REFERENCES

Achterbosch, M., Brautigam, K.R., Hartlib, N., Kupsch, C., Richers, U., and Stemmermann, P. 2003. Heavy metals in cement and concrete resulting from the co-incineration of wastes in cement kilns with regard to the legitimacy of waste utilization[Online]. Available from: htt://www.itas.fzk.de/deu /lit/2003/acua03b.pdf[2004, November 28]

Andradea, F.R.D., Maringolob, V., and Kiharaa, Y. (2003). Incorporation of V, Zn and Pb into the Crystalline Phases of Portland Clinker. Cement & Concrete Research. 33: 63-71.

American Society for Testing and Materials (ASTM). (1996). Annual book of ASTM standards. Cement, Lime, and Gypsum. pp.69-119. Danvers: Clearance Center.

Amir, S., Hafidi, M., Merlina, G., and Revel, J. (2005). Sequential extraction of heavy metals during composting of sewage sludge. Chemosphere. 59: 801-810.

Asavapisit, S., Fowler, G., and Cheesesman, C.R. (1997). Solution chemistry during cement hydration in the presence of metal hydroxide wastes. Cement & Concrete Research. 27: 1249-1260.

Asavapisit, S. and Chotlklang, D. (2004). Solidification of electroplating sludge using alkali-activated pulverized fuel ash as cementitious binder. Cement & Concrete Research. 34: 349-353.

Asavapisit, S., Naksrichumb, S. and Harnwajanawong, N. (2005). Strength, leachability and microstructure characteristics of cement-based solidified plating sludge. Cement & Concrete Research. 35: 1042-1049.

ASTDR. (2005). U.S. Department of Health and Human Services. Agency for Toxic Substance and Disease Registry. 245 pp.

Barros, A.M., Tenorio, J.A.S., and Espinosa, D.C.R. (2004). Evaluation of the Incoporation Ratio of ZnO, PbO and CdO into Cement Clinker. J. Hazardous Materials. 112: 71-78.

Ceki, H. and David, T. (2007). Measuring chloride concentrations for various cement-based materials systems. J. ACI Material. 37: 33-40.

Hardaway, C., Gauthreaux, K., Sneddon, J., Jane, and Beck, N. (1999). Evaluation of contaminated sediments by toxicity characteristic leaching procedure extraction techniques. J. Microchemical. 63: 398-404.

Holcim. (2006). Guidelines on co-processing waste materials in cement production. Summary guidline on co-processing. pp. 135. Germany: ROHLAND more mediengesellschaft mbh Offenbach.

Denise, D.R., Espinosa, Jorge, A.S., and Tenorio. (2000). Laboratory study of galvanic sludge's influence on the clinkerization process Microemulsion Formation with Mixed Chlorinated Hydrocarbon Liquides. J. Hazardous Materials. 31: 71-82.

Dumsri, O. 2004. Solidification and stabilization of spent calalyst from catalytic cracking in fludized bed-fly ash with Portland cement. Master's Thesis. Environmental Management, Inter-department of Environmental Science, Graduate School, Chulalongkorn University.

Elbeyl, Y. (2004). Utilization of Industrial Borax Wastes (BW) for Portland Cements Production.Improving. J. Engineering Environmental Science. 28: 281-287.

Espisona, D.C.R. and Tenorio, J.A.S. (2000). Laboratory study of galvanic sludge's influence on the clinkerization process. Resource, Conservation and Recycling. 31: 71-82.

Espisona, D.C.R. and Tenorio, .A.S. (2001). Thermal behavior of chromium electroplating sludge. Waste Management. 21: 405-410.

Filibeli, A., Buyakkamaci, N., and Senol, H. (2000). Solidification tannery waste. Resource, Conservation & Recycling. Vol. 29. pp. 251-261. Elsevier science.

Igarashi, S., Kawamura, M., and Watanabe, A. (2004). Analysis of cement pastes and mortars by a combination of backscatter-based SEM image analysis ana calculations based on the Power model. Cement & Concrete Composites. 26: 977-985.

Iwegbue, C.M.A., Emuh, F.N., Isirimah, N.O., and Egun, A.C. (2007). Review Fraction: Characterization and speciation of heavy metals in composts and compost-amended soils. Afr. J. Biotechnol. 6: 67-78.

Jindaprasert, P. and Jaturapituk, C. (2004). Cement, Pozzolan and Concrete. 1st ed. Thai Concrete Association (TCA).

Shovisian, W. (2001). Concrete Technology. 9th ed. Chauwisian, W.

Kaantee, U., Zevenhoven, R., Backman, R., and Hupa, M. (2004). Cement manufacturing using alternative fuels and the advantages of process modeling.Anionic. Fuel Processing Technology. 85: 293-301.

Kaewkanya, S. 2006. Physical properties and some heavy metals in mortars incorporating cement from co-incineration process using industrial wastes as alternative fuels and raw materials. Master's Thesis. Department of Environmental Engineering, Faculty of Engineering, Chulalongkorn University.

Kacimi, L., Masseron, A.S., Ghomari, A., and Derriche, Z. (2006). Influence of NaF, KF, and CaF_2 addition on the clinker burning temperature and its properti. Comptes Rendus Chimie. 9: 154-163.

Kakali, G., Parissakis, G., and Bouras, D. (1996). A study on the burnability and the phase formation of PC clinker containing Cu oxide. Cement & Concrete Research. 26: 1473-1478.

Kolovos, K., Tsivils, S., and Kakali, G. (2002). The effect of foreign ions on the reactivity of the CaO-SiO_2-Al_2O_3-Fe_2O_3 Systems: Part II. Cations. Cement & Concrete Research. 32: 463-469.

Li, X., Cole., J.B., Ramsey, H.M., and Thornton, I. (1995). Sequential extraction of soils for multielement analysis by ICP-AES. Chemical Geology. 124: 109-123.

Li, X.D., Poona, C.S., Suna, H., Lob, I.M.C., and Kirk, D.W. (2001). Heavy metal speciation and leaching behaviors in cement based solidified/stabilized waste materials. J. Hazardous Materials. 82: 215-230.

Lin, K.L., and Lin, C.Y. (2005). Hydration characteristics of waste sludge ash utilized as raw cement material. Cement & Concrete Research. 35: 1999-2007.

Long Lin, K. and Yi Lin, C. (2005). Hydration characteristics of waste sludge ash utilized as raw cement material. Cement & Concrete Research. 35: 1999-2007.

Mangialardi, T., Lonbardi, F., and Sirini, P. (2000). Mechanical and leaching properties of cement solidified hospital solid waste incinerator fly ash. J. Hazardous Materials. 91: 301-307.

Mindess, S., Young, J.F., and Darwin, D. (2003). Concrete. United States of America: Pearson Education.

Ministry of Industry. Notification of Ministry of Industry No.6 B.E. 2540 (1996)[Online]. 2002. Available from: http://www.diw.go.th/law.html [2004, June 23]

Murat, M., and Sorrentino, F. (1996). Effect of large additions of Cd, Pb, Cr, Zn to cement raw metal on the composition and the properties of the clinker and the cement. Cement & Concrete Research. 26: 377-385.

Neville, A.M. and Brooks, J.J. (1994). Concrete Technology. Singapore: Longman Singapore Publishers (Pte) Ltd.

Neville, A. M. (2003). Properties of Concrete. 4th ed. Malaysia: Pearson Education Ltd.

Papakonstantinou, G.C. and Tobolski, J.M. (2006). Used of waste tire steel beads in Portland cement concrete. Cement & Concrete Research. 36: 1686-1691.

Pipilikaki, P., Katsioti, M., Papageorgiou, D., Fragoulis, D., and Haniotakis, E. (2005). Use of tire derived fuel in clinker burning. Cement & Concrete Composites. 27: 843-847.

Poon, C.S., Peters, C.J., and Perry, R. (1985). Mechanisms of metal stabilization by cement based fixation processes. The Science of the Total Environment. 41: 55-71.

Quevauviller, P. (2002). Methodologies in soil and sediment fractionation studies: Single and sequential extraction procedures. Cornwall: The Royal Society of Chemistry.

Rachakornkij, M. 2000. Utilization of municipal solid waste incinerator fly ash in cement mortars. Doctoral dissertation. Civil Engineering, New Jersey Institute of Technology.

Ract, P.G., Espinosa, D.C.R.., and Tenorio, J.A.S. (2003). Determination of Cu and Ni incorporation ratios in Portland cement clinker. Waste Management. 23: 281-285.

Roy, A. and Cartedge, F.K. (1997). Long-term behavior of a portland cement-electroplating sludge waste from in presence of copper nitrate. J. Hazardous Materials. 52: 265-272

Roy, A., Eaton, H.C., Cartedge, F.K., and Tittlebeam, M.E. (1998). Solidification/stabilization of heavy metal sludge by Portland cement/fly ash binding mixture. Hazardous Waste & Hazardous Materials. 5: 125-141.

Ruangchuay, S. 2005. Utilization of bagasse and bagasse fly ash as adsorbents for removal of lead and chromium and subsequent utilization as construction materials. Doctoral dissertation. Environmental Management, Inter-department of Environmental Science, Graduate School, Chulalongkorn University.

Sammasut, P. 2004. Quantitative and qualitative characteristics of heavy metals in cement clinker from co-incineration process using copper slag. Master's Thesis. Department of Environmental Engineering, Faculty of Engineering, Chulalongkorn University.

Shih, P.H., Chang, J.E., Lu, H.C., and Chiang, L.C. (2005). Reuse of heavy metal containing sludge in cement production. Cement & Concrete Research. 35: 2110-2115.

Shih, P.H., Chang, J.E., Lu, H.C., and Chiang, L.C. (2003). Replacement of raw mix in cement production by municipal waste incineration ash. Cement & Concrete Research. 33: 1831-1836.

Spence, R.D. (2000). Chemistry and microstructure of solidified waste forms. Florida: Lewis Publishers.

Spung, S. (1985). Technological Problems in Pyroprocessing Cement Clinker. 1st ed. Beton-Verlag: Dusseldorf.

Stephan, D., Mallmann, R., Khofel, D., and Hardtl, R. (1999). High intakes of Cr, Ni, and Zinc in clinker Part II. Influence on the hydration properties. Cement & Concrete Research. 29: 1959-1967.

Tessier, A., Campbell, PGC., and Bisson, M. (1979). Sequential extraction procedure for the speciation trace metals. Analytical Chemistry. 51: 844.

Taylor, H. F .W. (1997). Cement Chemistry. 2nd ed. London: Thomas Telford Plublishing.

Teewakijvanich, E. 2004. Leaching behavior of metals from cement derived from the co-burning of hazardous waste. Master's Thesis. Environmental Management, Inter-department of Environmental Science, Graduate School, Chulalongkorn University.

Tezza, M.A., and Scian, A.N. (2000). Burning wastes as an industrial resource their effect on Portland cement clinker. Cement & Concrete Research. 30: 137-144.

U.S. Environmental Protection Agency. Toxicity characteristic Leaching Procedure [Online]. 1992. Available from: http://www.epa.gov/epaoswer/hazwaste /test/pdfs/1311.pdf [2004, December 3]

U.S. Environmental Protection Agency. Microwave assisted acid digestion of siliceous and organically based matrices [Online]. 1996. Available from: http://www.epa.gov/sw-846/pdfs/3052.pdf [2007, March 24]

Vincoli, W. Jeffrey. (1997). Risk Management for Hazardous Chemicals V.1 and V. 2, CRC Press, Inc., pp. 649.

Wang, S., and Vipulanandan, C. (2000). Solidification/stabilization of Cr(VI) with cement leachability and XRD analyses. J. Hazardous Materials. 30: 385-389.

Weng, C.H. and C.P., Huang. (1994). Treatment of metal and industrial wastewater by fly ash and cement fixation. J. Environmental Engineering. 120: 1470-1484.

Yamaguchi, O., Ida, M., Uchiyama, Y., and Hanehara, S. (2006). A method for the determination of total Cr (VI) in cement. J. The European Ceramic Society. 26: 785-790.

Zain, M.F.M., Islam, M.N., Radin, S.S., and Yap, S.G. (2004). Cement-based solidification for the safe disposal of blasted copper slag. Cement & Concrete Research. 26: 215-230.

APPENDICES

APPENDIX A

Compressive strength test

Table A-1 Compressive strength of cement mortar at 3-days curing time with difference percent of petroleum sludge addition

Percent replacement	Area (cm^2)	Compressive strength		
		kN	ksc	Average
0%	25.00	23.00	93.81	95.17
	25.05	25.00	101.97	
	25.05	22.00	89.74	
5%	25.00	21.00	85.66	89.74
	25.00	22.50	91.77	
	25.05	22.50	91.77	
10%	25.00	19.00	77.50	84.30
	25.00	20.50	83.62	
	25.05	22.50	91.77	
15%	25.05	22.00	89.74	84.30
	25.05	20.50	83.62	
	25.05	19.50	79.54	
20%	25.00	21.50	87.70	83.62
	25.00	20.50	83.62	
	25.05	19.50	79.54	

Table A-2 Compressive strength of cement mortar at 7-days curing time with difference percent of petroleum sludge addition

Percent replacement	Area (cm^2)	Compressive strength		
		kN	ksc	Average
0%	25.00	33.00	134.60	127.12
	25.00	30.50	124.41	
	25.05	30.00	122.37	
5%	25.00	31.50	128.48	125.76
	25.00	30.50	124.41	
	25.05	30.50	124.41	
10%	25.05	30.00	122.37	121.69
	25.05	30.50	124.41	
	25.05	29.00	118.29	
15%	25.00	29.50	120.33	121.01
	25.00	29.50	120.33	
	25.05	30.00	122.37	
20%	25.00	28.00	114.21	118.29
	25.05	28.50	116.25	
	25.05	30.50	124.41	

Table A-3 Compressive strength of cement mortar at 14-days curing time with difference percent of petroleum sludge addition

Percent replacement	Area (cm^2)	Compressive strength		
		kN	ksc	Average
0%	25.05	40.50	165.19	168.59
	25.05	42.50	173.35	
	25.05	41.00	167.23	
5%	25.00	37.00	150.92	161.79
	25.05	40.50	165.19	
	25.05	41.50	169.27	
10%	25.00	38.50	157.04	161.12
	25.00	40.00	163.15	
	25.05	40.00	163.15	
15%	25.00	36.00	146.84	154.32
	25.00	38.50	157.04	
	25.05	39.00	159.08	
20%	25.00	38.00	155.00	153.64
	25.05	37.50	152.96	
	25.05	37.50	152.96	

Table A-4 Compressive strength of cement mortar at 28-days curing time with difference percent of petroleum sludge addition

Percent replacement	Area (cm^2)	Compressive strength		
		kN	ksc	Average
0%	25.05	70.50	287.56	288.92
	25.05	70.50	287.56	
	25.05	71.50	291.64	
5%	25.00	69.50	283.48	286.88
	25.05	70.50	287.56	
	25.05	71.00	289.60	
10%	25.00	69.50	283.48	284.84
	25.00	70.00	285.52	
	25.00	70.00	285.52	
15%	25.00	66.00	269.21	276.00
	25.05	67.50	275.32	
	25.05	69.50	283.48	
20%	25.00	66.00	269.21	269.88
	25.00	66.00	269.21	
	25.00	66.50	271.24	

APPENDIX B

Leaching tests

Table B-1 Extracted concentration of chromium from M3052

Heavy metal	% replacement	Extracted concentration (mg/kg)			
		Sample 1	Sample 2	Sample 3	Average
Chromium	0%	40.30	40.29	40.28	40.29
	5%	716.42	724.20	728.20	722.94
	10%	724.48	735.06	744.20	734.58
	15%	804.34	804.40	810.00	806.25
	20%	886.20	887.94	907.98	894.04

Table B-2 Extracted concentration of nickel from M3052

Heavy metal	% replacement	Extracted concentration (mg/kg)			
		Sample 1	Sample 2	Sample 3	Average
Nickel	0%	12.22	12.21	12.21	12.21
	5%	296.48	302.62	304.60	301.23
	10%	319.98	319.98	331.34	323.77
	15%	389.34	391.28	394.44	391.67
	20%	431.72	431.92	447.24	436.96

Table B-3 Extracted concentration of zinc from M3052

Heavy metal	% replacement	Extracted concentration (mg/kg)			
		Sample 1	Sample 2	Sample 3	Average
Zinc	0%	11.46	10.33	9.47	10.42
	5%	1243.46	1262.24	1271.02	1258.91
	10%	1515.98	1519.22	1529.58	1521.59
	15%	1910.78	1922.42	1923.10	1918.77
	20%	2398.94	2432.64	2453.02	2428.20

Table B-4 Extracted concentration of lead from M3052

Heavy metal	% replacement	Extracted concentration (mg/kg)			
		Sample 1	Sample 2	Sample 3	Average
Lead	0%	9.68	9.59	9.49	9.59
	5%	31.74	31.86	32.71	32.10
	10%	42.64	43.58	44.43	43.55
	15%	63.02	65.07	65.26	64.45
	20%	72.24	72.65	74.48	73.13

Table B-5 Leached concentration of chromium from TCLP

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Chromium	0%	0.022	0.024	0.026	0.024
	5%	0.027	0.027	0.027	0.027
	10%	0.034	0.035	0.036	0.035
	15%	0.049	0.050	0.051	0.050
	20%	0.051	0.052	0.052	0.052

Remark: nd = not detected

Table B-6 Leached concentration of nickel from TCLP

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Nickel	0%	nd	nd	nd	-
	5%	nd	nd	nd	-
	10%	nd	nd	nd	-
	15%	nd	nd	nd	-
	20%	nd	nd	nd	-

Table B-7 Leached concentration of zinc from TCLP

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Zinc	0%	0.014	0.015	0.017	0.015
	5%	0.026	0.026	0.027	0.026
	10%	0.034	0.036	0.037	0.036
	15%	0.056	0.059	0.059	0.058
	20%	0.072	0.08	0.082	0.078

Table B-8 Leached concentration of lead from TCLP

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Lead	0%	nd	nd	nd	-
	5%	nd	nd	nd	-
	10%	nd	nd	nd	-
	15%	nd	nd	nd	-
	20%	nd	nd	nd	-

Table B-9 Leached concentration of chromium from the Notification of the Ministry of Industry No. 6 B.E. 2540 (1997)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Chromium	0%	0.019	0.021	0.021	0.020
	5%	0.023	0.024	0.026	0.024
	10%	0.035	0.036	0.036	0.036
	15%	0.041	0.041	0.042	0.041
	20%	0.052	0.052	0.053	0.052

Table B-10 Leached concentration of nickel from the Notification of the Ministry of Industry No. 6 B.E. 2540 (1997)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Nickel	0%	nd	nd	nd	-
	5%	nd	nd	nd	-
	10%	nd	nd	nd	-
	15%	nd	nd	nd	-
	20%	nd	nd	nd	-

Table B-11 Leached concentration of zinc from the Notification of the Ministry of Industry No. 6 B.E. 2540 (1997)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Zinc	0%	0.020	0.022	0.026	0.023
	5%	0.030	0.031	0.032	0.031
	10%	0.039	0.041	0.042	0.041
	15%	0.047	0.071	0.071	0.063
	20%	0.067	0.076	0.079	0.074

Table B-12 Leached concentration of lead from the Notification of the Ministry of Industry No. 6 B.E. 2540 (1997)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Lead	0%	nd	nd	nd	-
	5%	nd	nd	nd	-
	10%	nd	nd	nd	-
	15%	nd	nd	nd	-
	20%	nd	nd	nd	-

Table B-13 Leached concentration of chromium from the Notification of the Ministry of Industry B.E. 2548 (2005)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Chromium	0%	0.389	0.393	0.414	0.399
	5%	0.55	0.551	0.554	0.552
	10%	0.672	0.684	0.690	0.682
	15%	0.713	0.728	0.729	0.723
	20%	0.751	0.753	0.762	0.755

Table B-14 Leached concentration of nickel from the Notification of the Ministry of Industry B.E. 2548 (2005)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Nickel	0%	0.061	0.062	0.066	0.063
	5%	0.069	0.070	0.072	0.070
	10%	0.084	0.091	0.091	0.089
	15%	0.114	0.117	0.123	0.118
	20%	0.130	0.130	0.148	0.136

Table B-15 Leached concentration of zinc from the Notification of the Ministry of Industry B.E. 2548 (2005)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Zinc	0%	0.076	0.079	0.079	0.078
	5%	0.085	0.091	0.091	0.089
	10%	0.124	0.130	0.139	0.131
	15%	0.155	0.159	0.164	0.159
	20%	0.209	0.212	0.212	0.211

Table B-16 Leached concentration of lead from the Notification of the Ministry of Industry B.E. 2548 (2005)

Heavy metal	% replacement	Leached concentration (mg/L)			
		Sample 1	Sample 2	Sample 3	Average
Lead	0%	nd	nd	nd	-
	5%	nd	nd	nd	-
	10%	nd	nd	nd	-
	15%	nd	nd	nd	-
	20%	nd	nd	nd	-

Table B-17 Acceptable maximum value of heavy metals in waste for cement industry

Heavy metals	Maximum values of heavy metals in waste (mg/kg)
As	5,000
Cd	1,000
Cr	5,000
Cu	10,000
Hg	500
Tl	50
Ni	1,000
V	1,000
Pb	10,000
Zn	50

Source: Siam City Cement Company Public Limited.

Table B-18 Standard values of Cr, Ni, Zn, and Pb from MOI No.6 B.E. 2540 (1996), MOI B.E. 2548 (2005) and U.S. EPA (TCLP)

Heavy metals	Concentration (mg/L)		
	MOI No.6 B.E. 2540 (1996)	MOI B.E. 2548 (2005)	U.S.EPA (TCLP)
Cr	5	5	5
Ni	-	20	-
Zn	-	250	-
Pb	5	5	5

Table B-19 Extracted concentrations of heavy metals and percent extraction from sequential extraction test

Heavy metals	Fraction	Extracted concentration									
		0%		5%		10%		15%		20%	
		mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%
Cr	1	0.24	0.59	5.24	0.93	6.61	1.15	9.78	1.40	10.03	1.35
	2	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	3	16.95	42.06	242.92	43.02	250.52	43.43	306.19	43.69	332.01	44.56
	4	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	5	23.11	57.35	316.46	56.05	319.67	55.42	384.89	54.92	403.11	54.10
Ni	1	8.09	7.39	19.50	7.04	20.90	6.47	22.50	5.90	24.58	5.74
	2	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	3	7.82	7.15	13.36	4.83	19.60	6.07	38.84	10.19	54.75	12.78
	4	0.13	0.11	3.39	1.22	9.07	2.81	10.08	2.64	15.40	3.60
	5	93.37	85.35	240.64	86.91	273.48	84.66	309.86	81.27	333.61	77.88
Zn	1	0.02	0.19	6.20	0.54	6.63	0.45	7.61	0.45	9.30	0.53
	2	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	3	2.28	18.66	185.41	16.02	211.40	14.47	236.34	13.97	242.24	13.77
	4	0.23	0.21	8.20	0.71	27.73	1.90	39.40	2.33	60.44	3.44
	5	9.88	80.93	957.25	82.73	1214.90	83.17	1408.55	83.25	1446.65	82.26
Pb	1	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	2	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	3	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	4	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00
	5	nd	0.00	nd	0.00	nd	0.00	nd	0.00	nd	0.00

Table B-20 Extracted concentrations of heavy metals compare with the standard value of surface water quality Standards

Heavy metals	Fraction	Extracted concentration										Standard value
		0%		5%		10%		15%		20%		
		mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/L	mg/L
Cr	1	0.24	0.000	5.24	0.005	6.61	0.007	9.78	0.010	10.03	0.010	0.05
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	3	16.95	0.017	242.9	0.243	250.5	0.251	306.1	0.306	332.0	0.332	
	4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	5	23.11	0.023	316.4	0.316	319.6	0.320	384.8	0.385	403.1	0.403	
Ni	1	8.09	0.008	19.50	0.019	20.90	0.021	22.50	0.023	24.58	0.025	0.1
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	3	7.82	0.008	13.36	0.013	19.60	0.020	38.84	0.039	54.75	0.055	
	4	0.13	0.000	3.39	0.003	9.07	0.009	10.08	0.010	15.40	0.015	
	5	93.37	0.093	240.6	0.241	273.4	0.273	309.8	0.310	333.6	0.334	
Zn	1	0.02	0.000	6.20	0.006	6.63	0.007	7.61	0.008	9.30	0.009	1
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	3	2.28	0.002	185.4	0.185	211.4	0.211	236.3	0.236	242.2	0.242	
	4	0.23	0.000	8.20	0.008	27.73	0.028	39.40	0.039	60.44	0.060	
	5	9.88	0.099	957.2	0.957	1214.	1.215	1408.	1.409	1446.	1.447	
Pb	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.05
	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
	5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	

APPENDIX C

Scanning Electron Microscopy (SEM) with Energy Dispersive Spectroscopy (EDS).

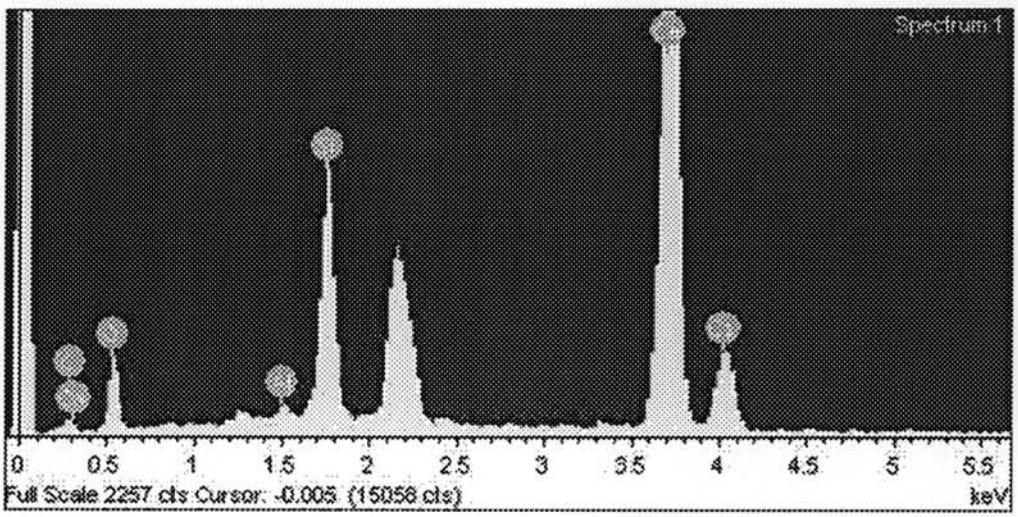

Figure C-1 Spectrum 1 of Energy Dispersive Spectroscopy of 0% addition

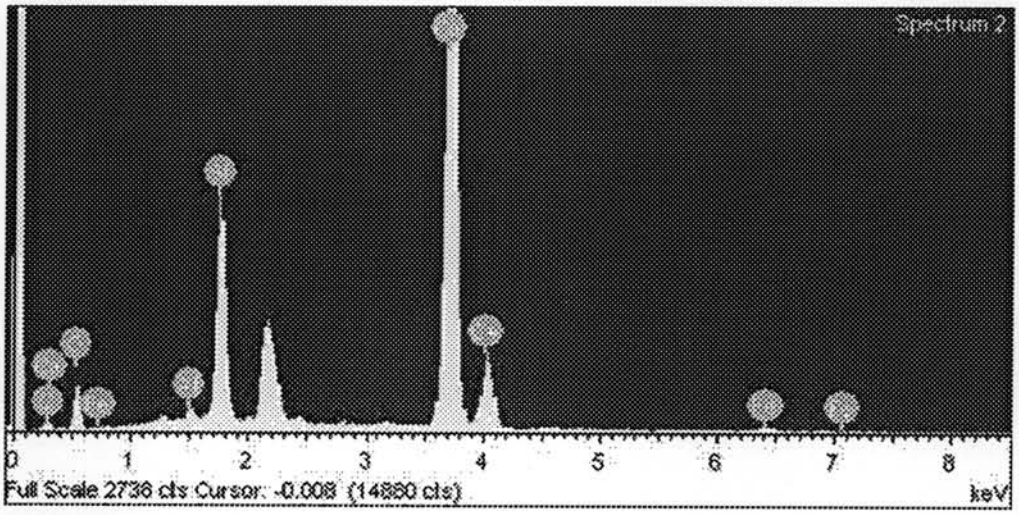

Figure C-2 Spectrum 2 of Energy Dispersive Spectroscopy of 0% addition

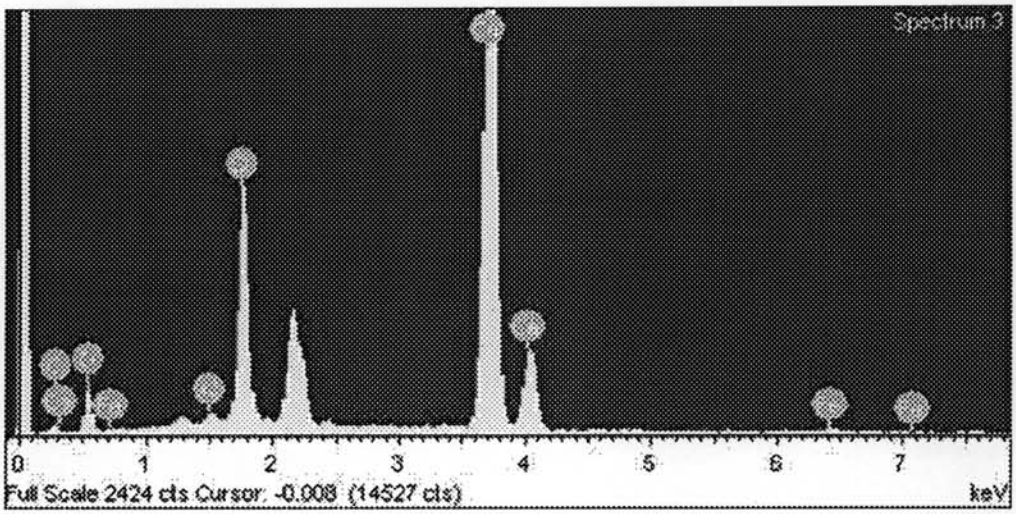

Figure C-3 Spectrum 3 of Energy Dispersive Spectroscopy of 0% addition

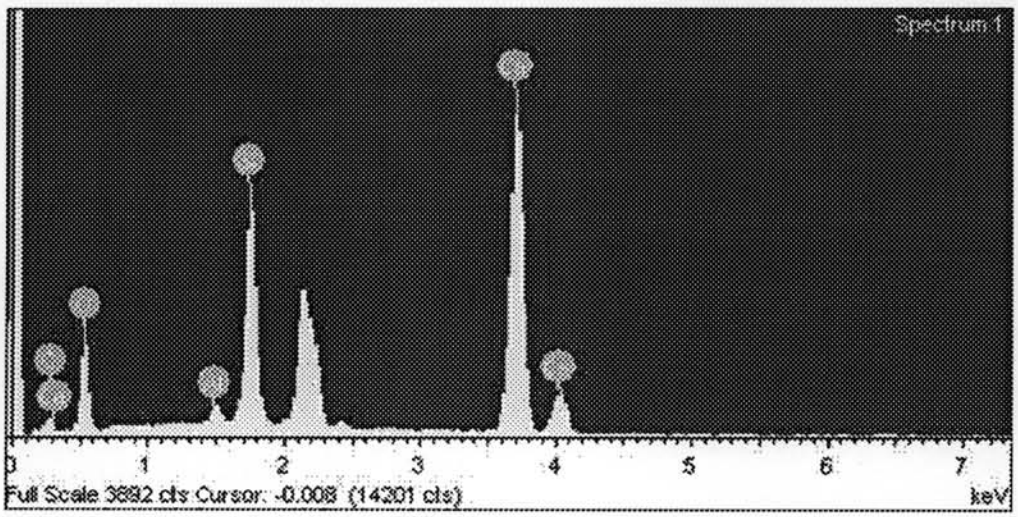

Figure C-4 Spectrum 1 of Energy Dispersive Spectroscopy of 5% addition

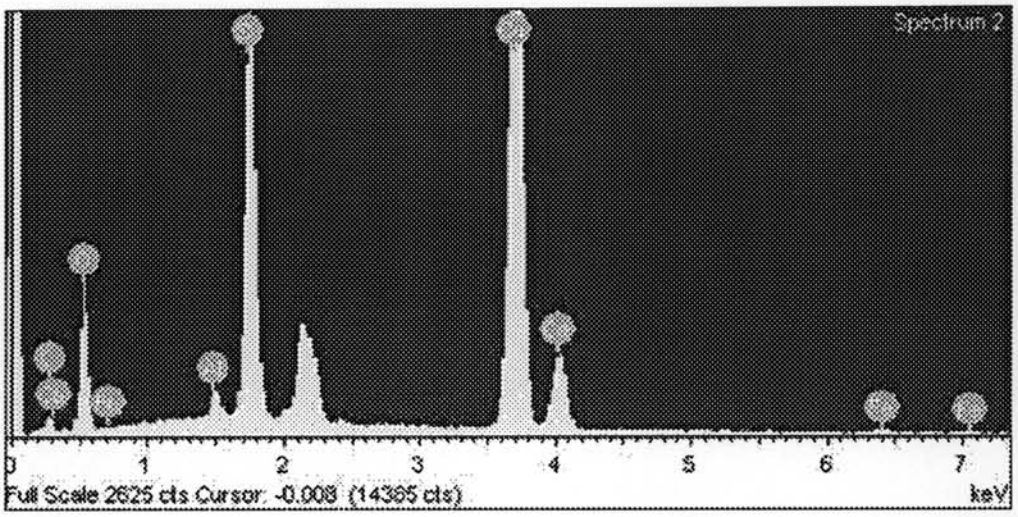

Figure C-5 Spectrum 2 of Energy Dispersive Spectroscopy of 5% addition

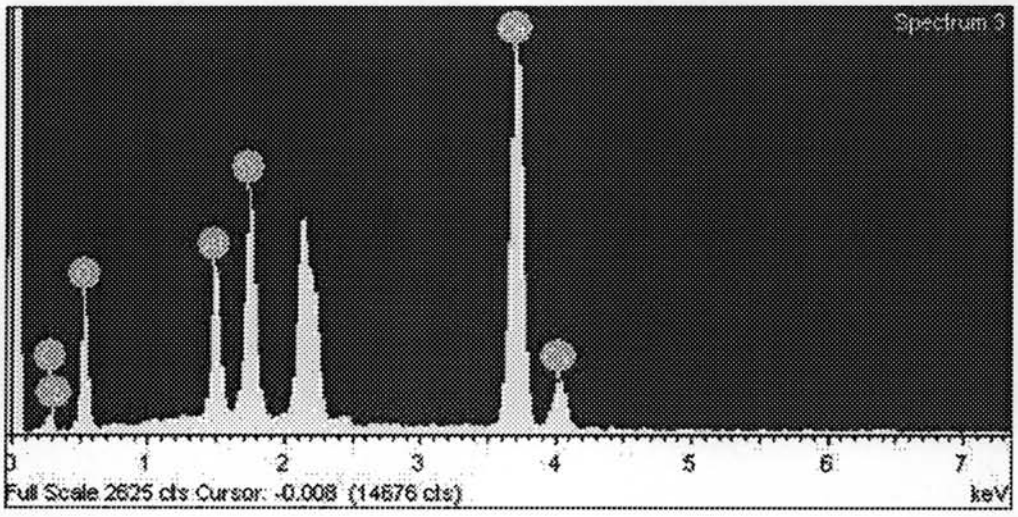

Figure C-6 Spectrum 3 of Energy Dispersive Spectroscopy of 5% addition

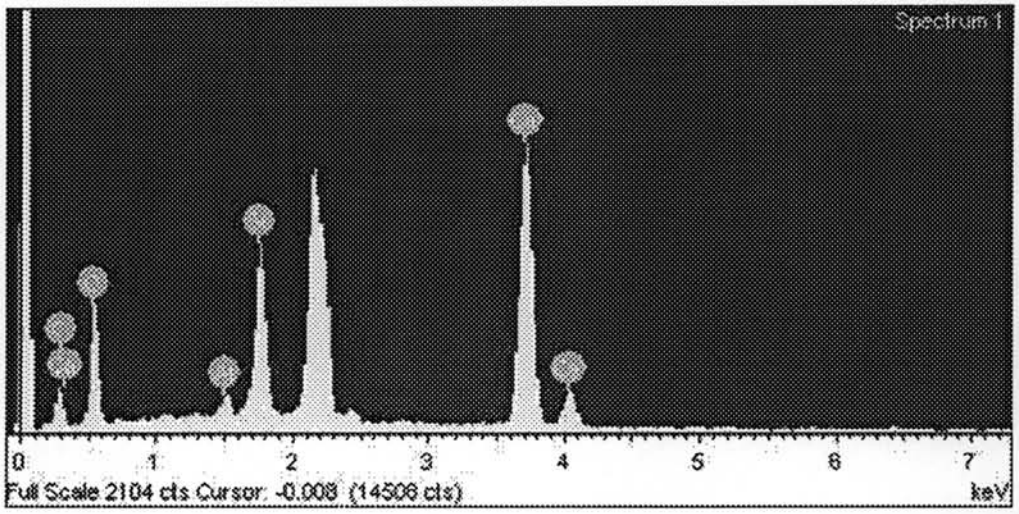

Figure C-7 Spectrum 1 of Energy Dispersive Spectroscopy of 15% addition

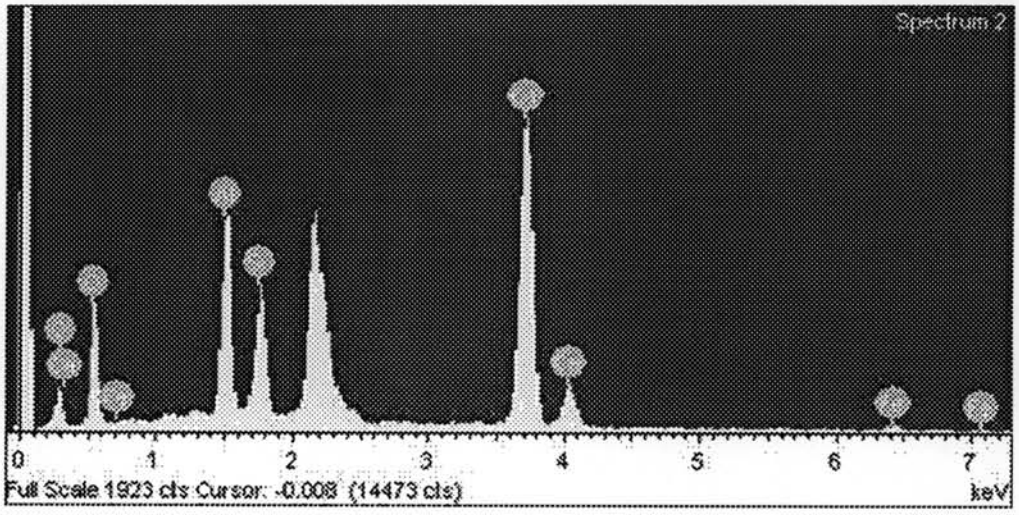

Figure C-8 Spectrum 2 of Energy Dispersive Spectroscopy of 15% addition

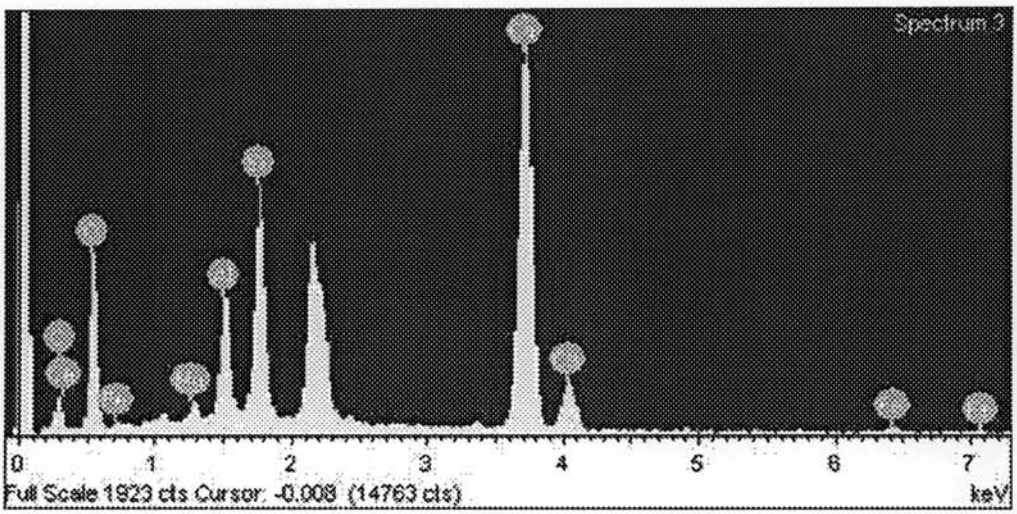

Figure C-9 Spectrum 3 of Energy Dispersive Spectroscopy of 15% addition

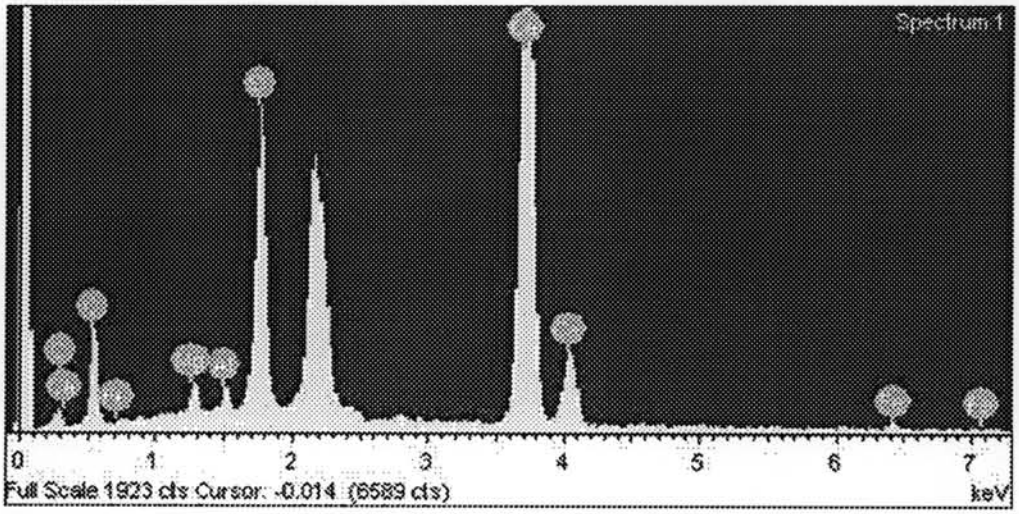

Figure C-10 Spectrum 1 of Energy Dispersive Spectroscopy of 20% addition

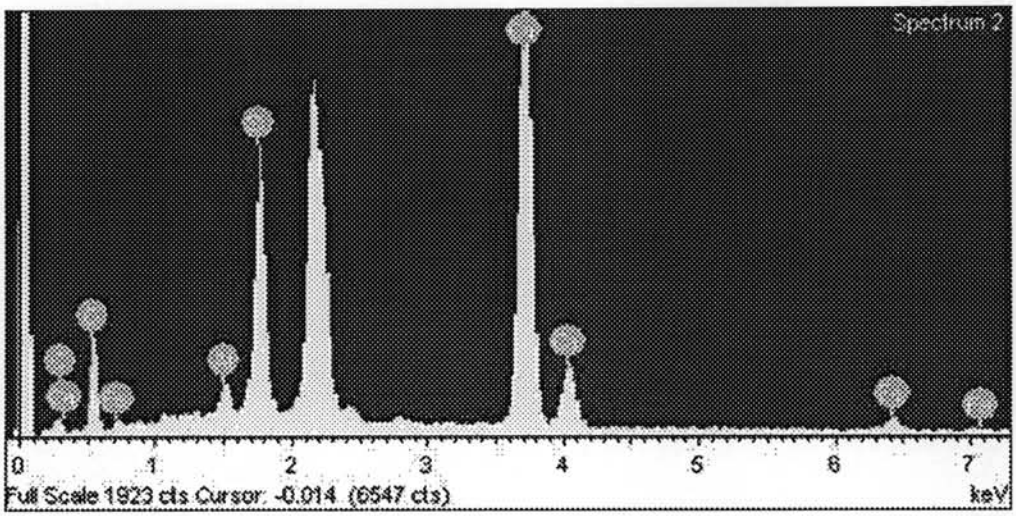

Figure C-11 Spectrum 2 of Energy Dispersive Spectroscopy of 20% addition

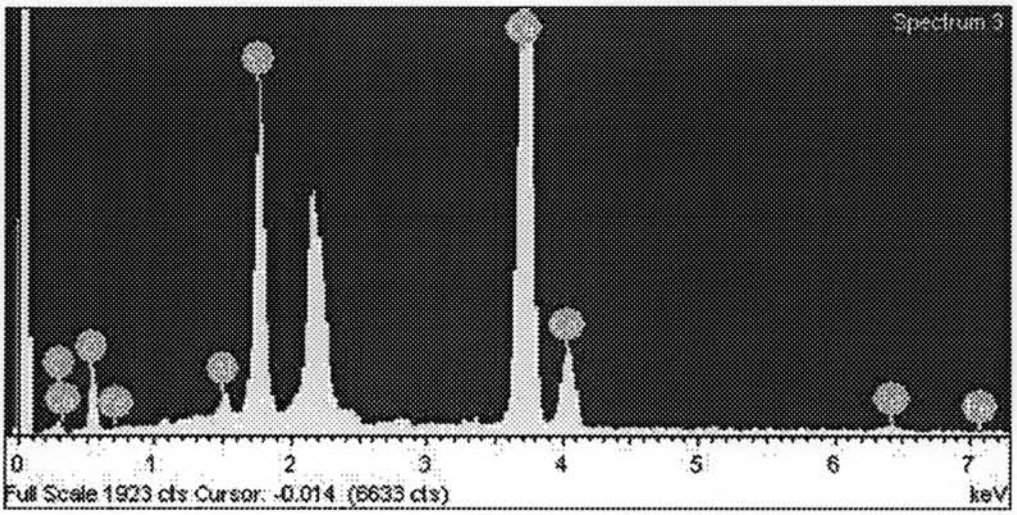

Figure C-12 Spectrum 3 of Energy Dispersive Spectroscopy of 20% addition

BIOGRAPHY

Name: Miss Nuntira Supasai

Date of Birth: May 22, 1982

Nationality: Thai

University Education: 2002-2005 Bachelor Degree of Science in Sanitary Science, Faculty of Public Health, Khonkaen University, Khonkaen, Thailand

Presentation:

- Manaskorn Rachakornkij, Nuntira Supasai, and Tantip Panmetarit. *Leaching of Heavy Metals from Cement from Co-processing of Industrial Sludge Containing Petroleum and Heavy Metals as Alternative Fuel.* The Proceedings of 7th National Environmental Conference 2008, Bangkok, Thailand, March 12 - 14, 2008. Chulabhon Research Institute.