0.123, 0.045, 0.105 and 0.088 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were statistical significance only at all stations in Mun River tributaries (Ubon and Mun station), which shown decreasing in concentration around 0.150 mg/l.

The box plot of $NO^{-}_{2\&3}$-N concentrations (Figure 3.9) shows the variation of $NO^{-}_{2\&3}$-N at individual station. The monitoring stations in Mekong River at Chiang Saen, Nakhon Phanom and Khong Chiam had pretty high variation range with high concentration, although the $NO^{-}_{2\&3}$-N discharge from tributaries had the same variation but lower in median. Thus, discharge from tributaries should not be effected the $NO^{-}_{2\&3}$-N concentrations in Mekong River.

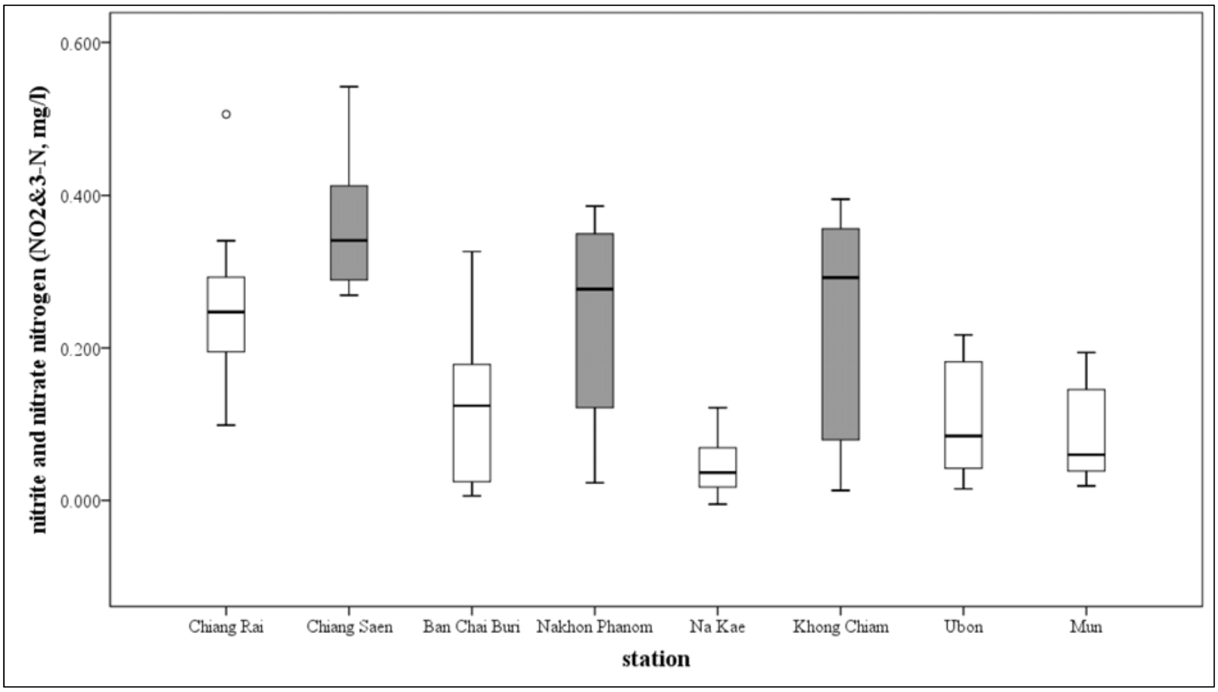


Figure 3.9 The observed $NO^{-}_{2\&3}$-N at monitoring stations in 2013

The variation of $NO_{2\&3}^{-}$-N concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.10. These plot figures out the Mekong River had quite stable variation range since 1985, and median of $NO_{2\&3}^{-}$-N seems to decrease since 2004. In the tributaries, these show the same result in smooth increasing of median since 2004, except Kam Rivers had sharp change. Please note that Song Khram River and Mun River had been moving to new station since 2004, so median and variation may be much different. Mun River is only tributaries which significantly decreasing in concentration in this year.

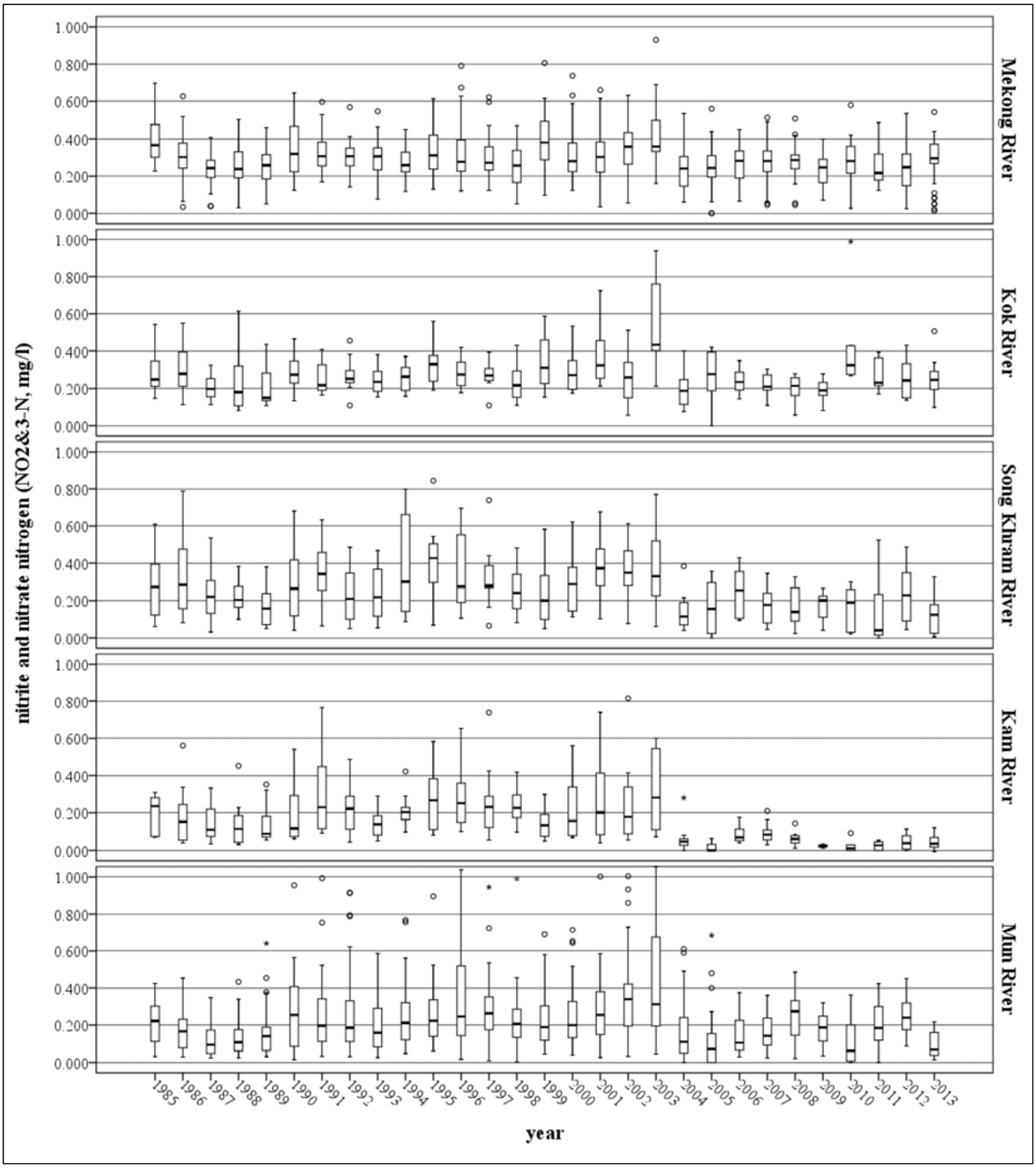


Figure 3.10 The variation of $NO_{2\&3}^{-}$-N in Mekong River and tributaries from 1985 to 2013

3) Total nitrogen (Total-N)

The average observed Total-N concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.532, 0.416 and 0.431 mg/l, respectively. These average Total-N concentrations were little higher than average Total-N concentrations of all mainstream stations in 2012 around 0.017 mg/l, but these still were not statistically significant differences in Total-N concentrations for all and each station observed in 2012 with 95% confidence, except at Khong Chiam station has higher concentration around 0.143 mg/l significantly.

The average observed Total-N concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.620, 0.345, 0.244, 0.438 and 0.346 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were statistical significance at station in Mun River.

The box plot of Total-N concentrations (Figure 3.11) shows the variation of Total-N at individual station. The all monitoring stations in Mekong River and tributary had the same high variation range with difference median concentrations. The median of Total-N in Mekong River had lower than in tributary, which discharge into upstream of monitoring station in Mekong River. Thus, discharge from tributaries should not be effected the Total-N concentrations in Mekong River.

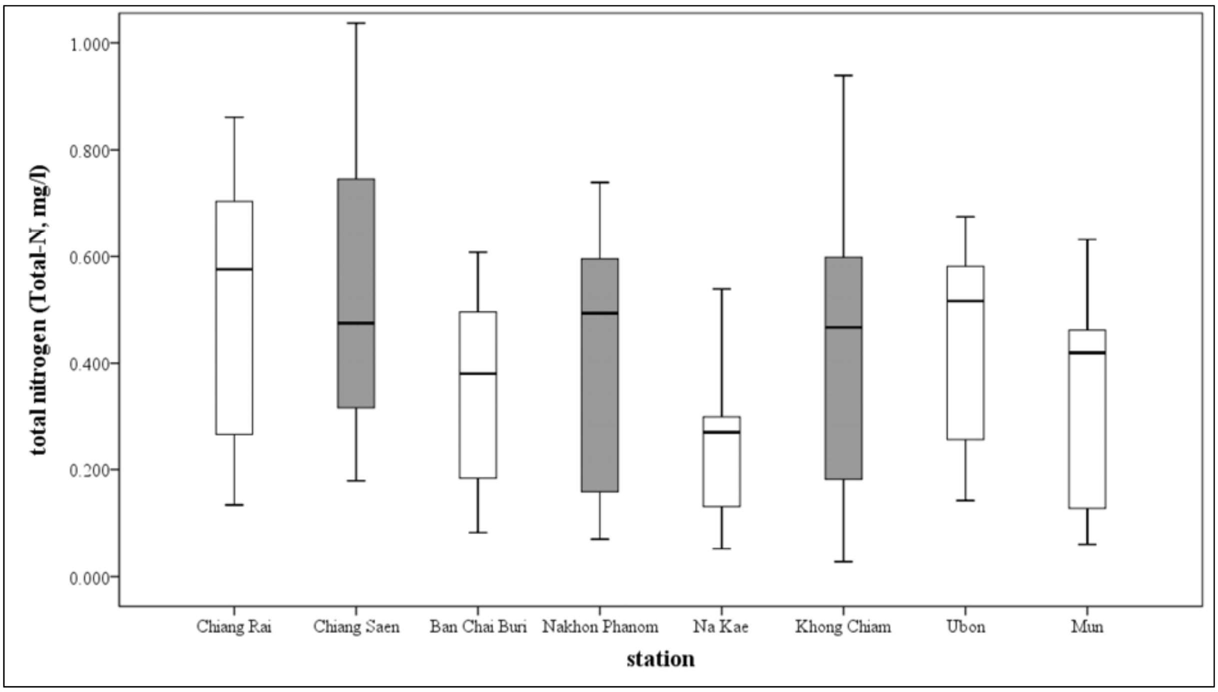


Figure 3.11 The observed Total-N at monitoring stations in 2013

The variation of Total-N concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.12. These plot figures out the Mekong River and all tributaries had the same pattern of variation range, and each stream had not much median concentration variation.

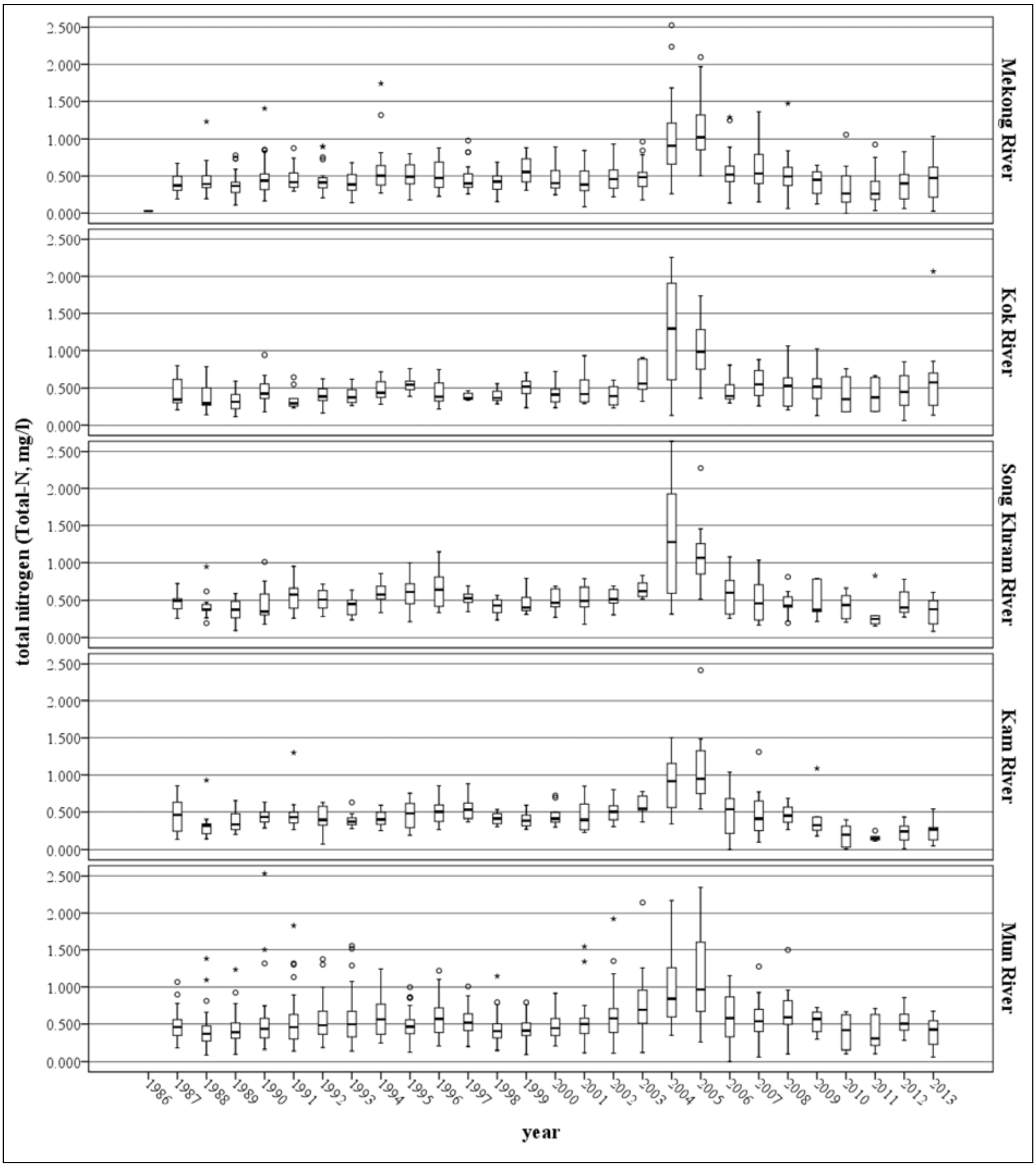


Figure 3.12 The variation of Total-N in Mekong River and tributaries from 1985 to 2013

4) Total phosphorus (Total-P)

The average observed Total-P concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.150, 0.122 and 0.110 mg/l, respectively. These average Total-P concentrations were little higher than average Total-P concentrations of same mainstreams station in 2012 around 0.024 mg/l, but these still were not statistically significant differences in Total-P concentrations for each stations observed in 2012 with 95% confidence, except at Khong Chiam station has higher concentration around 0.024 mg/l significantly

The average observed Total-P concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.214, 0.070, 0.053, 0.074 and 0.065 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were not statistical significant at all stations..

The box plot of Total-P concentrations (Figure 3.13) shows the variation of Total-N at individual station. The all monitoring stations in Mekong River and Kok River had the high variation of Total-P concentrations and the median of Total-P in Kok River was highest. The others tributaries had low variation and median in Total-P. Thus, discharge from tributaries should not be effected the Total-P concentrations in Mekong River.

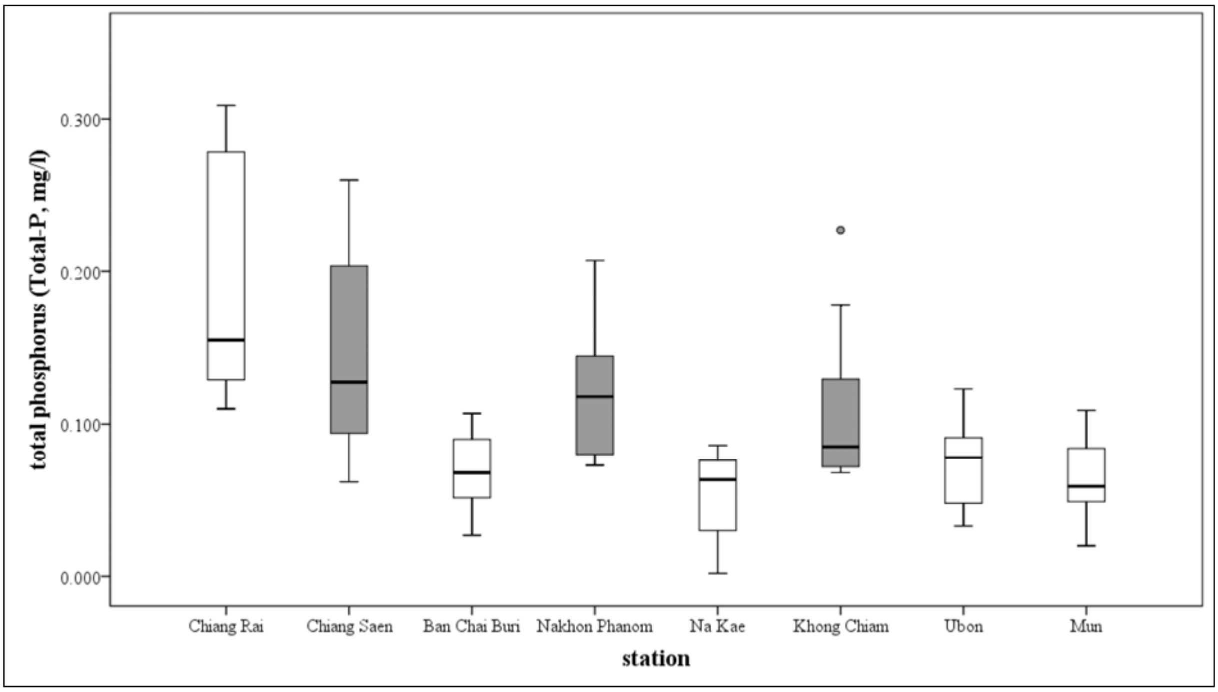


Figure 3.13 The observed Total-P at monitoring stations in 2013

The variation of Total-P concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.14. These plot figures out the Mekong River and Kok River had highly variation in Total-P concentrations, especially Kok River. While Total-P concentrations in the three rest tributaries show the stable with very low concentration and variation. These patterns had the same distribution compare to TSS concentration as Figures 3.6, two parameters should had the relationship in some reason.

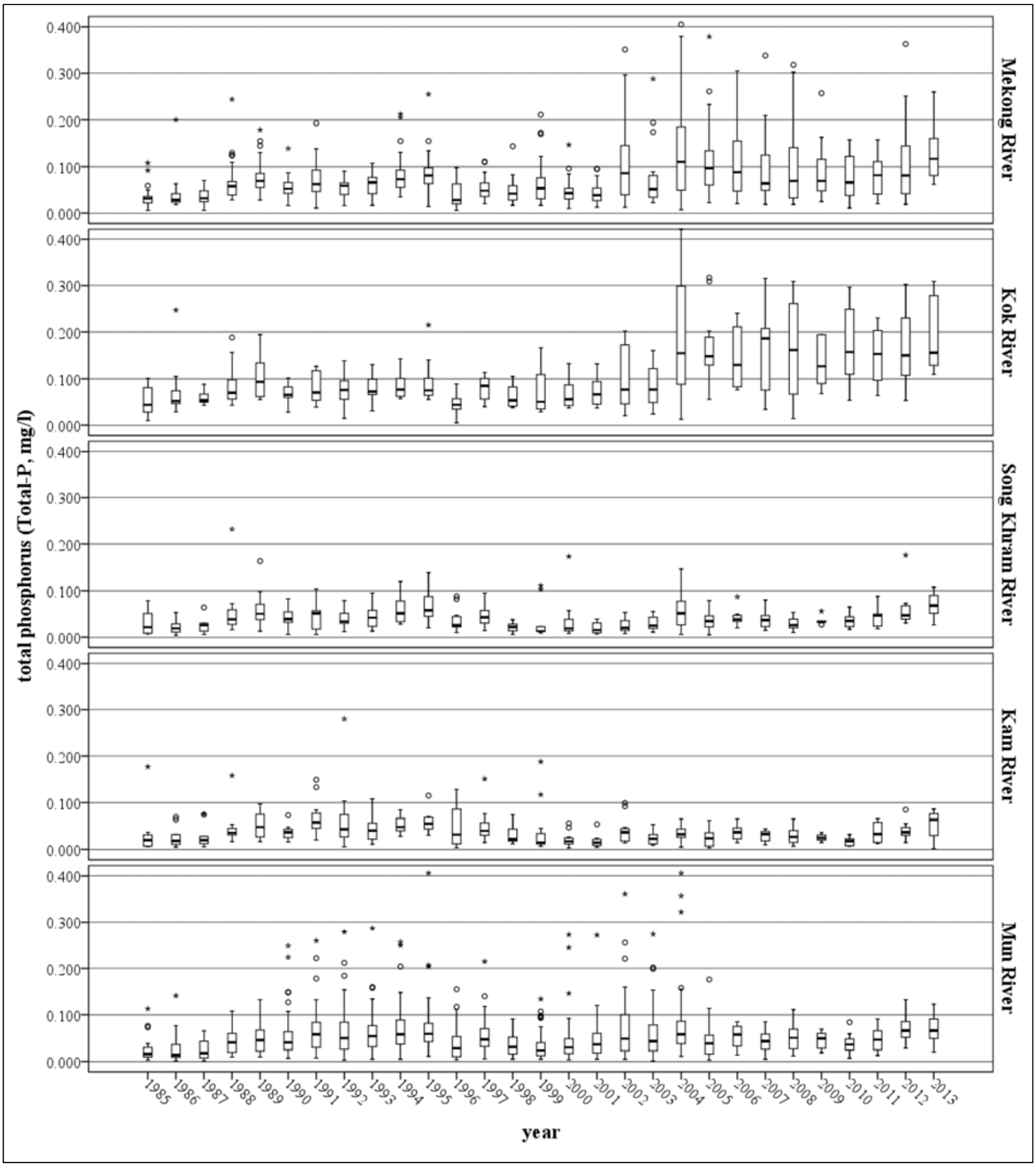


Figure 3.14 The variation of Total-P in Mekong River and tributaries from 1985 to 2013

3.1.3 Organic matters

1) Dissolved Oxygen (DO)

The average observed DO concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 9.05, 7.37 and 7.50 mg/l, respectively. These average DO concentrations were higher than average DO concentrations of all mainstream stations in 2012 around 0.75 mg/l, these were statistically significant differences in DO concentrations for mainstream and Chiang Sane station observed in 2012 with 95% confidence.

The average observed DO concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 7.87, 6.40, 6.59, 6.66 and 6.03 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were not statistical significance at all stations.

The box plot of DO concentrations (Figure 3.15) shows the variation of DO at individual station. The all monitoring stations in Mekong River had the pretty high variation range in the same compare to tributaries, and also higher median than all upstream tributaries. Thus, discharge from tributaries should not be effected the DO concentrations in Mekong River.

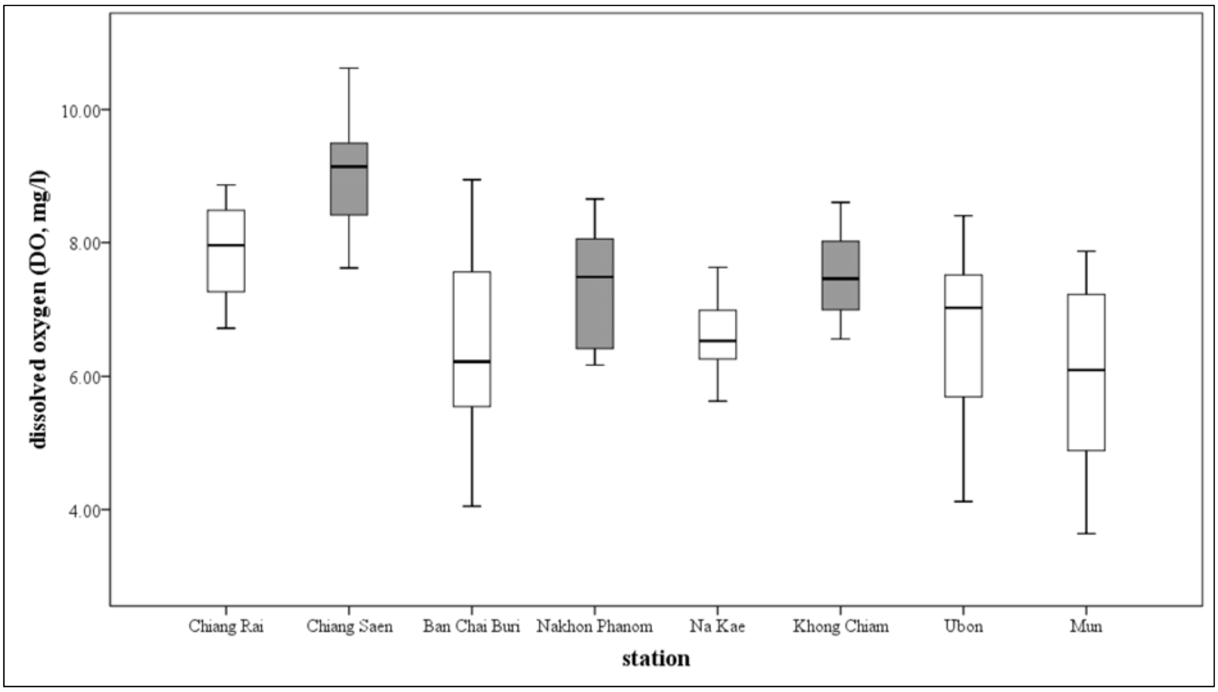


Figure 3.15 The observed DO at monitoring stations in 2013

The variation of DO concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.16. These plot figures out the Mekong River and all tributaries had the same pattern of variation range, and each stream had not much median concentration variation.

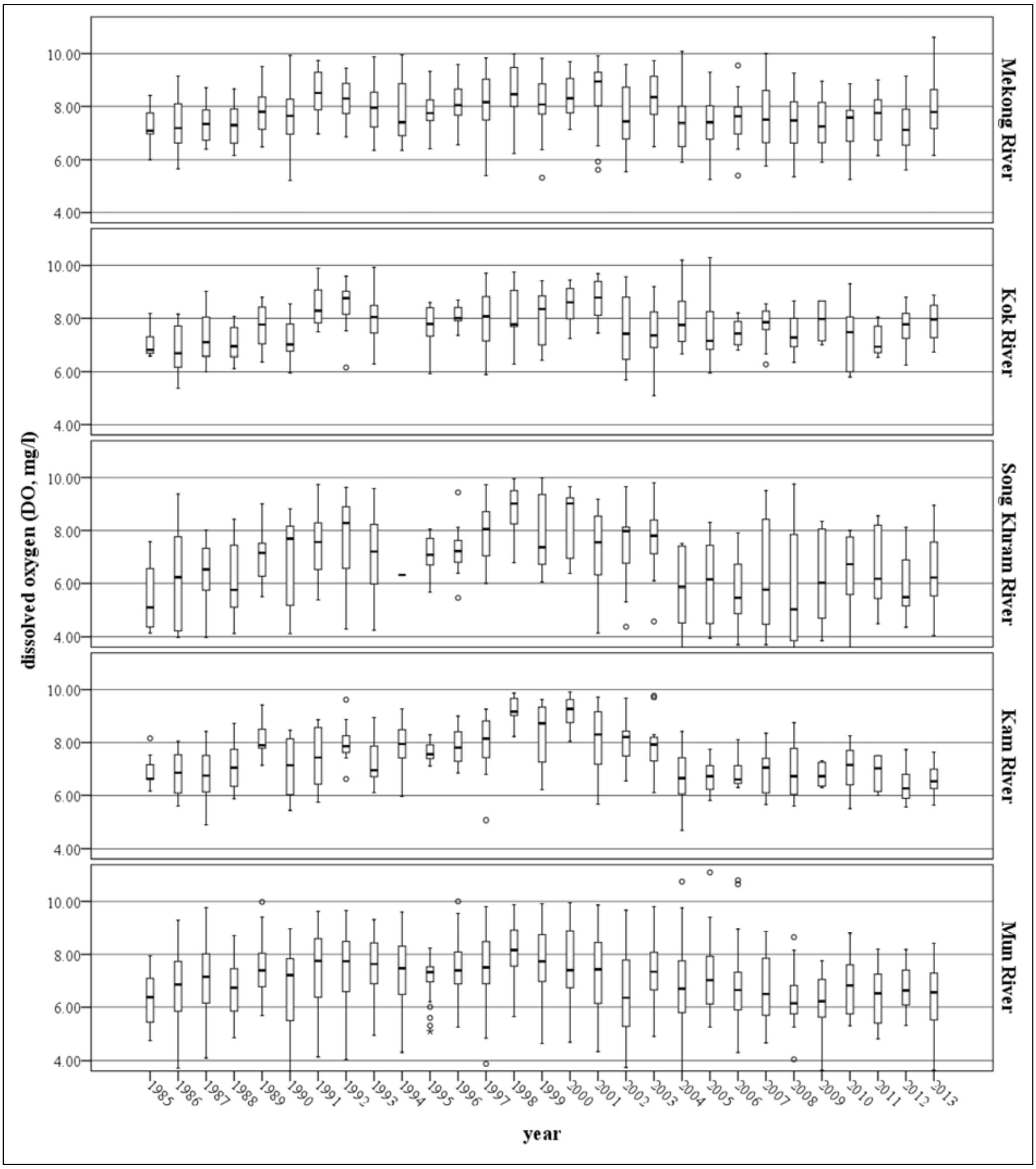


Figure 3.16 The variation of DO in Mekong River and tributaries from 1985 to 2013

2) Chemical Oxygen Demand (COD)

The average observed COD concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 3.50, 3.10 and 2.82 mg/l, respectively. These average COD concentrations were pretty higher than average COD concentrations of same station in 2012 around 0.68 mg/l, but these were not statistically significant differences in COD concentrations for each station observed in 2012 with 95% confidence.

The average observed COD concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 5.25, 2.84, 3.45, 4.82 and 3.92 mg/l, respectively. The difference between average concentrations in 2012 and 2013 with 95% confidence were not statistical significance at all stations.

The box plot of COD concentrations (Figure 3.17) shows the variation of COD at individual station. The all monitoring stations in Mekong River had the pretty high variation range in the same compare to tributaries, but lower median than all tributaries. Thus, discharge from tributaries should not be effected the COD concentrations in Mekong River.

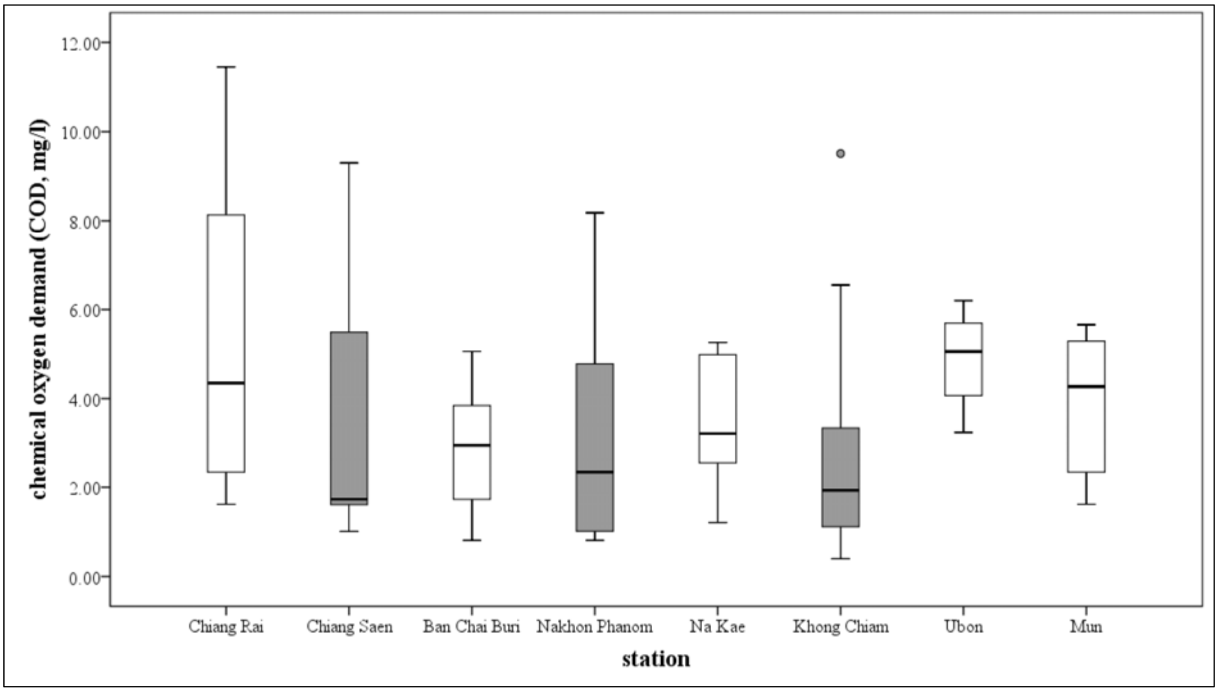


Figure 3.17 The observed COD at monitoring stations in 2013

The variation of COD concentrations along Mekong River and tributaries from 1985 to 2013 were compared in Figure 3.18. These plot figures out the Mekong River and all tributaries had the same pattern of variation range, and each stream had not much median concentration variation.

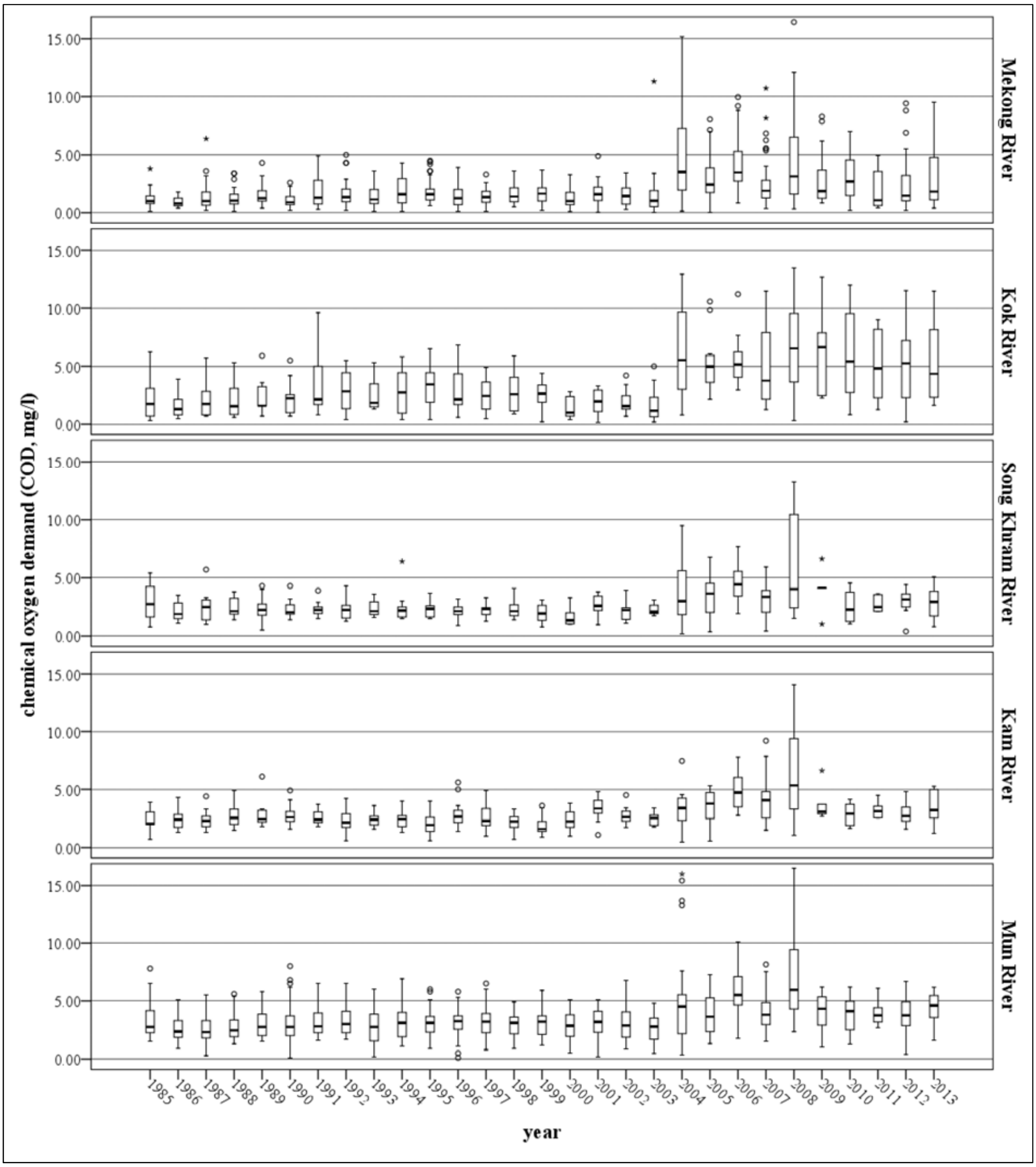


Figure 3.18 The variation of COD in Mekong River and tributaries from 1985 to 2013

3.2 Water Quality Indices (WQI)

Water Quality Index for aquatic life protection, human impacts and agricultural uses in 2013 were still determined following the Water Quality Indices methodology as applied in Appendix B. In this year, guideline values to developed WQI are picking from the Procedures for Water Quality approved in 2012, although these guidelines have not been officially approved by the MRC Joint Committee. The guidelines have been finalized by the Technical Body on Water Quality, a regional working group established to develop the guidelines, and have been used by the member countries to assess the Mekong River water.

Table 3.1 Water Quality Indices scores for Mekong River and tributaries in 2012 and 2013

Stations	Protection of aquatic life		Human impact		Agricultural use	
	2012	2013	2012	2013	2012	2013
Chaing Rai	9.50	9.25	6.46	5.63	10.00	10.00
Chiang Saen	9.58	9.58	7.50	6.04	10.00	10.00
Ban Chai Buri	9.58	9.33	6.88	5.63	10.00	9.58
Nakhon Phanom	9.67	9.58	7.08	6.46	10.00	10.00
Na Kae	10.00	10.00	8.54	7.50	10.00	10.00
Khong Chiam	9.83	9.75	8.13	7.08	10.00	10.00
Ubon	9.83	9.83	6.46	5.83	10.00	10.00
Mun	9.92	9.50	7.71	6.67	10.00	10.00

Remark Classify as following

Protection of aquatic life	Human impact	Agricultural use
High quality	Not impacted	None restriction
Good quality	Slightly impacted	Some restriction
Moderate quality	Impacted	Severe restriction
Poor quality	Severely impacted	

As illustrated in Table 3.1, the water quality indices for the aquatic life protection in year 2013 at 8 stations ranged from 9.25 to 10.00 which almost indicated as high quality. Even though the lowest index score was found in Kok River at Chiang Rai, the water quality was still high quality for aquatic living organisms. However, the indices scores also decreasing in 5 stations without one increasing, so this is a warning sign to aware the aquatic live may be more impacted.

Water quality index for agricultural uses were classified in 3 categories depend on purpose. Only electrical conductivity was used to determine the quality index, the guideline to defined parameter scores in assessing index for agricultural uses range shown while the electrical conductivity were lower than 70 mS/m, the water quality was most suitable for all types of agricultural. In year 2013, the maximum electrical conductivity value was 80.40 mS/m at Ban Chai Buri station in May, except this momentary extreme solely, the paddy field irrigation use, livestock use and general irrigation water quality indices at all stations were determined in good quality with full scale for all station as show in Table 3.1. Mekong River and tributaries can be used for all agricultural purpose with some restriction only at Song Khram River in dry season.

The index for human impacts on water quality ranged from 5.63 to 7.50 which indicated as severely impacted to impacted level. The lowest index was monitored in Song Khram River at Ban Chai Buri station and Kok River at Chiang Rai. Chiang Rai station is also the same station with lowest index for aquatic life protection. Mun River at Ubon Ratchatani central was also defined in severely for human impacts. The rest of all stations, except Na Kae and Khong Chiam station, were also defined in severely human impacts. These stations might get the high impact of total phosphorus and ammonium nitrogen in sewage discharge from domestic consumption into these rivers flow through the urban area and fertilizer from agricultural area. In overall, the indices of human impacts on water quality at monitoring stations comparing to the previous year (2012) were get worse than previous year.

Table 3.2 can be describe the clearly parameters scores which affected to water quality in Mekong River and all tributaries. The Chiang Rai station had zero scores in Total-P and low score in COD that likely to the Ubon and Nakhon Phanom station. Additional to these stations, also has very low score in NH_4^+-N. The parameters which indicated impact from human at Ban Chai Buri Station (Song Khram River) are DO and also NH_4^+-N. The main sources of these parameters are agricultural runoff with fertilizers, intensively fish cage culture and domestic sewage discharge.

Table 3.2 Parameters scores for each parameter consisted of Water Quality Indices on Human impact at each station

Station ID	Station Name	Parameters scores			
		DO	NH_4^+-N	Total-P	COD
H050104	Chiang Rai	12	8	0	7
H010501	Chiang Saen	12	8	1	8
H290103	Ban Chai Buri	6	3	7	11
H013101	Nakhon Phanom	12	7	3	9
H310102	Na Kae	10	6	11	9
H013801	Khong Chiam	12	8	4	10
H380104	Ubon	8	7	7	6
H380128	Mun	7	8	9	8

Remark: Possible maximum score for each parameter are 12.

Lower scores show the higher impact of each parameter from human.

Chapter 4
Conclusions and Recommendations

4.1 Conclusions

The water parameter related to water quality indices were conducted and analysis in year 2013. These parameters consist of pH, EC, TSS, NH_4^+-N, $NO_{2\&3}^-$-N, Total-N, Total-P, DO and COD. Almost parameters compared with data conducted and analysis in year 2012 were pretty different without statistical significant. In the other hand, the water quality parameters were not clearly change in predictable trend, except the nutrient parameters. The NH_4^+-N, $NO_{2\&3}^-$-N and Total-P parameters in year 2013 had a clearly higher around previous year along all stations in Mekong mainstream with 95% statistical significant.

The high concentrations of nutrients (NH_4^+-N, Total-P) and organic matters indication (COD) were still observed in the Kok River, Songkram River and Mun River more than it be in year 2012. These high concentration amounts were agricultural runoff with fertilizers, intensively fish cage culture and domestic sewage discharge from the localized urban via the tributaries. These have not been too much affected the water quality in the Mekong River. These conditions are probably the result of dilution due to the inflow of Mekong River. Thus, lower concentrations of these contents were found in Mekong River downstream of individual tributary discharge. However, the water quality indices along Mekong river main stream getting worse than previous year, it seems reasonable to conclude that the Mekong River self-purification had reduced.

In addition, the assessment of water quality index from data records at the Water Quality Monitoring Network (WQMN) of Mekong River Thailand in 2013 also provides a useful picture to quantify the major sources of pollution which affected the quality of the Mekong River and its tributaries. Three water quality indices (WQI) were applied. The WQI_{al} is ranged as high quality for the aquatic life protection in the Mekong River and tributaries. With regard to WQI_{hi}, the water quality index for human impacts on water quality all of each station was ranged from severely to slightly impacted class. The stations in Kok River, Song Khram River and Mun River were the relative low index values, defined as severely class which reflects the high population densities and urban development. For water quality index for agriculture uses ($WQI_{ag)}$, all tree subcategories consist of general irrigation, paddy rice irrigation and livestock and poultry are suitable for all agricultural purposes in all the mainstream and tributaries.

4.2 Recommendations

Composite samples obtained by combining portions of multiple grab samples of river water at specific spot should be introduced by specialist to provide more representative of water body. The capacity building program in the topic of collection of samples, sample storage and preservation must be arranged by the Environmental Program to harmonize the field technicians in sample handling. The guideline of method validation for current methodology uses should be proposed as an important issue for quality assurance to obtain reliable and comparable water quality data among the countries of Mekong Basin.

In this year, the nutrient parameters become higher concentration than previous, this should be the warning sign to initiated awareness on action plan to control water pollutions in water resources.

References

APHA, AWWA, and WPCP,1998. Standard Methods for the Examination of Water and Wastewater. 18th Edition. American Public Health Association, Washington D.C.

Barry, H.T., 2001. Transboundary Water Quality Issues in the Mekong River Basin. November 2001, Water Studies Centre, Monash University, Melbourne, Australia.

Clesceri *et al.*, 1998. The Standard Methods for the Examination of Water and Wastewater. 20th Edition. American Public Health Association.

Department of Water Resources, 2002. Report on water quality in the Lower Mekong River Basin (part of Thailand).

Pollution Control Department, 2000. Water Quality Standards and Criteria in Thailand. 4th ed, Ministry of Science, Technology and Environment. Thailand.

SIMACHAYA, W., 2003. MRC-Water Quality Monitoring Network (WQMN) Thailand Review. October 2003. Bangkok, Thailand.

Wilander, A., 2007. Lower Mekong Basin Water Quality Assessment. Copy

APPENDIX

Appendix A

Surface Water Quality Standards given by Thailand NEB

Table A1 Surface Water Quality Standards given by Thailand NEB

Parameter	Unit	Statistic	Sandard values for class *** 1	2	3	4	5
1. Odour, Colour, Taste	-	-	n	n	n	n	-
2. Temperature	°C	-	n	n	n	n	-
3. PH value	-	-	n	5-9	5-9	5-9	-
4. Dissolve oxygen	mg/l	P20	n	6	4	2	-
5. BOD (5 day,20 °C)	mg/l	P80	n	1.5	2.0	4.0	-
6. Coliform bacteria							
- Total coliform	MPN/100	P80		5,000	20,000	-	-
- Facial coliform	ml	P80					
7. NO_3-N	“	Max. allowance	n		5.0		-
8. NH_3-N	mg/l	“	n	:	0.5	:	-
9. Phenols	“	“	n	:	0.005	:	-
10. Cu	“	“	n	:	0.1	:	-
11. Ni	“	“	n	:	0.1	:	-
12. Mn	“	“	n	:	1.0	:	-
13. Zn	“	“	n	:	1.0	:	-
14. Cd	“	“	n	:	0.005*,0.05**	:	-
15. Cr (hexavalent)	“	“	n	:	0.05	:	-
16. Pb	“	“	n	:	0.05	:	-
17. Hg (total)	“	“	n	:	0.002	:	-
18. As	“	“	n	:	0.01	:	-
19. CN	“	“			0.005		
20. Radioactivity	“						
- Gross α	Becqurel/l	“	n	:	0.1	:	-
- Gross β	“	“	n	:	1.0	:	-
21. Pesticides (total)	mg/l	“	n	:	0.05	:	-
- DDT	µg/l	“	n	:	1.0	:	-
- α BHC	“	“	n	:	0.02	:	-
- Dieldrin	“	“	n	:	0.1	:	-
- Aldrin	“	“	n	:	0.1	:	-
- Heptachlor & Heptachlor epoxide	“	“	n	:	0.2	:	-
- Endrin	“	“	n		none		-

Note: 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 not more than 100 mg/l as $CaCO_3$

*** = Water Classification

Classification: Objective/Condition & Beneficial usages

Class 1: Extra clean fresh surface water resources using for:

(1) conservation, not necessary pass through water treatment processes require only ordinary process for pathogenic destruction

(2) ecosystem conservation which basic living organisms can spread breeding naturally

Class 2: Very clean fresh surface water resources using for:

(1) consumption which require the ordinary water treatment process before uses

(2) aquatic organism conservation for living and assisting for fishery

(3) fishery

(4) recreation

Class 3: Medium clean fresh surface water resources using for:

(1) consumption but have to pass through an ordinary treatment process before uses

(2) agriculture

Class 4: Fairly clean fresh surface water resources using for:

(1) consumption but require special water treatment process before uses

(2) Industry

(3) other activities

Class 5: The resources which are not classified in class 1-4 and using navigation

Appendix B
Water Quality Indices and guideline values

1. Water Quality Index for Aquatic Life Protection (WQI_{al})

Table B1 Parameters and threshold values used for assessing index for Aquatic Life Protection

Parameters	Symbol	Threshold		Weight factors
		Value	Unit	
pH value	pH	6 – 9		2
Electrical conductivity	EC	< 70	mS/m	2
Ammonia	NH_3	< 0.28	mg/l	2
Dissolved oxygen	DO	> 5	mg/l	2
Nitrite and nitrate nitrogen	$NO_{2\&3}^{-}$-N	< 0.7	mg/l	1
Total Phosphorous	Total-P	< 0.13	mg/l	1

Table B2 Guideline to defined parameter scores in assessing index for Aquatic Life Protection

Parameters	Requirement	Weight factors
pH, EC, NH_3, DO	Meets guidelines	2
	Does not meet guidelines	0
NO_{23}^{-}, Total-P	Meets guidelines	1
	Does not meet guidelines	0

For the calculation of a WQI the following equation is used:

$$WQI_{al} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}}{M} X10$$

where p = score of index parameter j at day i

n = number of parameter indices

m = number of sampling day in each year

M = maximum possible score in each year

Table B3 Score used for classifying the Water Quality Index for Aquatic Life Protection

Score	Class	Description
10 - 9	High Quality	All use are protected with a virtual absence of treat or impairment. No uses ever interrupted.
< 9 – 8	Good Quality	All use are protected with only a minor degree of treat or impairment. No uses ever interrupted.
< 8 – 7	Moderate Quality	Most uses protected but a few threatened or impaired a single use may be temporarily interrupted.
< 7	Poor Quality	Most uses threatened or impaired a several uses may be temporarily interrupted condition usually depart from natural or desirable levels.

2. Water Quality Index for Human Impact (WQI_{hi})

Table B4 Parameters and threshold values used for assessing index for Human Impacts

Parameter	Symbol	Threshold		Weight factor
		Value	Unit	
Dissolved oxygen	DO	≥ 6	mg/L	1
Chemical oxygen demand	COD	< 5	mg/L	1
Ammonium nitrogen	NH_4^+-N	< 0.05	mg/L	1
Total phosphorous	Total-P	< 0.08	mg/l	1

For the calculation of a WQI the following equation is used:

$$WQI_{hi} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}}{M} X10$$

where p = score of index parameter j at day i

n = number of parameter indices

m = number of sampling day in each year

M = maximum possible score in each year

Table B5 Score used for classifying the Water Quality Index for Human Impacts

Score	Human Impacts class
10 – 9.5	Not Impacted
< 9.5 – 8.5	Slightly Impacted
< 8.5 – 7	Impacted
< 7	Severely Impacted

3. Water Quality Index for Agricultural Uses (WQI_{ag})

Three different indices are used for water for agriculture use; general irrigation, paddy rice and livestock. Only conductivity is used and is divided into three groups with weights from 0 to 2.

Table B6 Salinity guideline to defined parameter scores in assessing index for Agricultural Uses

Agriculture use	Good quality	Fair quality	Poor quality
Irrigation Water - general	< 70	70 – 300	> 300
Irrigation Water – paddy rice	< 200	200 – 480	> 480
Livestock and poultry	< 500	500 – 800	> 800
Weight factor	2	1	0

For the calculation of a WQI the following equation is used:

$$WQI_{ag} = \frac{\sum_{i=1}^{m} p_i}{M} X10$$

where p = score of conductivity parameter at day i

m = number of sampling day in each year

M = maximum possible score in each year

Table B7 Score used for classifying the Water Quality Index for Agricultural Uses

Class	Quality	Scores
1	Good quality	8 – 10
2	Fair quality	7 – 8
3	Poor quality	< 7

Appendix C
Water quality parameters analysis results

Table C1 Statistical characteristic descriptions of WQI related parameters in 2013

Station	Values	Parameters									
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	NH_4^+ (mg/l)	$NO_{2\&3}^-$ (mg/l)	Total-N (mg/l)	Total-P (mg/l)	DO (mg/l)	COD (mg/l)
H010501 Chiang Saen	Range	6.5	0.51	18.86	348	0.292	0.273	0.858	0.198	3.00	8.29
	Minimum	20.0	6.15	14.24	12	0.010	0.269	0.179	0.062	7.62	1.01
	Maximum	26.5	6.66	33.10	360	0.302	0.542	1.037	0.260	10.62	9.30
	Mean	24.0	6.34	24.48	121	0.070	0.362	0.532	0.150	9.05	3.50
	SD	2.2	0.16	6.13	124	0.077	0.079	0.271	0.066	0.82	2.96
H013101 Nakhon Phanom	Range	9.0	0.51	12.69	292	0.165	0.363	0.669	0.134	2.49	7.37
	Minimum	21.0	6.23	12.46	13	0.007	0.023	0.070	0.073	6.17	0.81
	Maximum	30.0	6.74	25.15	305	0.172	0.386	0.739	0.207	8.66	8.18
	Mean	27.5	6.44	20.15	97	0.063	0.245	0.416	0.122	7.37	3.10
	SD	2.8	0.17	4.17	95	0.050	0.121	0.233	0.044	0.86	2.40
H013801 Khong Chiam	Range	6.5	0.52	10.59	342	0.209	0.382	0.911	0.159	2.05	9.10
	Minimum	23.5	6.24	12.27	6	0.006	0.013	0.028	0.068	6.56	0.40
	Maximum	30.0	6.76	22.85	348	0.214	0.395	0.939	0.227	8.61	9.51
	Mean	27.5	6.50	18.48	96	0.067	0.239	0.431	0.110	7.50	2.82
	SD	2.0	0.17	3.59	104	0.064	0.135	0.265	0.048	0.62	2.59
H050104 Chiang Rai	Range	10.8	0.82	6.82	1006	0.214	0.406	1.932	0.474	2.15	9.84
	Minimum	19.2	6.28	8.42	20	0.005	0.099	0.134	0.110	6.72	1.62
	Maximum	30.0	7.10	15.24	1027	0.219	0.506	2.066	0.584	8.87	11.45
	Mean	25.8	6.64	11.41	175	0.061	0.251	0.620	0.214	7.87	5.25
	SD	3.2	0.21	2.01	271	0.062	0.103	0.492	0.130	0.68	3.06
H290103 Ban Chai Buri	Range	9.0	0.98	72.60	42	0.178	0.321	0.526	0.080	4.90	4.25
	Minimum	22.0	6.23	7.80	2	0.015	0.006	0.082	0.027	4.05	0.81
	Maximum	31.0	7.21	80.40	44	0.192	0.326	0.608	0.107	8.95	5.06
	Mean	29.0	6.64	29.35	13	0.078	0.123	0.345	0.070	6.40	2.84
	SD	2.8	0.23	22.50	12	0.046	0.099	0.169	0.024	1.38	1.24
H310102 Na Kae	Range	9.0	0.93	15.35	57	0.153	0.127	0.488	0.084	2.00	4.04
	Minimum	22.0	6.22	6.25	1	0.000	0.005	0.052	0.002	5.63	1.21
	Maximum	31.0	7.15	21.60	58	0.153	0.122	0.539	0.086	7.63	5.26
	Mean	28.4	6.69	12.23	14	0.050	0.045	0.244	0.053	6.59	3.45
	SD	2.9	0.26	5.38	16	0.042	0.034	0.135	0.028	0.54	1.38
H380104 Ubon	Range	10.0	0.87	26.29	20	0.145	0.201	0.532	0.091	4.29	2.96
	Minimum	23.0	6.24	11.42	6	0.005	0.015	0.142	0.033	4.12	3.24
	Maximum	33.0	7.11	37.70	26	0.150	0.217	0.675	0.123	8.41	6.20
	Mean	29.4	6.61	31.29	13	0.060	0.105	0.438	0.074	6.66	4.82
	SD	3.0	0.23	8.18	6	0.050	0.071	0.180	0.026	1.23	0.95
H380128 Mun	Range	6.5	0.85	21.00	26	0.099	0.175	0.572	0.088	4.23	4.04
	Minimum	25.0	6.27	8.00	3	0.003	0.019	0.060	0.020	3.64	1.62
	Maximum	31.5	7.12	29.00	28	0.102	0.194	0.632	0.109	7.87	5.66
	Mean	29.1	6.66	15.31	12	0.043	0.088	0.346	0.065	6.03	3.92
	SD	2.1	0.22	6.93	9	0.034	0.059	0.190	0.025	1.37	1.45

Table C2 Statistical tests in differencing of WQI related parameters between 2012 and 2013

test	parameters	Mekong								Kok		Song Khram		Kam		Mun					
		ALL		Chiang Saen		Nakhon Phanom		Khong Chiam		Chiang rai		Ban Chai Buri		Na Kae		ALL		Ubon		Mun	
		mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p
paired sample t-test	PH	0.01	.913	-0.03	.787	0.01	.953	0.04	.756	0.13	.352	0.07	.594	0.04	.793	0.07	.423	0.07	.605	0.08	.563
	EC	0.77	.219	0.97	.527	0.78	.383	0.54	.501	-0.19	.659	-2.98	.509	2.10	.271	3.49	.055	8.02	.009	-1.04	.500
	TSS	-8	.738	17	.712	-60	.279	20	.194	59	.502	-14	.216	2	.704	-12	.000	-15	.001	-10	.052
	NH_4^+	0.028	.019	0.032	.214	0.024	.178	0.029	.172	0.029	.168	0.023	.112	0.008	.662	0.006	.585	0.004	.853	0.008	.461
	$NO_{2\&3}^-$	0.039	.028	0.037	.291	0.045	.225	0.037	.133	0.001	.987	-0.112	.076	0.000	.985	-0.150	.000	-0.156	.006	-0.144	.001
	Total-N	0.071	.093	0.050	.448	0.022	.817	0.143	.031	0.155	.341	-0.121	.150	0.011	.672	-0.137	.009	-0.172	.056	-0.102	.084
	Total-P	0.024	.024	0.040	.107	0.009	.650	0.024	.037	0.052	.237	0.009	.424	0.013	.204	0.002	.834	0.002	.846	0.001	.916
	DO	0.75	.000	1.50	.001	0.40	.184	0.37	.204	0.24	.392	0.39	.118	0.19	.359	-0.18	.634	0.29	.638	-0.66	.164
	COD	0.68	.129	0.98	.379	-0.19	.619	1.25	.085	0.19	.769	-0.13	.803	0.48	.230	0.45	.157	0.50	.365	0.40	.265
independent sample t-test	PH	0.01	.903	-0.03	.751	0.01	.945	0.04	.725	0.13	.344	0.07	.570	0.04	.786	0.07	.390	0.07	.578	0.08	.528
	EC	0.77	.533	0.97	.700	0.78	.654	0.54	.694	-0.19	.794	-2.98	.738	2.10	.252	3.49	.208	8.02	.027	-1.04	.674
	TSS	-8	.813	17	.735	-60	.456	20	.632	59	.503	-14	.332	2	.792	-12	.002	-15	.003	-10	.118
	NH_4^+	0.028	.025	0.032	.198	0.024	.213	0.029	.219	0.029	.167	0.023	.186	0.008	.689	0.006	.594	0.004	.842	0.008	.512
	$NO_{2\&3}^-$	0.039	.185	0.037	.336	0.045	.368	0.037	.487	0.001	.986	-0.112	.040	0.000	.988	-0.150	.000	-0.156	.001	-0.144	.000
	Total-N	0.071	.216	0.050	.635	0.022	.826	0.143	.140	0.155	.359	-0.121	.103	0.011	.848	-0.137	.012	-0.172	.024	-0.102	.151
	Total-P	0.024	.134	0.040	.193	0.009	.777	0.024	.312	0.052	.266	0.009	.500	0.013	.209	0.002	.820	0.002	.825	0.001	.909
	DO	0.75	.002	1.50	.001	0.40	.311	0.37	.199	0.24	.439	0.39	.480	0.19	.439	-0.18	.659	0.29	.664	-0.66	.195
	COD	0.68	.256	0.98	.396	-0.19	.857	1.25	.193	0.19	.886	-0.13	.789	0.48	.348	0.45	.284	0.50	.395	0.40	.488

Table C3 Overall results from water quality parameters analysis in 2013

Station	Date	General				Main Ions (meq/l)							Nutrients (mg/l)				Organic matters		Faecal Coliform (MPN/100ml)
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Alkalinity	SO_4^{2-}	Cl^{-}	NH_4^{+}	$NO_{2\&3}^{-}$	Total-N	Total-P	DO (mg/l)	COD (mg/l)	
H010501 Chiang Saen	16/1/2013	20.00	6.15	27.35	25	0.432	0.061	1.707	0.756	2.070	0.628	0.219	0.011	0.282	0.179	0.127	8.80	1.02	1,600
	13/2/2013	22.20	6.26	27.85	22	0.441	0.048	1.727	0.750	2.148	0.810	0.238	0.049	0.287	0.340	0.062	9.49	1.64	460
	12/3/2013	23.00	6.29	29.70	12	0.467	0.056	1.816	0.801	2.231	0.918	0.291	0.028	0.269	0.179	0.081	8.57	1.01	920
	17/4/2013	24.20	6.20	31.40	40	0.652	0.043	1.604	1.012	2.256	0.971	0.353	0.046	0.291	0.293	0.128	10.05	1.62	920
	14/5/2013	25.20	6.66	31.35	30	0.613	0.039	2.380	1.018	2.593	0.959	0.353	0.039	0.325	0.535	0.086	10.62	1.64	1,700
	18/6/2013	25.30	6.45	33.10	47	0.580	0.043	1.982	0.870	2.197	1.069	0.403	0.042	0.416	0.679	0.102	9.50	1.82	1,300
	16/7/2013	26.30	6.22	19.62	252	0.418	0.055	1.027	0.465	1.500	0.447	0.159	0.103	0.542	1.037	0.260	8.02	5.32	2,200
	15/8/2013	26.50	6.35	17.84	338	0.312	0.052	1.046	0.425	1.459	0.332	0.159	0.091	0.409	0.812	0.225	8.93	9.20	2,800
	17/9/2013	26.20	6.41	14.24	190	0.247	0.034	0.767	0.456	1.229	0.238	0.102	0.105	0.320	0.440	0.182	9.40	5.66	16,000
	15/10/2013	26.00	6.37	19.83	81	0.309	0.021	1.217	0.467	1.524	0.364	0.132	0.014	0.356	0.452	0.175	9.36	1.60	1,600
	12/11/2013	23.30	6.60	23.20	50	0.336	0.041	1.394	0.591	1.624	0.565	0.185	0.010	0.402	0.498	0.109	7.62	2.22	3,500
	17/12/2013	20.00	6.17	18.28	360	0.286	0.052	1.138	0.463	1.369	0.513	0.132	0.302	0.440	0.939	0.259	8.27	9.30	5,400
H013101 Nakhon Phanom	16/1/2013	22.00	6.23	22.95	16	0.385	0.052	1.538	0.594	1.995	0.342	0.185	0.015	0.084	0.095	0.123	8.61	0.82	79
	13/2/2013	27.00	6.31	23.35	22	0.379	0.038	1.459	0.553	1.884	0.484	0.251	0.046	0.160	0.222	0.073	7.40	1.02	240
	12/3/2013	30.00	6.51	23.35	16	0.365	0.050	1.476	0.588	1.894	0.566	0.212	0.080	0.081	0.078	0.092	7.57	0.81	540
	17/4/2013	29.00	6.42	22.85	13	0.489	0.028	1.272	0.674	1.880	0.481	0.235	0.028	0.023	0.070	0.084	7.70	1.21	280
	14/5/2013	29.00	6.74	25.15	38	0.621	0.035	1.808	0.692	2.055	0.529	0.466	0.068	0.386	0.588	0.076	8.41	2.86	920
	18/6/2013	30.00	6.30	22.30	152	0.499	0.037	1.247	0.481	1.598	0.462	0.349	0.034	0.372	0.739	0.143	6.48	4.45	240
	16/7/2013	28.00	6.28	16.25	153	0.421	0.019	0.903	0.295	1.224	0.303	0.238	0.147	0.297	0.603	0.146	6.30	5.11	460
	15/8/2013	29.00	6.31	12.46	305	0.258	0.048	0.811	0.259	1.104	0.120	0.159	0.172	0.279	0.551	0.196	6.17	8.18	490
	17/9/2013	28.00	6.71	12.88	256	0.265	0.027	0.751	0.316	1.149	0.118	0.160	0.034	0.274	0.587	0.207	6.35	6.67	1,400
	15/10/2013	29.00	6.47	16.84	96	0.286	0.016	1.060	0.387	1.416	0.172	0.159	0.007	0.275	0.370	0.140	7.16	3.20	540
	12/11/2013	28.00	6.68	21.75	63	0.354	0.041	1.355	0.509	1.667	0.414	0.237	0.028	0.385	0.655	0.113	7.62	1.82	2,800
	17/12/2013	21.00	6.39	21.65	39	0.332	0.040	1.429	0.539	1.712	0.524	0.185	0.094	0.326	0.436	0.074	8.66	1.01	920
H013801 Khong Chiam	16/1/2013	24.00	6.34	21.40	7	0.345	0.051	1.450	0.539	1.882	0.297	0.169	0.035	0.013	0.028	0.088	7.57	0.41	78
	13/2/2013	26.50	6.39	22.40	18	0.341	0.036	1.458	0.545	1.922	0.482	0.185	0.038	0.109	0.156	0.073	7.35	0.61	23
	12/3/2013	29.00	6.59	22.85	6	0.379	0.048	1.434	0.572	1.800	0.528	0.238	0.016	0.051	0.071	0.070	7.70	0.40	240
	17/4/2013	28.50	6.45	19.75	9	0.422	0.028	1.451	0.570	1.692	0.387	0.245	0.032	0.051	0.208	0.068	7.20	1.62	21
	14/5/2013	30.00	6.76	20.10	52	0.379	0.026	1.493	0.555	1.795	0.455	0.237	0.047	0.268	0.415	0.071	8.61	1.84	140
	18/6/2013	30.00	6.42	21.35	62	0.441	0.032	1.239	0.457	1.478	0.423	0.309	0.023	0.371	0.556	0.082	6.72	2.02	33
	16/7/2013	28.50	6.35	14.07	128	0.273	0.012	0.862	0.300	1.145	0.211	0.159	0.155	0.357	0.560	0.131	7.03	3.48	330
	15/8/2013	28.00	6.24	13.14	272	0.194	0.045	0.806	0.269	1.183	0.118	0.079	0.214	0.356	0.637	0.178	6.56	6.55	170
	17/9/2013	27.50	6.70	12.27	348	0.183	0.022	0.743	0.323	1.149	0.092	0.095	0.126	0.289	0.519	0.227	8.25	9.51	79
	15/10/2013	28.00	6.43	15.56	110	0.224	0.013	1.014	0.490	1.459	0.124	0.159	0.008	0.295	0.363	0.121	6.96	3.20	540
	12/11/2013	26.00	6.76	18.42	87	0.265	0.036	1.199	0.419	1.453	0.298	0.166	0.006	0.395	0.718	0.128	7.87	2.63	110
	17/12/2013	23.50	6.62	20.50	58	0.305	0.036	1.369	0.498	1.626	0.442	0.159	0.098	0.311	0.939	0.081	8.17	1.62	220

Table C3 Overall results from water quality parameters analysis in 2013 (Cont.)

Station	Date	General				Main Ions (meq/l)							Nutrients (mg/l)				Organic matters		Faecal Coliform (MPN/100ml)
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Alkalinity	SO_4^{2-}	Cl^{-}	NH_4^{+}	$NO_{2\&3}^{-}$	Total-N	Total-P	DO (mg/l)	COD (mg/l)	
H050104 Chiang Rai	16/1/2013	19.20	6.49	11.00	30	0.268	0.076	0.614	0.319	1.205	0.026	0.030	0.027	0.114	0.165	0.182	8.71	1.84	540
	13/2/2013	29.00	6.59	11.53	33	0.268	0.077	0.627	0.292	1.319	0.043	0.026	0.044	0.238	0.355	0.110	7.70	2.66	790
	12/3/2013	24.60	6.74	12.37	20	0.267	0.082	0.688	0.328	1.313	0.065	0.053	0.005	0.196	0.134	0.116	8.32	2.02	8
	17/4/2013	27.80	6.54	12.68	23	0.416	0.073	0.773	0.372	1.504	0.058	0.041	0.034	0.099	0.178	0.132	6.95	1.62	170
	14/5/2013	30.00	6.85	15.24	58	0.326	0.094	1.003	0.439	1.676	0.109	0.106	0.022	0.256	0.699	0.163	8.66	4.70	920
	18/6/2013	29.60	6.53	14.85	43	0.309	0.092	0.804	0.342	1.438	0.104	0.081	0.037	0.194	0.463	0.147	6.72	3.84	350
	16/7/2013	27.00	6.43	9.80	286	0.257	0.075	0.432	0.297	0.987	0.070	0.053	0.087	0.213	0.708	0.309	7.33	11.45	350
	15/8/2013	26.50	6.28	9.45	240	0.186	0.077	0.447	0.280	0.946	0.057	0.053	0.219	0.290	0.653	0.278	7.20	8.18	1,300
	17/9/2013	26.00	7.10	9.56	185	0.216	0.063	0.626	0.229	0.951	0.049	0.052	0.051	0.270	0.590	0.279	7.85	8.49	1,300
	15/10/2013	25.20	6.57	10.82	94	0.183	0.035	0.610	0.299	1.073	0.048	0.026	0.020	0.295	0.562	0.144	8.87	4.00	920
	12/11/2013	23.40	6.87	11.21	67	0.192	0.055	0.636	0.280	1.026	0.036	0.034	0.026	0.340	0.861	0.126	8.07	6.07	1,700
	17/12/2013	20.80	6.74	8.42	1027	0.241	0.079	0.376	0.176	0.728	0.078	0.053	0.162	0.506	2.066	0.584	8.07	8.09	1,600
H290103 Ban Chai Buri	16/1/2013	24.00	6.50	51.60	5	3.551	0.120	0.626	0.448	0.715	0.158	4.117	0.057	0.134	0.225	0.094	6.53	2.25	78
	13/2/2013	30.00	6.41	64.30	5	4.522	0.131	0.581	0.501	0.678	0.244	4.574	0.025	0.065	0.144	0.058	8.10	3.07	8
	12/3/2013	31.00	6.66	26.90	2	0.589	0.061	1.522	0.633	1.950	0.617	0.449	0.073	0.030	0.082	0.061	7.45	1.21	540
	17/4/2013	29.00	6.60	23.40	11	0.503	0.028	1.293	0.692	1.992	0.493	0.247	0.015	0.006	0.205	0.086	8.95	1.21	49
	14/5/2013	30.00	6.82	80.40	10	6.998	0.176	0.685	0.743	0.758	0.256	7.687	0.192	0.147	0.486	0.080	5.95	3.07	130
	18/6/2013	31.00	6.58	18.75	44	1.173	0.068	0.246	0.131	0.399	0.099	1.182	0.110	0.194	0.506	0.107	5.75	5.06	33
	16/7/2013	30.00	6.53	10.49	29	0.776	0.028	0.216	0.108	0.276	0.048	0.854	0.120	0.115	0.384	0.104	6.49	4.09	3,500
	15/8/2013	30.00	6.23	7.80	14	0.450	0.052	0.152	0.104	0.315	0.030	0.423	0.067	0.008	0.420	0.064	4.64	4.09	11
	17/9/2013	30.50	7.21	7.82	6	0.510	0.036	0.206	0.182	0.357	0.033	0.513	0.039	0.019	0.163	0.072	4.05	2.83	170
	15/10/2013	31.00	6.65	13.79	10	0.818	0.032	0.196	0.265	0.515	0.051	0.793	0.073	0.163	0.377	0.039	5.35	3.60	49
	12/11/2013	30.00	6.84	22.90	6	1.451	0.070	0.316	0.178	0.470	0.065	1.581	0.075	0.263	0.608	0.027	5.84	2.83	1,300
	17/12/2013	22.00	6.65	24.00	10	0.860	0.058	1.095	0.440	1.284	0.375	0.740	0.093	0.326	0.548	0.045	7.67	0.81	540
H310102 Na Kae	16/1/2013	23.00	6.55	20.50	1	1.154	0.055	0.531	0.251	0.715	0.143	1.195	0.006	0.005	0.052	0.079	6.62	1.43	23
	13/2/2013	27.00	6.40	15.84	1	0.829	0.043	0.419	0.195	0.754	0.118	0.714	0.040	0.040	0.081	0.033	7.10	2.66	7
	12/3/2013	29.50	6.93	15.49	1	0.825	0.053	0.377	0.205	0.638	0.114	0.767	0.000	0.028	0.097	0.054	7.63	2.83	94
	17/4/2013	29.50	6.74	17.59	6	1.240	0.048	0.427	0.237	0.752	0.107	1.180	0.011	0.010	0.165	0.078	7.00	1.21	110
	14/5/2013	31.00	6.76	21.60	18	1.460	0.067	0.530	0.223	0.798	0.174	1.480	0.153	0.122	0.539	0.073	6.93	5.11	79
	18/6/2013	31.00	6.60	9.42	24	0.403	0.033	0.283	0.106	0.479	0.033	0.376	0.061	0.075	0.277	0.074	5.84	5.06	350
	16/7/2013	29.00	6.47	8.63	17	0.407	0.021	0.297	0.205	0.553	0.028	0.317	0.069	0.061	0.403	0.074	6.25	4.09	80
	15/8/2013	30.00	6.22	6.46	32	0.258	0.044	0.219	0.195	0.434	0.028	0.212	0.094	0.010	0.316	0.049	5.63	4.91	5
	17/9/2013	30.50	7.15	6.25	58	0.211	0.024	0.316	0.134	0.476	0.031	0.205	0.074	0.072	0.283	0.086	6.40	5.26	110
	15/10/2013	30.00	6.65	7.19	7	0.256	0.009	0.277	0.236	0.558	0.038	0.238	0.028	0.067	0.281	0.010	6.27	3.60	33
	12/11/2013	28.00	7.03	8.06	5	0.294	0.032	0.318	0.114	0.513	0.011	0.295	0.013	0.033	0.169	0.002	6.98	2.43	70
	17/12/2013	22.00	6.80	9.70	3	0.443	0.036	0.344	0.130	0.471	0.041	0.423	0.050	0.025	0.264	0.027	6.44	2.83	17

Table C3 Overall results from water quality parameters analysis in 2013 (Cont.)

Station	Date	General				Main Ions (meq/l)							Nutrients (mg/l)				Organic matters		Faecal Coliform (MPN/100ml)
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	Na^+	K^+	Ca^{2+}	Mg^{2+}	Alkalinity	SO_4^{2-}	Cl^-	NH_4^+	$NO_{2\&3}^-$	Total-N	Total-P	DO (mg/l)	COD (mg/l)	
H380104 Ubon	16/1/2013	26.00	6.43	32.60	11	1.874	0.087	0.818	0.370	1.167	0.072	1.954	0.098	0.112	0.238	0.123	7.05	3.27	N/A
	13/2/2013	26.00	6.38	37.65	6	2.305	0.077	0.788	0.372	1.206	0.114	2.115	0.027	0.046	0.214	0.055	8.25	3.89	N/A
	12/3/2013	32.00	6.84	34.05	7	2.123	0.090	0.596	0.382	1.050	0.107	1.996	0.005	0.058	0.276	0.076	7.33	4.25	N/A
	17/4/2013	30.00	6.60	35.15	7	2.783	0.085	0.705	0.454	1.128	0.093	2.592	0.013	0.015	0.142	0.086	7.70	3.24	N/A
	14/5/2013	32.00	6.64	37.00	13	2.759	0.078	0.922	0.446	1.516	0.098	2.614	0.016	0.056	0.539	0.093	8.41	5.73	N/A
	18/6/2013	32.00	6.51	37.70	17	2.418	0.070	0.650	0.355	1.238	0.105	2.202	0.012	0.038	0.612	0.080	5.75	5.26	N/A
	16/7/2013	33.00	6.46	34.45	13	3.042	0.061	0.465	0.305	0.711	0.151	2.938	0.127	0.217	0.675	0.089	5.26	4.50	N/A
	15/8/2013	30.00	6.24	34.50	26	2.192	0.087	0.577	0.307	0.749	0.182	2.115	0.124	0.198	0.662	0.074	6.22	5.73	N/A
	17/9/2013	29.00	7.11	16.08	23	1.148	0.048	0.366	0.268	0.594	0.104	1.033	0.072	0.174	0.497	0.097	7.00	5.66	N/A
	15/10/2013	32.00	6.54	11.42	15	0.539	0.030	0.317	0.152	0.558	0.051	0.476	0.033	0.030	0.319	0.039	4.12	6.20	N/A
	12/11/2013	28.00	6.77	29.60	15	1.642	0.066	0.751	0.322	1.111	0.059	1.805	0.038	0.125	0.536	0.041	5.64	5.26	N/A
	17/12/2013	23.00	6.83	35.25	7	2.106	0.079	0.927	0.390	1.241	0.094	1.930	0.150	0.190	0.551	0.033	7.23	4.85	N/A
H380128 Mun	16/1/2013	26.00	6.47	14.84	4	0.687	0.059	0.529	0.231	0.753	0.117	0.740	0.008	0.078	0.063	0.109	6.91	1.84	45
	13/2/2013	27.50	6.48	11.87	4	0.547	0.040	0.392	0.162	0.678	0.054	0.476	0.026	0.043	0.175	0.044	7.20	2.66	11
	12/3/2013	30.00	6.82	8.00	3	0.365	0.044	0.267	0.123	0.450	0.048	0.370	0.003	0.037	0.060	0.057	7.70	2.02	13
	17/4/2013	31.00	6.54	10.37	5	0.516	0.032	0.464	0.176	0.752	0.093	0.412	0.011	0.019	0.080	0.068	7.25	1.62	33
	14/5/2013	31.50	6.75	23.00	8	1.534	0.072	0.652	0.267	1.157	0.078	1.487	0.006	0.039	0.486	0.061	7.87	4.70	49
	18/6/2013	31.00	6.72	15.52	7	0.844	0.045	0.332	0.157	0.599	0.052	0.779	0.093	0.039	0.438	0.042	4.38	3.84	33
	16/7/2013	31.50	6.53	13.51	11	0.883	0.045	0.378	0.173	0.592	0.054	0.870	0.089	0.194	0.632	0.100	3.64	4.50	33
	15/8/2013	30.00	6.27	10.49	22	0.576	0.060	0.257	0.242	0.473	0.094	0.502	0.102	0.155	0.555	0.064	5.72	5.32	70
	17/9/2013	29.50	7.12	9.10	28	0.580	0.035	0.382	0.062	0.436	0.055	0.496	0.047	0.115	0.395	0.100	6.00	5.66	110
	15/10/2013	29.50	6.52	10.43	23	0.482	0.028	0.288	0.337	0.558	0.045	0.423	0.036	0.038	0.425	0.054	4.07	5.60	110
	12/11/2013	27.00	6.78	29.00	23	1.604	0.065	0.738	0.316	0.983	0.061	1.814	0.035	0.136	0.414	0.056	5.40	5.26	79
	17/12/2013	25.00	6.91	27.60	3	1.688	0.059	0.660	0.286	0.942	0.050	1.586	0.057	0.164	0.425	0.020	6.19	4.04	27