CONTENTS

Page

Acknowledgements	c
Abstract in Thai	d
Abstract in English	f
List of Tables	k
List of Figures	n
List of Abbreviations	r
List of Symbols	S
Chapter 1 Introduction	1
1.1 Ping river	1
1.1.1 General background	1
1.1.2 Water quality parameters for the Ping river	2
1.2 Sequential injection analysis (SIA)	4
1.3 SIA colorimetric analysis	6
1.4 Iron	7
1.4.1 General background	7
1.4.2 Sequential injection analysis methods for iron determination	8
1.5 Manganese	11
1.5.1 General background	11

1.5.2 Sequential injection analysis methods for manganese	11
determination	
1.6 Phosphate	13
1.6.1 General background	13
1.6.2 Sequential injection analysis methods for phosphate	14
determination	
1.7 Ammonium	16
1.7.1 General background	16
1.7.2 Sequential injection analysis methods for ammonium	16
determination	
1.8 Aims of these studies	18
6 0 13	
Chapter 2 Experimental	19
2.1 Apparatus and components	19
2.2 Chemicals	19
2.3 Preparation of standard solutions and reagents	20
2.4 Sampling sites	23
2.5 Instrument setups	25
2.5.1 SI-colorimetric system for iron determination	25
2.5.2 SI-colorimetric system for manganese determination	27
2.5.3 SI-colorimetric system for phosphate determination	28
2.5.4 SI-colorimetric system for ammonium determination	30
2.6 Linearity of calibration graph	33
2.7 Limits of detection	33
2.8 Recoveries	33
2.9 Precision	33
2.10Interferences	33
2.11 Analysis of real water samples	34

Chapter	3	Posulte	and	Discu	ccion
Chapter	3	Results	anu	Discu	SSIOII

3.1	Sequential injection analysis (SIA) system for iron, manganese,	35
	phosphate and ammonium determination	
	3.1.1 Optimization	35
	3.1.2 Calibration graphs and analytical features	49
	3.1.3 Recoveries and comparison to standard method	52
	3.1.4 Precisions	55
3.2	Effect of interferences	55
3.3	Application to water samples from the Ping river	58
References	Conclusion s nce of the research work to Thailand	66 68 76 90
Curriculun	n Vitae	91

35

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

LIST OF TABLES

Table 1.1	Classification of water quality parameters	3
Table 1.2	Some researches on sequential injection analysis systems for determination of iron	9
Table 1.3	Some researches on sequential injection analysis systems for determination of manganese	12
Table 1.4	Some researches on sequential injection analysis systems for determination of phosphate	15
Table 1.5	Some researches on sequential injection analysis systems for determination of ammonium	17
Table 2.1	Details of various sampling points as shown in Figure 2.1	24
Table 2.2	The conditions for study effect of flow rate for iron determination	26
Table 2.3	The conditions for study effect of concentration of 1,10-phenanthroline for iron determination	26
Table 2.4	The conditions for study effect of sample volume for iron determination	26
Table 2.5	The conditions for study effect of flow rate for manganese determination	27
Table 2.6	The conditions for study effect of concentration of formaldoxime for manganese determination	28

29
29
30
30
31
31
32
32
32
53
54

Table 3.3	Effect of some interferences for determination of iron,	56
	manganese, phosphate and ammonium by the proposed system	
Table 3.4	Concentrations of iron in water samples determined by	58
	the proposed system	
Table 3.5	Concentrations of manganese in water samples determined	60
	by the proposed system	
Table 3.6	Concentrations of phosphate in water samples determined by	62
	the proposed system	
Table 3.7	Concentrations of ammonium in water samples determined	64
	by the proposed system	
Table 5.1	Some chemistry parameters of water samples in February 2015	87
Table 5.2	Some chemistry parameters of water samples in May 2015	88
Table 5.3	Some chemistry parameters of water samples in August 2015	88
Table 5.4	Some chemistry parameters of water samples in November 2015	89
	AI UNIVER	

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

LIST OF FIGURES

Figure 1.1	The map of the Ping river	3
Figure 1.2	Schematic of simple SIA system. HC = holding,	5
	RC = reaction coil, SV = selection valve	
Figure 1.3	The flow characteristics sample and reagent in the SIA system,	5
	P: product, R: reagent, S: sample	
Figure 2.1	The map of the study area showing sampling points	24
Figure 2.2	Sequential injection (SI) colorimetric system diagram for iron	25
	determination. $SP = 2.5 \text{ mL}$ barrel syringe pump, $HC = holding$	
	coil, $R1 = 5\%$ hydroxylamine, $R2 = 0.5\%$ w/v 1,10-phenanthrolin	e
Figure 2.3	Sequential injection (SI) colorimetric system diagram for	27
	manganese determination. $SP = 2.5 \text{ mL}$ barrel syringe pump,	
	HC = holding coil, $R1 = 5\%$ hydroxylamine, $R3 = 0.6$ mol L ⁻¹	
8	Formaldoxime	
Figure 2.4	Sequential injection (SI) colorimetric system diagram for	29
C	phosphate determination. $SP = 2.5 \text{ mL}$ barrel syringe pump,	
A	HC = holding coil, R4 = 10 g L^{-1} ammonium molybdate,	
	R5 = 2.5% w/v ascorbic acid	
Figure 2.5	Sequential injection (SI) colorimetric system diagram for	31
	ammonium determination. $SP = 2.5$ mL barrel syringe pump,	
	HC = holding coil, $R6 = 0.5\%$ w/v sodium hypochlorite and R7	
	$= 0.4 \text{ mol } L^{-1}$ sodium salicylate	

Figure 3.1	Effect of flow rate on sensitivity for the determination of iron	36
Figure 3.2	Effect of 1,10-phenthroline concentration on sensitivity for the determination of iron	37
Figure 3.3	Effect of sample volume on sensitivity for determination of iron	38
Figure 3.4	Effect of flow rate on sensitivity for determination of manganese	39
Figure 3.5	Effect of formaldoxime concentration on sensitivity for determination of manganese	39
Figure 3.6	Effect of sample volume on sensitivity for determination of manganese	40
Figure 3.7	Effect of flow rate on sensitivity for determination of phosphate	41
Figure 3.8	Effect of ammonium molybdate concentration on sensitivity for determination of phosphate	42
Figure 3.9	Effect of ascorbic acid concentration on sensitivity for determination of phosphate	43
Figure 3.10	Effect of sample volume on sensitivity for determination of phosphate	44
Figure 3.11	Effect of flow rate on sensitivity for determination of ammonium	45
Figure 3.12	Effect of sodium hypochlorite concentration on sensitivity for determination of ammonium	46
Figure 3.13	Effect of sodium salicylate concentration on sensitivity for determination of ammonium	47
Figure 3.14	Effect of sodium nitroprusside concentration on sensitivity for determination of ammonium	48

Figure 3.15	Effect of sample volume on sensitivity for determination of ammonium	49
Figure 3.16	The calibration graph of iron determination in a linear range of $0.2 - 10.0 \text{ mg L}^{-1}$	50
•	The calibration graph of manganese determination in a linear range of $0.2 - 10.0 \text{ mg L}^{-1}$	50
	The calibration graph of phosphate determination in a linear range of $0.2 - 5.0 \text{ mg L}^{-1}$	51
Figure 3.19	The calibration graph of ammonium determination in a linear range of $0.2 - 10 \text{ mg L}^{-1}$	52
Figure 3.20	Concentrations of iron in water samples at various sampling points	59
Figure 3.21	Concentrations of manganese in water samples at various sampling points	61
Figure 3.22	Concentrations of phosphate in water samples at various sampling points	63
Figure 3.23	Concentrations of ammonium in water samples at various sampling points	65
Figure 5.1	SIAgram of iron(II) standard solution (0.2, 0.3, 0.5, 2.0, 4.0, 8.0 and 10.0 mg L^{-1})	79
Figure 5.2	SIAgram of manganese(II) standard solution (0.2, 0.3, 0.5, 2.0, 4.0, 8.0 and 10.0 mg L ⁻¹)	80
Figure 5.3	SIAgram of phosphate standard solution (0.2, 0.3, 0.5, 1.0, 3.0 and 5.0 mg L^{-1})	80

Figure 5.4	SIAgram of ammonium standard solution (0.2, 0.3, 0.5, 2.0, 4.0, 8.0 and 10.0 mg L ⁻¹)	81
Figure 5.5	Ping Kong sampling point	82
Figure 5.6	Intaram temple sampling point	83
Figure 5.7	Kaeng Pan Tao sampling point	83
Figure 5.8	Thap Dua temple sampling point	84
Figure 5.9	Mae Taeng sampling point	84
Figure 5.10	Nawamin bridge sampling point	85
Figure 5.11	Nawarat bridge sampling point	85
Figure 5.12	Mae Kha canal sampling point	86
Figure 5.13	Mae Kha canal sampling point	86
	MAI UNIVERS	

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

LIST OF ABBREVIATIONS

CCD Charged coupled device FIA Flow injection analysis LDR Light dependent resistor 2102/23 Light emitting diode LED Limit of detection LOD RSD Relative standard deviation Standard deviation SD Sequential injection SI SIA Sequential injection analysis United States of America USA Water quality index WQI

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

LIST OF SYMBOLS

