An Investigation of Paper Mill Sustainable Development in Thailand-A Case Study of Double A Public Company Limited

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Abstract. The main object of the study is to research Double A’s water treatment programs to give good suggestion to other factory that face the pollution problem and analyzed the development trend of waste-water treatment. To do an integrated analysis of the environmental problems caused by printing paper production is essential for improving the understanding of effective management of the environment in Thailand. Therefore, the overall objective of this paper is to analyze the environmental pressure of the printing paper industry in Thailand, and to identify options to reduce this pressure and evaluate their cost-effectiveness.

1. Introduction

1.1. Paper industry and the environment

Water is the origin of life. The earliest life of ancient times was born in the ancient ocean. Even for animal coming to land, the water is still as a prerequisite. It can be said that there is no water. All the wonderful life will cease to exist. In today's world, the economy is growing at a high speed and we have a greater demand for water, but we are facing an unprecedented water crisis.

The Nation (2011) news agency conducted a survey which showed the biggest worries of Thai people as follows:

• 91.5% - Water shortage stemming from water pollution and the effects of global warming
• 90.3% - Polluted canals and rivers
• 89.94% - Dumping of garbage into waterways
• 84.5% - The impact on health from water pollution
• 84.1% - Toxic contamination in the food chain or environment[1]

Thai Burapha University researcher Voravit and Chulalongkorn University researcher Piamsak (2003) pointed out serious water pollution in Thailand include:

(1) Untreated municipal and industrial waste water are considered to be the most serious problems of Thailand due to limited waste water treatment facilities in the area.

(2) Eutrophication is an emerging problem in the Gulf of Thailand.

(3) Few problems have been documented from trace metals contamination in the Gulf of Thailand and public health threat from seafood contamination does not appear to be significant yet.” From the figure listed below, water pollution comes from urban runoff, landfills, petrol station, leaking sewers, oil storage tanks, industrial storage, pesticides application, uncovered road salt, septic tank. Surface water will seep through the soil to ground water. If ground water is contaminated, pollute public water supply will be polluted as well. [2]

The consumption level of paper and cardboard is an important symbol to measure level of modernization and civilization of the country. There are more than 360 pulp and paper enterprises in Thailand.

![Diagram](image-url)

*Chart[1]: Overview of pulp and paper industries in Thailand
*Source: Thai Pulp and Paper Industries Association*
Thailand has become one of the large paper industry production, consumption, and import countries. However, the paper industry compared to developed countries, the gap is very large. The problem is very prominent. One of the main problems is the high resource consumption and pollution prevention. While the paper industry has brought huge benefits to people, it has also created a serious environment pollution.

If the waste-water from the paper industry is discharged into the river without effective treatment. The organic substances in the waste water will be fermented, oxidized, and decomposed, consuming oxygen in the water and killing the aquatic organisms such as fish and shellfish. Paper industry waste-water makes the river muddy black and stench. It would be a serious threat to the health of the residents along the river.

Paper industry pollution has always been the focus of environmental protection. Environmental problems have become the fundamental problem that enterprises can survive and develop.

In the 1960s, the paper industry in the developed countries also caused serious pollution to the environment. Later, due to the research and development of pollution control technologies, especially the implementation of cleaner production and the development of recycling economy, reduced the paper industry damage to the environment. And in the past 10 years, a great part of the research on new technology and new equipment for industrial waste-water treatment is carried out for pulp and paper waste-water treatment, such as internal circulation anaerobic treatment.

The paper will do research for a very good example that shows how paper mill deals with pollution and takes the environmental responsibility.

1.2. The case of paper industry waste water treatment

According to the website[3], Double A (1991) Public Company Limited, a fully integrated pulp and paper mill, was incorporated in 1991. Located in Thailand’s central plains in the province of Prachinburi, the mill began operating in 1995 and has an annual capacity of 600,000 tons of pulp and 600,000 tons of paper.

Strategically situated 140km from Bangkok and 130km from Laem Chabang Seaport, the Double A mill is close to both a sustainable source of wood and a huge rainwater reservoir with a capacity of 36 million cubic meters to sustain its manufacture of pulp and paper.

The company’s broad portfolio of products extends from superior quality short fiber large paper sheets to innovative stationery products and premium copy papers—all made of sustainable fiber from Double A’s Paper Tree, which is grown along the rice paddy ridges of more than 1.5 million farmers across Thailand through a uniquely Asian solution to the sustainable sourcing of fiber that we call PFFT – Paper from Farmed Trees.[4]

With the further promotion of ecological civilization construction, paper industry continuously increases environmental protection efforts. As a large-scale waste-water discharger, the paper-making industry is facing more and more big challenges. It has also increased the intensity of waste-water treatment in order to reduce the discharge of waste water is imminently. This paper will discuss in more detail.

2. Analysis of current environmental pressure of the eucalyptus-based Kraft pulp industry in Thailand
The paper industry is an important raw material industry closely related to the national economy and social development. The consumption level of paper and cardboard is a measure of the level of modernization and civilization of a country. The paper-making industry is characterized by capital-intensive technology and significant economies of scale. It has strong industrial connection and large market capacity. It is an important force driving the development of industries such as forestry, agriculture, printing, packaging and machinery manufacturing. It has become a new national economic development growth point in Thailand.

In recent years, the technological progress of the world paper-making industry has developed rapidly. Due to the constraints of resources and environment, the paper-making enterprises are making greater efforts in saving energy and reducing consumption, protecting the environment, improving product quality and improving economic efficiency. It is moving toward high efficiency, high quality, and high efficiency. The paper industry also have low consumption and low emission. However, the paper industry faces three major problems in Thailand.

2.1. Paper mills develop too fast

At presently, the global paper industry production and consumption grew 2-3% annually, while Asia grew 8.5%, ranking first in all continents. Thailand's paper industry ranked first in Asia with 18.13% growth in 2016.[5]

![Chart 2: the increase rate of paper mills in Thailand](chart2.png)

Source: Thai Pulp and Paper Industries Association

Thailand's paper industry is in a period of rapid growth. Statistics over the years show that the total output of paper and paperboard in Thailand has been substantially lower than the total consumption. The per capita consumption of paper is far below the level of the developed countries in the world. It is a typical demand-driven industry.

In the last two decades (1980s-2000s), there have been an acceleration of emerging pulp and paper industries in Thailand. There are two main driving factors that highlight these emerging industries. Firstly, the government ready welcomed foreign direct investment (FDI) in many fields, including forest industries (pulp and paper) and approved joint ventures and even 100 percent ownership owned by foreign companies of domestic ventures. Secondly, the Thai government actively supported the development of the industry through easy access to credit, infrastructure (port and highway) construction, and subsidies to plantation owners, tax relief and favorable import duties on machinery.[6]
Since 2013, the growth rate has been at a relatively high level. It can be said that the paper industry in Thailand is at a rapid growth period. With the advent of office automation equipment, the market demand for printing paper is on the rise. According to Jurnal (2017), in 2016, the market consumption of writing paper reached 10.45 million tons, and accounted for 19.2% of the total paperboard consumption. In the past two or three years, the consumption of printing paper has been growing at a rate of 7%. It is estimated that the demand for printing paper will reach 15.7 million tons in 2020.[7]

2.2. Most of paper mills are small factories

According to Greenpeace. (2011), there are 104 paper making companies in Thailand. Most of them are small factories. Little paper mills have poor equipment, backward technology. It may has almost no control of pollution measures, which is a small paper mills pollute the whole river.[8]

It is difficult to meet the domestic market for high-grade paper products growing demand. Papermaking industry is too low concentration. The scale of enterprises is too small, serious pollution, environmental protection measures ineffective and so on. The Thailand government should encourage paper-making enterprises bigger and stronger and eliminated the polluting small paper mills, which will create the conditions for the full realization of circular economy in the paper industry.

According to Forestry Statistics of Thailand (2016), in 2015, the world's wood pulp mill (excluding Thailand) had an average size of 200,000 tons. In Thailand, there are more than 50 enterprises that have the capacity for making pulp. The average scale is only 100,000 tons / year. Only 4 enterprises have reached the world average. The world paper-making enterprises (excluding Thailand) have an average annual output of 80,000 tons. The average size of paper-making enterprises in Thailand is only 19,000 tons. There are only about 80 enterprises in the world average size. Compared with the top ten paper companies in the world, the output of the top ten paper mills in Thailand totaled only 4%. [9] Overall, at present, Thailand's large pulp and paper industry enterprises are too small. This situation makes the scale of enterprises cannot be achieved, limiting the technical level of enterprises, equipment levels, product quality improvement and effective prevention and control of pollution.

Paper industrial waste water contains many fine fibers, inorganic fillers and inks, etc. These factors led to a large amount of waste-water discharge, the composition of pollutants in different poses and with different chemical degradability. According to 2016 annual statistics of environmental in Thailand, paper products industrial waste-water emissions of 23.9 billion m³, accounting for 11% of the total industrial waste-water discharge. CODcr emissions in waste-water reached 3.21 million tons, accounting for about 41% of the total national emissions. In sharp contrast with the above data, the contribution rate of paper industry to Thailand's economy is only 2.2%. [10]

According to the Pollution Control Department, the agricultural sector is the largest polluter as the nation’s farms discharged up to 39 million m³ of waste-water per day in 2016. The industrial sector ranked second, discharging 17.8 million m³ per day. The residential sector ranked third with 9.6 million m³ per day. Waste-water treatment processes in the residential sector were only 18 percent effective, while only 52 percent of waste-water was treated. [11]

In 2015, Pollution Control Department (PCD) monitored the quality of 49 rivers and 4 lakes in Thailand. Finding revealed that 68% water bodies surveyed were suitable for agriculture and general consumption (“good” and “moderate” quality). Only less than 40% of Thailand’s surface waters were in poor or very poor quality. According to the survey of major rivers and lakes by PCD, no surface water was categorized as “very good” quality (extra clean water which is suitable for aquatic animals and human
consumption after normal treatment), and the surface water quality appeared to be slightly worse than that of last year in terms of dissolved oxygen (DO) and total coliform bacteria (TCB) indicators.

3. The case study of Double A paper industry

Although 70.8% of the Earth’s surface area is covered by water. Freshwater resources are extremely limited. What humans can really use is part of rivers and lakes and groundwater, accounting for only 0.26% of the Earth's total water. [12] It is unevenly distributed.

After the 1950s, the global population increased dramatically and the industry developed rapidly. The global water resources have deteriorated rapidly and the “water crisis” has become increasingly serious. On the one hand, the human demand for water resources is expanding at an alarming rate. On the other hand, the increasingly serious water pollution has eroded the large amount of water resources available for consumption.

According to World Desk Reference. (2011) about 200 tons of rubbish are poured into rivers, lakes and streams every day in the world. Every liter of waste water pollutes 8 liters of fresh water. All rivers flowing through Asian cities are polluted. 40% of the water resources in the Thailand are industry pollution[13]. In the 20th century, the world's population tripled and human consumption increased fivefold. Many countries in the world are facing a water crisis. Thailand is also facing the water crisis.

There is a lot of water used in the production of paper. The production of 1t paper requires about 300-500m³ of water. In paper-making waste-water, it contains not only a large amount of paper-making raw materials (about 20% of raw materials will be lost along with waste water), but also a large amount of chemicals and other impurities. [14] Therefore, Effluent discharged without any treatment will cause great harm to the water body.

In order to deal with the crisis, here is an example that can prove a solution way for paper making industry pollution. Double A focus on improving recycling efficiency, reducing water consumption and waste-water discharge. It actively explores various reliable, economical and able to fully utilize useful resources in waste-water.

Double A’s waste-water treatment is basically divided into deposition precipitation method and bacteria digestion method.

A. The process of precipitation method

Waste-water → Filtration → Collecting Basin → Precipitation → Emissions[14]

Filtration is the easiest way to remove fines and protects other treatment facilities. Filtering is usually made by fine mesh or filter. It is the first step for all method to deal with waste-water.

According to the actual situation of waste-water, the method can remove about 80% suspended solids and inorganic particulates. Some CODcr and BOD5 are also removed, greatly reducing the load of subsequent treatment processes.[15]

The advantage of this method

1. The method is mature and stable
2. Low power consumption
3. Simple operation

The disadvantage of this method

1. It needs large area to operation

Sludge need to be dehydrated after concentration

B. The process of bacteria digestion method

Waste-water → Filtration → Regulator → Precipitation → A / O → Secondary settling tank → Emissions[16]

Preliminary process: First, foreign materials (such as wood pieces) from the waste water are removed using a golden sieve. Second, the filtered water is put into a mixing pond to adjust the alkaline content (fit for bacteria operation and pulp precipitation). Lastly, the temperature is adjusted and Urea Phosphate is added (a special compound which increases the efficiency of bacteria to digest contaminated water).

The filtered water from the first process is delivered to an air accumulation pond wherein the oxygen content is increased. It will then digest all the contaminated substances and exhaust it. Lastly, dregs are separated through the sediment tanks, and thus produce clean water (with the right BOD and COD level compatible with regulated standard from the Factory Bureau) as a finished result.

A / O (hypoxia-aerobic) treatment process is adsorption of organic matter with the microorganisms in the aerobic oxidative decomposition. The process through the process of automatic control of water filling, reaction, sedimentation and drainage mud to make the chemical treatment of waste water.

The biological treatment of waste-water is to use the metabolic function of microorganisms to make dissolved and colloidal organic pollutants in waste-water. It can be degraded and transformed into harmless and stable substances. Biological wastewater treatment because of its low operating costs, better results in waste-water treatment has been widely used in Double A. Paper-making waste-water contains a large amount of organic matter and the waste-water has good biodegradability. It can provide a large amount of nutrients to the microorganisms in the biological method. It can ensure the normal growth and reproduction of the microorganisms and the normal operation of the biological treatment waste-water.

The process is simple and control. According to influent water quality and effluent quality control indicators to deal with the amount of water, change the operating cycle and process approach. It can make most of organic matter generate non-toxic and tasteless CO2, H2O and some simple inorganic, to achieve a one-time purpose of degradation of pollutants.

The advantage of this method

1. The treatment effect is stable and reliable

2. It needs small area to operation

3. Less sludge and easy to dehydration

The disadvantage of this method

1. Higher equipment costs

2. Higher operating power consumption
After the treatment, the water will be stored in a pond and will be used to water the factory yard and Paper Trees around the mill. Double A has paper trees planted on 20,000 – 30,000 Rai of land which consumes 100,000 m³ of treated water a day. The place is equipped with mini sprinklers (12 mm-centered watering) in order to save money and consumption. In addition, the company offers water supply to all the companies situated in the 304 industrial zone.

An engineer of Double A named Sampan told that the selection of process plays the most important role in the construction of sewage treatment facilities, ensuring the treatment effect of treatment facilities and reducing the operating costs. Therefore, it is necessary to select technology feasible and economy in combination with design scale, sewage water quality characteristics and local actual conditions. After a comprehensive technical and economic analysis, the company need choose the best methods.

In the overall process of sewage treatment follow the principles.

1. The selected technology must be advanced technology and adaptable to changes in water quality that effluent quality to meet factory use standards and national waste-water discharge standards.

2. The selected process should reduce capital investment and operating costs, save floor space and reduce energy consumption.

3. The selected process should be easy to operate, flexible operation and easy management. According to influent water quality, should be able to process the operating parameters and operation of the appropriate adjustments.

4. The selected process should be easy to achieve automatic control, improve operational management.

5. The selected process should minimize the adverse impact on the surrounding environment (smell, noise, aerosol, etc.).

At present, Double A factory’s waste-water treatment technology has been successfully developed and put into use. It achieved good results. However, there are still some limitations. Therefore, the paper-making waste-water treatment technology research cannot be stagnant. It is recommended to increase research and development efforts in the following areas.

1. To develop waste-water treatment at different stages, from the physical, chemical, physical and biological aspects of optimization Technology, and continue to develop new technologies.

2. To study zero-discharge clean production technology for waste-water in various situations so as to popularize zero discharge of industrial waste-water.

3. To strengthen the waste-water treatment equipment, handle the research and development of pharmaceuticals.

Double A's business philosophy is centered to the principles of Sustainable business development with the responsibility to faithfully practice international standards and spearhead significant environmental and socio-economic relevant campaigns in order to achieve a balance among the three pillars of Sustainability: Environmental, Social and Economic responsibilities. Double A always believes that in order to achieve long term sustainability, it must truly fulfil its responsibilities towards the 3 sustainable pillars of Double A Business.
4. The solution for paper industry in Thailand

Thailand's paper industry has entered a period of rapid development. Here are some features.

First, the policy environment is basically established. Second, it is rapid increase in production and consumption, significantly improve the quality of the industry operation. Third, raw material structure has improved. Fourth, the reorganization of enterprises were intensified and industrial concentration were increased. Fifth, pollution prevention and control achieved initial success and resource consumption was further reduced.

However, at the same time, according to Lang, Chris. (2003), Thailand’s paper industry is also facing resource constraints and environmental pressure. The problems are as follows. First, the scale of paper industry is irrational and the efficiency is low. Second, most paper industries depends on foreign companies. [17]Third, the resource consumption and pollution is high. Fourth, the equipment capability is poor. Advanced equipment relies on imports. Fifth, the structure of foreign investment needs to be optimized.

How to deal with these pressure. According to the case study of Double A company, the suggestion are follows. First, to build the adjustment of industrial layout, raw material structure, product structure and enterprise structure. Second, to construct a new pattern of reasonable layout. It is important to make raw materials suited to the national conditions and products meeting domestic demand. Finally, paper industry must be gradually formed to achieve the optimization and upgrading of industrial structure.

It also very important to increase technological innovation. To combine the production, learning and research with the technological innovation system. To cultivate high-quality personnel, research and development of advanced technology. It is significant to develop technology, equipment and products with independent intellectual property rights. To cultivate a number of leading enterprises in the field of pulp and paper manufacturing equipment. To improve Thailand's pulp and paper equipment capability and design and manufacturing level.

On the other hand, the society should increase the domestic waste paper recycling and improve domestic waste paper recycling rate. As soon as possible to encourage local governments to develop waste paper recycling management practices, cultivating large-scale waste paper business, the establishment of waste paper recycling market, regulating the recycling of waste paper. According to Ubukata, Fumikazu. (2016), Thailand's domestic utilization of waste paper increased from 32% to 38% in 2016.[18]

Adhere to the introduction of technology and independent research. Track and study international advanced technologies and develop advanced applicable technologies and equipment with independent intellectual property rights. Encourage the original innovation.

Paper-making industry technology should develop in the direction of high level, low consumption and less pollution. Encourage the development and application of high-yield pulping technology, biotechnology, low-pollution pulping technology. Strengthen water-saving awareness of the entire industry, and vigorously develop and promote the application of new water-saving technologies, new processes, and new equipment to increase water reuse. Water pollution prevention and control engineering is a technical field of environmental engineering, with the local natural conditions (topography, weather, rivers, soil properties, etc.), social conditions (urban, regional development, industrial are all closely related.
Therefore, it is necessary to comprehensively consider the generation of various types of sewage, the method of sewage treatment and the requirements for discharge and reuse. It is important to improve various waste-water treatment technologies, increase treatment efficiency and make full use of water resources.

In order to make full use of water resources and save energy, some new separation technologies, recycling water technologies, land treatment systems, and sewage-saving biological treatment technologies are important development trends for water pollution control technologies in the future.

5. Conclusion

For paper making industry, the most important thing is that reduce and eliminate the amount of waste-water discharged. Firstly, the reform process can be used to reduce or even eliminate waste water, or reduce the toxicity of waste water. Secondly, reuse the waste water. Reuse water and make recirculating water systems as much as possible to minimize the discharge of waste water or recycle the production waste water after proper treatment. Thirdly is to control the concentration of pollutants in the waste water and recover useful products. As much as possible, the raw materials and products that have been lost in the waste water are separated from the water and recovered on the spot. It will not only reduce the production cost, but also reduce the concentration of waste water. Fourthly, the treated waste water should be handled well to avoid polluting the nature water.

Paper making industry should be comprehensive planning, rational distribution, and comprehensive regional governance. Firstly, in the formulation of regional planning, urban construction planning, and industrial area planning, water pollution must be considered. Preventive measures should be taken for possible water pollution. Secondly, comprehensive planning and comprehensive treatment of water pollution sources. Thirdly, eliminate any industrial waste-water and urban sewage emissions, and set standards. Waste-water from the industry should be treated centrally to reduce the number of pollution sources and facilitate management.

Government should strengthen monitoring management and formulate laws or control standards. Firstly, set up national and local environmental protection management agencies to implement relevant environmental protection laws and control standards. It supervises all departments and factories to protect the environment and protect water resources. Secondly, promulgation of relevant laws and regulations, the formulation of specific regulations for the protection of water bodies and the management of water pollution.

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