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# APPENDIX

Table A.1 t-Test : Comparison between the proposed method and the standard method (ICP-OES) (drinking water A, n=3, confidential level 95%)

| *F-Test Two-Sample for Variances* | | |
|---|---|---|
| | *ICP-OES* | *proposed method* |
| Mean | 58.50476151 | 53.97515955 |
| Variance | 0.007144382 | 36.60173228 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 0.000195192 | |
| P(F<=f) one-tail | 0.000195154 | |
| F Critical one-tail | 0.052631579 | |

| t-Test: Two-Sample Assuming Equal Variances | | |
|---|---|---|
| | *ICP-OES* | *proposed method* |
| Mean | 58.50476151 | 53.97515955 |
| Variance | 0.007144382 | 36.60173228 |
| Observations | 3 | 3 |
| Pooled Variance | 18.30443833 | |
| Hypothesized Mean Difference | 0 | |
| df | 4 | |
| t Stat | 1.296664037 | |
| P(T<=t) one-tail | 0.132245135 | |
| t Critical one-tail | 2.131846786 | |
| P(T<=t) two-tail | 0.264490271 | |
| t Critical two-tail | 2.776445105 | |

Table A.2 t-Test : Comparison between the proposed method and the standard method (ICP-OES) (drinking water B, n=3, confidential level 95%)

*F-Test Two-Sample for Variances*

| | *ICP-OES* | *proposed method* |
|---|---|---|
| Mean | 59.62019 | 56.45949926 |
| Variance | 2.009029 | 8.655765973 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 0.232103 | |
| P(F<=f) one-tail | 0.18838 | |
| F Critical one-tail | 0.052632 | |

t-Test: Two-Sample Assuming Unequal Variances

| | *ICP-OES* | *proposed method* |
|---|---|---|
| Mean | 59.62019 | 56.45949926 |
| Variance | 2.009029 | 8.655765973 |
| Observations | 3 | 3 |
| Hypothesized Mean Difference | 0 | |
| df | 3 | |
| t Stat | 1.676359 | |
| P(T<=t) one-tail | 0.096131 | |
| t Critical one-tail | 2.353363 | |
| P(T<=t) two-tail | 0.192261 | |
| t Critical two-tail | 3.182446 | |

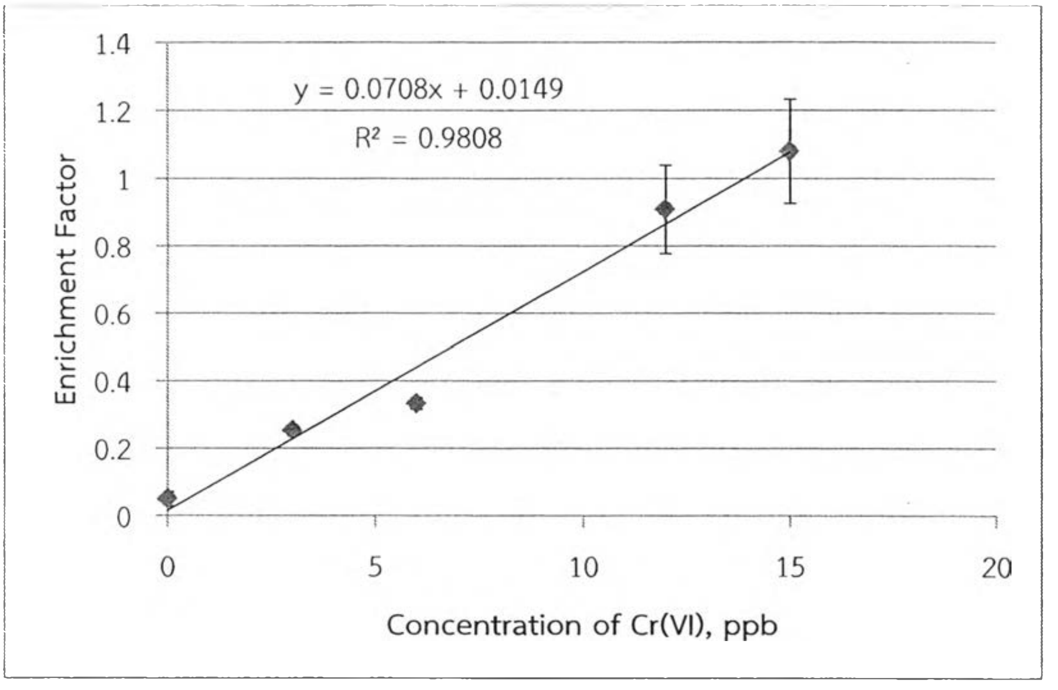



Figure A.1 Working range of Cr(VI) determined by electrical field assisted LPME in drinking water A

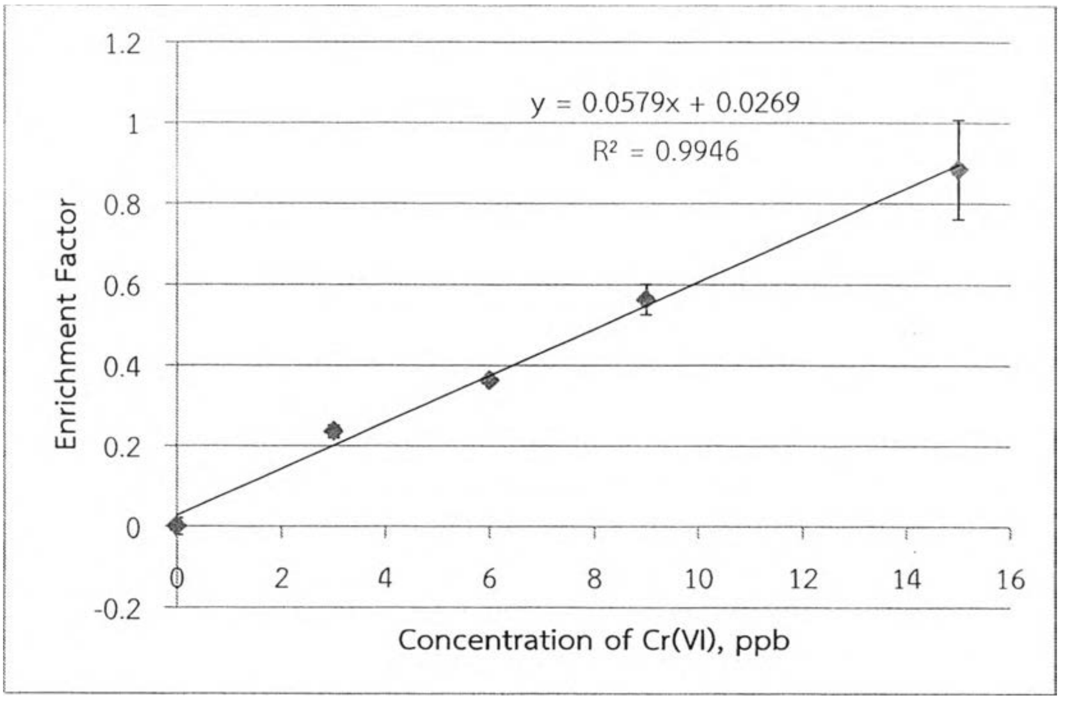



Figure A.2 Working range of Cr(VI) determined by electrical field assisted LPME in drinking water B

Table A.3 Calculation of standard deviation of slope of calibration curve.

| | Formular | Milli Q water | Drinking water A | Drinking water B |
|---|---|---|---|---|
| | $S_{xx} = \sum (x_i - \bar{x})^2$ | $S_{xx} = 472.5$ | $S_{xx} = 464.4$ | $S_{xx} = 399.6$ |
| | $S_{yy} = \sum (y_i - \bar{y})^2$ | $S_{yy} = 2.202$ | $S_{yy} = 2.454$ | $S_{yy} = 1.380$ |
| Standard deviation about regression | $S_r = \sqrt{\frac{S_{yy}}{n-2}}$ | $S_r = \sqrt{\frac{2.202}{18-2}} = 0.3710$ | $S_r = \sqrt{\frac{2.454}{15-2}} = 0.4345$ | $S_r = \sqrt{\frac{1.380}{15-2}} = 0.3258$ |
| Standard deviation of slope | $S_m = \sqrt{\frac{{S_r}^2}{S_{xx}}}$ | $S_m = \sqrt{\frac{0.3710^2}{472.5}} = 0.01707$ | $S_m = \sqrt{\frac{0.4345^2}{464.4}} = 0.02016$ | $S_m = \sqrt{\frac{0.3258^2}{399.6}} = 0.01630$ |

Table A.4 Analysis of Variance (ANOVA)

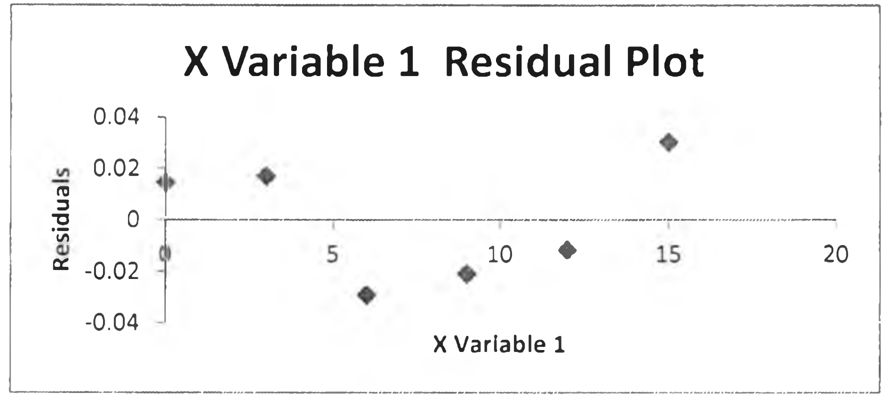
| | Milli Q water | Drinking water A | Drinking water B |
|---|---|---|---|
| Slope | 0.0671 | 0.0708 | 0.0579 |
| Standard deviation of slope | 0.01707 | 0.02016 | 0.01630 |
| Grand average | $\bar{\bar{x}} = \frac{(6\times0.0671)+(5\times0.0708)+(5\times0.0579)}{18} = 0.06538$ | | |
| Sum of square of factor (SSF) | $SSF = 6(0.0671-0.06538)^2 + 5(0.0708-0.06538)^2 + 5(0.0579-0.06538)^2 = 4.445 \times 10^{-4}$ | | |
| Sum of square of error (SSE) | $SSE = 5(0.01707)^2 + 4(0.02016)^2 + 4(0.01630)^2 = 4.150 \times 10^{-3}$ | | |
| Total sum of square (SST) | $SST = SSF + SSE = 4.594 \times 10^{-3}$ | | |
| Degree of freedom | SST, df = N-1 = 16-1 = 15<br>SSF, df = I-1 = 3-1 = 2 | SSE, df = N-I = 16-3 = 13 | |
| Mean square | $MSE = \frac{SSE}{N-I} = \frac{4.150 \times 10^{-3}}{13} = 3.192 \times 10^{-4}$ | $MSF = \frac{SSF}{I-1} = \frac{4.445 \times 10^{-4}}{2} = 2.223 \times 10^{-4}$ | |
| F-value | $F = \frac{MSF}{MSE} = \frac{2.223\times10^{-4}}{3.192 \times 10^{-4}} = 0.6964$<br>$F_{critical,\alpha=0.05,df=2,15} = 3.682$ | | |

Table A.5 ANOVA (one-way)

| *Source of variation* | *Sum of square (SS)* | *Degree of freedom (df)* | *Mean square (MS)* | *F* |
|---|---|---|---|---|
| Between Group | 4.443 x 10-4 | 2 | $2.222 \times 10^{-4}$ | 0.6961 |
| Within Group | 4.150 x 10-3 | 13 | $3.192 \times 10^{-4}$ | |
| Total | 4.594 x 10-3 | 15 | | |

Table A.6 SUMMARY OUTPUT FOR MILLI Q WATER

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.998006 |
| R Square | 0.996016 |
| Adjusted R Square | 0.99502 |
| Standard Error | 0.026629 |
| Observations | 6 |



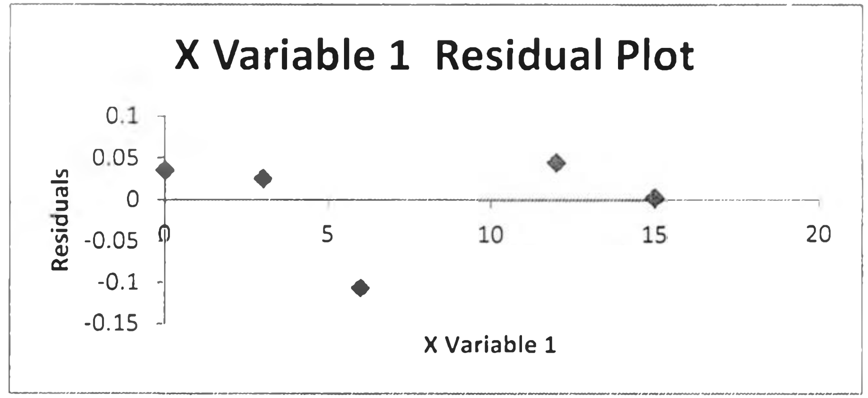

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 0.709095354 | 0.709095354 | 999.99525 | 5.96027E-06 |
| Residual | 4 | 0.002836395 | 0.000709099 | | |
| Total | 5 | 0.711931749 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -0.00071 | 0.019272588 | -0.036797884 | 0.97240937 | -0.054218474 | 0.052800093 | -0.05422 | 0.0528 |
| X Variable 1 | 0.067098 | 0.002121842 | 31.6227015 | 5.96027E-06 | 0.061207203 | 0.072989559 | 0.061207 | 0.07299 |

Table A.7 SUMMARY OUTPUT FOR DRINKING WATER A

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.990356 |
| R Square | 0.980806 |
| Adjusted R Square | 0.974407 |
| Standard Error | 0.071113 |
| Observations | 5 |



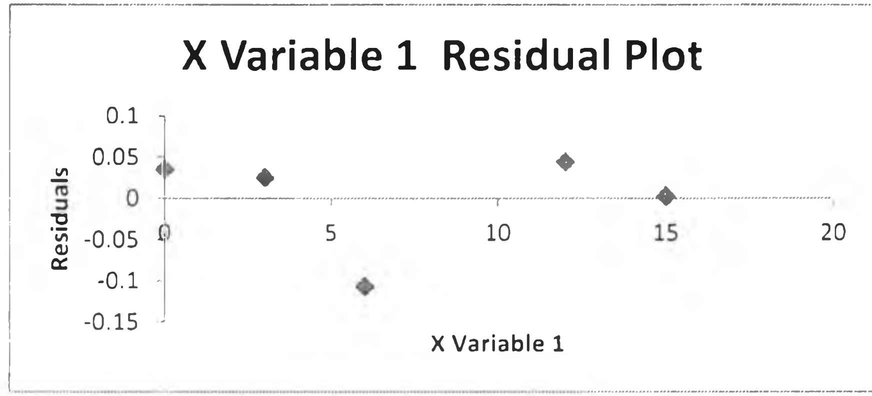

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 0.775213 | 0.775213 | 153.2948 | 0.001135 |
| Residual | 3 | 0.015171 | 0.005057 | | |
| Total | 4 | 0.790384 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.014879 | 0.052009 | 0.286093 | 0.793425 | -0.15064 | 0.180394 | -0.15064 | 0.180394 |
| X Variable 1 | 0.070766 | 0.005716 | 12.38123 | 0.001135 | 0.052577 | 0.088956 | 0.052577 | 0.088956 |

Table A.8 SUMMARY OUTPUT FOR DRINKING WATER B

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.990356 |
| R Square | 0.980806 |
| Adjusted R Square | 0.974407 |
| Standard Error | 0.071113 |
| Observations | 5 |




ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 0.775213 | 0.775213366 | 153.2948405 | 0.001135202 |
| Residual | 3 | 0.015171 | 0.005057009 | | |
| Total | 4 | 0.790384 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.014879 | 0.052009 | 0.28609313 | 0.793425149 | -0.150635754 | 0.180394455 | -0.15063575 | 0.180394 |
| X Variable 1 | 0.070766 | 0.005716 | 12.38122936 | 0.001135202 | 0.05257651 | 0.088955653 | 0.05257651 | 0.088956 |

# VITA

Miss Nattaporn Chanthasakda was born on the 11th of September 1988 in Bangkok, Thailand. She received her Bachelor's degree of Science from Chulalongkorn University in 2011 with second class honor. Then, she has continued the graduate study in the Department of Chemistry, Faculty of Science, Chulalongkorn University and her become a member of Chromaotgraphy and Separation Research Unit (ChSRU). She finished her Master's degree of Science in 2014.

Poster presentation and proceeding

"Electromembrane extraction for preconcentration of chromium(VI) ion" Nattaporn Chanthasakda, Pakorn Varanusupakul. Poster presentation and proceeding, 39th Congress on Science and Technology of Thailand (STT39), Bangkok International Trade & Exhibition Centre (BITEC), Bangkok, Thailand, 21-23 October, 2013.

"Electrical field assisted hollow fiber membrane liquid phase microextraction for determination of chromate ion" Nattaporn Chanthasakda, Pakorn Varanusupakul. Poster presentation, Ninth Mathematics and Physical Sciences Graduate Congress 2014 (9th MPSGC 2014), Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia, 8-10 January, 2014.

"Electrical field assisted hollow fiber membrane liquid phase microextraction for determination of metal oxoanion" Nattaporn Chanthasakda, Pakorn Varanusupakul. Poster presentation, The Science Forum 2013, Faculty of Science, Chulalongkorn Unviersity, Bangkok, Thailand, 14-15 March, 2013.