Efficient Use of Water for Food Industry to Conserve Groundwater: Case Study of Samut Sakhon Province, Thailand

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ABSTRACT: Thailand's Samut Sakhon province is approximately 80 kilometers southwest of Bangkok, the Kingdom's capital city. The province is very famous for its fisheries and food industry. However, as Samut Sakhon has long been faced with the problem of inadequate water supply, factories and businesses in the province resort to groundwater as an alternative to avoid water shortage. This research study aims to determine the degree of water use efficiency of the food industry in the area, which accounts for half of the total number of factories in Samut Sakhon province and to investigate water usages by different types of factories in the food industry of the province. The methods of study comprised of literature review, questionnaires, manufacturing process study and data analysis. The findings indicated that high efficiency water usage was applied by the food industry in the area to control the production cost. The practices adopted are minimal leakages in the pipe systems, application of 5Rs (*i.e.* reduce, reuse, recycle, reserve and re-visualise), and employees' active participation. The information from the representative food factories on the activities for which water is used revealed that the majority of the surveyed factories used water during the production activity except for food packaging plants where the main use of water is for consumption.

Keywords: efficiency of water usage, groundwater conservation, 5R, reduce, reuse, recycle, reserve and re-visualize

Introduction

Samut Sakhon is a vicinity town of Bangkok, located in between 13° 25' north latitude and 100° east longitude, far 40 kilometers in southwest of Bangkok, Thailand. It covers about 872.347 square kilometers which almost a lowland area with about 42 kilometers of the long shore. It is a tropical monsoon climate, influenced by the sea breeze and land breeze (Thailand Samut Sakhon province, 2014). Water resources are from Thachin River and tributaries, rainfall and groundwater (Buapeng *et al.*, 2006). The statistical records of Samut Sakhon province in 2013 showed the number of population and registered labors as 510,511 people and 334,817 people, respectively. About 30% of total number of labors worked in food industry (Thailand Ministry of Labor, 2013). The rapid growth of the industry in Samut Sakorn makes it a wealth town with the 6th largest GDP of Thailand. As there was high amount of water usage in industrial sector and households which led to high risk on salt intrusion of aquifer, conservation of groundwater is considered (Thailand Environment Institute, 2009).

The numbers of factories and percentage of textiles, chemicals, metals and food beverage industries located in Samut Sakhon province in year 2011 (Thailand Department of Groundwater Resources, 2012) are shown in Table 1 and Figure 1. The data shows that food and beverage industry accounts for half of the total number of selected factories in Samut Sakhon province.

As Samut Sakhon has long been faced with the problem of inadequate water supply, a SWOT analysis report of Samut Sakhon, has confirmed the shortage of tap water for domestic use that caused a lot of ground water drilling wells.

Table 1: The numbers of factories in textiles, chemicals, metals and food/beverage industry located in Samut Sakhon province

Industrial type	Size*			Total
	Small	Medium	Large	
Textiles	60	45	34	139
Chemicals	161	34	8	203
Metals	271	42	12	325
Food/Beverage	307	120	78	505
Total	799	241	132	1172

Note:

* The criteria to categorize the size of the industry are defined as:

Small industrial plants, with a total employment of not more than persons or have fixed assets worth over million baht.

Medium industrial plants, with a total employment of more than but not more than persons or have assets worth over million baht up to million baht.

Large industrial plants, with a total employment of more than people or have fixed assets worth more than million baht.

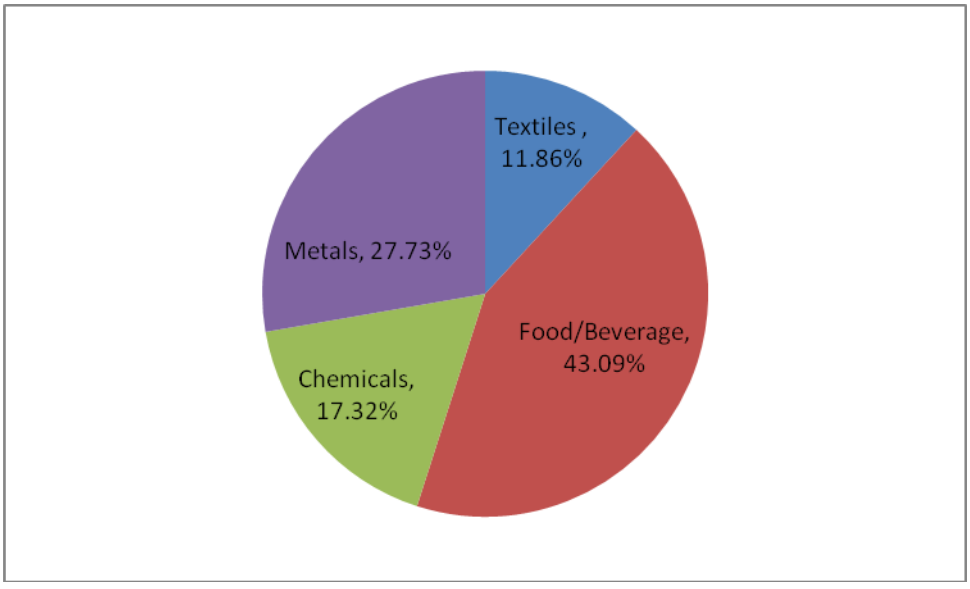

Figure 1: Percentage of each factory types in Samut Sakhon province

Figure 2 shows the water consumption from 1998-2006 (Thailand Department of Groundwater Resources, 2008). The data demonstrates the increasing of tap water consumption in this province. The groundwater consumption tends to decrease because of the law enforcement in this area to avoid land subsidence (Thailand Department of Mineral Resources, 2000)

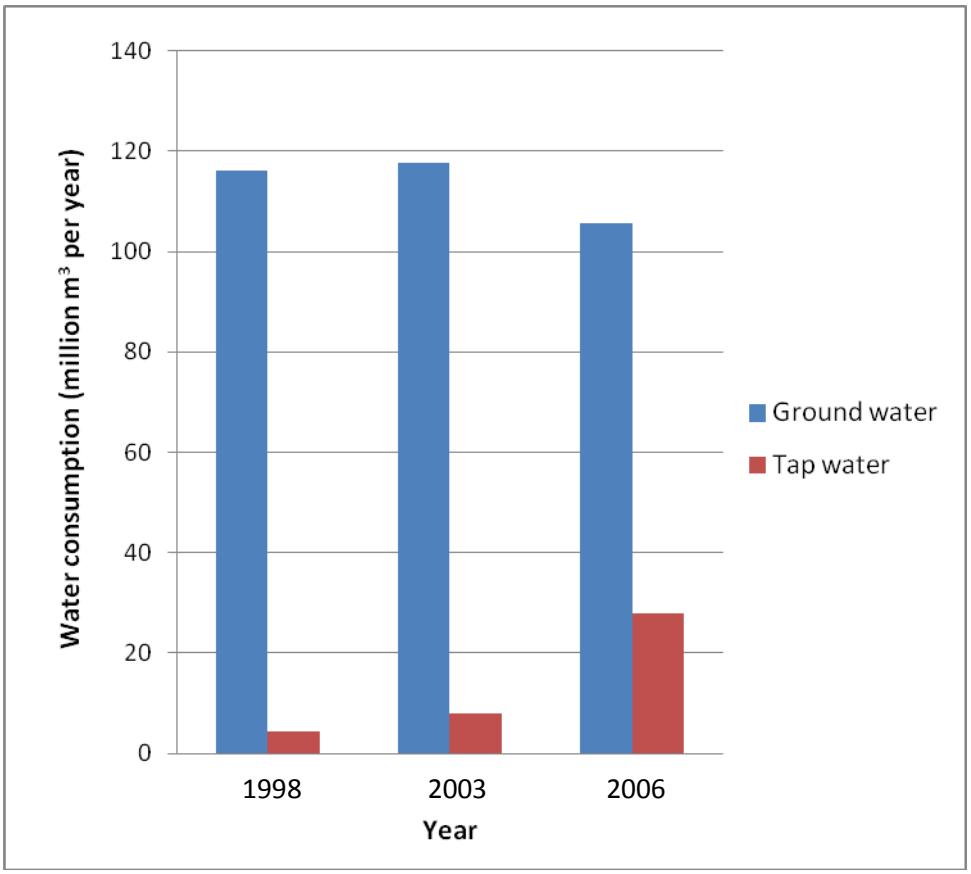

Figure 2: Water consumption (1998-2006) in SamutSakhon province

Normally, water uses in the production process are for cleaning equipment and plant, whereas the cooling water and boiler water are for steam production. Water used in plant has to be treated for the purpose by the water treatment unit such as water softener and reverse osmosis system. The research aimed to establish the efficiency use of water in the food industry to conserve the groundwater of Samut Sakhon province of Thailand by (i) determine the degree ofwater use efficiency of the food industry in the area and (ii) investigate the water usage by different types of factories in the food industry of the province. The number of the data was limited due to the restricted permission of the factory. The given information was only for academic purpose.

Methods of the Study

Our methods comprised of literature review, questionnaires, manufacturing process study and data analysis. This work was carried out from May 2010 to August 2011. The questionnaires forms were sent to the food factories in Samut Sakhon province. The questionnaire required data of the volume of water consumption, water quality, water usage problems, water unit cost, and water consumption adequacy. The manufacturing process study was conducted in the marine feed manufacturing industry to investigate the industrial water consumption efficiency. The data from the evaluation of processing and supporting units such as water utility unit were used in economic analysis. The process diagramme of shrimp feed production is illustrated in Figure 3.

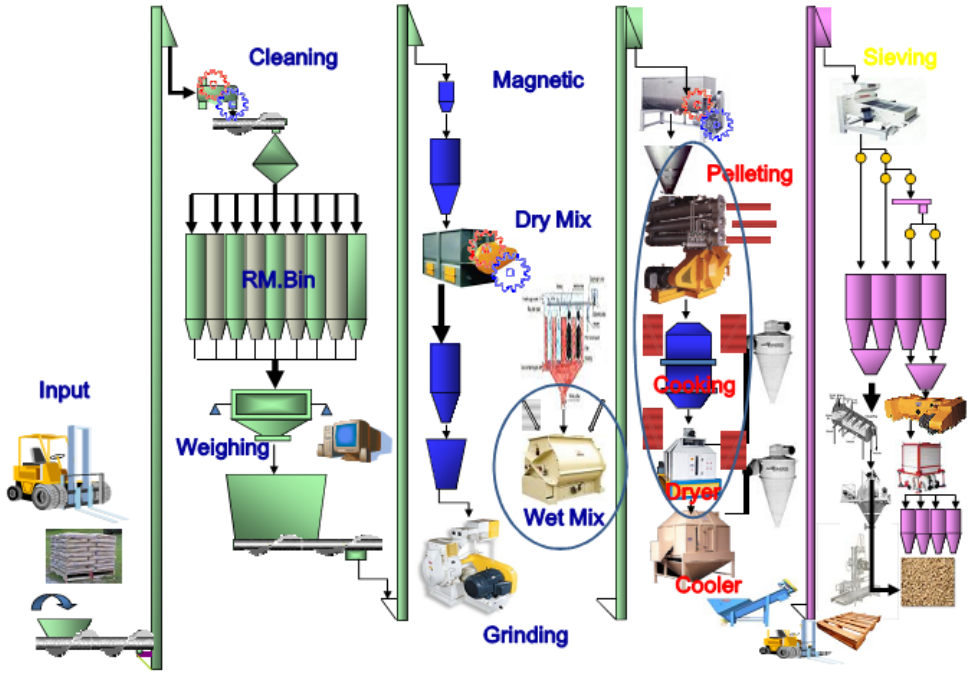

Figure 3: Process diagramme of shrimp feed production

The production of shrimp feed is as follows: Starting from the raw materials, the materials will be stored in each tank storages if their materials quality are satisfied,. Materials are weighed according to the formula and released into a dry mixer, and sent to the wet mixer to produce the pellets. This process includes the use of steam to mix with the food, and

compressed to form pellets. After that, the pellets will be forwarded to the ripening process and dry process before sending to packing.

Results and Discussion

Questionnaire data analysis

The data from 32 sets of questionnaires allowed the basics information on water use to be analysed. As shown in Figure 4, the sources of water use in food industry in this province were mainly from groundwater, surface water and tap water. The groundwater, which was more than 50%, was the major source of water consumption.

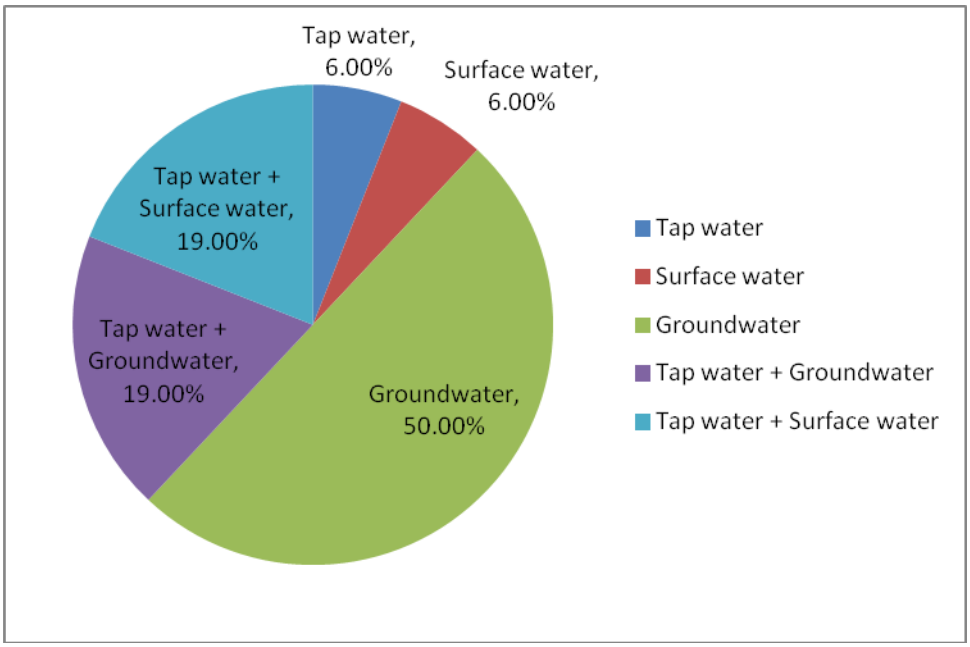

Figure 4: Sources of water use in Samut Sakhon province

The result of investigation on the activities water that involved the water usage by different types of factories in the food industry of the province is shown in Table 2. It remarked that the food packaging industry consumed small amount of water compared to the food processing industry. Water consumption in food packaging factory was mostly used as the potable water. For food processing industry, the degrees of water use efficiency depend on the type of factory that varied from 1.25-28.74 m^3 water per ton products. The large scale food processing factory mostly used water for cleaning. Besides, canned food, beverage and soy bean sauces also used water as the ingredient in their products. The low flow rate, broken pipe and expensive of water supply were stated as the problems in food industry of the province.

In addition, the data from questionnaires revealed that the solutions for water shortage included the use of water supply reservoirs, reuse water, recycled water, improving the manufacturing process for less water demand and also reducing the water use in raw materials.

Table 2: Type of the food factory and Water Use

Type of Food Factory	**Water Use (m^3/day)**	**Degree of water use (m^3 water/ton products)**	**Remark**
1)Packaging	5-15	0.05-0.70	About 12-100 labors(data from 3 factories)
2) Small –Medium Scale -Dried Food -Fishmeal	30-50	1.25-10.46	50-150 labors (data from 6 factories)
3) Medium Scale -Canned Food(Fruit Juice) -Soy Bean Sauce	50-150	9.52-27.50	100-250 labors (data from 7 factories)
4) Medium -Large Scale - Sea Food Process	200-400	11.99-28.74	100-600 labors (data from 8 factories)
5) Large Scale - Sea Food Process	550-1600	18.23-28.62	300-1600 labors (from 8 factories)

Manufacturing process study

The marine feed manufacturing was chosen as the representative factory for study of groundwater usage efficiency. The investigation showed that the representative industry was consumed only the groundwater due to the lacking of public water supply system in that area. The daily water consumption is 550 cubic meters. The main activities of water usage are in production and non-production line with the ratio of 83:17. The water uses in production are mainly steam production, accounting for 56% of total water usage as shown in Figure 5. The

other usages in production are for cleaning machines and plant floor. On the other hand, the water usages in non-production are for the staff dormitory, office, garden and lawn.

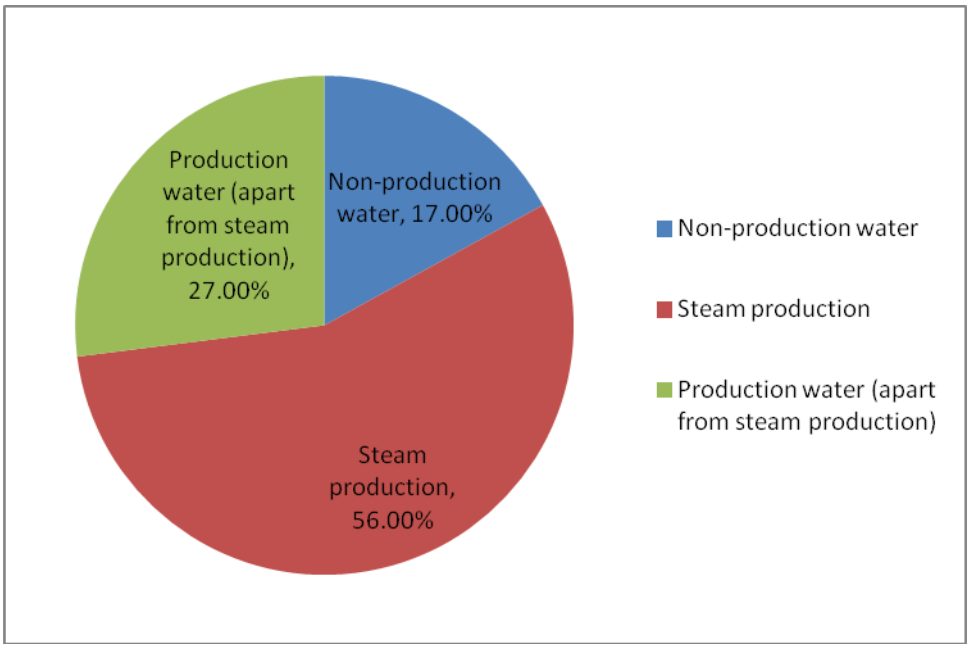

Figure 5: Water use in the representative factory

The representative factory has been investigated and the techniques listed below were applied to improve water consumption efficiency:

1. Using the condensation process from the boilers by installation the storage tank
2. Using the RO rejected water as the floor cleaning water
3. Equipped the nozzle at the cleaning hose
4. Using the backwash water from the water softening system for garden and lawn.

After those techniques were implemented, the follow up water consumption was investigated and the results showed that the index of water consumption per ton of products was decreased from 1.37 cubic meters water (average value in year 2011) to 1.24 cubic meters (average value in the first half year of 2012). Figure 6 displays the equipped nozzle at the cleaning hose. The economic analysis was also studied and shown in Table 3.

Figure 6: The equipped nozzle at the cleaning hose

The findings indicated the high water usage efficiency in the representative factory to control the production cost. This study showed that the using of the condensation of steam saved money significantly. Although the industry have to invest the equipment, payback period is less than three years.

Table 3: The economic analysis for improvement the water consumption efficiency

Technique	**Investment (Baht)**	**Saving per year (Baht)**	**Payback period (year)**
1. Using the condensate from the boilers by installation the storage tank	1,600,000	544,419	2.9
2. Using the RO reject as the floor cleaning water	100,000	54,000	1.85
3. Equipped the nozzle at the cleaning hose	5,000	40,500	0.12
4. Using the backwash water from the water softening system for garden and lawn	50,000	64,800	0.77

Apart from the techniques applied to the production area to achieve the high water usage efficiency, the minimal leakages in the pipe systems in the dormitory section were also investigated and improved the system.

Conclusion

This work showed that the main water resource in the food industry in Samut Sakhon province is from the groundwater. However, the trend of groundwater usage has been decreased due to the prevention of the land subsidence in the area of Bangkok and its vicinity. To solve the problem of water shortage and to reduce the cost of production, the concept of using high efficiency water usage was applied to the industry. The application of 5Rs (*i.e.* reduce, reuse, recycle, reserve and re-visualise), and employees' active participation were applied in the representative factory. The results from the representative factory showed that after the practices implemented, the degree of water usage efficiency was improved up to 10%.

Acknowledgements

We would like to thank the department of groundwater resources of Thailand for the support. A special appreciation goes to the King Mongkut's Institute of Technology Ladkrabang's staffs for their great cooperation and support throughout this study.

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