

APPENDIX A

Table A.1 Standard quality of tap water defined by metropolitan waterworks authority (WHO 2006) [64]

Parameters	Units	WHO 2006 (Guideline Value)
1. Bacteriological Quality		
Bacteria E. coli	Found-no found/100 ml	No found/100 ml
2. Physical and Chemical Quality		
Apperance colour	True colour unit	15
Turbidity	NTU	5
Taste and odour	-	-
Arsenic	mg/l	0.01
Cadmium	mg/l	0.003
Chromium	mg/l	0.05
Cyanide	mg/l	0.07
Lead	mg/l	0.01
Inorganic Mercury	mg/l	0.006
Selenium	mg/l	0.01
Fluoride	mg/l	1.5
Chloride	mg/l	250
Copper	mg/l	2

Note 1 mg = 1,000 µg

Table A.1 (Continued)

Parameters	Units	WHO 2006 (Guideline Value)
Iron	mg/l	0.3
Manganese	mg/l	0.4
Aluminium	mg/l	0.1
Sodium	mg/l	200
Sulfate	mg/l	250
Zinc	mg/l	3
Hydrogen sulfide	mg/l	0.05
Total dissolved solids	mg/l	1,000
Nitrate as NO ₃ ⁻	mg/l	50
Nitrite as NO ₂ ⁻	mg/l	3
Free residual chlorine	mg/l	> 0.2
Trichloroethene	mg/l	0.02
Tetrachloroethene	mg/l	0.04
Microcystin-LR	mg/l	0.001
3. Pesticides		
Aldrin/Dieldrin	µg/l	0.03
Chlordane	µg/l	0.2
DDT	µg/l	1
2,4-D	µg/l	30
Heptachlor and Heptachlor epoxide	µg/l	0.03
Hexachlorobenzene	µg/l	1
Lindane	µg/l	2

Note 1 mg = 1,000 µg

Table A.1 (Continued)

Parameters	Units	WHO 2006 (Guideline Value)
Methoxychlor	µg/l	20
Pentachlorophenol	µg/l	9
4. Trihalomethanes sum of the ratio		
Chloroform , CHCl ₃	mg/l	0.3
Bromodichloromethane , CHBrCl ₂	mg/l	0.06
Dibromochloromethane , CHBr ₂ Cl	mg/l	0.1
Bromoform , CHBr ₃	mg/l	0.1
5. Radioactive		
Gross alpha activity	Bq/l	0.5
Gross beta activity	Bq/l	1

Note 1 mg = 1,000 µg

Table A.2 Recommended minimum sample numbers for faecal indicator testing in distribution systems *

Population	Total number of samples per year
Point sources	Progressive sampling of all sources over 3 to 5 year cycles (maximum)
Piped supplies	
< 5000	12
5000 - 100000	12 per 5,000 head of population
> 100000 - 500000	12 per 10,000 head of population plus an additional 120 samples
> 500000	12 per 100,000 head of population plus an additional 180 samples

* Parameters such as chlorine, turbidity and pH should be tested more frequently as part of operational and verification monitoring.

APPENDIX B

The student t-Test [61]

$$t = \frac{\bar{x}_d \sqrt{n}}{S_d}$$

$$S_d = \sqrt{\frac{\sum (x_d - \bar{x}_d)^2}{n - 1}}$$

$$\bar{x}_d = \frac{\sum x_d}{n}$$

Where; x_d the difference between two method

$\bar{x}_d$ the mean difference

S_d the standard deviation

n number of sample

$n-1$ number of degree of freedom

The Table B.1 gives the concentration of aluminum (mg L^{-1}) determined by two difference methods for each seven test portions.

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Table B.1 Calculation of t-test for aluminum determination of rFIA

Water samples	Concentrations (mg L ⁻¹)		x_d	$x_d - \bar{x}_d$	$(x_d - \bar{x}_d)^2$
	rFIA*	ICP-OES*			
Sangpatong T.W.	0.115	0.127	-0.012	-0.010	0.0001
Muang T.W.	0.073	0.072	0.001	0.003	0.0000
Mae Jo T.W.	0.128	0.128	0.000	0.002	0.0000
Mae Rim T.W.	0.363	0.350	0.013	0.015	0.0002
CMU. T.W	0.231	0.252	-0.007	-0.005	0.0000
Boil water 3 hour	0.112	0.110	0.002	0.004	0.0000
Boil water 6 hour	0.023	0.031	-0.008	-0.006	0.0000
Σ			-0.011	-	0.0004
S_d			0.00816		
t			0.509		

* average of triplicate results

T.W. was tap water

CMU was Chiang Mai University

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$$\bar{x} = \frac{\sum x_i}{n}$$

$$= \frac{-0.011}{7}$$

$$= -0.00157$$

$$\begin{aligned}
 S_d &= \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \\
 &= \sqrt{\frac{0.0004}{7-1}} \\
 &= 0.00816 \\
 t &= \frac{\bar{x}_d \sqrt{n}}{S_d} \\
 &= \frac{-0.00157\sqrt{7}}{0.00816} \\
 &= -0.509
 \end{aligned}$$

The calculated value of t (0.509) is less than the t value from Table B.3 (2.45) for six degrees of freedom indicating that results obtained by both methods show no significant difference at 95% confidence intervals.

Table B.2 Calculation of t-test for aluminum determination of SIA

Water samples	Concentrations (mg L ⁻¹)		x_d	$x_d - \bar{x}_d$	$(x_d - \bar{x}_d)^2$
	rFIA*	ICP-OES**			
Sangpatong T.W.	0.121	0.127	-0.012	-0.004	0.000020
Muang T.W.	0.072	0.072	0.001	0.002	0.000002
Mae Jo T.W.	0.125	0.128	0.000	-0.001	0.000002
Mae Rim T.W.	0.357	0.350	0.013	0.009	0.000073
CMU. T.W	0.246	0.252	-0.006	-0.004	0.000020
Boil water 3 hour	0.111	0.110	0.002	0.003	0.000007
Boil water 6 hour	0.027	0.031	-0.008	-0.002	0.000006
Σ			-0.011	-	0.00013
S_d			0.00465		
t			0.893		

* average of triplicate results

T.W. was tap water

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$$\bar{x} = \frac{\sum x_i}{n}$$

$$= \frac{-0.011}{7}$$

$$= -0.00157$$

$$\begin{aligned}
 S_d &= \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \\
 &= \sqrt{\frac{0.00013}{7-1}} \\
 &= 0.00465 \\
 t &= \frac{\bar{x}_d \sqrt{n}}{S_d} \\
 &= \frac{-0.00157\sqrt{7}}{0.00465} \\
 &= -0.893
 \end{aligned}$$

The calculated value of t (0.893) is less than the t value from Table B.3 (2.45) for six degrees of freedom indicating that results obtained by both methods show no significant difference at 95% confidence intervals.

Table B.3 Values of t for various levels of confidence interval

Degrees of freedom	Confidence interval			
	80%	90%	95%	99%
1	3.08	6.31	12.70	63.7
2	1.89	2.92	4.30	9.92
3	1.64	2.35	3.18	5.84
4	1.53	2.13	2.78	4.60
5	1.48	2.02	2.57	4.03
6	1.44	1.94	2.45	3.71
7	1.42	1.90	2.36	3.50
8	1.40	1.86	2.31	3.36
9	1.38	1.83	2.26	3.25
10	1.37	1.81	2.23	3.17
15	1.34	1.75	2.13	2.95
20	1.32	1.72	2.09	2.84
30	1.31	1.70	2.04	2.75
60	1.30	1.67	2.00	2.66
α	1.29	1.64	1.96	2.58

CURRICULUM VITAE

Name: Miss. Arunee Suratpipit

Date of Birth: October 14, 1982

Present Address: 34 Chaun road, Soi Chaun 18/4, Sathorn, Tungwatdon
Bangkok 10120

Academic status:

- High school, Satri Sri Suriyothai School, 2000
- B.Sc. (Chemistry), Rajamangala University of Technology
Bangkok, 2004
- M.Sc. (Analytical Chemistry), Chiang Mai University, 2007

Awards/Scholarship:

- Center for Innovation in Chemistry: Postgraduate Education
and Research Program in Chemistry (PERCH-CIC)

Work Experiences:

- Demonatrator in chemistry laboratory for first year,
Department of Chemistry, Faculty of Science, Chiang Mai
University, 2005

List of publications:

National conferences

1. A. Suratpipit, T. Pojanagaroon, S. Liawruangrath, **“Copper diethyldithiocarbamate modified carbon paste electrode for the determination of mercury”** *The 5th Annual Symposium on TRF Senior Research Scholar, Chiang Mai, 2006*
2. A. Suratpipit, T. Pojanagaroon, S. Liawruangrath, **“Determination of iron (III) in underground water by using reversed flow injection spectrophotometry”**, *32th Congress on Science and Technology of Thailand, Bangkok, 2006.*
3. A. Suratpipit, T. Pojanagaroon, S. Liawruangrath, **“Determination of Iron (III) by Reversed Flow Injection Spectrophotometry Using Methyldopa”**, *The Fifth PERCH Annual Scientific Congress, Chonburi, 2007.*
4. A. Suratpipit, T. Pojanagaroon, S. Liawruangrath, **“Determination of Iron (III) by Reversed Flow Injection Spectrophotometry Using Methyldopa”**, *The 6th Annual symposium on TRF Senior Research Scholar and Research Group on Innovation on Analytical Instrumentation CHE, Chiang Mai, 2007.*

International conferences

1. Suratpipit, T. Pojanagaroon, S. Liawruangrath, **“Reverse Flow Injection Spectrophotometric Determination of Aluminium using Bromopyrogallol Red”**, *14th International Conference on Flow Injection Analysis, Berlin, Germany, 2007.*
2. A. Suratpipit, T. Pojanagaroon, S. Liawruangrath, **“Reverse Flow Injection Spectrophotometric System for Determination of Aluminium in water samples”**, *The 6th Princess Chulabhorn International Science Congress (PC VI), Bangkok, 2007.*

THE RELEVANCY OF THE RESEARCH WORK IN THAILAND

Recently, there have been world-wide efforts to develop environmentally friendly analytical methods. An increasingly great demand for small and powerful analytical systems concerns, particularly application in field measurements of environmental analysis. In such analyses analytical tasks usually take up a lot of time owing to a large number of samples to be analyzed. Therefore, analytical techniques with high sample throughput and minimum consumption of reagent/sample are required. This research group has been termed “ α -flow” group since 1990 as soon as most of our on-going researches are based on flow analysis which are greener analytical methods and application to real samples such as water, food and pharmaceutical.

The aims of this research are to develop a reverse flow injection and sequential injection methods for determining aluminum in water samples in Chiang Mai (Thailand). In terms of economic and environmental point of view, this research consumes little reagent with minimum waste release and reduces the cost of analytical instrumentation and sample analysis. This would be able to help the Thai Government to improve the economy and environmental problem of Thailand in the near future.