REFERENCES

Al-Awadhi, N., Al-Daher, R., ElNavavy, A. and Balba, M. T. (1996). Bioremediation of oil-contaminated soil in Kuwait: landfarming to remediate oil-contaminated soil. Journal of Soil Contamination 5: 243-260.

Alef, K. (1995). Dehydrogenase activity. In: Alef K, Nannipieri P(eds) Methods in applied soil microbiology and biochemistry. San Diego, Calif, Academic Press, pp 228-231.

Alexander, M. (1994). Biodegradation and Bioremediation. New York, Academic Press.

Atagana, H. I., Haynes, R. J. and Wallis, F. M. (2003). Optimization of soil physical and chemical conditions for the bioremediation of creosote-contaminated soil. Biodegradation 14: 297-307.

Bento, F. M., Camargo, F. A. O., Okeke, B. C. and Frankenberger, W. T. (2005). Comparative bioremediation of soils contaminated with diesel oil by natural attenuation, biostimulation and bioaugmentation. Bioresource Technology 96(9): 1049-1055.

Bhupathiraju, V. K., Hernandez, M., Landfear, D. and Alvarez-Cohen, L. (1999). Application of a tetrazolium dye as an indicator of viability in anaerobic bacteria. Journal of Microbiological Methods 37: 231-243.

Boopathy, R. (2000). Factors limiting bioremediation technologies. Bioresource Technology 74: 63-67.

Braddock, J. F., Ruth, M. L., Catterall, P. H., Walworth, J. L. and McCarthy, K. A. (1997). Enhancement and inhibition of microbial activity in hydrocarbon-contaminated Arctic soils: implications for nutrientamended bioremediation. Environmental Science and Technology 31: 2078-2084.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. Soil Science 59: 39-45.

Castillo, M. A., Felis, N., Aragon, P., Cuesta, G. and Sabater, C. Biodegradation of the herbicide diuron by streptomycetes isolated from soil. International Biodeterioration & Biodegradation In Press, Corrected Proof.

Cox, C. (2003). Diuron. Journal of Pesticide Reform 23(1): 12-20.

Crane, F. L., Sun, I. L., Barr, R. and Löw, H. (1991). Electron and proton transport across the plasma membrane. Journal of Bioenergetics and Biomembranes 23: 773-803.

Cullington, J. E. and Walker, A. (1999). Rapid biodegradation of diuron and other phenylurea herbicides by a soil bacterium. Soil Biology and Biochemistry 31(5): 677-686.

Dalton, R. L., Evans, A. W. and Rhodes, R. C. (1966). Disappearance of diuron from cotton field soils. Weeds 14: 31-33.

Dungan, R. S., Kukier, U. and Lee, B. (2005). Blending foundry sands with soil: Effect on dehydrogenase activity. Science of the Total Environment 191: 1-10.

Esposito, E., Paulillo, S. M. and Manfio, G. P. (1998). Biodegradation of the herbicide diuron in soil by indigenous actinomycetes. Chemosphere 37(3): 541-548.

Evans, G. M. and Furlong, J. C. (2003). Environmental Biotechnology: Theory and Application. England, John Wiley and Sons.

Forsyth, J. V., Tsao, Y. M. and Bleam, R. D. (1995). Bioremediation: when is augmentation needed?. In: R. E. Hinchee, J. Fredrickson and B. C. Alleman (Eds.). Bioremediation for site remediation. pp. 1-15. Columbus, Battelle Press.

Gee, G. W. and Bauder, J. W. (1979). Particle size analysis by hydrometer: a simplified method for routine textural analysis and a sensitivity test of measured parameters. Soil Science Society of America Journal 43: 1004-1007.

Giacomazzi, S. and Cochet, N. (2004). Environmental impact of diuron transformation: a review. Chemosphere 56(11): 1021-1032.

Gooddy, D. C., Chilton, P. J. and Harrison, I. (2002). A field study to assess the degradation and transport of diuron and its metabolites in a calcareous soil. The Science of the Total Environment 297: 67-83.

Heydrich, M. and Fernández, C. (1984). Changes in the composition of the actinomycete community in a soil tated with diuron, In Soil biology ad coservation of the biosphere, Vol. 1, Ed. J. Szegi. Budapest: Akademiai Klado.: 209-215.

Hupe, K., Koning, M., Luth, J. C., Heerenklage, J. and Stegmann, R. (2001). Optimization of microbial soil treatment. In R. Stegmann, G. Brunner, W. Calmano and G. Matz (eds.). Treatment of contaminated soil. New York, Springer: 343-354.

Jackson, M. (1958). Soil Chemical Analysis. Madison, Wisconsin, Prentice-Hall.

Johnson, C. R. and Scow, K. M. (1999). Effect of nitrogen and phosphorus addition on phenanthrene biodegradation in four soils. Biodegradation 10: 43-50.

Kaimi, E., Mukaidani, T., Miyoshi, S. and Tamaki, M. (2006). Ryegrass enhancement of biodegradation in diesel-contaminated soil. Environmental and Experimental Botany 55: 110-119.

Kaplan, C. W. and Kitts, C. L. (2004). Bacteria succession in a petroleum land treatment unit. Applied and Environmental Microbiology 70: 1777-1786.

Khadrani, A., Seigle-Murandi, F., Steiman, R. and Vroumsia, T. (1999). Degradation of three phenylurea herbicides (chlorotoluron, isoproturon and diuron) by micromycetes isolated from soil. Chemosphere 38(13): 3041-3050.

King, R. B., Long, G. M. and Sheldon, J. K. (1997). Practical environmental bioremediation : The field guide. New York, Lewis Publishers.

Klongdee, J., Petchkroh, W., Phuempoonsathaporn, K., Praserthdam, P., Vangnai, A. S. and Pavarajarn, V. (2005). Activity of nanosized titania synthesized from thermal decomposition of titanium (IV) *n*-butoxide for the photocatalytic degradation of diuron. Science and Technology of Advanced Materials 6: 290-295.

Klose, S., *Acosta-Martinez, V.* and Ajwa, H. A. (2005). Microbial community composition and enzyme activities in a sandy loam soil after fumigation with methyl bromide or alternative biocides. Soil Biology and Biochemistry 37(12): 2171-2182.

Liebeg, E. W. and Cutright, T. J. (1999). The investigation of enhanced bioremediation through the addition of macro and micro nutrients in a PAH contaminated soil. International Biodeterioration & Biodegredation 44(1): 55-64.

Liu, J. (2001). Phenylurea herbicides In: Krieger, R. eds. , Handbook of Pesticide Toxicology. San Diego, Academic Press: 1521-1527.

Liu, Q., Feng, J. and Buzin, C. (1999). Detection of virually all mutations-SSCP (DOVAM-S): a rapid method for mutation scanning with virtually 100% sensitivity. Biotechniques 26: 932-942.

Malato, S., Blanco, J., Caceres, J., Fernandez-Alba, A. R., Aguera, A. and Rodriguez, A. (2002). Photocatalytic treatment of water-soluble pesticides by photo-Fenton and TiO2 using solar energy. Catalysis Today 76: 209-220.

Mata-Sandoval, J. C., Karns, J. and Torrents, A. (2001). Influence of rhamnolipids and Triton X-100 on the biodegradation of three pesticides in aqueous phase and soil slurries. Journal of Agricultural and Food Chemistry 49: 3296–3303.

Maurines-Carboneill, C., Pernelle, J. J., Morin, L., Sachon, G. and Leblon, G. (1998). Relevance of the INT test response as an indicator of the ETS activity in monitoring heterotrophic aerobic bacterial populations in activated sludges. Water Research 32: 1213-1221.

McLeod, S. (1973). Studies on wet oxidation procedures for the determination of organic carbon in soils. CSIRO Division of Soils. Notes on Soil Techniques: 73-79.

Molnaa, B. A. and Grubbs, R. B. (1989). Bioremediation of petroleum contaminated soils using a microbial consortia as inoculum: Petroleum contaminated soils. Vol. 2. Chelsea, Lewis.

Mosher, J. J., Findlay, R. H. and Johnston, C. G. (2006). Physical and chemical factors affecting microbial biomass and activity in contaminated subsurface riverine sediments. Canadian Journal of Microbiology 52: 397-403.

Nakatsu, C. H., Torsvik, V. and Ovreas, L. (2000). Soil community analysis using of 16s rDNA polymerase chain reaction products. Soil Science Society America Journal 64: 1382-1388.

Okamura, H. (2002). Photodegradation of the antifouling compounds Irgarol 1051 and diuron released from a commercial antifouling paint. Chemosphere 48: 43-50.

Olaniran, A. O., Pillay, D. and Pillay, B. (2006). Biostimulation and bioaugmentation enhances aerobic biodegradation of dichloroethenes. Chemosphere 63: 600-608.

Orita, M., Iwahana, H., Kanazawa, H., Hayashi, K. and Sekiya, T. (1989). Detection of polymorphisms of human DNA by gel electrophoresis as Single-Strand Conformation Polymorphisms. Proceedings of the National Academy of Sciences of the United States of America 86: 2766-2770.

Phuempoonsathaporn, K. (2006). Leaching of diuron from soil by organic solvent and surfactant. Master's Thesis, Department of Biotechnology, Faculty of Science, Chulalongkorn University.

Prado, A. G. S. and Airoldi, C. (2001). The effect of the herbicide diuron on soil microbial activity. Pest Management Science 57: 640-644.

Providenti, M. A., Lee, H. and Trevors, J. T. (1993). Selected factors limiting the microbial degradation of recalcitrant compounds. Journal of Industrial Microbiology 12: 379-395.

Radianingtyas, H., Robinson, G. K. and Bull, A. T. (2003b). Characterization of a soil-derived bacterial consortium degrading 4-chloroaniline. Microbiology 149: 3279-3287.

Richard, J. Y. and Vogel, T. M. (1999). Characterization of a soil bacterial consortium capable of degrading diesel fuel. International Biodeterioration & Biodegradation 44: 4493-4503.

Said-El-Fantroussi, V., Verstraete, W. and Top, E. M. (1999). Effect of phenylurea herbicides on soil microbial communities estimated by analysis of 16S rRNA gene fingerprints and community-level physiological profiles. Applied and Environmental Microbiology 65: 982-988.

Salvestrini, S., Di-Cerbo, P. and Capasso, S. (2002). Kinetics of the chemical degradation of diuron. Chemosphere 48: 69-73.

Sebai, T. E., Lagacherie, B., Soulas, G. and Martin-Laurent, F. (2004). Isolation and characterisation of an isoproturon-mineralising Methylopila sp. TES from French agricultural soil. FEMS Microbiology Letters 239(1): 103-110.

Seghers, D., Verthe, K., Reheul, D., Bulcke, R., Siciliano, S. D., Verstraete, W. and Top, E. M. (2003). Effect of long-term herbicide applications on the bacterial community structure and function in an agricultural soil. FEMS Microbiology Ecology 46: 139-146.

Seklemova, E. and Pavlova, K. (2001). Biostimulation based bioremediation of diesel fuel: field demonstration. Biodegradation 12: 311-316.

Sentinelli, F., Lovari, S., Vitale, M., Giorgi, G., Mario, U. D. and Baroni, M. G. (2000). A simple method for non-radioactive PCR-SSCP using MDE™ gel solution and a midi gel format: Application for the detection of variants in the GLUT1 and CTLA-4 genes. Journal of Biotechnology 78: 201-204.

Smith, J. J. and McFeters, G. A. (1997). Mechanisms of INT (2-(4-iodophenyl)-3-(4-nitrophenyl)-5-phenyl tetrazolium chloride), and CTC (5-cyano-2,3-ditolyl tetrazolium chloride) reduction in *Escherichia coli* K-12. Journal of Microbiological Methods 29: 161-175.

Smith, V. H., Graham, D. W. and Cleland, D. D. (1998). Application of resource ratio theory to hydrocarbon biodegradation. Environmental Science and Technology 32: 3386-3395.

Sorensen, S. R., Bending, G. D., Jacobsen, C. S., Walker, A. and Aamand, J. (2003). Microbial degradation of isoproturon and related phenylurea herbicides in and below agricultural fields. FEMS Microbiology Ecology 45(1): 1-11.

Sumpono, Perotti, P., Belan, A., Forestier, C., Lavedrine, B. and Bohatier, J. (2003). Effect of Diuron on aquatic bacteria in laboratory-scale wastewater treatment ponds with special reference to *Aeromonas* species studied by colony hybridization. Chemosphere 50(3): 445-55.

Timmis, K. N. and Pieper, D. H. (1999). Bacteria designed for bioremediation. Trends Biotechnol 17(5): 200-4.

Tixier, C., Sancelme, M., Ait-Aissa, S., Widehem, P., Bonnemoy, F., Cuer, A., Truffaut, N. and Veschambre, H. (2002). Biotransformation of phenylurea herbicides by a soil bacterial strain, Arthrobacter sp. N2: structure, ecotoxicity and fate of diuron metabolite with soil fungi. Chemosphere 46(4): 519-26.

Trevors, J. T., C. I. Mayfield & W. E. Inniss, (1982). Measurement of Electron Transport System (ETS) activity in soil. Microbial Ecology 8: 163-168.

Van-Limbergen, H., Top, E. M. and Verstraete, W. (1998). Bioaugmentation in activated sludge: current features and future perspectives. Applied Microbiology and Biotechnology 50: 16-23.

Vogel, T. M. (1996). Bioaugmentation as a soil bioremediation approach. Current Opinion in Biotechnology 7: 311-316.

vonMersi, W. and Schinner, F. (1991). An improved and accurate method for determining the dehydrogenase activity of soils with iodonitrotetrazolium chloride. Biology and Fertility of Soils 36: 177-182.

Vroumsia, T., Steiman, R., Seigle-Murandi, F., Benoit-Guyod, J. L., Khadrani, A. and Groupe pour l'Etude du Devenir des Xenobiotiques dans, l. E. (1996). Biodegradation of three substituted phenylurea herbicides (chlortoluron, diuron, and isoproturon) by soil fungi. A comparative study. Chemosphere 33(10): 2045-2056.

Walkley, A. and Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 37: 29-38.

Widehem, P., Ait-Aissa, S., Tixier, C., Sancelme, M., Veschambre, H. and Truffaut, N. (2002). Isolation, characterization and diuron transformation capacities of a bacterial strain Arthrobacter sp. N2. Chemosphere 46(4): 527-534.

Yu, K. S. H., Wong, A. H. Y., Yau, K. W. Y., Wong, Y. S. and Tam, N. F. Y. (2005). Natural attenuation, biostimulation and bioaugmentation on biodegradation of polycyclic aromatic hydrocarbons (PAHs) in mangrove sediments. Marine Pollution Bulletin 51(8-12): 1071-1077.

APPENDICES

APPENDIX A

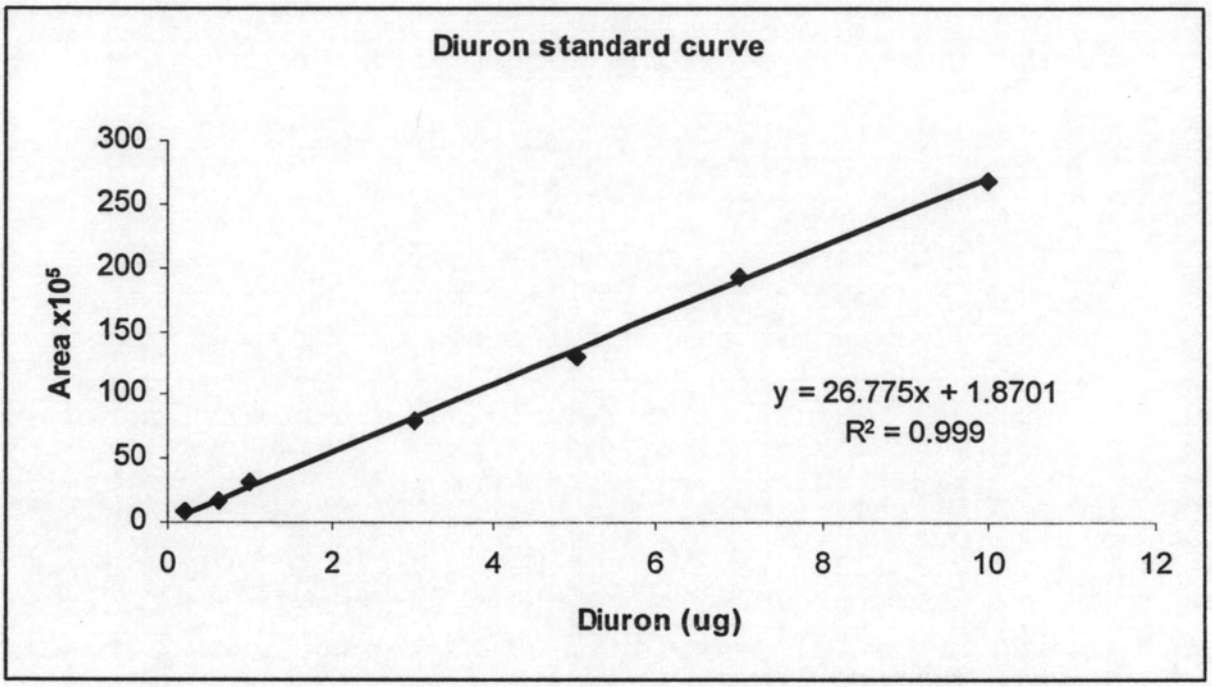


Figure A The standard curve of diuron plotted between the amount of diuron (μg) and peak area analyzed by HPLC.

The slope of standard curve was 26.775.

The amount of diuron can calculated followed the equation;

$$\text{The amount of diuron } (\mu g) = \frac{(\text{peak area} - 1.8701)}{26.775}$$

APPENDIX B

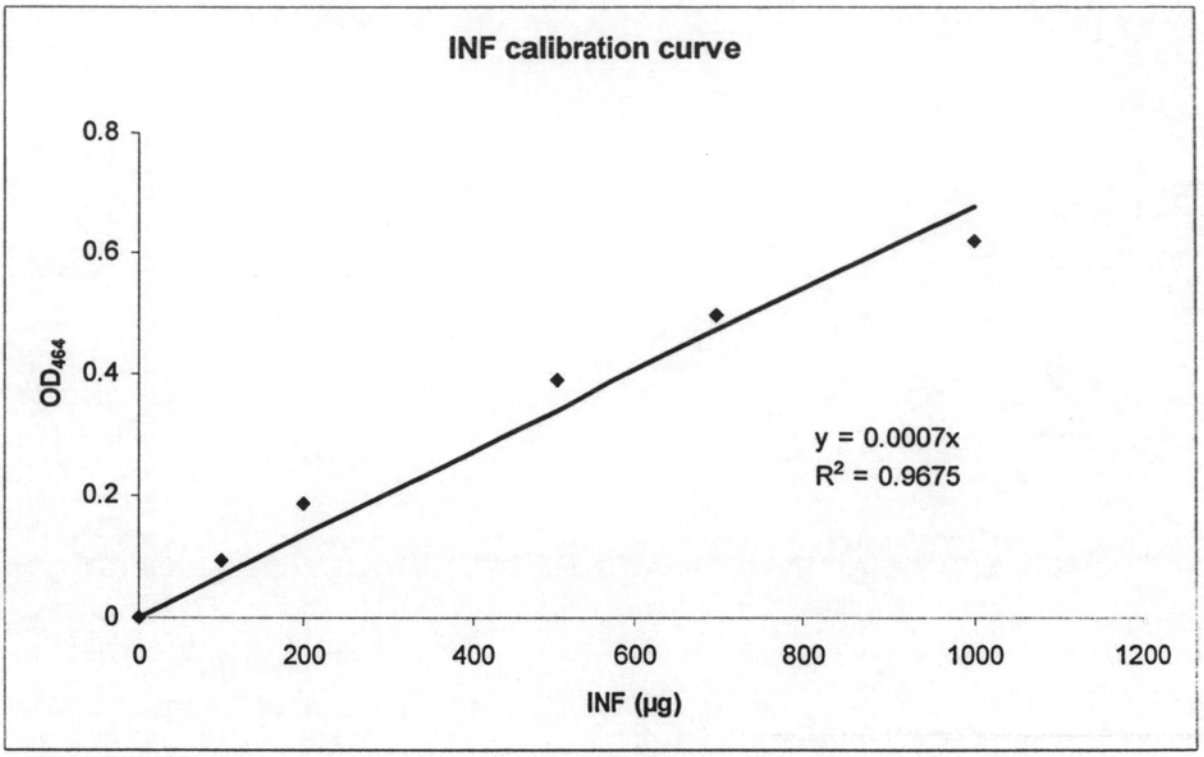


Figure B INF calibration curve for the calculation of total microbial activity (dehydrogenase activity).

$$INT + 2H^+ + 2e^- \rightleftharpoons INF + HCl$$

The dehydrogenase activity is expressed as µg INF g^{-1} dwt 2 h^{-1} and calculated according the following relationship:

$$INF\ (\mu g\ INF\ g^{-1}\ dwt\ 2\ h^{-1}) = \frac{(S_1 - S_0)}{dwt}$$

S_1 is the INF of the test

S_0 is the INF of the control

dwt is the dry weight of 1 g moist soil

APPENDIX C

Prepare of the Glass plates for SSCP analysis

Glass plate cleaning

1. Glass plates must be meticulously clean that the plate was cleaned water and 10% detergent then washed thoroughly with deionized water to remove detergent residue.
2. Glass plate was soaked in 10% NaOH for 30 min., rinsed by deionized water and washed by 95% ethanol at the plates 3 times.

The coating glass plate was prevented the tearing gel during silver staining.

Short glass plate preparation

Treat the short glass plate with binding solution each time a gel is prepared.

1. 800 µl Repel-Silane is add on glass plate and wipe with a tissue in one direction and then perpendicular to the first direction using gentle pressure and performed glass plate for 15 min.
2. The coated glass plate was washed by 95% ethanol.

Long glass plate preparation

1. Preparation fresh bind solution by adding 995 µl of 95% ethanol, 5 µl of acetic acid and 4 µl bind-silane (the solution is fast volatile), tissue was wipe in one direction and then perpendicular to the first direction using gentle pressure and performed glass plate for 15 min.
2. The coated glass plate was washed by 95% ethanol.

Appendix D

Preparation Polyacrylamide gel electrophoresis for SSCP

40% Polyacrylamide (37.5 : 1, Acrylamide : Bis-acrylamide)

Acrylamide	37 g
N.N'-methlene-bis-acrylamide	1 g

Adjust volume to 100 ml with distilled water and filtrate with 0.45 μm

10x TBE

Tris	108 g
Boric acid	55 g
0.5 M EDTA (pH 8.0)	40 ml

Adjust volume to 100 ml with distilled water.

17.5% Nondenaturing Polyacrylamide Gel Electrophoresis

40% Polyacrylamide	17.5 ml
10X TBE	4 ml
Distilled water	19.5 ml

This solution was degassed for 15 minutes

10% Ammonium persulphate	300 μl
TEMED	30 μl

Fixative / Stop Solution, 2 litres

Glacial acetic	200 ml
Distilled water	1,800 ml

Staining solution (0.1% Silver nitrate)

Silver nitrate	1.5 g
Formaldehyde	2.25 ml

Adjust volume to 1.5 litres (this solution was freshly prepared.)

Developing Solution

Sodium Carbonate	90 g

Adjust volume to 3 litres and divided to 1.5 litres, storage at 4°C

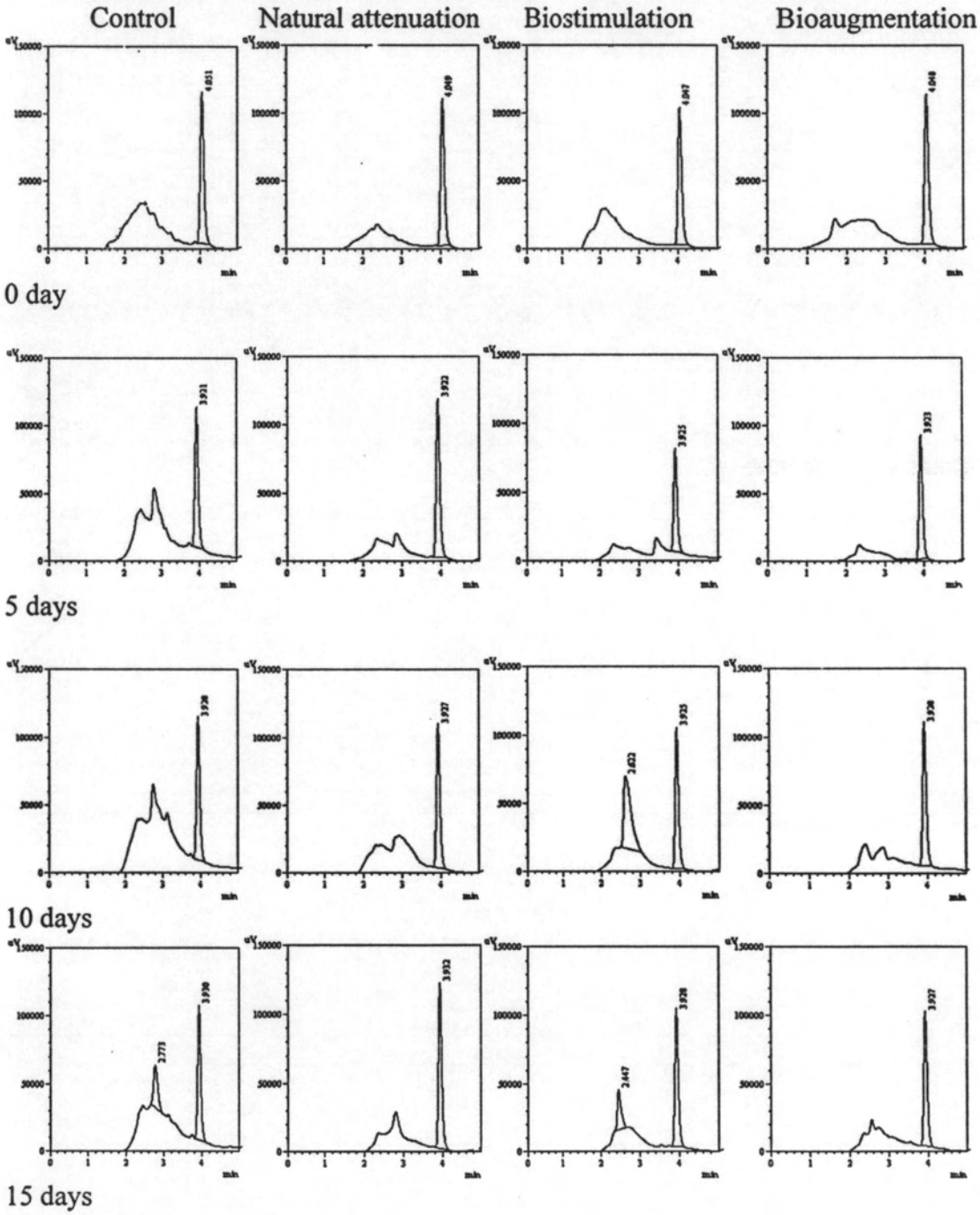
Add supplements in developing solution before used

10 mg/ml Sodium thiosulfate	300 µl
Formaldehyde	2.25 ml

Appendix E

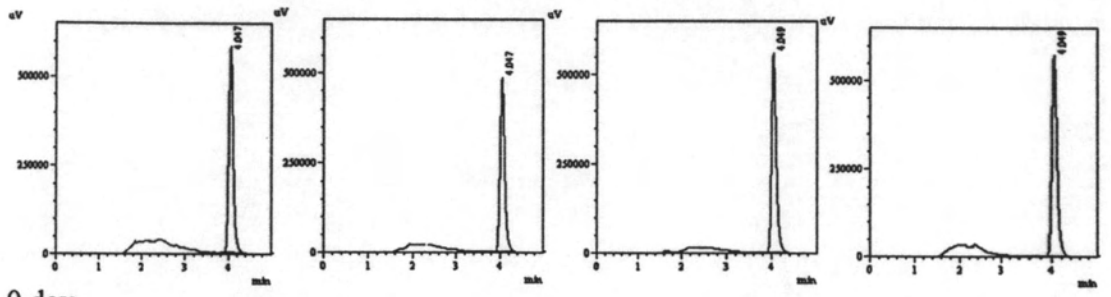
HPLC Chromatogram

Condition B: HPLC peak in each bioremediation treatment of loam soil with 20-ppm diuron during 15 days of the incubation time. Retention time of diuron is 4.0 min determined under the specific HPLC condition as described in 3.6.2.2.

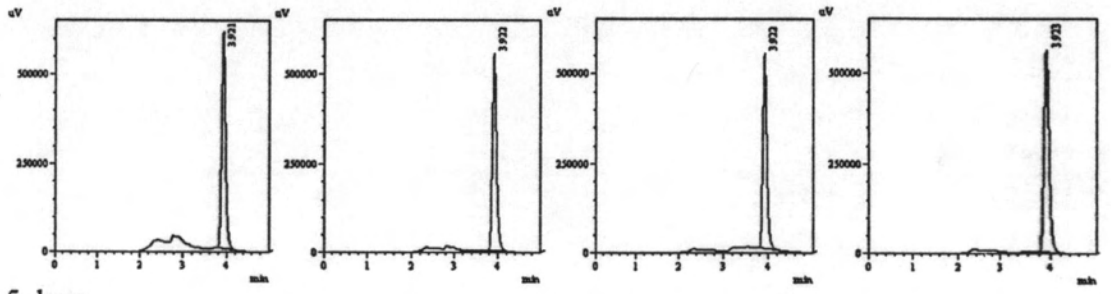


Condition B: HPLC peak in each bioremediation treatment of loam soil with 100-ppm diuron during 15 days of the incubation time. Retention time of diuron is 4.0 min determined under the specific HPLC condition as described in 3.6.2.2.

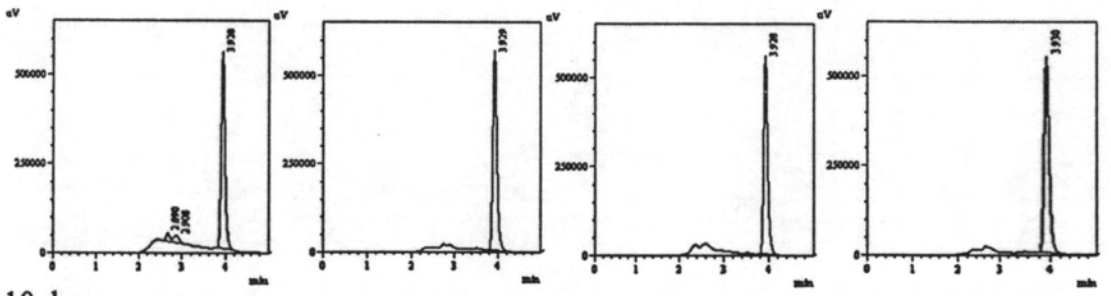
Control Natural attenuation Biostimulation Bioaugmentation



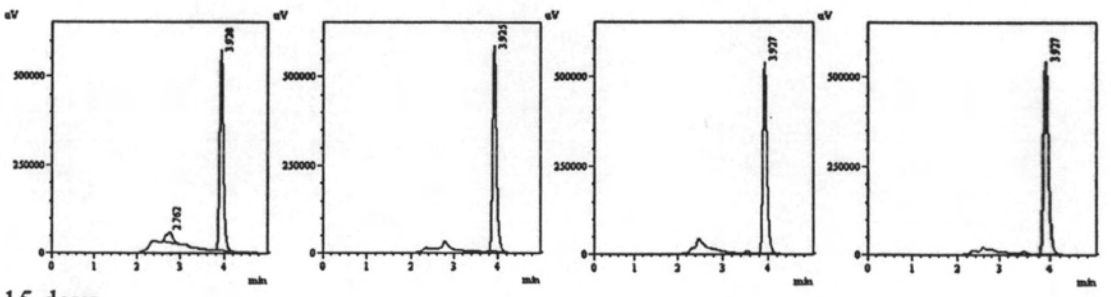
0 day



5 days

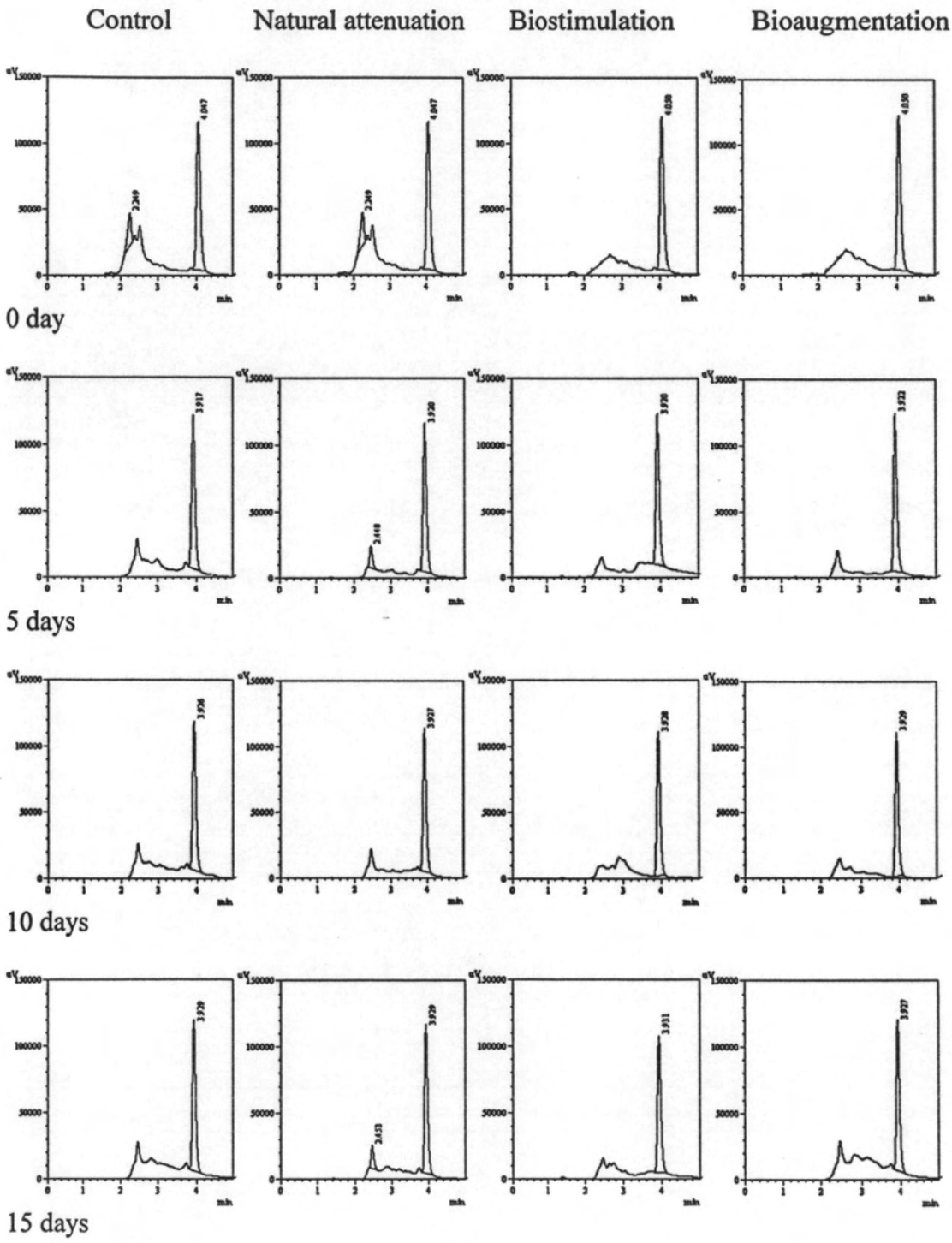


10 days

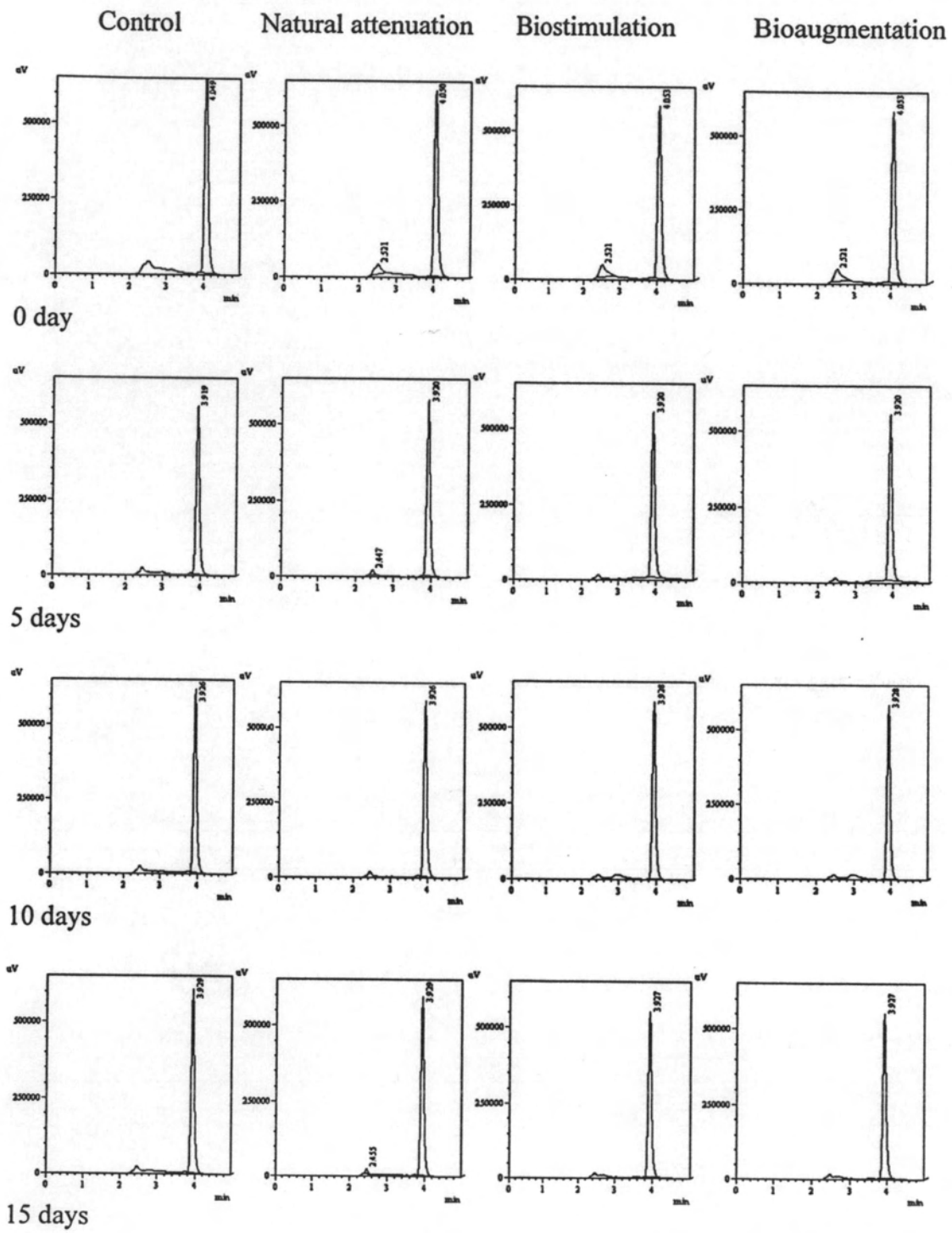


15 days

Condition B: HPLC peak in each bioremediation treatment of silty clay with 20-ppm diuron during 15 days of the incubation time. Retention time of diuron is 4.0 min determined under the specific HPLC condition as described in 3.6.2.2.



Condition B: HPLC peak in each bioremediation treatment of silty clay soil with 100-ppm diuron during 15 days of the incubation time. Retention time of diuron is 4.0 min determined under the specific HPLC condition as described in 3.6.2.2.



BIOGRAPHY

Mr. Surachai Sritampiwat was born on July 19, 1980. He graduated with the degree of Bachelor of Science in Biochemistry from Chulalongkorn University in 2003. He continued his study in the Master of Science Program in Biotechnology, Faculty of Science at Chulalongkorn University.