REFERENCES

Amsberg, Joachim von. 1995. Selected experiences with the use of economic instruments for pollution control in non-OECD countries. Washington DC: The World Bank.

Aran Hanpongkittikul, Poonsook Prasertsub, Saowalak Jitrbanjerdkul, Kanlaya Srisuwan, and Verasak Tonglimp. 1994. A study on oil separation from wastewater of palm oil mill industry: Site survey report. Songkla: Prince of Songkla University.

Bangkok Bank Public Company Limited, Research Department. 2001. The palm oil industry. (Online) Available from: http://www.bbl.co.th/mreview/200006 palm-oil1.htm, [2001, November 2].

Chapter 4: Harnessing the marketplace to cut pollution (Online) Available from: http://www.wcel.org/wcelpub/ 2537-4.html, [2000, March 18].

Christensen, Hans S. 1998.The financing environmental infrastructure – Danish experience. Denmark: Denish Environmental Protection Agency.

Department of the Environment, Transport and the Regions of UK. 1998. Economic instruments for water pollution. (Online) Available from: http://www. environment.detr.gov.uk/wqd/eiwp/eiwp01.thm, [2001, September 26].

Field, C. Barry. 1994. Environmental economics: An introduction. Singapore: McGraw-Hill. pp. 226-243.

Godard, Oliver. 1994. Centre for Co-operation with the Economies in Transition, OECD. Introducing environmental taxes in economies in transition: conditions and obstacles. Paris: Organization of Economic Cooperation for Development.

Hartje, Volkmar J. 1995. The use of economic instruments in European environmental policies. Berlin: Technical University Berlin, Germany.

Kraemer, R.A. 1995. The effectiveness and efficiency of water effluent charge system: Case study on Germany.

Lohman, A.F. de Savornin. 1995. The efficiency and effectiveness of water pollution charge in France, Germany, and the Netherlands: A synthesis of available evidence.

Malaysia Palm Oil Board.2000. By-products of milling [Online]. Available from: http://mpob.gov.my/mill_products12.htm, [2002, June 8]

Ministry of Industry, Department of Industrial Works (DIW). 1997. Development of economic tools in industrial environmental management. Bangkok: Thailand Environment Institute.

Ministry of Industry, Department of Industrial Works (DIW). 1997. Environmental management guideline for the palm oil industry. Bangkok: Department of Industrial Works.

Ministry of Industry, Department of Industrial Works (DIW). 1999. Project impact assessment: Palm oil industry. Bangkok: Consultants of Technology Co.,Ltd.

Ministry of Industry, Department of Industrial Works, Krabi Provincial Office. 2002. Wastewater analysis report.

Ministry of Industry, Department of Industrial Works. 2002. Final report: Implementation of economic instruments for industrial environmental management. Bangkok: Consultants of Technology Co., Ltd.

Ministry of Science, Technology and Environment, Department of Environment. 1995. Malaysia environmental quality report 1995. Shah Alam: Malindo Printers Sdn Bhd.

Ministry of Science, Technology and Environment, Department of Energy Development and Promotion. 2002. 1st Progress Report: A feasibility study on co-generation from palm oil mill bio-mass. Bangkok: Prince of Songkla University and Consultants of Technology.

New South Wales - Environment Protection Authority. 1995. Guidelines for the utilization of treated effluent by irrigation.. (Online) Available from: http://www.palm.act.gov.au/planning_and_development/planning_register/register_docs/reusegui.pdf, [2002, August 16].

O' Connor, David. 1996. OECD Development Center. Applying economic instruments in developing countries: From theory to implementation. Paris: Organization of Economic Cooperation for Development.

Office of Agricultural Economy. Annual report [Online]. (n.d.) Available from: http://oae.go.th/statistic/yearbook/2000-01/Index.html, [2002, July 10]

Office of the Permanent Secretary for Science, Technology and Environment. 2000. Environmental Impact Inspection Report of Palm Oil Mills in Surattani and

Krabi Provinces. Surattani: Environment Office Sector11th.

Organization for Economic Co-operation and Development. 1999. Economic instruments for pollution control and natural resources management in OECD countries: A survey. Paris: Organization of Economic Cooperation for Development.

Rattanapong Phaoborom. 1999. A study of technical efficiency of palm oil extracting industry in Thailand. Mater's Thesis, Department of Economics, Faculty of Economics, Chulalongkorn University.

SCB Research Institute. 2000. Palm oil's future rests with outcome of regional talks. (Online) Available from: http://scb.co.th/~scbri/eseng/es0005e.html, [2002, August 1].

The Thailand Research Fund. 2001. Final report: Developing environmental performance indicators for increased competitiveness for Thai industry. Bangkok: Thailand Environment Institute.

The World Bank. 1999. Greening industry: New roles for communities, markets, and governments. New York: Oxford University Press.

UNESCAP. 2001. Measurement for integrating environmental considerations into agriculture: Impact of environmental measures on Malaysian exports. (Online) Available from: http://www.unescap.org/drpad/pub3/integra/volume3/malaysia/3my04c02.htm, [2001, March 30].

APPENDIX

APPENDIX A

Comparison of Wastewater Abatement Cost of Different Sites (Domestic and Industrial Estates WWTP)

Conditions

Interest Rate = 10% | Working Life (Years) = 20

Annual Recovery Cost factor = 0.11746 | The costs are updated to the constant 1999 price

Project	Actual BOD Removing Capacities				Investment and Expenditures				Total Abatement Cost per kg BOD (baht)
	Flow rate (cu.m./d)	BOD inf. (mg/l)	BOD removed (mg/l)	BOD Loading (kg BOD/yr)	Const. Cost (mil.B)	O&M Cost (mil.B/yr)	Depriciation (mil.B)/yr	Total (mil.B)/yr	
Ladkrabang	11,000	500	480	1,900,800	-	14.48	-	14.48	7.62
Laemchabang	6,500	500	480	1,123,200	-	3.36	15.60	18.96	16.88
Hua Mark	600	200	180	38,880	1.79	0.52	0.21	0.73	18.75
Pinthong	1,200	500	480	207,360	15.32	2.15	1.80	3.95	19.03
Bangbao	1,200	200	180	77,760	8.64	0.49	1.01	1.50	19.35
Bang Phlee	2,500	500	480	432,000	-	6.36	3.16	9.52	22.03
Amata	4,000	500	480	691,200	69.01	7.15	8.11	15.26	22.08
Romklao	3,800	200	180	246,240	30.63	2.19	3.60	5.79	23.51
Thongsonghong 1	3,000	200	180	194,400	34.24	0.61	4.02	4.63	23.83
Klong Toey	1,450	200	180	93,960	12.57	0.84	1.48	2.31	24.61
Si Praya	30,000	200	180	1,944,000	302.27	12.50	35.50	48.00	24.69
Klong Jun	6,500	200	180	421,200	59.87	4.33	7.03	11.36	26.97
Tha Sai	1,400	200	180	90,720	17.63	0.35	2.07	2.42	26.64
Commercial complex	3,275	300	280	330,120	42.93	5.86	5.04	10.90	33.02
Pibul Wattana	400	200	180	25,920	4.51	0.32	0.53	0.85	32.66
Dindaeng	1,000	200	180	64,800	12.59	0.72	1.48	2.20	33.95
Pattaya	25,000	200	180	1,620,000	302.27	22.88	35.50	58.38	36.04
Bon Kai	400	200	180	25,920	3.46	0.58	0.41	0.99	38.06
Map ta Phut	1,190	500	480	205,632	-	3.18	7.80	10.98	53.40

Min =	7.62
Max =	53.40
Average =	26.48
Percentile 90 =	36.44

Source : Fundamental information were taken from;

1) COT's study reports

2) IEAT

3) Main report, vol. 2, A feasibility Study of Wastewater Management Fee Collection in Bankok, Progress Technology Consultant Co., Ltd. in assoociation with Metcalf & Eddy International, Inc., May 1998.

APPENDIX B

Questionnaire for Palm Oil Mill Industry Interview

Instruction

1. This questionnaire arranged in partial fulfillment of the requirements for a thesis of the Master degree of Science in Environmental Management, Inter-Department of Environmental Management Graduate School, Chulalongkorn University.
2. The information received from you will be kept as a confidential document and utilized only for the thesis. Factory name will not be appeared in any part of the thesis and will not be publicized without any permission from you.
3. The questionnaire was designed for interviewing to the executive levels or policy makers who have well acknowledgement on the factory economic performance, environmental and production process. The questionnaire is divided into 5 parts as below:
   - Part I General Information of Owner and Factory
   - Part 2 Production Process
   - Part 3 Economic Performance of Factory
   - Part 4 Waste Management
   - Part 5 Environmental Policy
4. Please answer all questions and based on actual data.
5. If there is not identified to others, please answer the questions based on year 2001 information.

Name……

Position……

Date……/……/……

Part 1 *General Information of Owner and Factory*

1. Factory Name.....
   Registered Number.....

2. Education level of Owner(s)
   1. Lower than Bachelor Degree
   2. Bachelor Degree
   3. Master Degree
   4. Other (identify).....

3. Year in operation.....

4. Factory location.....
   .....
   Tel..... Fax.....

5. Production Process Time
   5.1 Production days per year....., days per week .....
   Shift(s) per day....., hour(s) per shift.....

   5.2 Shut down for maintenance .....day per year
   Insufficient raw material shut down ..... day per year

Part 2 *Production Process*

1. Raw material types and quantities
   - Fresh Fruit Bunch (FFB) Consumption rate .....ton/day
   - ..... Consumption rate ..... ton/day
   - ..... Consumption rate ..... ton/day
2. Rated Production Capacity .....ton FFB/day
   .....tonCPO/day
   .....litrerCPO/day
   ..... tonCPO/tonFFB

3. Average production capacity .....tonFFB/day
..... tonCPO/day
..... litreCPO/day

4. Average water consumption rate.....m^3/day (Please attach production process and water consumption)

Part 3 Economic Performance

1. Production Cost

Expenditure	1997	1998	1999	2000	2001
Raw Material					
Fuel/Energy					
Labors					
Water/Electrical					
Transportation					
Marketing					
Others					
Total Production Cost					

2. Product Market
Domestic.....% Export.....%

Domestic Market

2.1 Market shared region
1.....quantity.....ton/yr, Value.....Baht/yr
2.....quantity..... ton/yr, Value.....Baht/yr
3.....quantity..... ton/yr, Value.....Baht/yr
4.....quantity ..... ton/yr, Value.....Baht/yr

2.2 Distribution of Products

1. Directly distribute to consumers
2. Distribute to agency/broker
3. Distribute to Refined factory

2.3 Tentative demand of domestic market

1. Increase
2. Decrease
3. Constant
4. Varied
5. Other (identify).....

2.4 Reason for increasing of domestic demand

1. Qualified products
2. Cheaper when compared to competitors
3. Non competitor
4. Other (identify) .....

.....

2.5 Reason for decreasing/constant/variation of domestic demand

1. Products quality not reply to the market demand
2. Expensive than competitor
3. High competitor
4. Other (identify) .....

2.6 Do you have the commercial competitor(s) ?

1. No (Monopoly)
2. Yes
3. Non data

2.7 Production marketing problem (please answer in order of important ascending)

1. .....
2. .....
3. .....
4. .....

Exported Market

2.1 Important exported market (in term of country)

1.....quantity.....ton/yr, value.....Baht/year

2..... quantity.....ton/yr, value.....Baht/year

3.....quantity.....ton/yr, value.....Baht/year

4..... quantity.....ton/yr, value.....Baht/year

2.2 Distribution of Products

1. Directly distribute to consumers
2. Distribute to agency/broker
3. Distribute to .....

2.3 Tentative demand of domestic market

1. Increase
2. Decrease
3. Constant
4. Varied
5. Other (identify).....

2.4 Reason for increasing of domestic demand

1. Qualified products
2. Cheaper when compared to competitors
3. Non competitor
4. Other (identify) .....

.....

2.5 Reason for decreasing/constant/variation of domestic demand

1. Products quality not reply to the market demand
2. Expensive than competitor
3. High competitor
4. Other (identify) .....

2.6 Do you have the commercial competitor(s) ?

1. No (Monopoly)
2. Yes
3. Non data

4.7 Important competitors (please answer in order of important ascending by

1 = High significant , 2 = significant, 3 = fair , 4 = poor)

Country	Important rank
- Malaysia	
- Indonesia	
- Singapore	
- Japan	
- Netherlands	
-.....	
-.....	

2.8 Production marketing problem (please answer in order of important ascending)

1. .....

2. .....

3. .....

4. .....

3. Actual Sale of Crude Palm Oil

Year	Actual Sale (Baht/yr)
2001	
2000	
1999	
1998	
1997	

4. Year 2001 Net Profit .....Million Baht

Part 4 ***Waste Mnagement***

1. Water supply for production process line

1.1 Source of water supply

1. Surface water 2. Ground water

3. Tap water 4. Other (identify) .....

1.2 Consumption rate……..m^3/day or payment bill of last month.....….Baht

2. Water supply for employees or labors (included households, if any)

2.1 Source of water supply

1. Surface water 2. Ground water

3. Tap water 4. Other (identify) ……..

2.2 Consumption rate……..m^3/day or payment bill of last month.....….Baht

3. Do you have wastewater treatment system in your factory?

1. No

2. Yes

4. If there is no wastewater treatment system in your factory, please identify why not

1. Sent to ex-situ treatment and expense for ……Baht/month

2. In constructing period

3. No budget

4. No necessity due to …….

5. No preserved area for an installation

6. Other (identify) ……..

5. If there is a wastewater treatment system in your factory, please identify its type

1. Oxidation Pond 2. Aerated Lagoon)

3. Stabilization Pond) 4. Other (identify ……

(please attach wastewater treatment flow diagram)

6. Wastewater receiving body

1. Surface water body 2. Public sewer

3. Underground water body 4.Other (identify) ……

7. Construction cost and operation & maintenance cost

Total .....Baht

7.1 Land value.....Bath, Area.....rai

7.2 Construction cost.....Bath, (established for.....years)

7.3 Machine cost .....Baht

7.4 Maintenance cost.....Baht/month

7.5 Operation cost.....Baht/month

7.6 Other (identify) .....

8. Wastewater treatment system operator(s) ..... person(s)

1. Name.....reg. no.....
2. Name.....reg. no.....
3. Name.....reg. no.....
4. Name.....reg. no.....

9. Education level of wastewater supervisor(s)

1. Lower than bachelor degree / major.....
2. Bachelor degree/major.....
3. Higher than bachelor degree / major.....
4. Other (identify).....

10. Wastewater characteristics and inspection

10.1 wastewater quality analysis frequency.....time (s)/month

10.2 Analyzed agency or lab (identify).....

10.3 wastewater characteristics (average from last 3 month data)

inf. BOD.....mg/l

eff. BOD.....mg/l

(please attach wastewater quality analysis report)

10.4 Updated wastewater quality analysis (date.....month.....year.....)

Inf. BOD.....mg/l

Eff. BOD.....mg/l

(please attach wastewater quality analysis report)

11. Wastewater treatment problems

1. Malodor
2. Expensive equipment/ spared parts
3. High operation and maintenance cost
4. Insufficiency of expert
5. Hardly comply with effluent standard
6. Other (identify).....

Part 5 Environmental Policy

1. Existing wastewater management has conducted to fulfill the purpose of
   1. Compliance with effluent standard
   2. Not pay attention to the effluent standard due to.....
   3. Other (identify) .....

2. Please ranking for the factors influencing to your environmental management policy especially on wastewater management
   (4= most important, 3= very important, 2= important, 1= not much important, 0= not important)

Issue	Ranking
Domestic Clients	
International Clients	
Shareholders	
Employees	
NGOs	
Surrounded Communities	
Press or Public	
Petitions the court	
Regulations	
Subsidize on soft load, grant, or tax exemption	
Energy and raw material conservation	
Environmental Deterioration	
Environmental conservation cost	

3. Do you have engaged the environmental management staffs or teams for your in-plant management?
   1. Yes, please identify.....
   .....
   2. No

4. Are the environmental management staffs also empowered in the board of director.
   1. Yes, please identify.....
   .....
   2. No

5. During the last 5 years, how much has your factory invested for environmental issue?
   Amount.....Baht, or.....% of total investment cost

6. Nowadays, which environmental management principals your factory is applying?
   1. Environmental Management System (EMS)
   2. Cleaner Technology/Pollution Prevention by .....
   3. ISO 140000 Certification
   4. Other (identify) .....

7. Have you ever been informed about the implementation of economic instruments on industrial pollution management following to polluter-pays-principal?
   1. Yes, from.....
   2. No, have not informed
8. Have you ever been informed that DIW is preparing for implementation of economic instrument as called "emission charge" and "pollution management fee" system on industrial pollution management which encourage factories to abate pollution load to environment?
   1. Yes, from.....
   2. No,

9. Do you agree to the application of "emission charge" and "pollution management fee" scheme for environmental management in Thailand?

   1.Yes, because.....

   .....

   2.No, because.....

   .....

   .....

*** ***Following questions have to integrate all above data and information from concerned governments or organizations , therefore, the 'x' symbol will be substituted by the values from integration and synthesis of all information. Additional information from your will be requested further by telephone or fax interviews. An equation for emission charge calculation is as below:***

Emission Charge (EC) = 35 Baht/kgBOD x effluent BOD load (kgBOD/year)

Conclusion:

From the performance of palm oil mill industry (source: DIW and/or Ministry of Commercial and/or stock market, year 2002) and wastewater characteristics (source: Palm oil mill industry and/or DIW, year 2001) it can be concluded that your factory:

- Has crude palm oil products = x,xxx ton/yr ---------- A
- Has average wastewater generation rate = x,xxx m^3/yr ---------- B
- Has effluent BOD concentration = xxx mg/liter ---------- C

Effluent BOD load	=	$\frac{B \times C}{1,000}$	kg/yr
Emission charge	=	$\frac{B \times C}{1,000} \times 35$	Baht/yr
or as per products	=	$\frac{B \times C \times 35}{1,000 \times A}$	Baht/tonCPO

By varying BOD concentration at several level, it could be conclude that:

BOD (mg/l)	Emission Charge	
	(Baht/yr)	(Baht/tonCPO)
- if discharged BOD as current level		
- if discharged BOD = 10 mg/l		
- if discharged BOD = 20 mg/l		
- if discharged BOD = 60 mg/l		

3. From the emission charge that your factory has to pay based on current BOD load, is it an appropriated rate?
   1. Appropriate, because.....
      .....
      .....
   2. Not appropriate, because.....
      .....
      .....

      The level of emission charge that you expect it will not effect to your economic performance or your willingness to pay for EC is about.....Baht/tonCPO.

4. If you have to pay for emission charge, what are expected options that you prefer to do?
   1. Improve or modify the production process to reduce BOD load
   2. Install new equipment of machine to reduce BOD load
   3. Apply wastewater for land application, irrigation, reuse and recycle or other utilization to reduce discharged wastewater
   4. Improve and/or increase wastewater treatment capacity to reduce BOD concentration
   5. Increase crude palm oil price
   6. Other (identify).....
      .....

APPENDIX C

Cost Estimation for Wastewater Treatment of Palm Oil Mill Industry

Assumption

1 Interest Rate 0.095 (Bank of Thailand, 2002)
2 Annual Recovery Cost factor = 0.1017
3 Working Life (Years) = 30
4 Capital cost of land for wastewater treatment is assigned based on rental rate
5 Land Application
- included cost of pump, and piping system (as shown in capital cost)
- included cost of electricity for wastewater pumping, of soil loosening for 1 time/year (as shown in operation and maintenance cost)
- excluded cost of land due to wastewater is applied for oil palm or rubber plantation area
- wastewater application rate is of 40 kg/ha/day (NSW-EPA, 1995)

Factory A

Wastewater Treatment Plant

Wastewater Flow =	76,650	m^3/yr	
Inf. BOD concentration =	36,000	mg/l	
Eff. BOD concentration from oxidation p	3,600	mg/l	
Eff. BOD concentration from aerated lago	180	mg/l	
BOD load generation =	2,759,400	kg/yr	
Wastewater Treatment System =	Oxidation Pond + Aerated Lagoon		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	118	rai	
Wastewater treatment pond area	50	rai	
Pond Volume	153,000	m^3	
Total BOD load removal	**2,759,400**	**kg/yr**	
BOD load removal of oxidation pond =	2,483,460	kg/yr	
BOD load removal of land appication =	275,940	kg/yr	

Capital Cost

Construction Cost	7,650,000	Baht	(excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	1,550,000	Baht	(pumps &aerators)
Land rental	250,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,185,461	Baht/yr	

Operation & Maintenance Cost

Labor	-	Baht/yr	(no operator)
Electricity	220,297	Baht/yr	(for pumps and aerators)
Chemical	-	Baht/yr	
Maintenance	300,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	
Soil loosening expense	1,890,000	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	2,414,594	Baht/yr	
Total Abatement Cost	**3,600,055**	Baht/yr	

Factory B

Wastewater Treatment Plant

Wastewater Flow =	93,450	m^3/yr	
Inf. BOD concentration =	50,000	mg/l	
Eff. BOD concentration from oxidation p	5,000	mg/l	
BOD load generation =	4,672,500	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	200	rai	
Wastewater treatment pond area	60	rai	
Pond Volume	160,000	m^3	
Total BOD load removal	**4,672,500**	**kg/yr**	
BOD load removal of oxidation pond =	4,205,250	kg/yr	
BOD load removal of land appication =	467,250	kg/yr	
Capital Cost			
Construction Cost	8,000,000	Baht	(excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	350,000	Baht	(pumps)
Land rental	300,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,149,033	Baht/yr	
Operation & Maintenance			
Labor	120,000	Baht/yr	(2 workers @ 5,000 Baht/month/worker)
Electricity	4,297	Baht/yr	(for pumps)
Chemical	-	Baht/yr	
Maintenance	300,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	
Soil loosening expense	3,200,342	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	3,628,936	Baht/yr	
Total Abatement Cost	**4,777,969**	Baht/yr	

Factory C

Wastewater Treatment Plant

Wastewater Flow =	86,400	m^3/yr	
Inf. BOD concentration =	20,000	mg/l	
Eff. BOD concentration from Biogas =	2,000	mg/l	
Eff. BOD concentration from Polishing P	200	mg/l	
BOD load generation =	1,728,000	kg/yr	
Wastewater Treatment System =	Biogas + Anearobic Pond + Polishing Pond		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	74	rai	
Wastewater treatment pond area	35	rai	
Pond Volume	112,000	m^3	(Estimate from avg. depth of pond = 2 m.)
Total BOD load removal	**1,728,000**	**kg/yr**	
BOD load removal of biogas =	1,555,200	kg/yr	

BOD load removal of land appication =	172,800	kg/yr	
Capital Cost			
Construction Cost	8,600,000	Baht	(Biogas system = 3 million Baht, excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	350,000	Baht	(pumps)
Land rental	175,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,085,041	Baht/yr	
Operation & Maintenance			
Labor	300,000	Baht/yr	(1 env. Engineer and 2 workers @ 15,000 Baht/month/engineer and 5,000 Baht/month/worker)
Electricity	4,297	Baht/yr	(for pumps)
Chemical	-	Baht/yr	
Maintenance	300,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	
Soil loosening expense	1,183,562	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	1,792,156	Baht/yr	
Total Abatement Cost	**2,877,197**	Baht/yr	

Factory D

Wastewater Treatment Plant			
Wastewater Flow =	315,800	m^3/yr	
Inf. BOD concentration =	36,000	mg/l	
Eff. BOD concentration from Oxidation P	3,600	mg/l	
BOD load generation =	11,368,800	kg/yr	
Wastewater Treatment System =	Oxidation Pond + Stabilization Pond		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	487	rai	
Wastewater treatment pond area	16	rai	
Pond Volume	89,250	m^3	(DIW's Provincial Offfice)
Total BOD load removal	**11,368,800**	**kg/yr**	
BOD load removal of oxidation pond =	10,231,920	kg/yr	
BOD load removal of land appication =	1,136,880	kg/yr	
Capital Cost			
Construction Cost	6,462,500	Baht	(improvment cost = 2 million Baht, excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	500,000	Baht	(pumps)
Land rental	2,433,390	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	3,141,341	Baht/yr	
Operation & Maintenance			
Labor	120,000	Baht/yr	(2 workers @ 5,000 Baht/month/worker)
Electricity	8,640	Baht/yr	(for pumps)

Chemical	-	Baht/yr	
Maintenance	300,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	8,640	Baht/yr	
Soil loosening expense	7,786,849	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	8,224,129	Baht/yr	
Total Abatement Cost	**11,365,471**	Baht/yr	

Factory E

Wastewater Treatment Plant

Wastewater Flow =	57,930	m^3/yr	
Inf. BOD concentration =	30,000	mg/l	
Eff. BOD concentration from oxidation p	3,000	mg/l	
Eff. BOD concentration from aerated lago	150	mg/l	
BOD load generation =	1,737,900	kg/yr	
Wastewater Treatment System =	Oxidation Pond + Aerated Lagoon		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	74	rai	
Wastewater treatment pond area	38	rai	
Pond Volume	147,675	m^3	
Total BOD load removal	**1,737,900**	**kg/yr**	
BOD load removal of oxidation pond =	1,564,110	kg/yr	
BOD load removal of land appication =	173,790	kg/yr	

Construction Cost

Construction Cost	7,383,750	Baht	(excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	1,050,000	Baht	(pumps & aerators)
Land rental	189,492	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,047,041	Baht/yr	

Operation & Maintenance

Labor	120,000	Baht/yr	(2 workers @ 5,000 Baht/month/worker)
Electricity	87,276	Baht/yr	(for pumps and aerators)
Chemical	24,000	Baht/yr	(lime)
Maintenance	100,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	1,313	Baht/yr	(electricity cost for pumps)
Soil loosening expense	1,190,342	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	1,522,931	Baht/yr	
Total Abatement Cost	**2,569,972**	Baht/yr	

Factory F

Wastewater Treatment Plant

Wastewater Flow =	50,400	m^3/yr	
Inf. BOD concentration =	44,000	mg/l	
Eff. BOD concentration from oxidation p	4,400	mg/l	

Eff. BOD concentration from aerated lago	220	mg/l	
BOD load generation =	2,217,600	kg/yr	
Wastewater Treatment System =	Oxidation Pond + Aerated Lagoon		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	95	rai	
Wastewater treatment pond area	47	rai	
Pond Volume	151,639	m^3	
Total BOD load removal	**2,217,600**	**kg/yr**	
BOD load removal of oxidation pond =	1,995,840	kg/yr	
BOD load removal of land appication =	221,760	kg/yr	
Capital Cost			
Construction Cost	7,581,950	Baht	(excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	1,050,000	Baht	(pumps & aerators)
Land rental	236,936	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,114,638	Baht/yr	
Operation & Maintenance			
Labor	60,000	Baht/yr	(1 worker @ 5,000 Baht/month/worker)
Electricity	65,676	Baht/yr	(for pump and aerator)
Chemical	-	Baht/yr	
Maintenance	100,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	876	Baht/yr	(electricity cost for pump)
Soil loosening expense	1,518,904	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	1,745,455	Baht/yr	
Total Abatement Cost	**2,860,093**	Baht/yr	

Factory G

Wastewater Treatment Plant			
Wastewater Flow =	135,000	m^3/yr	
Inf. BOD concentration =	25,000	mg/l	
Eff. BOD concentration from Oxidation P	2,500	mg/l	
BOD load generation =	3,375,000	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Storage in holding pond		
Wastewater treatment pond area	40	rai	
Pond Volume	128,000	m^3	(Estimate from avg. depth of pond = 2 m.)
Total BOD load removal	**3,037,500**	**kg/yr**	
BOD load removal of oxidation pond =	3,037,500	kg/yr	
Capital Cost			
Construction Cost	6,400,000	Baht	(excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	270,000	Baht	(pumps)
Land rental	200,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	878,209	Baht/yr	

Operation & Maintenance			
Labor	144,000	Baht/yr	(1 scientist @ 12,000 Baht/month/scientist)
Electricity	6,048	Baht/yr	(for pump)
Chemical	-	Baht/yr	
Maintenance	300,000	Baht/yr	(for annual excavation work)
Land Application Cost	-	Baht/yr	(storage in holding ponds))
Total O&M Cost	450,048	Baht/yr	
Total Abatement Cost	**1,328,257**	Baht/yr	

Factory H

Wastewater Treatment Plant			
Wastewater Flow =	144,000	m^3/yr	
Inf. BOD concentration =	50,000	mg/l	
Eff. BOD concentration from Oxidation P	5,000	mg/l	
BOD load generation =	7,200,000	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Storage in holding pond		
Wastewater treatment pond area	51	rai	
Pond Volume	162,957	m^3	
Total BOD load removal	**6,480,000**	**kg/yr**	
BOD load removal of oxidation pond =	6,480,000	kg/yr	
Capital Cost			
Construction Cost	8,147,856	Baht	
Machine Cost	270,000	Baht	(pumps)
Land rental	250,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,105,933	Baht/yr	
Operation & Maintenance			
Labor	-	Baht/yr	(on operator)
Electricity	6,048	Baht/yr	(for pump)
Chemical	-	Baht/yr	
Maintenance	100,000	Baht/yr	(for annual excavation work)
Land Application Cost	-	Baht/yr	(storage in holding ponds))
Total O&M Cost	106,048	Baht/yr	
Total Abatement Cost	**1,211,981**	Baht/yr	

Factory I

Wastewater Treatment Plant			
Wastewater Flow =	64,800	m^3/yr	
Inf. BOD concentration =	35,000	mg/l	
Eff. BOD concentration from oxidation p	3,500	mg/l	
Eff. BOD concentration from aerated lago	175	mg/l	
BOD load generation =	2,268,000	kg/yr	
Wastewater Treatment System =	Oxidation Pond + Aerated Lagoon		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	97	rai	

Wastewater treatment pond area	45	rai	
Pond Volume	144,000	m^3	(Estimate from avg. depth of pond = 2 m.)
Total BOD load removal	**2,268,000**	**kg/yr**	
BOD load removal of oxidation pond =	2,041,200	kg/yr	
BOD load removal of land appication =	226,800	kg/yr	
Capital Cost			
Construction Cost	7,200,000	Baht	
Machine Cost	1,150,000	Baht	(pumps & aerators)
Land rental	225,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,074,033	Baht/yr	
Operation & Maintenance			
Labor	120,000	Baht/yr	(2 workers @ 5,000 Baht/month/worker)
Electricity	69,097	Baht/yr	(for pump and aerator)
Chemical	-	Baht/yr	
Maintenance	100,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	(electricity cost for pump)
Soil loosening expense	1,553,425	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	1,846,819	Baht/yr	
Total Abatement Cost	**2,920,851**	Baht/yr	

Factory J

Wastewater Treatment Plant			
Wastewater Flow =	64,800	m^3/yr	
Inf. BOD concentration =	36,000	mg/l	
Eff. BOD concentration from oxidation p	3,600	mg/l	
Eff. BOD concentration from aerated lago	180	mg/l	
BOD load generation =	2,332,800	kg/yr	
Wastewater Treatment System =	Oxidation Pond + Aerated Lagoon		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	100	rai	
Wastewater treatment pond area	27	rai	
Pond Volume	85,500	m^3	
Total BOD load removal	**2,332,800**	**kg/yr**	
BOD load removal of oxidation pond =	2,099,520	kg/yr	
BOD load removal of land appication =	233,280	kg/yr	
Capital Cost			
Construction Cost	4,275,000	Baht	
Machine Cost	1,150,000	Baht	(pumps & aerators)
Land rental	133,594	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	685,211	Baht/yr	
Operation & Maintenance			
Labor	-	Baht/yr	(no operatior)
Electricity	60,457	Baht/yr	(for pump and aerator)
Chemical	-	Baht/yr	

Maintenance	100,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	
Soil loosening expense	1,597,808	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	1,762,562	Baht/yr	
Total Abatement Cost	**2,447,773**	Baht/yr	

Factory K

Wastewater Treatment Plant

Wastewater Flow =	27,420	m^3/yr	
Inf. BOD concentration =	36,000	mg/l	
Eff. BOD concentration from Oxidation P	3,600	mg/l	
BOD load generation =	987,120	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	42	rai	
Wastewater treatment pond area	15	rai	
Pond Volume	48,000	m^3	(Estimate from avg. depth of pond = 2 m.)
Total BOD load removal	**987,120**	**kg/yr**	
BOD load removal of oxidation pond =	888,408	kg/yr	
BOD load removal of land appication =	98,712	kg/yr	

Capital Cost

Construction Cost	2,400,000	Baht	(excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	200,000	Baht	(pumps)
Land rental	75,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	339,370	Baht/yr	

Operation & Maintenance

Labor	120,000	Baht/yr	(consultant company @ 10,000 Baht/month)
Electricity	576	Baht/yr	(for pump)
Chemical	-	Baht/yr	
Maintenance	100,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	576	Baht/yr	(storage in holding ponds))
Soil loosening expense	676,110	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	897,262	Baht/yr	
Total Abatement Cost	**1,236,631**	Baht/yr	

Factory L

Wastewater Treatment Plant

Wastewater Flow =	60,360	m^3/yr	
Inf. BOD concentration =	30,000	mg/l	
Eff. BOD concentration from oxidation p	3,000	mg/l	
Eff. BOD concentration from filtration =	10	mg/l	
BOD load generation =	1,810,800	kg/yr	

Wastewater Treatment System =	Oxidation Pond + Filtration		
Treated Wastewater Management =	Reuse & Recycle in the Plant		
Wastewater treatment pond area	4	rai	
Pond Volume	11,228	m^3	
Total BOD load removal	**1,810,196**	**kg/yr**	
BOD load removal of oxidation pond =	1,629,720	kg/yr	
BOD load removal of filtration =	180,476	kg/yr	
Capital Cost			
Construction Cost	3,561,400	Baht	(filtration system = 3 million Baht, excavation cost of 50 Baht/cu.m of pond volume
Machine Cost	120,000	Baht	(pumps)
Land rental	17,544	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	391,871	Baht/yr	
Operation & Maintenance			
Labor	264,000	Baht/yr	(1 scientist and 2 workers @ 12,000 Baht/month/scientist and 5,000 Baht/month/worker)
Electricity	576	Baht/yr	(for pump and filtation)
Chemical	30,180	Baht/yr	(for poly aluminium chloride = 0.5 Baht/m3)
Maintenance	100,000	Baht/yr	(for annual excavation work)
Land Application Cost	-	Baht/yr	(reuse and recycle in the plant)
Total O&M Cost	394,756	Baht/yr	
Total Abatement Cost	**786,627**	Baht/yr	

Factory M

Wastewater Treatment Plant			
Wastewater Flow =	97,200	m^3/yr	
Inf. BOD concentration =	40,000	mg/l	
Eff. BOD concentration from Oxidation P	4,000	mg/l	
BOD load generation =	3,888,000	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	166	rai	
Wastewater treatment pond area	8	rai	
Pond Volume	17,536	m^3	
Total BOD load removal	**3,888,000**	**kg/yr**	
BOD load removal of oxidation pond =	3,499,200	kg/yr	
BOD load removal of land appication =	388,800	kg/yr	
Capital Cost			
Construction Cost	6,500,000	Baht	(factory data)
Machine Cost	350,000	Baht	(pumps)
Land rental	39,447	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	735,959	Baht/yr	
Operation & Maintenance			

Labor	144,000	Baht/yr	(1 technician @ 12,000 Baht/month/technician)
Electricity	4,297	Baht/yr	(for pump)
Chemical	-	Baht/yr	
Maintenance	120,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	(electricity cost for pump)
Soil loosening expense	2,663,014	Baht/yr	(6,000 sq.m./month/worker @ 5,000 Bath/month/worker
Total O&M Cost	2,935,608	Baht/yr	
Total Abatement Cost	**3,671,567**	Baht/yr	

Factory N

Wastewater Treatment Plant			
Wastewater Flow =	74,400	m^3/yr	
Inf. BOD concentration =	36,000	mg/l	
Eff. BOD concentration from Oxidation P	3,600	mg/l	
BOD load generation =	2,678,400	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Land Application		
Minimum required area for land applicati	115	rai	
Wastewater treatment pond area	50	rai	
Pond Volume	257,167	m^3	
Total BOD load removal	**2,678,400**	**kg/yr**	
BOD load removal of oxidation pond =	2,410,560	kg/yr	
BOD load removal of land appication =	267,840	kg/yr	
Capital Cost			
Construction Cost	12,858,350	Baht	
Machine Cost	350,000	Baht	(pumps)
Land rental	250,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	1,593,033	Baht/yr	
Operation & Maintenance			
Labor	180,000	Baht/yr	(1 engineer @ 15,000 Baht/month/engineer)
Electricity	4,297	Baht/yr	(for pump)
Chemical	-	Baht/yr	
Maintenance	100,000	Baht/yr	(for annual excavation work)
Electricity cost for land application	4,297	Baht/yr	(electricity cost for pump)
Soil loosening expense	1,834,521	Baht/yr	(6,000 sq.m./month /worker @ 5,000 Bath/month/ worker
Total O&M Cost	2,123,114	Baht/yr	
Total Abatement Cost	**3,716,147**	Baht/yr	

Factory O

Wastewater Treatment Plant			
Wastewater Flow =	11,640	m^3/yr	
Inf. BOD concentration =	36,000	mg/l	

Eff. BOD concentration from Oxidation P	3,600	mg/l	
BOD load generation =	419,040	kg/yr	
Wastewater Treatment System =	Oxidation Pond		
Treated Wastewater Management =	Storage in holding pond		
Wastewater treatment pond area	10	rai	
Pond Volume	32,000	m^3	(Estimate from avg. depth of pond = 2 m.)
Total BOD load removal	**377,136**	**kg/yr**	
BOD load removal of oxidation pond =	377,136	kg/yr	
Capital Cost			
Construction Cost	1,000,000	Baht	(factory data)
Machine Cost	90,000	Baht	(pumps)
Land rental	50,000	Baht/yr	rental rate = 5,000 Baht/rai/yr
Total annual cost	160,832	Baht/yr	
Operation & Maintenance			
Labor	264,000	Baht/yr	(1 technocian and 2 workers @ 12,000 Baht/month/ tecnician and 5,000 Baht/ month/worker)
Electricity	213	Baht/yr	(for pump)
Chemical	-	Baht/yr	
Maintenance	240,000	Baht/yr	(for annual excavation work)
Land Application Cost	-	Baht/yr	(storage in holding ponds))
Total O&M Cost	504,213	Baht/yr	
Total Abatement Cost	**665,045**	Baht/yr	

BIOGRAPHY

Miss Poonsook Sricharoen was born on 18th March, 1974 in Chiang Rai. She finished her higher secondary course from Damrongratsongkroh School, Chiang Rai in March 1993. Afterward, she pursued bachelor's degree in the major of Environmental Engineering in Faculty of Environmental Engineering at King Mongkut's University of Technology, Thonburi. She has worked in Consultants of Technology Company Limited for 3-year full time and 2-year part time as an environmental engineer. Correspondingly, she continued her master's degree in International Environmental Management Science at Chulalongkorn University and achieved her master's degree in October 2002.