REFERENCES

Albarran, A., Celis, R., Hermosin, M. C., Lopez-Pineiro, A., and Cornejo, J. 2004. Behaviour of simazine in soil amended with the final residue of the olive-oil extraction process. Chemosphere 54:717-724.

Agricultural Toxic Substances Division, AgrEvo (Thailand) Ltd., and Makhteshim Chemical Work Ltd. 2000. Dissipation of endosulfan in rice fields. Toxic substances news (in Thai). 27:12-32.

ATSDR. 2000. Physical and chemical information. Available from http://www.atsdr.cdc.gov/toxprofiles/tp41-c3.pdf

Awsathi, N., Ahuja, R., and Kumar, A. 2000. Factors influencing the degradation of soil-applied endosulfan isomer. Soil Biol. & Biochem. 32:1697-1705.

Awasthi, N., Singh, A. K., Jain, R. K., Khangarot, B. S., and Kumar, A. 2003. Degradation and detoxification of endosulfan isomers by a defined co-culture of two *Bacillus* strains. Appl. Microbiol. Biotechnol. 62: 279-283.

Barnes, and Ware. 1965. The sorption and metabolism of C-14-labeled endosulfan in the house fly. Econ. Entomal. 58: 286-291.

Barriuso, E., Calvet, R., and Houot, S. 1995. Field study on the effect of sewagw sludge application on antrazine behavior in soil. Environ. Anal. Chem. 59:107-121.

Barriuso, E., Feller, C., Calvet, R., and Cerri, C. 1992. Sorption of antrazine, terbutryn and 2,4-D herbicide in two Brazilian Oxidols. Geoderma 53:155-167.

Barriuso, E., Houot, S., and Serrowittling, C. 1997. Influence of compost addition to soil on the behaviour of herbicides. Pestic. Sci. 49:65-75.

Barry. 1995. Effect of algal food concentration on toxicity of two agricultural pesticides to Daphnia carinata. Ecotoxicol. Environ. Saf. 32: 273-279.

Bellin, C. A., O'Connor, G. A., and Jin, Y. 1990. Sorption and degradation of pentachlorophenol in sludge-amended soil. Environ. Qual. 19:603-608.

Berry, D. F., and Boyd, S. A. 1985. Decontamination of soil through enhanced formation of bound residues. Environ. Sci. Technol. 19:1132-1133.

Black, C. A., Evens, D. D., White, J. L., Ensminger, and Clark, F. E. 1969. Method of soil analysis part 2 chemical and microbiological properties. 2 Vols. 2 nd ed.

Boething, R. S., and Mackay, D. 2000. Handbook of property estimation methods for chemicals. Environmental and health science. USA: Lewis publishers.

Bollag, J. 1992. Decontaminating soil with enzymes: An in situ method using phenolic anilinic compounds. Environ. Sci. Technol. 26:1876-1881.

Bollag, J., and Mayers, C. 1992. Detoxification of aquatic and terrestrial sites through binding of pollutants to humic substances. Sci. of Tot. Environ. 117/118:357-366.

Calderbank, A. 1989. The occurence and significance of bound pesticide residue in soil. Environ. Contam. and Toxicol. 108:71-103.

Chiangmai. 2003. Annual report 2003-2004. Available from http://202.28.249.249/cmgo/meet_files/intro1.pdf.

Chopra, N. M., and Mahfou, A. M. 1977. Metabolism of endosulfan 1, endosulfan 11 and endosulfan sulfate in tobacco leaf. Agri. Food Chem. 25:32-39.

Clapp, S. A., Stark, S. A., Clay, D. E., and Larson, W. E. 1986. Sewagw sludge organic matter and soil properties. In: Chen,Y., Avnimelech, Y. (Eds.), The

role of organic matter in modern agriculture. Martinus Nijhoff Publishers, Netherlands:226-281.

Cox, L., Celis, R., Hermosin, M. C., Becker, A., and Cornejo, J. 1997. Porosity and herbicide leaching in soils amended with olive-mill wastewater. Agri., Ecosys. and Environ. 65:151-161.

Davi et., a. 1981. Relative toxicity of th technical grade material, isomers and formulations of endosulfan to the fish Channa punctata. Environ. Contam. Toxicol. 27:239-243.

Dec, J., and Bollag, J. 1997. Determination of covalent and non-covalent binding interactions between xenobiotic chemicals and soil. Soil Sci.162:858-874.

Deutsch, W. J. 1997. Groundwater Geochemistry: Fundamentals and Applications to Contamination. Lewis Publishers, Florida.

ESCAP/EC. 1994. Database on pesticide and the environment. Asean version.

German Federal Environment Agency. 2004. Umweltbundesamt: Preliminary Risk Profile of Endosulfan. Available from http://www.unece.org/env/popsxg/docs/2004/Dossier_Endosulfan.2004.pdf

Gevao, B., Semple, K. T., and Jones, K. C. 2000. Bound pesticide residues in soils: a review. Environ. Pollut. 108:3-14.

Golueke, C. G. 1977. Land disposal of primary and seondary domestic sewage sludges. Biological reclamation of solid wastes. Rodale press, Emmaus, PA:117-142.

GonZalez-Pradas, E., Urena-Amate, M. D., Flores-Cespedes, F., Fernandez-Perez, M., Garrata, J., and Wilkins, R. 2002. Leaching of imidaclopid and

Procymidone in a greenhouse of Southeast of Spain. Soil Sci. Soc. 66:1821-1828.

Graber, E. R., Sluszny, C., and Gerstl, Z. 1997. The influence of sludge amendment on transport and sorption ideality of striazines in soil column. Environ. Toxicol. Chem. 16:2463-2469.

Guo, L., Bikki, T. J., and Hinesly, T. D. 1991. Effect of carbon-rich waste materials on movement and sorption of atrazine in a sandy, coarse-textured soil. Environ. Toxicol. Chem. 10:1273-1282.

Guo, L., T.J., B., A.S., F., and T.D., H. 1993. Sorption and movement of alachlor in soil modified by carbon-rich wastes. Environ. Qual. 22:186-194.

Guo, L., Wagenet, R. J., and Jury, W. A. 1999. Adsorption effects on kinetics of aldicarb degradation: equilibrium model and application to incubation and transport experiments. Soil Sci. Soc. 63:1637-1644.

Guo, M., Yates, S. R., Zheng, W., and Papiernik, S. K. Leaching potential of persistent soil fumigant residues. Environ. Sci. & Technol. 37:5181-5.

Harper, S. 1994. Sorption-desorption and herbicide behavior in soil. Rev. Weed. Sci. 6:207-255.

Huang, W., Schlautman, M. A., and Jr., W. J. W. 1996. A distributed reactivity model for sorption by soils and sediments 5: The influence of near-surface characteristics in mineral domain. Environ. Sci. Tech. 30:2993-3000.

Hulscher, Th.E.M. and Cornelissen,G., 1996. Effect of temperature onsorption equilibrium and sorptionkinetics of organic micropollutants- a review. Chemosphere 32, 609-626.

IAEA-TECDOC-695. 1991. Use of isotopes in studies of pesticides in rice-fish ecosystem. Report of a final research co-ordinaton meeting, Bangkok, Thailand.

Ismai, B., Enoma, A., Cheah, U., Lum, K., and Malik, Z. 2002. Adsorption, desorption, and mobility of two insecticides in Malaysian agricultural soil. Environ. Sci. Health 37(4):355-364.

Jin, Y., and O'Connor, G. A. 1990. Behavior of toluene added to sludge amended soils. Environ. Qual. 19:573-579.

Jury, W. A., Spencer, W. F., and Farmer, W. J. 1984. Behavior assessment model for trace organics in soil: II. Chemical classification and parameter sensitivity. Environ. Qual. 13:567-572.

Kamble, S. T. 1996. Fate of insecticide used for termite control in soil. Institute of Agriculture and Natural Resources, University of Nebraska

Karickhoff, S. W. 1981. Semi-empirical estimation of sorption of hydrophobic pollutants on natural sediments and soils. Chemosphere 10:833-846.

Karnchanasest, B., and Jailuk, R. 2004. Developing simple QSAR models to predict soil sorption of PAH. Environ. Research 26:37-55.

Katayama, A., and Matsumura, F. 1993. Degradation of organochlorine pesticides particularly endosulfan, by Trichoderma harzianum. Environ. Toxicol. Chem. 12:1059-1065.

Kathpal, T. S., Singh, A., Dhankar, J. S., and Singh, G. 1997. Fate of endosulfan in cotton soil under sub-tropical conditions of Northern India. Pestic. Sci. 50:21-27.

Kennedy, I., Ahmed, N., Beasley, H., Chapman, J., Hobbs, J., Simpson, B., and Woods, N. 1998. Quality assurance in pesticide sampling and analysis. Occasional paper no. 14/98. Land and Water Resour. Res. and Development Corp., Canberra, ACT, Australia.

Kennedy, I. R., Sanchez-Bayo, F., Kimber, S. W., Hugo, L., and Ahmad, N. 2001. Off-side movement of Endosulfan from irrigated cotton in New South Walses. Environ. Qual. 30:683-696.

Kwon, G.-S., Kim, J.-E., Kim, T.-K., Sohn, H.-Y., Koh, S.-C., Shin, K.-S., and Kim, D.-G. 2002. *Klebsiella pneumoniae* KE-1 degrades endosulfan without formation of the toxic metabolite, endosulfan sulfate. FEMS Microbiol. Letters 215, 255-259.

Laabs, V., Amelung, W., Pinto, A., Alttstaedt, A., and Zech, W. 2000. Leaching and degradation of corn and soybean pesticides in an Oxisol of Brazilian Cerrados. Chemosphere 41:1441-1449.

Lagrega, M. D., Buckingham, P. L., and Evens, J. C. 2001. Hazardous Waste Management. McGraw-Hill, Singapore.

Leahy, G. J., Byrne, A. M., and Olsen, R. H. 1996. Comparison of factors influencing trichloroethylene degradation by toluene-oxidizing bacteria. Appl. Environ. Microbiol. 62:825-833.

Lenheer, J. A., and Aldrichs, J. 1971. A kinetic and equilibrium study of the adsorption of cararyl and parathion upon soil organic matter surfaces. Soil Sci. Soc. 35:700-705.

Leonard, A. W., Hyne, R. V., Lim, R. P., Leigh, K. A., Le, J., and Beckett, R. 2001. Fate and toxicity of endosulfan in Namoi river water and bottom sediment. Environ. Qual. 30:750-759.

Mackay, D. M. 1989. Characterization of the distribution and behavior of contaminants in the subsurface. represented at NRC-WSTB colloquium entitled ground water and soil contamination remediation: Are science, policy and public perception compatible?

Meister, R.T. 1994. Farm Chemicals Handbook 1994. Meister Publishing Company. Willoughby, Ohio.

Martens, R. 1976. Degradation of [8,94C] endosulfan by soil microorganisms. Appl. Environ. Microbiol. 31:853-858.

McEwen, F. L., and Stephenson, G. R. 1979. The use and significance of pesticides in environment. A Wiley-Interscience publication, Canada.

Metzger, L., Levanon, D., and Mingelgrin, U. 1987. The effect of sewage sludge on soil structure stability: microbiological aspects. Soil Sci. Soc. 51:346-351.

Metzger, L., and Yaron, B. 1987. Influence of sludge organic matter on soil physical properties. Advan. Soil Sci. 7:141-163.

Miles, J. R. W., and Moy, P. 1979. Degradation of endosulfan and its metabolites by a mixed culture of soil microorganisms. Bull. Environ. Contam. Toxicol. 23:13-19.

Miller, R. W., and Gardiner, D. T. 2001. Soil in our environment 9 th ed. Prentice-Hall, New Jersey.

Montgomery, J. H. 1993. Agrochemical desk reference: Environmental data. Lewis Publishers, Ann Arbor, Miami, USA.

Mordaunt, C. J., Geova, B., Jones, K. C., and Semple, K. T. 2005. Formation of non-extractable pesticide residues: observations on compound differences, measurement and regulatory issues. Environ. Pollut. 133:25-34.

National Cancer Institute, 1978. Bioassay of Endosulfan for Possible Carcinogenicity, U. S. Department of Health, Education and Welfare, Public Health Service, National Institutes of Health, Technical Report Series No. 62.

National Institute for Occupational Safety and Health, 1985-86. Registry of Toxic Effects of Chemical Substances, U. S. Department of Health and Human Services, Centers for Disease Control.

O'Connor, G. A., Lujan, J. R., and Jin, Y. 1990. Adsorption, degradation, and plant availability of 2,4-dinitrophenol in sludge- amended calcareous soil. Environ. Qual. 19:587-593.

Oi, M. 1999. Time-dependent sorption of imidaclopid in two different soils. Agric. Food Chem. 47:327-332.

Peterson, S. M., and Batley, G. E. 1993. The fate of endosulfan in aquatic systems. Environ. Pollut. 82:143-152.

Pignatello, J. J., and Xing, B. 1996. Mechanisms of slow sorption of organic chemicals to natural particles. Environ. Sci. and Tech. 30:1-11.

Rao, D. M. R., and Murty, A. S. 1980. Persistance of endosulfan in soils. Agric. Food Chem. 28:1099-1101.

Rao, P. S. C., and Hornsby, A. G. 2001. Behavior of pesticides in soils and water. Institute of food and agriculture sciences, University of Florida http://edis.ifas.ufl.edu.

Rice, C. P., Nochetto, C. B., and Zara, R. 2002. Volatilization of trifluralin, atrazine, metolachlor, chlorpyrifos, α-endosulfan, and β-endosulfan from freshly tilled soil. Agri. Food Chem. 50:4009-4017.

Robert C. Knox, David A. Sabatini. 1993. Subsurface transport and fate transport. Boca Raton, Florida: Lewis Publishers.

Roberts, T. R. 1984. Non-extractable pesticide residues in soils and plants. Pure and Appli. Chem. 56:945-956.

Samuel, T., and Pillai, M. K. K. 1991. Impact of repeated application on the binding and persistence of [14C]-DDT and [14C]-HCH in a tropical soil. Environ. Pollut. 74:205-216.

Schulz, R. 2004. Field studies on exposure, effects, and risk mitigation of aquatic nonpoint-source insecticide pollution: a review. Environ. Qual. 33:419-448.

Senesi, N. 1992. Binding mechanisms of pesticides to soil humic substances. Sci. of Total Environ. 123/124:63-76.

Seol, Y., and Lee, L. S. 2000. Effect of dissolved organic matter in treated effluents on sorption of atrazine and prometryn by soils. Soil Sci. Soc. 64:1976-1983.

Setunathan, N., Megharaj, M., Chen, Z., Singh, N., Kookana, R. S., and Naidu, R. 2002. Persistance of endosulfan and endosulfan sulfate in soil as affected by moisture regime and organic matter addition. Environ. Contam. Toxicol. 68:725-731.

Siddique, T., Okeke, B. C., Arshed, M., and William . Frankenberger, J. 2003. Enrichment and isolation of endosulfan-degrading microorganisms. Environ. Qual. 32:47-54.

Siriwong, W. 2001. The efficiency of ozone to reduce endosulfan residues in Chinese cabbage. Thammasart University, Bangkok.

Sluszny, C., Graber, E. R., and Gerstl, Z. 1999. Sorption of striazine herbicides in organic matter amended soils: fresh and incubated systems. Water, Air and Soil Pollut. 115:395-410.

Spark, K. M., and Swift, R. S. 2002. Effect of soil composition and dissolved organic matter on pesticide sorption. The Sci. of The Total Environ. 298:147-161.

Tan, K. H. 1998. Principles of soil chemistry. 3rd ed. USA. Marcel Dekker.

Tester, C. F. 1990. Organic amendment effects on physical and chemical properties of a sandy soil. Soil Sci. Soc. 54:827-831.

Thapinta, A., and Hudek, P. F. 2000. Pesticide use and residual occurence in Thailand. Environ. Monitoring and Assess. 60:103-114.

US Department of Health and Human Services, 1990. Toxicological Profile for Endosulfan. Draft. Public Health Service, Agency for Toxic Substances and Disease Registry.

US. EPA. 1996. Fate and transport of parameters. Available from http://www.epa.gov/earth1r6/6pd/rcra_c/protocol/volume_2/a_3_095.pdf

Van Dyk, L. P., and Linde, V. d. 1976. Persistance of endosulfan in soil of the Loskop Dam irrigation area. Agrochemophysica 8:31-34.

Wania, F., and Mackey, D. 1996. Tracking the distribution of persistent organic pollutants. Environ. Sci. Technol. 30:390A-410A.

Weber, J. B., wilkerson, G. G., and Reinhardt, C. F. 2004. Calculation pesticide sorption coefficients (Kd) using selected soil properties. Chemosphere 55:157-166.

Weber, W. J., Jr. 1972. Physiochemical process for water quility control. New York: John Wiley & Sons,Inc.

Weber, W. J., Jr., Mcginley, P. M., and Katz, L. E. 1991. Sorption phenomena in subsurface systems: Concepts, models and effects on contaminant fate and transport. Water Res. 25:499-528.

Weston, D. P., You, J., and Lydy, M. J. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's central valley. Environ. Sci. Technol. 38:2752-2759.

Wu, Q., Riise, G., and Kretzschmar, R. 2003. Size distribution of organic matter and associated propiconazole in agriculture runoff material. Environ. Qual. 32:2200-2206.

Yaron, B., Calvet, R., and Prost, R. Soil Pollution: Processes and Dynamics. Germany: Springer-Verlag Berlin Heidelberg, 1996.

Zhang, L. Z., Khan, S. U., Akhtar, M. H., and Ivarson, K. C. 1984. Persistence, degradation and distribution of deltamethrin in an organic soil under laboratory conditions. Agri. Food Chem. 32:1207-1211.

Zhou, M. , Li, Y. C., Nkedi-Kizza, P., and O'Hair, S. K. 2002. Endosulfan Losses through Runoff and Leaching from Calcareous Gravelly or Marl Soils Available from http://vzj.scijournals.org/cgi/content/full/2/2/231#TBL3

APPENDICES

APPENDIX A

Determination of soil and wastewater treatment sludge characteristics

1. pH (soil : water 1:1)

10 g of soil was weighed in a beaker and 10 ml of distilled water was added. The slurry was stirred for about and hour. Then the pH was measured using a pH meter.

2. Moisture content

5 g of soil was weighted in preweight flask (PF). Then the flask and its content was dried at 103-110 °C for 24 hour in an oven. At the end of the 24 hours, allowed the flask to cool down in a desicator and weighed the flask and its content again (F). The moisture content is calculated based on tee equation below.

$$\% \text{ moisture} = \frac{(PF - F)}{PF} \times 100$$

3. Cation exchange capacity (ammonium saturation method)

10 g of soil was weighed and added 250 ml of neutral 1 N ammonium acetate (NH_4OAC). The flask was shaken thoroughly and allowed it to stand overnight. The soil was filtered with light suction suing buchner funnel. The soil was leached with

the neutral ammonium acetate reagent (NH_4OAC) until no trace of calcium found in the effluent solution. The leachate was combined for the determination of exchangeable bases. Then the soil was leached four times with 1 N ammonium chloride (NH_4Cl) and once with 0.25 N ammonium chloride (NH_4Cl) and washed out the electrolyte with 150 to 200 ml of 99% isopropyl alcohol. Determined the adsorbed ammonium (NH_4) by leacing the ammonium-saturated soil with 10% acidified sodium chloride (NaCl) until 225 ml have passed through the samples. The leachate was transferred quantitatively to kjeldahl flask, added 25 ml of 1 N sodium hydroxide (NaOH), and distilled 60 ml of the solution into 50 ml of 2% BORIC ACID (H_3BO_3) 10 drops of bromocresol green-methyl red mixed indicator was added, and titrated the boric acid solution with standard 0.1 N H_2SO_4. The color change is from bluish green through bluish purple to pink at the end point. Run blanks on the reagents. Corrected the titration figure for the blanks, and calculate the centimoles of cations per kilogram of dry soil ($cmol_c/kg$).

4. Electroconductivity (soil : water 1: 5)

2 g of soil was weighed in a beaker and 10 ml of distilled water was added. The slurry was stirred for about and hour. Then the electroconductivity was measured using a EC meter.

5. Organic carbon content (wet oxidation method)

2 g of soil was transferred into an erlenmeyer flask. Added 10 ml of 1 N potassium dichromate ($K_2Cr_2O_7$) and swirled the flask gently to disperse the soil in the solution. Then rapidly added 10 ml of concentrated H_2SO_4, directing the stream into the suspension. Immediately swirl the flask gently until soil and reagents were mixed, then swirled more vigorously for a total of 1 minutes. Allowed the flask to stand for 30 minutes. Then added 100 ml of water to the flask, added 3 to 4 drops of o-phenanthroline indicator, and titrated the solution with 0.5 N ferrous sulphate ($FeSO_4$). As the endpoint was approached, the solution takes on a greenish cast and then changed to dark green. At this point, added the ferrous sulfate drop by drop until the color changes from bleu to red. Made a bland determination in the same manner, but without soil, to standardize the $Cr_2O_7^{2-}$.

6. Soil Texture (hydrometer)

100 g of soil was weighed and transferred into a blender cup. Filled the blender cup with distilled water to within 10 cm of the top and added 10 ml of sodium metaphosphate solution $(NaPO_3)_x.Na_2O$. Attached the cup to a blending machine and blend mechanically for 15 minutes. Transferred the soil suspension into an ASTM soil-testing cylinder. Made up the volume in the cylinder with a stirring rod. Record the exact time when stirring was stopped.

Placed a hydrometer into the suspension, and exactly 40 seconds after the stirring was stopped, read tee nearest 0.5 scale division the top of the meniscus on the hydrometer. Stirred the suspension again and repeated the analysis of the 40 second reading. The average of the 2 reading was taken as the result, which equals the amount of silt + clay in grams. Determined and recorded the temperature of the suspension after removed the hydrometer. Stirred the suspension again thoroughly. Take a third hydrometer and temperature reading after 120 minutes of settling time. This reading will measure tee amount of clay in grams.

7. Metals

The method to determine metals in soil is described in SW-846 method 3051. This method utilizes microwave to promote acid digestion of soil for the metals such as Copper (Cu), Manganese (Mn), Nikel (Ni), Zinc (Zn) etc. It is design to supply an accelerated multi-element acid leach digestion prior to analysis. Digests produced by the method are appropriate for analysis by atomic absorption spectrophotometer (AA).

A representative soil and sludge sample of up to 0.5 g is digested in 10 milliliters of concentrated nitric acid. The soil sample is put on hot plate to heat. The sample is digested until the solution is clear. After cooling, the vessel contents are filtered or allowed to precipitate and then diluted to 100 milliliters in volumetric flask and then they will test the amount of metals by AA.

APPENDIX B

Calibration curve of endosulfan

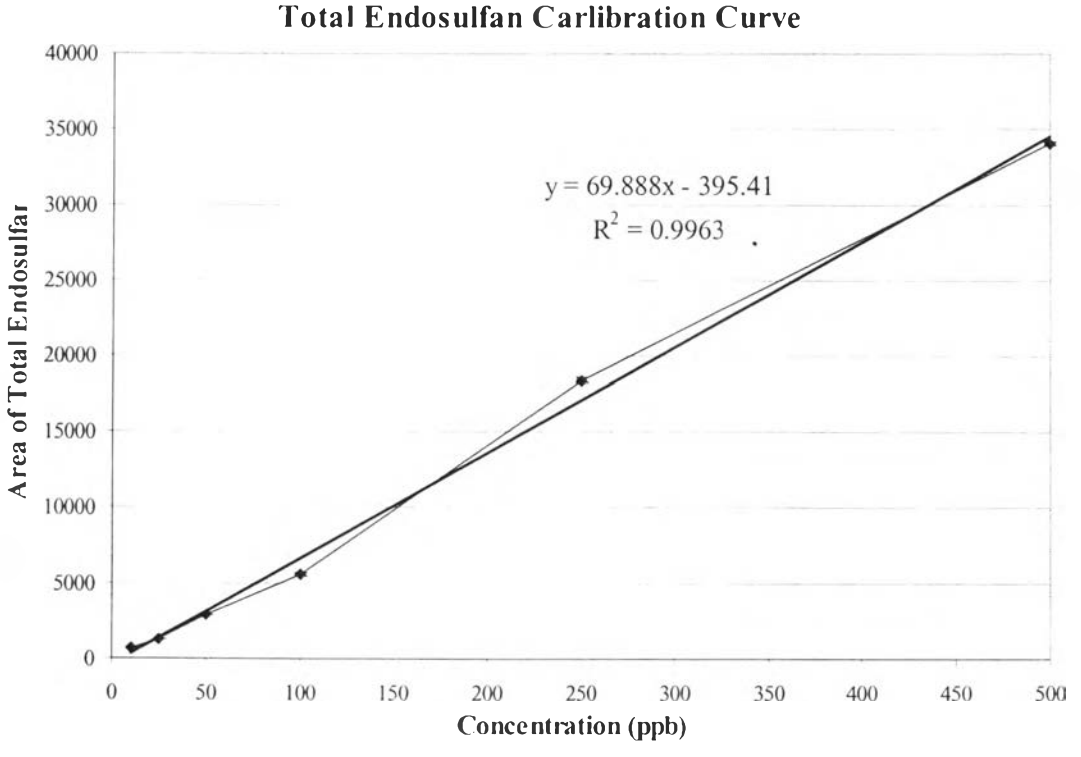


Figure B1 Calibration curve of endosulfan

APPENDIX C

The equilibrium time in soil and wastewater treatment sludge

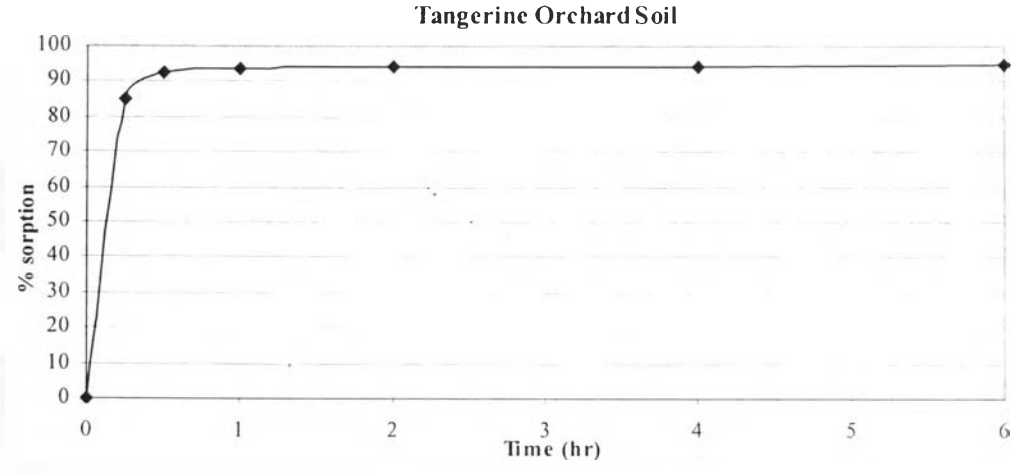


Figure C1 equilibrium time of Soil

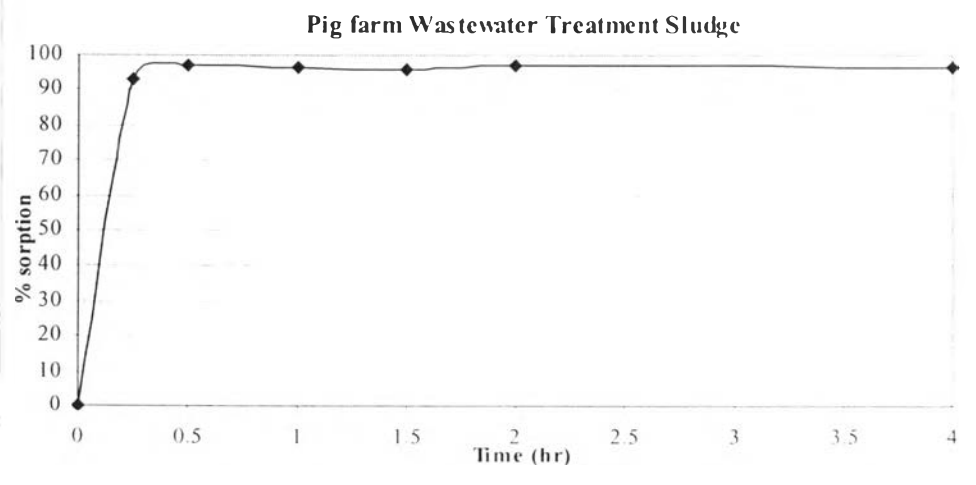


Figure C2 equilibrium time of wastewater treatment sludge from pig farm

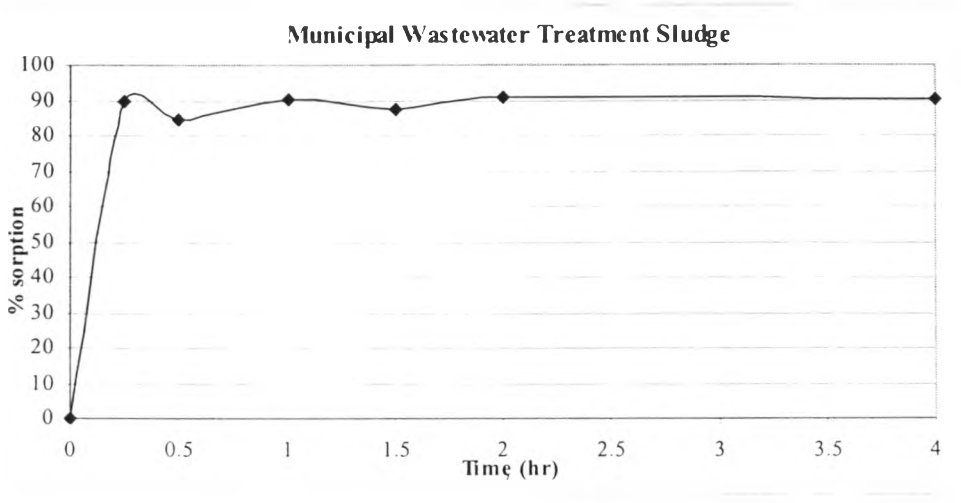


Figure C3 equilibrium time of municipal wastewater treatment sludge

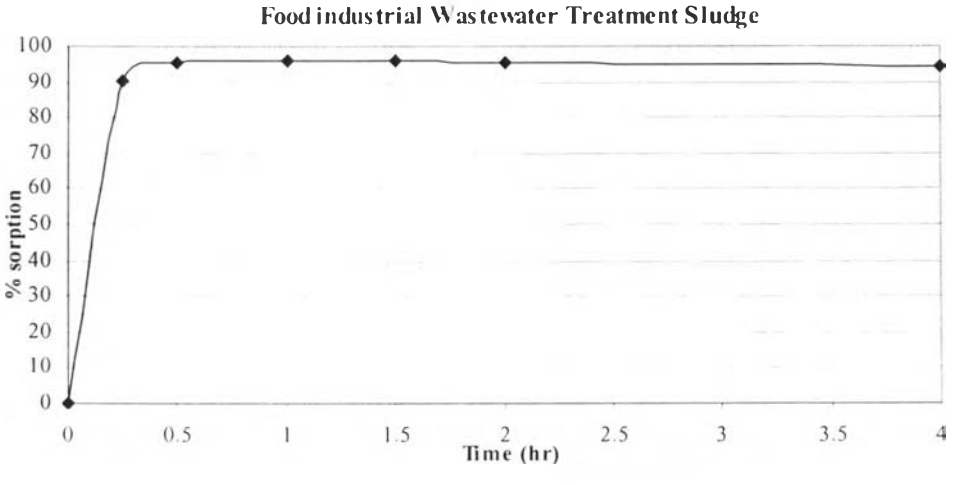
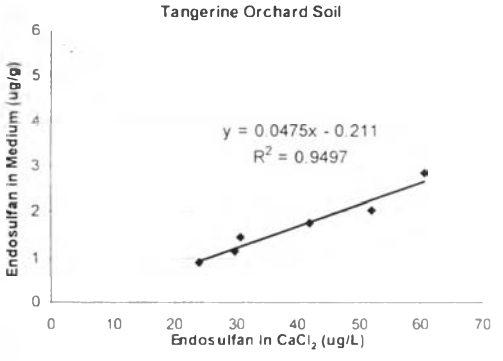


Figure C2 equilibrium time of wastewater treatment sludge from food industrial-sweet corn canning

APPENDIX D

The result of sorption isotherm and desoprtion efficiency of endosulfan on soil and wastewater treatment sludge

(1) Soil



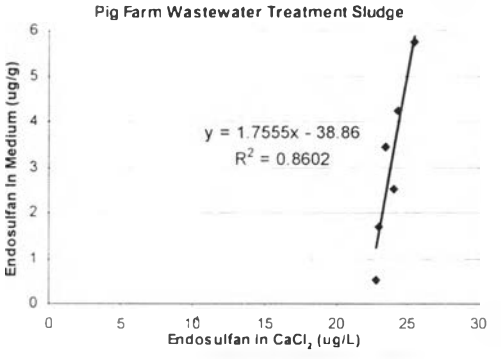
Sorption isotherm

	Concentration (ppb)	Mass (g)	Endosulfan in $CaCl_2$ (ug/L)	Endosulfan in media (ug/kg)
Sorption	50	0.5	24.06	725.78
	100	0.5	29.75	1248.20
	150	0.5	30.82	3382.82
	200	0.5	41.94	2820.60
	250	0.5	52.01	3544.90
	300	0.5	60.61	4118.13
Desorption	50	0.5	18.90	623.10
	150	0.5	23.48	3281.79
	300	0.5	40.57	4001.85

Desorption efficiency

Concentration (ppb)	Conc. In $CaCl_2$ (ug/L)	Desorption (ug/kg)
50	18.90	189.04
150	23.48	234.82
300	40.57	405.72
	Average	276.53

(2) Wastewater treatment sludge from pig farm



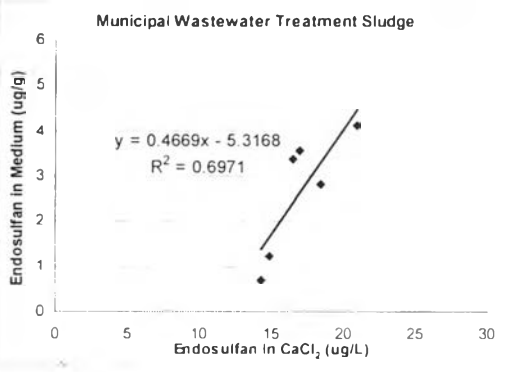
Sorption isotherm

	Concentration (ppb)	Mass (g)	Conc. In $CaCl_2$ (ug/L)	Conc. In media (ug/kg)
Sorption	50	0.5	22.83	725.78
	100	0.5	22.97	1248.20
	150	0.5	24.05	3382.82
	200	0.5	23.50	2820.60
	250	0.5	24.35	3544.90
	300	0.5	25.47	4118.13
Desorption	50	0.5	12.80	623.10
	150	0.5	11.12	3281.79
	300	0.5	13.11	4001.85

Desorption rate

Concentration (ppb)	Conc. In $CaCl_2$ (ug/L)	Desorption (ug/kg)
50	12.80	128.02
150	11.12	111.18
300	13.11	131.10
	Average	123.43

(3) Municipal wastewater treatment sludge



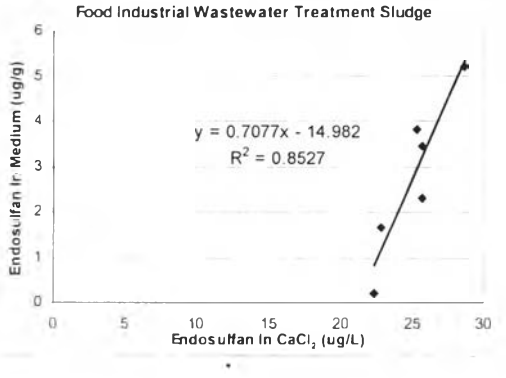
Sorption isotherm

	Concentration (ppb)	Mass (g)	Conc. In $CaCl_2$ (ug/L)	Conc. In media (ug/kg)
Sorption	50	0.5	14.35	725.78
	100	0.5	14.92	1248.20
	150	0.5	16.55	3382.82
	200	0.5	18.50	2820.60
	250	0.5	16.98	3544.90
	300	0.5	20.95	4118.13
Desorption	50	0.5	10.27	623.10
	150	0.5	10.10	3281.79
	300	0.5	11.63	4001.85

Desorption rate

Concentration (ppb)	Conc. In $CaCl_2$ (ug/L)	Desorption (ug/kg)
50	18.90	189.04
150	23.48	234.82
300	40.57	405.72
	Average	276.53

(4) Wastewater treatment sludge from food industrial-sweet corn canning



Sorption isotherm

	Concentration (ppb)	Mass (g)	Conc. In $CaCl_2$ (ug/L)	Conc. In media (ug/kg)
Sorption	50	0.5	22.34	725.78
	100	0.5	22.83	1248.20
	150	0.5	25.69	3382.82
	200	0.5	25.66	2820.60
	250	0.5	25.35	3544.90
	300	0.5	28.68	4118.13
Desorption	50	0.5	10.26	623.10
	150	0.5	13.70	3281.79
	300	0.5	16.25	4001.85

Desorption rate

Concentration (ppb)	Conc. In $CaCl_2$ (ug/L)	Desorption (ug/kg)
50	10.26	102.64
150	13.70	137.00
300	16.25	162.50
	Average	134.05

APPENDIX E

The result of soil column experiment

(1) Preliminary study

Unit : ppb

Depth (cm)	1 day		5 days	
	.without sludge	with sludge	without sludge	with sludge
Sludge	-	26231	-	22802
0-1 cm	4618	65	7014	14
1-2 cm	62	157	336	12
2-3 cm	69	133	33	10
3-4 cm	82	120	20	12
4-5 cm	87	70	13	13
5-10 cm	91	99	37	34
10-15 cm	45	41	37	41

(2) Soil column experiment : 1 application and weekly application

Unit : ppb

0 day samples

	single/weekly application		
	without sludge	1-cm sludge	2-cm sludge
Sludge	-	15018	13549
0-2.5 cm	8996	2973	13
2.5-5 cm	18	28	17
5-7.5 cm	n/a	n/a	n/a
7.5-10 cm	18	20	16
10-15 cm	18	18	16

7 days samples

	single application			weekly application		
	without sludge	1-cm sludge	2-cm sludge	without sludge	1-cm sludge	2-cm sludge
Sludge	-	13958	14675	-	33409	16630
0-2.5 cm	8737	3369	46	29567	3775	3272
2.5-5 cm	88	52	37	137	629	270
5-7.5 cm	54	42	32	62	32	33
7.5-10 cm	57	39	32	43	35	30
10-15 cm	41	44	35	35	30	33

14 days samples

	single application			weekly application		
	without sludge	1-cm sludge	2-cm sludge	without sludge	1-cm sludge	2-cm sludge
Sludge	-	17304	14737	-	67902	55622
0-2.5 cm	10337	5551	3047	34080	4763	61
2.5-5 cm	94	178	33	1734	142	20
5-7.5 cm	63	31	25	53	34	23
7.5-10 cm	46	30	33	50	29	22
10-15 cm	n/a	n/a	n/a	n/a	n/a	n/a

21 days samples

	single application			weekly application		
	without sludge	1-cm sludge	2-cm sludge	without sludge	1-cm sludge	2-cm sludge
Sludge	-	10661	8927	-	90786	40331
0-2.5 cm	5460	2404	296	14100	45	1721
2.5-5 cm	117	25	26	457	20	136
5-7.5 cm	32	21	19	28	16	30
7.5-10 cm	25	22	16	16	16	18
10-15 cm	n/a	n/a	n/a	n/a	n/a	n/a

28 days samples

	single application			weekly application		
	without sludge	1-cm sludge	2-cm sludge	without sludge	1-cm sludge	2-cm sludge
Sludge	-	18851	13900	-	83075	84755
0-2.5 cm	7674	2716	60	20714	83	1531
2.5-5 cm	256	48	48	506	92	80
5-7.5 cm	107	64	81	54	38	26
7.5-10 cm	n/a	n/a	n/a	n/a	n/a	n/a
10-15 cm	n/a	n/a	n/a	n/a	n/a	n/a

35 days samples

	single application			weekly application		
	without sludge	1-cm sludge	2-cm sludge	without sludge	1-cm sludge	2-cm sludge
Sludge	-	14747	8152	-	107775	68329
0-2.5 cm	3243	1003	28	16373	88	655
2.5-5 cm	133	152	23	384	40	27
5-7.5 cm	26	23	56	29	18	20
7.5-10 cm	25	20	21	21	19	18
10-15 cm	n/a	n/a	n/a	n/a	n/a	n/a

BIOGRAPHY

Mr.Panuwat Kraijitmatewas born on November 14, 1979 in Lampang Province, Thailand. He attended Bunyawat Witthayalai School and graduated in 1996. He received his Bachelor's Degree in Department of Environmental Engineering from Faculty of Engineering, Chiang Mai University in 2001. He worked as Environmental Engineer at Nikon (Thailand) Co., Ltd. since 2001 to 2003. He pursued his Master Degree study in the International Postgraduate Programs in Environmental Management, Inter-Department of Environmental Management, Chulalongkorn University, Bangkok, Thailand in May 2003. He was awarded Master Degree of Science in Environmental Management in April 2005.