REFERENCES

Adamo, R.D., Pelosi, S., Trotta, P. and Sansone, G. 1997. Bioaccumulation and biomagnification of polycyclic aromatic hydrocarbons in aquatic organisms. Mar. Chem. 56:45-49.

Agency for Toxic Substance and Disease Registry. 1995. Toxical Profile Information Sheet. [Online] Available from: http://www.atsdr.cdc.gov/toxprofile/ [2002, March 15].

Altschul, Stephen F., Thomas L.M., Alejandro A.S., Jinghui Z., Zheng Z., Webb M., and David J.L. 1997. Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. Nucleic Acids Res. 25:3389-3402.

Auburn University Environmental Institute. 2002. Identification of Bacteria in the Environment. [Online] Available from: http://www.auburn.edu/academic/classes/biol/4600/dale/Lab%20project.htm

Ausubel, F.A., Brent, R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.G., and Struhl, K. 1999. Current Protocols in Molecular Biology. 4th ed. John Wiley & Son. New York.

Bauer, J.E. and Capone, D.G. 1988. Effect of co-occuring aromatic hydrocarbons on degradation of individual polycyclic aromatic hydrocarbons in marine sediment slurries. Appl. Environ. Microbiol. 54:1649-1655.

Bastiaens, L., Springael, D., Wattiau, P., Harms, H., deWachter, R., Verachtert, H. and Diels, L. 2000. Isolation of adherent polycyclic aromatic hydrocarbon (PAH)-degrading bacteria using PAH-sorbing carriers. Appl. Environ Microbiol. 66: 1834–1843.

Bezelel, L.,Hader, Y.,Cerniglia, C.E. 1996. Mineralization of polycyclic aromatic hydrocarbons by the white rot fungus *Pluerotus ostreatus*. Appl. Environ. Microbiol. 62:292-295.

Blumer, M. 1976. Polycyclic aromatic hydrocarbon in nature. Sci. Am. 234:35-45.

Bixian, M., Jiamo, F., Gan, Z., Zheng, L., Yushun, M., Guoying, S. and Xingmin, W. 2001. Polycyclic aromatic hydrocarbons in sediments from the Pear river and estuary, China: spatial and temporal distribution and sources. Appl. Geochem. 16:1429-1445.

Boldrin, B., Tiehm, A., and Fritzsche, C. 1993. Degradation of phenanthrene, fluorene, fluoranthene, and pyrene by a *Mycobacterium* sp. Appl.Environ. Microbiol. 59: 1927-1930

Bogan, B.W., Lamer, R.T., Burgos, W.D., and Tien, M. 1999. Extent of humification of anthracene, fluoranthene and benzo(a)pyrene by *Pleurotus ostreatus* during growth in PAH-contaminated soils. Lett. Appl. Microbiol. 28:250-254.

Boonchan, S. 1998. Biodegradation of polycyclic aromatic hydrocarbon : application of fungal-bacterial co-culture and surfactants. Doctoral Dissertation, Victoria University of Tecnology, Melborne, Austraria.

Bouchez, M., Blanchet, D., and Vandecasteele, J. P. 1995. Degradation of polycyclic aromatic hydrocarbons by pure stain and by defined strain association: inhibition phenomena and cometabolism. Appl. Environ. Bitechnol. 43:156-164.

Brunson, E.L., Canfield, T.J., Dwyer, F.J., Ingersoll, C.G., Kembel, N.E. 1998. Assessing the bioaccumulation of contaminants from sediments of the upper Mississippi River using field-collected oligochaetes and laboratory-exposed *Lumbriculus variegates*. Arch. Environ. Contam. Toxicol., 35:191-201.

Camargo, M. C. R., Toledo, M. C. F. 2003. Polycyclic aromatic hydrocarbons in Brazilian vegetables and fruits. Food Control 14:49-53.

Canada Council of Ministry of the Environment, 1999. [Online] Available from: http://www.ccme.ca [2004, April 13].

Carpentier, S., Moilleron, R., Beltran, C., Hervé, D. and Thévenot, D. 2002. Quality of dredged material in the river Seine basin (France).II.Micropollutants. Sci. Total. Environ. 299:57-72.

Cerniglia, C.E. 1992. Biodegradation of polycyclic aromatic hydrocarbons. Biodegradation. 36:351-368.

Cerniglia, C.E., Kelly, D.W., Freeman, J.P. and Miller, D.W. 1986. Microbial metabolism of pyrene. Chemical-Biological Interaction. 57:302-216.

Chaineau, C.H., Morel, J., Dupont, J., Bury, E., and Oudot, J. 1999. Comparison of the fuel oil biodegradation potential of a hydrocarbon-assimilating microorganism isolated from a temperate agricultural soil. Sci. Total Environ. 227:237-247.

Charlesworth, M., Service, M., and Gibson, C.E. 2002. PAH contamination of western Irish sea sediments. Mar. Poll. Bull. 44:1421-1434.

Chen, S.-H. and Aitken, M.D. 1999. Salicylate stimulates the degradation of high molecular weight polycyclic aromatic hydrocarbons by *Pseudomonas saccarophila* P15. Environ. Sci. Technol. 33:435-439.

Chung, W.K. and King, G.M. 2001. Isolation and characterization, and polyaromatic hydrocarbon degradation potential of aerobic bacteria from marine macrofaunal burrow sediments and description of *Lutibacterium analoederans* gen. nov., sp.nov., and *Cycloclasticus spirillensus* sp. nov. Appl. Environ. Microbiol. 67:5585-5592.

Churchill, S.A., Harper, J.P., and Churchill, P.F. 1999. Isolation and characterization of a *Mycobacterium* spcies capable of degrading three- and four-ring aromatic and aliphatic hydrocarbon. Appl. Environ. Microbiol. 65:549-552.

Daane, L.L., Harjono I., Zylstra G.J., and Häggblom M.M. 2001. Isolation and characterization of polycyclic aromatic hydrocarbon-degrading bacteria associated with the rhizosphere of salt marsh plants. Appl. Environ. Microbiol. 67:2683-2691.

Dean-Ross, D. and Cernigia C.E. 1996. Degradation pyrene by *Mycobacterium flavescens*. Appl. Microbiol. Technol. 46:307-312.

Dean-Ross, D., Moody J., and Cernigia C.E. 2002. Utilization of mixture of polycyclic aromatic hydrocarbons by bacteria isolated from contaminated sediment. FEMS Microbiol. Ecol. 41:1-7.

Deshpande, A.D., Huggett, R.J., Halbrook, R.A. 2002. Polycyclic aromatic hydrocarbon metabolites in bile of a territorial benthic fish, Oyster Toadfish (*Opsanus tau*) from the Elizabeth River, Virginia. Arch. Environ. Contam. Toxicol. 42:43-52.

Draft sediment guideline criteria U.S. EPA. [Online] Available from: http://www.epa.gov/sedimentguideline [2004, April 13].

Fleurat-Lessard, P., Pointet K. And Renou-Gonnord, M-F. 1999. Quantitative determination of PAHs in diesel engine exhausts by GC-MS. J. Chem. Ed. Chem. 76:962-965.

Foght, J.M. and Westlake, D.W. 1988. Degradation of polycyclic aromatic hydrocarbon heterocycles by *Psuedomonas* species. Can. J. Microbiol. 34:1135-1141.

Freeman, D. J. and Cattell, F. C. R. 1990. Woodburning as a source of atmospheric polycyclic aromatic hydrocarbons. Environ. Sci. Technol. 24:1581-1585.

Geiselbrecht, A.D., Hedlund B.P., Tichi, M.A. and Staley J.T. 1998. Isolation of marine polycyclic aromatic hydrocarbon (PAH)-degrading *Cycloclasticus* strains from the Gulf of Mexico and comparison of their PAH degradation ability with that of Puget Sound *Cycloclasticus* strains. Appl. Environ. Microbiol. 64:4703-4710.

Grifoll, M., Casellas, M., Bayona, J.M. and Solanas, A.M. 1992. Isolation and characterization of a fluorene-degrading bacterium: identification of ring oxidation and ring fission products. Appl. Environ. Microbiol. 60:2438-2449.

Grifoll, M., Selifonov, S. A., and Chapman, P.J. 1994. Evidence for a novel pathway in the degradation of fluorene by *Pseudomonas* sp. strain F274. Appl. Environ. Microbiol. 60:2438-2449.

Hammel, K.E., Kalyanaraman, B. and Kirk, T.K. 1986. Oxidation of polycyclic aromatic hydrocarbons and dibenzo(p)dioxins by *Phanerochaete chrysosporium* liginase. J. Biol. Chem. 261:16948-16952.

Hauge, A., Konieczny, R.M., Halvorsen, P.O. and Heikum, A. 1998. Remediation of contaminated sediments in Oslo Harbour, Norway. Water. Sci. Technol. 37:299-305.

Heitkamp, M.A., and Cerniglia, C.E. 1987. Effects of chemical structure and exposure on the microbial degradation of polycyclic aromatic hydrocarbons in freshwater and estuarine ecosystems. Environ. Toxico. Chem. 6:35-46.

Heitkamp, M.A., Franklin, W. and Cerniglia, C.E. 1988. Microbial metabolism of polycyclic aromatic hydrocarbons: isolation and chacterization of pyrene degrading bacterium. Appl. Environ. Microbiol. 54:2549-2555.

Hedlund, B.P., Geiselbrecht, A.D., Bair, T.J. and Staley J.T. 1999. Polycyclic aromatic hydrocarbon degradation by a new marine bacterium, *Neptunomonas naphthovorans* gen. nov., sp. nov. Appl. Environ. Microbiol. 65: 251-259.

Ho, Y., Jackson, M., Yang, Y., Mueller J.G., and Pritchard P.H. 2000. Characterization of fluoranthene- and pyrene degrading bacteria isolated from PAH-contaminated soil and sediments. J. Indust Microbol Biotechnol. 24:100-112.

Hoffman, E.J., Mills, G.L., Latimer, J.S., Quinn, J.G. 1984. Urban runoff as a source of polycyclic aromatic hydrocarbons to coastal waters. Environ. Sci. Technol. 18:580-587.

Hyötyläinen, T. and Oikari, A. 1998. The toxicity and concentration of PAHs in creosote contaminated lake sediment. Chemosphere. 38:1135-1144.

Interim Canadian sediment quality guideline. 1995. Canadian Council of Ministry of the Environment. [Online] Available from: http://www.ccme.ca

Irwin, R.J., Mouwerik, M.V., Stevens, L., Seese, M.D. Basham, W. 1997. Environmental contaminants encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado.

Jimenez, I.Y., and Bartha, R. 1996. Solvent augmented mineralisation of pyrene by a *Mycobacterium* sp. Appl. Environ. Microbiol. 62:23112316.

Juhasz, A.L. 1998. Microbial degradation of high molecular weight polycyclic aromatic hydrocarbons. Doctoral Dissertation, Victoria University of Technology, Melbourne, Australia.

Juhasz, A.L., Britz, M.L. and Stanley, G.A. 1997. Degradation of fluoranthene, pyrene, benzo(a)anthracene and dibenzo[a,h]anthracene by *Pseudomonas cepacia*. J. Appl. Microbiol. 83:189-198.

Juhasz, A.L. and Naidu, R. 2000. Bioremediation of high molecular weight polycyclic aromatic hydrocarbons: a review of the microbial degradation of benzo(a)pyrene. International biodeterioration and biodegadation. 45:57-88.

Kasai, Y., Kishira, H., and Harayama, S. 2002. Bacteria belonging to the genus *Cycloclasticus* play a primary role in the degrading of aromatic hydrocarbons released in a marine environment. Appl. Environ. Microbiol. 68:5625-5633.

Kanaly, R.A. and Harayama, S. 2000. Biodegradation of high molecular weight polycyclic aromatic hydrocarbons by bacteria. J. Bacteriol. 182:2059-2067.

Karlsson, J. and Frejd, J. 2003. Air Pollutions in Thailand. Minor Field Studies Report. Swedish International Development Cooperation Agency.

Kayal, S.I. and Connell, D.W. 1989. Occurrence and distribution of polycyclic aromatic hydrocarbons in surface sediments and waters from the Brisbane river estuary Australia. Estuarine. Coastal. Shelf. Sci. 29:473-487.

Kazunga, C., Aitken M.D., Gold,A. and Sangaiah, R. 2001. Fluoranthene-2,3- and 1,5-diones are novel products from the bacterial transformation of fluoranthene. Environ. Sci. Technol. 35:917-922.

Kelly, I. and Cerniglia, C.E. 1991. The metabolism of phenanthrene by a species of *Mycobacterium*. J. Indus. Microbiol. 7:19-26.

Kelly, I., Freeman, J.P., Evans, F.E. and Cerniglia, C.E. 1993. Identification of metabolites from the degradationof fluoranthene by *Mycobacterium* sp. strain PYR-1. Appl. Environ. Microbiol. 59:800-806.

Krieg N.R. and Hott, J.G. 1994. Bergey's manual of systematic bacteriology. The William & Wikins Co., Baltimore, Md.

Kiyohara, H., Nagao, K., and Yana, K. 1982. Rapid screen for bacteria degrading water insoluble, solid hydrocarbon on agar plates. Appl. Environ. Microbiol. 43:454-457.

Lal, B. and Khanna, S. 1996. Degradation of crude oil by *Acinobacter calcoaceticus* and *Alcaligenes odorans*. J. Appl. Bacteriol. 81:355-362.

Lang, E., Nerud, F., Novotna, E., Zadrazil, F. and Martens, R. 1996. Production of lignolytic exoenzymes and ^{14}C-pyrene mineralization by *Pleutorus* sp. in ligninocellulose substrate. Folia Microbiol. 41:489-493.

Lambert, L.H., Cox, T., Mitchell, K., Rossello-Mora, R.A., Del Cueto, C., Dodge, D.E., Cano, R.J. 1998. *Staphylococcus succinus* sp. nov., isolated from dominican amber. International Journal of Systematic Bacteriology. 48:511–518.

Latimer, J.S., Hoffman, E.J., Hoffman, G., Fasching, J. L., Quinn, J. G. 1990. Source of petroleum hydrocarbons in urban runoff. Wat. Air Soil Pollut. 52:1-21.

Lau, S.S.S. and Chu, L.M. 1999. Contaminant release from sediments in a coastal wetland. Water. Res. 33:909-918.

Launen, L., Pinto, L., Wiebe, C.,Kiehlmann,E. and Moore, M. 1995. The oxidation of pyrene and benzo(a)pyrene by nonbasidiomycete soil. Fungi. Can. J. Microbiol. 41:477-488.

Laurie, A.A., Jennifer, C. and Michael, T. M. 2002. Photosynthetic and phylogenetic primers for detection of anoxygenic phototrophs in natural environments. Appl. Environ. Microbiol. 67:2922–2926.

Lee, R.F. 1980. Hydrocarbon. In: Marine environmental pollution. Vol. 1. Geyer, R.A. (ed). New york:Elsevier Scienctific. 337-351 pp.

Lim, L.H., Marrison, R.M. and Harrad, S. 1999. The contribution of traffic at atmospheric concentrations of polycyclic aromatic hydrocarbons. Environ. Sci. Technol. 33:3538-3542.

Lodolo, A., 2003. Remediation technologies and promotion of related projects. [Online] Available from: http://www.ics.trieste.it [2004, April 3].

Macias-Zamora, J.V., Mendoza-Vega, E., Villaescusa-Celaya, J.A. 2002. PAHs composition of surface marine sediments : a comparison to potential local sources in Todos Santos Bay, B.C.,Mexico. Chemoshpere. 46:459-468.

Mahro, B., Schaefer, G. and Kastner, M. 1994. Pathways of microbial degradation of PAHs in soil, In. Bioremediation of chlorinated and PAH compound. Hinchee, R. E. et al. (ed), Lewis Publishers, Boco Raton, Florida.

Mersch-Sundermann, V., Mochayedi, S., Kevekordes, S. 1992. Genotoxicity of polycyclic aromatic hydrocarbons in *Escherichia coli* PQ37. Mutation Research. 278:1-9.

Molina, M., Araujo, R. and Hodson, R.E. 1999. Cross induction of pyrene and phenanthrene in a *Mycobacterium* sp. isolated from polycyclic aromatic hydrocarbon contaminated river sediments. Can J. Microbiol. 45:520-529.

Mueller, J.G., Chapman, P.J., Blattmann, B.O. and Pritchard, P.H. 1990a. Isolation and characterizationof a fluoranthene utilizing strain of *Pseudomonas paumobilis*. Appl. Environ. Microbiol. 56:1079-1086.

Mueller, J.G., Chapman, P.J. and Pritchard, P.H. 1990b. Action of fluoranthene-utilising bacterial community on polycyclic aromatic hydrocarbon components of creosote. Appl. Environ. Microbiol. 55:3085-3090.

Narro, M.L., Cerniglia, C.E., Balen, C. and Gibson, D.T. 1992. Metabolism of phenanthrene on the marine cyanobacterium *Agmellum quadruplicatum* PR-6. Appl. Environ. Microbiol. 58:1079-1086.

Neff, J.M. 1979. Polycyclic aromatic hydrocarbons in the aquatic environment: source, fate and biological effects. Applied Science Publishers, London.

Nohynek, L.J., Suhomen, E.L., Nurmiaho-Lassila, E.-L., Hantula, J. and Salkinoja-Salonen, M.. 1995. Description of four pentachlorophenol-degrading bacterial strains as *Sphingomonas chlorophenolica* sp. nov. Syst. Appl. Microbiol. 18:527-538.

Nylund, L., Heikkila, P., Hameila, M., Pyy, L., Linnaimaa, K., Sorsa, M. 1992. Genotoxic effects and chemical composition of four creosotes. Mutation Research. 265:223-236.

Oliver, B.G. and Niimi, A.J., 1988. Trophodynamic analysis of polychlorinated biphenyl congeners and other chlorinated hydrocarbons in the Lake Ontario ecosystem. Environ. Sci.Technol., 22: 388-397.

Omori, T., Monna, L., Saiki, Y., and Komma, T. 1992. Desulfurization of dibenzothiphene by *Corynebacterium* sp. strain SY1. Appl. Environ. Microbiol. 58:911-918.

Patarasiriwong, V. and Boonyoy, C. 2002. Study on the distribution of polycyclic aromatic hydrocarbons (PAHs) in water resources of urban area of Thailand. In. Technical report in 1994-2000 of Environmental Research and Training Center, Department of Environmental Quality Promotion, Ministry of Natural Resources and Environment, 1-11 pp.

Pereira, W.E., Domagalski, J.L. , Hostettler, F.D., Brown, L.R. and Rapp, J.B. 1996. Occurrence of accumulation of pesticide and organic contaminants in river sediments, water and clam tissue from the San Joaquin River and tributaries, California. Environ. Toxicol. Chem. 15:172-180.

Pollution Control Department, Ministry of Natural resource and Environment. 2003. State of pollution in Thailand [Online] Available from: http://www.pcd.go.th [2004, March 20].

Pollution Control Department, Ministry of Natural resource and Environment. 1992. The Enhancement and Conservation of National Environmental Quality Act B.E.2535. [Online] Available from: http://www.pcd.go.th [2004, April 5].

Pothuluri, J.V., Freeman, J.P., Evans, F.E. and Cerniglia, C.E. 1990. Fungal transformation of fluoranthene. Appl. Environ. Microbiol. 56:2974-2983.

Pothuluri, J.V., Heflich, R.H., Fu, P.P.and Cerniglia, C.E. 1992. Fungal metabolism and detoxification fluoranthene. Appl. Environ. Microbiol. 58:937-941.

Prahl, F.G. and Carpenter, R. 1979. The role of zooplankton fecal pellets in the sedimentation of polycyclic aromatic hydrocarbons in Dabob Bay, Washington. Geochim. Cosmochim. Acta. 43:1959-1972.

Pruell, R.J., Norwood, C.B., Bowen, R.D. Boothmas, W.S., Rogerson, P.F., Hackett, M. and Butterworth, B.C. 1990. Geochemical study of sediment concentration in New Bedford harbor. Mass. Mar. Environ. Res. 29-77-101.

Rathbone, K., Fuchs, J., Anderson, K, Karthikeyan, R. and Nurhidaya, N. 1998. Effects of PAHs on microbial activity and diversity in freshly contaminated and weathered soils. Conference on Hazardous Waste Research.

Ravelet, C., Krivobok, S., Sage L., Steiman, R. 2000. Biodegradation of pyrene by sediment fungi. Chemosphere 40:557-563.

Readman, J.W., Mantoura, R.F.C., Llewellyn, C.A., Preston, M.R. and Reeves, A.D. 1986. The use of pollutant and biogenic markers as a source discriminates of organic inputs to estuarine sediments. Int. J. Environ. Anal. Chem. 27:29-54.

Rehmann, K. Hertkorn, N. and Kettrup A. 2001. Fluoranthene metabolism in degrader *Mycobacterium* sp. strain KR20 : identity of pathway intermediates during degradation and growth. Microbiology. 147:2783-2794.

Rockne, D.J. and Reddy, K. R. 2003. Bioremediation of contaminated sites. International e-conference on Modern Trends in Foundation Engineering: Geotechnical Challenges and Solution, Indian Institute of Technology, Madras, India.

Romero, M.C., Cazau, M.C., Giorgieri, S. and Arambarri, A. M. 1998. Phenanthrene degrading by microorganisms isolated from a contaminated stream. Environ. Poll. 101:355-359.

Sack, U. and Gunther, T. 1993. Metabolism of PAHs by fungi and correlation with extracellular enzymatic activities. J. Basic Microbiol. 33:268-277.

Sack, U., Hofrichter M. and Fritsche, W. 1997a. Degradation of polycyclic aromatic hydrocarbons by manganese peroxidase of *Nematoloma frowardii*. FEMS Microbiol. Lett. 152:227-234.

Sack, U., Heinze, T.,M., Deck, J., Cerniglia, C.E., Martens, R., Zadrazil, F. and Fritsche, W. 1997b. Comparison of phenanthreneand pyrene degradation by different wood decay fungi. Appl. Environ. Microbiol. 63:3919-3925.

Saiphet, A. 2002. Biodegradation of polycyclic aromatic hydrocarbons by acenaphthene degrading bacteria. Master's Thesis, Department of Microbiology, Faculty of Science, Chulalongkorn University.

Salicis, F., Krivobok, M.J.S. and Benoit-Guyod, J.L. 1999. Biodegradation of fluoranthene by soil fungi. Chemosphere. 38:3031-3039.

San Francisco Estuary Institutes. 2000. Regional Monitoring Program 2000. [Online] Available from: http://www.sfei.org/rmp/2000/RMP_2000_sediment.pdf [2004, April 13].

Savinov, V.M., Savinov, T.N., Matishov, G.G., Dahle, S., Naes, K., 2003. Polycyclic aromatic hydrocarbons (PAHs) and organochlorines (OCs) in bottom sediment of the Guba Pechenga, Barents Sea, Russia. Sci.Total. Environ. 306:39-56.

Sayler, A. A. and Whitt, D. D. 1994. Tuberculosis. In. Bacterial pathogenesis: a molecular approach., A. A. Salyers, and D. D. Witt (ed.). Washington, D.C.: ASM Press, 307-320 pp.

Schneider, J., Grosser, R., Jayasimhulu, K., Xue, W. and Warshawsky, D. 1996. Degradation of pyrene, benzo(a)anthracene and benzo(a)pyrene by *Mycobacterium* sp., strain RJGII-135, isolated from a former coal gasification site. Appl. Environ. Microbiol. 62:13-19.

Schutzendubel, A., Majcherczyk, A., Johannes, C. and Hutterman, A. 1999. Degradation of fluorene, anthracene, phenanthrene, fluoranthene, and pyrene lack connection to the production of extra-cellular enzyme by *Pleurotus ostreatus* and *Bjerkandera adjusta*. International Biodeterioration and Biodegradation. 43:93-103.

Sepic, E., Bricelj, M. and Leakovsek, H. 1998. Degradation of fluoranthene by *Pasteurella* sp. IFA and *Mycobacterium* sp. PYR-1:isolation and identification of metabolites. J. Appl. Microbiol. 85:746-754.

Shi, T., Fredrickson, J. K., Balkwill, D. L. 2001 Biodegradation of polycyclic aromatic hydrocarbons by *Sphingomonas* strains isolated from the terrestrial subsurface. J.Ind. Micro. Biotechnol. 26:283-289.

Shiaris, M.P. and Jambard-Sweet, D. 1986. Polycyclic aromatic hydrocarbons in surface sediments of Boston Harbor, MA, USA. Mar. Pollut.Bull. 17:469-472.

Shuttleworth, K.L. and Cerniglia. 1996. Bacterial degradation of low concentration of phenanthrene and inhibition by naphthalene. Microbial Ecology. 31:305-317.

Simck, M. F., Eisenreich, S. J., Golden, K. A., Liu, S., Lipiatou, E., Swackhamer, D.L., Long, D.L. 1996. Atmosphoric loading of polycyclic aromatic hydrocarbons to Lake Michigan as recorded in the sediments. Environ. Sci. Technol. 30:3039-3046.

Sims, R. C., Overcash, M. R. 1983. Fate of polynuclear aromatic compounds (PNAs) in soil-plant systems. Residue Reviews. 88:1-68.

Spies, R.B., Rice Jr., D.W. and Felton, J., 1988. Effects of organic contaminants on reproduction of the starry flounder *Platichrhys stellatus* in San Francisco Bay. I. Hepatic contamination and mixed-function oxidase (MFO) activity during the reproductive season. Mar. Biol., 98: 181-189.

Stanley, G.A., Britz, M.L., Boonchan, S. and Juhazs, A.L. 1999. Detoxification of soil containing high molecular weight polycyclic aromatic hydrocarbons by gram-negative bacteria and bacterial-fungal co-cultures. In. Remediation of hazardous waste contaminated soil. Wise, D.L., Trantolo, D.J., Cichon, E.J., Inyang, H.I. and Stottmeister, U. (eds). New York: Marcel Dekker, 161-179 pp.

Stapleton, R.D., Bright, N.G. and Sayler, G.S. 2000. Catabolic and genetic diversity of degrading bacteria from fuel-hydrocarbon contaminated aquifers. Microb. Ecol. 39:211-221.

Stout, S.A., Mager, V.S., Uhler, R.M., Ickes, J. and Brenner, R. 2001. Characterization of naturally occurring and anthropogenic PAHs in urban sediments-Wycoff/Eagle Harbor superfund site. Environmental Forensics. 2:287-300.

Stringfellow, W. and Aitken, M.D. 1995. Competitive metabolism naphthalene, methyl naphthylene and fluorene by phenanthrene degrading Pseudomonas. Appl. Environ. Microbiol. 61:357-362.

Supaka, N., Pinpanichakarn, P., Pattaragulwanit, K., Thaniyavarn, S., Omori, T. and K. Junthongjin (2001) Isolation and characterization of a phenanthrene-degrading Sphingomonas sp. strain P2 and its ability to degrade fluoranthrene and pyrene via cometabolism. Science Asia 27:21-28.

Thomas, J. M., Lee, M. D., Scott, M. J., and Ward, C.H. 1989. Microbial ecology of the subsurface at an abandoned creosote waste site. J. Indus. Microbiol. 4:109-120.

Trzesicka-Mlynarz, D. and Ward, O. P. 1995. Degradation of polycyclic aromatic hydrocarbons (PAHs) by a mixed culture and its component pure cultures, obtained from contaminated soil. Can. J. Microbiol. 41:470-476.

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS). 2000. [Online] Available from: http://www.epa.gov/ngispgm3/iris [2004, March 5].

Van der Oost, R., Heida, H. and Opperhuizen. A.. 1988. Polychlorinated biphenyl congeners in sediments, plankton, molluscs. crustaceans and eel in a freshwater lake: implications of using reference chemicals and indicator organisms in bioaccumulation studies. Arch. Environ. Contam. Toxicol. 17: 721-729.

Verrhiest, G.J., Clément, B., Valat, B. Montuelle, B. and Perrodin, Y. 2002. Interaction between a polycyclic aromatic hydrocarbon mixture and the microbial communities in a natural freshwater sediment. Chemosphere. 46:187-196.

Vila, J., Zaira, L., Jordi, S., Cristina, M., Solanas, A., M., and Grifoll, M. 2001. Identification of a novel metabolite in the degrading of pyrene by *Mycobacterium* sp. strain AP1: action of the isolate on two- and three- ring polycyclic aromatic hydrocarbons. Appl. Environ. Microbiol. 67: 5497-5505.

Wagrowski, D. M. and Hitrs R. A. 1997. Polycyclic aromatic hydrocarbon accumulation in urban, suburban, and rural vegetation. Environ. Sci. Technol. 31: 279-282.

Walter, U. Beyer, M., Klien, J. and Rehm, H.J. 1991. Degradation of pyrene by *Rhodococcus* sp. UW1. Appl. Environ. Microbiol. 34:671-676.

Wania, F. and Mackey, D. 1996. Tracking the distribution of persist organic pollutants Environ. Sci. Technol. 30:390-396.

Weber S., Stubner S. and Conrad R. 2001. Bacterial populations colonizing and degrading rice straw in anoxic paddy soil. Appl. Environ. Microbiol. 67:1318-1327.

Weissenfels, W.D., Beyer, M., Klien, J. and Rehm, H.J. 1991. Microbial metabolism of fluoranthene: isolation and identification of ring fission products. Appl. Microbiol. Technol. 34:528-335.

White, J. C. and Triplett, T. 2002. Polycyclic aromatic hydrocarbons (PAHs) in the sediments and fish of the Mill River, Newhaven, Connecticut, USA. Bull.Environ.Contam.Toxicol. 68:104-110.

Wilcke, W., Müller, S., Kanchanakool, N., Niamskul, C., Zech, W. 1999. Polycyclic aromatic hydrocarbons in hydromorphic soil of the tropical metropolis Bangkok. Geoderma 91:297-309.

Wilson, S. C. and Jones, K. C. 1993. Bioremediation of soil contaminated with polycyclic aromatic hydrocarbons (PAHs). Environ. Pollt. 81:229-249.

Yabuuchi, E., Yano, I., Oyaizu, H., Hashimoto, Ezaki, Y. T. and Yamamoto, H. 1990. Proposals of *Sphingomonas paucimobilis* gen. nov. and comb. nov., *Sphingomonas parapaucimobilis* sp. nov., *Sphingomonas yanoikuyae* sp. nov., *Sphingomonas adhaesiva* sp. nov., *Sphingomonas capsulata* comb. nov. and two genospecies of the genus *Sphingomonas*. Microbiol. Immunol. 34:99-119.

Ye, D., Siddiqi, M. A., Maccubbin, A. E., Kumar, S. and Sikka, H. C. 1996. Degradation of Polycyclic aromatic hydrocarbons by *Sphingmonas paucimobilis*. Environ. Sci.Technol. 30:136-142.

Zakaria, M.P., Takada, H. Tsutsmi, S., Ohno, K. Yamada, J., Kouno, E. and Kumata, H. 2002 Distribution of polycyclic aromatic hydrocarbons (PAHs)in rivers and estuaries in Malasia: a widespread input of petrogenic PAHs. Environ. Sci. Technol. 36:1907-1918.

Zhuang, W.Q., Tay, J.H., Maszenan, A.M., and Tay, S.T. 2001 Isolation of naphthalene-degrading bacteria from tropical marine sediments. In. Proceedings of the IWA Asia Environmental Technology 2001 International Conference. Wilson F, Sun DD (eds), Singapore. ENV-NTU Environmental Engineering Research Centre (Singapore) and International Water Association (London), pp 631-638.

APPENDICES

APPENDIX A

The reagents of PAHs degrading bacteria isolation and PAH concentration analysis

1) PAHs in Dimethyl sulfoxide solution

PAH powder	0.1 g
Dimethyl sulfoxide	10 ml

Sterilized by filtering through a 0.20 μm pore size filter.

2) 0.85% NaCl

NaCl	0.85 g
Distilled water	100 ml

Sterilized by autoclave at 15 psi fro 20 minutes.

3) Methanol 80% (v/v)

Methanol	80 ml
Deionized distilled water (DDW)	20 ml

Filtered methanol through a 0.5 μm FH filter and added filtered DDW

Sonicated the mixture until the bubble left.

4) 2% PAH diethyl ether

PAH powder	0.2 g
Diethyl ether	10 ml

Mixed to completely dissolve and filtered the mixture through a 0.22 μm pore size filter.

Kept in dark bottle (should freshly prepare for every usage).

APPENDIX B

The reagents of genomic DNA extraction

1) 10% Sudium dodecyl sulphate (10% SDS)

SDS	10 g
Distilled water	70 ml

Dissolved at 70 °C.

Brought up with distilled water to 100 ml.

2) Hexadeyl trimethyl ammoniumbromide/sodium chloride solution (CTAB/NaCl solution)

NaCl	4.1 g
Distilled water	80 ml
CTAB	10 g

Slowly added with stirring, while heating at 65°C.

Brought up with distilled water to 100 ml.

3) 5 M NaCl

NaCl	14.61 g

Distilled water to 50 ml

4) Phenol/chloroform/isoamyl alcohol solution

Phenol	25 ml
Chloroform	25 ml
Isoamyl alcohol	1 ml

Equilibrated by extraction several times with 0.1 M Tris-HCl (pH 7.6).

Stored the equilibrated mixture under equal volume of 0.01 M Tris-HCl (pH 7.6) in dark glass bottle.

5) Phenochloroform/isoamyl alcohol solution

Chloroform	24 ml
Isoamyl alcohol	1 ml

Mixed and stored the mixture at 4°C.

6) 50xTris-acetate/EDTA buffer (50xTAE buffer, pH 8)

Tris-base	242 g
Glacial acetic acid	57.2 ml
0.5 M EDTA	100 ml

Distilled water to 1 liter.

7) TE buffer

1 M Tris-HCl, pH 8	1 ml
0.5 M EDTA, pH 8	0.2 ml

Distilled water to 100 ml.

Sterilized by autoclaving at 15 psi for 20 minutes.

8) Loading Dye

A) Bromophenol blue	0.05 ml
Absolute ethanol	1 ml
B) Sucrose	12 g
Distilled water	17 ml
C) 1 M EDTA, pH 8	2 ml

Autoclaved parted A and B at 15 psi for 20 min.

Mixed part A, B and C after autoclaving and kept at –20 °C

9) Ethidiumbromide solution

Dissolved ethidiumbromide powder in TAE buffer at final concentration of 10 µg/ml and kept in dark.

APPENDIX C

16S rDNA nucleotide sequence

1) 16S rDNA nucleotide sequence of *Mycobacterium* sp. strain PY1

```
5'- TTAACACATGCAACGTCGAACGGAAAGGCCCTTCGGGGTACTCGAGTGGCGAACGGGTGA 60
    GTAACACGTGG-TGATCTGCCCTGCACTTTGGGATAAGCCTGGGAAACTGGGTCTAATAC 119
    CGAATAGGACCGCATGCTTCATGGTGTGTGGTGGAAAGCTTTTGCGGTGTGGGATGGGCC 179
    CGCGGCCTATCAGCTTGTTGGTGAGGTAATGGCTTACCAAGGCGACGACGGGTAGCCGGC 239
    CTGAGAGGGTGACCGGCCACACTGGGACTGAGATACGGCCCAGACTCCTACGGGAGGCAG 299
    CAGTGGGGAATATTGCACAATGGGCGCAAGCCTGATGCAGCGACGCCGCGTGAGGGATGA 359
    CGGCCTTCGGGTTGTAAACCTCTTTCGCCAGGGACGAAGCGCAAGTGACGGTACCTGGAG 419
    AAGAAGGACCGGCCAACTACGTGCCAGCAGCCGCGGTAATACGTAGGGTCCGAGCGTTGT 479
    CCGGAATTACTGGGCGTAAAGAGCTCGTAGGTGGTTTGTCGCGTTGTTCGTGAAAACTCA 539
    CAGCTTAACTGTGGGCGTGCGGGCGATACGGGCAGACTTGAGTACTGCAGGGGAGACTGG 599
    AATTCCTGGTGTAGCGGTGGAATGCGCAGATATCAGGAGGAACACCGGTGGCGAAGGCGG 659
    GTCTCTGGGCAGTAACTGACGCTGAGGAGCGAAAGCGTGGGGAGCGAACAGGATTAGATA 719
    CCCTGGTAGTCCACGCCGTAAACGGTGGGTAGGTGTGGGTTTCCTTCCTTGGGATCCGTG 776
    CCGTAGCTAACGCATTAAGTACCCCGCCTGGGGAGTACGGCCGCAAGGCTAAAACTCAAA 836
    GCAATTGACCGGGGGCCCGCACAAGCGGCGGAGCATGTGGATTAATTCGATGCAACGCGA 896
    AGAACCTTACCTGGGTTTGACATGCACAGGACGCCGGCAGAGATGTCGGTTCCCTTGTGG 956
    CCTGTGTGCAGGTGGTGCATGGCTGTCGTCAGCTCGTGTCGTGAGATGTTGGGTTAAGTC 1016
    CCGCAACGAGCGCAACCCTTGTCTCATGTTGCCAGCACGTTATGGTGGGGACTCGTGAGA 1076
    GACTGCCGGGGTCAACTCGGAGGAAGGTGGGGATGACGTCAAGTCATCATGCCCCTTATG 1136
    TCCCAGGGCTTCACACATGCTACAATGGCCGGTACAAAGGGCTGCGATGCCGTGAGGTGG 1196
    AGCGAATCCTTTCAAAGCCGGTCTCAGTTCGGATCGGGGTCTGCAACTCGACCCCGTGAA 1256
    GTCGGAGTCGCTAGTAATCGCAGATCAGCAACGCTGCGGTGAATACGTTCCCGGGCCTTG 1316
    TACACACCGCCCGTCACGTCATGAAAGTCGGTAACACCCGAAGCCGGTGGCCTAACCCCT 1376
    TGTGGGAGGGAGCCGTCGAAGGTGGGATCGGCGA - 3'
```

2) 16S rDNA nucleotide sequence of *Sphingomonas* sp. strain FT1

```
5'- ATGCCTAATACATGCAAGTCGAACGAATCTTCGGATCTAGTGGCGCACGGGTGCGTAACG 71
    CGTGGGAATCTGCCCTTGGGTTCGGAATAACTTCTGGAAACGGAAGCTAATACCGGATGA 131
    TGACGTAAGTCCAAAGATTTATCGCCCAAGGATGAGCCCGCGTAGGATTAGCTAGTTGGT 191
    GGGGTAAAGGCTCACCAAGGCGACGATCCTTAGCTGGTCTGAGAGGATGATCAGCCACAC 251
    TGGGACTGAGACACGGCCCAGACTCCTACGGGAGGCAGCAGTAGGGAATATTGGACAATG 311
    GGCGAAAGCCTGATCCAGCAATGCCGCGTGAGTGATGAAGGCCTTAGGGTTGTAAAGCTC 371
    TTTACCCGGGATGATAATGACAGTACCGGGAGAATAAGCTCCGGCTAACTCCGTGCCATG 431
    CAGCCGCGGTAATACGGAGGGAGCTAGCGTTGTTCGGAATTACTGGGCGTAAAGCGCACG 491
    TAGGCGGCTATTCAAGTCAGAGGTGAAAGCCCGGGGCTCAACCCCGGAACTGCCTTTGAA 551
    ACTAGATAGCTTGAATCCAGGAGAGGTGAGTGGAATTCCGAGTGTAGAGGTGAAATTCGT 611
    AGATATTCGGAAGAACACCAGTGGCGAAGGCGGCTCACTGGACTGGTATTGACGCTGAGG 671
    TGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGATG 731
    ATAACTAGCTGTCAGGGCACATGGTGTTTTGGTGGCGCAGCTAACGCATTAAGTTATCCG 791
    CCTGGGGAGTACGGTCGCAAGATTAAAACTCAAAGGAATTGACGGGGGCCTGCACAAGCG 851
    GTGGAGCATGTGGTTTAATTCGAAGCAACGCGCAGAACCTTACAACGTTTGACATCCCTA 910
    TCGCGGATCGTGGAGACACTTTCCTTCAGTTCGGCTGGATAGGTGACAGGTGCTGCATGG 970
    CTGTCGTCAGCTCGTGTCGTGAGATGTTGGGTTAAGTCCCGCAACGAGCGCAACCCTCGC 1030
    CTTTAGTTGCCAGCATTTAGTTGGGTACTTAAAGGAACCGCCGGTGATAACCGGAGGAAG 1088
    GTGGGGATGACGTCAAGTCCTCATGGCCCTTACGCGTTGGGCTACACACGTGCTACAATG 1148
    GCGACTACAGTGGGCAGCCACCTCGCGAGAGGGAGCTAATCTCCAAAAGTCGTCTCAGTT 1208
    CGGATCGTTCTCTGCAACTCGAGAGCGTGAAGGCGGAATCGCTAGTAATCGCGGATCAGC 1268
    ATGCCGCGGTGAATACGTTCCCAGGCCTTGTACACACCG-CCGTCACATCCATGGGAGTT 1327
    GGATTCAACTTGAAGGCGTTGAGCTAACCGTAAGGAGGACAGGCGACTCACCAGTGGGTT 1387
    TAGCGACCTGGGGTGAAGTCGTAA - 3'
```

Appendix D

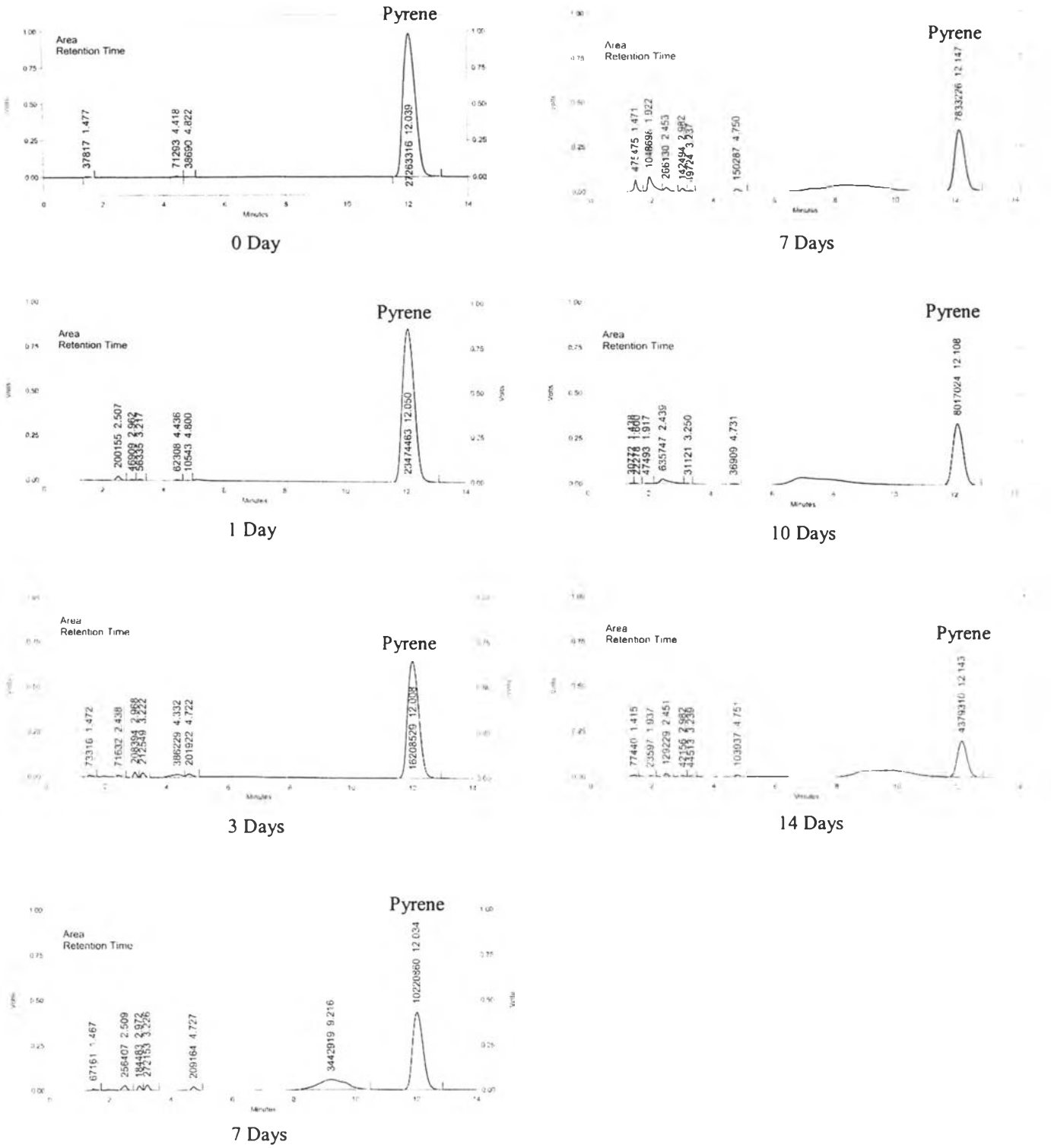

Figure D.1 Reverse phase HPLC profile of pyrene degradation from *Mycobacterium* sp. strain PY1 in 0, 1, 3, 5, 7, 10 and 14 days.

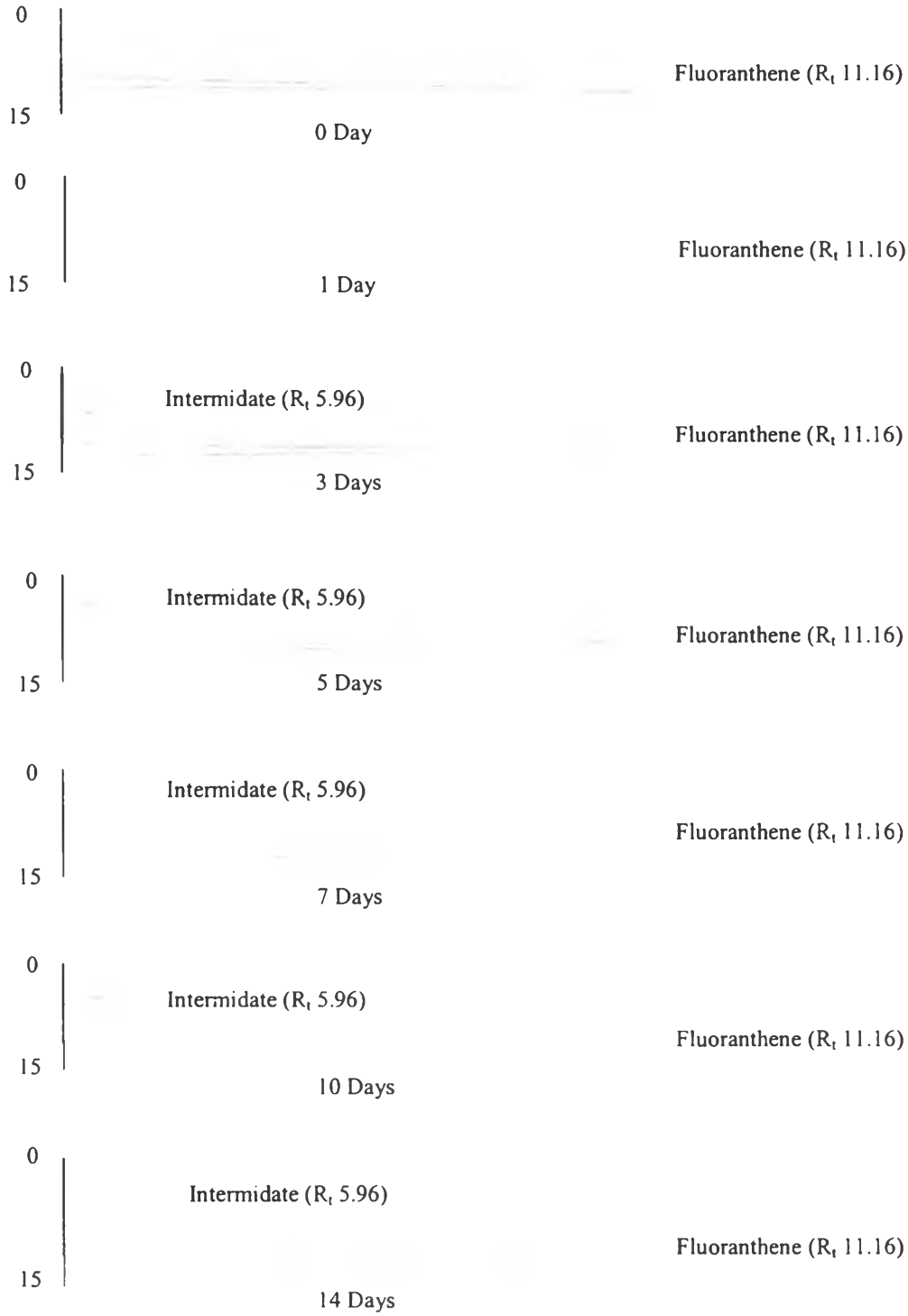

Figure D.2 Reverse phase HPLC profile of fluoranthene degradation by *Sphingomonas* sp. strain FT1 in 0, 1, 3, 5, 7, 10 and 14 days.

Appendix E

Sampling sites in this study

Figure E.1 S_1, Ratchathewi pier (The Saen-Saeb Canal)

Figure E.2 S_2, Pratunam pier (The Saen-Saeb Canal)

Figure E.3 S_3, Panfa-leelard pier (The Saen-Saeb Canal)

Figure E.4 S_4, Wat Sri-boon-reung pier (The Saen-Saeb Canal)

Figure E.5 S_5, Phrachulachomklao Royal Navy Dockyard (The Chao-Phraya River)

Figure E.6 S_6, See-phraya pier (The Chao-Phraya River)

Figure E.7 S_7, Sa-thon pier (The Chao-Phraya River)

Figure E.8 S_8, Padungkrungkasem Canal

Appendix E

Sampling sites in this study

Figure E.1 S_1, Ratchathewi pier (The Saen-Saeb Canal)

Figure E.2 S_2, Pratunam pier (The Saen-Saeb Canal)

Figure E.3 S_3, Panfa-leelard pier (The Saen-Saeb Canal)

Figure E.4 S_4, Wat Sri-boon-reung pier (The Saen-Saeb Canal)

Figure E.5 S_5, Phrachulachomklao Royal Navy Dockyard (The Chao-Phraya River)

Figure E.6 S_6, See-phraya pier (The Chao-Phraya River)

Figure E.7 S_7, Sa-thon pier (The Chao-Phraya River)

Figure E.8 S_8, Padungkrungkasem Canal

BIOGRAPHY

Miss Saranya Prapatsompinyo was born on June 21, 1980 in Chonburi Provience, Thailand. She attend Chongunyanukon in Chonburi and graduated in 1998. She received her Bachelor's degree in Science from Department of Microbiology, Faculty of Science, Chulalongkorn University in 2002. She pursued her Master Degree in The International Postgraduate Programs in Environmental Management, Interdepartment of Environmental Managementin May 2002.