CONTENTS

			Page
CONTENTS			vi
LIST OF TABLES			viii
LIST OF FIGURES			xi
CHAPTER			
1	INTRODUCTION		1
	1.1	Introduction	1
	1.2	Background	3
	1.3	Literature reviews	29
	1.4	Objectives	33
2	EXPERIMENTAL		34
	2.1	Chemicals and materials	34
	2.2	Instruments and apparatus	34
	2.3	Methodology	36
	2.4	Sample preparation using solid phase extraction	39
	2.5	Determination of Cu, Cd and Pb in rainwater samples	42
3	RESULTS AND DISCUSSION		47
	3.1	Optimization of graphite furnace atomic absorption spectrometer (GFAAS)	47
		3.1.1 Pyrolysis temperature	47
		3.1.2 Atomization temperature	50
		3.1.3 The effect of utilizing a matrix modifier and without a matrix modifier for determination of Cu, Cd and Pb	55
		3.1.4 Type of matrix modifiers	58
		3.1.5 Linear range	60
		3.1.6 Detection limit	63
		3.1.7 Accuracy and precision	66

CONTENTS (CONTINUED)

			Page
3.2	Sample preparation using solid phase extraction		67
	3.2.1	Effect of eluent concentration on desorption of Cu, Cd and Pb on Amberlite IRC-748 resin	67
	3.2.2	Effect of pH of sample solution on adsorption of Cu, Cd and Pb on Amberlite IRC-748 resin	68
	3.2.3	Effect of column volume on adsorption of Cu, Cd and Pb on Amberlite IRC-748 resin	70
	3.2.4	Effect of flow rate on adsorption of Cu, Cd and Pb on Amberlite IRC-748 resin	71
	3.2.5	Effect of eluent volume on desorption of Cu, Cd and Pb on Amberlite IRC- 748 resin	72
	3.2.6	The comparison of the calibration and standard addition method for determination of Cu, Cd and Pb in rainwater samples	74
	3.2.7	The study of percentage recovery of Cu, Cd and Pb in rainwater, drinking water and deionized water	77
	3.2.8	Accuracy and precision	78
	3.2.9	Determination of Cu, Cd and Pb in rainwater samples	79
4	CONCLUSION		84
BIBLIOGRAPHY			85
APPENDIX			90
VITAE			102

LIST OF TABLES

Table		Page
1-1	Summary of some relevant physicochemical properties of copper	3
1-2	Some physical properties of cadmium	5
1-3	Some physical properties of lead	6
1-4	The Maximum Contaminant Level (MCLs) of Cu, Cd and Pb in drinking waters	6
1-5	Trace elements released into the atmosphere from human activities	11
1-6	Primary Associations in Rain	15
1-7	Techniques for determination of heavy metals in rainwater samples	16
1-8	Location of big emission sources in Songkhla Province	25
2-1	Data of rainwater samples	44
3-1	The absorbance of 40.0 μg L^{-1} Cu standard working solution at various pyrolysis temperatures	47
3-2	The absorbance of 4.0 μg L^{-1} Cd standard working solution at various pyrolysis temperatures	48
3-3	The absorbance of 80.0 μg L^{-1} Pb standard working solution at various pyrolysis temperatures	49
3-4	The absorbance of 40.0 μg L^{-1} Cu standard working solution at various atomization temperatures	51
3-5	The absorbance of 4.0 μg L^{-1} Cd standard working solution at various atomization temperatures	51
3-6	The absorbance of 80.0 μg L^{-1} Pb standard working solution at various atomization temperatures	52
3-7	The optimum conditions of GFAAS for determination of Cu, Cd and Pb	55
3-8	The comparison of the absorbance with and without matrix modifier	55
3-9	The absorbance of 40.0 μg L^{-1} Cu standard working solution at various types of matrix modifiers	58

LIST OF TABLES (CONTINUED)

Table		Page
3-10	The absorbance of 4.0 μg L^{-1} Cd standard working solution at various types of matrix modifiers	59
3-11	The absorbance of 80.0 μg L^{-1} Pb standard working solution at various types of matrix modifiers	59
3-12	The relation between the peak area and the various Cu standard concentrations (μg L^{-1})	60
3-13	The relation between the peak area and the various Cd standard concentrations (μg L^{-1})	61
3-14	The relation between the peak area and the various Pb standard concentrations (μg L^{-1})	62
3-15	The data of the blank measurements of Cu, n = 10	63
3-16	The data of the blank measurements of Cd, n = 10	64
3-17	The data of the blank measurements of Pb, n = 10	65
3-18	The detection limit for Cu, Cd and Pb standard solution with optimum conditions of GFAAS	66
3-19	The percent recovery of Cu, Cd and Pb at concentration of 40.00, 8.00 and 80.00 μg L^{-1}, respectively in 1 % (v/v) nitric acid	66
3-20	Effect of eluent concentration on desorption of Cu, Cd and Pb on Amberlite IRC-748 resin	67
3-21	Effect of pH of sample solution on adsorption of Cu, Cd and Pb on Amberlite IRC-748 resin	69
3-22	The percent recovery of Cu, Cd and Pb on Amberlite IRC-748 resin at different column volume	70
3-23	The percent recovery of Cu, Cd and Pb on Amberlit IRC-748 resin at various flow rates	71
3-24	Effect of eluent volume on desorption of Cu, Cd and Pb on Amberlite IRC-748 resin	73
3-25	The comparison of peak area using calibration and standard	74

LIST OF TABLES (CONTINUED)

Table		Page
	addition method for Cu determination in rainwater	
3-26	The comparison of peak area using calibration and standard addition method for Cd determination in rainwater	75
3-27	The comparison of peak area using calibration and standard addition method for Pb determination in rainwater	76
3-28	Analytical recovery of Cu, Cd and Pb added to some water samples	78
3-29	The concentration of Cu in nine rainwater samples	79
3-30	The concentration of Cd in nine rainwater samples	81
3-31	The concentration of Pb in nine rainwater samples	82

LIST OF FIGURES

Figure		Page
1-1	Illustration of atmospheric depositional processes	2
1-2	Adapted from illustration of atmospheric depositional processes	13
1-3	HGA and THGA graphite tubes with integrated L'vov platform for larger sample volumes	18
1-4	The transversely heated graphite tube provides	19
1-5	Iminodiacetic acid immobilised on styrene matrix	23
1-6	Solid phase extraction operation steps	24
1-7	Map of Songkhla Province	27
1-8	Total amount of rainfall in 1969-2004	28
1-9	Amount of day with rainfall in 1969-2004	28
2-1	Preparation of Amberlite IRC-748 resin column	39
2-2	Sampling sites in Hat Yai City Municipality	43
2-3	Sample collections at the Fountain Circus of Hat Yai City Municipality	43
2-4	Conductivity measurements (EC, $\mu S\ cm^{-1}$)	45
2-5	pH measurements	45
2-6	Sample filtration 1) Syringe 2) Filters and 3) Polyethylene bottle	46
3-1	The absorbance of 40.0 $\mu g\ L^{-1}$ Cu standard working solution at various pyrolysis temperatures	48
3-2	The absorbance of 4.0 $\mu g\ L^{-1}$ Cd standard working solution at various pyrolysis temperatures	49
3-3	The absorbance of 80.0 $\mu g\ L^{-1}$ Pb standard working solution at various pyrolysis temperatures	50
3-4	The absorbance of 40.0 $\mu g\ L^{-1}$ Cu standard working solution at various atomization temperatures	51
3-5	The absorbance of 4.0 $\mu g\ L^{-1}$ Cd standard working solution at various atomization temperatures	52
3-6	The absorbance of 80.0 $\mu g\ L^{-1}$ Pb standard working solution at various atomization temperatures	53

LIST OF FIGURES (CONTINUED)

Figure		Page
3-7	Peak shape of 40.0 μg L^{-1} Cu standard working solution at optimum temperature	53
3-8	Peak shape of 4.0 μg L^{-1} Cd standard working solution at optimum temperature	54
3-9	Peak shape of 80.0 μg L^{-1} Pb standard working solution at optimum temperature	54
3-10	Peak shape of 40.0 μg L^{-1} Cu standard working solution with modifiers	56
3-11	Peak shape of 40.0 μg L^{-1} Cu standard working solution without modifiers	56
3-12	Peak shape of 4.0 μg L^{-1} Cd standard working solution with modifier	56
3-13	Peak shape of 4.0 μg L^{-1} Cd standard working solution without modifiers	57
3-14	Peak shape of 80.0 μg L^{-1} Pb standard working solution with modifier	57
3-15	Peak shape of 80.0 μg L^{-1} Pb standard working solution without modifier	57
3-16	Peak shape of 40.0 μg L^{-1} Cu standard working solution at optimum temperature and types of matrix modifiers	58
3-17	Peak shape of 4.0 μg L^{-1} Cd standard working solution at optimum temperature and types of matrix modifiers	59
3-18	Peak shape of 80.0 μg L^{-1} Pb standard working solution at optimum temperature and types of matrix modifier	60
3-19	The linear dynamic range of Cu standard concentration (μg L^{-1})	61
3-20	The linear dynamic range of Cd standard concentration (μg L^{-1})	61
3-21	The linear dynamic range of Pb standard concentration (μg L^{-1})	62
3-22	The calibration curve of Cu	64

LIST OF FIGURES (CONTINUED)

Figure		Page
3-23	The calibration curve of Cd	65
3-24	The calibration curve of Pb	66
3-25	Effect of eluent concentration on desorption of Cu, Cd and Pb on Amberlite IRC-748 resin	68
3-26	Effect of pH of sample solution on adsorption of Cu, Cd and Pb on Amberlite IRC-748 resin	69
3-27	The percent recovery of Cu, Cd and Pb on Amberlite IRC-748 at different column volume	70
3-28	The percent recovery of Cu, Cd and Pb on Amberlit IRC-748 resin at various flow rates	72
3-29	Effect of eluent volume on desorption of Cu, Cd and Pb on Amberlite IRC-748 resin	73
3-30	The comparison of calibration and standard addition graph for Cu determination in rainwater	75
3-31	The comparison of calibration and standard addition graph for Cd determination in rainwater	76
3-32	The comparison of calibration and standard addition graph for Pb determination in rainwater	77
3-33	The concentration of Cu in nine rainwater samples (preconcentration factor = 10, n=3)	80
3-34	The concentration of Cd in nine rainwater samples (preconcentration factor = 10, n=3)	81
3-35	The concentration of Pb in nine rainwater samples (preconcentration factor = 10, n=3)	82
3-36	The concentration of Cu, Cd and Pb in nine rainwater samples (preconcentration factor = 10, n=3)	83