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THAILAND

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1. Introduction

2. Present State of sludge treatment & disposal in Thailand

2.1 Background for waste sludge quantity change and trend in recent years

Since late 2001, DIW has started the survey of wastewater discharge from industries throughout the country. The survey was conducted by DIW inspectors from the Control and Inspection Bureau 1 to 4 (under DIW) and was first completed in 2002. Data from the survey was intentionally prepared for decision-makers to counteract with water pollution resulted from industrial effluent in the major watersheds of Thailand.

However, this data is also useful for our study to estimate figures about the amount and distribution of waste biological sludge from industries.

In order to interpret this report correctly, it is important to know and understand the background conditions and limitations of raw data, which are listed as follows:

- Number of industries surveyed equal to 5,176 factories (these factories are classified as potential water polluters)
- Number of industries having some kind of wastewater treatment equal to 4,538 factories
- Number of industries where figure of influent BOD loading are available equal to 3,477 factories (these factories are basis for our study)
- All 3,477 factories are classified into 3 ranges for detail analysis as:
    - Group A: Design influent BOD loading less than 2,000 kg/day
    - Group B: Design influent BOD loading between 2,000 kg/day to less than 10,000 kg/day and
    - Group C: Design influent BOD loading more than 10,000 kg/day

The result of the survey demonstrated that

1. At present time, 63% of total BOD loading or 1,506 ton/day comes from 98 factories, another 24% come from 187 factories and the last 13% come from small and scattering 3,192 factories. Total BOD loading sums up to 2,373 ton/day.
2. If design figure is used to estimated for the future trend, total BOD loading adds up to 4,626 ton/day. But the distribution still follow the existing pattern which are 72%, 19% and 9% for each group respectively.
3. Since group B and C seem to be the major portion of organic loading, the initial focus will be on these two groups.

In order to estimate amount of waste sludge to be as close as possible, type of wastewater treatment applied in factories of group B and C are essential. In the study, wastewater treatment systems are categorized into

- Activated sludge or other aerobic treatment as part of the system
- Aerated lagoon as part of the system
- UASB and
- Ponds and other anaerobic process

2.2 Change and trend of industrial shipment (evacuation) amount and waste sludge quantity

Currently, waste sludge is dewatered and used for land-reclamation or soil conditioner. However, a little portion of this waste sludge is applied correctly and efficiently. Moreover, factories having this waste sludge which is generally rendered non-hazardous in 14 provinces* are legally required

by law to get approval from DIW before evacuating waste sludge from factory premises. The list of provinces is due to cover the whole country in the near future.

So far the cost of non-hazardous waste sludge disposal falls around 1,000 – 2,000 Baht/ton** This cost varies considerably because of many factors such as distance from disposal facilities, method and standard of the facilities. DIW has already defined 3 new factory categories in order to promote and regulate these kinds of facility. According to DIW permission records, the total amount of waste sludge from 14 provinces currently transported to legal facilities in year 2002 can sum up to 64,990 ton.

*14 provinces include Bangkok metropolis, Samut Prakarn, Nonthaburi, Pathum Thani, Samut Sakhon, Nakhon Pathom, Chon Buri, Chasoengsao, Rayong, Prachin Buri, Nakhon Ratchasima, Lamphun, Sara Buri and Phra Nakhon Si Ayutthaya
** Cost can vary considerably according to distance and characteristics of waste e.g. water content etc.

2.3 Water quality standards of wastewater

From regulation point of view, DIW, PCD and IEAT are authorized to control and regulate industries in Thailand. Job descriptions of each organization maybe described in the following manners.

DIW is authorized to:
- Approve and monitor industrial operation and its environmental impact
- Set industrial emission standards
- Monitor emissions from industrial plants

PCD is authorized to:
- Formulate and recommend environmental quality and emission standards
- Monitor national environmental quality and take action on public complaints related to environmental pollution

IEAT is authorized to:
- Develop and manage or jointly manage the state's industrial estates
- Operate and regulate the industrial estates
- Set standard and proper maintenance of utilities and facilities
- Set emission standards for the factories in the estate

Relevant wastewater standards are shown in Appendix A, B and C

2.4 Waste regulation and sludge disposal

In 1997 MOI issued the Ministerial Notification No.6 B.E. 2540 (1997): Disposal of wastes or unusable materials (Hazardous waste), requiring factories throughout the country to

- Carry out the disposal of the wastes or unusable materials as defined in the notification
- Wastes or unusable materials as defined in the notification shall not be taken out of the factory without prior approval from DIW
- Details on type, quantity, characteristics, properties and storing place of the wastes or unusable materials concerned as well as method of storage, detoxification, disposal, discarding, landfilling and transport shall be annually reported to DIW

This notification, however, covers all wastes and unusable material including both hazardous and yet-to-be-proved hazardous.

Later in 1998, MOI issued the second series of industrial waste regulation, the Ministerial Notification No.1 B.E. 2541 (1998): Disposal of wastes or unusable materials (Non-hazardous waste), requiring factories in 14 provinces to

- Carry out the disposal of the wastes or unusable materials as defined in the notification
- Wastes or unusable materials as defined in the notification shall not be taken out of the factory without prior approval from DIW

This notification clarifies the ambiguous definition of yet-to-be-proved list in the notification No.6. It also suggests the following detoxification, disposal, discard or landfilling methods to factory operators.

- Landfilling with appropriate liner system, leak detection system, gas emission and wastewater treatment system according to wastes to be landfilled. And the selected process shall be approved by DIW.
- Incineration with flue gas emission control system, emission shall not exceed the Notification of the Ministry of Science, Technology and Environment regarding emission standards of solid waste incinerator dated on 17th June 1997
- Any other methods to be approved by DIW i.e., composting, land reclamation, and recycle/reuse/recovery

Majority of waste biological sludge of our interest falls into section 2 item 3.6. From statistics of the year 2002, wastes of section 2 item 3.6 (as per the Ministerial Notification No.1) add up to 0.06 million ton from the total non-hazardous waste of 1.83 million ton (3.3%). It must be noted that this figure is the permission figure of factories in 14 provinces not the actual occurred figure throughout the country.

2.5 Wastewater statistics in industrial field

As mentioned early on, from DIW survey result, in the year 2002, 87% of influent BOD loading comes from only 285 factories. Of these 285 factories, 98 factories have more than 10,000 kg/day loading each and contribute totally 1,506 ton/d (63% of country BOD loading). Another 187 factories of BOD loading between 2,000 – 10,000 kg/day each contribute to 580 ton/d (24%).

If wastewater treatment types are used as criteria for further classification, the result is shown in table 2.1 and graphically presented in figure 2.1 and 2.2.

Table 2.1 Variation of wastewater treatment system used in factories of BOD loading more than 2,000 kg/day

Wastewater treatment system	Number of Factories		BOD loading (ton/day)	
	Number	Percentage	Number	Percentage
With AS/aerated type with excess sludge	83	29.1	540	25.9
With AL	72	25.3	278	13.3
UASB	10	3.5	73	3.5
Ponds and other anaerobic process	120	42.1	1,195	57.3
Total	285	100.0	2,086	100.0

Figure 2.1 Percentage of factories classified by treatment system (Influent BOD loading 2,000 - 10,000 kg/day)

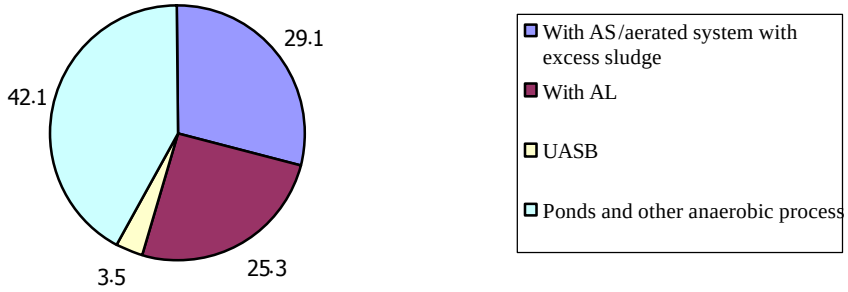
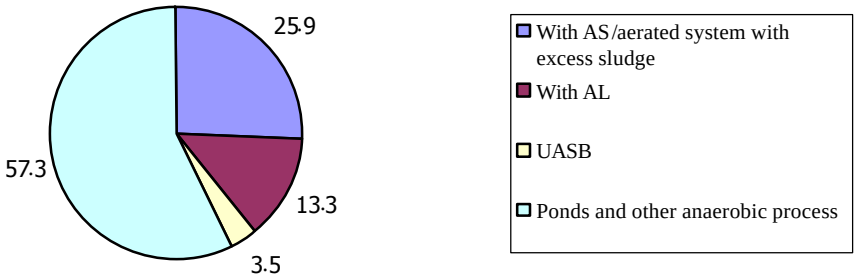


Figure 2.2 Percentage of factories classified by treatment system (Influent BOD loading more than 10,000 kg/day)



In order to estimate the amount of excess sludge at present and its projection in the future. The following assumptions are assumed.

- The amount of waste sludge is estimated from BOD removal of the system using Activated Sludge or other aerobic treatment. The rest three categories (AL, UASB and Ponds) are not likely to create significant waste excess sludge unless the existing systems are altered due to some specific reasons.
- Factors of 0.25 and 0.4 are used as minimum and maximum cell yield factor compared with BOD removal in aerobic part in order to estimate the amount of waste sludge generated both for present time and for design value.
- In this estimate, 60% removal rate is used for anaerobic cutoff if anaerobic treatment is used.
- The total number of factories in this category is 83, 62 are in Group B (loading 2,000 – 10,000 kg/day) and 21 are in Group C (loading more than 10,000 kg/day). The result is showed in table 2.2.

Table 2.2 Estimated range of waste sludge dry-weight at present and at design figure

	Existing amount (ton/day as dry weight)		Design amount (ton/day as dry weight)	
	Min (Y_{obs} = 0.25)	Max (Y_{obs} = 0.4)	Min (Y_{obs} = 0.25)	Max (Y_{obs} = 0.4)
Group B	38.6	61.8	58.3	93.4
Group C	68.9	110.3	165.1	264.2
Total	**107.5**	**172.1**	**223.4**	**357.6**

It is further assumed that dewatering process of the excess amount of sludge reaches solid content of 20%, volume of waste sludge generation is shown in table 2.2.

Tables 2.3 Estimated range of waste sludge volume at present and at design figure (20% solid)

	Existing volume (m3/day)		Design volume (m3/day)	
	Min (Y_{obs} = 0.25)	Max (Y_{obs} = 0.4)	Min (Y_{obs} = 0.25)	Max (Y_{obs} = 0.4)
Group B	193	309	292	467
Group C	345	551	825	1,321
Total	**538**	**860**	**1,117**	**1,788**

2.6 Relationship of major industrial activity and waste sludge

These large sludge generators can be classified according to industrial activity in table 2.4 and in figure 2.3 and 2.4 (percentage shown in the figures are number of factories)

Table 2.4 Number of large sludge generators by industrial activity

Industrial activity	Group B (2,000 – 10,000 kg/day)	Group C (> 10,000 kg/day)	Total
Seafood, meat and other food processing	20	5	25
Alcoholic beverage	3	4	7
Non-alcoholic beverage	3	-	3
Textile-dyeing	8	-	8
Pulp and paper	8	7	15
Chemical and plastic	7	-	7
Latex	3	-	3
Central wastewater treatment plant (101)	10	5	15
Total	62	21	83

(Remarks: Anaerobic treatment sludge not included)

Figure 2.3 Percentage of industrial activities of large scale sludge generators (having 2,000 - 10,000 kg/d influent BOD loading)

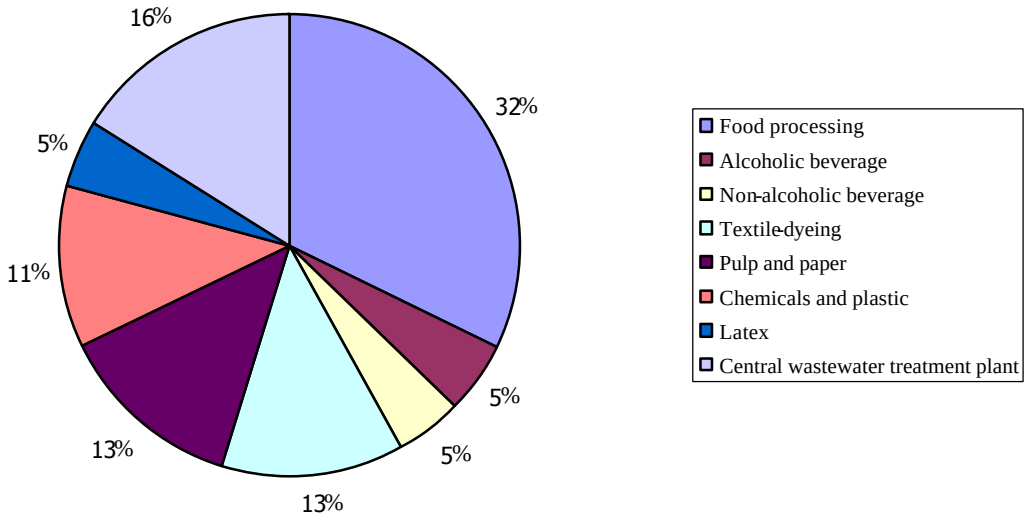
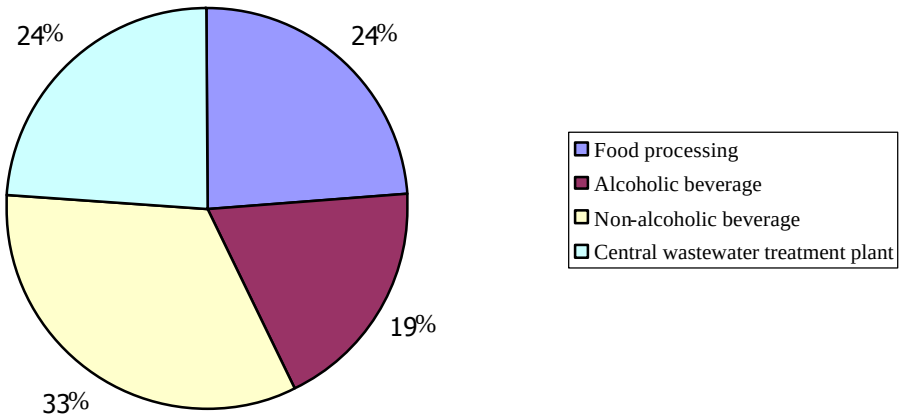


Figure 2.4 Percentage of industrial activities of large scale sludge genrators (having more than 10,000 kg/d influent BOD)



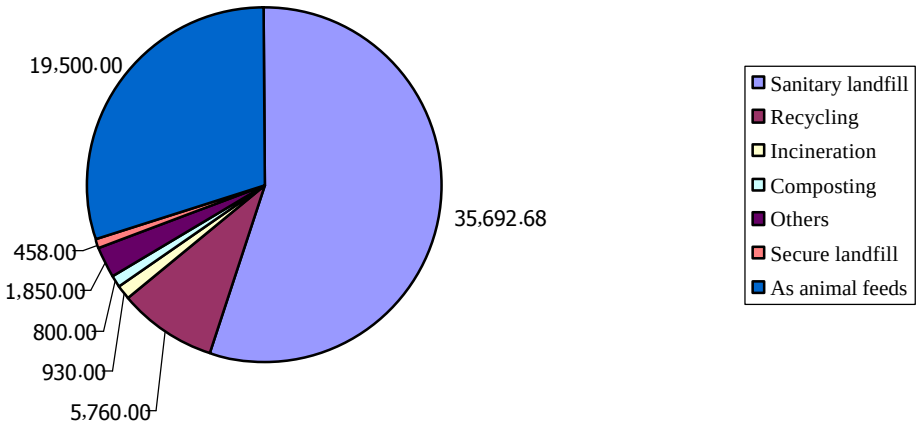
2.7 Classification of wastes treatment and disposal method and its volume

From the statistics in the Year 2002 exclusively, 64,990 ton of waste sludge (both chemical and biological) generated in 14 provinces, with disposal permission from DIW, were processed by various methods as shown in table 2.5. Figure 2.5 show the proportion graphically.

Table 2.5 Methods of sludge treatment and disposal (Year 2002)

Method	ton/year	%
Sanitary landfill	35,692.68	54.9
Recycling	5,760.00	8.9
Incineration	930.00	1.4
Composting	800.00	1.2
Others	1,850.00	2.8
Secure landfill	458.00	0.7
Animal feeds	19,500.00	30.0
Total	64,990.68	100.0

Figure 2.5 Waste sludge (Chemical and Biological) disposal method (Year 2002)



It is noteworthy that, in the future factories using area intensive wastewater treatment system (mostly open system) will have to switch to smaller and more efficient system (preferably closed) like anaerobic pre-treatment plus activated sludge system especially in urban area to minimize its intrinsic nature nuisance caused by the existing system. The future estimation in table 2.2 and 2.3 does not include the effect of this situation only the maximum design loading is used in the estimation.

If looking back to the industrial activities contributing to BOD loading, it is obvious that our initial focus will be on some specific sectors of large loading figure. Less than 2,000 kg/day factories are scattering around and need more effort to approach and moreover it will be less economic viable than the more than 2,000 kg/day, which in itself further divided into two groups as stated before. The reason is simply to prioritize the target group.

It should be further noted that, even the observation yield used between 0.25 – 0.4 seems reasonable at this state. Practice of each factory can vary considerably and therefore effect these figures.

3. Problems of sludge treatment and disposal

Industrial wastes and residues are currently a subject of interest to the public, especially, wastes that rendering hazardous. Non-hazardous waste including biological sludge, however, does not effect health and safety as much as hazardous waste. But it tends to create bad odor and nuisance to neighboring communities if not handling properly. In many cases, biological sludge is disposed of together with chemical sludge and/or other hazardous materials, then it is considered hazardous.

The problems associated with sludge treatment and disposal will be discussed topic by topic as follows. (It should be note that the sludge problem itself is complicated, discussion topic by topic is one easy way to visualize the situation, but actions required to encounter the situation need more integrated and holistic approach.)

3.1 Law and regulations

Comprehensive mechanism to control and monitor wastes flow needs to be maturated. So far, only permission system for evacuating wastes from factory premises is in place. The manifest system of the actual movement of the wastes is yet to be developed. DIW is currently working with registered waste processors to strengthen the waste manifest system. This system will focus initially on hazardous wastes and then to non-hazardous wastes as well.

The amount of registered waste processors was once the limitation factor to this business. The situation is improving as DIW attempts to make this business as a free competitive market by facilitating more new processors to the business. Two new types of factory operation are added to the factory type list i.e. 105 (Separation and Landfilling facility) and 106 (Recycling facility) following the forerunner 101 (Central industrial wastewater treatment plant).

DIW also faces difficulties with the coverage of the Ministerial Notification No.1 B.E. 2541 (1998) because it covers only 14 provinces. DIW intends to modify the notification to cover 76 provinces nationwide.

Another challenge to wastes treatment and disposal from law and regulation point of view is the decentralization issue. Even though, the functions of DIW have been gradually decentralized into provincial office. Issue regarding industrial wastes is going vice versa. Both waste evacuating permission and operating permit for waste processors are centralized in DIW head office. The staff in the Waste Management Division is loaded with routine tasks and has little time for creative work. Both staff of local authorities and provincial office staffs still need more training and skill to work on complicated industrial waste scheme.

3.2 Alternative technology

Since activated sludge process is one of the most common technology found in industrial wastewater treatment in Thailand. This process inevitably produces a certain amount of excess biological sludge depending on the design.

The excess raw sludge still contains some nutrient values but unstable (i.e. further biodegradable exists). These valuable nutrients can be stabilized by composting and reused as soil conditioner. The limitation of this environmentally sound method is long composting time and high transportation cost, which often offer less economic benefits for commercial scale.

In practice, waste sludge is dewatered, dried or partly dried and distributed to ones who need either as soil conditioner or as animal feeds, generally free of charge. The problem, which may occur, is that if the sludge is not well stabilized, bad smell prevails. And some sludge may contain high amount of heavy metal or some toxic substances, which may accumulate and/or contaminate to groundwater if the users apply such materials without knowledge.

Another alternative option available at present time and share the largest proportion of treatment and disposal is landfilling. This option costs factory landfill tipping fee and sludge may react with other waste materials in the landfill cell (co-landfill) and may produce more hazardous materials.

In some design, excess sludge is kept minimal by the so-called "extended aeration". The lower cost of sludge handling has to compensate with more power consumption from aeration.

3.3 Local conditions

It is obvious that urban communities will not accept improper sludge handling either at industrial plant or waste processing facilities. Contrary to urban area, rural area, which is less populated, tends to be able to accept sub-standard practice. Rural communities also possibly benefit from the waste sludge as source of nutrients.

3.4 Economic feasibility

No matter how advance the technology is, any option is to be economically feasible to compete with the existing/alternative practice. Detail cost analysis of existing technology and the suggested technology per ton of sludge handling is necessary.

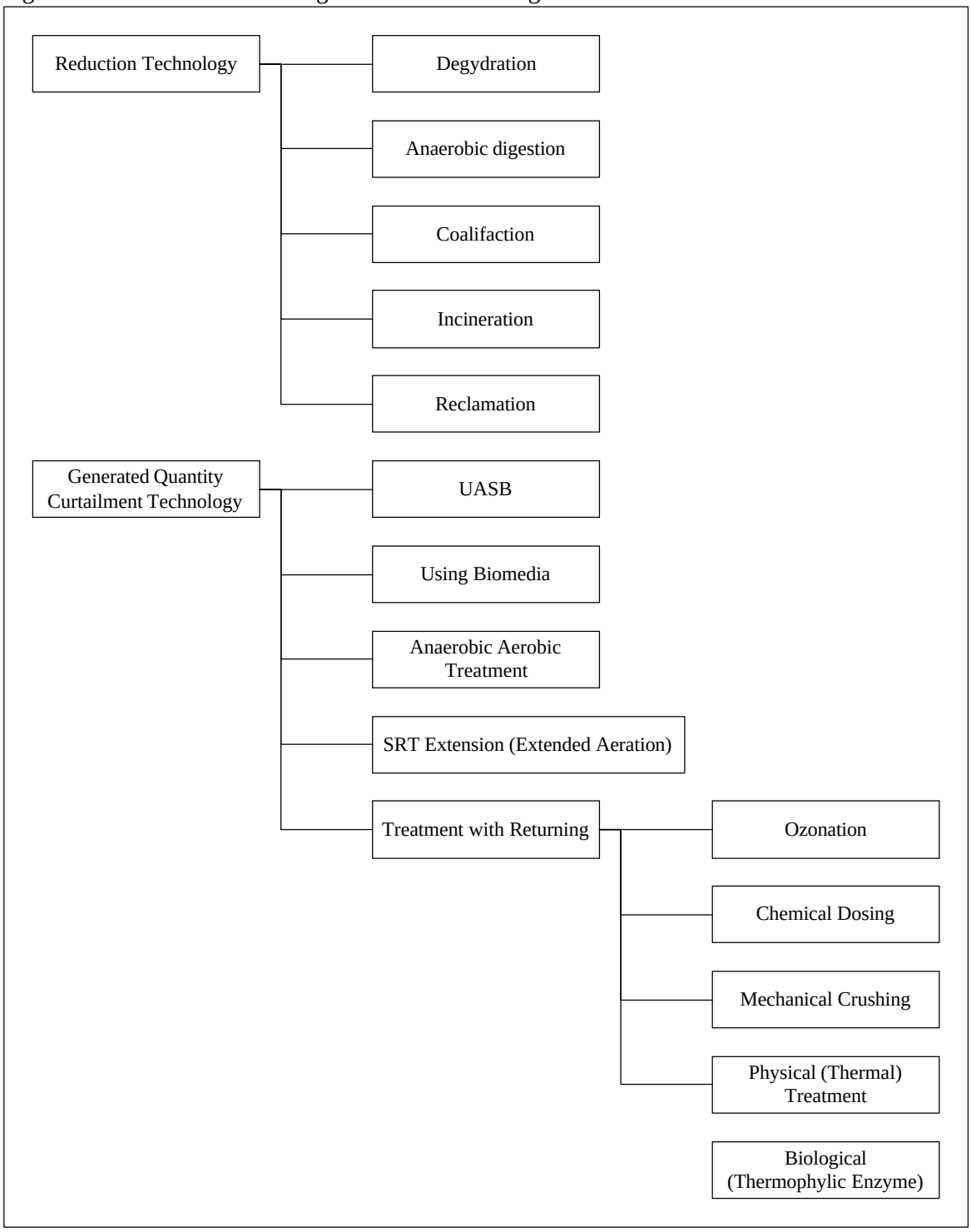
3.5 Environmental protection

The best way for environmental protection is to produce less organic loading. Once wastewater is generated, environmental impact occurs.

4. Necessity of sludge reduction technologies in Thailand

Considering sludge reduction technologies for wastewater treatment, there are mainly two methods i.e. reduction technology or sludge treatment (reduce the amount of sludge generated) and generated quantity curtailment technology (reduce the generation of sludge or not allow sludge to be generated). Tree diagram of the two methods are shown in figure 4.1

Figure 4.1 Classification of sludge treatment technologies for wastewater treatment



From diagram 4.1 most of the reduction technologies and some of the generated quantity curtailment technologies are currently applied to wastewater treatment in Thailand. Except to Treatment with Returning technology, which is relatively new to our context.

The present technologies (both reduction and generated quantity curtailment) have pros and cons and not one solution for all situations. More often more than one technology is combined and applied together.

More alternative reduction technologies will assist engineers and factory owners to select the most social, environmental and economically viable process. So far, all technology either needs off-site handling or lots of energy consumption. New and innovative technologies that can compete with these two limitations can make new ground.

It is worth to mention that in the year 2002, more than half of waste sludge in 14 provinces covered by DIW regulation is disposed of in sanitary landfill. These landfill sites are generally co-landfilled and biochemical processes in the cells are unknown. Minimizing the amount of waste sludge to landfill as soon as possible is necessary.

5. Expectation and demand on sludge reduction technologies

Industrial plants with large BOD loading will gain benefits from alternative sludge reduction technologies. From statistics in chapter 2, 83 out of 285 plants (the 285 plants contribute to 87% or 2,086 ton/day of total BOD loading) have activated sludge as part of the treatment process. This figure does not include municipal wastewater treatment throughout the country, which will be also benefited by the introduction of new technologies.

Not only the large-scale BOD generators, but also the rest 13% of country BOD loading from 3,192 sites will beneficially adopt new technologies later when the technologies are proven with the large-scale industries. For these smaller generators, activated sludge process is generally common. However, low investment and maintenance-free technologies are important factors for this group. It is advisable to focus on large industries and municipal wastewater treatment plants at the first step.

It is safe to say that the present technologies and management practices for sludge treatment and disposal have not yet met the requirement of DIW, other government agencies and the public. Demonstration of alternative technologies such as:

- Thermophilic enzyme
- Ozonation
- Mechanical crushing
- Chemical dosing
- Water oxidation and anaerobic treatment and
- Dehydration

will assist policy makers in government agencies and industries to comprehend and find the best available technology to handle sludge problem properly.

6. Social, environmental and economic conditions for sludge treatment and disposal

The relationship between social, environmental and economic issue and wastewater and sludge problem maybe visualized through complaints from the public sending to DIW. The figure from Factory Control and Inspection Bureau 1 (there are 4 Bureaus in DIW with roughly similar figures) from the year 2001 (October 2000 – September 2001) show that

- Total amount of factories causing complaints are 808 factories
- Total cases are 1,198 cases
- 217 cases concern with wastewater
- 383 cases concern with smell
- 50% of the cases concern with wastewater and smell

Even direct complaints regarding waste sludge problem is not classified, it maybe implied from the statistics that the problems persist.

To minimize this problem, not only appropriate on-site sludge reduction with lower cost but also technology rendering less offensive smell is needed.

7. Sludge reduction technologies applicable for Thailand

The alternative sludge reduction technologies to be applicable for Thailand have to compete with other existing reuse/recycling and disposal methods mainly in terms of cost. Apart from landfilling, which is less favorable, so far, composting and reuse as animal feeds are currently more favorable. However, these options have hindrance on transportation and handling cost and maybe less economically viable on commercial scale. Not all of the waste sludge can be reused or composted successfully. Other drawbacks of these two options are that the legal standard on organic recycling products is yet to be developed. DIW presently has not much control over the products from waste processors. This situation can be more problematic to environmental protection in longer term and can create misunderstanding and negative attitudes to the users. Therefore, competition with other alternative technologies is still widely opened.

The alternative technologies should have the following features:

- Have lower total cost including direct investment, maintenance, externalities, etc.
- Be energy and environmentally efficient
- Be easy to maintain
- Be able to reactivate in relatively short time due to discrete inputs
- Be odor free operation
- Be easily equipped to the existing facilities

8. Conclusion and recommendations

The following conclusion and recommendations can be drawn.

1. The amount of waste sludge generation estimated from DIW survey data (2002) can be summarized in the following table

Tables 10.1 Estimated range of waste sludge volume at present and at design figure (20% solid)

	Existing volume (m3/day)		Design volume (m3/day)	
	Min (Y_{obs} = 0.25)	Max (Y_{obs} = 0.4)	Min (Y_{obs} = 0.25)	Max (Y_{obs} = 0.4)
>2,000 kg/day design influent BOD loading factories*	538	860	1,117	1,788

* BOD loading equals to 87% of country BOD loading, but only 8.9% of total number of factories in the survey

2. The variation of wastewater treatment system used in 1. are classified in table 10.2

Table 10.2 Variation of wastewater treatment system used in factories of BOD loading more than 2,000 kg/day

Wastewater treatment system	Number of Factories		BOD loading (ton/day)	
	Number	Percentage	Number	Percentage
With AS/aerated type with excess sludge	83	29.1	540	25.9
With AL	72	25.3	278	13.3
UASB	10	3.5	73	3.5
Ponds and other anaerobic process	120	42.1	1,195	57.3
Total	285	100.0	2,086	100.0

3. Industrial activities of the large sludge generators in 1. are tabulated in table 10.3

Table 10.3 Large sludge generators by industrial activity

Industrial activity	Total
Seafood, meat and other food processing	25
Alcoholic beverage	7
Non-alcoholic beverage	3
Textile-dyeing	8
Pulp and paper	15
Chemical and plastic	7
Latex	3
Central wastewater treatment plant (101)	15
Total	83

4. DIW records on waste sludge (chemical and biological) licenses to dispose of the year 2002 and its methods of disposal are shown in table 10.4 (from 14 provinces covered by Notification No.1 (1998)

Table 10.4 Methods of waste sludge treatment and disposal (Year 2002)

Method	ton/year	%
Sanitary landfill	35,692.68	54.9
Recycling	5,760.00	8.9
Incineration	930.00	1.4
Composting	800.00	1.2
Others	1,850.00	2.8
Secure landfill	458.00	0.7
Animal feeds	19,500.00	30.0
Total	64,990.68	100.0

5. DIW is currently working on the manifest system in order to have more control and closer monitoring of the whole waste disposal cycle. Reuse/recycling products from waste processors to be standardized could be one of the most important issue affecting waste sludge management. Non-hazardous waste regulation is also planned to cover 76 provinces nationwide.

6. Alternative reduction technologies are needed and in order to be compete with existing practices, they need to

- Have lower total cost considering direct investment, maintenance, externalities, etc.
- Be energy and environmentally efficient
- Be easy to maintain
- Be able to reactivate in relatively short time
- Be odor free operation
- Be easily equipped to the existing facilities
- Greatly reduce sludge volume

7. Necessity of new sludge reduction technologies is obvious. Target factories at the very beginning should be aimed at large sludge generators. Expansion of the technologies to smaller scale factories would be possible with success stories from large-scale generators. Municipal wastewater treatment facilities and central industrial wastewater treatment plants (101) are also potential sites of the demonstration.

9. References

Many companies are active in industrial waste management including waste sludge treatment and disposal. Companies shown in the list (table 9.1) are some of those companies. The listed companies are classified in EEAT yearbook & directory 2002

Table 9.1 List of companies

Company	Business category									
	Haz. Waste Management & Disposal	Solid Waste Management & Disposal	Dewatering Machines	Haz. Waste Disposal Equipment	Incinerator	Landfill Site Compactors	Package Treatment Units	Sludge Treatment & Disposal Facilities	Solid waste Treatment & Disposal	Solid/Liquid Waste Disposal Facility
AEA Technology (Thailand) Co.,Ltd.	O	O							O	
B.B. Engineering & Consultant Co.,Ltd.								O		
Banpan Engineering & Holding Co.,Ltd.	O	O			O					
Black & Veatch (Thailand) Ltd.	O	O								
BTG-Golder Co.,Ltd.		O								
Carbokarn Co., Ltd.	O	O		O		O			O	
Chemitreat (Thailand) Co.,Ltd.			O				O	O		
CMS Engineering & Management Co,.Ltd.	O	O			O					
Consultants of Technology Co.,Ltd.	O	O								
Ecology Consultants (Thailand) Co.,Ltd.										
Entech Products Co.,Ltd.							O	O		
Envitrade Engineering Co.,Ltd.			O	O		O				
ERM-Siam Co.,Ltd.	O	O								
Eurochem Co.,Ltd.			O		O		O	O	O	
Green Innovation Engineering Co.,Ltd.	O	O		O	O			O	O	
INOX International Co.,Ltd.			O					O	O	
International Environmental Management Co.,Ltd.	O									
IQA-Norwest Labs Co.,Ltd.	O									
Loxley Plc.	O		O		O		O			
Macro Consultants Co.,Ltd.		O								
Mahanakorn Unicersity fo Technology Library	O	O								
March Utilities Co., Ltd.	O	O								

Table 9.1 List of companies (Cont.)

Company	Business category									
	Haz. Waste Management & Disposal	Solid Waste Management & Disposal	Dewatering Machines	Haz. Waste Disposal Equipment	Incinerator	Landfill Site Compactors	Package Treatment Units	Sludge Treatment & Disposal Facilities	Solid waste Treatment & Disposal	Solid/Liquid Waste Disposal Facility
Min Sen machinery Co.,Ltd.						O				
O.H. Group Co.,Ltd.		O		O	O		O			
Pass Ad Co.,Ltd.		O								
Phathai Science of Technology Co.,Ltd.	O	O		O	O		O		O	
Prima Techmark Co.,Ltd.	O	O						O	O	
Roediger (Thailand) Co.,Ltd.			O					O	O	
Swentech (Thailand) Co.,Ltd.					O					
Team Consulting Engineering & Management Co.,Ltd.		O								
Thammasorn Co.,Ltd.		O	O		O	O	O		O	
Trend Intertrade Co.,Ltd.	O	O			O					
Waste Management Siam co.,Ltd.										O
Water Development Consultants Co.,Ltd.		O								
Wetco International Co.,Ltd.			O							

From: EEAT Yearbook & Directory 2002

Appendix A

Royal Emblem

Ministerial Notification No.2 B.E. 2539 (1996) Issued in accordance with the Factory Act B.E. 2535

Subject : Industrial effluent standards

By virtue of clause 14 of Ministerial Regulation No.2 (B.E. 2535) under the Factory Act B.E. 2535 as specified that "Effluent discharged out of any factory's premise is prohibited, unless treated to be in accordance with the quality prescribed by the Minister and published in the Royal Government Gazette, but not by means of dilution", the Minister of Industry hereby announces the notification on industrial effluent standards as follows:

Item 1 Definition

"Effluent" means wastewater from any process of factories discharged into public receiving waters or environment, including any wastewater generated from water usage by workers and other activities in the factories. Effluent shall meet the effluent standards announced in this Notification.

Item 2 Effluent must have the following characteristics:

(1) pH shall be within the range of 5.5-9.0

(2) TDS (Total Dissolved Solids):

2.1 TDS shall not exceed 3000 mg/l or depending on effluent flow rates, receiving waters or types of factory as defined by Department of Industrial Works, but shall not exceed 5000 mg/l in any case.

2.2 TDS for effluent discharged into receiving waters having salinity higher than 2000 mg/l shall not exceed TDS of such receiving waters by 5000 mg/l.

(3) SS (Suspended Solids) shall not exceed 50 mg/l or depending on effluent flow rates, receiving waters or types of factory as defined by Department of Industrial Works, but shall not exceed 150 mg/l in any case.

(4) Heavy metals

4.1 Mercury	not more than	0.005	mg/l
4.2 Selenium	not more than	0.02	mg/l
4.3 Cadmium	not more than	0.03	mg/l
4.4 Lead	not more than	0.2	mg/l
4.5 Arsenic	not more than	0.25	mg/l
4.6 Chromium			
4.6.1 Hexavalent Chromium	not more than	0.25	mg/l
4.6.2 Trivalent Chromium	not more than	0.75	mg/l
4.7 Barium	not more than	1.0	mg/l
4.8 Nickel	not more than	1.0	mg/l
4.9 Copper	not more than	2.0	mg/l
4.10 Zinc	not more than	5.0	mg/l

4.11 Manganese not more than 5.0 mg/l

(5) Sulphide (as H_2S) shall not exceed 1.0 mg/l.

(6) Cyanide (as HCN) shall not exceed 0.2 mg/l.

(7) Formaldehyde shall not exceed 1.0 mg/l.

(8) Phenol compounds shall not exceed 1.0 mg/l.

(9) Free Chlorine shall not exceed 1.0 mg/l.

(10) Pesticides shall not be detectable.

(11) Temperature shall not exceed 40° C.

(12) Colour shall not be offensive.

(13) Odour shall not be offensive.

(14) Oil and Grease shall not exceed 5.0 mg/l or depending on effluent flow rates, receiving waters or types of factory as defined by Department of Industrial Works, but shall not exceed 15 mg/l in any case.

(15) BOD (Biochemical Oxygen Demand) at temperature 20° C, 5 days shall not exceed 20 mg/l or depending on effluent flow rates, receiving waters or types of factory as defined by Department of Industrial Works, but shall not exceed 60 mg/l in any case.

(16) TKN (Total Kjeldahl Nitrogen) shall not exceed 100 mg/l or depending on effluent flow rates, receiving waters or types of factory as defined by Department of Industrial Works, but shall not exceed 200 mg/l in any case.

(17) COD (Chemical Oxygen Demand) shall not exceed 120 mg/ or depending on effluent flow rates, receiving waters or types of factory as defined by Department of Industrial Works, but shall not exceed 400 mg/l in any case.

Item 3 Determination methods for Effluent Standards as stated in item 2 are as follows:

(1) pH is measured by a pH Meter.

(2) TDS is determined by evaporation at 103° C to 105° C, 1 hour.

(3) SS is determined by using Glass Fibre Filter Disc.

(4) Heavy metals are determined by the following methods:

4.1 Zinc, chromium, cadmium, barium, lead, nickel and manganese are determined by Direct Aspiration -Atomic Absorption Spectrophotometry or Inductively Coupled Plasma

(ICP)-Plasma Emission Spectroscopy,

4.2 Arsenic and selenium are determined by Hydride Generation-Atomic Absorption Spectrophotometry or Inductively Coupled Plasma (ICP)-Plasma Emission Spectroscopy,

4.3 Mercury is determined by Atomic Absorption Cold Vapour Technique.

(5) Sulphide is determined by titration.

(6) Cyanide is determined by distillation, followed by Pyridine-Barbituric Acid method.

(7) Formaldehyde is determined by Spectrophotometry.

(8) Phenol compounds are determined by distillation, followed by 4-Aminoantipyrine.

(9) Free chlorine is determined by Iodometric method.

(10) Pesticides are determined by Gas-Chromatography.

(11) Temperature is measured by thermometer while sampling.

(12) Oil and grease is determined by solvent extraction, followed by evaporation.

(13) BOD is determined by by using Azide Modification method at 20° C, 5 days or any other methods approved by Department of Industrial Works.

(14) TKN is determined by Kjeldahl method.

(15) COD is determined by Potassium Dichromate Digestion method.

Item 4 Determinations of effluent characteristics stated in Item 3 shall follow either Water and Wastewater Analysis Handbook published by the Environmental Engineer Association of Thailand or Standard Methods for the Examination of Water and Wastewater edited by the American Public Health Association, the American Water Work Association and the Water Environment Federation of America.

Issued on : 14 June, B.E. 2539 (1996)

(Mr. Chaiwat Sinsuwong)
Minister of Industry

This Notification was published in the Royal Government Gazette, volume 113, part 52D, dated 27 June, B.E. 2539 (1996)

<u>Remarks</u>: This is the unofficial translated version prepared by the working group appointed by Department of Industrial Works (Order No.141/2541). In case of any differences, the original Thai version shall prevail.

Royal Emblem

Notification of Department of Industrial Works

Subject: Define Effluent Standards Differentiated from Ministerial Notification No.2 B.E. 2539 (1996) subject: Industrial Effluent Standards

With reference to Ministerial Notification No.2 B.E. 2539 (1996) subject: Industrial Effluent Standards, item 2 (15), (16), and (17), Department of Industrial Works is designated to issue different effluent standards regarding BOD (Biochemical Oxygen Demand), TKN (Total Kjeldahl Nitrogen) and COD (Chemical Oxygen Demand) from which announced in that Notification depending on effluent flow rates, receiving waters or types of factory.

Department of Industrial Works hereby announces the effluent standards differentiated from Ministerial Notification No.2 B.E. 2539 (1996) subject: Industrial Effluent Standards as follows:

Article 1 BOD (Biochemical Oxygen Demand) at 20° C, 5 days shall not exceed 60 mg/l for the following types of factory specified in the schedule annexed to Ministerial Regulation (B.E. 2535) issued under the Factory Act B.E. 2535:

1.1 Serial No.4(1) A factory engaged in activities connected with non-aquatic animals i.e., animal slaughtering.

1.2 Serial No.9(2) A factory engaged in activities connected with plant grain or root i.e., starch producing.

1.3 Serial No.10 A factory engaged in production of items of food from flour having the following activities:
- (1) producing bread or cake,
- (2) producing biscuit or crackers,
- (3) producing products from flour in strings, pellets, or pieces.

1.4 Serial No.15 A factory engaged in the following activities:
- (1) producing mixed or ready-made feed for animals,
- (2) grinding or crushing plant, plant seed, plant residue, meat, animal bones, animal hair or shells for preparing or mixing in animal feed.

1.5 Serial No.22 A factory engaged in production of items of textile, thread, or fibre other than asbestos having the following activities:
- (1) retting, carbonizing, carding, combing, pressing, spinning, ginning, winding, threading, texturizing, bleaching or dyeing fibre,
- (2) weaving or preparing warps for weaving,
- (3) bleaching, dyeing or finishing thread or textile,
- (4) printing textile.

1.6 Serial No.29 A factory engaged in soaking, cutting,drying, crushing or grinding, tanning, polishing and finishing, currying, embossing or colouring animal hides.

1.7 Serial No.38 A factory engaged in production of pulp or paper having the following activities :
- (1) producing pulp from wood or other materials,
- (2) producing paper, cardboard, or paper for construction made from fibre or fibreboard.

1.8 Serial No.42 A factory engaged in production of items of chemical substances, chemical compounds or chemical materials which are not fertilizers having the following activities :

(1) producing chemical substances, chemical compounds or chemical materials,
(2) storing, conveying, separating, sorting or re-containing hazardous chemical substances.

1.9 Serial No.46 A factory engaged in production of items of drugs having the following activities:

(1) producing materials certified in the pharmacopoeia as notified by the Minister of Public Health,
(2) producing materials intended for use in analyzing, curing, relieving, or preventing diseases or pains in human beings or animals,
(3) producing materials intended for bringing about effects to health, structures, or functions of body of human beings and animals, as notified by the Minister of Public Health.

Nevertheless, materials pursuant to (1) or (2) do not include materials intended for use as food, sport equipment, cosmetics, instrument and parts thereof for practising therapeutics and their accessories.

1.10 Serial No. 92 A cold storage

Article 2 TKN (Total Kjeldahl Nitrogen) shall not exceed 200 mg/l for the following types of factory specified in the schedule annexed to Ministerial Regulation (B.E. 2535) issued under the Factory Act B.E. 2535:

2.1 Serial No.13(2) A factory engaged in production of items of ingredients or food flavouring i.e., producing food flavouring, condiment or food dyestuff.

2.2 Serial No. 15(1) A factory engaged in production of animal feed i.e., producing mixed or ready-made feed for animals.

Article 3 COD (Chemical Oxygen Demand) shall not exceed 400 mg/l for the following types of factory specified in the schedule annexed to Ministerial Regulation (B.E. 2535) issued under the Factory Act B.E. 2535:

3.1 Serial No.13(2) A factory engaged in production of items of ingredients or food flavouring i.e., producing food flavouring, condiment or food dyestuff.

3.2 Serial No. 15(1) A factory engaged in production of animal feed i.e., producing mixed or ready-made feed for animals.

3.3 Serial No.22 A factory engaged in production of items of textile, thread, or fibre other
than asbestos having the following activities:

(1) retting, carbonizing, carding, combing, pressing, spinning, ginning, winding, threading, texturizing, bleaching or dyeing fibre,
(2) weaving or preparing warps for weaving,
(3) bleaching, dyeing or finishing thread or textile,
(4) printing textile.

3.4 Serial No.29 A factory engaged in soaking, cutting,drying, crushing or grinding, tanning, polishing and finishing, currying, embossing or colouring animal hides.

3.5 Serial No.38 A factory engaged in production of pulp or paper having the following activities :

(1) producing pulp from wood or other materials,
(2) producing paper, cardboard, or paper for construction made from fibre or fibreboard.

Issued on : 18 February, B.E. 2540 (1997)

Mr. Thien Mekanontchai
Director General
Department of Industrial Works

<u>Remarks</u>: This is the unofficial translated version prepared by the working group appointed by Department of Industrial Works (Order No. 141/2541). In case of any differences, the original Thai version shall prevail.

Appendix B

Table B1 Effluent standards from Enhancement and Conservation of National Environmental Act B.E. 2535 (1992)

Items	Unit	Standard values
pH	-	5.5 - 9.0
Total Dissolved Solids (TDS)	mg/l	not more than 3,000 mg/l depending on receiving water or type of industry under consideration of Pollution Control Committee (PCC) but not exceed 5,000 mg/l not more than 5,000 mg/l exceed TDS of receiving water having salinity of more than 2,000 mg/l or TDS of sea if discharge to sea
Suspended Solids (SS)	mg/l	not more than 50 mg/l depending on receiving water or type of industry or type of wastewater treatment system under consideration of PCC but not exceed 150 mg/l
Temperature	^{o}C	not more than 40
Colour and Odor	-	not objectionable
Sulfide (as H_2S)	mg/l	not more than 1.0
Cyanide (as HCN)		not more than 0.2
Heavy Metals		
Zinc	mg/l	not more than 5.0
Chromium (Hexavalent)	mg/l	not more than 0.25
Chromium (Trivalent)	mg/l	not more than 0.75
Arsenic	mg/l	not more than 0.25
Copper	mg/l	not more than 2.0
Mercury	mg/l	not more than 0.005
Cadmium	mg/l	not more than 0.03
Barium	mg/l	not more than 1.0
Selenium	mg/l	not more than 0.02
Lead	mg/l	not more than 0.2
Nickel	mg/l	not more than 1.0
Manganese	mg/l	not more than 5.0
Fats Oil and Grease (FOG)	mg/l	not more than 5 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 15 mg/l
Formaldehyde	mg/l	not more than 1.0
Phenols	mg/l	not more than 1.0
Free Chlorine	mg/l	not more than 1.0
Pesticides	mg/l	not detectable
Biochemical Oxygen Demand (BOD)	mg/l	not more than 20 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 60 mg/l
Total Kjeldahl Nitrogen (TKN)	mg/l	not more than 100 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 200 mg/l
Chemical Oxygen Demand (COD)	mg/l	not more than 120 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 400 mg/l

Remarks:
Notification of the Pollution Control Committee (PCC) No.3 B.E. 2539 (1996) has issued types of factories that are allowed to discharge effluent having different standards from the Ministerial Notification above as follows:

BOD up to 60 mg/l:
Animal finishing factories, Starch factories, Food from starch factories, Animal food factories, Textile factories, Tanning factories, Pulp and paper factories, Chemical factories, Pharmaceutical factories, Frozen food factories

COD up to 400 mg/l:
Food furnishing factories, Animal food factories, Textile factories, Tanning factories, Pulp and paper factories.

Appendix C

Table C1 Standards for discharge from factories in IEAT

Industrial Estate	BOD_5 at 20^oC	COD	SS	TDS	TKN	pH	Heavy Metal													Total Iron	Fluoride	Sulphide	Cyanide as HCN	Formaldehyde	Phenols Compound	Chloride as Cl_2	Free Chlorine	Pesticide	Temperature ^oC	Color	Odor	Oil & Grease	Radioactive	Surfactants
							Hg	Sc	Cd	Pb	As	Cr^{3+}	Cr^{6+}	Ba	Ni	Cu	Zn	Mn	Ag															
Bangchan[1)]	20	120	50	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	-	-	5	1	.2	1	1	-	1	.	40	.	-	5	.	-
Laemchabang	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Lampoon	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Map Ta Phut																	5	5			5													
- To central plant	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
- To sea[1) 2)]	20	120	50	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	-	-	5	1	.2	1	1	2000	1	.	40	.	-	5	.	-
Lardktrbang	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Kangkoy	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Plangyao	500	750	200	3000	100	5.5-9	.005.	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Banwa	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Bangpayin	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Bangplee	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Phadang[1),2)]	20	120	50	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	-	-	5	1	.2	1	1	-	1	.	40	.	-	5	.	-
Welgrow	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Eastern	750	1000	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Borwin	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Hnongkhae	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Samutsakorn	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Sahrattana	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
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Eastern Seaboard	500	120	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Unyatanee	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Southern	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Bangpu																	5	5			5													
- General	1000	1500	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
- General (A) &	500	120	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Export	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Pichit	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Amato Nakorn	500	750	200	3000	100	5.5-9	.005.	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
- Phase 1,2,3 and 4	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
- Phase 5 and 6	500	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Pinthong	**500**	750	200	3000	100	5.5-9	.005	0.02	0.03	.2	.25	.75	.25	1	1	2	5	5	1	10	5	1	.2	1	1	2000	1	.	45	.	-	10	.	30
Amata City																												.		.	-	.		

Remarks: 1) Factories located in Bangchan, Phadaeng, and Map Ta Phut industrial estate can discharge their effluent to the sea. However, only for COD have to comply with the standard of Ministry of Industry and Ministry of Science. In addition, each case depends on the quality of water receiver basin and COD must lower than 400 mg/l in all cases.

2) Effluent, which discharged to sated water basin which, has salinity higher than 2,000 mg/l, TDS must not exceed TDS in fresh water basin than 5,000 mg/l

' is refer to must not be monitored by the selected method.

" is refer to must not be versioned.