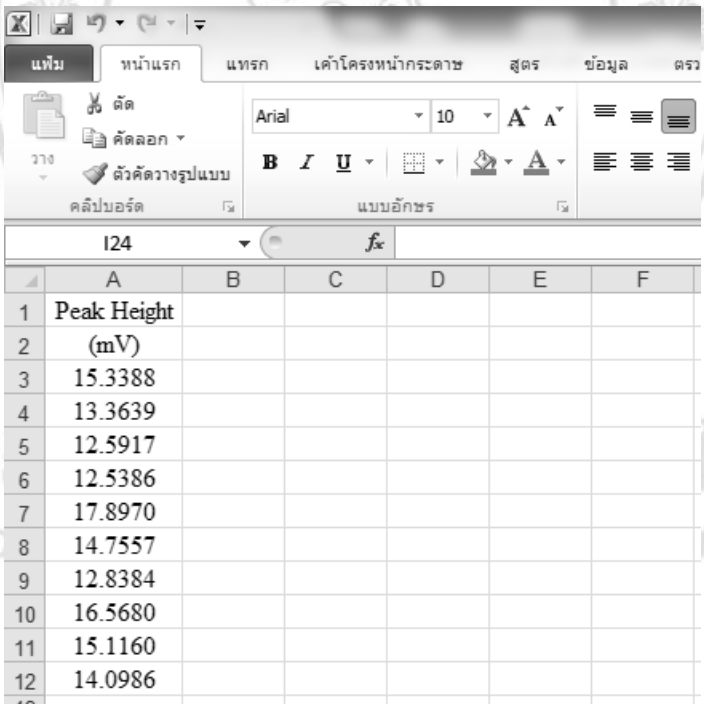
APPENDIX A

Detection limit calculation

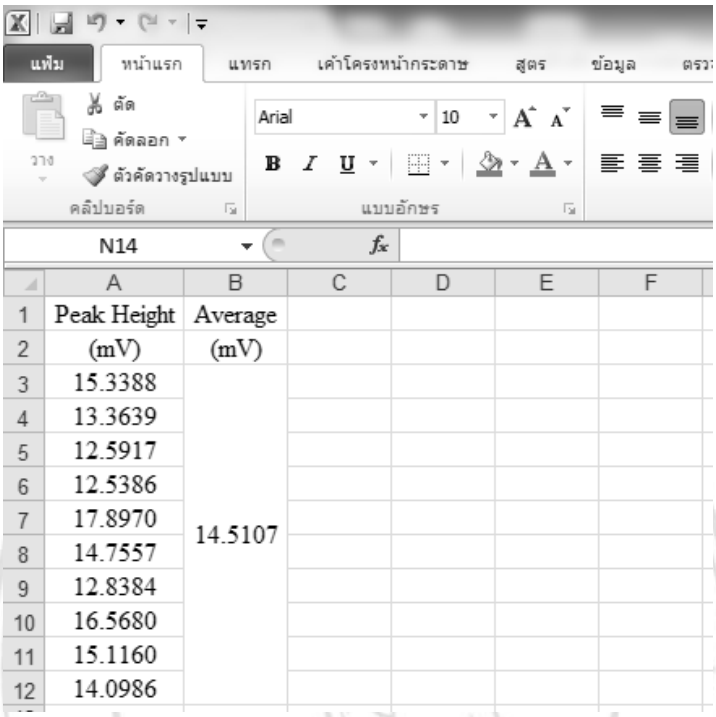
The detection limit is the concentration of analyte that give signal equal to three times the standard deviation of blank signal [Vickers, 1987]. In this work, it was calculated from standard deviation the blank (n=10). The method can be followed these steps:

1. Peak height of the blank signal was examined and put in one column of Excel program.



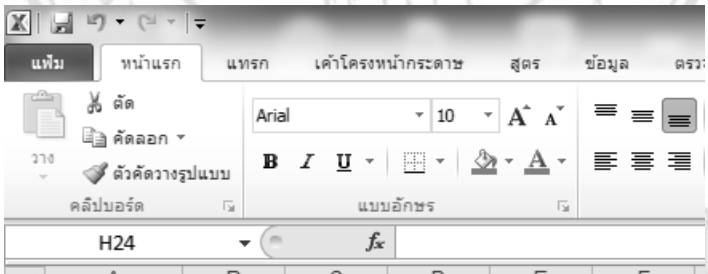
	A	B	C	D	E	F
1	Peak Height					
2	(mV)					
3	15.3388					
4	13.3639					
5	12.5917					
6	12.5386					
7	17.8970					
8	14.7557					
9	12.8384					
10	16.5680					
11	15.1160					
12	14.0986					

2. Calculate the average of the values in column A by using the AVERAGE formula in the formula bar.



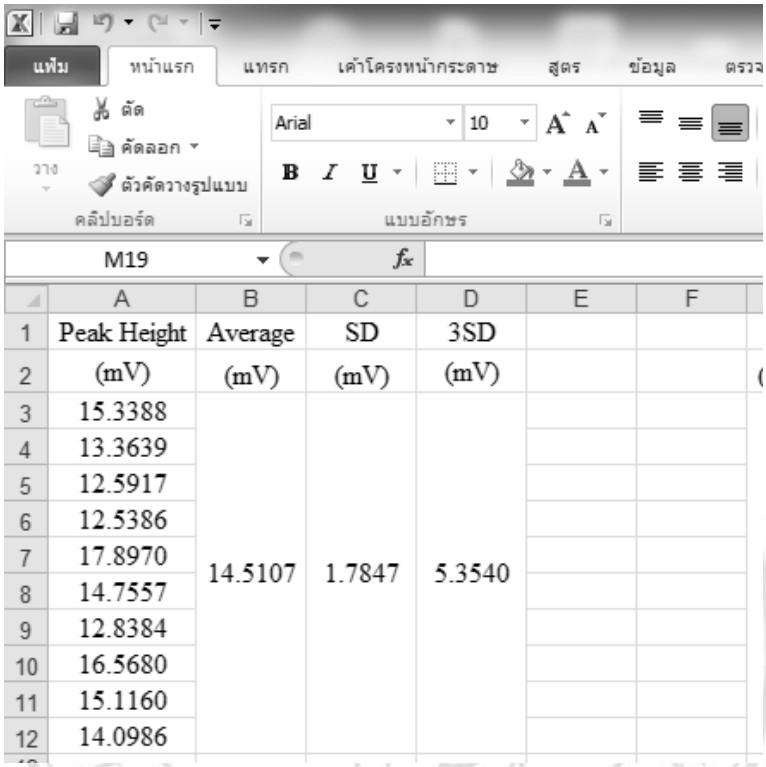
	A	B	C	D	E	F
1	Peak Height	Average				
2	(mV)	(mV)				
3	15.3388					
4	13.3639					
5	12.5917					
6	12.5386					
7	17.8970	14.5107				
8	14.7557					
9	12.8384					
10	16.5680					
11	15.1160					
12	14.0986					

3. Calculate the standard deviation of the values in column A by using the STDEVA formula in the formula bar.



	A	B	C	D	E	F
1	Peak Height	Average	SD			
2	(mV)	(mV)	(mV)			
3	15.3388					
4	13.3639					
5	12.5917					
6	12.5386					
7	17.8970	14.5107	1.7847			
8	14.7557					
9	12.8384					
10	16.5680					
11	15.1160					
12	14.0986					

4. Calculate the 3SD from standard deviation value in column C. The 3SD is y value in a linear calibration equation.



	A	B	C	D	E	F
1	Peak Height	Average	SD	3SD		
2	(mV)	(mV)	(mV)	(mV)		
3	15.3388					
4	13.3639					
5	12.5917					
6	12.5386					
7	17.8970	14.5107	1.7847	5.3540		
8	14.7557					
9	12.8384					
10	16.5680					
11	15.1160					
12	14.0986					

5. The detection limit can be calculated as following:

$y = mx + c \longrightarrow y = 273.4x + (-9.608)$

$LOD = (y - c)/m$

$LOD = (5.3540 - (-9.608))/273.4$

$LOD = 0.05 \text{ mg } L^{-1}$

Therefore, detection limit is 0.05 mg L^{-1}

APPENDIX B

SIAgram of standard solutions for iron, manganese, phosphate and ammonium

SIAgrams were obtained from injecting various concentration of iron, manganese, phosphate and ammonium standard solutions into the proposed SI-colorimetric system, these are shown in Figure 5.1 – 5.4, respectively.

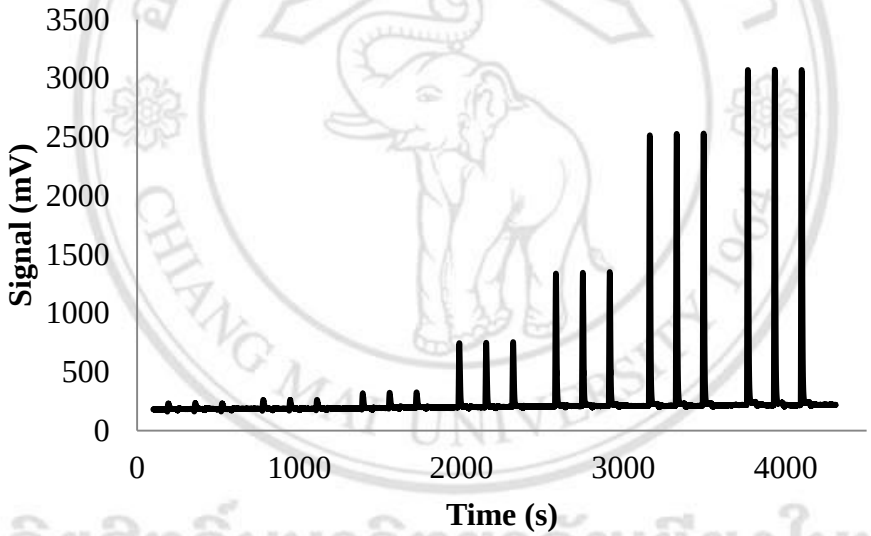


Figure 5.1 SIAgram of iron(II) standard solution (0.2, 0.3, 0.5, 2.0, 4.0, 8.0 and 10.0 mg L^{-1})

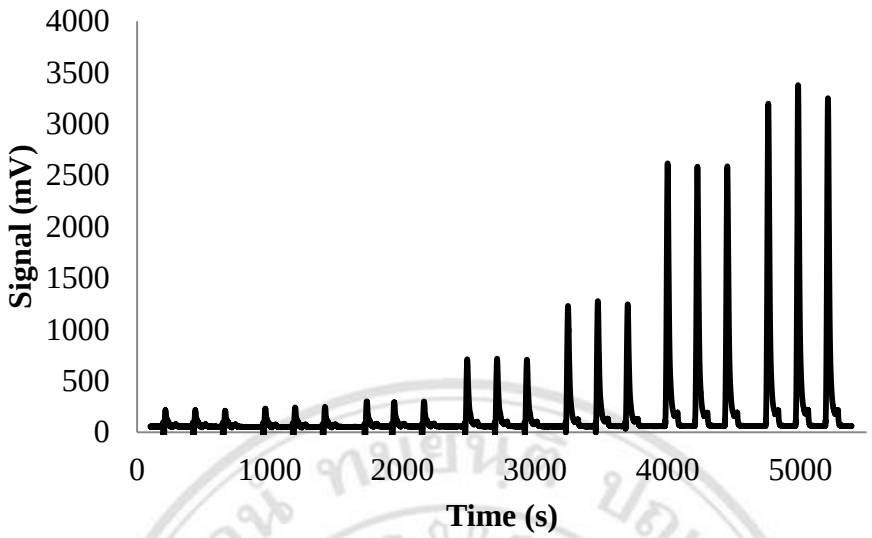


Figure 5.2 SIAgram of manganese(II) standard solution (0.2, 0.3, 0.5, 2.0, 4.0, 8.0 and 10.0 mg L^{-1})

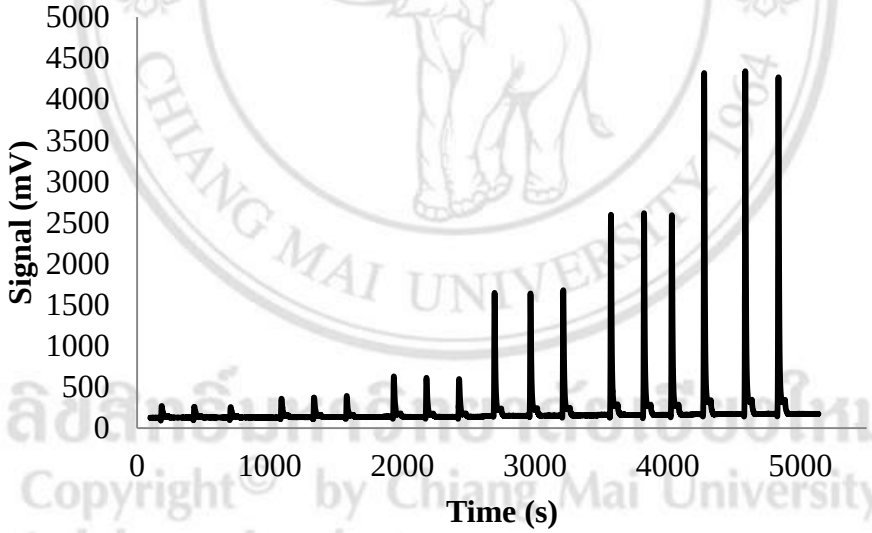


Figure 5.3 SIAgram of phosphate standard solution (0.2, 0.3, 0.5, 1.0, 3.0 and 5.0 mg L^{-1})

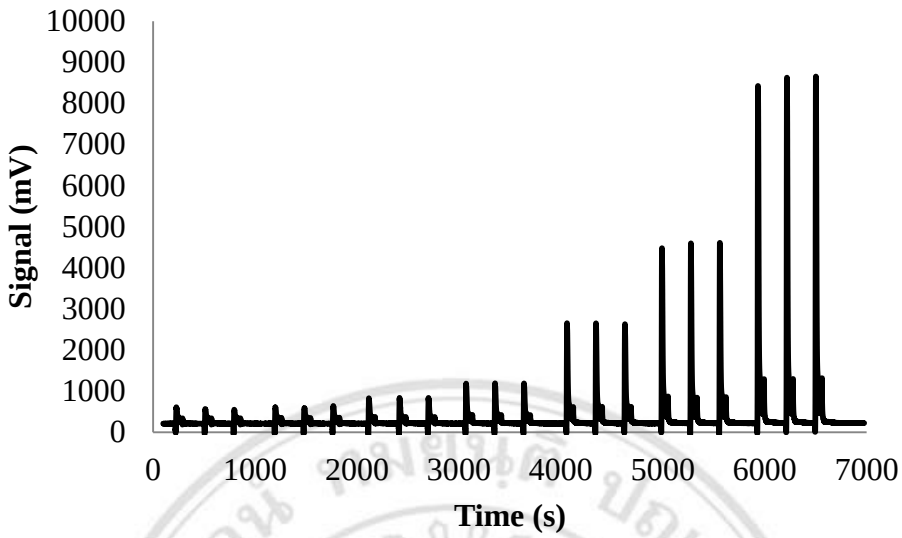


Figure 5.4 SIAgram of ammonium standard solution (0.2, 0.3, 0.5, 2.0, 4.0, 8.0 and 10.0 mg L^{-1})

APPENDIX C

Sampling points

Water samples were collected from 9 sampling points along the Ping river in Chiang Mai, Thailand, beginning from Amphur Chiang Dao to Amphur Muang of Chiang Mai province as the map shown in Figure 2.1 (page 24). The pictures of sampling points are shown in Figure 5.5 – 5.13.

Figure 5.5 Ping Kong sampling point

Figure 5.6 Intaram temple sampling point

Figure 5.7 Kaeng Pan Tao sampling point

Figure 5.8 Thap Dua temple sampling point

Figure 5.9 Mae Taeng sampling point

Figure 5.10 Nawamin bridge sampling point

Figure 5.11 Nawarat bridge sampling point

Figure 5.12 Mae Kha canal sampling point

Figure 5.13 Padad sampling point (after discharge of water from Mae Kha canal into Ping river)

APPENDIX D

Chemical parameters of water samples of the Ping river

The general water chemical parameters, including pH, dissolved oxygen (DO) and conductivity, of Ping river in a year are shown in Table 5.1 – 5.4 for February, May, August and November of 2015, respectively.

Table 5.1 Some chemical parameters of water samples in February 2015

Sampling points	pH	Dissolved oxygen (mg L^{-1})	Conductivity (µS cm^{-1})
1	8.01	2.65	140
2	8.01	5.50	320
3	8.13	6.50	310
4	8.35	3.30	310
5	7.19	6.90	170
6	7.51	7.00	190
7	7.55	6.40	190
8	7.48	1.80	430
9	7.47	4.10	320

Table 5.2 Some chemical parameters of water samples in May 2015

Sampling points	pH	Dissolved oxygen (mg L^{-1})	Conductivity (µS cm^{-1})
1	6.84	5.20	257
2	7.09	6.00	447
3	7.47	7.00	411
4	7.18	10.00	403
5	6.50	5.30	305
6	5.50	5.20	296
7	6.78	5.40	266
8	7.10	1.30	653
9	6.85	4.50	266

Table 5.3 Some chemical parameters of water samples in August 2015

Sampling points	pH	Dissolved oxygen (mg L^{-1})	Conductivity (µS cm^{-1})
1	7.41	6.40	507
2	7.36	6.20	756
3	7.57	5.80	736
4	7.68	6.50	683
5	6.94	5.10	539
6	7.28	5.00	668
7	7.29	4.60	628
8	7.16	0.40	1132
9	7.01	1.60	782

Table 5.4 Some chemical parameters of water samples in November 2015

Sampling points	pH	Dissolved oxygen (mg L^{-1})	Conductivity (µS cm^{-1})
1	6.73	7.00	467
2	6.54	6.95	329
3	6.65	6.95	363
4	6.77	8.30	341
5	6.88	6.40	157
6	6.24	5.50	243
7	6.58	5.40	190
8	6.76	1.10	605
9	6.70	3.20	266

THE RELEVANCE OF THE RESEARCH WORK TO THAILAND

The quality of water resources is very important for application of water in various fields. Recently, various activities of humans and animals can affect the quality of water. Therefore, monitoring of water quality becomes necessary for ecological assessment. The determination of water quality parameters requires a lot of resources and takes long time. In addition, most of the standard methods requires expensive and complicated instruments. Cost-effective analytical instruments are necessary for developing country, especially Thailand.

This research work had developed sequential injection colorimetric system for determination of different parameters that indicating water quality. The developed system offered automatic operation, multi-parameter analysis, low reagent consumption, low detection limit, high precision, and cost effective instrument for determination of iron, manganese, phosphate, and ammonium in one system. It was applied for analysis of water samples from the Ping river, which is the main water supply for Chiang Mai, and it is also an upstream river which flows through many provinces of Thailand. The proposed methods could be an alternative for measurement of water quality parameters of water samples.

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Experience	2014	Teaching assistant for Chemistry Laboratory I Course
	2014	N. Kaewwonglom and J. Jakmunee, "Sequential injection colorimetric system for determination of total iron and manganese in water sample (Poster presentation)," The 19th International Conference on Flow Injection Analysis (ICFIA), 30 November – 5 December, 2014, Fukuoka, Japan
	2015	N. Kaewwonglom and J. Jakmunee, "Development of Multi-parameter Analysis System for Determination of Total Iron and Manganese in Water Sample of River Ping in Chiang Mai Province, Thailand (Poster presentation)," TRF Seminar Series in Basic Research CVIII, 14 January, 2015, Chiang Mai, Thailand

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