

REFERENCES

- ศิริ กอนันตกุล. 2542. การเพาะเลี้ยงปลานิลแปลงเพศ. กรมประมงน้ำจืด, กรมประมง กระทรวงเกษตรและสหกรณ์. หน้า 62.
- เพ็ญพรรณ ศรีสกุลเดียว. 2547. การศึกษาสถานภาพการแปลงเพศ ปลานิลเพื่อลดต้นทุนการผลิต. นานาสัตว์น้ำ 3.
- วิเชียร วัตตสินท. 2542. การแปลงเพศปลานิล. ใน สัมพันธ์ สังขารักษ์ (บรรณาธิการ), คู่มือการเลี้ยงปลานิล, หน้า 166-176. กรุงเทพมหานคร: สำนักพิมพ์เกษตรวิชาการ.
- Andersen, L., Goto-Kazeto, R., Trant, J.M., Nash, J.P., Korsgaard, B., Bjerregaard, P. 2006. Short-term exposure to low concentrations of the synthetic androgen methyltestosterone affects vitellogenin and steroid levels in adult male zebrafish (*Danio rerio*). **Aquatic Toxicology** 76: 343-352.
- APHA, AWWA, and WPCF. 1995. **Standard Methods for The Examination of Water and Wastewater**. 19th ed. New York: American public health association.
- Bandelj, E., Van Den Heuvel, M.R., Leusch, F.D.L., Shannon, N., Taylor, S., and McCarthy, L.H. 2006. Determination of the androgenic potency of whole effluents using mosquitofish and trout bioassays. **Aquatic Toxicology** 80: 237-248.
- Bauer, E.R.S. 2002. **Expression of Recombinant Human Androgen Receptor and Its Use for Screening Methods**. Doctoral dissertation. Institute of Physiology FML Welhenstephan, Technische Universitat Munchen.
- Beck, I.C., Bruhn, R., and Gandrass, J. 2006. Analysis of estrogenic activity in coastal surface waters of the Baltic Sea using the yeast estrogen screen. **Chemosphere** 63: 1870-1878.
- Berrevoets, C.A., Veldscholte, J., and Mulder, E. 1993. Effects of antiandrogens on transformation and transcription activation of wild type and mutated (LNCaP) androgen receptors. **Journal of Steroid Biochemistry and Molecular Biology** 46: 731-736.

- Bhandari R. K., Nakamura M., Kobayashi T., and Nagahama Y. 2006. Suppression of steroidogenic enzyme expression during androgen-induced sex reversal in Nile tilapia (*Oreochromis niloticus*). **General and Comparative Endocrinology** 145: 20-24.
- Birkett, J.W. 2003. Scope of problem. In J.W. Birkett, and J.N. Lester (eds), **Endocrine Disrupters in Wastewater and Sludge Treatment Processes**, pp. 6-25. New York: Lewis publishers.
- Casey, F.X.M., Hakk, H., Simunek, J., and Larsen, G.L. 2004. Fate and transport of testosterone in agricultural soils. **Environmental Science and Technology** 38: 790-799.
- Castine, S.A., Bourne, D.G., Trott, L.A., and McKinnon, D.A. 2009. Sediment microbial community analysis: Establishing impacts of aquaculture on a tropical mangrove ecosystem. **Aquaculture** 297: 91-98.
- Chao, Y., Kurisu, F., Saitoh, S., and Yagi, O. 2004. Degradation of 17 β -estradiol by *Sphingomonas* sp. Strain D12 isolated from soil. **Journal of Environmental Biotechnology** 3(2): 89-94.
- Chotisukarn, P. 2008. **Sorption of methyltestosterone onto sediments and soils**. Master's thesis. Graduate school, Chulalongkorn university.
- Contreras-Sánchez, W. M., Couturier, G. M., and Schreck, C. B. 2002. Fate of methyltestosterone in the pond environment: use of MT in earthen ponds with no record of hormone usage. In K. McElwee, K. Lewis, M. Nidiffer, and P. Buitrago (eds), **Pond Dynamicx/Aquaculture CRSP Nineteenth Annual Technical Report**, Oregon.
- Contreras-Sánchez, W. M., Fitzpatrick, M. S., and Schreck, C. B. 2001. Fate of methyltestosterone in the pond environment: detection of MT in pond soil from a CRSP site. In A. Gupta, K. McElwee, D. Burke, J. Burright, X. Cummings, and H. Eгна (eds), **Pond Dynamics/Aquaculture CRSP Eighteenth Annual Technical Report**, Oregon.
- Contreras-Sánchez, W.M., Fitzpatrick, M.S., and Schreck, C.B. 2001. Fate of methyltestosterone in the pond environment: impact of MT-contaminated soil on tilapia sex differentiation. In A. Gupta, K. McElwee, D. Burke, J. Burright, X. Cummings, and H. Eгна (eds), **Pond Dynamics/Aquaculture CRSP Eighteenth Annual Technical Report**, pp. 83-86. Oregon.

- Czajka, C.P., and Londry, K.L. 2006. Anaerobic biotransformation of estrogens. **Science of The Total Environment** 367: 932-941.
- Damstra, T., Barlow, S., Bergman, A.R., and van der Kraak, G. 2002. Global assessment of the State-of-the-Science of endocrine disruptors. **International Program on Chemical Safety**. World Health Organization, Geneva.
- Das, B.S., Lee, L.S., Rao, P.S.C., and Hultgren, R.P. 2004. Sorption and degradation of steroid hormones in soils during transport: column studies and model evaluation. **Environmental Science and Technology** 38: 1460-1470.
- De las Heras, L.F., Fernández, E.G., Llorens, J.M.N., Perera, J., and Drzyzga, O. 2009. Morphological, physiological, and molecular characterization of a newly isolated steroid-degrading actinomycete, identified as *Rhodococcus ruber* strain Chol-4. **Current Microbiology** 59: 548-553.
- Dean-Ross, D., Moody, J.D., Freeman, J.P., Doerge, D.R., and Cernigia, C.E. 2001. Metabolism of anthracene by a *Rhodococcus* species. **FEMS Microbiology Letter** 204: 205-211.
- Dewhurst, J. and Gordon, R.R. 1984. Fertility following change of sex: a follow-up. **Lancet** 2: 1461-1462.
- Di Gennaro, P., Rescalli, E., Galli, E., Sello, G., and Bestetti, G. 2001. Characterization of *Rhodococcus opacus* R7 a strain able to degrade naphthalene and o-xylene isolated from a polycyclic aromatic hydrocarbon-contaminated soil. **Research in Microbiology** 152: 641-651.
- Dou, J., Liu, X., and Ding, A. 2009. Anaerobic degradation of naphthalene by the mixed bacteria under nitrate reducing conditions. **Journal of Hazardous Materials** 165: 325-331.
- Dou, J., Liu, X., Hu, Z., and Deng, D. 2008. Anaerobic BTEX biodegradation linked to nitrate and sulfate reducing. **Journal of Hazardous Materials** 151: 720-729.
- Druzhinina, A.V., Andryushina, V.A., Stytsenko, T.S., and Voishvillo, N.E. 2008. Conversion of 17 α -methyltestosterone to methandrostenolone by the bacterium *Pimelobacter simplex* VKPM Ac-1632 with the presence of cyclodextrins. **Applied Biochemistry and Microbiology** 44 (6): 580-584.

- European Commission. 1997. European Workshop on the Impact of Endocrine Disrupters on Human Health and the Environment. Environment and Climate Research Programme, DG XII, European Commission **Report No. EUR 17549**.
- Ferner, R.E., and Rawlins, M.D. 1988. Anabolic steroid: the power and the glory? **British Medical Journal** 297: 877-878.
- Fitzpatrick, M.S., Contreras-Sánchez, W. M., Milston, R. H., Hornick, R., Feist, G. W., and Schreck, C. B. 1999. Detection of MT in aquarium water after treatment with MT food. In K. McElwee, D. Burke, M. Niles, and H Eгна (eds). **Pond Dynamics/Aquaculture CRSP Sixteenth Annual Technical Report**, pp. 84-81. Oregon.
- Fitzpatrick, M.S., Contreras-Sánchez, M., and Schreck, C. 2000. Fate of methyltestosterone in the pond environment: detection of MT in soil after treatment with MT food. In K. McElwee, D. Burke, M. Niles, X. Cummings, and H. Eгна H. (eds), **Pond Dynamicx/Aquaculture CRSP Seventeenth Annual Technical Report**, pp. 109-112. Oregon.
- Fitzpatrick, M. S., Pereira, C. B., and Schreck, C. B. 1993. In vitro steroid secretion during early development of mono-sex rainbow trout: sex differences, onset of pituitary control, and effects of dietary steroid treatment. **General Comparative Endocrinology** 91: 199-215.
- Fujii, K., Kikuchi, S., Satomi, M., Ushio-Sata, N., and Morita, N. 2002. Degradation of 17 β -estradiol by a gram-negative bacterium isolated from activated sludge in a sewage treatment plant in Tokyo, Japan. **Applied and Environmental Microbiology** 68(4): 2057-2060.
- Gaido, K.W., Leonard, L.S., Lovell, S., Gould, J.C., Baba, D.R., Portier, C.J., and McDonnell, D.P. 1997. Evaluation of chemicals with endocrine modulating activity in a yeast-based steroid hormone receptor gene transcription assay. **Toxicology and Applied Pharmacology** 143: 205-212.
- Green, B.W., Veverica, K.L., and Fitzpatrick, M.S. 1997. Fry and fingerling production. In: H. Eгна, and C. Boyd (eds), **Dynamics of Pond Aquaculture**, pp. 215-243. Florida: CRC Press.

- Gustavo, J.W., and Luis, O.A. 2003. Sex reversal in Nile Tilapia (*Oreochromis niloticus* Linnaeus) by androgen immersion. **Aquaculture Research** 34: 65-67.
- Haiyan, R., Shulan, J., ud din Ahmad, N., Dao, W., and Chengwu, C. 2007. Degradation characteristics and metabolic pathway of 17 α -ethynylestradiol by *Sphingobacterium* sp. JCR5. **Chemosphere** 66: 340-346.
- Haldane, J.B.S. 1930. **Enzymes**. pp. 28-64. London: Longmans, Green and Co.
- Horinouchi, M., Hayashi, T., and Kudo, T. 2007. Chapter XIII: Testosterone degradation by bacteria. In L.I. Ardis (ed), **Testosterone Research Trends**, pp. 255-257. New York: Nova science publisher.
- Hornung, M.W., Jensen, K.M., Korte, J.J., Kahl, M.D., Durhan, E.J., Denny, J.S., Henry, T.R., and Ankley, G.T. 2004. Mechanistic basis for estrogenic effects in fathead minnow (*Pimephales promelas*) following exposure to the androgen 17 α -methyltestosterone: conversion of 17 α -methyltestosterone to 17 α -methylestradiol. **Aquatic Toxicology** 66: 15-23.
- Hulak, M., Paroulek, M., Simek, P., Kocour, M., Gela, D., Rodina, M., and Linhart, O. 2008. Water polluted by 17 α -methyltestosterone provides successful male sex inversion of common carp (*Cyprinus carpio* L.) from gynogenetic offspring. **Journal of Applied Ichthyology** 24: 707-710.
- Juang, R., and Tsai, S. 2006. Growth kinetics of *Pseudomonas putida* in the biodegradation of single and mixed phenol and sodium salicylate. **Biochemical Engineering Journal** 26: 191-197.
- Kang, I.J., Yokota, H., Oshima, Y., Tsuruda, Y., Shimasaki, Y., and Honjo, T. 2008. The effects of methyltestosterone on the sexual development and reproduction of adult medaka (*Oryzias latipes*). **Aquatic Toxicology** 87: 37-46.
- Kelce, W.R., and Wilson, E.M. 1997. Environmental antiandrogens: developmental effects, molecular mechanisms, and clinical implications. **Journal of Molecular Medicine** 75: 198-207.
- Kemppainen, J.A., Langley, E., Wong, C.I., Bobseine, K., Kelce, W.R., and Wilson, E.M. 1999. Distinguishing androgen receptor agonists and antagonists: distinct mechanisms of activation by medroxyprogesterone acetate and dihydrotestosterone. **Molecular Endocrinology** 13: 440-454.

- Kennedy, M.C. 1992. Anabolic steroid abuse and toxicology. **Australian and New Zealand Journal of Medicine** 22: 374-381.
- Khanal, S.K., Xie, B., Thompson, M.L., Sung, S., Ong, S.K., and van Leeuwen, J.H. 2006. Fate, transport, and biodegradation of natural estrogens in the environment and engineered systems. **Environmental Science and Technology** 40(21): 6537-6546.
- Kim, J.S., Powalla, M., Lang, S., Wagner, F., Lunsdorf, H., and Wray, V. 1990. Microbial glycolipid production under nitrogen limitation and resting cell condition. **Journal of Biotechnology** 13: 257-266.
- Korsgaard, B. 2006. Effects of the model androgen methyltestosterone on vitellin in male and female eelpout *Zoarces viviparus* (L). **Marine Environmental Research** 62: S205-S210.
- Lai, K.M., Johnson, K.L., Scrimshaw, M.D., and Lester, J.N. 2000. Binding of waterborne steroid estrogens to solid phases in river and estuarine systems. **Environmental Science and Technology** 34: 3890-3894.
- Lee, H.B., and Liu, D. 2002. Degradation of 17 β -estradiol and its metabolites by sewage bacteria. **Water, Air and Soil Pollution** 134: 353-368.
- Lee, L.S., Strock, T.J., Sarmah, A.K., and Rao, P.S.C. 2003. Sorption and dissipation of testosterone, estrogens and their primary transformation products in soils and sediment. **Environmental Science and Technology** 37: 4098-4105.
- Leusch, F.D.L., Chapman, H.F., van den Heuvel, M., Tan, B.L.L., Gooneratne, S.R., and Tremblay, L.A. 2006. Bioassay-derived androgenic and estrogenic activity in municipal sewage in Australia and New Zealand. **Ecotoxicology and Environmental Science** 65: 403-411.
- Li, J., Ma, M., and Wang, Z. 2008. A two-hybrid yeast assay to quantify the effects of xenobiotics on retinoid X receptor-mediated gene expression. **Toxicology Letters** 176: 198-206.
- Lobaccaro, J.M., Poujol, N., Terouanne, B., Georget, V., Fabre, S., Lumbroso, S., and Sultan, C. 1999. Transcriptional interferences between normal or mutant androgen receptors and the activator protein 1-dissection of the androgen receptor functional domains. **Endocrinology** 140: 350-357.
- Lewis, R.J. 1997. Hawley's Condensed Chemical Dictionary. **Van Nostrand Reinhold**, p. 750. New York.

- Macintosh, D.J. and Little, D.C. 1995. Nile tilapia (*Oreochromis niloticus*). In N.R. Bromage, and R.J. Roberts, (eds), **Broodstock Management and Egg and Larval Quality**, pp. 277–320. Marry land.
- Maness, S.C., McDonnell, D.P., and Gaido, K.W. 1998. Inhibition of androgen receptor-dependent transcriptional activity by DDT isomers and Methoxychlor in HepG2 human hepatoma cells. **Toxicology and Applied Pharmacology** 151: 135-142.
- Marwah, A., Marwah, P., and Lardy, H. 2005. Development and validation of a high performance liquid Chromatography assay for 17alpha-methyltestosterone in fish feed. **Journal of Chromatography B** 842: 107-115.
- Masanori, S., Hirofumi, Y., Haruki, M., Masanobu, M., Hiroshi, T., and Kunio, K. 2004. Fish full life-cycle testing for androgen methyltestosterone on Medaka (*Oryzias latipes*). **Environmental Toxicology and Chemistry** 23: 774-781.
- Matthiessen, P. 2003. Endocrine disruption in marine fish. **Pure and Applied Chemistry** 75: 2249-2261.
- McKinney, A.R., Suann, C.J., and Stenhouse, A.M. 2007. A stereochemical examination of the equine metabolism of 17 α -methyltestosterone. **Analytica Chimica Acta** 581: 377-387.
- Meng, J.J., Rojas, M., Bacon, W., Stickney, J.T., and Ip, W. 2005. Methods to study protein-protein interactions. **Methods in Molecular Biology** 289: 341-358.
- Meylan, W.M., and Howard, P.H. 1991. Bond Contribution method for estimating Henry's Law Constants. **Environmental Toxicology and Chemistry** 10: 1283-1293.
- Miyamoto, H., Yeh, S., Lardy, H., Messing, E., and Chang, C. 1998. Delta5-androstenediol is a natural hormone with androgenic activity in human prostate cancer cells. **Proceeding of The National Academy of Sciences of The United State of America** 95 (19): 11083-11088.
- Mosbach, E.H., Shefer, S., and Abell, L.L. 1968. Identification of the fecal metabolites of 17 α -methyltestosterone in the dog. **Journal of Lipid Research** 9: 93-97.

- Murad, F., and Haynes, R.C. 1985. Androgens. In G.A. Goodman, L.S. Goodman, T.W. Roll, F. Murad, (eds), **The Pharmacological Basis of Therapeutics 7th Edition**, pp 1440-1458. New York.
- Nakata, S., Hasumi, M., Sato, J., Ogawa, A., and Jamanaka, H. 1997. Prostate cancer associated with long-term intake of patent medicine containing methyltestosterone: a case report. **Hinyokika Kyo** 43(11): 791-793.
- Nelson, N. 1944. A photometric adaptation of the Somogyi method for the determination of glucose. **Journal of Biological Chemistry** 153: 375-380.
- Núñez, F.A.A., and Yalkowsky, S.H. 1997. Correlation between log P and Clog P for some steroid. **Journal of Pharmaceutical Sciences** 86(10): 1187-1189.
- O'Connor, J., and Chapin, R. 2003. Critical evaluation of observed adverse effects of endocrine active substances on reproduction and development, the immune system, and the nervous system. **Pure and Applied Chemistry** 75: 2099-2123.
- Ogura, M., Kurisu, F., and Yagi, O. 2004. Isolation and characterization of estrogen-degrading bacteria isolated from soils. **The 10th International Symposium on Microbial Ecology**, p. 134. Mexico.
- Onda, K., Yang, S.Y., Miya, A., and Tanaka, T. 2002. Evaluation of estrogen-like activity on sewage treatment processes using recombinant yeast. **Water Science and Technology** 46: 367-373.
- O'Neil, M. J., ed. 2001. **The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals**, p.1091. New Jersey: Merck & Co.
- Ong, S.K., and A. R. Bowers. 1990. Steady-state analysis for biological treatment of inhibitory substrates. **ASCE Journal of Environmental Engineering** 116(6):1013-1028.
- Overy, W.L., Dankoff, J.A., Wang, B.K., and Singh, U.D. 1984. Androgens and hepatocellular carcinoma in an athlete. **Annals of Internal Medicine** 100: 158-159.
- Paje, M.L., and Couperwhite, I. 1996. Benzene metabolism via the intradiol cleavage in a *Rhodococcus* sp. **World Journal of Microbiology and Biotechnology** 12: 653-654.

- Peng, F., Liu, Z., Wang, L., and Shao, Z. 2007. An oil-degrading bacterium: *Rhodococcus erythropolis* strain 3C-9 and its biosurfactants. **Journal of Applied Microbiology** 102: 1603-1611.
- Popma, T., and Masser, M. 1999. Tilapia life history and biology. **Southern Regional Aquaculture Center** 283.
- Purdom, C., Hardiman, P., Bye, V., Eno, N., Tyler, C., and Sumpter, J. 1994. Estrogenic effects of effluents from sewage treatment works. **Chemistry and Ecology** 8: 275-285.
- Rajendran, N., Matsuda, O., Rajendarn, R., and Urushigawa, Y. 1996. Comparative description of microbial community structure in surface sediments of eutrophic bays. **Marine Pollution Bulletin** 34: 26-33.
- Raton, F.L. and Lyman, W. J. 1985. Environmental exposure from chemicals., p. 31. Florida: CRC Press.
- Rijk, J.C.W., Bovee, T.F.H., Wang, S., Van Poucke, C., Van Peteghem, C., and Nielen, M.W.F. 2008. Detection of anabolic steroids in dietary supplements: the added value of an androgen yeast bioassay in parallel with a liquid chromatography-tandem mass spectrometry screening method. **Analytica Chimica Acta** 637: 305-314.
- Roberts, J. T., and Essenhig, D. M. 1986. Adenocarcinoma of prostate in 40-year old body builder. **Lancet** 2: 742.
- Rongone, E.L., and Segaloff, A. 1962. Isolation of urinary metabolites of 17 α -methyltestosterone. **The Journal of Biological Chemistry** 237(4): 1066-1067.
- Ross, R.B., and Deutsch, S.I. 1990. Hooked on hormones. **Journal of the American Medical Association** 263: 2048-2049.
- Ryan, A.J. 1981. Anabolic steroids are fool's gold. **Federation Proceedings** 40: 2682-2688.
- Sallam, L.A., El-Abyad, M.S., El-Refai, A.M.H., El-Menofi, H.A., Adham, N.Z. 1995. Bioconversion of 19-Nortestosterone by *Rhodococcus* sp. DSM 92-344. I: Optimization of transformation parameters. **Process Biochemistry** 30: 25-34.
- Schulte-Oehlmann, U., Oetken, M., Bachmann, J., and Oehlmann, J. 2004. Effects of ethyloestradiol and methyltestosterone in prosobranch snails. In K.

- Kümmerer (ed), **Pharmaceuticals in The Environment. Sources, Fate, Effects and Risk**. 2nd Edition, pp. 233-247. Heidelberg: Springer-verlag
- Selzsam B., Grote K., Gericke C., Niemann L., Wittfoht W., and Chahoud I. 2005. Effects of methyltestosterone on reproduction in the Japanese quail (*Coturnix coturnix japonica*). **Environmental Research** 99: 327-334.
- Shi, J.H., Suzuki, Y., Lee, B.D., Nakai, S., and Hosomi, M. 2002. Isolation and characterization of the ethynylestradiol biodegrading microorganisms *Fusarium proliferatum* strain HNS-1. **Water Science and Technology** 45(12): 175-179.
- Shi, J., Fujisawa, S., Nakai, S., and Hosomi, M. 2004. Biodegradation of natural and synthetic estrogens by nitrifying activated sludge and ammonia-oxidizing bacterium *Nitrosomonas europaea*. **Water Research** 38: 2323-2330.
- Shinohara, Y., Isurugi, K., and Hashimoto, T. 2000. Stable isotope dilution analysis of human urinary metabolites of 17 α -methyltestosterone. **Journal of Chromatography B** 741: 271-278.
- Singh, R.K., Kumar, S., Kumar, S., and Kumar, A. 2008. Biodegradation kinetic studies for the removal of p-cresol from wastewater using *Gliomastix indicus* MTCC 3869. **Biochemical Engineering Journal** 40: 293-303.
- Soe, K.L., Soe, M., and Gluud, C. 1992. Liver pathology associated with the use of anabolicandrogenic steroids. **Liver International** 12: 73-79.
- Sohoni, P., and Sumpter, J.P. 1998. Several environmental oestrogens are also anti-androgens. **Journal of Endocrinology** 158: 327-339.
- Song, Y., Deng, S.P., Acosta-Martinez, V., and Katsalirou, E. 2008. Characterization of redox-related soil microbial communities along a river floodplain continuum by fatty acid methyl ester (FAME) and 16S r RNA genes. **Applied Soil Ecology** 40: 499-599.
- Stryer, L. 1996. **Biochemistry**. 4th ed. Heidelberg: Spektrum Akademischer Verlag.
- Sugaya, Y., Yoshiba, T., Kajima, T., and Ishihama, Y. 2002. Development of solubility screening methods in drug discovery. **Journal of The Pharmaceutical Society of Japan** 122(3): 237-246.
- Suzuki, T., Ide, K., Ishida, M., and Shapiro, S. 2001. Classification of environmental estrogens by physicochemical properties using principal component analysis

- and hierarchical cluster analysis. **Journal for Chemical Information and Computer Sciences** 41: 718-726.
- Takahashi, H., Taniguchi, S., and Egami, F. 1956. Nitrate reduction in aerobic bacteria and that in *Escherichia coli* coupled to phosphorylation. **The Journal of Biochemistry** 43(2): 223-233.
- Ternes, T.A., Kreckel, P., and Mueller, J. 1999. Behaviour and occurrence of estrogens in municipal sewage treatment plants-II: Aerobic batch experiments with activated sludge. **The science of The Total Environment** 225: 91-99.
- Thomas, K.V., Hurst, M.R., Matthiessen, P., McHugh, M., Smith, A., and Waldock, M.J. 2002. An assessment of *in vitro* androgenic activity and the identification of environmental androgens in United Kingdom estuaries. **Environmental Toxicology and Chemistry** 21: 1456-1461.
- Urbatzka, R., van Cauwenberge, A., Maggioni, S., Viganò, L., Mandich, A., Benfenati, E., Lutz, I., and Kloas, W. 2007. Androgenic and antiandrogenic activities in water and sediment samples from the river Lambro, Italy, detected by yeast androgen screen and chemical analyses. **Chemosphere** 67: 1080-1087.
- U.S. Environmental Protection Agency. 1997. Special report on environmental endocrine disruption: An effects assessment and analysis. **Report No. EPA/630/R-96/012**, p. 111. Washington D.C.
- Vader, J.S., van Ginkel, C.G., Sperling, F.M.G.M., de Jong, J., de Boer, W., de Graaf, J.S., van der Most, M., and Stokman, P.G.W. 2000. Degradation of ethinyl estradiol by nitrifying activated sludge. **Chemosphere** 41: 1239-1243.
- Van Emmerik, T., Angove, M.J., Johnson, B.B., Wells, J.D., and Fernandes, M.B. 2003. Sorption of 17beta-estradiol onto selected soil minerals. **Journal of Colloid Interface Science** 226: 33-39.
- Vinggaard, A.M., Joergensen, E.C., and Larsen, J.C. 1999. Rapid and sensitive reporter gene assays for detection of antiandrogenic and estrogenic effects of environmental chemicals. **Toxicology and Applied Pharmacology** 155: 150-160.
- Wagner, J.C. 1989. Abuse of drugs used to enhance athletic performance. **American Journal of Hospital Pharmacy** 46: 2059-2067.

- Walter, U., Beyer, M., Klein, J., and Rehm, H.J. 1991. Degradation of pyrene by *Rhodococcus sp.* UW1. **Applied Microbiology and Biotechnology** 34: 671-676.
- Wason, S., Pohlmeier-Esch, G., Pallen, C., Palazzi, X., Espuña, G., Bars, R. 2003. 17 α - methyltestosterone: 28-day oral toxicity study in the rat based on the "Enhanced OECD Test Guideline 407" to detect endocrine effects. **Toxicology** 192: 119-137.
- Wattanodorn, T. 2007. **Biodegradation of 17alpha-Methyltestosterone under Aerobic and Anaerobic Conditions**. Master's thesis. Graduate school, Chulalongkorn university.
- Weber, S., Leuschner, P., Kämpfer, P., Dott, W., and Hollender, J. 2005. Degradation of estradiol and ethinyl estradiol by activated sludge and by a defined mixed culture. **Applied Microbiology and Biotechnology** 67: 106-112.
- Williams, T.M., Kind, A.J., Hyde, W.G., and Hill, D.W. 2000. Characterization of urinary metabolites of testosterone methyltestosterone, mibolerone and boldenone in greyhound dogs. **Journal of Veterinary Pharmacology and Therapeutics** 23: 121-129.
- Xingqing Z., Liuyan, Y., Zhenyang, Y., Naiying, P., Lin, X., Daqiang, Y., and Boqiang, Q. 2008. Characterization of depth-related microbial communities in lake sediment by denaturing gradient gel electrophoresis of amplified 16S rRNA fragments. **Journal of Environmental Science** 20: 224-230.
- Yalkowsky, S. H., and He, Y. 2003. An Extensive Compilation of Aqueous Solubility Data for Organic Compounds Extracted from the AQUASOL dATABASE. **Handbook of Aqueous Solubility Data**, p. 1165. Florida: CRC Press.
- Ying, G.G., and Kookana, R.S. 2003. Degradation of five selected endocrine-disrupting chemicals in seawater and marine sediment. **Environmental Science and Technology** 37: 1256-1260.
- Ying, G.G., Kookana, R.S., and Dillon, P. 2003. Sorption and degradation of selected five endocrine disrupting chemicals in aquifer material. **Water Research** 37: 3785-3791.
- Yoshimoto, T., Nagai, F., Fujimoto, J., Watanabe, K., Mizukoshi, H., Makino, T., Kimura, K., Saino, H., Sawada, H., and Omura, H. 2004. Degradation of

estrogens by *Rhodococcus zopfii* and *Rhodococcus equi* isolated from activated sludge in wastewater treatment plants. **Applied and Environmental Microbiology** 70: 5283-5289.

Yu, C.H., Roh, H., and Chu, K.H. 2007. 17 β -estradiol-degrading bacteria isolated from activated sludge. **Environmental Science and Technology** 41: 486-492.

APPENDICES

APPENDIX A

Table A-1: Glucose concentration in control test and biodegradation test with glucose under aerobic condition

Day	Control test					Positive control test				
	Glucose concentration (mM)					Glucose concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	1.25	0.94	1.09	0.22	0.30	1.07	1.09	1.08	0.01	0.02
3						0.26	0.33	0.29	0.05	0.07
4						0.27	0.43	0.35	0.11	0.15
9						0.23	0.30	0.26	0.04	0.06
11	0.99	0.94	0.97	0.03	0.05	0.65	0.48	0.57	0.12	0.16
13						0.41	0.45	0.43	0.03	0.04
15						0.31	0.56	0.44	0.17	0.24
17						0.36	0.31	0.34	0.03	0.05
19						0.29	0.21	0.25	0.06	0.08
21	0.88	0.77	0.83	0.08	0.11	0.40	0.26	0.33	0.10	0.14

Table A-2: Glucose concentration in control test and biodegradation test with glucose under nitrate reducing condition

Day	Control test					Positive control test				
	Glucose concentration (mM)					Glucose concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	1.16	1.40	1.28	0.17	0.24	1.31	1.21	1.26	0.07	0.10
2						0.35	0.88	0.61	0.38	0.52
8						0.22	0.80	0.51	0.41	0.57
16						0.16	0.78	0.47	0.44	0.61
24	1.26	1.78	1.52	0.37	0.51	0.20	0.41	0.30	0.15	0.20
30						0.12	0.40	0.26	0.20	0.28
34						0.51	0.48	0.50	0.02	0.02
38						0.51	0.57	0.54	0.04	0.06
42	1.10	1.01	1.05	0.06	0.09	0.39	0.66	0.52	0.20	0.27

Table A-3: Glucose concentration in control test and biodegradation test with glucose under iron (III) reducing condition

Day	Control test					Positive control test				
	Glucose concentration (mM)					Glucose concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	1.01	0.91	0.96	0.07	0.10	0.92	1.00	0.96	0.05	0.07
4						0.36	0.27	0.31	0.06	0.09
8						0.20	0.21	0.20	0.01	0.01
16	1.10	1.02	1.06	0.06	0.08	0.54	0.27	0.40	0.19	0.26
20						0.25	0.22	0.24	0.03	0.03
28						0.35	0.18	0.26	0.12	0.16
48						0.17	0.11	0.14	0.04	0.06
55	0.91	1.03	0.97	0.08	0.12	0.40	0.26	0.33	0.10	0.14

Table A-4: Glucose concentration in control test and biodegradation test with glucose under sulfate reducing condition

Day	Control test					Positive control test				
	Glucose concentration (mM)					Glucose concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	1.14	1.70	1.42	0.39	0.54	0.91	0.86	0.89	0.04	0.05
4						0.20	0.18	0.19	0.02	0.03
8						0.25	0.20	0.23	0.04	0.05
12						0.13	0.14	0.14	0.01	0.01
16	0.95	0.78	0.86	0.12	0.16	0.11	0.22	0.17	0.07	0.10
20						0.14	0.12	0.13	0.01	0.01
30						0.17	0.15	0.16	0.02	0.02
32	0.78	1.11	0.94	0.23	0.32	0.10	0.14	0.12	0.03	0.04

Table A-5: Glucose concentration in control test and biodegradation test with glucose under methanogenic condition

Day	Control test					Positive control test				
	Glucose concentration (mM)					Glucose concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	1.18	1.29	1.24	0.07	0.10	1.00	0.88	0.94	0.08	0.12
2						0.10	0.13	0.11	0.02	0.03
4										
8						0.06	0.16	0.11	0.07	0.10
16	0.78	0.85	0.82	0.05	0.06	0.08	0.09	0.08	0.01	0.01
20						0.10	0.15	0.12	0.03	0.04
26	1.05	1.61	1.33	0.39	0.55	0.09	0.05	0.07	0.03	0.04

Table A-6: MT concentration in control test and biodegradation test under aerobic condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	9.58	9.91	9.75	0.23	0.32	10.50	10.44	9.70	10.21	0.45	0.50
2						10.39	10.09	9.07	9.85	0.69	0.78
4	8.26	8.33	8.30	0.05	0.07	7.83	8.04	8.77	8.21	0.49	0.56
6						6.06	4.99	0.27	3.77	3.08	3.49
7						3.93	1.59	1.19	2.24	1.48	1.67
8	8.14	8.28	8.21	0.10	0.14	1.00	0.92	0.56	0.83	0.23	0.27
20	8.22	8.19	8.21	0.02	0.03	0.18	0.37	0.00	0.18	0.19	0.21

Table A-7: MT concentration in control test and biodegradation test under nitrate reducing condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	9.14	9.81	9.48	0.47	0.66	9.96	10.12	10.09	10.06	0.09	0.10
4						10.54	9.96	10.38	10.29	0.30	0.34
8						9.32	9.81	9.23	9.45	0.31	0.35
12	9.08	9.6	9.34	0.37	0.51	9.00	9.49	9.86	9.45	0.43	0.49
20						8.56	9.63	7.48	8.56	1.08	1.22
24						9.28	8.80	8.13	8.74	0.58	0.65
32	8.26	7.38	7.82	0.62	0.86	8.04	8.03	9.30	8.46	0.73	0.83
34						7.50	7.97	9.01	8.16	0.77	0.87
52						8.80	8.30	8.35	8.48	0.28	0.31
59						8.50	7.69	8.54	8.24	0.48	0.54
66	8.66	8.57	8.62	0.06	0.09	6.83	7.60	7.77	7.40	0.50	0.57

Table A-8: MT concentration in control test and biodegradation test under nitrate reducing condition with enrichment of MT under aerobic condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	9.95	11.33	10.64	0.98	1.35	9.38	9.38	9.99	9.58	0.35	0.40
4						8.78	9.57	9.63	9.33	0.47	0.54
10						8.67	9.79	8.96	9.14	0.58	0.66
14						8.23	9.56	9.69	9.16	0.81	0.91
20						8.93	9.15	8.37	8.82	0.40	0.46
24	10.32	9.61	9.97	0.50	0.70	8.38	8.94	9.02	8.78	0.35	0.39
28						8.28	9.69	8.70	8.89	0.72	0.82
34						8.20	9.61	9.57	9.13	0.80	0.91
46	10.14	9.63	9.89	0.36	0.50	8.61	8.63	8.34	8.53	0.16	0.18

Table A-9: MT concentration in control test and biodegradation test under nitrate reducing condition by sludge without enrichment of MT under aerobic condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	11.01	10.38	10.70	0.45	0.62	10.25	9.68	11.17	10.37	0.75	0.85
5						9.08	9.98	8.63	9.23	0.69	0.78
10						8.35	7.50	8.36	8.07	0.49	0.56
14						6.58	7.14	7.56	7.09	0.49	0.56
18						6.39	7.03	7.31	6.91	0.47	0.53
22						5.70	6.35	5.97	6.01	0.33	0.37
26	9.68	9.25	9.47	0.30	0.42	4.75	5.83	6.37	5.65	0.82	0.93
32						3.95	5.02	3.00	3.99	1.01	1.14
36						3.08	3.26	3.50	3.28	0.21	0.24
46	9.06	9.58	9.32	0.37	0.51	2.92	2.86	2.40	2.73	0.28	0.32

Table A-10: MT concentration in control test and biodegradation test under nitrate reducing condition by sludge with firstly enrichment of MT under aerobic condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	8.77	10.05	9.41	0.91	1.25	9.88	9.53	9.64	9.68	0.18	0.20
4						8.21	9.52	11.21	9.65	1.50	1.70
9						8.39	7.83	6.88	7.70	0.76	0.86
14						6.11	5.88	6.91	6.30	0.54	0.61
18						4.93	5.45	4.92	5.10	0.30	0.34
20						2.68	5.01	4.65	4.11	1.25	1.42
24	9.96	9.84	9.90	0.08	0.12	3.94	3.96	4.08	3.99	0.08	0.09
28						4.08	3.88	4.09	4.02	0.12	0.13
46	9.82	9.71	9.77	0.08	0.11	0.37	0.34	0.96	0.56	0.35	0.40

Table A-11: MT concentration in control test and biodegradation test under iron (III) reducing condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	9.74	9.76	9.75	0.01	0.02	10.14	11.45	8.22	9.94	1.62	1.84
4						8.44	9.48	8.94	8.95	0.52	0.59
8						8.91	8.81	8.96	8.89	0.08	0.09
16	8.77	8.75	8.76	0.01	0.02	8.33	7.45	8.55	8.11	0.58	0.66
20						7.32	7.77	7.75	7.61	0.25	0.29
28	8.34	8.53	8.44	0.13	0.19	5.88	7.58	7.52	6.99	0.96	1.09
48						2.76	6.44	7.03	5.41	2.31	2.62
55						2.37	6.92	7.02	5.44	2.66	3.01
62						5.89	6.54	6.67	6.37	0.42	0.47
79	8.3	8.49	8.40	0.13	0.19	5.97	4.62	4.98	5.19	0.70	0.79

Table A-12: MT concentration in control test and biodegradation test under sulfate reducing condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	10.78	10.32	10.55	0.33	0.45	10.11	10.02	9.76	9.96	0.18	0.21
4						10.67	9.72	9.54	9.98	0.61	0.69
8	8.34	9.19	8.77	0.60	0.83	8.14	11.20	6.23	8.52	2.51	2.84
12						4.09	3.19	3.07	3.45	0.56	0.63
16						0.11	0.16	0.10	0.12	0.03	0.04
20	11.06	10.92	10.99	0.10	0.14	0.00	0.18	0.19	0.12	0.11	0.12
24						0.08	0.02	0.09	0.06	0.04	0.04
32	9.12	8.07	8.60	0.74	1.03	0.03	0.12	0.06	0.07	0.05	0.05

Table A-13: MT concentration in control test and biodegradation test under methanogenic condition

Day	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	10.42	8.83	9.63	1.12	1.56	9.99	10.45	10.32	10.25	0.24	0.27
2						10.10	10.42	9.66	10.06	0.38	0.43
4						9.36	11.41	10.55	10.44	1.03	1.16
6						5.68	6.09	5.31	5.69	0.39	0.44
8						0.41	0.47	0.36	0.41	0.06	0.06
10	10.48	9.88	10.18	0.42	0.59	0.06	0.26	0.26	0.19	0.12	0.13
14						0.16	0.23	0.17	0.19	0.04	0.04
20						0.25	0.18	0.16	0.20	0.05	0.05
24	10.33	9.92	10.13	0.29	0.40	0.19	0.18	0.17	0.18	0.01	0.01
46						0.11	0.07	0.08	0.09	0.02	0.02

Table A-14: Nitrate concentration in control test and control test with sterilized sediment under nitrate reducing condition

Day	Control test					Control test with sterilized sediment				
	Nitrate concentration (mM)					Nitrate concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	25.26	23.68	24.47	1.12	1.55	22.84	20.9	21.87	1.37	1.90
8						16.72	15.16	15.94	1.10	1.53
12	22.30	27.74	25.02	3.85	5.33	12.34	13.16	12.75	0.58	0.80
20						11.48	14.62	13.05	2.22	3.08
24						15.22	13.46	14.34	1.24	1.72
32	21.18	21.56	21.37	0.27	0.37					
34						12.04	12.52	12.28	0.34	0.47
52						16.58	16.44	16.51	0.10	0.14
59										
66	20.70	21.00	20.85	0.21	0.29					

A-15: Nitrate and nitrite concentration in biodegradation test under nitrate reducing condition

Day	Biodegradation test											
	Nitrate concentration (mM)						Nitrite concentration (mM)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	19.80	21.40	33.52	24.91	7.50	8.49	0.00	0.00	0.00	0.00	0.00	0.00
8	16.08	14.14	13.42	14.55	1.38	1.56	3.03	3.09	3.08	3.07	0.03	0.04
12	12.16	11.26	14.60	12.67	1.73	1.96	1.90	2.20	3.38	2.49	0.78	0.89
20	8.78	12.40	22.28	14.49	6.99	7.91	0.84	1.03	2.84	1.57	1.10	1.25
24	9.38	12.22	19.84	13.81	5.41	6.12	0.60	1.38	0.34	0.77	0.54	0.61
32	7.40	10.48	17.04	11.64	4.92	5.57	0.62	0.00	2.73	1.12	1.43	1.62
34	30.00	30.18	37.14	32.44	4.07	4.61	0.19	0.26	0.76	0.40	0.31	0.35
52	25.70	31.58	43.66	33.65	9.16	10.36						
59	36.70	30.58	44.36	37.21	6.90	7.81	0.48	0.00	0.00	0.16	0.28	0.31
66	27.54	28.16	32.90	29.53	2.93	3.32	0.04	0.10	0.00	0.05	0.05	0.06

Table A-16: Nitrate concentration in control test under nitrate reducing condition with firstly enrichment of MT under aerobic condition

Day	Control test				
	Nitrate concentration (mM)				
	1	2	Average	SD	95%
0	19.54	19.92	19.73	0.27	0.37
4					
10					
14					
20					
24	19.86	20.04	19.95	0.13	0.18
28					
34					
46	19.44	19.84	19.64	0.28	0.39

Table A-17: Nitrate and nitrite concentration in biodegradation test under nitrate reducing condition with firstly enrichment of MT under aerobic condition

Day	Biodegradation test											
	Nitrate concentration (mM)						Nitrite concentration (mM)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	18.88	20.44	21.54	20.29	1.34	1.51	0.00	0.00	0.00	0.00	0.00	0.00
4	16.12	18.26	17.60	17.33	1.10	1.24	3.03	3.43	2.96	3.14	0.25	0.29
10	11.20	12.94	12.44	12.19	0.90	1.01	1.51	1.34	1.14	1.33	0.19	0.21
14	9.90	12.16	12.22	11.43	1.32	1.50	0.00	0.00	0.68	0.23	0.39	0.44
20	9.92	10.54	9.40	9.95	0.57	0.65	0.00	0.00	0.00	0.00	0.00	0.00
24	10.20	9.48	9.94	9.87	0.36	0.41	0.00	0.00	0.00	0.00	0.00	0.00
28	9.28	10.00	8.76	9.35	0.62	0.70	0.00	0.00	0.00	0.00	0.00	0.00
34	9.06	9.76	9.48	9.43	0.35	0.40	0.00	0.00	0.00	0.00	0.00	0.00
46	7.82	7.44	9.78	8.35	1.26	1.42	0.00	0.00	0.00	0.00	0.00	0.00

Table A-18: Nitrate concentration in biodegradation test by sludge under nitrate reducing condition without enrichment of MT under aerobic condition

Day	Control test				
	Nitrate concentration (mM)				
	1	2	Average	SD	95%
0	21.54	22.88	22.21	0.95	1.31
5					
10					
14					
18					
22					
26	21.16	20.48	20.82	0.48	0.67
32					
36					
46	20.40	20.24	20.32	0.11	0.16

Table A-19: Nitrate and nitrite concentration in biodegradation test by sludge under nitrate reducing condition without enrichment of MT under aerobic condition

Day	Biodegradation test											
	Nitrate concentration (mM)						Nitrite concentration (mM)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	20.94	19.68	22.48	21.03	1.40	1.59	0.00	0.00	0.00	0.00	0.00	0.00
5	19.34	20.46	21.36	20.39	1.01	1.15	0.09	1.09	0.20	0.46	0.55	0.62
10	19.42	19.84	19.40	19.55	0.25	0.28	0.00	0.00	0.00	0.00	0.00	0.00
14	21.26	19.34	20.98	20.53	1.04	1.17	0.00	0.00	0.00	0.00	0.00	0.00
18	20.80	19.00	20.74	20.18	1.02	1.16	0.00	0.41	0.00	0.14	0.24	0.27
22	18.84	19.44	19.74	19.34	0.46	0.52	0.00	0.00	0.00	0.00	0.00	0.00
26	19.50	19.62	18.98	19.37	0.34	0.38	0.00	0.00	0.00	0.00	0.00	0.00
32	21.22	21.38	20.26	20.95	0.61	0.69	0.00	0.00	0.00	0.00	0.00	0.00
36	21.78	20.92	20.78	21.16	0.54	0.61	0.00	0.00	0.00	0.00	0.00	0.00
46	21.68	20.48	20.96	21.04	0.60	0.68	0.00	0.00	0.00	0.00	0.00	0.00

Table A-20: Nitrate concentration in control test by sludge under nitrate reducing condition with firstly enrichment of MT under aerobic condition

Day	Control test				
	Nitrate concentration (mM)				
	1	2	Average	SD	95%
0	20.90	21.28	21.09	0.27	0.37
4					
9					
14					
18					
20					
24	20.42	21.72	21.07	0.92	1.27
28					
46	20.08	21.20	20.64	0.79	1.10

Table A-21: Nitrate and nitrite concentration in biodegradation test by sludge under nitrate reducing condition with firstly enrichment of MT under aerobic condition

Day	Biodegradation test											
	Nitrate concentration (mM)						Nitrite concentration (mM)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	21.08	21.42	22.24	21.58	0.60	0.67	0.00	0.00	0.00	0.00	0.00	0.00
4	20.38	20.84	22.00	21.07	0.83	0.94	0.00	0.71	0.84	0.52	0.45	0.51
9	19.24	19.08	19.76	19.36	0.36	0.40	0.14	0.11	0.03	0.09	0.06	0.06
14	19.26	19.58	18.52	19.12	0.54	0.62	0.11	0.00	0.52	0.21	0.27	0.31
18	23.52	19.50	19.06	20.69	2.46	2.78	0.04	0.36	0.00	0.13	0.20	0.22
20	22.92	19.70	19.20	20.61	2.02	2.28	0.04	0.04	0.00	0.03	0.02	0.03
24	20.34	19.94	19.78	20.02	0.29	0.33	0.06	1.72	1.89	1.22	1.01	1.14
28	19.84	19.16	19.52	19.51	0.34	0.38	0.00	0.00	0.06	0.02	0.03	0.04
46	18.72	19.24	18.16	18.71	0.54	0.61	0.00	0.09	0.00	0.03	0.05	0.06

Table A-22: Iron (III) concentration in control test and control test with sterilized sediment under iron (III) reducing condition

Day	Control test					Control test with sterilized sediment				
	Iron (III) concentration (mM)					Iron (III) concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	22.64	20.26	21.45	1.68	2.33	22.95	21.67	22.31	0.91	1.26
4						22.10	20.28	21.19	1.29	1.79
8						17.05	20.59	18.82	2.50	3.47
16	21.74	16.08	18.91	4.00	5.55	16.55	18.28	17.41	1.23	1.70
20										
28	23.45	22.82	23.14	0.44	0.62	20.24	18.61	19.43	1.16	1.60
48						18.03	15.06	16.54	2.10	2.91
55						14.71	12.36	13.54	1.66	2.31
62										
79	20.40	16.63	18.51	2.67	3.69					

Table A-23: Iron (III) concentration in biodegradation test sediment under iron (III) reducing condition

Day	Biodegradation test					
	Iron (III) concentration (mM)					
	1	2	3	Average	SD	95%
0	20.22	21.86	25.24	22.44	2.56	2.90
4	17.12	21.68	21.72	20.17	2.64	2.99
8	14.46	13.92	24.03	17.47	5.69	6.44
16	20.34	15.35	15.10	16.93	2.96	3.35
20	10.66	20.89	22.08	17.88	6.28	7.10
28	16.83	24.69	13.79	18.44	5.63	6.37
48	18.15	17.13	19.92	18.40	1.42	1.60
55	15.55	13.29	17.51	15.45	2.11	2.39
62	12.50	10.03	17.02	13.18	3.54	4.01
79	14.57	13.21	15.18	14.32	1.01	1.14

Table A-24: Sulfate concentration in control test and control test with sterilized sediment under sulfate reducing condition

Day	Control test					Control test with sterilized sediment				
	Sulfate concentration (mM)					Sulfate concentration (mM)				
	1	2	Average	SD	95%	1	2	Average	SD	95%
0	22.48	25.12	23.8	1.87	2.59	20.02	21.84	20.93	1.29	1.78
4										
8	22.04	22.68	22.36	0.45	0.63	20.8	21.46	21.13	0.47	0.65
12										
16										
20	22.74	23.4	23.07	0.47	0.65	15.82	15.56	15.69	0.18	0.25
24										
32	22.6	23.22	22.91	0.44	0.61	16.62	16.90	16.76	0.20	0.27

Table A-25: Sulfate concentration in biodegradation test under sulfate reducing condition

Day	Biodegradation test					
	Sulfate concentration (mM)					
	1	2	3	Average	SD	95%
0	16.94	17.28	33.90	22.71	9.70	10.97
4	16.80	18.62	19.16	18.19	1.24	1.40
8	12.38	18.64	16.94	15.99	3.24	3.66
12	18.14	17.60	18.16	17.97	0.32	0.36
16	15.72	17.38	17.68	16.93	1.06	1.19
20	17.56	17.22	18.04	17.61	0.41	0.47
24	14.68	17.92	17.76	16.79	1.83	2.07
32	18.14	17.90	13.90	16.65	2.38	2.70

Table A-26: Methane production during biodegradation under methanogenic condition

Day	Methane production					
	Concentration (mM)					
	1	2	3	Average	SD	95%
0	0.03	0.01	0.01	0.02	0.01	0.01
2	0.01	0.01	0.04	0.02	0.01	0.02
4	0.03	0.03	0.03	0.03	0.00	0.00
6	0.03	0.03	0.05	0.04	0.01	0.01
8	0.06	0.08	0.09	0.08	0.02	0.02
10	0.21	0.26	0.27	0.25	0.03	0.03
14	0.28	0.30	0.32	0.30	0.02	0.02
20	0.28	0.25	0.30	0.28	0.03	0.03
24	0.33	0.29	0.32	0.31	0.02	0.02
46	0.00	0.00	0.00			

Table A-27: TEQ and relative TEQ in biodegradation test under aerobic condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.77	9.71	9.02	9.50	0.41	0.47	10.66	8.69	9.47	9.61	0.99	1.12
2	9.66	9.38	8.44	9.16	0.64	0.73						
4	7.28	7.48	8.16	7.64	0.46	0.52						
6	5.64	4.64	0.25	3.51	2.87	3.24						
7	3.65	1.48	1.11	2.08	1.38	1.56	5.27	5.80	4.31	5.13	0.75	0.85
8	0.93	0.86	0.52	0.77	0.22	0.25						
20	0.17	0.34	0.00	0.17	0.17	0.19	nd	nd	nd	0.00	0.00	0.00

Table A-28: TEQ and relative TEQ in biodegradation test under nitrate reducing condition

day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/l)						TEQ (mg/l)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.26	9.41	9.38	9.35	0.08	0.09	10.11	11.62	7.75	9.83	1.95	2.21
4	9.80	9.26	9.65	9.57	0.28	0.32						
8	8.67	9.12	8.58	8.79	0.29	0.33						
12	8.37	8.83	9.17	8.79	0.40	0.45						
20	7.96	8.96	6.96	7.96	1.00	1.13						
24	8.63	8.18	7.56	8.13	0.54	0.61						
32	7.48	7.47	8.65	7.86	0.68	0.77	8.63	11.67	5.27	8.52	3.20	3.63
34	6.98	7.41	8.38	7.59	0.72	0.81						
52	8.18	7.72	7.77	7.89	0.26	0.29						
59	7.91	7.15	7.94	7.67	0.45	0.50						
66	6.35	7.07	7.23	6.88	0.47	0.53	3.70	9.17	8.06	6.97	2.89	3.27

Table A-29: TEQ and relative TEQ in biodegradation test under nitrate reducing condition with firstly enrichment of MT under aerobic condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	8.72	8.72	9.29	8.91	0.33	0.37	8.71	9.63	7.15	8.50	1.25	1.42
4	8.17	8.90	8.96	8.67	0.44	0.50						
10	8.06	9.10	8.33	8.50	0.54	0.61						
14	7.65	8.89	9.01	8.52	0.75	0.85						
20	8.30	8.51	7.78	8.20	0.37	0.42						
24	7.79	8.31	8.39	8.17	0.32	0.37	9.76	11.05	6.31	9.04	2.45	2.77
28	7.70	9.01	8.09	8.27	0.67	0.76						
34	7.63	8.94	8.90	8.49	0.75	0.84						
46	8.01	8.03	7.76	7.93	0.15	0.17	10.59	4.93	10.03	8.52	3.12	3.53

Table A-30: TEQ and relative TEQ in biodegradation test by sludge under nitrate reducing condition without firstly enrichment of MT under aerobic condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.53	9.00	10.39	9.64	0.70	0.79	13.77	6.32	13.23	11.11	4.16	4.70
5	8.44	9.28	8.03	8.58	0.64	0.72						
10	7.77	6.98	7.77	7.51	0.46	0.52						
14	6.12	6.64	7.03	6.60	0.46	0.52						
18	5.94	6.54	6.80	6.43	0.44	0.50	4.48	5.68	15.32	8.49	5.94	6.72
22	5.30	5.91	5.55	5.59	0.30	0.34						
26	4.42	5.42	5.92	5.25	0.77	0.87						
32	3.67	4.67	2.79	3.71	0.94	1.06						
36	2.86	3.03	3.26	3.05	0.20	0.22						
46	2.72	2.66	2.23	2.54	0.26	0.30	3.63	4.04	4.45	4.04	0.41	0.47

Table A-31: TEQ and relative TEQ in biodegradation test by sludge under nitrate reducing condition with firstly enrichment of MT under aerobic condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.19	8.86	8.97	9.01	0.17	0.19	7.09	11.47	9.63	9.40	2.20	2.49
4	7.64	8.85	10.43	8.97	1.40	1.58						
9	7.80	7.28	6.40	7.16	0.71	0.80						
14	5.68	5.47	6.43	5.86	0.50	0.57	2.53	2.40	4.01	2.98	0.89	1.01
18	4.58	5.07	4.58	4.74	0.28	0.32						
20	2.49	4.66	4.32	3.83	1.17	1.32						
24	3.66	3.68	3.79	3.71	0.07	0.08						
28	3.79	3.61	3.80	3.74	0.11	0.12						
46	0.34	0.32	0.89	0.52	0.33	0.37	1.51	1.89	2.56	1.99	0.53	0.60

Table A-32: TEQ and relative TEQ in biodegradation test under iron (III) reducing condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						MT concentration (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.43	10.65	7.64	9.24	1.51	1.71	5.03	9.56	9.57	8.06	2.62	2.96
4	7.85	8.82	8.31	8.33	0.48	0.55						
8	8.29	8.19	8.33	8.27	0.07	0.08						
16	7.75	6.93	7.95	7.54	0.54	0.61						
20	6.81	7.23	7.21	7.08	0.24	0.27	4.31	11.39	4.60	6.77	4.01	4.53
28	5.47	7.05	6.99	6.50	0.90	1.02						
48	2.57	5.99	6.54	5.03	2.15	2.44						
55	2.20	6.44	6.53	5.06	2.47	2.80						
62	5.48	6.08	6.20	5.92	0.39	0.44						
79	5.55	4.30	4.63	4.83	0.65	0.74	6.84	11.94	3.91	7.56	4.07	4.60

Table A-33: TEQ and relative TEQ in biodegradation test under sulfate reducing condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.40	9.32	9.08	9.27	0.17	0.19	13.84	7.77	6.47	9.36	3.93	4.45
4	9.92	9.04	8.87	9.28	0.56	0.64						
8	7.57	10.42	5.79	7.93	2.33	2.64						
12	3.80	2.97	2.86	3.21	0.52	0.59	4.76	4.29	4.76	4.60	0.27	0.31
16	0.10	0.15	0.09	0.11	0.03	0.03						
20	0.00	0.17	0.18	0.11	0.10	0.11						
24	0.07	0.02	0.08	0.06	0.04	0.04						
32	0.03	0.11	0.06	0.07	0.04	0.05	nd	nd	nd	0.00	0.00	0.00

Table A-34: TEQ and relative TEQ in biodegradation test under methanogenic condition

Day	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	9.29	9.72	9.60	9.54	0.22	0.25	6.77	11.24	11.90	9.97	2.79	3.16
2	9.39	9.69	8.98	9.36	0.35	0.40						
4	8.70	10.61	9.81	9.71	0.96	1.08						
6	5.28	5.66	4.94	5.29	0.36	0.41	16.57	11.63	13.62	13.94	2.48	2.81
8	0.38	0.44	0.33	0.38	0.05	0.06						
10	0.06	0.24	0.24	0.18	0.11	0.12						
14	0.15	0.21	0.16	0.17	0.04	0.04						
20	0.23	0.17	0.15	0.18	0.04	0.05						
24	0.18	0.17	0.16	0.17	0.01	0.01	5.34	3.45	10.49	6.43	3.64	4.12
46	0.10	0.07	0.07	0.08	0.02	0.02	6.12	3.70	6.01	5.27	1.37	1.55

APPENDIX B

Table B-1 Percentage of biodegradation by MT-degrading bacteria isolated from sediment in 3-day bioassays

Source	Colony type	MT concentration (mg/L)	% Biodegradation				
			01	02	03	04	05
Sediment (S)	A	001	0	0	4	na	na
	B		97	97	97	100	99
	C		5	5	8	na	na
	D		6	5	6	na	na
	E		1	1	1	na	na
	A	010	23	0	3	0	0
	B		54	78	98	42	76
	A	100	0	0	3	0	0
	B		73	82	46	35	88

na = not analysis

Table B-2 Percentage of biodegradation by MT-degrading bacteria isolated from water in 3-day bioassays

Source	Colony type	MT concentration (mg/l)	% Biodegradation				
			01	02	03	04	05
Water (W)	A	001	0	4	3	na	na
	B		94	99	99	98	98
	C		3	5	7	na	na
	D		14	5	7	na	na
	A	010	0	0	0	0	19
	B		77	67	81	100	72
	A	100	0	0	20	5	0
	B		45	40	75	75	14

na = not analysis

APPENDIX C

Table C-1: Biodegradation of MT by MT-degrading bacteria strain SB010-03 at initial MT concentration of 0.5 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	0.51	0.52	0.52	0.01	0.01	0.50	0.50	0.48	0.49	0.01	0.01
2						0.28	0.30	0.29	0.29	0.01	0.01
4	0.50	0.46	0.48	0.03	0.04	0.18	0.21	0.17	0.19	0.02	0.02
6						0.02	0.02	0.02	0.02	0.00	0.00
12						0.00	0.03	0.02	0.02	0.02	0.02
18	0.51	0.43	0.47	0.06	0.08	0.00	0.00	0.00	0.00	0.00	0.00

Table C-2: Amount of cells of MT-degrading bacterium strain SB010-03 at initial MT concentration of 0.5 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.10E+06	4.00E+05	9.00E+05	1.55E+06	1.25E+06	1.00E+06	1.03E+06	3.84E+05	3.07E+05
2	2.40E+06	8.00E+05	1.05E+06	9.50E+05	1.55E+06	1.25E+06	1.33E+06	5.84E+05	4.67E+05
4	5.50E+05	5.50E+05	9.00E+05	1.15E+06	1.15E+06	7.00E+05	8.33E+05	2.77E+05	2.22E+05
6	1.80E+06	1.30E+06	1.10E+06	5.50E+05	1.15E+06	1.45E+06	1.23E+06	4.16E+05	3.33E+05
12	1.30E+06	1.10E+06	1.05E+06	9.50E+05	1.30E+06	1.45E+06	1.19E+06	1.88E+05	1.51E+05
18	1.60E+06	9.50E+05	1.05E+06	1.40E+06	8.50E+05	5.00E+05	1.06E+06	3.94E+05	3.15E+05

Table C-3: Biodegradation of MT by MT-degrading bacteria strain SB010-03 at initial MT concentration of 1.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	1.00	1.04	1.02	0.03	0.04	0.98	1.05	1.13	1.05	0.08	0.08
2						0.74	0.71	0.69	0.71	0.03	0.03
4						0.52	0.52	0.48	0.51	0.02	0.03
6						0.43	0.44	0.59	0.49	0.09	0.10
12	1.01	1.02	1.02	0.01	0.01	0.18	0.02	0.03	0.08	0.09	0.10
18						0.10	0.00	0.00	0.03	0.06	0.07
26	0.95	0.93	0.94	0.01	0.02	0.00	0.00	0.15	0.05	0.09	0.10

Table C-4: Amount of cells of MT-degrading bacterium strain SB010-03 at initial MT concentration of 1.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.45E+06	1.45E+06	1.15E+06	7.00E+05	8.50E+05	8.50E+05	1.08E+06	3.25E+05	2.60E+05
2	1.20E+06	1.05E+06	1.25E+06	1.15E+06	7.50E+05	7.00E+05	1.02E+06	2.36E+05	1.89E+05
4	8.00E+05	1.55E+06	5.50E+05	6.50E+05	9.00E+05	7.00E+05	8.58E+05	3.60E+05	2.88E+05
6	1.20E+06	1.40E+06	7.00E+05	1.50E+06	1.00E+06	9.00E+05	1.12E+06	3.06E+05	2.45E+05
12	1.20E+06	9.00E+05	1.45E+06	7.50E+05	8.50E+05	8.00E+05	9.92E+05	2.75E+05	2.20E+05
18	4.50E+05	5.00E+05	1.30E+06	1.40E+06	1.50E+06	1.15E+06	1.05E+06	4.60E+05	3.68E+05
26	1.50E+06	1.40E+06	1.20E+06	9.00E+05	2.15E+06	6.50E+05	1.30E+06	5.22E+05	4.18E+05

Table C-5: Biodegradation of MT by MT-degrading bacteria strain SB010-03 at initial MT concentration of 5.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	4.98	5.18	5.08	0.14	0.20	5.26	5.14	5.23	5.21	0.06	0.07
4						2.15	2.42	2.36	2.31	0.14	0.16
8						0.31	0.41	0.43	0.38	0.06	0.07
12.5						0.09	0.04	0.04	0.06	0.03	0.03
16						0.40	2.06	0.03	0.22	1.08	1.22
24	4.50	4.80	4.65	0.21	0.29	1.47	1.99	0.01	1.16	1.03	1.16
34						0.09	1.57	2.42	0.83	1.18	1.33
42						0.03	0.03	0.15	0.07	0.07	0.08
90	5.02	5.03	5.03	0.01	0.01	0.05	0.24	0.16	0.15	0.10	0.11

Table C-6: Amount of cells of MT-degrading bacterium strain SB010-03 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.45E+06	1.70E+06	1.15E+06	1.05E+06	1.10E+06	1.30E+06	1.29E+06	2.48E+05	1.98E+05
4	1.65E+06	1.75E+06	1.30E+06	1.05E+06	1.00E+06	1.55E+06	1.38E+06	3.16E+05	2.53E+05
8	1.30E+06	1.10E+06	1.55E+06	1.05E+06	2.30E+06	1.20E+06	1.42E+06	4.68E+05	3.74E+05
12.5	2.00E+06	1.30E+06	9.50E+05	1.65E+06	1.60E+06	1.65E+06	1.53E+06	3.59E+05	2.87E+05
16	1.80E+06	9.00E+05	8.50E+05	2.05E+06	1.65E+06	1.45E+06	1.45E+06	4.87E+05	3.90E+05
24	2.40E+06	1.75E+06	1.40E+06	1.90E+06	2.00E+06	1.80E+06	1.88E+06	3.28E+05	2.63E+05
34	1.60E+06	2.55E+06	1.65E+06	2.85E+06	9.00E+05	2.10E+06	1.94E+06	7.08E+05	5.67E+05
42	2.00E+06	2.20E+06	1.15E+06	2.25E+06	1.35E+06	2.10E+06	1.84E+06	4.71E+05	3.77E+05
90	1.66E+06	2.55E+06	2.05E+06	2.05E+06	1.55E+06	1.75E+06	1.95E+06	3.45E+05	2.76E+05

Table C-7: TEQ and relative TEQ in biodegradation test by MT-degrading bacterium strain SB010-03 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	4.89	4.78	4.86	4.85	0.06	0.07	4.38	5.46	5.35	5.06	0.59	0.67
4	2.00	2.25	2.19	2.15	0.13	0.15	3.64	2.11	3.27	3.01	0.80	0.90
8	0.29	0.38	0.40	0.36	0.06	0.07	1.00	3.17	2.36	2.17	1.10	1.24
12.5	0.08	0.04	0.04	0.05	0.03	0.03						
16	0.37	1.92	0.03	0.77	1.01	1.14						
24	1.37	1.85	0.01	1.08	0.95	1.08						
34	0.08	1.46	2.25	1.26	1.10	1.24						
42	0.03	0.03	0.14	0.07	0.06	0.07						
90	0.05	0.22	0.15	0.14	0.09	0.10	nd	nd	nd	nd	0.00	0.00

Table C-8: Biodegradation of MT by MT-degrading bacteria strain SB010-03 at initial MT concentration of 10.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	10.88	10.63	10.76	0.18	0.24	10.75	9.76	13.14	11.22	1.74	1.97
4						7.73	7.33	7.95	7.67	0.31	0.36
8						4.84	4.01	6.38	5.08	1.20	1.36
12.5						0.63	1.11	1.38	1.04	0.38	0.43
16						0.41	0.79	0.87	0.69	0.25	0.28
24	10.24	10.10	10.17	0.10	0.14	0.40	0.22	0.00	0.21	0.20	0.23
34						7.58	0.23	0.10	2.64	4.28	4.84
42						0.12	0.15	4.70	1.66	2.64	2.98
90	10.36	10.30	10.33	0.04	0.06	0.24	0.03	0.09	0.12	0.11	0.12

Table C-9: Amount of cells of MT-degrading bacterium strain SB010-03 at initial MT concentration of 10.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.65E+06	1.40E+06	1.30E+06	1.05E+06	1.10E+06	1.05E+06	1.26E+06	2.40E+05	1.92E+05
4	7.50E+05	8.00E+05	1.50E+06	1.25E+06	1.20E+06	1.00E+06	1.08E+06	2.88E+05	2.30E+05
8	1.30E+06	8.00E+05	1.10E+06	1.00E+06	1.45E+06	7.00E+05	1.06E+06	2.87E+05	2.30E+05
12.5	1.10E+06	1.55E+06	2.15E+06	1.65E+06	1.35E+06	2.15E+06	1.66E+06	4.25E+05	3.40E+05
16	1.25E+06	1.75E+06	1.60E+06	1.75E+06	1.70E+06	1.35E+06	1.57E+06	2.16E+05	1.73E+05
24	1.65E+06	1.80E+06	3.65E+06	2.65E+06	1.05E+06	1.30E+06	2.02E+06	9.69E+05	7.76E+05
34	1.65E+06	1.40E+06	1.15E+06	8.00E+05	2.10E+06	2.35E+06	1.58E+06	5.82E+05	4.66E+05
42	3.55E+06	1.75E+06	2.55E+06	1.15E+06	1.35E+06	1.50E+06	1.98E+06	9.12E+05	7.30E+05
90	9.50E+05	9.00E+05	3.05E+06	1.40E+06	9.50E+05	1.50E+06	1.46E+06	8.21E+05	6.57E+05

Table C-10: Biodegradation of MT by MT-degrading bacteria strain SB010-03 at initial MT concentration of 50.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	48.98	44.96	46.97	2.84	3.94	50.00	52.47	49.77	50.75	1.50	1.69
12						30.89	32.38	30.79	31.35	0.89	1.01
24						8.91	11.31	10.50	10.24	1.22	1.38
36						2.01	2.82	2.24	2.36	0.42	0.47
48						5.63	1.92	2.40	3.32	2.02	2.28
60						0.06	0.01	0.05	0.04	0.03	0.03
109	45.42	47.47	46.45	1.45	2.01	2.19	5.49	0.07	2.58	2.73	3.09
186						1.81	1.74	2.48	2.01	0.41	0.46
236	49.15	46.24	47.70	2.06	2.85	1.01	1.75	2.58	1.78	0.79	0.89

Table C-11: Amount of cells of MT-degrading bacterium strain SB010-03 at initial MT concentration of 50.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.25E+06	1.15E+06	1.30E+06	8.00E+05	1.25E+06	1.45E+06	1.20E+06	2.19E+05	1.75E+05
12	7.00E+05	1.25E+06	1.50E+06	1.25E+06	1.40E+06	1.05E+06	1.19E+06	2.85E+05	2.28E+05
24	1.50E+06	2.05E+06	4.95E+06	1.31E+07	4.60E+06	4.55E+06	5.12E+06	4.15E+06	3.32E+06
36	4.80E+06	2.40E+06	4.80E+06	2.20E+06	2.40E+06	2.20E+06	3.13E+06	1.29E+06	1.04E+06
48	1.16E+07	1.44E+07	1.86E+07	1.80E+07	1.76E+07	1.24E+07	1.54E+07	3.04E+06	2.43E+06
60	9.55E+06	7.05E+06	4.00E+06	7.45E+06	1.60E+07	1.16E+07	9.27E+06	4.16E+06	3.33E+06
109	1.72E+07	1.44E+07	1.10E+07	7.60E+06	5.60E+06	8.80E+06	1.08E+07	4.36E+06	3.49E+06
186	5.20E+06	4.40E+06	2.60E+06	2.80E+06	4.00E+06	4.40E+06	3.90E+06	1.01E+06	8.08E+05
236	4.20E+06	7.00E+06	7.60E+06	5.40E+06	5.00E+06	5.60E+06	5.80E+06	1.27E+06	1.02E+06

Table C-12: TEQ and relative TEQ in biodegradation test by MT-degrading bacterium strain SB010-03 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	46.50	48.80	46.29	47.19	1.39	1.58	56.60	78.75	41.51	58.95	18.73	21.19
12	28.73	30.11	28.63	29.16	0.83	0.94						
24	8.29	10.52	9.77	9.52	1.14	1.28	37.60	15.67	6.11	19.79	16.15	18.27
36	1.87	2.62	2.08	2.19	0.39	0.44						
48	5.24	1.79	2.23	3.08	1.88	2.12						
60	0.06	0.01	0.05	0.04	0.02	0.03						
109	2.04	5.11	0.07	2.40	2.54	2.87						
186	1.68	1.62	2.31	1.87	0.38	0.43						
236	0.94	1.63	2.40	1.66	0.73	0.83	1.49	1.46	1.36	1.44	0.07	0.08

Table C-13: Biodegradation of MT by MT-degrading bacteria strain SB010-03 at initial MT concentration of 100.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	105.53	99.26	102.40	4.43	6.14	98.98	105.37	105.83	103.39	3.83	4.33
12						65.64	72.82	86.07	74.84	10.36	11.73
24						58.85	48.80	55.41	54.35	5.11	5.78
36						32.40	41.08	38.93	37.47	4.52	5.12
48						21.94	38.78	32.21	30.98	8.49	9.60
60						9.68	11.89	7.25	9.61	2.32	2.63
109	100.2	107.43	103.82	5.11	7.09	1.97	22.44	3.84	9.42	11.32	12.81
186						1.35	3.60	1.33	2.09	1.30	1.48
236	98.71	115.00	106.86	11.52	15.96	2.32	1.68	6.40	3.47	2.56	2.90

Table C-14: Amount of cells of MT-degrading bacterium strain SB010-03 at initial MT concentration of 100.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.00E+06	1.00E+06	1.20E+06	1.20E+06	1.20E+06	6.00E+05	1.03E+06	2.34E+05	1.87E+05
12	8.00E+05	1.40E+06	1.00E+06	1.40E+06	1.00E+06	1.40E+06	1.17E+06	2.66E+05	2.13E+05
24	1.20E+06	8.00E+05	2.00E+06	8.00E+05	1.40E+06	1.20E+06	1.23E+06	4.46E+05	3.57E+05
36	4.00E+06	5.20E+06	3.20E+06	3.60E+06	7.00E+06	2.40E+06	4.23E+06	1.64E+06	1.31E+06
48	4.40E+06	3.80E+06	3.00E+06	1.80E+06	2.60E+06	2.40E+06	3.00E+06	9.55E+05	7.64E+05
60	3.20E+06	1.12E+07	1.38E+07	1.68E+07	7.80E+06	8.40E+06	1.02E+07	4.81E+06	3.85E+06
109	1.38E+07	6.40E+06	8.60E+06	1.48E+07	1.20E+07	1.06E+07	1.10E+07	3.17E+06	2.54E+06
186	2.16E+07	2.24E+07	1.66E+07	1.24E+07	1.00E+07	1.68E+07	1.66E+07	4.90E+06	3.92E+06
236	1.88E+07	3.08E+07	2.30E+07	1.60E+07	1.86E+07	2.20E+07	2.15E+07	5.19E+06	4.16E+06

APPENDIX D

Table D-1: Biodegradation of MT by MT-degrading bacteria strain SB100-05 at initial MT concentration of 0.5 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	0.54	0.60	0.57	0.04	0.06	0.52	0.54	0.44	0.50	0.05	0.06
1						0.33	0.38	0.34	0.35	0.03	0.03
3						0.18	0.17	0.20	0.18	0.02	0.02
5						0.00	0.06	0.10	0.05	0.05	0.06
7						0.00	0.00	0.00	0.00	0.00	0.00
9						0.00	0.00	0.00	0.00	0.00	0.00
15	0.64	0.58	0.61	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00
27	0.50	0.55	0.53	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00

Table D-2: Amount of cells of MT-degrading bacterium strain SB100-05 at initial MT concentration of 0.5 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	9.00E+05	1.00E+06	1.10E+06	9.50E+05	1.10E+06	9.50E+05	1.00E+06	8.37E+04	6.69E+04
1	8.50E+05	1.30E+06	2.05E+06	1.00E+06	1.10E+06	8.00E+05	1.18E+06	4.61E+05	3.69E+05
3	7.50E+05	9.00E+05	1.05E+06	1.45E+06	1.70E+06	1.40E+06	1.21E+06	3.65E+05	2.92E+05
5	1.35E+06	8.50E+05	1.60E+06	1.70E+06	1.70E+06	2.10E+06	1.55E+06	4.20E+05	3.36E+05
7	1.20E+06	8.00E+05	2.15E+06	2.40E+06	1.80E+06	1.70E+06	1.68E+06	5.93E+05	4.75E+05
9	1.60E+06	4.50E+05	1.70E+06	2.05E+06	1.50E+06	1.35E+06	1.44E+06	5.40E+05	4.32E+05
15	8.00E+05	1.40E+06	2.55E+06	1.70E+06	2.40E+06	1.60E+06	1.74E+06	6.50E+05	5.20E+05
27	1.35E+06	9.00E+05	2.35E+06	2.65E+06	1.70E+06	1.70E+06	1.78E+06	6.41E+05	5.13E+05

Table D-3: Biodegradation of MT by MT-degrading bacteria strain SB100-05 at initial MT concentration of 1.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	1.02	1.14	1.08	0.08	0.12	1.02	0.97	0.90	0.96	0.06	0.07
1						0.94	0.96	0.73	0.88	0.13	0.14
3						0.48	0.52	0.46	0.49	0.03	0.03
5						0.29	0.17	0.20	0.22	0.06	0.07
7						0.06	0.05	0.00	0.04	0.03	0.04
9						0.10	0.00	0.00	0.03	0.06	0.07
15	1.00	1.08	1.04	0.06	0.08	0.08	0.00	0.00	0.03	0.05	0.05
27	1.16	1.08	1.12	0.06	0.08	0.06	0.00	0.00	0.02	0.03	0.04

Table D-4: Amount of cells of MT-degrading bacterium strain SB100-05 at initial MT concentration of 1.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	9.00E+05	1.00E+06	1.00E+06	1.15E+06	8.50E+05	1.15E+06	1.01E+06	1.24E+05	9.93E+04
1	1.25E+06	8.50E+05	1.55E+06	1.45E+06	1.25E+06	1.70E+06	1.34E+06	2.97E+05	2.38E+05
3	1.10E+06	1.35E+06	1.40E+06	1.80E+06	1.70E+06	1.75E+06	1.52E+06	2.77E+05	2.22E+05
5	1.05E+06	6.50E+05	1.40E+06	1.45E+06	1.40E+06	1.65E+06	1.27E+06	3.59E+05	2.87E+05
7	9.00E+05	1.00E+06	1.45E+06	1.95E+06	1.55E+06	1.55E+06	1.40E+06	3.90E+05	3.12E+05
9	1.05E+06	1.15E+06	1.70E+06	2.20E+06	1.90E+06	1.55E+06	1.59E+06	4.40E+05	3.52E+05
15	1.15E+06	8.50E+05	1.45E+06	1.90E+06	1.40E+06	1.65E+06	1.40E+06	3.69E+05	2.95E+05
27	1.40E+06	9.00E+05	1.85E+06	1.90E+06	2.30E+06	2.30E+06	1.78E+06	5.44E+05	4.35E+05

Table D-5: Biodegradation of MT by MT-degrading bacteria strain SB100-05 at initial MT concentration of 5.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	5.04	4.86	4.95	0.13	0.18	4.90	4.94	4.96	4.93	0.03	0.04
1						4.49	3.84	3.58	3.97	0.47	0.53
5						1.92	1.62	1.75	1.76	0.15	0.17
9						0.27	0.46	0.42	0.38	0.10	0.11
10						0.54	0.15	0.38	0.36	0.20	0.22
13						0.50	0.44	0.61	0.52	0.08	0.09
23	4.64	4.69	4.67	0.04	0.05	0.49	0.50	0.47	0.49	0.02	0.02
147	4.80	4.94	4.87	0.10	0.14	0.30	0.13	0.11	0.18	0.10	0.12

Table D-6: Amount of cells of MT-degrading bacterium strain SB100-05 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	9.00E+05	1.00E+06	1.10E+06	9.50E+05	1.00E+06	1.15E+06	1.02E+06	9.31E+04	7.45E+04
1	1.50E+06	9.50E+05	1.55E+06	1.25E+06	1.10E+06	1.20E+06	1.26E+06	2.31E+05	1.85E+05
5	2.65E+06	1.75E+06	1.40E+06	1.80E+06	2.00E+06	2.05E+06	1.94E+06	4.16E+05	3.33E+05
9	3.60E+06	1.75E+06	2.60E+06	3.15E+06	2.45E+06	2.80E+06	2.73E+06	6.31E+05	5.05E+05
10	3.20E+06	3.05E+06	2.05E+06	2.85E+06	3.35E+06	2.35E+06	2.81E+06	5.08E+05	4.07E+05
13	2.85E+06	4.75E+06	3.30E+06	5.30E+06	3.35E+06	3.10E+06	3.78E+06	9.99E+05	8.00E+05
23	2.90E+06	3.25E+06	3.25E+06	4.90E+06	4.45E+06	3.30E+06	3.68E+06	8.00E+05	6.40E+05
147	5.06E+06	2.76E+06	4.80E+06	4.80E+06	2.95E+06	4.25E+06	4.10E+06	1.00E+06	8.04E+05

Table D-7: TEQ and relative TEQ in biodegradation test by MT-degrading bacterium strain SB100-05 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	4.56	4.59	4.61	4.59	0.03	0.03	4.41	3.85	6.39	4.88	1.33	1.51
1	4.18	3.57	3.33	3.69	0.44	0.49						
5	1.79	1.51	1.63	1.64	0.14	0.16	5.02	4.37	4.25	4.55	0.41	0.47
9	0.25	0.43	0.39	0.36	0.09	0.11						
10	0.50	0.14	0.35	0.33	0.18	0.21						
13	0.47	0.41	0.56	0.48	0.08	0.09						
23	0.46	0.47	0.44	0.45	0.01	0.02						
147	0.28	0.12	0.10	0.17	0.10	0.11	nd	nd	nd	nd	0.00	0.00

Table D-8: Biodegradation of MT by MT-degrading bacteria strain SB100-05 at initial MT concentration of 10.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	9.59	8.94	9.27	0.46	0.64	9.69	9.99	11.02	10.23	0.70	0.79
1						9.44	9.25	10.35	9.68	0.59	0.66
5						6.16	6.04	4.74	5.65	0.79	0.89
9						2.23	1.90	1.81	1.98	0.22	0.25
10						0.69	0.85	1.90	1.15	0.66	0.74
13						0.21	0.19	0.62	0.34	0.24	0.27
15						0.09	0.28	0.00	0.12	0.14	0.16
27	9.67	9.43	9.55	0.17	0.24	0.00	0.17	0.82	0.33	0.43	0.49
147	10.07	10.00	10.04	0.05	0.07	0.01	0.14	0.16	0.10	0.08	0.09

Table D-9: Amount of cells of MT-degrading bacterium strain SB100-05 at initial MT concentration of 10.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	9.00E+05	1.00E+06	1.00E+06	1.30E+06	1.50E+06	1.15E+06	1.14E+06	2.25E+05	1.80E+05
1	4.50E+05	9.00E+05	4.60E+06	4.60E+06	3.40E+06	4.20E+06	3.03E+06	1.88E+06	1.50E+06
5	5.00E+05	4.00E+05	3.20E+06	7.20E+06	5.40E+06	6.20E+06	3.82E+06	2.92E+06	2.34E+06
9	1.85E+06	1.20E+06	5.20E+06	5.40E+06	5.40E+06	6.60E+06	4.28E+06	2.20E+06	1.76E+06
10	5.50E+05	1.60E+06	7.20E+06	8.20E+06	8.40E+06	8.80E+06	5.79E+06	3.71E+06	2.97E+06
13	1.35E+06	1.60E+06	7.80E+06	1.34E+07	1.14E+07	9.20E+06	7.46E+06	5.01E+06	4.01E+06
15	1.35E+06	2.40E+06	1.08E+07	9.20E+06	1.20E+07	2.06E+07	9.39E+06	7.04E+06	5.64E+06
27	2.80E+06	2.40E+06	1.24E+07	1.28E+07	1.66E+07	1.62E+07	1.05E+07	6.38E+06	5.10E+06
147	1.00E+07	1.40E+07	1.30E+07	1.66E+07	1.68E+07	1.62E+07	1.44E+07	2.66E+06	2.13E+06

Table D-10: Biodegradation of MT by MT-degrading bacteria strain SB100-05 at initial MT concentration of 50.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	49.12	47.71	48.42	1.00	1.38	48.12	49.31	55.44	50.96	3.93	4.44
2						52.83	50.98	49.42	51.08	1.71	1.93
12						18.71	33.98	57.44	36.71	19.51	22.07
16						20.65	16.30	26.01	20.99	4.86	5.50
24						9.39	9.83	7.54	8.92	1.21	1.37
38						3.44	2.40	0.10	1.98	1.71	1.93
48						4.44	5.10	5.86	5.13	0.71	0.81
60	46.34	52.69	49.52	4.49	6.22	2.34	0.53	0.26	1.04	1.13	1.28
124	46.38	52.47	49.43	4.31	5.97	3.26	2.18	8.13	4.52	3.17	3.58

Table D-11: Amount of cells of MT-degrading bacterium strain SB100-05 at initial MT concentration of 50.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	9.00E+05	1.00E+06	1.15E+06	8.50E+05	7.00E+05	1.55E+06	1.03E+06	2.98E+05	2.38E+05
2	6.00E+05	5.50E+05	5.00E+06	5.60E+06	3.20E+06	4.20E+06	3.19E+06	2.18E+06	1.75E+06
12	1.55E+06	5.50E+05	5.00E+06	5.80E+06	6.20E+06	6.00E+06	4.18E+06	2.48E+06	1.99E+06
16	2.25E+06	7.50E+05	6.80E+06	7.00E+06	6.80E+06	8.00E+06	5.27E+06	2.99E+06	2.39E+06
24	5.75E+06	6.65E+06	1.22E+07	1.12E+07	9.20E+06	1.76E+07	1.04E+07	4.31E+06	3.45E+06
38	1.52E+07	2.20E+06	2.32E+07	2.32E+07	1.60E+07	1.44E+07	1.57E+07	7.70E+06	6.16E+06
48	1.95E+06	1.75E+06	2.06E+07	2.02E+07	1.70E+07	2.08E+07	1.37E+07	9.30E+06	7.44E+06
60	9.70E+06	5.45E+06	1.76E+07	2.06E+07	1.94E+07	1.96E+07	1.54E+07	6.28E+06	5.02E+06
124	6.20E+06	1.35E+07	1.98E+07	1.70E+07	1.96E+07	2.06E+07	1.61E+07	5.51E+06	4.41E+06

Table D-12: TEQ and relative TEQ in biodegradation test by MT-degrading bacterium strain SB100-05 at initial MT concentration of 50.0 mg/L

Hour	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	44.75	45.86	51.56	47.39	3.65	4.13	59.97	70.21	33.35	54.51	19.03	21.53
2	49.13	47.41	45.96	47.50	1.59	1.79						
12	17.40	31.60	53.42	34.14	18.14	20.53						
16	19.20	15.16	24.19	19.52	4.52	5.12	8.68	6.61	4.08	6.46	2.30	2.60
24	8.73	9.14	7.02	8.30	1.13	1.28						
38	3.20	2.23	0.10	1.84	1.59	1.80						
48	4.13	4.74	5.45	4.78	0.66	0.75						
60	2.18	0.49	0.24	0.97	1.05	1.19						
124	3.03	2.03	7.56	4.21	2.95	3.33	0.78	0.82	0.19	0.60	0.35	0.40

Table D-13: Biodegradation of MT by MT-degrading bacteria strain SB100-05 at initial MT concentration of 100.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	84.24	128.00	106.12	30.94	42.88	96.19	97.18	110.09	101.15	7.75	8.78
2						118.88	112.42	82.93	104.74	19.17	21.69
12						100.72	97.39	99.14	99.08	1.67	1.88
16						90.49	70.94	62.47	74.63	14.37	16.26
24						44.55	52.26	42.02	46.28	5.33	6.04
38						29.80	16.70	12.38	19.63	9.07	10.26
48						16.76	13.28	15.46	15.17	1.76	1.99
77	105.72	111.82	108.77	4.31	5.98	9.06	13.49	3.26	8.60	5.13	5.81
172	104.84	113.13	108.99	5.86	8.12	3.41	3.85	10.54	5.93	3.99	4.52

Table D-14: Amount of cells of MT-degrading bacterium strain SB100-05 at initial MT concentration of 100.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	9.00E+05	1.00E+06	9.00E+05	1.00E+06	1.45E+06	1.95E+06	1.20E+06	4.21E+05	3.37E+05
2	4.50E+05	4.50E+05	4.60E+06	4.40E+06	4.60E+06	2.80E+06	2.88E+06	2.00E+06	1.60E+06
12	3.60E+06	1.05E+06	3.60E+06	5.40E+06	4.20E+06	4.40E+06	3.71E+06	1.46E+06	1.17E+06
16	1.85E+06	1.70E+06	6.00E+06	5.60E+06	8.60E+06	4.80E+06	4.76E+06	2.64E+06	2.11E+06
24	2.00E+06	4.70E+06	6.20E+06	9.80E+06	1.02E+07	9.00E+06	6.98E+06	3.26E+06	2.61E+06
38	1.75E+07	8.50E+05	1.16E+07	1.48E+07	1.68E+07	1.36E+07	1.25E+07	6.10E+06	4.88E+06
48	7.10E+06	1.72E+07	1.76E+07	2.24E+07	1.92E+07	2.12E+07	1.74E+07	5.46E+06	4.37E+06
77	2.40E+07	3.86E+07	2.10E+07	2.48E+07	2.10E+07	2.20E+07	2.52E+07	6.73E+06	5.39E+06
172	3.33E+07	1.31E+07	2.14E+07	2.04E+07	2.66E+07	2.78E+07	2.38E+07	7.03E+06	5.62E+06

Table D-15: Biodegradation of MT by MT-degrading bacteria strain WB100-05 at initial MT concentration of 0.5 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	0.7	0.51	0.61	0.13	0.19	0.51	0.44	0.53	0.49	0.05	0.06
4.5						0.22	0.20	0.33	0.25	0.07	0.08
7						0.18	0.16	0.14	0.16	0.02	0.02
11						0.07	0.01	0.02	0.03	0.03	0.04
15	0.51	0.43	0.47	0.06	0.08	0.00	0.00	0.00	0.00	0.00	0.00
20	0.52	0.51	0.52	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Table D-16: Amount of cells of MT-degrading bacterium strain WB100-05 at initial MT concentration of 0.5 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.00E+06	1.35E+06	1.40E+06	5.50E+05	9.00E+05	1.00E+04	8.68E+05	5.24E+05	4.19E+05
4.5	3.00E+05	7.00E+05	1.45E+06	1.50E+06	1.45E+06	1.55E+06	1.16E+06	5.27E+05	4.21E+05
7	1.00E+06	1.35E+06	1.30E+06	1.85E+06	1.05E+06	1.00E+06	1.26E+06	3.28E+05	2.62E+05
11	8.50E+05	3.50E+05	9.50E+05	1.20E+06	2.10E+06	1.20E+06	1.11E+06	5.77E+05	4.62E+05
15	3.00E+05	1.50E+05	1.75E+06	2.05E+06	1.30E+06	1.45E+06	1.17E+06	7.75E+05	6.20E+05
20	4.35E+06	4.00E+05	1.25E+06	1.00E+05	1.70E+06	1.60E+06	1.57E+06	1.51E+06	1.21E+06

Table D-17: Biodegradation of MT by MT-degrading bacteria strain WB100-05 at initial MT concentration of 1.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	1.03	1.13	1.08	0.07	0.10	1.06	1.15	0.86	1.02	0.15	0.17
4.5						0.91	0.91	0.94	0.92	0.02	0.02
7						0.80	0.84	0.76	0.80	0.04	0.04
11						0.48	0.48	0.59	0.52	0.06	0.07
15	1.11	1.16	1.14	0.04	0.05	0.15	0.19	0.16	0.17	0.02	0.02
20	1.02	1.02	1.02	0.00	0.00	0.00	0.00	0.09	0.03	0.05	0.06

Table D-18: Amount of cells of MT-degrading bacterium strain WB100-05 at initial MT concentration of 1.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.10E+06	3.95E+06	1.10E+06	5.50E+05	4.50E+05	1.25E+06	1.40E+06	1.29E+06	1.03E+06
4.5	3.80E+06	5.00E+06	9.50E+05	1.20E+06	1.15E+06	1.20E+06	2.22E+06	1.74E+06	1.39E+06
7	1.35E+06	3.50E+05	1.10E+06	1.70E+06	1.50E+06	2.10E+06	1.35E+06	5.95E+05	4.76E+05
11	5.35E+06	3.10E+06	1.25E+06	1.45E+06	3.10E+06	2.10E+06	2.73E+06	1.51E+06	1.21E+06
15	7.50E+05	1.62E+06	1.55E+06	1.50E+06	1.60E+06	1.70E+06	1.45E+06	3.51E+05	2.81E+05
20	2.35E+06	2.80E+06	1.55E+06	1.40E+06	1.70E+06	1.55E+06	1.89E+06	5.56E+05	4.45E+05

Table D-19: Biodegradation of MT by MT-degrading bacteria strain WB100-05 at initial MT concentration of 5.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	5.02	4.83	4.93	0.13	0.19	5.32	5.94	5.99	5.75	0.37	0.42
4						5.04	5.18	6.78	5.67	0.97	1.09
11						3.62	4.61	4.86	4.36	0.66	0.74
19	5.49	5.52	5.51	0.02	0.03	1.40	0.17	0.78	0.78	0.62	0.70
27						0.20	0.24	0.94	0.46	0.41	0.47
74	5.13	5.22	5.18	0.06	0.09	0.06	0.00	0.15	0.07	0.08	0.09

Table D-20: Amount of cells of MT-degrading bacterium strain WB100-05 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.00E+06	1.45E+06	1.70E+06	6.50E+05	1.15E+06	1.00E+06	1.16E+06	3.71E+05	2.97E+05
4	9.00E+05	1.00E+06	1.50E+06	1.30E+06	1.45E+06	1.50E+06	1.28E+06	2.64E+05	2.11E+05
11	7.00E+05	5.50E+05	9.50E+05	2.20E+06	9.50E+05	1.65E+06	1.17E+06	6.31E+05	5.05E+05
19	1.80E+06	9.50E+05	1.80E+06	1.30E+06	1.25E+06	2.15E+06	1.54E+06	4.47E+05	3.57E+05
27	2.60E+06	1.30E+06	1.50E+06	1.80E+06	1.25E+06	1.35E+06	1.63E+06	5.13E+05	4.11E+05
74	5.35E+06	1.90E+06	1.65E+06	1.75E+06	1.45E+06	2.10E+06	2.37E+06	1.48E+06	1.18E+06

Table D-21: TEQ and relative TEQ in biodegradation test by MT-degrading bacterium strain WB100-05 at initial MT concentration of 5.0 mg/L

Hour	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	4.95	5.52	5.57	5.35	0.35	0.39	4.27	5.81	5.88	5.32	0.91	1.03
4	4.69	4.82	6.30	5.27	0.90	1.02						
11	3.37	4.29	4.52	4.06	0.61	0.69	3.64	5.71	3.73	4.36	1.17	1.32
19	1.30	0.16	0.73	0.73	0.57	0.65						
27	0.19	0.22	0.87	0.43	0.39	0.44						
74	0.06	0.00	0.14	0.07	0.07	0.08	nd	nd	nd	nd	0.00	0.00

Table D-22: Biodegradation of MT by MT-degrading bacteria strain WB100-05 at initial MT concentration of 10.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	10.95	10.00	10.48	0.67	0.93	11.36	13.45	11.28	12.03	1.23	1.39
4						11.44	11.08	11.29	11.27	0.18	0.20
11						8.73	8.23	7.52	8.16	0.61	0.69
19						2.67	2.54	2.68	2.63	0.08	0.09
31	11.60	10.40	11.00	0.85	1.18	0.02	0.03	0.28	0.11	0.15	0.17
74	10.32	10.36	10.34	0.03	0.04	0.00	0.00	0.09	0.03	0.05	0.06

Table D-23: Amount of cells of MT-degrading bacterium strain WB100-05 at initial MT concentration of 10.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.20E+06	7.00E+05	6.50E+05	1.10E+06	2.25E+06	1.25E+06	1.19E+06	5.77E+05	4.62E+05
4	1.60E+06	2.75E+06	1.75E+06	1.65E+06	1.00E+06	1.35E+06	1.68E+06	5.88E+05	4.70E+05
11	2.30E+06	6.00E+05	1.50E+06	1.35E+06	1.90E+06	1.90E+06	1.59E+06	5.90E+05	4.72E+05
19	5.00E+05	2.50E+05	1.40E+06	1.60E+06	1.60E+06	2.20E+06	1.26E+06	7.39E+05	5.91E+05
31	1.55E+06	7.50E+05	1.50E+06	2.55E+06	1.85E+06	1.85E+06	1.68E+06	5.88E+05	4.70E+05
74	1.25E+06	2.30E+06	2.70E+06	2.50E+06	1.40E+06	2.05E+06	2.03E+06	5.91E+05	4.73E+05

Table D-24: Biodegradation of MT by MT-degrading bacteria strain WB100-05 at initial MT concentration of 50.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	49.17	49.17	49.17	0.00	0.00	50.04	51.44	48.73	50.07	1.36	1.53
17						44.35	52.59	39.71	45.55	6.52	7.38
30						13.1	19.34	13.78	15.41	3.42	3.87
48						4.51	2.66	1.85	3.01	1.36	1.54
147.5	51.43	49.11	50.27	1.64	2.27	6.13	5.76	4.82	5.57	0.68	0.77
245	49.09	49.20	49.15	0.08	0.11	6.59	4.45	0.49	3.84	3.10	3.50

Table D-25: Amount of cells of MT-degrading bacterium strain WB100-05 at initial MT concentration of 50.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	1.00E+06	9.00E+05	2.00E+06	1.20E+06	6.50E+05	1.10E+06	1.14E+06	4.61E+05	3.69E+05
17	6.50E+05	5.00E+05	1.20E+06	1.70E+06	1.60E+06	1.10E+06	1.13E+06	4.86E+05	3.89E+05
30	6.40E+06	2.35E+06	1.85E+06	1.80E+06	2.80E+06	3.10E+06	3.05E+06	1.72E+06	1.38E+06
48	3.75E+06	2.05E+06	5.70E+06	7.45E+06	2.00E+07	2.32E+07	1.04E+07	8.95E+06	7.16E+06
147.5	9.70E+06	9.50E+06	2.18E+07	1.54E+07	1.24E+07	1.46E+07	1.39E+07	4.57E+06	3.66E+06
245	5.60E+06	3.05E+06	2.14E+07	1.74E+07	3.10E+07	1.84E+07	1.61E+07	1.04E+07	8.30E+06

Table D-26: TEQ and relative TEQ in biodegradation test by MT-degrading bacterium strain WB100-05 at initial MT concentration of 50.0 mg/L

Hour	Biodegradation test						Biodegradation test					
	Relative TEQ (mg/L)						TEQ (mg/L)					
	1	2	3	Average	SD	95%	1	2	3	Average	SD	95%
0	46.54	47.84	45.32	46.56	1.26	1.43	29.00	67.90	38.11	45.00	20.34	23.02
17	41.25	48.91	36.93	42.36	6.07	6.86						
30	12.18	17.99	12.81	14.33	3.18	3.60	9.37	12.80	28.99	17.05	10.48	11.86
48	4.19	2.47	1.72	2.80	1.27	1.44						
147.5	5.70	5.36	4.48	5.18	0.63	0.71						
245	6.13	4.14	0.45	3.57	2.88	3.26	1.04	1.07	1.03	1.04	0.02	0.03

Table D-27: Biodegradation of MT by MT-degrading bacteria strain WB100-05 at initial MT concentration of 100.0 mg/L

Hour	Control test					Biodegradation test					
	MT concentration (mg/L)					MT concentration (mg/L)					
	1	2	Average	SD	95%	1	2	3	Average	SD	95%
0	101.52	105.24	103.38	2.63	3.65	100.65	101.8	100.26	100.90	0.80	0.91
17						105.35	105.48	93.69	101.51	6.77	7.66
30						69.29	48.92	58.88	59.03	10.19	11.53
48						45.24	59.11	41.23	48.53	9.38	10.62
68						9.96	9.58	14.68	11.41	2.84	3.22
147.5	103.08	105.34	104.21	1.60	2.21	6.11	3.37	2.91	4.13	1.73	1.96
245	94.77	107.12	100.95	8.73	12.10	8.79	1.37	1.15	3.77	4.35	4.92

Table D-28: Amount of cells of MT-degrading bacterium strain WB100-05 at initial MT concentration of 100.0 mg/L

Hour	Biodegradation test						Average	SD	95%
	Amount of Cell (cells/mL)								
	1		2		3				
	1	2	1	2	1	2			
0	8.50E+05	9.50E+05	1.31E+06	1.69E+06	2.30E+06	7.50E+05	1.31E+06	5.96E+05	4.77E+05
17	3.00E+05	3.50E+05	1.60E+06	2.60E+06	3.40E+06	3.20E+06	1.91E+06	1.38E+06	1.10E+06
30	4.00E+05	2.40E+06	5.40E+06	6.20E+06	1.12E+07	8.60E+06	5.70E+06	3.95E+06	3.16E+06
48	2.50E+06	3.15E+06	1.40E+07	1.06E+07	1.00E+07	1.16E+07	8.64E+06	4.71E+06	3.77E+06
68	8.95E+06	1.75E+07	2.44E+07	2.46E+07	1.64E+07	1.82E+07	1.83E+07	5.81E+06	4.65E+06
147.5	1.51E+07	1.16E+07	3.18E+07	4.02E+07	3.02E+07	2.78E+07	2.61E+07	1.08E+07	8.64E+06
245	1.30E+07	1.80E+07	4.34E+07	4.20E+07	3.38E+07	2.88E+07	2.98E+07	1.24E+07	9.95E+06

APPENDIX E

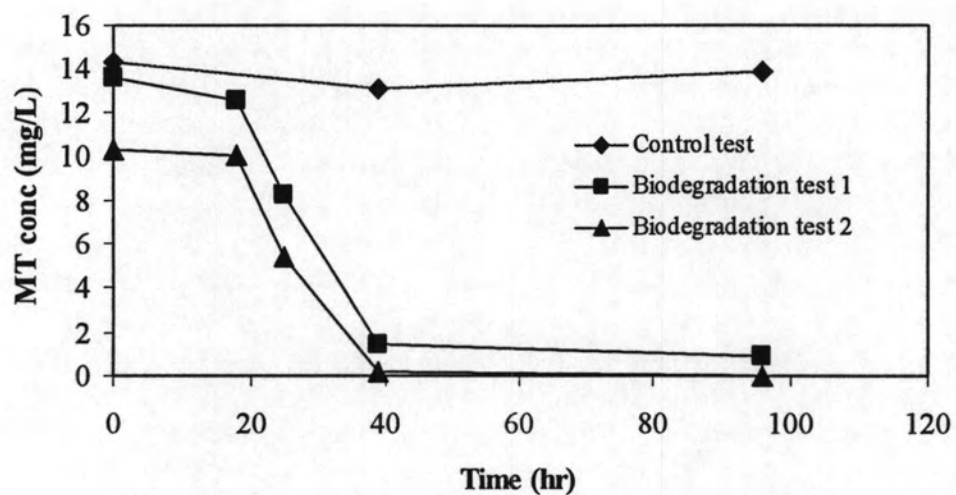


Figure E-1: Study of limitation of high MT concentration (10.0 mg/L) on biodegradation of MT by MT-degrading bacterium (pure culture)

Control test: MT + inorganic salt medium

Biodegradation test 1 and 2: MT + inorganic salt medium + pure culture

Sample preparation (liquid liquid extraction):

Control test + methanol

Biodegradation test 1 + methanol

Biodegradation test 2 + 2% sodium aside solution

APPENDIX F

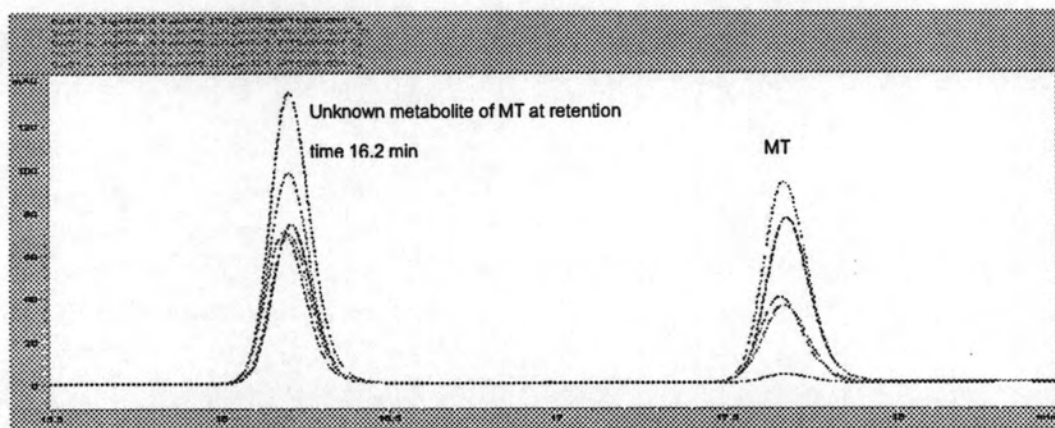


Figure F-1: HPLC chromatogram of MT (at retention time 17.8 min) and unknown metabolite of MT (at retention time 16.2 min)



BIOGRAPHY

Miss Supreeda Homklin was born on February 7, 1981 in Nan, Thailand. She obtained her B.Sc. in Environmental Engineering from the Faculty of Engineering, Chiang Mai University in 2003. She graduated with a Master's degree in Environmental Management from the International Postgraduate Programs in Environmental Management, National Center of Excellence for Environmental and Hazardous Waste Management, Chulalongkorn University, Bangkok, Thailand in May 2005.

Publication in book chapter

1. Limpiyakorn T., Homklin S., and Ong S.K. 2009. Hormones. In: **Contaminants of Emerging Concern** (ISBN:9780784410141). American Society of Civil Engineers (ASCE). Preston, VA.

Publication in international journal

1. Homklin S., Limpiyakorn T., and Ong S.K. 2009. Biodegradation of 17-alpha-methyltestosterone (MT) and isolation of MT-degrading bacteria from sediments of Nile tilapia masculinization pond. **Water science and technology** 59 (2): 261-265.

Publication in national journal

1. Sermwaraphan P., Homklin S., and Limpiyakorn T. 2552. Biodegradation of Estrogens by Activated Sludge and Nitrifying Activated Sludge. **Songklanakarinn journal of science and technology**. (in press)
2. Wattanodom T., Homklin S., Ong S.K., Limpiyakorn T. 2552. Biodegradation of 17 alpha-methyltestosterone by Microorganisms from Wastewater Treatment Systems and Sediments under Aerobic Conditions. **Songklanakarinn journal of science and technology**. (in press)

Publication in international presentation

1. Homklin S., Ong S.K., and Limpiyakorn T. Isolation of 17alpha-methyltestosterone-degrading Bacterium from Water of Masculinizing Pond of Nile Tilapia Fry. **IWA World Water Congress and Exhibition**, Vienna, Austria, September 7-12, 2008.
2. Homklin S., Ong S.K., and Limpiyakorn T. Isolation of 17 alpha-methyltestosterone-degrading Bacteria from Sediment of Masculinizing Pond of Nile tilapia. **12th Biological Sciences Graduate Congress**, Kuala Lumpur, Malasia, December 17-19, 2007.
3. Homklin S., Ong S.K., and Limpiyakorn T. Isolation of 17alpha-Methyltestosterone-Degrading Bacterium, *Nocardioides* Strain P-1 from Water of Masculinizing Pond of Nile Tilapia Fry. **The Fifth International Symposium on Southeast Asian Water Environment**, Chiang Mai, Thailand, November 7-9, 2007.
4. Homklin S., Wattanodorn T., Ong S.K., and Limpiyakorn T. Biodegradation of 17 alpha-methyltestosterone and isolation of 17 alpha-methyltestosterone-degrading bacteria from sediment of masculinizing pond of Nile tilapia fry. **2nd IWA – ASPIRE Asia-Pacific Regional Group Conference & Exhibition**, Perth, Australia, October 28 – November 1, 2007.