

# Strategies for development of industrial wastewater reuse in Thailand

C. Visvanathan and A. Cippe

Environmental Engineering Program, Asian Institute of Technology, PO Box 4, Klong Luang, Pathumthani-12120, Thailand (E-mail: [visu@ait.ac.th](mailto:visu@ait.ac.th))

**Abstract** Majority of the industrial activities in Thailand are concentrated around Bangkok Metropolitan Area. The ever increasing industrial activities have led to over exploitation of water resources and discharge of significant pollution load. Therefore, it is important to identify the wastewater reuse potentials and develop strategies for its promotion within the industrial sector. Although technological advances have made it possible to treat effluents for industrial re-use, in practice, the Thai industries do lack in implementation of such technologies. Promotion of cleaner production concepts and advanced new technologies such as membrane technologies could assist the industry for the implementation of wastewater reuse projects in Thailand. This paper discusses various technical, institutional and management related issues to promote industrial wastewater reuse, with few case studies.

**Keywords** Industrial wastewater reuse; Thailand; industrial estates; cleaner production

## Introduction

Thailand is traditionally an agriculture-based country, however in recent years higher emphasis has been given to the increased industrial activities. The hydrological basin in Thailand covers approximately 512,000 km<sup>2</sup> of drainage areas, divided into 25 river basins (ESCAP, 1991), with an average population of 60 millions. The major national water sources could be categorized as follows.

- *Surface water.* This is the major source of water, with an annual volume of 199 km<sup>3</sup>/year. 80 to 90% of this flow is generated during the monsoon period. Chao Phraya river basin is the major surface water source providing the water from North to Gulf of Thailand, especially to the industrially concentrated Bangkok Metropolitan Area (BMA).
- *Ground Water.* The average volume of ground water consumption is estimated around 8.99 km<sup>3</sup>/year. Hydrological balance studies indicate that only about 12.5 per cent of rainfall infiltrates the soils and about 8.75 per cent of rainfall eventually reaches the aquifers. The largest sources of ground water are found in BMA and its surrounding regions. To a large extent the industries located in this region depend on this ground water source. However in BMA, due to unfavorable geological conditions and excessive water withdrawal, contamination of groundwater due to salt water intrusion, and land subsidence are found to be the major environmental issues.

Thailand, like many of the rapidly industrializing South East Asian countries, faces seasonal water crisis problems. In the recent past, there was a significant conflict in water resources sharing between the agricultural, domestic and industrial sectors. In 1995, the ratio of water use to water availability exceeded 16 per cent of annual total renewable water resources, whereas the threshold limit is 20 per cent. The rapid growth in population and the manufacturing industries, especially in BMA and surrounding province has led to the excessive water extraction and pollution problems. In order to avoid the continued degradation of water quality and quantity, appropriate institutional and administrative policies should be adopted to prevent further environmental degradation. Therefore, there is a

significant interest among the environmental groups to promote measures favoring reducing water consumption, wastewater recycling and reuse both at domestic and industrial sectors.

As in many other Asian countries, wastewater reuse is practiced more in an informal manner in Thailand. At the moment there exist no technical, administrative and/or institutional guidelines to promote wastewater reuse in large scale. Due to high industrial growth and associated increased water consumption, industrial sector represents an important potential for reuse and recycling of wastewater. The objective of this paper is to analyze the current potentials of industrial wastewater reuse in Thailand. The concept of wastewater reuse within industries has not been practiced in a systematic manner. In order to assess the wastewater reuse practices and potential, an industrial survey was carried out. Based on this survey data, a policy promotional and management plan was proposed to promote the reuse and recycling practices within the industrial sectors.

#### Industrial sector growth and the water use

According to the Lima Declaration of UNIDO, by the year 2000, 25 percent of the global industrial production should take place in developing countries. The industrial sector, which is the driving force behind the economy, is growing rapidly in many Southeast Asian countries. For example, in 1996 the Thai manufacturing sector accounted for 30 per cent of the total GDP (ESCAP, 1998).

Figure 1 represents relationship trend between the growth of manufacturing industry and the total Thai GDP. Textile, pulp and paper, food processing, petrochemical, leather processing industries are rapidly growing. It is also interesting to note that not only do all these industries consume significant amounts of water, but they also discharge high pollution load.

The major industrial water consumption processes can be categorized as: cooling, boiler feed, washing and process water. While the first two streams consume large volumes of water, they generate relatively very low pollution load. In contrast the other two streams contribute to the major industrial wastewater pollution loads. This different pattern in water quality and quantity per stream, indicates various degree of water reuse and recycling potential. The current focus in industrial wastewater reuse in Thailand is mainly for the streams with high volume and low quality requirements.

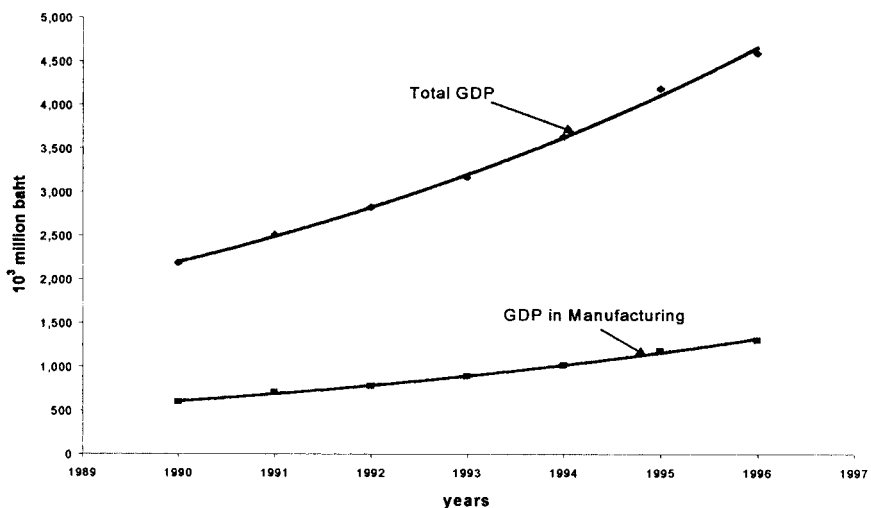


Figure 1 Growth of industrial sector in Thailand (Source: Thai Textile Statistics 1997)

The industrial sector in Thailand is a relatively small water user compared to agriculture, which uses about 30 times the amount of water per unit of GDP that industry does. The growth in industrial water use is normally expected to continue with an annual rate of about 8 to 10 percent, while the growth in agricultural water use is leveling off (ESCAP, 1991). In 1996, the industrial water demand including commercial sector, in Bangkok, was 421 millions/m<sup>3</sup> (McIntosh & Yniguez 1997). 60 to 80 per cent of the industrial water demand is used for cooling processes and does not require a high water quality. This represents a real potential for reuse and recycling of treated water.

Until recently, there was a significant difference between the cost of water supplied by the waterworks facilities and the deep well water. Thus, most of the industries in the BMA region use ground water, and its actual cost is only price of the pumping. This difference in cost of water was one of the major negative factors for not promoting industrial wastewater recycling and reuse. However, due to the salt water intrusion and the land subsidence problems, the government has made more stringent restrictions in regards to withdrawal of ground water for industrial application. Due to this new government legislation, there is a 10 fold increase in the water bills in some of the industries located in BMA regions, such as Pathumthani. Meanwhile, the Ministry of Industry, as part of the industrial promotion, promotes industrial parks and estates. These, industrial parks are equipped with central water supply and effluent treatment facilities. All the industries located in such parks, need to use the relatively expensive centrally treated water supply systems, rather than the individual ground water sources.

Table 1 below presents the summary of the industrial survey conducted in regard to the wastewater reuse potential in Thailand. These results reveal that most of the industries do not practice wastewater reuse.

Here, it was noted that the cost of investment of new technologies for industrial wastewater treatment is the major negative factor. Meanwhile, it is interesting to note 16% of the surveyed industries indicated that currently there is no financial or administrative incentives for developing and implementing water reuse projects. Few (10.5%) of the industries surveyed reuse their treated effluent especially for rinsing, washing, cooling and secondary applications such as watering gardens etc. It is also interesting to note many of the industries which are in the process of applying for ISO 14000 certification, have envisaged to incorporate wastewater reuse as their future management goal and environmental policy statements. However, due to current structure of the cost of portable water, and non-stringent enforcement strategy in regard to the effluent standard, it not attractive for many industries to invest of water reuse technologies.

## Issues related to the promotion of industrial wastewater reuse

### Technical aspects

Promotion of recycling and reuse of treated water in Thai industrial sector will depend on

**Table 1** Potential negative factors for non-adoption of industrial wastewater reuse practices

Reasons for non-adoption of industrial wastewater reuse	Percentage
Unawareness of new technologies	10.5
Unwillingness to adopt new technologies	0
No incentives for wastewater reuse	16
Investment cost for new technologies and treatment cost	48
Others Reasons:	
–Not necessary	5
–Need pure water for the process	5
–Inconvenient to reuse wastewater while water supply is considered very cheap	5
Industries with Water reuse projects	10.5

the technologies implemented for production processes and effluent treatment plants. In fact, the technology selection criteria are different in developed and developing countries. The developing countries are principally interested in the factors such as: construction costs, sustainability, simplicity and operational costs of the technologies. The environmental impacts, efficiency, reliability, sludge disposal and land requirements have a much smaller magnitude compared to developed countries.

The conventional wastewater treatment technologies used by the Thai industries are stabilization pond systems, lagoons, activated sludge systems, trickling filter systems and anaerobic systems. Combining these technologies after screening and grit removal constitutes the typical effluent treatment trains. For example:

- screening-grit removal/ activated sludge/ secondary sedimentation tank and effluent discharge;
- screening-grit removal/ primary sedimentation tank/ trickling filter/ secondary sedimentation tank and effluent discharge;
- screening-grit removal/ anaerobic reactor and effluent discharge;
- screening-grit removal/ anaerobic – aerobic waste stabilization ponds/ effluent discharge.

These conventional effluent treatment technologies were designed and operated in view of meeting the effluent standards rather than reuse. If wastewater reuse is to be envisaged, one has to add-on additional unit operation such as rapid sand filtration, granular activated carbon, etc to achieve much higher effluent quality. These add-on units are relatively expensive in terms of capital, operation and maintenance costs. Therefore in future, the conventional wastewater treatment systems should be designed such as way that they could favor recycling and reuse of treated water, while assuring the required effluent quality. These primary technologies must be replaced by innovative technologies which could favor recycling and reuse of treated water, while assuring effluent quality according to the control requirements.

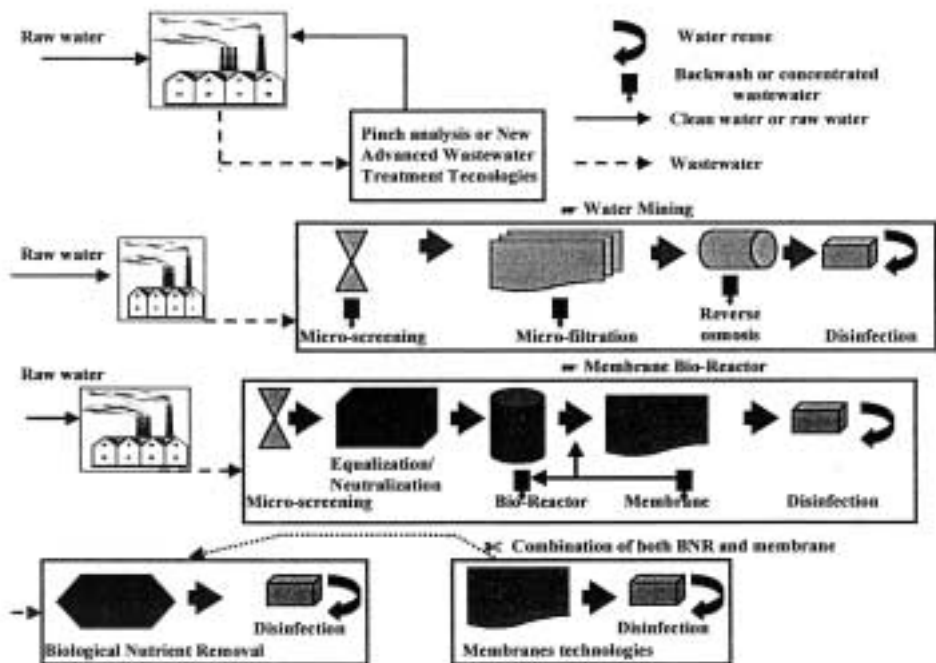


Figure 2 Innovative technology development for industrial wastewater reuse

Figure 2 presents the advanced wastewater treatment units needs to be developed and implemented, in order to promote wastewater reuse. Here, rapid sedimentation systems, membrane bioreactors, biological nutrients removal, and dissolved solids removal systems are some of the major unit operations which needs to be effectively developed and implemented. From the technical point of view, at industrial sector, the priority should be placed on the process modifications taking into consideration cleaner production and “pinch analysis”, waste segregation, adaptation of closed loop systems, counter-current washing, etc., These measures will allow a drastic reduction in water consumption and facilitate the water reuse and recycle.

#### Cleaner production and industrial wastewater reuse

The concept of cleaner production (CP) plays a significant role in industrial wastewater reuse. Thailand Environmental Institute and Industrial Works Department are actively engaged in promotion of CP in the Thai industrial circles. The recent demonstration studies have indicated a significant water reduction or saving with inline treatment potentials in industrial sectors such as electro-plating, food processing, tannery, pulp and paper, etc (Visvanathan & Hufemia, 1998, Visvanathan *et al.*, 1999, Vigneswaran *et al.*, 1999). The following case study demonstrates the potential of application of membrane technology to recover salts and reuse water from the process effluents of a sugar manufacturing plant. Here CP techniques are used to recover and recycle materials from the effluent from certain processes, and recycle in-line treated effluent.

*Background and methodology.* The plant studied is a sugar producing factory situated in Northeast Thailand and handles  $22 \times 10^3$  tons of sugarcane per day. Decolorisation of the raw sugar is achieved by ion exchange i.e. the brown sugar liquor (after carbonation and filtration) is passed through an ion exchange resin column, producing a fine liquor which can be evaporated and crystallised as refined sugar product.

The regenerant used in the ion exchange process is 10% sodium chloride brine solution. Here, industrial grade salt is used, which has to be remelted and filtered before use. A sand filter was used for this purpose and the filtrate solution is pumped to the ion exchange column. The waste brine produced from ion exchange regeneration is discharged to two holding ponds of 40,000 m<sup>3</sup> capacity each. This waste brine contains colloids, colour material and large amounts of NaCl. Biological degradation of this waste is impossible due to the high salts content. Secondly, the stored brine waste can leach and contaminate ground water. During rainy season, it was often observed that the ponds overflow, resulting in damage to adjoining areas.

Four tons of NaCl is daily used for regeneration. Cost of NaCl is about 0.12 US \$ per kg, i.e. about US \$ 480 per day were spent on NaCl. About 150 m<sup>3</sup> of waste brine is generated from the ion exchange unit daily. The spent NaCl during regeneration was not recovered and was discharged into the ponds. Thus, fresh stock of the salt and pure water was required daily.

*Process modification using membrane technology.* Here a membrane filtration system is used to handle these problems. A series of microfiltration (MF), nanofiltration (NF) and reverse osmosis (RO) membrane systems were installed in the same order as in Figure 3.

The plant uses a unique three stage membrane process to fully treat and recycle the effluent. The process involves three distinct stages of treatment. The first stage microfiltration, removes all contaminants and particles from raw brine solution. The second stage, nanofiltration, removes the sugar color from the effluent. The final stage, reverse osmosis, concentrates the brine that can be recycled back to the manufacturing process. The product from

the final stage is the equivalent of drinking water and partly it is used as a coolant and partly as the process water.

*Membrane filtration installation.* The primary advantages achieved through such a combination of membrane systems are:

- segregation of various contaminants, which result in effluent treatment plant load;
- potential to recover and reuse the regenerate NaCl;
- obtain fresh water to be reused in the process, thereby reducing daily fresh water demand; and
- decrease wastewater load on ponds, thus avoiding the problems mentioned earlier.

The concentrates from the MF and NF contain only colour and organic matter and a small amount of salts. These streams were combined and fed to the waste brine ponds.

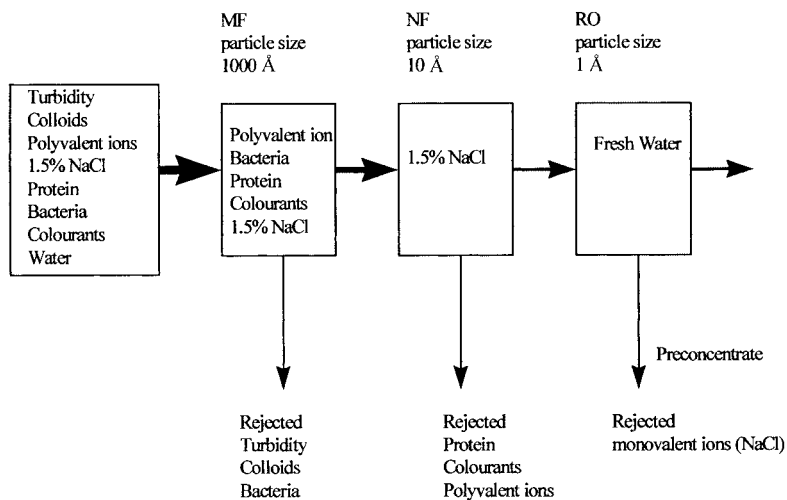
### Institutional, management and financial aspects

The institutional aspect in Thailand is mainly focused on the issue of industrial water pollution controls, and little attention is given to the concept of sustainable industrial development. In fact there are no institutional or legislative arrangements at the moment to advocate industrial wastewater water reuse. The Table 2 summarizes the main policies need to be developed for promotion of wastewater reuse in industrial sectors in Thailand.

As presented in the above table, a legislative and institutional framework needs to be developed by the Thai government authorities. Only strong administrative issues can facilitate the industries to adopt wastewater reuse. In addition government's water conservation policy is the key factor in wastewater reclamation and reuse. These policies should be related to incentives for industry to promote internal recycling, implementation of economic instruments and discouraging effluent discharge through stringent standards. Centralizing industries into industrial estates is an advantage in Thailand, compared to the other Asian countries. This helps to regroup industries with the same effluent characteristics in the same area in order to promote recycling and reuse easily and to reduce the capital and operating/maintenance costs.

These industries will be able to afford for the investment in advanced treatment technologies, which will help them to:

- obtain a high effluent quality according to the standards applied in relation with the activities but also,



**Figure 3** Flowcharts for salt recovery and water reuse in a sugar producing industry

**Table 2** Policies to promote industrial wastewater reuse in Thailand

Institutional and Management Aspects	
Current Status	Potential Policy Approaches
<ul style="list-style-type: none"> <li>• Lack of monitoring and enforcement of the existing industrial effluent standards;</li> <li>• Lack regulations or guidelines for industrial wastewater reuse and associated health risks.</li> <li>• Lack of communication between industrial associations, the government and the public on the advantages of wastewater reuse.</li> <li>• There exist no coordinated institutional arrangement to assist research, development and implementation of wastewater reuse projects.</li> <li>• Irrational water pricing structure between surface and ground water supply systems.</li> <li>• Ignorance of general public and industries on the benefits of wastewater reuse for resources and environment protection.</li> </ul>	<ul style="list-style-type: none"> <li>• Development of institutional structure to develop wastewater reuse, in association with the existing industrial pollution control organizations;</li> <li>• Setting-up guidelines or legislation for industrial wastewater reuse.</li> <li>• Prioritization of industrial sectors, which need to implement wastewater reuse based on criteria such as specific water consumption rate or high pollution load generation.</li> <li>• All large scale industrial projects EIAs should include wastewater reuse component.</li> <li>• Need to modify the existing industrial water pricing structure, to reflect the actual cost of the water, and to promote water reuse.</li> <li>• Development of industrial wastewater reuse permit structure and guideline.</li> <li>• Industrial associations should play an active role in promotion not only effluent treatment but also recycle and re-use.</li> </ul>
Financial Aspects	
Current Status	Potential Policy Approaches
<ul style="list-style-type: none"> <li>• Absence of special incentives to incite industrialists applying wastewater reclamation, recycling and reuse.</li> <li>• Lack of subsidies to implement new technologies for recycling and reusing wastewater in industries.</li> <li>• Low taxes and charges for industrial water consumption</li> </ul>	<ul style="list-style-type: none"> <li>• Implementation of enforcement tools such as: industrial wastewater discharge fines according to the pollutants, fines for non compliance with the law, etc.</li> <li>• Subsidies and credit lines should be accorded for industries that would like to adopt wastewater reuse programs.</li> </ul>

- reuse the treated water for various uses such as direct recycling in the process, watering plants, washing, rinsing, groundwater recharge, etc.

Recycling of water within industrial process and reuse of industrial treated water for external usage will contribute in both water resources conservation and quality. The concept of a central effluent treatment plant within an industrial complex should be encouraged. However, it is better to accommodate different types of industries requiring different water qualities in one complex. Similarly, permits should be given to wastewater plant owners to supply effluent of required quality to industries located nearby. Proper care has to be taken in reclaiming municipal wastewater for industrial applications, especially with regard to microbiological quality. Water quality criteria required for some industries may not require stringent microbial standards but health is an important consideration and basic minimum criteria for microbial content should be reflected in standards for reclaimed water. Monitoring systems with high level detection and sensitivity should be developed to control wastewater reuse and recycle.

## Conclusion

Industrial sectors in Thailand could invest easily in water recycling and reuse activities. In fact, textiles, food, machinery, electroplating, petroleum refineries and brewery industries, consuming high volume of water for washing, rinsing and cooling water processes, represent a high potential for reuse of treated water. Given the proper government initiatives and incentives, it is certain that industries will be dealing more with reduction of water

consumption, and effluent reuse. A few of the case studies clearly demonstrate that this water demand could be attained around 40–50%. CP concepts such as segregation of waste and multiple reuse after simple treatment are the priority activity the government should promote. Meanwhile segregation of waste and multiple reuse after simple treatments is practiced in industries which require less pure water. Industries demanding a high volume of water for cooling and boiler feed should be the first priority. Furthermore integrated development of industrial estates can play an important role in effluent treatment and reuse.

## References

- ESCAP (1991). *Assessment of water resources and water demand by user sectors in Thailand*. United Nations, Technical Report, Bangkok, Thailand.
- ESCAP (1998). *Sources and Nature of water quality problems in Asia and the Pacific*. United Nations, Technical Report, Bangkok, Thailand.
- McIntosh, A.C. and Yniguez, C.E. (1997). *Second water utilities data book*. Asian Development Bank (ADB), Manila, Philippines.
- Thai Textile Statistics (1997). Textile industry division, Bureau of industrial sectors development and Department of industrial promotion, Bangkok, Thailand.
- Visvanathan, C and Hufemia, A.M. (1998). "Exploring Zero Discharge Potentials for the Sustainability of a Bottle Washing Plant", *Water Science & Technology*, **35**(9), 181–190.
- Visvanathan, C., Parasnis, M. and Arunee, A. (1999). "Multimedia Environmental Audit for Cleaner Production : A Case Study in Thailand", *J. of Cleaner Production*, **6**(2), 98–101.
- Vigneswaran, S., Jegatheesan, V. and Visvanathan, C. (1999). "Industrial Waste Minimization Initiatives in Thailand; Concepts, examples and pilot scale trails", *J. of Cleaner Production*, **7**(1), 43–47.