Wastewater Reuse Potentials in Thailand

C. Visvanathan and Prajapati Shapkota
Environmental Engineering and Management, Asian Institute of Technology
PO Box 4, Khlong Luang, Pathumthani 12120, Thailand.
Email: visu@ait.ac.th

Abstract

This paper is intended to highlight the potentials of wastewater reuse in three sectors of water users – domestic, agriculture and industry in Thailand. It describes and examines the country's water resources with respect to its basins *vis-à-vis* its present surface and groundwater water use scenario. It illustrates the current situation with regards to the municipal and industrial wastewater treatment and the trend for increasing their capacities. Reuse practices of treated effluents by municipalities, industries and agriculture is described as well as practices and potentials of desalination of brackish and sea water. The consequences of excessive groundwater withdrawal are cited and how aquifer recharge could be achieved to prevent land subsidence in areas of excessive withdrawal. The requirement of administrative and legislative framework for water resource inventory, planning, use, reuse, quality control and protection is described so that a future crisis of water availability and use in the country can be averted. Suggestions for optimizing the reuse potential of wastewater have been given.

Keywords: Water basins, surface water, underground water, effluent, reuse

1. Introduction

Thailand is an agrarian country having a population of 63 million and a total area of 51.3 million hectares. Its hydrological basin is divided into 25 river basins and it receives average annual rainfall of 1630 millimeters that translates into 836 billion m^3 of water. The precipitation is not uniform being confined to the monsoon season (85%) between May and October. It is concentrated mostly in the central and the southern regions causing floods while the northern regions experience drought. This uneven distribution of water is not in accordance to the distribution of water demand throughout the country. Thailand of late has witnessed increased industrial activities as a newly agro-industrializing nation. Consequently, water consumption by the increased agricultural activities and the mushrooming industrial sector has severely put constraints on the available and abstractable water resources. In addition, the increase in employment opportunities in the urban/industrial sector has induced the rural to urban migration of the population increasing the pressure on water demand.

1.1 National water resources

Thailand's surface runoff has been estimated to be 212 billion m^3 (OEPP, 1999) after deducting evaporation and infiltration losses. The average per capita water availability is the lowest in Asia being only 1854 m^3. The surface water volume per person is also the lowest in Asia indicating that the country is under stress in water resources (TEM, 2001). The total annually available renewable reserve of water is estimated at 199 billion m^3 of surface and groundwater. Of this, 80-90% is generated during the rainy season (Visvanathan and Cippe, 2002). The major provider of surface water is the basin of Chao Phraya River which begins in the north and flows into the Gulf of Thailand passing through the major industrial belt of the country, the Bangkok Metropolitan Region (BMR) and its suburban areas. Groundwater abstraction is estimated to be 8.99 billion m^3 mostly confined to the BMR and it suburbs.

Thailand's river basins, based on the regions are given in table 1. The country has paid large environmental costs for its rapid economic development. The forest cover has reduced from 53% in 1961 to 25% in 1998 followed soil erosions and decreased precipitation. Only about 14% of surface water resources are suitable for general human consumption. About 37% of the surface water has been assessed to be unfit even for agricultural use in the industrial region primarily the lower reaches of the Chao Phraya and Tha Chin rivers (Laplante and Meisner, 2001). This is mainly caused by discharges of domestic sewage, industrial effluents and agricultural runoffs. The rest (49%) is regarded as safe for agri-aquaculture use and general consumption. An assessment of the water consumption pattern and discharge of pollution loads from industrial activities would provide a broader view on the environmental damage to the water bodies that happens to be the severest in the BMR. Table 1 also illustrates sector contribution of the discharge of organic pollution load by agriculture, industry and domestic sources into the surface water bodies.

Table 1. Water basins in Thailand per region (TEM, 2001)

Region/ Water Basin	Basins	Percentage of Sector Contribution to Total BOD Generation		
		Agriculture	Domestic	Industry
Central (4)	Chao Phraya, Tha Chin, Mae Klong, Lower Pasak, Sakae Krung	37	39	24
Eastern (4)	Bang Pakong, Tonle Sap, East Coast-Gulf, Prachinburi	17	50	33
Northern (10)	Nan, Ping, Wang, Yom, Upper Pasak, Kok, Ing Kuang Li	6	83	11
Northeastern (3)	Chi, Mekong, Moon	41	57	2
Southern (7)	Songkhla, Bangnara, Khlongta, Kuiburi, Langsuan, Pattani, Pranburi, Saiburi, Tapipum, Trang	26	63	11

2. Water Use and Wastewater Generation

Water withdrawal or use in the country is primarily in agriculture (89.5%), domestic sector (7%) and by industry, and have had to face a crisis of sharing. The past two decades of rapid industrial activities in Thailand shows increasing water use with agriculture dominating the scenario while domestic and industrial consumption has trebled in the last decade. This increasing trend of water use from table 2 is an indication of the country's rapid economic growth and in the current decade, a similar trend is anticipated. The ratio of water use to availability was more than 16% of the total annual renewable resource in 1995. This is close to the threshold limit of 20%. This increasing trend and forecast for 2010 indicate a danger zone of water use – a clear issue of unsustainable development. The remaining water after use remains as the buffer stock in case of water scarcity and other environmental problems due to salination of coastal aquifers and desertification. However, increase in use would ultimately result in the consumption of this stock and hence measures are required to prevent further use by recycling the resource.

Table 2. Water quantity required by major sector (TDRI, 1990)

Year	Amount of Renewable Resource (billion m^3)	Total Amount Withdrawn	Domestic	Industry	Agriculture
1990	199	43	2	1	40
2000	199	85	6	3	76
2010	199	167	15	8	144

2.1 Wastewater generation

Water demand generates wastewater, the characteristics of which depend on the end use of water. Each of the river basins cited above in table 1 indicate the level of sector organic pollution. The discharge of the wastewater into the environment in addition to the natural causes, contaminates the natural water systems making it unsuitable for use. For the purpose, wastewater requires to be treated prior to disposal. This treated effluent can be either directly reused or indirectly used for which suitable secondary and advanced treatment systems that meet the water quality requirement would be necessitated. The resultant wastewater from the use would then find its way into the buffer stock and deteriorate its quality for which preventive measures are required. An assessment of the pollution load by the industries is presented in terms of biochemical oxygen demand (BOD) and suspended solids (SS) discharge by the different types of industries (Table 3). To reduce the pollution load, wastewater treatment has been made mandatory with set standards for discharges. Various initiatives and incentives are being provided to the industrial sector for decrease in water use and adoption of cleaner technology, and reuse of water. Ways to minimize net water consumption by a closed loop between use and reuse requires to be established.

Table 3. Contribution of industrial sectors to industrial water pollution in Thailand (Laplante and Meisner, 2001)

BOD	% Contribution to Total
Pulp, Paper and Paperboard	32
Industrial Chemicals except Fertilizer	15
Sugar Factories and Refineries	10
Distilled Spirits	9
Dairy Products	8
Nonferrous Metals	7
TSS	
Iron and Steel	61
Pulp, Paper and Paperboard	9
Nonferrous Metals	9
Jewelry and Related Articles	7
Drugs and Medicines	3
Sporting and Athletic Goods	2

3. Wastewater Treatment and Reuse

3.1 Wastewater treatment

There are 83 wastewater treatment plants (WWTP) throughout Thailand with a total capacity of treating 2.84 million m^3 of wastewater per day. However, currently only half of them are in good operational condition (ONEP, 2001). The number of WWTPs may reach 250 within the next 20 years. BMR has six central WWTP in operation to treat almost a million m^3 of domestic wastewater and serve an area of 191.7 km^2 with a population about 3 million. Table 4 shows the municipal WWTPs of Bangkok with their capacity, service area and population served. There are three new proposed projects that would treat an additional 1.12 million m^3 of wastewater and provide service to 177 km^2 of BMR. Four more projects are being included in the 6th Bangkok Metropolitan Development Plan. Bangkok Metropolitan Administration (BMA) also operates 12 community WWTPs with a total capacity of 25,700 m^3/day. A portion of the treated effluent is used for street washing and watering plants along the street as a demonstration pilot project. Whereas the major portion of the treated effluent is being discharged either directly into Chao Phraya River or into the canals to help improve their water quality (UNEP, 2001).

Onsite system is widely practiced for domestic wastewater treatment in Thailand mainly for large buildings. Most of the residential units in a municipality use septic tanks and soak-pits to treat toilet wastewater while the grey water is directly discharged into storm drains.

Table 4. Wastewater Treatment Plants of Bangkok Municipal Region (UNEP, 2001)

Plant	Capacity (m^3/day)	Area served (km^2)	Population
Si Phraya	30,000	2.7	120,000
Rattanakosin	40,000	4.1	70,000
Dindaeng (BMA-1)	350,000	37.0	1,080,000
Chongnonsi	200,000	28.5	580,000
Nongkhaem-Phasicharoen- Ratburana	157,000 65,000	44.0 42.0	520,000 177,000
Bangkok-4	150,000	33.4	432,500
Total	**992,000**	**191.7**	**2,979,500**

There are 30 industrial estates in Thailand and each is equipped with a Central Effluent Treatment Plant (CETP). The total effluent treatment capacity is more than 300,000m^3/day in addition to individual treatment units of some of the industries. A portion of the treated effluent is used on ad-hoc basis within the industrial estate and the excess is discharged into the water bodies.

The largest CETP in Thailand is under construction in Samut Prakarn province, Thailand's primary industrial region. It was envisaged to manage 450,000 m^3/day of discharge from the industrial, commercial and residential sectors with a BOD loading of 150 tons per day (as in 1995) This Samut Prakarn Wastewater Management Project (SWMP) would be able to collect industrial effluents and treat 525,000 m^3/day (ADB, 2003).

The primary problem in the non-functional treatment plants is lack of manpower, budget constraints and lack of revenue raising methods. Though many of the CEPTs in industrial estates have been able to organize the user charges, most of the municipal WWTPs do not have such a mechanism and are considering the option of levying user charges.

3.2 Wastewater reuse

The tariff of treated water has increased from US$ 0.095 – 0313 (THB 4.00 – 13.00) in recent years (TEM, 2001). A further increase is anticipated and the consumers would have to find options of reducing net water consumption by adopting reclamation of wastewater and its reuse. In many industrial sectors, this change in water tariff was found to be the driving force behind promoting internal wastewater reuse. The present scenario of treated wastewater being discharged into water bodies (river and canals) provides an insight into the quantity available for reuse for which necessary guidelines and initiatives are required.

3.2.1 Industrial effluent reuse

The industrial effluent from the 30 CETPs are being used within the estates for secondary purposes. Source removal of industrial pollutants where technically feasible would facilitate recycling and reuse of the pollutant constituents as well as the reuse of the wastewater. This method of wastewater management would shift from the conventional end-of-pipe approach to a source treatment approach by creating a closed loop (recycle) water metabolism. There are some examples of wastewater reuse in a pulp and paper and a sugar industry which have used the concept of cleaner production and closed loop for reclamation and reuse of effluent

3.2.2 Agricultural reuse

Most often, the peri-urban areas use reclaimed municipal wastewater and nutrients for agricultural purposes for which a large proportion of water supplied to cities can be collected and redirected to the surrounding environment. This source of water is reliable with a more or less constant rate flowrate. Treatment and reuse of wastewater solve the urban waste problem, maximise water use efficiency and sustain or promote agriculture. Wastewater can be used as a source of irrigation water as well as a source of plant nutrients, allowing farmers to reduce or even eliminate the purchase of chemical fertilizers. Many of the WWTPs in Thailand are located in agricultural areas at the outskirts of the urban areas with a high potential of effluent reuse in agriculture. Reuse of treated municipal effluent would help reduce fertilizer demands (presence of nutrients in the effluent) and act as a reservoir to alleviate shortage of water during the dry seasons. Wastewater is also a potential source of fertilising elements (UNDP, 1987). The treated effluents from the CETP are being informally used for irrigation of the industrial estates and parks.

Another example of wastewater reuse is in fish farming that assists in the treatment of wastewater by reducing the levels of suspended solids and algal growth in wastewater. This improves the quality of the final effluent that can be used for crop irrigation and other uses. Wastewater treatment using fishponds is a natural process that degrades and stabilizes organic wastes. The organic wastes fertilize a fishpond and stimulate growth of microorganisms to serve as fish food.

In Thailand, there is a tremendous potential for agri-aquaculture reuse, and it has been practiced for generation more on informal/ad-hoc approach. Most of the peri-urban agri-aquaculture activities depend to a large extent partially treated domestic and industrial wastewater. Nevertheless, promotion of reuse by the government with appropriate technical and legislative assistance would pave way for increased reuses enabling added benefits to the farming community.

3.2.3 Groundwater recharge

Ground water supply serves for one-fifth of Thailand's 200 towns and cities, and half of 700 municipalities with more than 200,000 wells of 7.55 million m^3/day capacity. This is estimated to be 75% of domestic supply to about 35 million people (Gupta and Babel, 2002). The withdrawal can be replenished with recharge of the aquifers by the effluent from the treatment plants with infiltration from aerated lagoons and stabilization ponds (Kijjanapanich and Karnchanawong, 2002). Other methods of groundwater recharge can be using percolation tanks, trenching, well injection etc. In developing countries, discharge into the environment of untreated or inadequately treated wastewater can result in unplanned and uncontrolled infiltration to aquifers in arid climates. This incidental infiltration becomes a significant reuse of urban wastewater. Though this is a natural treatment of wastewater, it can also pollute the aquifers used for potable water supply unless the aquifer recharge is monitored.

The amount of wastewater treated and discharged in BMR and Samut Prakarn Wastewater project would be able to provide about three million m^3 of treated effluent (when in full operation) which could be potentially used for agricultural purposes in the province both for crops and ornamental plantations, aquaculture (freshwater fisheries), and groundwater recharge in the province. The costal zone and BMR is facing land subsidence due to excessive withdrawal of ground water by the industries. BMR has been making restrictions on groundwater withdrawal by raising the price of groundwater from US$ 0.075 – 0.20 (THB 3 - 8) per m^3 over a period of 4 years and has identified area for recharging the aquifers using reclaimed water (Seemakachorn, 2002). This raise in price would discourage the industries that depend on groundwater and divert to public surface water supplies.

3.2.4 Other reuses

In Thailand, the use of the treated or untreated effluent is not formalized but is widely practiced primarily during the dry season as water availability decreases for the peri-urban areas and unplanned segments of the urban habitats. These peri-urban irrigated areas devote to the production of different crops, vegetables and practice aquaculture. To use reclaimed water for the irrigation of fodder crops, field crops (cereals, industrial crops) or forest trees, a secondary treated effluent should be of sufficient quality. Unless a right combination of wastewater treatment is used, protection of public health cannot be achieved for its use in agriculture. Wastewater and sewage sludge can be used in the peri-urban areas with wastewater reuse as an integral part of overall environmental pollution control and a country’s overall water resources balance.

Other reuses of wastewater that are currently practiced more on ad-hoc manner are:

- Irrigation of urban environments: parks, gardens, golf courses, clubs, residential areas, cemeteries, green belts, lawns and flowers beds;
- Environmental and recreational uses: lakes and reservoirs, wetlands and increase of runoff; and
- Urban non-potable uses: fire fighting and toilet flushing.

4. Administrative and Legislative Aspects

Thailand is experiencing an increased water demand in its three sectors (agriculture, industry and domestic) and the requirement exceeds the readily available supply. There is a need for research and development (R&D) for projecting the future demand for water and potentials for reuse. Setting up water rights and allocation plans would be able to tackle and minimize the conflicts in water distribution and reuse. The administration would have to organize means for legislating relevant regulations for water use and administering them vis-à-vis R&D in the sector.

4.1 Administrative aspects

Thailand has established 30 industrial estates and parks to promote industrial growth and help pollution monitoring and control. Common effluent treatments plants (CETP) have been established to meet the stringent effluent standards set by the Pollution Control Department (PCD). Taking into consideration the water demand and wastewater disposal issues, various water reuse potentials need to be studied with a view to develop sustainable industrial water reclamation and reuse. For effective planning of the reuse of wastewater be it from industries, agriculture or domestic sources, the issues that would have addressed to optimize the reuse potentials are:

- Project planning and adoption of reuse technology along with its economic feasibility and advantage over the use of fresh water;
- Establishment of market for reclaimed water; and
- R&D of economically attractive technology.

Further, the Royal Thai Cabinet has initiated privatization of water resource management by forming a corporate agency East Water Company under the Provincial Water Authority (PEA) for water management in the eastern region and the coastal areas. Similarly, in the BMR, the Metropolitan Waterworks Authority manages the water supply. Privatizing or corporatizing of water supply schemes would be a positive approach for water management in the country, which would fix user charges and promote reuse presently practiced informally by the East Water Company. Such a method would spearhead development of further reuse of wastewater.

4.2 Legislative aspects

There is no well-planned legal framework in Thailand for water resource inventory, planning, use, reuse, quality control and protection (Gupta and Babel 2003). Watercourses are freely available for withdrawal and use. Legislative provisions do not enforce reuse of wastewater. What is practiced on ad-hoc basis requires to be formalized under set legislative and administrative provisions. Thailand has over the past 15 years focused on management of water pollution with infrastructure for domestic and industrial wastewater treatment systems and setting up of effluent discharge standards. It is imperative for the environmental agencies to develop appropriate water reuse guidelines and set effluent standards for various reuses to prevent the associated potential environmental and health risks. The increasing demand for water and the limited availability of surface water and over-used ground water has brought about a water stress in the country.

The use of wastewater would affect the handlers and consumers of produce (agriculture and aquaculture products) due crop-contamination and disease links to water based pathogen and bioaccumulation of the toxic metals and substances through plants that absorb from the soil or wastewater. Therefore, legislation should make stringent effluent standards and guidelines to enable reuse and protect human and environmental health:

- Remove or detoxify the contaminants in wastewater and disinfect it;
- Modify agri–aquacultural practices (prohibit irrigation of leafy vegetables with untreated sewage and use holding ponds for aquaculture);
- Regulate human consumption of certain products; and
- Educate handlers and consumers for protective practices.

At the same time, legislation should take into consideration the reduction of fresh water usage and promotion for reclaiming and recycling activities within the framework of the industries by adopting cleaner production strategies with internal and external reuses. PCD has prioritized high water consuming industries for R&D in water use and options for its reduction by encouraging in-plant waste segregation, recycling and reuse. The initial step for waste minimization and reduction of water consumption by as high as 50% is targeted to be achieved within the next five years.

Legislation and administrative aspects should consider the role of stakeholders in wastewater reuse that are basically three groups: potential end users, relevant government agencies that monitor the water usages, and the community. A common consensus to identify water reuse possibilities would pave way for effective management and control over water demand as well as decrease of the pollution load thus enabling a better control over water quality.

5. Potentials for Wastewater Reuse

Treated effluent from the industries and municipalities can be targeted for several potential uses. That would significantly decrease or stabilize the freshwater consumption that increases with the population while the available resources are limited. These reuses are:

1. Reuse can be within the industry by a closed loop water metabolism or recycle by which the industrial units categorize the use of water based on the quality and the processes. Secondary purposes could be for cooling, boiler feed, surface cleaning, dust suppression, toilet flushing and gardening.
2. Reuse of the effluent from a CETP in an industrial estate/park within it or by another industry within a close range depends upon the quality of water requirement. This internal use has greater potentials. All industrial estates or parks are required by law to make provisions for greenery within its boundary, which are being irrigated to a certain extent by the treated effluents. Cooling water for power plants, metal smelting industries, cutting and fabrication units, brick kilns etc. could use treated wastewater.
3. Treated municipal and industrial effluents can be used to recharge the aquifers as excessive withdrawal of ground water has caused land subsidence (up to 10cm/year in BMR) and seawater intrusion (some wells in the coastal zones report up to 3000 mg/L of dissolved solids). Plans are being made in BMR and Samut Prakarn province.

4. In the BMR, effluents are being discharged into the canals to replenish the water level that decreases during the dry season and to avoid silting, which also help recharge aquifers.
5. Municipal effluents could be safely used for street cleaning, watering plants and parks within a city or municipality with adequate transport arrangements rather using the canal water for the purpose.
6. Thailand has numerous golf courses which have an average water demand of 1000m^3/day and could be the ideal end users of treated effluents.

The primary constraints and reservations for reuse of municipal effluent in parks, golf courses, watering of plants within street premises and street cleaning would be the odor problem, microbial quality and economical transport of reclaimed water.

The use of CETP effluents for secondary purposes within the industrial estates has similar reservations with regard to odor problems and toxic constituents. In addition to the regulation of standards, the cost involved for advanced treatment processes, transport costs (conveyance by pipelines or tankers) need to be attractive and less than the abstraction costs from the ground or centralized supply. Recharge of aquifers would require stringent effluent standards to prevent contamination of good aquifers by toxic substances and dissolved salts for which standard guidance is required.

Technologies can be developed for the reclamation and reuse of building wastewater as in Japan. The treated wastewater can be utilized to flush toilets, irrigating gardens etc. Using biological treatment and membrane separation, sludge generation can be reduced with methane gas recovery in a compact facility. This reuse is primarily suitable for large commercial complexes, shopping malls, hotels and even institutions.

Desalination: Salinization has become a major concern in the northeast and south of Thailand along the coast caused by saline water intrusion into the aquifers due to excessive groundwater withdrawals, saline water irrigation and expansion of brackish water aquaculture. Areas with scarcity of fresh water would require to adopt desalination of the brackish water and seawater in the coastal zones using modern methods like reverse osmosis, which in particular is reliable, consumes less energy, and is easy to operate and maintain. Industries too could adopt the desalination process for obtaining fresh water. Thailand has a desalination capacity of 24,075m^3/day. One such industrial unit is the salination plant operated by Esso Sriracha Refinery, Chonburi.

6. Conclusion

The potentials for reuse of wastewater are increasing with the ad-hoc adoption of various technologies by the industrial and municipal sector for tapping the resources. In the agricultural sector, greater emphasis is required. Since the reuse process is already underway, albeit in a small scale, the potentials would further increase if the legislative and administrative sector make efforts to formalize reclaiming of water and reuse in view of the increasing population and water demand as well rapid industrialization. The legal measures have so far focused only on the prevention of pollution with setting up of stringent effluent discharge standards for municipal and industrial discharges. The legislative measures should encourage reclaiming and reuse of wastewater in industries and industrial estates, enforce strict measures to decrease excessive ground water withdrawals and regulate surface water use between the consumers to avert a water stress in the country. The present use of water and its escalating tendency would require resource conservation and it can only be achieved with sincere efforts and consensus among the stakeholders. Adoption and adaptation of appropriate technology would enhance the recycle and reuse of water from all sectors of consumption.

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C. Visvanathan, Ph D
P. Shapkota, M. Eng

Environmental Engineering and Management Program
Asian Institute of Technology, Thailand

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Wastewater Reuse Potentials in Thailand

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8. To conclude

Introduction

Thailand

- Is an agrarian country of area of 51.3 million ha and population of 63 million
- Hydrological basin has 25 river basins
- 85% of rainfall mostly during May–Oct. in central and southern regions
- Total rainfall of 1630mm = 836 km^3 of water
- With rapid agro-industrialization, water consumption in agriculture, industry and domestic sectors has been increasing significantly

There are constraints on the available and abstractable water resources due to rapid unplanned urbanizations and rural to urban migrations

Thailand's National Water Resources

Surface water resources

- **Surface runoff is estimated to be 212 km^3 and renewable reserve of water - 199 km^3**
- **Av. per capita availability - 1854m^3**
- **Major provider - Chao Phraya basin has the major industrial belt – Bangkok Metropolitan Region**
- **Of the total, 14% is suitable for domestic/industrial use, 37% is unfit and 49% regarded safe for agri/aquaculture use**

Groundwater resources

- **Abstraction - 8.99 km^3 mostly in BMR and its suburbs which is causing subsidence**

Throughout Thailand, forest cover has reduced from 53- 25% (from 1961 to 1998)

Environmental damage to water bodies is severest in the Bangkok Metropolitan Region

Water Basins and Pollution by Sector

Region/ Water Basins	Basins	Percentage of Sector Contribution to Total BOD Generation		
		Agri.	Dom.	Ind.
Central (4)	Chao Phraya, Tha Chin, Mae Klong, Lower Pasak, Sakae, Krung	**37**	**39**	**24**
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Southern (7)	Songkhla, Bangnara, Khlongta, Kuiburi, Langsuan, Pattani, Pranburi, Saiburi, Tapipum, Trang	**26**	**63**	**11**

Water Use

Water quantity required by major sector (TDRI, 1990)

Year	Amount of Renewable Resource (10^9 m^3)	Total Amount Withdrawn	Dom.	Ind.	Agri.
1990	199	43	2	1	40
2000	199	85	6	3	76
2010	199	167	15	8	144

Water use: agriculture - 89.5%; domestic 7%; industry – 3.5%

Water use : availability was 16% of the total resource in 1995 which is close to threshold limit of 20%. By 2010 a danger zone of water use is seen which is clearly unsustainable for the country.

Wastewater Generation

- Characteristics depend on end use of water
- Discharge of wastewater into the environment contaminates natural water systems making them unsuitable for use
- WW requires to be treated with suitable secondary and advanced systems
- Assessment of pollution load by industries is presented in terms of BOD and SS
- To reduce pollution load, treatment is mandatory with set standards.

Various initiatives and incentives are being provided to decrease water use, adopt cleaner technology and reuse of water.

Wastewater Treatment

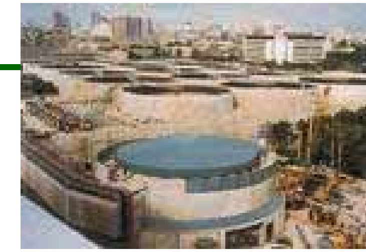
National scenario for domestic wastewater

- **83 WWTPs of 2.84 Mm^3/day capacity but only half are operational**
- **Number of WWTPs may reach 250 within the next 20 years**
- **Onsite system is widely practiced for domestic wastewater treatment in large buildings**

Bangkok Metropolitan Region (BMR) Scenario

- **BMR has 6 WWTPs to treat 1.0Mm^3/day of domestic wastewater**
- **Additional 1.12 Mm^3 of wastewater treatment is envisaged**
- **BMA operates 12 community WWTPs of 25,700 m^3/day capacity**
- **Major portion of treated effluent is discharged into the Chao Phraya River or into the canals**

Wastewater Treatment …



Plants of BMR

Plant	Cap. (m^3/day)	Area (km^2)	Pop. served
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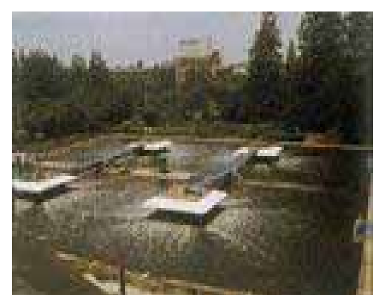


Wastewater Treatment…..

Central Effluent Treatment Plants

- **One in each of the 30 industrial estates**
- **Total effluent capacity < 300,000m^3/day**
- **Portion of the treated effluent is used on ad-hoc basis**
- **Ind. estates organize user charges from each industry**
- **The largest one, Samut Prakarn Wastewater Project has been designed to collect and treat 525,000 m^3/day**

Non-functional treatment plants

- **Manpower, budget constraints and lack of revenue raising methods.**

Most municipal WWTPs do not have a mechanism of levying charges for wastewater treatment as in the CETPs where the industries in the estates are obliged to pay by default.

Industries and Water Pollution

BOD	% Contr.
Pulp, Paper and Paperboard	32
Industrial Chemicals except Fertilizers	15
Sugar Factories and Refineries	10
Distilled Spirits	9
Dairy Products	8
Nonferrous Metals	7
TSS	
Iron and Steel	61
Pulp, Paper and Paperboard	9
Nonferrous Metals	9
Jewelry and Related Articles	7
Drugs and Medicines	3
Sporting and Athletic Goods	2

Wastewater Reuse

Water Supply

- **Tariff of treated water has been increased from US$ 0.095 – 0.313**
- **Increased water tariff has helped reduce net water consumption**
- **It is the driving force for the reclamation of wastewater and its internal reuse**

Presently, most treated wastewater is discharged into water bodies

For reuse, necessary policy guidelines and initiatives are required

Wastewater Reuse ...

Industrial effluent reuse

- **Effluents from CETPs used within the estates**
- **Pollutants where feasible are recycled and reused**
  - **Examples - pulp & paper and sugar industries with cleaner production strategies**

Agricultural reuse

- **WWTPs are located in agricultural areas and hence have high potential of effluent reuse**
- **Reuse solves urban waste problem, maximizes water use efficiency and promotes agriculture**
- **Treated municipal effluent helps reduce fertilizer demands**
- **Used in irrigation of industrial estates and parks**

Wastewater is reliable with an almost constant flowrate and is a reservoir for dry seasons

Wastewater Reuse ...

Agricultural reuse (contd.)

- **Reuse in fish farming helps to reduce suspended solids levels and algal growth in wastewater**
- **WW treatment using fishponds degrades and stabilizes organics**
- **Organic wastes fertilize a fishpond and stimulate growth of microorganisms**
- **Thailand has tremendous potential for agri-aquaculture reuse and has been practiced for generations on informal/ad-hoc basis**
- **Peri-urban agri-aquaculture depend to a large extent on partially treated domestic and industrial wastewater**
- **Promotion of reuse by government with technical and legislative assistance would increase reuse and add benefits to the farming community**

Wastewater Reuse: Groundwater Recharge

Groundwater usage

- **Used for $^1/_5$ th of 200 towns and cities, and ½ of 700 municipalities**
- **75% of domestic supply to about 35 million people with 200,000 wells of 7.55 Mm^3/day capacity**
- **BMR faces land subsidence due to excessive withdrawal**

Groundwater recharge

- **Withdrawal can be replenished with recharge using lagoons, stabilization ponds, percolation tanks, trenching, well injection**
- **BMR and Samut Prakarn WWTPs would provide ~ 3 Mm^3**
- **Incidental infiltration is a significant reuse but can also pollute the aquifers**

Raising of groundwater tariff would discourage industries to withdraw it and would divert them to use surface water supplies and thus help to prevent further subsidence and saline intrusion.

Wastewater Reuse….

Other reuses

- **Use of treated or untreated effluent is informally but widely practiced primarily during the dry season in suburban area agri-aquaculture**
- **Wastewater and sewage sludge can be used in suburban areas as general environmental pollution control and the country's overall water resources balance**
- **Irrigation of urban environments: parks, gardens, golf courses, clubs, residential areas, cemeteries, green belts, lawns, etc**
- **Environmental and recreational uses**
- **Urban non-potable uses: fire fighting and toilet flushing**

Secondary treated effluent should be of appropriate quality for protection of public health

Managing Water Resources

To tackle increased water demand in three sectors - agriculture, industry and domestic sectors

- **Research and development for projecting future demand for water and potentials for reuse**
- **Setting up water rights and allocation plans would tackle and minimize the conflicts in water distribution and reuse**
- **Organizing means for legislating relevant regulations for water use**

Administrative Aspects

Reuse potentials need to be studied to develop sustainable wastewater reclamation facilities and reuse

- **Project planning and adoption of reuse technology to be studied with its economic feasibility**
- **Establishment of market for reclaimed water**
- **R&D of economically attractive technology**

Royal Thai Cabinet has initiated privatization of water resource with a corporate agency East Water Company

- **Corporatizing of water supply schemes would be a positive approach for water management in the country**
- **Spearhead development of further reuse of wastewater**

Legislative Aspects

Thailand has no well-planned legal framework for water resource inventory, planning, use, reuse, quality control and protection

- **Legislative provisions do not enforce reuse of water**
- **Country focused on pollution management with wastewater treatment systems and effluent discharge standards to prevent environmental health risks**
- **Legislation needed for stringent effluent standards and guidelines to enable reuse and protect human and environmental health**

Legislative Aspects

Measures that are required to enable proper reuse of wastewater

- **Remove or detoxify the contaminants**
- **Modify agri/aquaculture practices**
- **Regulate human consumption of certain products and educate handlers and consumers for protective practices**
- **Reduce fresh water usage and promote reclamation and recycling activities**
- **Adopt cleaner production strategies**
- **Encourage in-plant waste segregation, recycling and reuse**
- **Can reduce water consumption by 50% by minimizing waste**

Legislation and administrative aspects should consider the role of stakeholders

- **Potential end users, relevant government agencies that monitor water usages and the community**

Potentials for Wastewater Reuse

Several potential uses would help to decrease or stabilize freshwater consumption

- **Reuse can be within an industry by a closed loop water metabolism or recycle**
- **Recharge of aquifers to replenish withdrawals**
- **Discharge into the canals to replenish water level**
- **Street cleaning, watering plants and parks within a city**
- **Watering golf courses**
- **Establishment of a sustainable urban water cycle**

Potentials for Wastewater Reuse

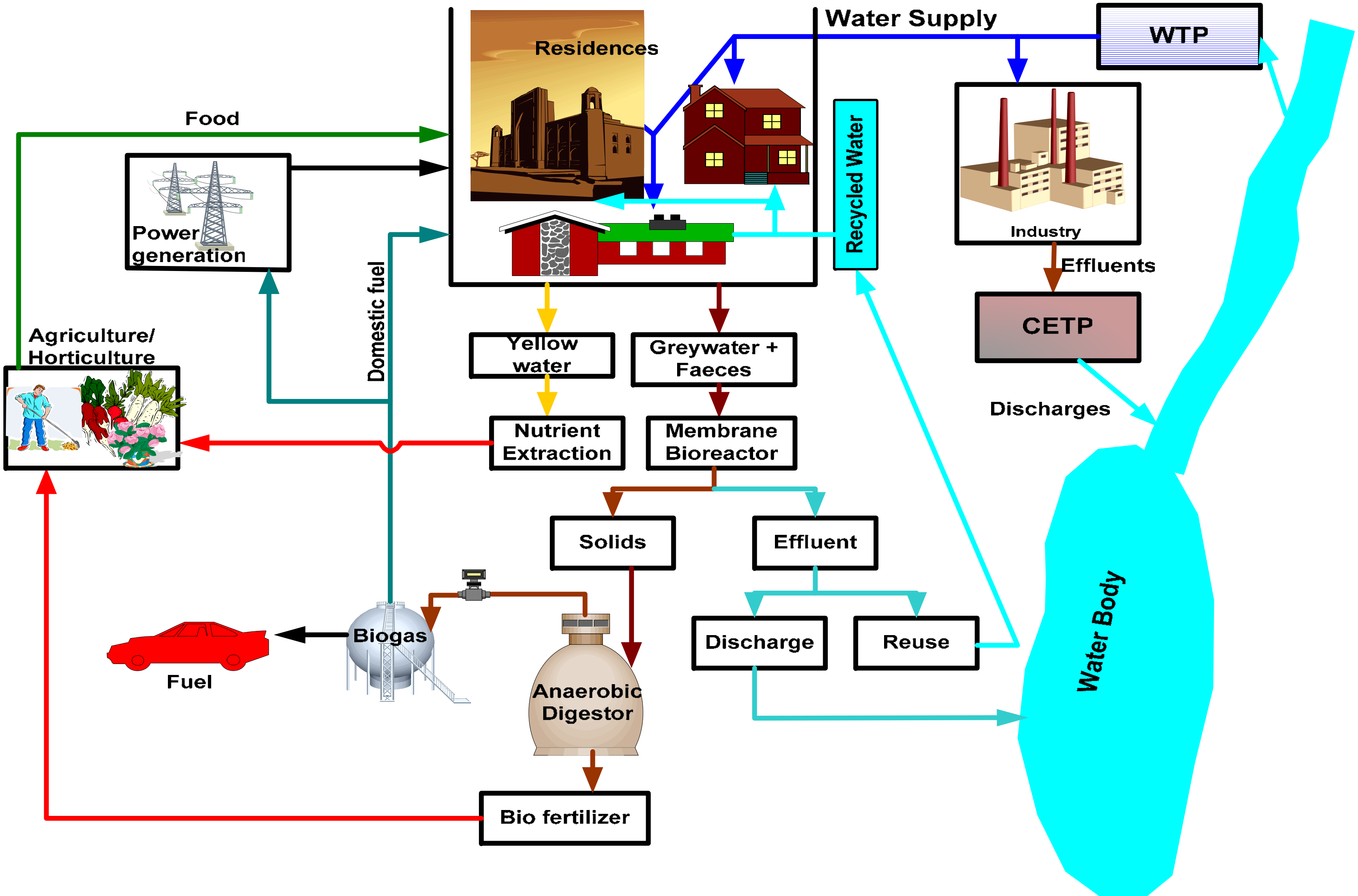
Reservations of wastewater use

- **Cost involved for advanced treatment processes**
- **Odor, contaminations and pathogens**

Present Trends

- **Technologies can be developed for the reclamation and reuse of building wastewater as in Japan**
- **Treated wastewater can be utilized to flush toilets, irrigating gardens**
- **Biological treatment and membrane separation, sludge generation can be reduced with methane gas recovery in a compact facility**
- **Large commercial complexes, shopping malls, hotels and even institutions are being planned for water recycle**

Sustainable Urban Water Cycle



This is a move towards sustainable water use

Desalination

Salinization has become a major concern in the northeast and south Thailand

- **Excessive groundwater withdrawals, saline water irrigation and expansion of brackish water aquaculture**
- **Desalination of brackish water and seawater in the coastal zones using reverse osmosis is advantageous**
- **Thailand's desalination capacity is 24,075m^3/day**
- **Desalination plant is operated by Esso Sriracha Refinery, Chonburi**

To Conclude

- Potentials for WW reuse is increasing with improved technologies
- Greater emphasis is required for agriculture reuse
- Legislative & administrative measures should increase potentials of reuse
- Legal measures should not only prevent pollution by stringent standards for municipal and industrial discharges
- Measures should encourage reclamation and reuse in industries/industrial estates
- Strict measures should be enforced to decrease excessive groundwater withdrawals and regulate surface water use
- Adopt and adapt appropriate technology
- Resource conservation can only be achieved with sincere efforts and consensus among the stakeholders.

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Thank you for your kind attention!