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The implementation of industrial wastewater management policies in Thailand: relationship between companies, the public and government

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Abstract

Wastewater is a cause of environmental concern throughout the world; industry, municipalities and agriculture are major sources of wastewater. About 6.8 million cubic meters of industrial wastewater are produced per day in Thailand, which contributes to an industrial wastewater problem in natural waterways because of inadequate wastewater treatment facilities. There are many government organizations and also laws involved with industrial wastewater in Thailand. Moreover, technology and public are involved in environmental management.

The aim of the research is to analyze the influences on industrial waste water management in Thailand in the field of policies and also technologies. Besides, to what extent are companies incentivized by public and public policy in decisions to adopt more sustainable behavior? A mixed method (interviews, survey questionnaires, and secondary data) was used to analyse industrial wastewater management in Thailand. A questionnaire survey was carried out in two rural provinces (Ayutthaya and Khon Kaen) with a total of approximately 200 respondents from communities in industrial areas. Additionally, 12 interviews were carried out with government officers, company and NGO representatives.

The findings indicate that main law involve with industrial wastewater is Factory Act, B.E. 2535 (1992) which is used to inspect all process of the factory including with establishment, operation, and waste management. The Act does not specify the types of technology used in wastewater management but the government officials from the Department of Industrial Works have responsibility to approve the technology used before establishment. Besides, Khon Kaen uses both technology and plant and algae-based systems (adopted from the King Bhumibol Adulyadej Rama IX's project) in treating their wastewater. While, Ayutthaya company uses only technology to treat their wastewater. The public are concerned about water quality locally and nationally in Thailand, whilst suggesting that standards of environmental practices vary between companies. The view of the public in local government decision making is represented via elected village leaders. Village leaders also provide information on environmental issues to the community via public meetings. The interviews indicated that government and company representatives thought public participation is an important factor in environmental management. However, the NGO suggested that public engagement such as opening the company for visits are mostly effective in protecting the image of the company, rather than influencing practices. Thus, although there can be a harmonious relationship between companies and their local communities, it is difficult to gauge the practical influence of public participation on company environmental behaviour. In this project, brewing industry may be an example of “good practice” for public participation on industrial wastewater management in Thailand. However, wastewater is still a problem and need cooperation between government, companies, and also public to manage it.

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Chapter One: Introduction

1.1 Background

Wastewater is a cause of environmental concern throughout the world (Azgin and Peker, 2015); industry, municipalities and agriculture are major sources of wastewater. The dairy industry (Adulkar and Rathod, 2015), and textile industry (Isa, 2015) are main examples of industry in producing wastewater. Inadequate clean water is a significant in developing countries (Azgin and Peker, 2015). Climate change, rapid population growth, and industrialisation have all affected freshwater resources (Marleni *et al*., 2015).

Wastewater is one of the most severe environmental problems in urbanised and industrialised areas in Thailand (Simachaya, 2009). About 6.8 million cubic metres of industrial wastewater are produced per day (Chokewinyoo and Khanayai, 2013), which contributes to an industrial wastewater problem in natural waterways because of inadequate wastewater treatment facilities (Cheevaporn and Menasveta, 2003). Thailand uses an end-of-pipe water quality standard in environmental regulations: factories are legally obliged to treat their wastewater before discharge to the environment in order to meet industrial effluent standards (Klayklung *et al*., 2010). However, wastewater from companies located in an industrial estate can drain pre-treated wastewater to a central wastewater treatment facility provided by the Industrial Estate Authority of Thailand (IEAT) (Simachaya, 2009). Additionally, recent work indicates that industrial wastewater is being used within the factory for secondary purpose because the tariff on treated water has increased (Chokewinyoo and Khanayai, 2013).

There are many government organisations involved with industrial wastewater in Thailand. Department of Industrial Works, Ministry of Industry is the main government organisation which has responsibilities to supervise, promote, and support industrial business operation activities for sustainable development and acceptability for international countries (Department of Industrial works, 2014). Factory Act (1992) B.E. 2535 is the act about factory operation and construction, factory expansion, and safety requirements. Besides, there are many acts to regulate industrial wastewater such as National Environmental Promotion and Protection Act (1992) B.E. 2535, Navigation in Thai Waters Act (1913) B.E. 2456, Fisheries Act

(1947) B.E. 2490, Public Health Act (1992) B.E. 2535, Industrial Estate Authority of Thailand Act (1996) B.E. 2539, and Royal Irrigation Command (Department of Industrial Works, 2005). However, although there are both policies and government organisations which force and control factory operations, the environmental regulations, or the manner in which they are implemented, are ineffective to protect the environment because the total quantity of wastewater exceeds the carrying capacity of receiving river ecosystem (PCD, 2005).

Technologies have a major role in reducing water pollution from the industry. Selection of industrial wastewater treatment system depends on the characteristics of wastewater from the industry such as types of pollutants to be removed (Chokewinyoo and Khanayai, 2013). Woodard (2001) indicated that the main limitations of wastewater treatment in Thailand are cost of investment and lack of operation and continuous maintenance.

Many stakeholders are involved in environmental management, each having some degree of influence on companies' response to environmental matters. Government agencies are the main role in setting up laws and regulations and also enforce implementation by companies (Panyathanakun *et al*., 2013). Local people or local communities are an important stakeholder to participate and encourage companies to aware about environment (Veiga and Magrini, 2009; Lombardi and Laybourn, 2012). Academic institutions are a third party to educate and provide information to the local and communities (Panyathanakun *et al*., 2013).

A role for the public in wastewater management in Thailand has been recognised in policy for many years (PCD, 2014). According to the Pollution Control Department (PCD), the participation of people has many levels: inform, consult, involve, collaborate, and empower (PCD, 2014). The PCD is a government organisation with functions involving public relations. These include the provision of basic information through many channels: websites, brochure, newspaper, radio, and exhibition. Moreover, the public have opportunities to participate for consulting in TORs, laws and regulations, reports etc. (PCD, 2014).

However, public participation procedures in Thailand have failed to integrate local communities' opinions in decision-making of environmental protection and management (Chompunth and Chonphan, 2012; Chompunth, 2013). This is because in practice public consultation in Thailand has usually been held after a conflict between stakeholders in a project had already affected to the people and nothing can be changed (Chaisomphob *et al*., 2004; Chompunth and Chonphan, 2012). The engagement of the public with respect to a specific event (such as a planning decision) is in contrast to that of the public influencing decision making by companies in terms of their ongoing environmental management. The latter circumstance has received little attention in Thailand, but could play a critical role in improving environmental performance, and consequently air or water quality in industrial areas as well as neighbouring residential areas. Current evidence suggests that people are interested in environmental quality, but the government does not necessarily respond to concerns. News reports have mentioned farmers in Ayutthaya province, complaining to government officials about wastewater from the factories nearby, but there was no recording response from officials (Dailynews, 2013).

This project will examine the implementation of the wastewater policies and the technologies used in industry in Thailand. For example, are the standards set in the policies are too low; are the policies are internationally acceptable but not well enforced; are companies trying to meet water quality standards with sub-standard technology? Moreover, this project will investigate public engagement related to environmental management and also wastewater management. For example, are people aware of a problem with wastewater, how and why have they attempted to communicate concerns? How does the company respond to the public; are the public involved in forcing the company to meet water quality standards? The brewing industry in Thailand will be used as a case study.

1.2 Aims and research questions

The aim of the research is to analyse the influences on industrial wastewater management in Thailand in the field of policies and also technologies. Besides, to what extent are companies incentivised by the public and public policy in decisions to adopt more sustainable behaviour?

The research questions of this study are:

1. What policies relevant to industrial waste water management have been established by the Thai government and how are they enforced by regulatory agencies?

2. How do companies engage with industrial effluent policies, standards and the regulatory agencies?

3. What are similarities and differences of the technologies to international comparators?

4. How have the public attempted to engage with industrial wastewater management and how effective has this been?

5. How do companies engage with the public with respect to industrial wastewater?

6. Have non-government organisations (NGOs) engaged with the public in industrial wastewater management, and if so how?

1.3 Structure of the study

Chapter Two: Theories relating to the implementation of sustainable development

In this chapter, sustainability with ecological modernisation and industrial ecology are reviewed. Moreover, relationship between stakeholders and public engagement are involved with the sustainable development on industrial wastewater in Thailand.

Chapter Three: Industrial Wastewater

This chapter describes brewing industry with process and residues. Besides, technology used in treating brewing wastewater and also other techniques which are wetlands and algae-based system are presented.

Chapter Four: Research Design and Methodology

In this chapter, will clarify the aims and research questions of the study. Describing the research design and methods for this thesis and also discussing why Thailand was focused on in the research.

Chapter Five: Regulatory context and policies in industrial wastewater

This chapter will analyse the policies and regulatory context involved in industrial wastewater in Thailand, especially in the brewing industry. Moreover, industrial effluent standards in Thailand will be discussed and compared to international standards.

Chapter Six: Wastewater management

In this chapter, examines industrial wastewater treatment technologies used in breweries and investigates how different between two case studies (Khon Kaen and Ayutthaya).

Chapter Seven: Public participation

This chapter will examine and clarify public participation with industrial wastewater management. The two companies are compared on public participation on industrial wastewater management. Besides, NGO is also investigated with public engagement on industrial wastewater management in Thailand.

Chapter Eight: Discussion

This chapter analyses the main themes to emerge from the research. Relating to policy, ecological modernisation approach, technology, industrial symbiosis, and relationships between different stakeholders in industrial wastewater management in Thailand.

Chapter Nine: Conclusion and recommendation

This chapter criticises how Thailand has managed industrial wastewater including with regulatory context, and technology. Besides, to evaluate how public has participated in wastewater management. Besides, this chapter also provides research recommendations and recommendations for further study on wastewater management in Thailand.

Chapter Two: Theories relating to the implementation of sustainable development

This thesis is exploring the relationship between business, government and the public in the content of the management of industrial residues and in particular around the selection of technology for managing those residues. Within the broad sustainable development literature, there are a number of theoretical fields exploring different, but related, ideas about how sustainability can be implemented, especially considering technological developments. This chapter reviews literature relating to ecological modernisation and industrial ecology, before exploring ideas relating to stakeholders in environmental policy implementation, including the involvement of the public and finally considers environmental justice.

2.1 Sustainability and drivers for technology uptake

Sustainability became a publicly and politically prominent concept incorporating environmental and water resources management following the 1992 Rio World Summit on Environmental and Development (Sathaye *et al*., 2007; Paredis, 2011; Harmancioglu *et al*., 2013). The UN World Commission on Environment and Development (WCED, 1987; p.8) defined sustainable development as development that ‘meets the needs of the present without compromising the ability of future generations to meet their own needs’. Sustainability involves environmental, social and economic criteria (Shiroyama *et al*., 2012). It needs to be applied in policy objectives in many aspects such as population and human resources, food security, species and ecosystems, energy, industry, and urbanisation challenge (WCED, 1987, Farla *et al*., 2012).

Sustainable development discourse involves a strong technological component. New technologies were seen from early discussion of sustainable development to play a role in higher productivity, increasing efficiency and decreasing pollution (WCED, 1987: 16). The Brundtland report advocated the advantages of technology ‘for raising productivity and living standards, for improving health, and for conserving the resource base’, but also cautioned against new hazards, warning that technologies ‘are not all intrinsically benign’ (WCED, 1987: 217, 219). The development and diffusion of new technology is seen as one of the core methods to solve environmental and development problems (Paredis, 2011). Johnson and Wetmore (2009: 441) pointed out that many philosophers and sociologists of technology indicate the relationship between technology and society 'is the key to building a better world'. Nonetheless, there is a large difference between a technology being available and it being used. Social, economic, political and cultural issues influence to the uptake of technology. Furthermore, the desirability of uptake may be contested, whilst issues of equity arise in access to technology. Mandating of technological requirements in industrial production can become a form of trade barrier and/or source of dependency between developing and developed countries (Boehmer-Christiansen, 2002). A number of theoretical approaches are relevant to the exploration of technology for sustainable development.

2.2 Ecological modernisation

A key theme in the sustainable development literature is the concept of ecological modernisation (EM). Huber (1985, cited in Spaargaren and Mol, 1992: 334) stated a concept of ecological modernisation as the idea that 'the dirty and ugly industrial caterpillar transform into and ecological butterfly'. Hajer (1995: 26) gave description of ecological modernisation as 'the discourse that recognises the structural character of the environmental problematique but none the less assumes that existing political, economic, and social institutions can internalise the care for the environment'. Or, based largely on the European experience from the 1970s, EM may be defined as 'the social scientific interpretation of environmental reform processes at multiple scales in the contemporary world' (Mol *et al.*, 2014: 34). Mol (2003: 56) stated that aims of ecological modernisation are to understand, interpret, and conceptualise 'the nature, extent and dynamics of this transformation process', more specifically the 'social dynamics behind these changes'. However, the focus of EM is on production and consumption, regarding this cluster of activities as significant to current environmental problems (Spaargaren, 2000). Furthermore, EM does not question the centrality of production and consumption to the economy (Vlachou, 2004; Warner, 2010) it is not a degrowth approach to environmentalism.

Indeed, in contrast to degrowth, EM promotes the solving of environmental problems through economically driven innovations, 'super-industrialisation' (Huber, 1982, 1984, 1985), implying the modification of production with the improvement and operation of more complex technologies. Early work in EM in particular emphasised the potential for the convergence of economic and environmental benefits, and in even argued that the state would hamper the process of development and diffusion of clean technology through interfering with businesses' ability to direct its own operations (Huber 1982, 1985). This extreme view was argued against e.g., by Mol and Spaargaren (1993) who were sceptical about the ability for a radical change in business behaviour without governmental involvement.

EM is a pragmatic political programme supporting and reliant on financial advantages from business responding to environmental problems through ideas of profitable enterprise (Harvey, 1996; Weale, 1992). This could happen in several ways. First, reducing pollution and waste production removes inefficiencies from business. Second, preventing future financial debts from environmental liabilities. Third, creating a better environment has benefits for, and attractions to, a company's workforce. Fourth, a market is created for environmentally-friendly products and services such as pollution prevention and abatement technologies (Dryzek, 1997). Thus, according to ecological modernisation theory, economic development can protect and conserve the environment but it can also precipitate technology development (Gibbs, 2002). Whilst the integration of economic development and environmental policy in 'win-win' opportunities is widely seen as a main idea of EM (Pataki, 2009), Jänicke (2008) cautions that the most accessible opportunities 'win-win's' are likely to have already been adopted; more specific and more demanding regulations may be required to achieve the level of results required for example by climate change agreements.

Besides emphasis on economic and environmental-co-benefits, a second key theme in EM is a reliance on technological change to lessen the environmental impacts of production and consumption (Memon *et al.*, 2011; Davidson, 2012). Government action towards EM has focused on creation, innovation, and expansion of new technologies and techniques in the process of operation of the industry (Murphy, 2000). Flexible regulations, such as market instruments are favoured (Bailey *et al.*, 2011), providing economic incentives towards technological solutions. The assumption is that market instruments allow industry to find means to respond which accomplish the purpose of the regulation, without interfering with operation, i.e., accepting that industry knows best how to run itself and although some direct government involvement may be necessary, that involvement should still be a relatively light touch. Authors have found that the participation of industry representatives in implementation and formulation of policy has achieved a better environmental outcome than imposed solutions (Angel and Rock, 2003; Holiday *et al*., 2002; Marcus *et al*., 2002; Revell and Rutherford, 2003). In addition, EM theorists and acknowledged the role of non-business and non-governmental stakeholders in influencing business performance: companies may be influenced by the opinions of consumers (Spaargaren, 2000, 2003); and NGOs, at least those prepared to accept the EM pro-growth agenda, can become useful allies of business and government rather than antagonists (Mol, 2000).

The improvement from end of pipe technologies in the early 1970s to pollution prevention technologies by the late 1980s can be seen as one of the key achievements of the early stages of EM in the EU (Spaargaren, 2000). EM has been a cornerstone of EU approaches to the environment (Baker, 2000; Konak, 2008) up to and including the circular economy resource efficiency strategy (Yuan *et al*., 2006), which covers activities relating to industrial ecology (discussed below). However, whilst both early and subsequent EU regulations have had an effect on standards and behaviour of companies (e.g., Deutz *et al*., 2017), macro-economic restructuring has also been a factor in the apparent decoupling of economic growth and environmental impact within Europe (Jänicke, 1985; Jänicke et al., 1988, 1989; Simmonis, 1989a, b). This process of shifting 'the emphasis of the macro-economy away from energy and resource intensive industries towards service and knowledge intensive industries' (Gouldson and Murphy, 1997: 75) may have been in part intentional, as the authors imply, but also describes the movement of heavy and polluting industry to non-European locations.

The extent to which companies may have relocated or invested abroad with differences in environmental policy in mind is open to question, but they have not always responded in the manner expected to environmental regulations. Industry responses to regulations trying to promote EM are not necessarily in the form of technological innovation. Organisational responses may be used as a simpler alternative (Gouldson and Murphy, 1998), and regulations appear to be more effective at ensuring that minimum standards are met than in driving up standards by incentivising technological innovation (Roediger-Schluga, 2004).

Notwithstanding either these shortcomings or the strong academic and empirical ties of EM with Europe (e.g., Spaargaren and Mol, 1992; Hajer, 1995), many countries throughout the world have taken a practical and/or research interest. These include Japan, Vietnam, Korea, Thailand, Malaysia, and especially China, North America, Latin America, Australia and New Zealand, and also Russia (Mol *et al*., 2014). There remains an imbalance, however, with most studies within the EM tradition focusing on large, transnational, industries in the developed world while small and medium sized industries in developing countries receiving relatively little attention (Wattanapinyo and Mol, 2013). One country that has overtly adopted a policy of EM, in response to severe environmental issues associated with rapid industrialisation is China. With its early adoption of circular economy policies (McDowall *et al*., 2017) and more recent embracing of renewable technologies, China appears to support the 'leap-frog' theory (Zhang *et al*., 2007). The latter proposes that in some circumstances developing countries can jump from polluting to cleaner technologies more quickly than western counterparts. Zhang *et al*. (2007) suggest that China's efforts at EM are managing to avoid the slower pace of adapting industry to environmental considerations that happened in the west. Interestingly, Chinese industrial parks have sought to improve their environmental performance along the lines outlined by Gouldson and Murphy (1997), that is by seeking to attract fewer polluting industries (Wang *et al*., 2015). There can also be variations in technology uptake within countries. A study of the uptake of domestic renewables technology in China (Yu and Gibbs, 2018) found that a provincial city showed evidence of leap-frogging to a renewable energy technology, whereas residents in Beijing appeared to be locked into a standard technology.

The irony is, though, that countries most at need from achieving benefits from economic and environmental gains being associated with each other are not able to achieve this because they lack the institutional capacity and perhaps support for research and development required (Milanez and Bührs, 2008). These countries are unlikely to be able to benefit from a leap frog effect (Zhang et al., 2007), but will follow a slow path to environmental improvements notwithstanding the existence of suitable technologies. Attempts in Brazil, for example, to mimic the EU's extended produced responsibility regulations met with only partial success (Milanez and Bührs, 2008). Brazilian companies complied with requirements for cleaner batteries by importing rather than developing new technology. Environmentally that may be an adequate solution to the problem, and also cost effective for the companies, but it is not a route to an innovation-driven economy. Other aspects of the regulation were also met only in the letter of what transpired to be a poorly framed law. A used battery collection system complied with the law requiring companies to establish such a system, but only one in ten used batteries were captured by the system because there was nothing in place to monitor its operation.

Further to challenges of developing new technology in a developing country, imported technology can also be problematic. Technology needs to be carefully selected to fit not just the technical requirements (e.g., for the type of wastewater) but also the social, cultural and economic constraints of the circumstances (Luken and Rompaey, 2008; Etriki, 2013). Given that technology is often developed in and for developed countries, transfer of technology to developing countries has often met with unsuccessful outcomes with restrictions and incompatibilities caused by uneven development (Steinbach, 1999). Confused organisational structures and the lack of a tradition of comprehensive tax collection by which to fund policies are among the issues encountered (Etriki, 2013). The concept of 'environmentally sound technologies' (EST) emerged to try to capture social as well as environmental needs (UNEP/DTIE/IETC 1996; 2003). However, the concept of EST still has the implication of technology transfer (Luken and Rompaey, 2008). By contrast so-called 'appropriate technology' (Schumacher, 1973, in Lee *et al*., 2018) implies a more bottom-up approach whereby decisions on technology are made with direct input from the people involved in using the technology (Lee *et al*., 2018). This may nonetheless still involve too much emphasis on technology as a solution to problems (Atkin *et al*., 2017). Or indeed perhaps the only issues that are recognised as problems are the ones with apparent technological solutions.

There have been limited studies of EM in Thailand, although the government has adopted an approach to environmental protection which rests on the same principles as those behind EU regulations. Environmental policies in Thailand include economic instruments based on principles such as polluter-pays and pollution-prevention-pays-principle (DIW, 2002), which are fundamental of EU environmental regulation. There is also an interest in environmentally sound technology and cleaner technology (DIW, 2002). The perceived pressure for uptake of EST in the textile industry in Thailand (based on a survey of 28 production facilities) was primarily to reduce production costs (Luken and Rompaey, 2008), though notably those companies were not responding to international markets, in contrast to the breweries in this study. Those companies perceived environmental regulations as the third greatest pressure for EST, behind expected future regulations. This suggests EM is an influence on manufacturers in Thailand, albeit in 2008 not the primary one. A subsequent study (Er *et al.*, 2012) indicated that the policy formulation process in Thailand allowed only a limited role for industry representatives. The authors thought this resulted barrier faced by state and industry in policy matters related to ecological restructuring. However, the maintenance of a distance between government and industry could be seen as positive in terms of promoting a strong regulatory approach.

Thailand has tried to decentralise environmental governance; local organisations of the Department of Industrial Works, Ministry of Industry (provincial industry office) have the statutory responsibility to ensure that the local environment is managed and protected. The assumption is that local bodies will be more responsive, have a better understanding of the local conditions and so can more promptly and effectively deal with any problems that arise within their area (Thappom, 2003). The local organisations use the same policies and regulation as the Department of Industrial Works. Although, government officials from the local organisations and also the Department of industrial Works inspect the factory together, officials of the Department of Industrial Works have the responsibility to consider penalty if a problem is identified. The local officials who respond to the problems have limited capabilities due to less education and also limited budgets compared to national bodies (Thappom, 2003; Wattanapinyo and Mol, 2013). Thus, local organisations take responsibility only for factories that have less potential impact on the environment, i.e., factory type 1 and 2. Moreover, whilst local organisations collect all comments and complaints from locals, they have to contact the Department of Industrial Works to follow up the comments and investigate whether factories follow by the laws and regulations.

Aside from debates on the appropriateness of EM for developing countries, there is a critique of the literature's grasp of institutional factors within developed countries. EM is not a field that has covered social aspects of sustainability and the social context of EM has been said to be inadequately addressed by the literature (Gibbs, 2002). The significance of non-regulatory institutions (culture and practices) and in particular the power relationship between different stakeholders in environmental regulation have been poorly addressed by the EM literature (Peck, 2000, Gibbs, 2006). Other authors, especially from a critical theory perspective content that changes under EM are a short-term approach to environmental issues, and are not likely to provide real solutions (Hovardas, 2016).

In summary, EM is a theory and policy approach emphasising the economic and environmental co-incidence of environmental regulation and technology as a solution to environmental issues. Critiques of the approach variously consider its lack of environmental ambition or conversely the lack of understanding of the influence of relationships between different parties to environmental policy making. Numerous areas of research have opened up in recent years that coincidentally or intentionally tackle some of the gaps in EM. Those that are relevant to the present study are reviewed in the coming sections.

2.3 Industrial ecology

Related to ecological modernisation, industrial ecology is an industry-focussed concept that also promotes the idea that sustainable development can be achieved within existing political and economic structures and also draws on the idea of economic and environmental benefits being interrelated (Deutz, 2009). The distinction between the two is that industrial ecology has traditionally been for more focussed-on material exchanges (including potential benefits and how to bring them about), and less concerned about the social and policy context than ecological modernisation (Deutz, 2009). Industrial ecology is about identifying all possible exchanges of energy and material that reduce resources used (Eckkelman and Chertow 2009; Gerber, *et al*. 2013). Industrial ecology and industrial metabolism integrate end of pipe approaches and prevention methods into the wider perspective (Erkman, 1997).

Industrial ecology has been seen as having a role in addressing environmental concerns including depletion of natural resources and water, air, and soil pollution (Despeisse, *et al*. 2012; Quijorna, *et al*. 2011; Thatcher, 2013) and its part of the process of building a circular economy (Deutz and Ioppolo, 2015), which aims to maximize the value form resources and minimise waste production, whilst implementing approaches which regenerate rather than degrade the environment (Ellen MacArthur Foundation, 2017).

Industrial ecology is highly relevant to the brewing industry, which draws on biological processes both in production and to cope with residues, several of which are seen as suitable for re-use (see Chapter Two). This is emphasised by Erkman's (1997: 1-2) statement of industrial ecology and industrial ecosystem involving with three key elements: 'it is a systemic, comprehensive, integrated view of all the components of the industrial economy and their relations with the biosphere; it is emphasises the biophysical substratum of human activities, i.e. the complex patterns of material flows within and outside the industrial system, in contrast with current approaches which mostly consider the economy in terms of abstract monetary units, or alternatively energy flows; and it considers technological dynamics, i.e. the long term evolution (technological trajectories) of clusters of key technologies as a crucial (but not exclusive) element for the transition from the actual unsustainable industrial system to a viable industrial ecosystem'. For a food and drink industry, such as brewing, the biological links are relatively clear, but in addition the consideration of the adoption of technology and what might be suitable (or 'viable') in a given context is of relevance to this study.

An important route to implement industrial ecology is known as industrial symbiosis (Chertow, 2000). Industrial symbiosis is the use of residues (energy, water, material) from one entity as an input to another (Chertow, 2000; Deutz, 2014). Those residues may be by-products from an industrial process that already have an established market (such as iron slag) or a waste product for which presently the only economic option is disposal. Finding uses for residues requires a match of quantity and quality of material between companies within cost effective distance. Studies have indicated the significance of a policy context conducive to avoiding disposal as well as the need for trust between companies (e.g., Velenturf, 2016).

Industrial symbiosis has been implemented both between companies in their pre-existing locations and within specific locations. The latter can be on the scale of a city, or on a specific industrial site, which can be known as an eco-industrial park. Eco-industrial estate (or park) is defined as '…a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water and materials' (Lowe and Evans, 1995). Lambert and Boons (2002) stated that eco-industrial park is participating of the companies to improve economy and also to reduce environmental impacts. In term of eco-industrial estate, the physical exchange of materials, energy, water, and by-product is an important factor (Chertow, 2007), but one that is often aspirational rather than existing (Gibbs and Deutz, 2007). Pilouk and Koottatep (2017) point out that aspects of eco-industrial parks and industrial symbiosis can be seen in the cooperation and participation involved in the eco-city concept.

Industrial ecology and related concepts are not only used in developed countries, but also in developing countries such as China, most prominently, but also India, Nigeria and Colombia (Erkman, 1999; Chiu and Yong, 2004; Deutz et al., 2015). As with EM, these studies (e.g., Olayide 2015; van Hoof, 2015) discuss the importance of approaches to IE suiting the local circumstance. In China, academics and the central government have paid attention to industrial ecology for more than a dozen years (Yuan et al., 2006). Thailand has adopted industrial ecology to development economy by supporting from the Deutsche Gesellschaft für Technische Zusammenarbei and Industrial Estate Authority of Thailand (Chiu and Yong, 2004).

Eco-industrial development practices, such as eco-industrial parks have been implemented in Thailand since 2000 (Pilouk and Koottatep, 2017). The goal of eco-industrial estates and networks in Thailand, which initiated in 2000, were to reduce decrease consumption, degrade environmental impacts, enhance environmental quality, improve quality of life of community, reduce negative impacts of industrial operations on community, boost succession of the business by reducing raw material costs, reduce energy consumption, and decrease cost of waste treatment and disposal (Panyathanakun *et al*., 2013). Moreover, Panyathanakun *et al*. (2013) stated that some of factories in the 'Development of Eco-Industrial Estates and Networks' project at the Northern region industrial estate of Thailand in 2000 adopted 3Rs concept (reduce, reuse, and recycle) and also donated some of by-products and waste to the community. Although environmental performance of eco-industrial parks is considered the primary concern in attempting to quantify their achievements, impacts on communities and the ability of communities to engage are also important sought for in the designation of higher performing parks (Pilouk and Koottatep, 2017). The relationship between the case study businesses and their communities is central to this thesis.

2.4 Stakeholders

As has been alluded to above, many different types of organisations can be involved in promoting and implementing environmental policies. In addition to business and the rule-making and enforcing authorities, other groups and individuals (the public, or groups representing sections of the public, and NGOs representing social or environmental interests) all have an expectation of a right to be heard. The idea of community participation in some form was included in the early discussions around sustainable development and later codified in the UN Aarhus Convention of 1998 (Hartley and Wood, 2005). Following Freeman, 'those groups and individuals that can affect, or are affected by, the accomplishment of the business enterprise' (Freeman, 1984: 25) are its stakeholders. These can include policymakers and public authorities, firms, social movements, civil society and consumers, experts and research organisations (Bakker *et al*., 2012; Budde *et al*., 2012; Konrad *et al*., 2012; Musiolik *et al*., 2012; Penna and Geels, 2012).

This study is focussing primarily on three key stakeholders (company, national government and regional representation, and the public in the form of local communities). These have previously been identified as significant in studies of technology and environmental performance, including in Thailand specifically (as discussed above). The following sections review the roles of these stakeholder categories.

2.4.1 Governmental bodies

Policymakers and public authorities have a role establishing the formal institutions governing environmental management. This may refer to some or all of the following: requirements for monitoring environmental performance; emissions limits for specified substances; specific technology required; establishing of a body to monitor performance in these areas; setting and enforcing penalties for non-compliance. As discussed under EM, public policy can incentivise, or more directly promote, technological innovation, e.g. by financing innovations in pre-competitive phases, funding demonstration facilities for sustainable technologies or supporting organisational changes (Bakker *et al*., 2012; Quitzao *et al*., 2012).

2.4.2 Companies

There are many studies of stakeholders and stakeholder theory relating to companies, which identify various stakeholders (Laplume *et al*., 2008). These studies are largely looking from an industry perspective, so see a company as the central point to the stakeholder community (e.g., Geng *et al*., 2017). Other stakeholders are the supply chain partners (other companies buying from, or selling to the main company) and governmental bodies (Seuring and Müller,

2008) and communities are also often included (Geng *et al*., 2017). The latter, however, may refer to the public at large, which might be interpreted as potential customers, rather than 'community' in the sense of neighbourhoods/residents proximal to the company. International companies have additional stakeholders to consider, such as international agreements or agencies as well as multiple national governments (Scherer *et al*., 2013) and possibly multiple sets of 'the public' from different publics. Studies of public services, such as waste or water, derive a similar list of stakeholders but with a different balance and wherein the public are directly involved service users, or potentially customers (Wilson *et al*., 2013; Boschet and Rambonilaza (2018). In addition, non-governmental organisations (NGOs) have become an important stakeholder in corporations (Dahan *et al*., 2010; Hansen and Spitzeck, 2010; Spitzeck, 2009; Spitzeck and Hansen, 2010).

Arguably, environmental protection could be seen as a public service overseen by a regulator – whereby companies involved in a given location are part of delivering that service to the community, rather than holding a privilege. Nonetheless, in the absence of regulations specifically requiring a certain technology, companies are the key decision maker determining the environmental technology they employ. Many studies have examined the influences on companies, which will vary between location and sectors (e.g., Luken and Rompaey, 2008). Corporate response to the environment is influenced by legislation, stakeholder pressure, economic opportunities, and ethical motives (Bansal and Roth, 2000). Corporate reputation (Hart, 1995; Russo and Fouts, 1997), learning capability (Bonifant *et al*., 1995; Hart, 1995), and product quality (Shrivastava, 1995) may all also be important. Penalties and fines are critical to back up legislation (Cordano, 1993; Lampe *et al*., 1991). Along the lines proposed by EM, cost savings are also important drivers (Cordano, 1993; Lampe *et al*., 1991; Porter and van der Linde, 1995), they may not be sufficient to achieve more than superficial environmental gains (Jänicke, 2008).

Companies can try to be sustainable not only by complying with regulations, but also by taking environmental, social, and governance factors into account in their financial and decision making (Keefe, 2007). Sustainable business models represent embedding sustainability into the core business of a company – so that sustainability becomes an aspect of making money (e.g., by sale of an environmental product of service) rather than a subsidiary service that might be a distraction to making money (Schaltegger *et al*., 2017). Corporate contributions to sustainable development goals has led to concepts such as corporate social performance (CSP) (Swanson and Orlitzky, 2017) and corporate sustainability performance (Schaltegger and Wagner, 2006), which focus on contributions of corporation to environmental preservation, societies' economic progress and human well-being. As in other areas national context is significant, with firms in different countries systematically displaying different sustainability behaviours even when they have all signed up to the same international standards (Ortas *et al*., 2015).

Small and medium-sized enterprises (SMEs) differ from large companies on the engagement of environmental and social issues. Implementation of social and environmental policies has been less in SMEs than in larger companies (Hamann *et al*., 2009; Spence, 2007); they seem less engaged in environmental and social behaviours than larger companies (Lawrence *et al*., 2006). Managers in SMEs can have more freedom in decision-making than those in large companies (Hamann *et al*., 2009), and thereby may conduct to more engagement with environmental and social issues (Jenkins, 2004; Vives, 2006). However, small businesses have usually been found to have limited capability and willingness in engaging with pro-environmental issues because SMEs have small number of customers and staff and have limited financial and administrative resources (Biondi *et al*., 2000; Gerrans and Hutchinson, 2000; Hamann *et al*., 2009; Hillary, 2000; Spence, 2007).

2.4.3 Publics

Social movements, civil society and consumers, experts and research organisations have a role to promote change within a system (Schuitmaker, 2012) and can help to create a demand for new technology (Johnson and Wetmore, 2009). Penna and Geels (2012) showed that social movements can push policymakers to enforce legislation (Paredis, 2011). Communities have been identified as stakeholders involved in eco-industrial estate in the Northern region industrial estate of Thailand, alongside government agencies, the federation of Thai industries, community, and academic institutes (Panyathanakun *et al*., 2013). Veiga and Magrini (2009) stated that a strong relationship to the community around the area gives a positive effect to the eco-industrial estate development. Moreover, public advantages become main encouragement to force eco-industrial system (Lombardi, 2012). Panyathanakun *et al*. (2013) pointed out that community has a main role in the eco-industrial project. So, the public can be beneficiaries of environmental improvements initiated by companies, or may be part of the process bringing about change – either through pressure on policy makers or directly on companies. The public, however, are not a homogeneous group, but rather include many different interests/opinions and can be a challenging element with which to engage alongside the organisational stakeholders (Eden, 2016). As mentioned above, though, public, or community, involvement in decisions is a critical element of sustainability and (as outlined below) is written into environmental regulations in Thailand.

2.5 Public engagement

Public perception, public awareness or public opinion relate to people's understanding of public issues (Chesoh, 2010; Dowler *et al*., 2006). Public perceptions are influenced by policymakers because the public's opinion plays a part in policy priorities (Hunter, 2004). People obtain information and knowledge from both the government and project owners (Bureekul, 2000). Media also have an influence on public perception or public awareness or public opinion. Bord *et al*. (1998) pointed out that improving of public perceptions in global warming in the U.S. could occur by informing scientific and policy discussion of climate change. However, Bi *et al*. (2010) indicated that sex, ages, income, education, officials, and also urban area influence public perception in environmental issues or concerns within Wujin County, China. In Thailand, Chesoh (2010) showed that most local people, about 97%, learned Chana power plant development programmes from neighbours, community leaders, as well as project public relations documents every month.

Public perception is always studied as a subjective social indicator in sociological research (Chesoh, 2010). However, some authors use public perception to be the same as public awareness or public opinion, seeing public perception a method to obtain public's opinion or to provide understanding (Dowler *et al*., 2006; Chesoh, 2010). Public perception or awareness can be a motivating factor to encourage people to accept changes to their surroundings (Choi and Lee, 1995; Bureekul, 2000; Huang *et al*., 2010), but it can also motivate them to protest for or against change. Bureekul (2000) said that providing information or acknowledging people's concern can help achieve public participation. Therefore, public awareness of an issue, with a perception of a need to act, are necessary for public participation. This needs to be matched by the perception that the public's views are acknowledged and taken into account in decision making.

Many authors suggested methods to achieve successful public participation. Chesoh (2010) stated that model of participation needed four factors. First factor is freedom, ability and willingness. Second factor is two-way communication. Third factor is transparency and the last factor is co-management practice. Moreover, characteristics of leaders and calibres of public relation staff are factors affecting level of public participation. Bureekul (2000) suggested that achieving the public participation involves following these conditions. First condition is encouraging the advantageous image of project agent. Next condition is providing information to the public from the first stage of the project. And the last condition is promoting participation in every stage of the project. Similarly, but with significant differences, Chesoh (2010) pointed out that the conditions to achieve public participation are (1) creating benefit of the project to the public particularly the environmental conservation and public health (2) demonstrating confidence and trust of the project by informing the public every stages of the project (3) encouraging transparency public participation in every stage (4) supporting village funding. Therefore, to achieve successful public participation is to work through public relations, but Chesoh (2010) emphasises actual benefits to the public, or that the public will see as being to the advantage of their neighbourhood. In addition, trust is one of the factors affecting the public participation. When the degree of trust between stakeholders increases, level of public participation would increase (Bureekul, 2000).

2.5.1 Public participation in Thailand

Thailand adopted public participation into the regulatory framework because the government realised its potential for solving environmental conflicts (Chompunth and Chonphan, 2012; Chompunth, 2013). There are many forms of public participation which are used in environmental impact analysis (EIA), feasibility studies for construction, and government policies (Bureekul, 2000; Manowong and Ogunlana, 2006). However, public participation procedures in Thailand have failed to integrate local's opinions into decision-making for environmental protection and management (Chompunth and Chonphan, 2012; Chompunth, 2013). Public consultation in Thailand has usually been held after a conflict between stakeholders in a project had already affected to the people and nothing can be changed

(Chaisomphob *et al*., 2004; Chompunth and Chonphan, 2012). Similarly, other scholars around the world have also indicated that public participation often happens after a decision has already been made (Richardson *et al*., 1998; Palerm, 1999; Garin *et al*., 2002; Almer and Koontz, 2004; Depoe and Delicath, 2004; Diduck *et al*, 2007; Flynn, 2008; Okello *et al*., 2009).

An example of consultation after the event in Thailand is provided by mega development projects such as the Hin Krut power plant project. The public hearing happened after the government had signed an agreement with the Electricity Generating Authority of Thailand (EGAT) (Bureekul, 2000). Although the Environmental Impact Assessment (EIA) was officially approved, local residents opposed the project because of its potential impact on marine ecology (Union Power Development Co., Ltd., 1999). Similarly, the Bo Nok power plant project was approved by the government before the public hearing (Bureekul, 2000). Therefore, the government had to use public hearing to reduce the opposition. Bureekul (2000) outlined process of public hearing of the Hin Krut and Bo Nok power plant projects as the following activities. The government set up a public hearing committee. The hearing activity was set for two days. However, there were a lot of people registered for participating in public hearing. Therefore, the local people were divided into three groups according to whether they were pros, cons, or neutral; each group of stakeholders had to choose representatives to express their opinion in the conference room. After the hearing process, some people were unsatisfied because the chairman was not neutral. Moreover, locals participated in the hearing for only one day because they felt they could not trust the committee (Matichon, 2000).

A number of other problems have been identified with the public participation process in Thailand. The provision of education and information from the government and other authorities to the public on the subject, problems, and situations is inadequate. There were also some mistakes and difficulties in understanding technical terms, which are in English in EIA report. This resulted in public mistrust in the government and the developers such as a case study of Hin Krut power plant project, Prachuap Khiri Khan Province (Chompunth, 2011; Chompunth and Chomphan, 2012). Although, there are the constitution and the Official Information Act which said that the public has right to know or access official information, some officials were not familiar with the law and need to disclose information (Bureekul, 2000). Bureekul (2000) suggested that making more information available to people would promote environmental awareness, and thereby the level of public participation would be higher.

Next, some meetings or seminars are unavailable to all people or in some cases were held by different authorities but the people wanted to attend only one meeting held by their favourite one. Although there are more methods to give information to the public such as exhibitions and open houses, these activities were held after the problem happened. Furthermore, not all stakeholders had the opportunities to attend in the forum or it was hard to gather all stakeholders and parties in public participation. Most of people who were affected by any projects felt that they did not have enough opportunities in public participation by the government and project owners (Bureekul, 2000). Also, an inequality between local people, government officials, and experts in the public hearing process made local people felt unfair and boycotted the forum (Chompunth, 2011; Chompunth and Chomphan, 2012). Furthermore, most public hearings were set up on workdays, many people could not attend to the hearing (Bureekul, 2000)

In the same way, there is no transparency in implementing in many projects in Thailand. For example, the leader of the villagers who opposed the Hin Krut power plant project were disappoint to the government ignored their opinion in the decision-making process (Awakul and Ogunlana, 2002; Chompunth, 2011). Chesoh (2010) stated that conflicts and protests could happen if lack of transparency and participation from local and also stakeholders in the early stage of the project. Moreover, the government normally responded negatively to the public participation because the government did not concern the local's opinion (Bureekul, 2000).To avoid these problems, the government should increase transparency by informing the public, and conducting public participation to establish their opinion before any decisions have been made (Bengston and Fan, 1999; Phongpaichit, 2001; Smith and McDonough, 2001; Diduck and Mitchell, 2003; Stagl, 2006; King Prajadhipok's Institute, 2007).

A public hearing can be a simple method to solve conflict in construction projects and thereby to avoid violent protests (Ogunlana *et al*., 2001). However, this method was not successful for solving the conflict (Nicro and Apikul, 1999; Bureekul, 2006). In addition, public hearing and public participation in Thailand in the case of Hin Krut power plant project is one-way communication which is a communication from the government to the public while stakeholders wanted two-way communication in the participation processes (Chompunth and Chomphan, 2012). Palerm (1999) stated that lacking of two-way communication increased the conflicts and suggested that two-way communication should be used in the participation processes. Moreover, to achieve successful public hearing, public relation is an important factor, so some project owners hired local residents to be public relations officers to inform other people about the project such as the Hin Krut power plant project (Bureekul, 2000).

In the past, many power plant development projects in Thailand ignored community consultation or public participation in decision-making processes (Chaisomphob and Sa-nguanmanasak, 2004). However, EGAT (2009) claimed that the EGAT's Chana power plant is a real prototype power plant which integrated public participation in every stage of the project by the following activities: (1) educating and informing about the ecological system to committee and local people (2) demonstrating tools and equipment in environmental monitoring by technical experts from Prince of Songkla University (3) participating of the local in monitoring water, air, and noise quality during the commissioning test of the power plant.

Most of mega developed projects such as power plant projects always locate in the rural area which found difficulties to access and unavailable information from the government and also companies (Chompunth and Chomphan, 2012). Moreover, local people in Thailand will oppose to environmental issues when they have been affected by pollution already or there are NGOs or other power to push them (Chaisomphob *et al*., 2004; Chompunth and Chonphan, 2012). These showed that there is unequal distributive justice in the society. Similarly, in USA, nuclear waste repositories located in the west while the east has more population and consume more power of electricity (Easterling and Kunreuther, 1995). However, Frankfurt (1988) suggested the principle of sufficiency, which pointed out that everyone should have 'enough' not the same, to solve unequal distributive justice problem.

However, although there are public hearing and also public participation in environmental laws and also in environmental hazards in Thailand, the use of focus groups is still limited (Chompunth, 2013). This is because local people have no chance to express their opinion (Chompunth, 2011). Some of methods which are used in public hearing or public participation are uploading the draft of law or regulation in the internet or have a meeting for collecting comments or brainstorming in the hotel (Chompunth and Chomphan, 2012). Moreover, local people may not be aware of or understand the effect of the environmental hazards, possibly because of a lack of knowledge (Chompunth, 2011). Therefore, people who are directly affected by environmental hazards may not participate in any formal process or projects.

To sum up, most of many projects in Thailand have used public participation or a public hearing as a tool to solve conflicts after the project was set up. There are many factors involved in the failure of public participation in environmental issues in Thailand. For example, there is only one-way communication from the government to the public. The government and companies overlook the importance of public opinion, which could cause the public mistrust to the government and also companies. Besides, the lack of education and information provided to people likely contribute to a failure of public awareness. However, there is to date no study about public participation in brewing industry environmental management or more generally relating to industrial wastewater in Thailand. Therefore, this study will examine how to implement public participation in industrial wastewater management. Moreover, this research will investigate behaviour of public in participating and how public participation encouraging government and also companies in industrial wastewater management.

As can be seen, most of literature on public participation in Thailand concerns power plant projects. This is because of the power plant projects can affect large communities and also can cause pollution in many ways such as air, water, noise, marine etc. Moreover, the power plant projects are mega developed projects which have high production costs and a high public profile (Bureekul, 2000; Vatanasapt, 2003; King Prajadhipok's Institute, 2007; Chompunth, 2011). Studies of public engagement with routine environmental management initiatives are far scarcer, though work on eco-industrial parks indicates that communities are a significant consideration significant (Panyathanakun *et al*., 2013). It is useful therefore to investigate in more detail how the public have been engaged in specific cases, and how the perception of the public in that experience may differ from that of the companies involved. The exclusion of stakeholders, notably the public, from environmental decision making, can result in problems under the heading of environmental justice, which is briefly considered below.

2.6 Environmental justice

Environmental justice (EJ) was defined by Bullard (1996: 493) as a fundamental concept 'embracing the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations'. Moreover, the US Environmental Protection Agency (EPA) said that EJ focuses on outcomes more than process and set the goal of EJ as 'to ensure that all people, regardless of race, national origin or income, are protected from disproportionate impacts of environmental hazards' (US Environmental Protection Agency, 2001). Most of the EJ literature concerns indigenous or native people, and the poor who are exposed to pollution risks, especially in the U.S (Wang and Feliberty, 2009; Lee, 2010), Canada (Jerrett *et al*., 1997, 2001; Buzzelli *et al*., 2006; Agyeman *et al*., 2009), Australia (Lloyd-Smith and Bell, 2003), Europe (Varga *et al*., 2002; Laurian, 2008), but there are few studies in Asia (Holifield, 2012; Huang *et al*., 2013; Temper and Martinez-Alier, 2013).

Schlosberg (2007) classified EJ into three main dimensions: distribution, recognition, and participation which is called procedural justice. The distribution focuses on social justice analysis on income or social standings (Young, 1990). The recognition is not only individual right (Honneth, 2001), but also collective identities (Urkidi and Walter, 2011). Procedural justice relates to (in)equality of participation in decision-making processes (Cole and Foster, 2001; Schlosberg, 2007) and is the most relevant to this study.

Huang et al. (2013) identified six elements of procedural justice. Firstly, non-discrimination requires equal treatment for all decision-making processes. Secondly, political participation (Schlosberg, 2003; Freudenberg and Steinsapir, 1992) in environmental decisions. Thirdly, access to information in both disseminate information and provide technical advisors to the local? (Schlosberg, 2003). The fourth is the incorporation of local knowledge in decision-making (Huang *et al*., 2013). Fifth, trust between communities and governments or companies, and between other stakeholders (Huang *et al*., 2013). Lastly, recognition and sensitivity to differences especially cultural differences between groups of people (Young, 1990; Schlosberg, 2004).

2.7 Environmental governance

Governance is 'the art of steering societies and organisations' or 'the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say' (Maurice, 1999: 368-271). In term of 'governance' can be used in six ways which are: the minimal state; corporate governance; the new public management; good governance; a socio-cybernetic system; and self-organising networks (Rhodes, 1996). Moreover, governance comprises of connecting of networks and communities with public and private sector participants, which networks are shaped from trust and cooperation (Rhodes, 1996). Leftwich (1994: 610) stated that good governance involves 'an efficient public service, an independent judicial system and legal framework to enforce contracts; the accountable administration of public funds; an independent public auditor, responsible to a representative legislature; respect for the law and human rights at all levels of government; a pluralistic institutional structure, and a free press'. UNDP (1997) defines good governance in five principles which are: legitimacy and voice; direction; performance; accountability; and fairness. Graham *et al*. (2003) and Lockwood (2010) stated that good governance focuses more on equity, transparency and legitimacy but less on effectiveness. Pimbert and Wakeford (2001: 23) pointed out that 'democracy without citizen deliberation and participation is ultimately an empty and meaningless concept'. However, only public participation does not affect to reduce distrust and increase trust (Earle and Cvetkovich, 1995). Traditional forms of public participation fail to build an effective communication process because many weaknesses such as strongly believe that everyone to participate, failing to identify the limits of human capacities etc. (Earle and Cvetkovich, 1995). Besides, governance is one kind of factors that can enhance conservative and environmental management effectiveness (Armitage *et al.*, 2012; Lockwood *et al.*, 2010; Ostrom, 1999).

Environmental governance refers to group of regulatory procedures, methods and organisations through which political actors affect environmental activity and results (Lemos and Agrawal, 2006). Environmental governance's objectives are 'to be effective, to be equitable, to be responsive, and to be robust' which should connect between them simultaneously (Bennett and Satterfield, 2018: 7). Moreover, environmental governance can flexible to fit in many contexts (Epstein *et* al., 2015; Sarkki, Rantala, and Karjalainen, 2015).

Environmental governance can fit in many scales including with spatial, ecological, and administrative scale (Bridge and Perreault, 2009) such as forestry (McCarthy, 2006), fisheries (Manfields, 2004), and urban water systems (Swyngedouw, 2005). Moreover, environmental governance can focus with many actors in political process (Bridge and Perreault, 2009). Harashima (2000) stated that a central government is a main important actor which effect to environmental governance in Asian developing countries. Moreover, he also stated that sovereignty and the public are traditional actors in environmental governance in Thailand. However, decentralisation of government has become a characteristic in environmental governance (Hardin, 2002; Luong and Weinthal, 2001; Wantchekon, 2004; Watts, 2005). Lemos and Agrawal (2006: 303) pointed out that there are three main advantages of decentralisation of environmental governance: 'produce greater efficiency; bring decision making closer to those affected by governance; and help decision makers take advantage of more precise time and place specific knowledge about natural resources'. Gueye (1999) clarified that environmental governance actors in Thailand were national institutions, NGOs, civil society, business, and regional and international cooperation.

Environmental governance is how public cope with the environmental problems (Harashima, 2000). Public hearing is one of the oldest and most widely used to let public participates in governance in Western countries to rise participation in decision-making (Checkoway, 1981; Fiorino, 1990; Liu, 2004) and have been applied also in environmental governance (Zhong and Mol, 2008). Public hearing and public participation in governmental decision-making are important factors on water tariffs in China (Zhong and Mol, 2008). Global Water Partnership gave definition of water governance as 'the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society' (Rogers and Hall, 2002: 16). Water governance is involved with those political, social, and economic organisations and institutions which are essential for water management and development (Rogers and Hall, 2002). Water governance in Western Europe has a regional governance as a central role in policy-making (Fürst, 2007). Cultural practices, financing mechanisms, social norms, bias, and perception in effluent treatment processes are important factors used to design urban wastewater governance (Pacheco-Vega, 2015).

Ecological modernisation theorisations relate fundamentally to governance. There is an assertion that improved environmental performance can be negotiated between government and industry (Murphy, 2000). Different approaches to EM have varying degrees of trust in industry to take the initiative as opposed to the direct imposition of stringent requirements (Christoff, 1997). The environmental management literature can be seen as examining responses and influences within that negotiated space between government and industry, even though the literature may not explicitly frame itself as a study of either EM or environmental policy. The public are important in this scenario on the one hand needed to engage in environmental activity, but also influential (variously depending on the political setting) on government via the electoral process, and on industry via purchasing power. This arena of negotiation between government, industry and the public is as a space of governance. And throughout that space an important issue is the level of trust between the different parties.

2.8 Discussion and conclusions

Trust is one of concepts to succeed in many areas of public policy including with the environment (Tsang *et al*., 2009). Trust is challenging to give a definition (Castaldo, 2002; Kramer, 1999; Mayer *et al*., 1995). Sztompka (1999: 25) gives a definition of trust as 'trust is a bet about the future contingent actions of others'. Trust comprises of two main parts which is beliefs and commitment (Sztompka, 1999). Mayer *et al*. (1995) argued that there are three factors that get trust: ability, benevolence, and integrity. Moreover, Luhmann *et al*. (1979: 24) stated that 'trust is only involved when the trusting expectation makes a difference to a decision'. Besides, trust 'is a relational notion: it generally lies between people, people and organisations and people and events' (Gilson, 2003: 1454). The decision of trust depends on an interpretation of trustworthiness which based on 'competence, credibility, openness, accountability, reliability, intentions, benevolence and honesty' (Tsang *et al*., 2009: 101). Furthermore, Tyler (2003) indicated that trust is a necessary factor of democratic governance and trust is the most essential perception forming people's reactions to authorities. Thus, if the public trust the government, they are more likely to obey regulations and the government better to receive the public willingness (Tsang *et al*., 2009).

Communication is an important factor for any government to receive trust of the public or a particular group of them (Tsang *et al*., 2009). Public participation is inadequate process on environmental risk management, but increasing trust and decreasing mistrust can promote a more effective dialogue (Bradbury *et al*., 1999). Yang (2005) indicated that an authority's trust in the public is equally as significant as the public trust in the participatory process itself. Besides, Yang (2005) argued that trust could: reduce transaction costs; increase the chance that actors will spend their resources and so on in cooperation; encourage education and the transformation of information and knowledge; and trust could stimulate innovation. Moreover, the level of stakeholder trust in policy participants is the main factor in selection of stakeholder participation which are expert trust, government trust, and social trust (Tsang *et al*., 2009). Similarly, Tsang *et al*. (2009) indicated that performance of the government leads to the trust in the government. Thus, trust is an important role in the interaction of knowledge exchange and intensive interaction (Klijn *et al*., 2010). Moreover, communication is an important for any government to achieve trust of the public or a particular group of citizens (Tsang *et al*., 2009). Wang and Wart (2007) suggested that public trust increase when government officials have honour and show ethical leadership in the public participation process.

Trust is also a process of environmental reform, and institutional and social transformation (Tsang *et al*., 2009).

In industrial ecology, trust has been seen as It a main factor to eliminate five main barriers which are technical, informational, economic, regulatory, and motivational barriers (Gibbs, 2003). Moreover, Raco (1999) pointed out that trusts and exchange in their daily relations achieve industrial ecology approach. Besides, trust and cooperation are key factors that affect to networking and interchange activity in industrial ecology (Gibbs, 2003). Krishnan *et al*. (2016) clarified that if environmental uncertainty increases, the effect of trust-based governance on alliance performance will decline. For effective of environmental policy, the public has to trust the government (Tsang *et al*., 2009). Head (2005) clarified that it is difficult to build trust in natural resource management as long as the government conceal the use of institutionalised power in the rhetoric of partnerships, despite the partners having unequal power to influence a given situation. Good multi-level governance requires effective multilateral engagement involving every organisation at each level, relation of trust, and transparency in decision-making procedures (Lockwood *et al*., 2009).

Thus, government needs the population to trust that is functioning effectively in the interest of the people, and (by law in Thailand) companies and the government need to be seen to listening to public opinion on specific issues. There is trust involved in the effectiveness of these processes, as well as between government and industry. Although the environmental performance is regulated, there is level of trust in the behaviour of companies and that governments are implementing regulations with a justifiable purpose.

Harashima (2000) argues that the government, sovereignty and the public are main actors in environmental governance in Thailand. The environmental governance for the factory in Thailand consists of accessibility, participation, transparency, accountability, rule of law, social justice, and sustainability (Ministry of Industry, 2010). The public has right to access information from the company or the government which is related to the environmental governance in Thailand (Ministry of Industry, 2010). If the public receive an important information from the company and the government, the public will trust them. Yang (2005) indicated that an authority's trust in public is evenly significant as the public trust in the participatory process itself. The two companies have many channels that the public can access the information. As Gilson (2003: 1454) defined trust is 'a relational notion: it generally lies between people, people and organizations and people and events'. Besides, public participation has been applied in environmental governance (Zhong and Mol, 2008).

Informed by the literature reviewed above, the empirical contribution of this study is within the space of negotiation between the government, industry and the public – investigating the relationship between each party and the effectiveness of that relationship in the eyes of each. This study focuses on the relationships between the three stakeholders in policy implementation. The study focuses on relationships between stakeholders in part to understand the influences on technology use, which in the EM literature is seen as an important strategy for environmental management, and subject to development in response to regulation.

Chapter Three: Industrial wastewater

This study is going to use the brewing industry in Thailand as a case study to analyse the influences on industry decision making relating to environmental management in a developing country context. In particular, the focus is on the choice of technology and the extent to which it is being employed in compliance with international standards. The following sections provide an overview of the brewing process, focusing on the environmental implications, especially as regards to wastewater. There is also a brief discussion of the idea of sustainable brewing.

3.1 Brewing industry

Brewing, a food industry, has a significant impact on the world economy (FAO Source, 2003). Beer is one of the most consumed drinks behind tea, carbonates, milk and coffee in the world (Fillaudeau *et al*., 2006). World beer production increased by 5.4% in 2007 (FAO, 2009). Average alcohol consumption has decreased in many OECD countries over the past three decades, whilst in some countries such as Iceland, Finland, and Mexico it has increased (OECD, 2011). Drinking habits in some countries across OECD have changed from wine-consumption to beer-consumption and vice versa. In 2007 Thailand produced beer at 30 kg/person/year which was ninth of other agricultural products such as cassava, rice, and sugar etc. (Knoema, 2014).

The brewing industry internationally works within many environmental protection laws. Therefore, the brewing industry has had to increase its awareness of environmental protection and adoption of sustainable production processes (Driessen and Vereijken, 2003). The brewing industry has concerns for both marketing image and cost (Fillaudeau *et al*., 2006).

3.1.1 Brewing process

The brewing process (Figure 1) starts with cereals passing through a milling machine to produce a coarse powder. The cracked cereals are steeped with hot water in a mash tun, which is a large stainless-steel tank, to produce wort. The wort is brewed for two hours in a brew kettle. The wort is cooled and transported to a fermentation tank in which yeasts are used to change sugar to alcohol. Liquid or beer passes through a filter to remove yeast residues. The wort is then pumped into a conditioning tank for further fermentation and the beer becomes naturally carbonated. The beer is pasteurised to kill yeasts and other microorganisms and then is mechanically bottled (FAO, 2009).

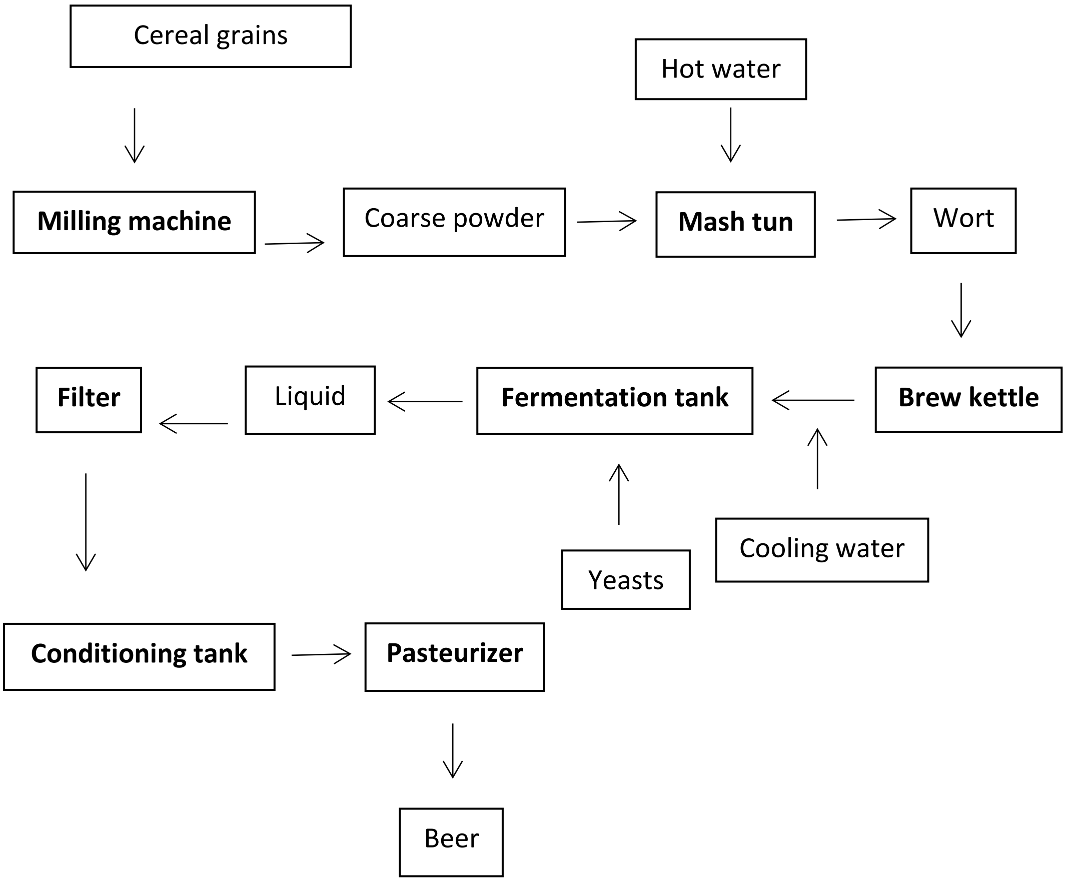


Figure 1 Flow chart to illustrate the brewing process (Adapted from FAO, 2009)

3.1.2 Brewing residues

Residue from the brewery (Figure 2) can be divided into wastewater and other wastes such as solids, yeasts, and other components etc. which come from filtration, discharging from equipment, washing of containers, and cleaning (Arantes *et al*., 2017). The most common residues from brewery processes are spent grains, spent hops, and surplus yeast (dos Santos Mathias *et al*., 2014; Mussatto, 2009). These can be considered by-products that are substances that can readily be used as inputs for other processes (e.g., Deutz, 2014). Wastewater treatment is a key issue for the brewers, originating from both the brewing and cleaning processes (Doubla *et al*., 2007).

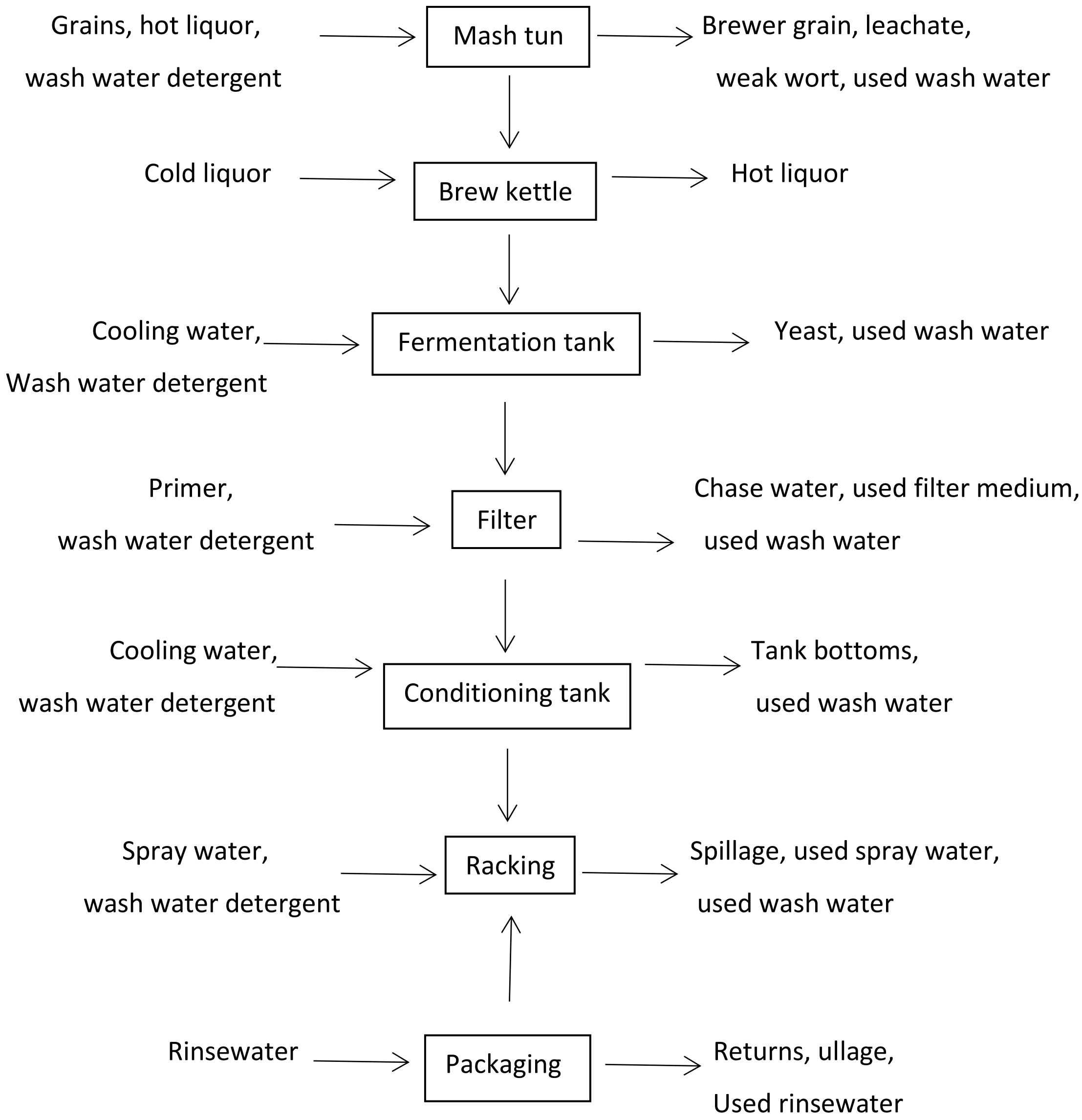


Figure 2 Input and output from the brewing process (Adapted from Accepta, 1998; FAO, 2009)

Wastewater

A high proportion of water used in the brewing process becomes effluent for disposal. The average of water consumption in brewing industry is about 4.5 litre of water/litre of beer (Arantes *et al*., 2017). The ratio of water to beer varies between 3-10 litre of water/litre of beer (Simate *et al*., 2011; Chen *et al*., 2016), resulting in significant annual emissions of potentially polluting water (Braeken *et al*., 2004; Parawira *et al*., 2005). Arantes *et al*. (2017) clarified sources of wastewater from breweries as 38% is packaging, 25% is brewhouse, 20% is utilities, and 17% is cellars. Wastewater from brewery industry in China is estimated at 0.3 billion m^3 per year which is 1.5%-2.0% of total wastewater of the whole country (Guo, 2005).

Disposal of wastewater is done in in different ways: directly to a waterway, directly to municipal sewer system, drained after pretreatment into the waterway or municipal sewer system, or drained into a wastewater treatment plant operated by the brewing industry (Huige, 2006; Goldammer, 2008).

Brewery wastewater has a high chemical oxygen demand (COD), temperature between 25°C and 38°C, pH between 2 and 12 (Goldammer, 2008). Table 1 shows characteristics of brewery wastewater and found that values of some parameters vary depending on dilution of wastewater which is related to quantity of water used for washing equipment (Arantes *et al*., 2017).

Sludge

Sludge comes from an aerobic biological treatment process such as activated sludge (AS) (Alemu *et al*., 2017; Kanagachandran and Jayaratne, 2006). The sludge has typcially been disposed to landfill, which contributes to environmental problems in the future (Saviozzi *et al*., 1994; Kanagachandran and Jayaratne, 2006; *Scholz, 2016*). There have been many attempts to manage sludge in an environmentally friendly manner (Barker *et al*., 1999; Craft and Nelson, 1996; Kanagachandran, 2004; 2005; Luque *et al*., 1990; Stocks *et al*., 2002). Kanagachandran and Jayaratne (2006) and Scholz (2016) pointed out that sludge is a source of nutrients for plants and could be a substitute for inorganic fertilizer. Moreover, sundried sludge can be directly applied as a soil improver to boost growth of plants (Luque *et al*. 1990; Olajire, 2012).

Grains

The grains come from the mashing process in brewing. The total amount of solid in the mash (spent grain and wort) is about 25-30% by weight (Fillaudeau *et al*., 2006). Spent grains comprise about 85% of total by-products from the brewing process (Mussatto, 2009; Tang *et al*., 2009). Stojceska *et al*. (2008) reported that there are 3.4 million tonnes of spent grains from the brewery industry in the EU every year, of which 0.5 million tonnes are produced in the UK (Aliyu and Bala, 2011). The spent grains are rich in cellulose, hemicellulose, lignin, and also have high protein content (Mussatto, 2009). They can be used as livestock feed (Aliyu and Bala, 2011; Fillaudeau *et al*., 2006; Lima, 2010; Mussato *et al*.,2006), for production of value-added compounds (xylitol, lactic acid, among others), microorganisms cultivation and enzyme production, or raw material for extraction of compounds such as sugars, proteins, acids and antioxidants (Aliyu and Bala, 2011; Mussatto, 2009). Moreover, Aliyu and Bala (2011) and Kerby and Vriesekoop (2017) indicated that spent grains can be used in food for human consumption, having good nutritional value (Mussato *et al*., 2006; Fãrcaş *et al*., 2014; Lima, 2010). There is small-scale production of food products using spent grains such as high-fibre breads and cookies (Kerby and Vriesekoop, 2017). Besides, spent grains are used as fertilizers but have to be combined with other wastes such as sludge and bulking agents before they can be composted because of their heavy moisture content (Aliyu and Bala, 2011; Lima, 2010; Mussato *et al*., 2006; Stocks *et al*., 2002; Thomas and Rahman, 2006). In addition, some larger breweries use spent grains for biogas production via anaerobic digestion by the company itself or by a third-party energy producer (Deublein and Steinhauser, 2011; Keller-Reinspach, 1989; Panjičko *et al*., 2017).

Hops/trub

Only 15% of hops used in making beer remain in the finished product; 85% become spent hops (Huige, 2006). Spent hops are high in nitrogen free extract, fibers, and proteins (Mussatto, 2009). O'Rourke (1994) and Huige (2006) said that spent hops from brewing industry are used as fertilizer or soil conditioner. Spent hops are a source of essential oil and are used as insect repellent (Bedini *et al*., 2015). Kerby and Vriesekoop (2017). Priest and Stewart (2006) stated that trub is mixed with spent grains or other ingredients that precipitate from wort (Mussatto, 2009; Thomas and Rahman, 2006). It is used for animal feed and also can be added to wort to increase yeast vitality, yield, and also fermentation performance (Kühbeck *et al*., 2007; Mussatto, 2009).

Kieselguhr sludge

Filtering is an important part of the brewing process. The brewing process uses diatomaceous earth, known as Kieselguhr, for filtration (Baimel *et al*., 2004). The beverage industry including wine, beer, fruit juice and liqueurs, is a major user of diatomaceous earth (Fischer, 1992), and has been for a century or more (Olajire, 2012); efforts to find a replacement have not yet come to fruition. The earth can be used more than once, but eventually it is dumped in landfills, which can be a high cost (dos Santos Mathias et al., 2014). Kieselguhr sludge is high in suspended solids and BOD/COD. Recovering, recycling, and disposing Kieselguhr is challenging because of their potentially polluting effects; the weight of the kieselguhr increases three-fold by uptake of water and organic substances during the filtration process (Olajire, 2012). Methods of disposal for Kieselguhr sludge are agriculture and recycling with an average cost of €170/ton (Fillaudeau *et al*., 2006). However, Kieselguhr sludge, which is a source of silicon, can be used to produce calcium silicate bricks by combination with lime and gypsum (Pimraksa and Sridang, 2004; Russ *et al*., 2006).

Yeast surplus

Yeasts are used in the fermentation tank for the conversion of sugar to alcohol. Surplus yeast is found by natural sedimentation at the end of fermentation (Fillaudeau *et al*., 2006), and accumulates at the base of the tank. The yeast is a concern because of the large quantity produced and the chemical composition (Mussatto, 2009). Surplus yeast is normally reused (Vieira *et al*., 2013); the number usages depends on species of yeast, types of beer, content of wort, and ensuring microbiological culture which does not affect the quality of beer (Ferreira *et al*., 2010). Residue yeast has a higher content of protein, vitamins, and amino acid than spent grains (Djuragic *et al*., 2010; Fillaudeau *et al*., 2006). Yeast extract is used in the food industry as a flavouring agent in soup, sauces, gravies, stews, snack food and canned food (Chae *et al*. 2001). In addition, there are many studies showing that brewers' spent yeast is used as a feed supplement in foods for ruminants, horses, poultry, swine, and fish. (Aliyu and Bala, 2011; Ben-Hamed *et al*., 2011; Cheung, 2002; Djuragic *et al*., 2010; Ferreira *et al*., 2010; Mussatto, 2014; Newbold *et al*., 1996). The spent yeast is also used in human nutrition and in the food industry to provide flavour (Kerby and Vriesekoop, 2017; Munch *et al*., 1997; Sombutyanuchit *et al*., 2001).

Table 1 Characteristics of brewery wastewater

Sources	**Total COD** (mg/L)	**Total N** (mg/L)	**P-total** (mg/L)	**TSS** (mg/L)	**BOD** (mg/L)	**pH**
Rao *et al*. (2007)	2000-6000	25-80	10-50	2901-3000	1200-3600	3-12
Chen *et al*. (2016)	8000-14000	80-280	20-90	500-1300		5.2-6.2
Sinbuathong *et al*. (2015)	6000	90	0.5		2350	6.3
Boboescu *et al*. (2014)	6558	76	58			
Shao *et al*. (2008)	22500-32500	320-450	144-216			3.2-3.9
Enitan *et al*. (2015)	2000		21.25	2449	1877	6.9
Golub *et al*. (2014)	3000 6000	50-100		200-600		4.5-11.0
Shi *et al*. (2010)	2400	90	3.2	620		

COD = Chemical oxygen demand; TSS = total soluble solids; BOD = biological oxygen demand.

Concentration unit: mg/L

3.1.3 Technology of wastewater pretreatment in brewing

Brewery wastewater can be pretreated prior to disposal, or following pretreatment can undergo further treatment for re-use. Pretreating of brewery wastewater can be divided into three methods which are physical, chemical, and biological methods (Simate *et al*., 2011). One or more methods of pretreatment may be required to meet municipal bylaws, if the brewery is permitted to discharge into a municipal sewer.

Physical methods

The first treatment is by physical methods, used to remove contaminants which are coarse solid substances rather than dissolved pollutants (Sheehan and Greenfield, 1980; Simate *et al*., 2011). Flow equalisation is used to collect wastewater in tanks for balancing before draining to a wastewater treatment plant or the municipal sewage system. Screening is used to remove coarse solid substances such as glass, labels, and spent grains etc. Grit removal is used to settle sand, grit, and small stones. Gravity sedimentation is used to remove small particles (Olajire, 2012).

Chemical methods

Chemical methods are used to modify water chemistry, this involves pH adjustment or coagulation and flocculation (Simate *et al*., 2011). Waste CO_2 is used to balance caustic effluents from clean-in-place (CIP) system and also bottle washers (Lampinen and Quirt, 1987). Moreover, waste CO_2 can be used to decrease pH in alkaline wastewater (Rao et al., 2007). Coagulation and flocculation are physiochemical processes which remove colloidal substances or colour from water and wastewater. Chemical methods are composed of chemical precipitation, adsorption, disinfection, chlorination, and other chemical applications (Simate *et al*., 2011).

Biological methods

Biological methods are divided into aerobic (with oxygen) and anaerobic (without oxygen) (Goldammer, 2008; Olajire, 2012).

Aerobic biological treatment is a wastewater treatment which uses aerobic microorganisms (bacteria) to metabolise organic matter. These microorganisms transform suspended solids to precipitated solids. Aerobic biological treatment consists of activated sludge, attached growth (biofilm), and lagoons. Activated sludge process (AS) is a suspended system that many aerobic microorganisms mix by aeration devices (Olajire, 2012; Simate *et al*., 2011). Most of the current sewage treatment systems are using AS (Nancharaiah and Reddy, 2018) and Lu *et al*. (2017) stated that the well-established AS system has been used in most wastewater treatment systems. The attached growth (biofilm) process fixes microorganisms on a solid surface. Whilst lagoons use interaction of sunlight, algae, microorganisms, and oxygen to treat wastewater (Olajire, 2012; Simate *et al*., 2011).

Anaerobic biological treatment is a wastewater treatment in the absence of oxygen. Anaerobic microorganisms will change organic matter to methane, carbon dioxide, and hydrogen sulphide which can be a biogas or fuel (Briggs *et al*., 2004; Lu *et al*., 2017). Therefore, the anaerobic biological treatment can be used for a sustainable brewing process (Simate *et al*., 2011). An anaerobic sludge blanket (UASB) allows wastewater to flow through a vertical tank from the bottom which contains a dense bed of anaerobic sludge (Seneviratne, 2007). Organic matter in the wastewater is attacked by the anaerobic microorganisms and releases biogas. When biogas increases, it will bring some of the granular microbial blanket. At the top of UASB process the biomass can be separated from the wastewater and biogas in a process called three-phrase separator or gas-liquid-solid-separator (Driessen and Vereijken, 2003; Seneviratne, 2007). Biogas has many benefits such as energy and cost saving, environmental protection, and conservation of resources (Rajput *et al*., 2012; Tiwari *et al*., 2006). UASB can produce more methane and give better quality of treated wastewater in thermophilic condition than mesophilic condition (Zhu *et al*., 2018). Fluidised Bed Reactor (FBR) allows wastewater pass through bottom of the reactor and sand or activated carbon (Olajire, 2012; Simate *et al*., 2011). Main benefits of FBR are higher biomass and higher mass transfer which results in a higher rate of biodegradation (Fan, 1989; Ochieng *et al*., 2003). The Internal circulation (IC) reactor adopted UASB principles and consists of two reaction chambers (Ding and Wang, 2005). The IC reactor is widely used to treat many types of industrial wastewater because of its high rate of loading, considerable feasibility, robust resistance to outside accidents, and relatively lower cost of investment, compared to UASB (Deng *et al*., 2006; Lu and Liao, 2010).

3.1.4 Brewery wastewater treatment for reuse

Brewery wastewater treatment for reuse is used to treat wastewater from the pretreatment processes (Simate *et al*., 2011). There are eight alternative processes of brewery wastewater treatment including membrane filtration, non-thermal quenched plasma, membrane bioreactor, combined anaerobic and aerobic treatment, carbon nanotubes, electrochemical methods, microbial fuel cells, and carbon. However, wastewater reuse in the brewing industry is not generally practiced because public perception of what is safe and acceptable to consume and also quality of water (Janhom *et al*., 2009). The brewery wastewater reuse may become a higher priority in the future in response to water shortage and environmental problems (Simate *et al*., 2011).

Membrane filtration can be categorised by pore size of the membrane into four types: microfiltration, ultra-filtration, nanofiltration, and hyperfiltration (reverse osmosis) (Simate *et al*., 2011). Hyperfiltration or reverse osmosis has the smallest of pore size (less than 2 nm) while microfiltration has the largest pore size (100-3000 nm) (Gregory, 2006). Moreover, membrane filtration can divide into two methods which are dead-end filtration and cross-flow filtration. Dead-end filtration allows wastewater flow through the membrane whilst large impurities get caught in the membrane. During cross-flow filtration, wastewater flows parallel to the surface of the membrane and passes through the membrane but impurities remain in the retentate (Simate *et al*., 2011). Additionally, membranes can be categorised by materials such as ceramics and polymers (Brock, 1983; Gregory, 2006; Seneviratne, 2007). Membrane filtration has been used in the brewing industry for many years for separating solids (Daufin *et al*., 2001). Microfiltration (MF) is the most widely used in brewery industry to remove solid from liquid. However, ultrafiltration (UF), reverse osmosis (RO), dialysis (DI), pervaporation (PV), and gas separation (GS) are already used in other operations of the brewery industry (Ambrosi *et al*., 2014).

Non-thermal quenched plasma: plasma is a highly ionized gas and can be found at high temperatures (Simate *et al*., 2011). In brewery wastewater, humid air plasma is used to decrease organic pollutants (Doubla *et al*., 2007).

Membrane bioreactor (MBR) is a successful technology in water and wastewater treatment (Visvanathan and Pokhrel, 2003). The MBR integrates two technologies which are activated sludge and membrane filtration (Simate *et al*., 2011).

Combined anaerobic and aerobic treatment are usually used in brewery wastewater treatment (Driessen *et al*., 1997, 2000; Driessen and Vereijken, 2003). Integrated anaerobic-aerobic bioreactors consist of four types including: integrated bioreactors with physical separation of anaerobic-aerobic zone, integrated bioreactors without physical separation of anaerobic-aerobic zone, Anaerobic-aerobic sequencing batch reactor (SBR), and combined anaerobic-aerobic culture system (Driessen *et al*., 2000).

Carbon nanotubes (CNTs) are cylinders of grapheme sheets with a few of nanometres of diameter and many microns or centimetres of length (Dai, 2002; Tasis *et al*., 2006). There are two forms of CNTs depending on the number of grapheme layers of the tube which are single-walled carbon nanotubes (SWCNT) and multi-walled carbon nanotubes (MWCNT) (Merkoci, 2006; Liu, 2008; Simate *et al*., 2011).

Electrochemical methods are suitable to degrade organic pollutants. The electrochemical treatment is used to treat industrial wastewater with high refractory organics and chloride content (Vijayaraghavan *et al*., 2006; Barrera-Díaz *et al*., 2009).

Microbial fuel cells (MFC) combines between anaerobic and aerobic systems. This method is used for treating brewery wastewater and generating electricity from organic substances in wastewater (Bennetto, 1984; Feng *et al*., 2008; Habermann and Pommer,1991; Mathuriya and Sharma, 2010; Wang *et al*., 2008; Wen *et al.*, 2010). Liu *et al*. (2004) reported that this method has efficiency to remove chemical oxygen demand (COD) at 80% of domestic wastewater. MFC can function at environment temperature and produce less sludge than AS and anaerobic biological treatment.

Carbon adsorption in tannic acid treatment is used to remove flavour and odour in brewing. Moreover, carbon is used in colour and flavour removal from malts in clear beers and malt beverages (Simate *et al*., 2011).

3.1.5 Summary of wastewater treatment options

As can be seen in Table 2 reverse osmosis is the only process which can individually reduce COD to the required level, but two or three of the other processes can be combined to give adequate results.

Table 2 Quality of brewery wastewater treatment process

Process	**COD reduction (%)**	**Reference**
Quenched plasma	98	Doubla *et al*., 2007
Upflow Anaerobic Sludge Blanket (UASB)	73-91	Cronin and Lo, 1998
Aerobic reactor	90-98	Driessen and Vereijken, 2003
Combined bioreactor	98	Biothane, 2014
Membrane bioreactor	96	Dai *et al*., 2010
Electrochemical method	97	Bockris, 1977
Microbial fuel cells	94	Wang *et al*., 2008
Nanofiltration	96	Braeken, 2004
Hyperfiltration (Reverse osmosis)	100	Madaeni and Mansourpanah, 2006

Simate *et al*. (2011) reported that quenched plasma, membrane bioreactor, electrochemical method, and microbial fuel cell have high potential in brewery wastewater treatment for reuse. However, all of these processes need more research at field-scale and experience of application. Besides, the application of membrane filtration requires improved quality of the membrane and decreases the costs of the membrane. Thus although, the membrane filtration has high potential, the integration with different pre-treatment processes would improve their performance in the short term.

Nowadays, renewable energy demand is increasing in the world. Therefore, microbial fuel cell can be used for the first pretreatment stage and is integrated with other filtration techniques. The microbial fuel cell can generate energy from organic matter (Mathuriya and Sharma, 2010).

The electrochemical method is suitable to be used in the latter stages in the integrated process because it can be used as an organic oxidation in the disinfecting stage. (Simate *et al*., 2011).

Although, the plasma method is very effective, the process is very expensive both in isolation or with other methods (Simate *et al*., 2011). Carbon nanotubes combined with ultrafiltration gives significant organic removal (Simate *et al*., 2011). Brito *et al*. (2007) pointed out that anaerobic processes are used in pretreating brewery wastewater because of saving energy and minimised cost in sludge disposal. However, the anaerobic processes combined with aerobic processes give the best result in brewery wastewater (Rodrigues *et al*., 2001; Nogueira *et al*., 2002).

What is uncertain from the literature is the geographic variability in technology application. It is also difficult to assess whether certain technologies are more sustainable than others, or are more widely accepted as sustainable. This study will help to clarify the picture by undertaking an international comparison of practice and examining in particular the practice of breweries acknowledged by the industry to be sustainable.

3.2 Constructed wetland and algae based-system

3.2.1 Constructed wetland

Wetlands are plant systems and can be used to treat wastewater (Kadlec, 1987; Wissing, 1995; Stottmeister *et al*., 2003). This potentially can be harnessed for industrial wastes by the development at an artificial wetland, known as a constructed wetland. The constructed wetlands are artificial systems that act as natural wetlands with a specific environment and can be controlled to achieve the best result (Ezeah *et al*., 2015). These systems consist of vegetation, substrates, soil, microorganisms, and water with physical, chemical, biological mechanisms to remove pollutants or improve water quality (Vymazol, 2011; Saeed and Sun, 2012). There are different types of constructed wetlands depending on three main criteria; hydrology (subsurface and open-water surface flow), types of macro phytic growth (emergent, submerged, and free-floating), and flow path (vertical and horizontal) (Ezeah *et al*., 2015; Vymazal, 2005; and Vymazal, 2008).

Constructed wetlands are used to achieve a better performance in removal of ammonia and total nitrogen and are identified as a wastewater treatment technology; wetland plants were used to treat wastewater in the first full-scale system during the late 1960s (Vymazal, 2011). The constructed wetland and microorganisms on the stems and roots take up nitrogen and phosphorus (Tilley *et al*., 2008). They are attractive options because of their flexibility, cost effectiveness of operation and maintenance (Rai *et al*., 2013; Ezeah *et al*., 2015). In addition to environmental advantages such as wildlife habitats, constructed wetlands offer economic and social activities, walking routes, and other opportunities for tourism etc (USEPA, 2004; Ezeah *et al*., 2015). However, the constructed wetlands require more land than other technologies, which is a limiting factor in some locations (Wu *et al*., 2014, 2015). Brix (1998) and Veenstra (1998) argued that land requirement is relatively small; constructed wetlands are used in Denmark and the Netherland which have high densities of population.

Constructed wetlands with surface flow (free water surface constructed wetlands: FWS CWs) have open water and floating, submerged, and emergent plants (Kadlec and Wallace, 2008). Wastewater is treated by three processes which are physical (sedimentation, filtration, UV exposure), chemical (precipitation, adsorption, volatilisation), and biological (microbial degradation, microbial nutrient transformations, uptake from water column root zone, microbial competition, and bacterial die-off) (Merz, 2000). FWS CWs have the ability to remove organics by microbial degradation and suspended solids by filtration and sedimentation (Kadlec et al., 2000). Removal of nitrogen depends on inflow concentration, chemical form of nitrogen, water temperature, season, organic carbon availability, and dissolved oxygen concentration (Kadlec and Wallace, 2008). Phosphorus is removed by adsorption and precipitation with slow rate (Vymazal *et al*., 1998). FWS are usually used as the tertiary treatment of municipal wastewater, storm water runoff, and mine drainage water after activated sludge (Hoffmann *et al*. 2011; Kadlec and Knight, 1996; Kadlec and Wallace, 2008; and Vymazal and Kröpfelová, 2008). Kadlec and Wallace (2008) indicated that FWS is suited for use in all climates but ice formation can reduce efficiency of the FWS especially in the removal of nitrogen. The most common wetland plant genera used in FWS are *Typha*, *Scirpus* (*Schoenoplectus*), *Phragmites*, *Juncus* and *Eleocharis* (Vymazal, 2013b).

Constructed wetlands with subsurface flow consist of horizontal subsurface flow constructed wetlands (HF CWs) and vertical flow constructed wetlands (VF CWs). HF CWs are usually called "Reed Beds" in Europe and are called "Reed Bed Treatment System" (RBTS) in the United Kingdom. This is because reed (*Phragmites australis*) is often planted (Cooper *et al*., 1996). Vymazal and Kröpfelová (2008) stated that HF CWs are usually used as secondary treatment of municipal wastewater. HF CWs have the ability to remove organics by bacteria (Brix, 1990; and Vymazal and Kröpfelová, 2008), and suspended solids by filtration (Kadlec *et al*., 2000). However, removal of ammonia-N is limited and also removal of phosphorus is low (Vymazal and Kröpfelová, 2008; and Vohla *et al*., 2010). A disadvantage of the HF CWs is clogging and the resulting surface flow but this problem can be solved by removing suspended solids in pre-treatment and selection of coarse filtration materials (Vymazal, 2011). VF CWs have high ability to remove organics and suspended solids (Vymazal and Kröpfelová, 2008). Besides, VF CWs use less land than HF CWs (Cooper, 2005). Vymazal and Kröpfelová (2008) pointed out that VF CWs are generally used to treat on-site domestic wastewater or sewage from small communities. In addition, disadvantage of VF CWs is clogging of filtration substrates. To solve this problem, choosing filtration materials carefully, spreading wastewater equally all over wetland surface, and selecting the best hydraulic loading rate (Vymazal, 2011).

Hybrid constructed wetlands are a combination of various constructed wetlands (Vymazal, 2013a). This is because VF wetland has the ability to remove organics and suspended solid and to provide nitrification while HF wetland has ability of denitrification and to remove further organics and suspended solids (Vymazal, 2011). So, VF-HF and HF-VF are the most familiar hybrid system. However, any types of wetland can be combined to receive higher efficiency in wastewater treatment (Vymazal, 2005). Multi-stage constructed wetlands are a combination of constructed wetlands with more than three stages to use (Kadlec and Wallace, 2008).

Enhanced constructed wetlands are used to increase efficiency of the removal of pollutants such as artificial aerated, baffle flows, and hybrid towery constructed wetlands etc. (Wu *et al*., 2014).

The constructed wetlands have been used to treat not only wastewater from municipalities, but also wastewater from wineries in California (USA), and Italy (Grismer *et al*., 2003; Masi *et al*., 2002), leaching in France, and Turkey (Reeb and Werckmann, 2005; Yalcuk and Ugurlu, 2009), tanneries in Portugal (Calheiros *et al*., 2007; Küçük *et al*., 2003), shrimp aquaculture in Taiwan (Lin *et al*., 2005), and swine in Ireland (Harrington and Scholz, 2010) etc. Wu *et al*. (2014) also stated that the constructed wetlands are used to treat wastewater from agriculture, industries, mine, landfill leachates, polluted river and lake, and urban and runoff highways. Moreover, the constructed wetlands also have been developed for use in many types of climate conditions such as warm and humid, arid and cold, and tropical climates around the world (Kadlec and Wallace, 2008; Mæhlum and Stålnacke, 1999; Mander and Jenssen, 2003; Tunçsiper *et al*., 2015; Vymazal and Kröpfelová, 2008; Wu *et al*., 2014) . Wang *et al*. (2017) defined cold climate as places where the coldest month has an average temperature − 3°C and the warmest an average above 10°C. There were more than 50,000 constructed wetlands in Europe and more than 10,000 constructed wetlands in North America in 2015 (Kadlec and Wallace, 2008; Vymazal, 2011b; Wu *et al*., 2015; Yan and Xu, 2014). Besides, the constructed wetlands are an optional wastewater treatment in developing countries especially in China (Chen *et al*., 2011). However, Vymazal (2011) indicated that the constructed wetlands have limited effectiveness to remove phosphorus unless specific media with high absorption are used. So, users have to consider this problem if they would like to use the constructed wetlands. The constructed wetlands are not only used to treat wastewater but also to promote water reuse, wildlife habitats, and public use benefits (USEPA, 2004).

To achieve sustainability of the constructed wetlands, Akratos *et al*. (2009) and Kadlec and Wallace (2008) clarified criteria to operate the constructed wetland as follows; site selection, plant selection, substrate selection, types of wastewater, plant material selection, hydraulic loading rate, hydraulic retention time, depth of water, maintenance and operational procedures. However, the constructed wetlands require expert design and construction (Tilley *et al*., 2008).

Plant selection depends on tolerance to anaerobic water, hyper-eutrophic conditions, and capacity to absorb pollutants (Wu *et al*., 2015). Substrate selection is an important parameter because the substrate can provide proper medium for growing plants and also allow wastewater to pass through (Kadlec and Wallace, 2008). Moreover, Ju *et al*. (2014) stated that substrate is an important factor in absorbing many pollutants such as phosphorus. Water depth is relevant to the constructed wetlands when choosing types of plant and its effect on redox status and dissolved oxygen level in removing pollutants (Song *et al*., 2009). Lee *et al*. (2009) pointed out that hydraulic rate and retention time are also important factors in the constructed wetlands' performance depending on plant species and temperature. Besides, influent of water is another important factor that affects the constructed wetlands' performance (Zhang *et al*., 2012).

3.2.2 Algae based-system of wastewater treatment

Algae have been used in the commercial treating of wastewater for 75 years and many countries are interested in developing algae approaches, including Australia, Thailand, USA, Mexico, and Taiwan (Abdel-Raouf *et al*., 2012; Borowitzka and Borowitzka, 1988; Borowitzka and Borowitzka, 1989a,b; Moreno *et al*., 1990; Renaud *et al*., 1994; and Wong and Chan, 1990). Microalgae are interesting because of their capability of photosynthesis which can change solar energy to biomass and can also absorb nitrogen and phosphorus to protect against eutrophication (De la Noüe and De Pauw, 1988). Lavoie and De la Noüe (1985) stated that hyper concentrated algae have efficiency to remove nitrogen and phosphorus from wastewater within very short periods of time such as less than an hour. The algae based-systems can treat many types of wastewater including human sewage (Ibraheem, 1998; Mohamed, 1994; Shelef *et al.,* 1980), livestock wastes (Lincoln and Hill, 1980), agro-industrial wastes (Ma *et al*., 1990; Phang, 1990, 1991; Zaid-Iso, 1990), industrial wastes (Kaplan *et al*., 1988), swine industry (De Pauw *et al*., 1980; Martin *et al*., 1985; Pouliot *et al*., 1986), food processing factories (Rodrigues and Oliveira, 1987), and other agriculture wastes (Phang and Ong, 1988). Using microalgae in treating wastewater as tertiary and quinary treatments give an excellent result in removing nitrogen and phosphorus (Richmond, 1986; Oswald, 1988a, b; Garbisu *et al*., 1991, 1993; Tam and Wong, 1995). Moreover, algae have the ability to remove heavy metals (Rai *et al*., 1981) and some toxic organic compounds (Redalje *et al*., 1989). Besides, algae produce oxygen and make the pH level higher during photosynthesis which has disinfecting effect (Mara and Pearson, 1986; De la Noüe and De Pauw, 1988).

In addition, microalgae from treatment systems are an important biomass for producing biofuel. But most of the treatment systems do not harvest algae and let them decompose to the pond bottom which releases methane to the atmosphere and reduces water quality (Chaiprasert, 2011). Algae biomass could be extracted for lipid and be used as fuel for transportation or could be anaerobically digested to make biogas (Brune *et al*., 2009; US, DOE, 2009).

There are many factors that affect algae growth and nutrient uptake which are physical factors such as pH (Azov and Shelef, 1987), light intensity, temperature (Talbot and De la Noüe, 1993), and biotic factors or density (Lau *et al*., 1995).

Abdel-Raouf *et al*. (2012) stated that there are three types of stabilisation ponds. Anaerobic ponds are 2-5 m deep and collect high organic loads of wastewater. BOD is removed in the anaerobic ponds by sedimentation of solids and sludge with temperature above 15 °c and a shorter retention time of 1-1.5 days. There are two types of facultative ponds which are 1-2 m deep: primary facultative ponds which collect raw wastewater, and secondary facultative ponds which collect particle free wastewater (from anaerobic ponds, septic tanks, primary facultative ponds, and shallow sewerage systems). The facultative ponds have water retention time at 2-3 weeks to remove BOD with naturally-growing algae in the ponds. Thirdly, maturation ponds which are 1-1.5 m deep and collect wastewater from facultative ponds. The maturation ponds have the ability to remove excreted pathogens.

Algae mats were developed by Adey (1982) and are used to remove nutrients. The algae mats grow algae on a net or mesh and nutrient-rich wastewater is passed over them (Abdel-Raouf *et al*., 2012).

3.3 Sustainability in brewery

Sustainable development is a critical issue in breweries. Larger breweries stress improvements in efficiency and stakeholders around the world force them to factor sustainability in their decision making (Tokos *et al*., 2012). Therefore, sustainability assessment is a method to track and develop sustainable activities of the companies and also compare between companies (Jasch, 2000). However, small companies found that sustainability assessment and reporting require knowledge and time that they struggle to access (Quaak *et al*., 2007). There were only nine breweries that published sustainability reports in 2009 which are Ambev, Asahi Breweries, Diageo-Guinness, Fosters, Heineken, Kirin, Lion Nathan, SabMiller, and Tsingtao Brewery (Tokos *et al*., 2012). Mazzoni (2014) ranked the top 10 most sustainable breweries in the USA as follow: New Belgium Brewing; Yards Brewing Co; Brooklyn Brewery; Sierra Nevada Brewing Co.; Full Sail Brewing; Lakefront Brewery; Brewery Vivant; Alaskan Brewing Co.; Bison Organic Beers; and Great Lakes Brewing Co.

Modern breweries have reduced their by-products or pollution of the environment by accepting new technologies and techniques. Efficiency technologies are used to increase energy efficiency, and decrease energy expenses of the breweries. However, the difficulty of the breweries and sustainability is capital cost to buy or upgrade energy efficiency and environmental control instruments (Sloane, 2012). Because breweries are intensive energy consumers, sustainability programmes should include reducing energy consumption and employing clean, renewable energy sources. This has been a particular issue in California, where a rising demand for beer coincided with a time of energy shortage and environmental concern (Asmus, 2009; Sloane, 2012). Environmental concerns and also the Public Utility Regulatory Policy Act (PURPA) forced many private companies in California to construct renewably sourced energy plants (Asmus, 2009). California's breweries improved sustainability by implementing a state program to help breweries in buying and implementing energy-efficiency instruments and environmental controls (Sloane, 2012). For instance, the brewery Sierra Nevada implemented a closed loop system by using grains to feed cattle in

California State University and after harvest the beef would be dinner in the brewery's restaurant. Moreover, treated wastewater is used in the hop field of the brewery. Furthermore, used water in one operational system can be reused in another (Higgins, 2009, 2010). In addition, Garcia-Garcia *et al*. (2017) studied sustainable management of brewery waste and found that Molson Coors in UK could make improvements in sustainability by using organisational measures such as reducing the mislabelling of beer (which consequently had to be disposed of), and also identified potential routes to re-use of by-products.

There is, therefore, active interest in both industry and academia to improve the sustainability of the brewing industry both by implementation of techniques and technologies outlined above, and by seeking novel routes to residue recovery. This work has been concentrated in developed country settings.

3.4 Practice in Thailand

Royally initiated Leam Phak Bia environmental research and development project. Some breweries in Thailand have adopted processes that a royal project developed for municipal wastewater. The King royally initiated Leam Phak Bia environmental research and development project is one of many royal projects that the late King of Thailand, "King Bhumibol Adulyadej Rama IX" initiated. The King's concerns and approach are illustrated by his announcement:

"…Another important problem that concerns the environment is the matter of pollution and garbage. Solutions are not that difficult, there are the technologies to do the job. It can be done in Thailand. I am thinking of doing so, but still have to find the location for this…" His Majesty the King Bhumibol Adulyadej Rama IX's Initiatives on the 12th of September 1990 (LPB, 2016).

The Leam Phak Bia royal project is at Tumbol Lham Phak Bia, Amphor Bann Laem, Petchaburi province of Thailand under the Chaipattana foundation (Industrial Technology Review, 2009). The main missions of the royal project are: to study and research litter and domestic wastewater management, and the social and environmental effects of the product; as well as setting up a place to learn about technology used in the management of litter and wastewater by using the King's idea which is nature helping nature process; to hold seminars and conferences to teach the community; and to help with environmental issues of the public, government organisations, private sectors, and other organisations. There are three types of technology in this project: composting technology from waste by landfilling in concrete boxes; wastewater treatment technology with wastewater treatment system; and wastewater treatment technology with plant therapy system (LPB, 2016).

Boonbongkarn (2016) and Srisuk (2013) stated that technology that is used to treat wastewater in the Leam Phak Bia royal project is comprised of four systems: lagoon treatment; plant and grass filtration; constructed wetland; and mangrove forest filtration. Lagoon treatment comprises of five ponds which one is a sediment pond, three are oxidation ponds, and the last one is a polishing pond. The lagoon treatment can collect wastewater at the maximum quantity of 20,000 m^3/day (Chaichana and Dampin, 2016) and water retention time depends on the quality of the wastewater. The oxidation ponds use the photosynthesis of algae as a source of oxygen, as well as using wind to merge oxygen from air into the wastewater. After that, microorganisms in the ponds will decompose pollutants. The lagoon treatment can reduce BOD to 85-90% of wastewater (Ungpanitkul, 2009). Plant and grass filtration (Figure 3) use bulrush, rush, and grass to filter and absorb pollutants. Bulrush, rush, and grass will be planted for 45 days and is then replanted. Grass is used for animal's feed and bulrush, and rush are used to make wickers such as mat etc. (EITPRBlog, 2015). Constructed wetland also uses bulrush and rush to absorb pollutants while wastewater passes through. After 45 days, bulrush and rush have to be replanted. The wastewater that passes through the constructed wetland could drain to waterways because the quality of wastewater meets the standards. Mangrove forest filtration (Figure 4) is a natural system that is drained by sea water at high tide. The sea combines with the wastewater, diluting it and at low tide the water drains back to the sea. Jitthaisong *et al*. (2012) studied efficiency of mangrove forest filtration at the Leam Phak Bia royal project and found that the mangrove can increase DO and decrease phosphate, nitrate, and ammonia in wastewater.

The benefits of the Leam Phak Bia royal project from 1990 until now have been identified as an improvement in the water quality of Petchaburi river, the mangrove system is healthier, wastewater that is treated from the project can be used to grow any plants, and plants from the treatment systems is used to make wickers and be animal's feed (Chunkao *et al*.,n.d.).

In addition, Phewnil *et al*. (2016) stated that plant and grass filtration, and constructed wetland initiated by the late King of Thailand, “King Bhumibol Adulyadej Rama IX” which is nature by nature process, is useful for use in treating industrial wastewater (Cui *et al*.,2010; Borkar and Mahatma, 2011; Zhu *et al*., 2012).

Figure 3 Plant and grass filtration (Source: Industrial Technology Review, 2009)

Figure 4 Mangrove forest filtration (Source: Industrial Technology Review, 2009)

3.5 Conclusions

This chapter has outlined the brewing process, the residues produced and available treatment options. The latter include both technology-driven and biologically mediated options and collectively contribute to safeguarding against environmental impacts. The brewing industry is under external scrutiny for sustainability, resulting in companies engaging in various practices not only based on those reviewed, but are seeking additional customised options (e.g., for re-use of solid or liquid residues). Numerous options have been identified that would involve a level of collaboration with another company or organisation. This is known as industrial symbiosis, ideas around which are presented in the next chapter. Breweries in Thailand have responded to international environmental protection agendas as well as domestic ones coming in part from the King. The literature, however, is predominantly western in origin; a better understanding is required of the engagement of companies in a developing country context.

Chapter Four: Research design and methodology

This chapter will describe the methodological approach which was used to find answers to the research questions and the theory behind these approaches. Section 4.1 will clarify the aims and research questions of the study. Section 4.2 will describe the research design for this thesis. Section 4.3 will describe the case study method which was used in the study. Section 4.4 explains the mixed methods which were used to collect data. Section 4.5 will discuss the secondary data which was examined in this thesis. Section 4.6 discusses why Thailand was focused on in the research, whilst section 4.7 describes the brewing industry in Thailand and justifies the selection of the case study companies. Section 4.8 will describe the regions (Khon Kaen and Ayutthaya) where the case study companies are located and the last section will be the risk assessment and ethical assessment which was conducted for the research.

4.1 Research aim and questions

The overall aim of the research was to analyse the influences on industrial wastewater management in Thailand in the field of policies and also technologies. Besides, to what extent are companies incentivised by the public and public policy in decisions to adopt more sustainable behaviour? The specific research questions addressed by the research are as follows:

1. What policies relevant to industrial waste water management have been established by the Thai government and how are they enforced by regulatory agencies?

2. How do companies engage with industrial effluent policies, standards and the regulatory agencies?

3. What are the similarities and differences between technologies used in Thailand and those used in international comparator countries?

4. How has the public attempted to engage with industrial wastewater management and how effective has this been?

5. How do companies engage with the public with respect to industrial wastewater?

6. Have non-government organisations (NGOs) engaged with the public in industrial waste water management and how?

The methods to be used, sources of data and analysis are summarised in Table 3; the following sections review and justify the methods selected.

Table 3 Summary of methods to use in the thesis

Research question	Methods	Sources of data	Analysis
What policies relevant to industrial waste water management have been established by the Thai government and how are they enforced by the regulatory agencies?	Analysis of relevant documents Interviews with government officers	Websites Documents Government officers	Descriptive Compare standards Critical analysis
How do companies engage with industrial effluent policies, standards and the regulatory agencies?	Analysis of relevant documents Interviews with factory representatives	Websites Document Engineers or factory managers	Descriptive Compare standards Critical analysis
What are similarities and differences between technologies used in Thailand and those used in international comparator countries?	Analysis of relevant documents Interviews with factory representatives	Websites Document Engineers or factory managers	Descriptive Compare standards Critical analysis
How have the public attempted to engage with industrial wastewater management and how effective has this been?	Analysis of relevant documents Survey of public in communities near the factories using questionnaires	Websites Document Local population	Critical analysis
How do companies engage with the public?	Analysis of relevant documents Interviews with factory representatives	Websites Document factory representatives	Descriptive Critical analysis
Have non-government organisations (NGOs) engaged with the public in industrial wastewater management and how?	Analysis of relevant documents Interview with NGO representative	Websites Document NGO	Descriptive Critical analysis

4.2 Research design

This study used both qualitative and quantitative methods (mixed methods) to provide an in-depth analysis of the case study. The use of a case study approach enables the multi-faceted investigation of an issue in context. Case studies are a strategy by which the interviewers collect information by using many methods to collect data over a period of time (Stake, 1995).

Suitable methods were chosen depending on three considerations; construction of research questions, ability of the researcher to access and control situations, and possibility to cover of the events according to time scale of the research (Yin, 1994).

Thailand was chosen as a case study because of experience of the researcher. The researcher has a background and knowledge in water quality and the environment (MSc in Fisheries and also Environmental Management). Therefore, the researcher was interested in problems linked to water quality which is still a key environmental issue in Thailand. Besides, the researcher works as a government official at the Ministry of Higher Education, Science, Research and Innovation (the previous name was Ministry of Science and Technology), so dealing with other government organisations such as Department of Industrial Works, Ministry of Industry in consultation and interviewing was convenient. Moreover, the government officials from the Department of Industrial Works also suggested and introduced companies and an NGO for interviewing.

4.3 Case study

A case study has been defined as 'an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, programme or system in a 'real life' context. It is research-based, inclusive of different methods and is evidence-led. The primary purpose is to generate in-depth understanding of a specific topic (as in a thesis), programme, policy, institution or system to generate knowledge and/or inform policy development, professional practice and civil or community action'. (Simons, 2009: 21) The case study is one of many methods in social science research besides histories, surveys, experiments, and economic and epidemiological research (Yin, 2009). Case study research focuses on understanding a present event within a single setting (Eisenhardt, 1989) and can utilise many different data collection methods such as questionnaires and interviews (Eisenhardt, 1989; Gomm *et al*., 2000; Yin, 2009), i.e., potentially including qualitative and quantitative approaches. Indeed Stake (2005) argued that a case study is the choice of what to study and can be used to achieve many goals: to give description (Kidder, 1982), analyse theory (Anderson, 1983; Pinfield, 1986), or build theory (Eisenhardt, 1989; Gersick, 1988; Harris and Sutton, 1986). In this case the purpose is to use case studies to provide rich empirical understanding in order to analyse theory.

A major strength of the case study approach is that it can be adapted to different types of research questions and different data collection allowing triangulation of finding (Rose *et al*., 2015; Yin, 2009). Besides, the case study has advantages in studying phenomena in detail especially in when there are many variables of interest (Rose *et al.*, 2015). Another benefit of case study is that the format of the case study can make it more accessible to readers than other methods (Dubé and Paré, 2003; Rose *et al.*, 2015)

On the other hand, Rose *et al.* (2015) also indicated some limitations of case study research, including that the choice of studies can be biased, which can affect findings of research. Another concern of the single case study is that it is unsuitable to generalise statistically even though other methods may be applied. And the last limitation is ‘It can be very demanding to carry out’ (Rose *et al.*, 2015: 9), reflecting the breadth and depth of relevant information to be synthesised.

Therefore, this study used a case study method to answer most of the research questions which are ‘Why’ and ‘How’ questions. Moreover, this research focused in industrial wastewater which is an environmental problem in the world in the present day.

The research was carried out in two provinces of Thailand which are Ayutthaya and Khon Kean. The main considerations in choosing these two provinces were:

- These two provinces are the places where two large breweries in Thailand are situated.
- Ayutthaya has been an important province for a long time because it used to be a capital city in the kingdom of Siam until 1767. Ayutthaya has an area of about 2,556.64

km^2. There are four rivers passing through the province and it has 1,254 canals connected to the rivers all over area (Ayutthaya province, 2016).

- Ayutthaya province ranked 5th highest Gross Provincial Product per capita (GPP per capita) in Thailand in 2014 (Office of the National Economic and Social Development Board, 2016). Ayutthaya has three industrial estates (Industrial Estate Authority of Thailand, 2016) and has two industrial areas (Department of Industrial Works, 2016).

- Khon Kean has area about 10,885.99 km^2 and has two rivers passing through it (Khon Kaen province, 2016). Khon Kean is ranked 4th most populous province in Thailand in 2012 (National Statistical Office, 2012).

- Khon Kean ranked 32nd in GPP per capita in Thailand in 2014 and is ranked 1st in GPP per capita in the Northeast of Thailand in 2014 (Office of the National Economic and Social Development Board, 2016).

4.4 Methods

Yin (2009:2) explained that choosing each method depends on three conditions which are 'the type of research question, the control an investigator has over actual behavioural events, and the focus on contemporary as opposed to historical phenomena'. Moreover, Yin (2009) pointed out that the case studies are usually used when the research questions are 'How' or 'Why', focusing on present events, and where the researchers have little control over events.

The mixed methods approach combines both qualitative and quantitative methods, yet there are many different types of methods to collect and analyse data (Creswell, 2009). Using mixed methods can be more powerful than using either qualitative or quantitative methods alone (Creswell and Plano Clark, 2007).

Sayer (1992) uses the terms intensive and extensive to describe two methodological approaches. Intensive research links to qualitative approaches while extensive research links to quantitative approaches (Clifford *et al*., 2010; Sayer, 1992). Methods for intensive research includes interviews and observation while methods for extensive research are questionnaires and statistics (Sayer, 1992). Sayer (1992: 242) demonstrated that 'In intensive research the primary questions concern how some casual process works out in a particular case or limited number of cases. Extensive research, which is more common, is concerned with discovering some of the common properties and general pattern of a population as a whole'.

There is an argument, however, that it is difficult to combine both approaches in one study because each method has particular epistemology and ontology (Brannen, 1992; Brannen, 2005; Grix, 2004; Tashakkori and Teddlie, 1998). Watkins and Gioia (2015) have said that a mixed method approach is not just only combining both qualitative and quantitative data but also integrating methodologies, research questions and data for interpretation by combining the strength of qualitative and quantitative approaches. Abrahamson (1983) said that almost every method has its own benefits and problems, so mixed methods allows the robustness of one method to counter the limitations of another. Grix (2004) expressed the same opinion and added the condition that 'As long as you are aware of how you are employing a specific method, and what this method is pointing you towards, and how this relates to the way you employ other methods, there should be no problem' (Grix, 2004: 84). Denzin (1989: 13) said the same about mixed methods which is '…no single method can ever completely capture all the relevant features of the reality; consequently, sociologists must learn to employ multi methods in the analysis of the same empirical events'.

This study used qualitative approaches to identify knowledge and understanding of the policies and technologies of brewery wastewater management. The qualitative methods were used to clarify how the companies and NGOs engage with public. On the other hand, quantitative approaches were used to study behaviours and understanding of local people on wastewater management. This is because the qualitative approaches can expand more understanding and also obtain more detailed information from the specialists (Hay, 2005). While the quantitative methods can show correlation between population and wastewater management and can obtain information from large number of population (Oppenheim, 1992).

4.4.1 Qualitative techniques to approach the 'elite' stakeholders

Qualitative techniques, notably semi-structured interviews, are often used in research when engaging with elite stakeholders. Qualitative research requires the researchers to engage themselves to the topic they are studying and to attempt interaction between the researchers and participants (Dickson-Swift *et al*., 2006). Therefore, the outcome of qualitative research is a deep understanding of experiences from the attitude of participants or respondents in the study (Maykut and Morehouse, 1994). Intensive research uses flexible and sensitive methods to collect data on social phenomena (Grix, 2004) 'by addressing How and Why questions' (Yin, 2014: 11). Intensive research embraces specific methods which are qualitative techniques including 'participant observation, informal and unstructured interviews, life-histories, ethnographies' (Cloke *et al.*, 1991: 156). Moreover, the intensive research concentrates on groups of people who have either similarities or differences which actually connect to each other structurally and causally in a way that relates to the situation being addressed by the research (Geertz, 2000; Sayer, 1992).

This study used semi-structured, open ended interviews to engage with people in their professional capacity (e.g., company environmental managers or environmental protection officers), as well as members of the public from neighbouring communities. Interviewing is a method for investigating people's knowledge and feelings by asking question face-to-face between researcher and the interviewees (Bryman, 2004; Hay, 2005; Hoggart *et al*., 2002; Kitchin and Tate, 2000; Valentine, 1997). The flexibility of the in-depth interview can help the researcher to ask and clarify the interviewee's answer (Hoggart *et al*., 2002; Valentine, 1997). Moreover, the interviewer should give confidence to the interviewee all the time of the interview such as if the interviewee wants an anonymous. This is an important thing which the researcher should concern, so that they are comfortable in providing a response (Cloke *et al*., 2004; Hoggart *et al*., 2002). Opdenakker (2006) indicated several advantages of face to face interviews: interview by face to face involves simultaneous communication in both time and place, the interviewers can observe social hints from the interviewees such as body language, intonation etc, the face to face interview can save time between question and answer. However, potential bias of the interviewee is an important factor which can reduce the accuracy of the interview (Cloke *et al*., 2004; Dunn, 2010). Holstein and Gubrium (1997) pointed out strategies for developing good questions which include building an atmosphere leading to a good relationship and delivering straight communication between the interviewer and the interviewee. However, in-depth interviews also have disadvantages such as a company representative might be careful what they say, people or staff might be afraid to say anything negative or they might be blaming the company for all their problems.

Moreover, answers from the interviewees are their opinion and points of view. So, the researcher should exercise some judgment in analysis of the results by using triangulation, i.e., seeking independent sources of information. E.g. secondary data, the government or company reports, newspaper, other interviewees etc. (Hoggart *et al*., 2002; Valentine, 1997).

Interviews were carried out with the government officials and also factory representatives to question their views on policies, public participation, and technologies in industrial wastewater (Table 5). Interviewees were approached by letters to the head of their organisation or company, in order identify the most appropriate people to interview. I interviewed 12 persons, in order to gain a better understanding of how the body operates and engages with the other relevant bodies. Moreover, I interviewed a representative of an NGO on their opinion on both the public and industrial wastewater (Table 4).

Identifying and interviewing the elite required particular measures (Burgess, 1984; Coteerill and Letherby, 1994). First of all, stakeholders in every sector were identified. They were be informed about the research in letters which included all aims and objectives of the research and which asked for permission to interview them (Appendix 1 and 2). A schedule and topics were included with the letters for letting interviewees know and have a chance to prepare themselves to answer the questions. Interviewees were contacted directly for setting up date, time and place to interview.

Every interview, I started by introducing myself and also summarising objectives of the research. I asked the interviewees for permission to record the interview. During the interview, I found that all of the interviewees were willing to answer all questions as much as they can and also add important information which could help to improve wastewater problem in Thailand. This can assume that all respondents thought wastewater was a problem and wanted to solve it.

Table 4 Organisations of interviewees

Organisation	Topic
Department of Industrial Works (National and regional levels)	- Policy - Role and function - Public engagement/participation/awareness
Company (Environmental manager/director, Public relations, Board member)	- Government policy - Technology - Public engagement/participation/awareness
NGOs (National / international organization)	- Industrial wastewater - Public engagement/participation/awareness

Table 5 Examples of questions for government officials and factory representatives

Government officers	Factory representatives
How are the policies enforced?	How the factory responded to the policies?
How to inspect industrial wastewater?	How the factory acknowledged the policies?
How do you respond to public concerns?	How do you respond to public concerns?
What advice is provided on technology options?	What is main factors in choosing a technology?
	How significant are operation and maintenance cost in technology choice, e.g. Compared to the capital cost?
Which technology gives the best result for treating industrial wastewater?	
How is technology used for sustainability? (e.g., for reuse/recycle)	

Methods to analyse data depend on the types of data from primary and secondary sources (Flowerdew and Martin, 2005). The researcher should be aware how to select methods to analyse any data. This research used both qualitative and quantitative methods, so analysis of data should focus on both.

Regarding qualitative data, the researcher had various notes and tapes which were raw data. Crang (2005) writes that tapes need to be transcribed and notes need to be typed. However, there are many styles of transcript depends on the researchers and ways and have greatly detailed schemes that can be used (Crang, 2005). There are many computer software packages that can be used to analyse qualitative data, each slightly different to the other (Crang, 2005). While Flowerdew and Martin (2005); and Robinson (1998) preferred manual methods of analysis because it is better understanding data by allowing greater interaction. Therefore, this research adopted a manual method to interpret the qualitative data. However, the researcher should read through all data to gain an understanding of the context before starting manual method. The main ideas were summarised and coded after that. Crang (2005: 222) said that 'it is a good idea to write down what they mean or what idea they sparked off in a separate set of memos-both so you can decipher them later and so good ideas can build up. These memos to yourself are often termed 'theoretical memos' and are worth keeping, and again need to be labelled so they can be linked to the bits of materials they refer to'. The next step is coding all keywords, phrases, and paragraphs in different categories. All findings from the qualitative research were used to write the results of this research further.

4.4.2 Quantitative techniques to gain views of the public

The questionnaire has been used for a large number of samples relating to people's attitude, opinion, and behaviour (McLafferty, 2010; Oppenheim, 1992; Parfit, 2005). This method is quite simple and easy to understand and answer by the respondents (Bryman, 2004; McLafferty, 2010; Parfit, 2005). The questionnaires can give understanding of social trends, processes, values, attitudes, and interpretations (McGuirk and O'Neill, 2016). Moreover, the cost of distributing the questionnaires is cheaper than the managing an interview because of food, snack, drinks or complimentary gifts (Bryman, 2004; Parfit, 2005; Simmons, 2008). Besides, the questionnaires are flexible and can combine with qualitative research (McGuirk and O'Neill, 2016). The quantitative approaches are used to test hypotheses by investigating relationship between variables (Creswell, 2009).

The questionnaire has specific questions, so the respondents would answer only what the question is (Bryman, 2004). Moreover, duration of time which is used in quantitative method is shorter per participant than qualitative approach (Bryman, 2004; Dunn, 2010). This approach is therefore appropriate in order to gain a perspective on the views of the community.

Advantages of the questionnaires are it can be distributed to the large amount of population (Bryman, 2004). The questionnaires are easy to distribute to the people via mail or internet etc. (Brace, 2013). Moreover, the time period which was used for questionnaires is shorter than interviews or focus groups (Bryman, 2004; Kitchin and Tate, 2000). In addition, the researcher can use simple coding which is different from the interviews and focus groups (Simmons, 2008). Besides, using specific programmes on a computer can consume less time to fill out and analyse data (Bryman, 2004; Simmons, 2008). However, the questionnaires also have disadvantages. If the set of questions are wrong, poorly phases, or wrong order, the answer will be meaningless because the respondents were misleading (Brace, 2013). The respondents can skip or quit the survey if they are not sure how to answer, so it can affect the response rate (Bryman, 2004: Cloke *et al.*, 2004). In addition, the respondents may not willing to express their opinion or attitude either consciously and subconsciously (Brace, 2013). Moreover, the questionnaires can limit the respondent's opinion on specific issues because they should stick with the questions (Bryman, 2004). Besides, there is a sampling error from the questionnaires and can be reduced by increasing sample size which it will affect to the cost (Brace, 2013).

Questionnaires can have many types of question to provide different routes to find something relevant to the research (Parfit, 2005: 90). However, Parfit (2005) clarified two types of basic question in the survey which are open and closed questions. Open questions allow the respondents to express their opinion, however it can take more time to answer and time to analyse (Bryman, 2012). The respondents can use their own term of answer but they have to use more effort to finish it (Bryman, 2012). As Oppenheim (1992: 113) says, 'free-response questions are often easy to ask, difficult to answer, and still more difficult to analyse'. On the other hand, closed questions are mostly applied and the selection of answers can be basic, for example 'Yes' or 'No' (Parfit, 2005: 91). The respondents can choose categories, rank orders, or choose scales (Sarankatos, 2012) by 'tick or circle an answer' (Bryman, 2012: 250). The closed question is easy to ask, answer, and analyse but it may lead the respondents to the wrong positions from the bias to certain answer (Bryman, 2012; Parfit, 2005). Besides, the result from the closed questions can be compared between answers (Bryman, 2012). However, Bryman (2012) stated the range of answers of closed questions should not overlap. Moreover, the closed questionnaires may make the respondents annoy when they cannot find the answers they want (Bryman, 2012). Therefore, most questionnaires use both open and closed questions to deal with the same issues.

In this research, the survey was carried out in two provinces (Ayutthaya and Khon Kaen province). The respondents were selected from the local people around the area nearby the rivers and/or companies. The selected respondents would be above 18 years old which includes students, working group, and non-working group. The total of questionnaires was a hundred set in each district. Questionnaires (Appendix 3) were delivered by hand to local people within approximately 1 km radius of the factories. This study used SPSS software to analyse the data.

In Ayutthaya, I distributed a hundred questionnaires to factory workers in the brewery located in one of my study areas and also staff in a hotel where I lived. For the factory, there is a river nearby (about a kilometer) called Noi river. The hotel is located by the Pa Sak river which is the main river in the province. Therefore, both places I distributed the questionnaires would give some points of view from local people who have lived or worked nearby the river. I explained and described about objectives of the research and also the questionnaires to hotel manager and also factory manager before distributed it. An interviewee in the factory and also a manager of the hotel helped me to explain and distribute the questionnaires to the factory workers and hotel staff.

In Khon Kaen, I chose Tha Phra municipality because it is nearby the brewery which is one of my case studies. I had a chance to talk and explain the objectives of my research to the mayor of Tha Phra municipality. The mayor was interested and wanted to know the results from the questionnaires to help him in developing his area in the future. Therefore, the mayor helped to distribute 100 questionnaires to village leaders in the municipality. Moreover, the village leaders went along with this research to improve their wastewater and other wastes in the area. The result from this area thereby the local's opinion whose want to help and improve the environmental issue.

Analysis of quantitative data from the questionnaires used SPSS software to perform statistical description and tests. First of all, descriptive statistics was used for grouping variables in frequencies and percentages (Field, 2000; Tabachnick and Fidell, 2001).

The Fisher's exact test, Mann-Whitney, and Chi-squared test were used in this thesis to find differences between variables and provinces (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)**.** If the significant value is less than critical value the null hypothesis (Ho) is accepted that there is a statistically significant difference between variables. On the other hand, if the significant value is equal or greater than critical value the null hypothesis (Ho) is rejected that there is no a statistically significant difference between variables. The test of (Ho) was carried out at the 0.05 level.

4.5 Secondary data

Secondary data is data or information which the researcher will use from other's research or reports (Montello and Sutton, 2006). The researcher could use the secondary data for studying and comparing background information. This study will use secondary data as the following topic: policies in industrial wastewater, effluent standards, brewery wastewater treatment. Secondary data can be important to triangulate information provided in interviews.

I consulted public records which is anonymous to see what information is available on the environmental performance of the case study companies, and the extent to which the public consult these.

The public library or newspaper offices were investigated as sources of information on company environmental behaviour and public engagement.

4.6 Thailand as the study location

Thailand was chosen to be a study area because Thailand is the researcher's home country. In the 'factsheet the water sector in Thailand' indicated that 'Thailand is the second economy of Southeast Asia with an open, export-orientated economy and a Gross Domestic Product (GDP) of 405 billion in 2014' (Kingdom of the Netherlands, 2016: 1). In addition, Thailand is an upper middle-income country with a half of GDP of exports, is an opened, export-oriented economy and also Thailand is a moderately economic growth (Kingdom of the Netherlands, 2016). Therefore, other countries have business opportunities to invest in Thailand such as the Netherlands.

Wastewater in Thailand has been an environmental problem for many years as can search and find in the internet or publication/broadcasting. Similar to other countries, Thailand faces problems linked with climate change and shortage of clean water (Kingdom of the Netherlands, 2016). Besides, wastewater from the factories in Thailand can be drained to the public waterways which can cause environmental and health problems (Kingdom of the Netherlands, 2016). Kingdom of the Netherlands (2016) reported that many rivers in Thailand such as lower part of Chao Phraya river can easily be polluted because the drainage wastewater from many factories and also can affect to the sea water. Moreover, the United Nations said that 'urged the Thai government to make water sanitation as a key focus for investment' because the wastewater treatment sectors have sufficiently undeveloped for many years (Kingdom of the Netherlands, 2016: 3).

4.7 Brewing industry in Thailand

The researcher chose the brewing industry as a case study because of the amount of water used in relation to the amount in the final product. The average water consumption in the brewing industry is 5-6 litres for every litre of beer produced (Perry and De Villiers, 2003). Braeken *et al*. (2004) and Parawira *et al*. (2005) reported that the brewing industry produces a large amount of polluted water all the year. Wastewater from the brewing industry may be drained in many ways. For example: drains directly to a waterway, drains directly to municipal sewer system, drains wastewater after pre-treatment into the waterway or municipal sewer system, and drains into wastewater treatment plant in the brewing industry (Huige, 2006; Goldammer, 2008). Wastewater from the brewery has a high chemical oxygen demand (COD), temperature between 25°c and 38°c, pH between 2 and 12 (Goldammer, 2008). Therefore, wastewater from the brewing industry can directly and indirectly effect the population and also the environment.

Moreover, the market for alcoholic beverages in Thailand is enormous with about three billion litres beer and spirits sold annually (Tris Rating, 2013). The main factors which stimulate demand in alcoholic beverage are marketing campaigns of beer companies, population growth, and increasing availability of new products.

Before 1992, the beer industry in Thailand was a monopoly market which was operated by two companies: Boon Rawd Brewery Co., Ltd. and Thai Amarit Brewery Co., Ltd. Five large beer companies in Thailand are Boon Rawd Brewery Co., Ltd. (Singha brand), Thai Amarit Brewery Co., Ltd. (Kloster brand), Carlsberg Brewery Co., Ltd. (Carlsberg brand), Thai Beverage Public Co., Ltd. (Chang brand), and Thai Asia Pacific Brewery Co., Ltd. (Heineken brand) had competed in Thai beer market since 1992 (Thailand Development Research Institute, 2005). However, the government set up tariffs to avoid increasing domestic beer companies because it is a luxury good (Chumnanwej, 2001; Ramasut and Saranpattranon, 2009; Warisrit, 2006).

Since 1997, beer is the main alcoholic beverage market in Thailand because of the marketing strategies of the two big domestic companies. Beer is the most popular alcoholic beverage which takes about two-thirds of Thai alcoholic beverage consumed. Moreover, in term of excise tax revenue, beer accounted for 54.81 percent in fiscal year 2012 (Tris Rating, 2013). Between 2000-2005, the quantity of sales and growth of beer were higher than other alcoholic beverages. Thai Beverage PCL, one of the big companies in Thailand, was successful in economy lager beer which is Chang brand. The company raised a campaign to target low income consumers and then Chang became a popular brand in Thailand (Advanced research, 2013). However, Boon Rawd Brewery Co., Ltd. takes the largest volume in market share, followed by Thai Beverage Public Co., Ltd. in Thai beer market (Tris Rating, 2013).

Prasad (2004); Pecotich and Shultz (2006) indicated that Thai beer companies had set different prices by using the following criteria; premium, standard, and economy. Premium refers to top brands of beer which have the quantity of sales about 6.8 percent of total beer market (Positioning Magazine, 2007). Target groups for the premium product are high income consumers (Warisrit, 2006). Standard refers to beer brands which average income consumers are target groups. There is the quantity of sales about 10 percent of total Thai beer market (Positioning Magazine, 2007). Economy refers to the lowest price of beer which produced from low quality of materials and high level of alcohol. This type of beer consumed about 83.2 percent of total Thai beer market (Positioning Magazine, 2007).

From the Figures 5 and 6, domestic consumption has continuously increased since 2001 and peaked in 2008. After that Tris Rating (2013) pointed out that the consumption decreased because of factors such as higher tax rate, political uncertainty, strict regulations etc.

However, the beer consumption climbed up again in 2012 because rebounding of private sector spending and increasing consumer confidence. However, beer production decreased again in 2013 due to the increasing of excise tax and slowing down of economic growth (Tris Rating, 2013).

Figure 5 Beer consumption in Thailand (Office of Industrial Economics, 2018).

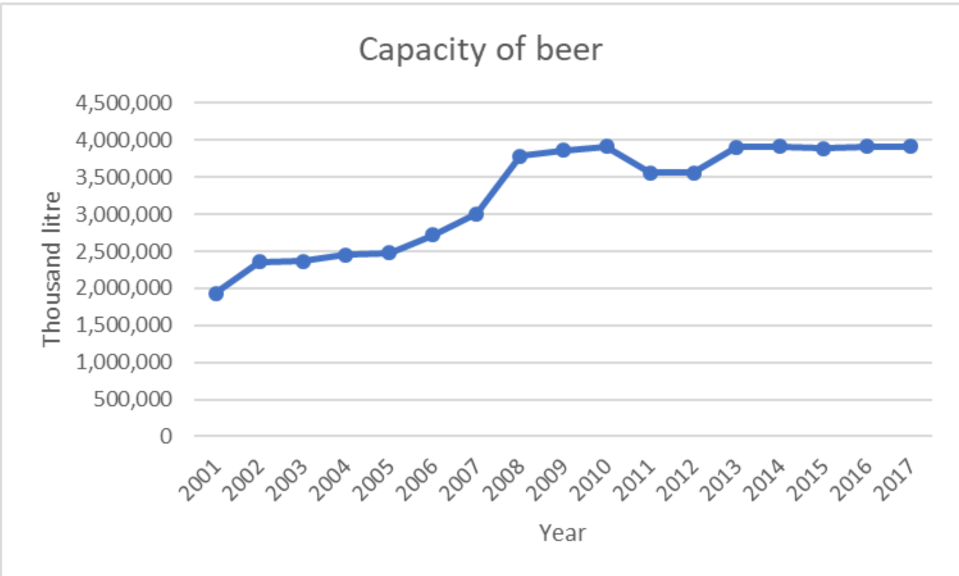


Figure 6 Production of beer in Thailand (The Office of Industrial Economics, 2018).

The researcher chose the two case study companies because they are big competitive companies in Thailand and are also well-known in the international countries including the United Kingdom. Both companies have many brewing factories located in different parts of Thailand and all of brewing factories have their best in wastewater management. Moreover, both companies' websites show their ability to manage their wastewater and also the other wastes. Thus, the researcher sent letters to the companies to give a permit to use one of each company as a case study. The company chose one of their best factories in wastewater management and also has received many awards in environmental management including with environmental governance from the government. Besides, both case studies used to be a case study for many institutes in environmental management. Moreover, the two companies have open house activities to allow other organisations to observe their environmental management. Ayutthaya's and Khon Kaen's brewery company located in different part of Thailand; the waste water management of each was studied in the thesis of the public's opinion on wastewater management in each province.

4.7.1 Overview of Ayutthaya's brewery company

The brewery company in Ayutthaya has beer, soda, and drinking water as their products same as the one in Khon Kaen. Ayutthaya's brewery company was first launched in 1997. Production rate of beer, drinking water, and soda are 700, 200, and 100 million litres per year, respectively.

Ayutthaya's parent company's slogan is 'Always with you' and see their mission to be 'Making a relationship in every way between the company and stakeholders'. The Ayutthaya company is not only concerned about stakeholders, but also concerned about the environment. They state that they follow Thai and international laws and/or regulations to manage their wastes. Their parent website and also the interviews show their ability to engage with the public in many ways.

4.7.2 Overview of Khon Kaen's company

The case study drinks company in Khon Kaen was established in 1994 and produces beer, soda, and drinking water. Their annual production capacity is 700 million litres of beer, 150 million litres of soda, and 100 million litres of drinking water. Thus, the company consumes a large amount of water to produce the products and also uses it in every step of the production process. Wastewater is one of the main emissions, and therefore potential sources of pollution, from the company.

Khon Kaen's company is actively engaged in public participation and also the environment as is indicated by their slogan: 'Sustainable co-habitation of the factory, communities, and environment'. The company states on their website that they abide by national laws and regulations and has industrial certificates and awards to certify on the quality of their products and also the factory performance. For examples, a 3Rs award in 2012 from Department of Industrial Works, Ministry of Industry which adapts and uses 3Rs principle in wastes management and a certificate from the Ministry of Industry in Environmental Good Governance project in 2009 to confirm that the company meets the Environmental Good Governance. They clearly state that they are concerned about natural resources and the environment, and include information on their website about wastewater and other waste management principles. They also state that the company tries to enhance the quality of the public's life and is aware of its social responsibility.

4.8 Case study areas

Thailand (Figure 7) is in Southeast of Asia with coasts on the Andaman Sea and the Gulf of Thailand. It borders Myanmar to the northwest, Laos to the northeast, Cambodia to the southeast and Malaysia to the south.

The research was studied in two provinces located in the Central and the Northeast of Thailand called Ayutthaya and Khon Kaen, respectively. The main consideration to choose these locations was that they are home to the two main brewing companies in Thailand. These are large companies with significant international markets.

Figure 7 Overview of Thailand (Wikitravel, 2014)

4.8.1 Ayutthaya province

Ayutthaya or Phra Nakorn Si Ayutthaya is located in the centre of Thailand and not far from Bangkok, the capital city, about 40 miles (64 kilometres) to the North. Ayutthaya is also located at the junction of the three main rivers which are Chao Phraya, Lopburi and Pa Sak rivers. The Bureau of Registration Administration, Ministry of Interior reported in 2017 that Ayutthaya has population about 811,900 persons divided into male 391,037 and female 420,863 person with an area 2,556.64 km^2 (Department of Provincial Administration, 2018). Density of population per area is 316.18 person/km^2. Department of Industrial Works, Ministry of Industry reported that there are 2,423 factories in Ayutthaya in 2018 (Department of Industrial Works, 2018). Regional government structure in Ayutthaya is shown in the chart below (Figure 8).

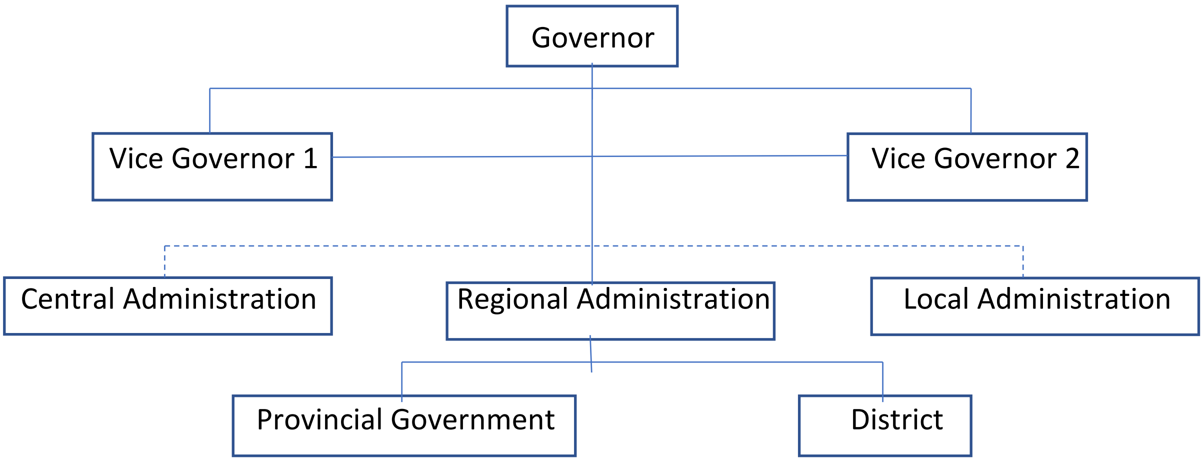


Figure 8 Regional government structure (Ayutthaya province, 2014a)

The strategic plan of Ayutthaya for 2014-2017 has three main strategic issues including the following issues: developing the quality of tourist sites with world-class services, developing the city and community with liveability, and developing production, trade, and service sectors with eco-friendliness to environment (Ayutthaya province, 2014b). The Gross Provincial Product (GPP) of Ayutthaya was 365,966 million baht and GPP per capita was 420,963 baht in 2014 (National Statistical Office, 2014).

Tambon Kamang, Amphoe (district) Phra Nakorn Si Ayutthaya, Phra Nakorn Si Ayutthaya was selected to be a study area because it was the place of the hotel I stayed. There are nine factories in the Tambon Kamang which are noodles and tofu factory, wood factory, and concrete factory (Department of Industrial Works, 2017). Tambon Kamang has the Pa Sak river run though the area (Ayutthaya province, 2016).

Figure 9 Tambon Kamang (Google Maps, 2016a)

Tambon Namtoa, Amphoe (district) Bangban, Phra Nakhon Si Ayutthaya was selected to be the study area because the brewery is located there. Tambon Namtoa has nine factories which are sand dredging factory, ice factory, brewing and beverage factory, shoes factory, chemical factory, concrete factory, and constructing boat factory (Department of Industrial Works, 2017). There are Noi river and Bang Luang canal run through this area (ThaiTambondotcom, 2016).

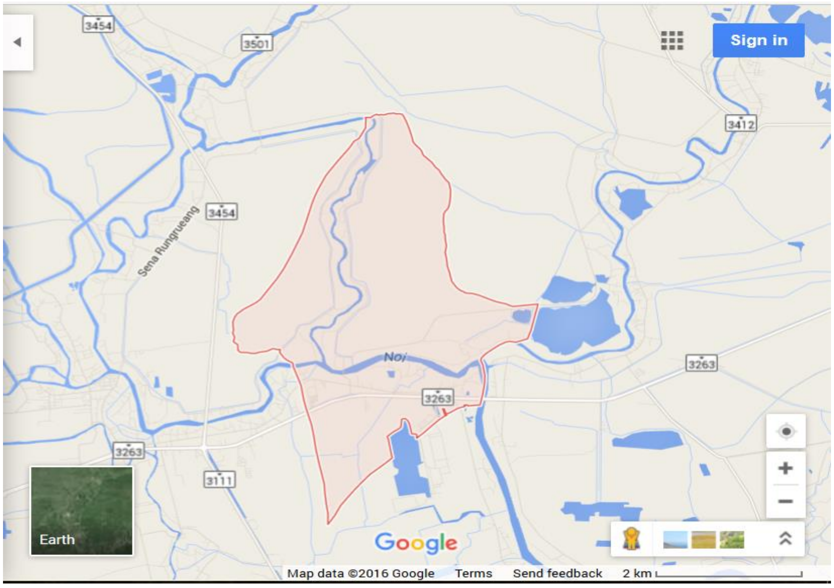


Figure 10 Tambon Namtoa (Google Maps, 2016b)

4.8.2 Khon Kaen province

Khon Kaen is one of the big cities which located in the Northeast of Thailand. Khon Kaen lies about 286 miles (450 kilometres) North to Northeast of Bangkok. There are three main rivers in Khon Kaen which are the Phong, Chern, and Chi rivers. The population in 2017 was about 1,802,988 persons, of which 888,402 are male and 914,586 are female, in an area is 10,886 km^2 (Department of Provincial Administration, 2018). The density of population is 165.17 person/km^2. Moreover, there are 4,404 factories in this province in 2018 (Department of Industrial Works, 2018). Regional government structure in Khon Kaen is almost the same in Ayutthaya and shows in the Figure 11.

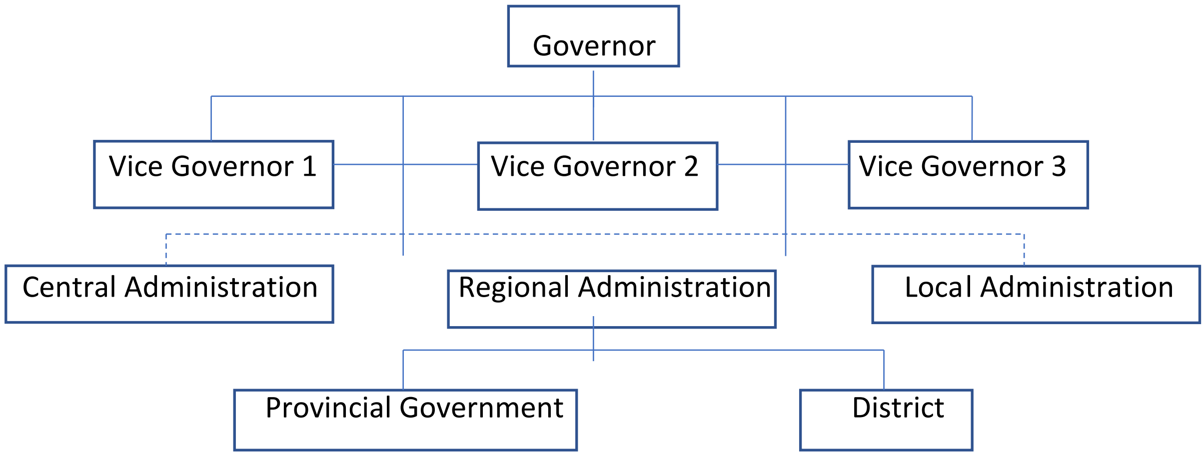


Figure 11 Regional government structure (Khon Kaen province, 2018)

Khon Kaen's strategic plan between 2014-2017 has five issues which are Developing economic and ability of competition, developing quality of human and community, developing sustainable of natural resources and environment, developing safety and stability in life and asset, and Developing public management (Khon Kaen province, 2017). Gross Provincial Product (GPP) of Khon Kaen was 187,348 million baht and GPP per capita was 107,565 baht in 2014 (National Statistical Office, 2014).

Tambon Tha Phra, Amphoe (district) Khon Kaen, Khon Kaen was selected to be the second study area. There are 82 factories which are dairy factory, rice mill, tapioca factory, bakery factory, flour factory, vinegar factory, feed factory, bine-dust factory, brewing factory, beverage factory, sewing factory, carpet factory, furniture factory, organic fertilizer factory, paint brush factory, sack factory, glass factory, concrete factory, solder factory, motor factory, agricultural equipment factory, solar cell mill, fish sauce factory, liquid propane gas factory, cold storage, automobile repair, bottle washing, steaming factory, and waste sorting factory (Department of Industrial Works, 2017). There is Chi river pass through Tambon Tha Phra (ThaiTambondotcom, 2016).

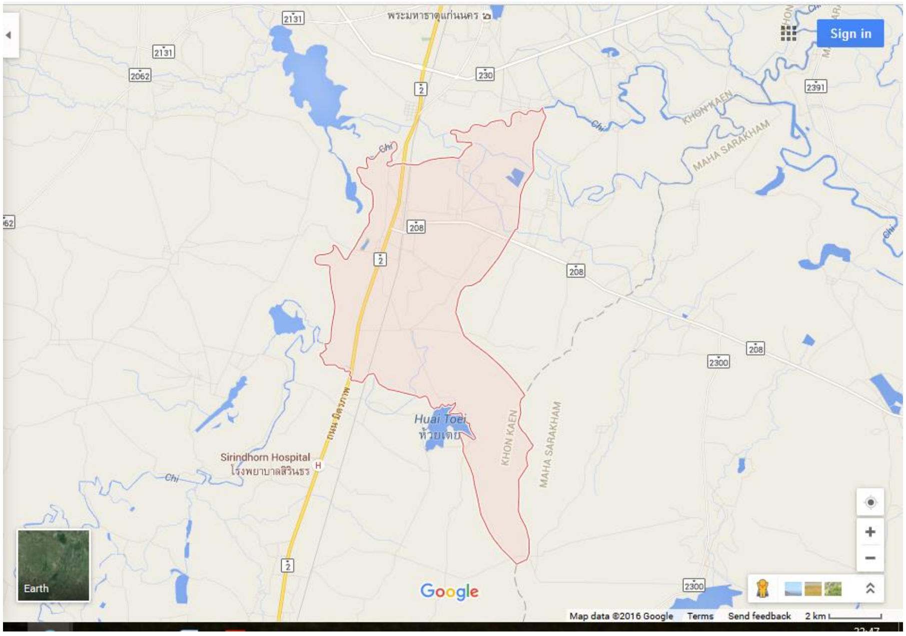


Figure 12 Tambon Tha Phra (Google Maps, 2016c)

Tha Phra municipality has 9,224 person which are male 4,448 persons and female 4,776 persons in the area 8 km^2. Size of population per area is 1,153 person/km^2 (Department of Provincial Administration, 2018). There is the Chi river pass through and has six factories in the area. The six factories are carbonated water factory, bakery factory, fish sauce factory, cloth factory, and thread factory. The Tha Phra municipality has ten communities and each community has village leaders who are elected by local people in each community. Village leaders are mediator between local governments and local people. They acknowledge any information from the government and transfer to the locals. Moreover, they listen any problems from the local people and inform the government to know and find methods to solve problems. This is discussed further in Chapter Five: Regulatory context and policies in industrial wastewater.

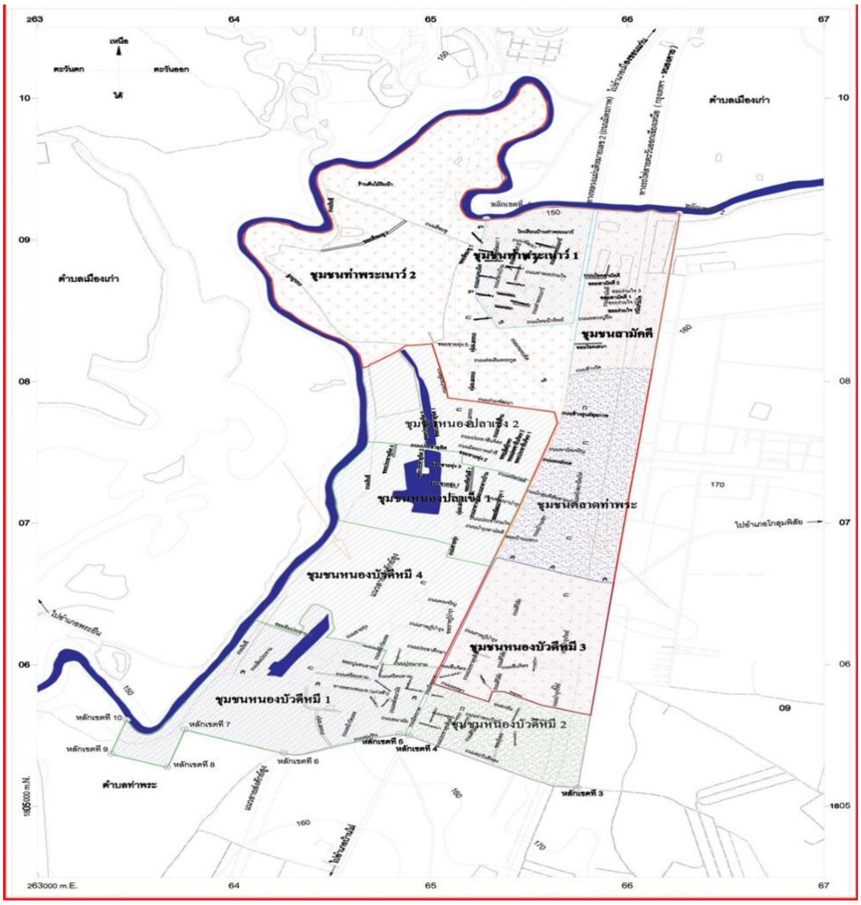


Figure 13 Tha Phra municipality (Tha Phra municipality, 2017)

4.9 Risk and ethical considerations

This research involved human participants. Ethical and also risk assessments were required as followed by the ethical guidelines of School of Environmental Sciences, University of Hull, UK. The respondents from surveying awareness, perception, and participation of people in wastewater management have an age above 18 years old. A covering letter was included with the name and contact details of the researcher, aims and objectives of the research (Appendix 4). Moreover, the researcher informed the respondents how to withdraw from the survey, if they did not want their information and answers to the survey to be used in this research. No participants have so far withdrawn. For the interview, there was a consent form which was provided to the interviewees before started the interview (Appendix 5). In addition, this consent form included the option to receive copy of the research findings or publications. The names of the companies are known only to the author and are not recorded with the data or analysis in order to preserve confidentiality.

Chapter Five: Regulatory context and policies in industrial wastewater

This chapter will analyse the policies and regulatory context involved in industrial wastewater in Thailand, especially in the brewing industry. The goals of this chapter are to review relevant industrial policies and organisations to address research questions: 1) How are the relevant policies established by the government and enforced by the regulatory agencies? and 2) How do companies engage with industrial effluent policies, standards and the regulatory agencies? Section 5.1 outlines the political structure in Thailand. Section 5.2 reviews Environmental Good Governance as a policy process in Thailand. Section 5.3 examines the regulatory context of industrial wastewater. Section 5.4 clarifies and compares industrial effluent standards in Thailand to international standards. Section 5.5 investigates the regulatory context of brewing industry. And the last section is the conclusion. All sections draw on interviews with policy makers from the Department of Industrial Works, factory representatives from Khon Kaen and Ayutthaya provinces, and NGO from Ecological Alert and Recovery-Thailand (EARTH). They also analyse information from policy documents, secondary data, and websites from these organisations.

5.1 Political structure in Thailand

The Thai government's structure has undergone evolutionary changes socially, politically and economically over the last eighty years. Thailand turned from absolute monarchy to constitutional monarchy in 1932 and the first constitution was legislated on 10th December 1932 (Technical services and planning division, Department of local administration, 2001). The following sections outline the present roles of the various branches of government.

5.1.1 Monarchy of Thailand and roles of the King

The institution of monarchy carries a large amount of respect and reverence from the Thai people (Technical services and planning division, Department of local administration, 2001). Although a Thai monarch today has no executive power, the King has the power to approve or disapprove any bills affirmed by the Parliament. If the King disapproves, Parliament can reapprove. If the King still refuses to sign the bill, the Prime Minister is authorised to declare the bill as a law by publishing it in the Government Gazette, the official newspaper of the Government, as though the King had signed it (Thailand Law Forum, 1997).

The late King of Thailand, “King Bhumibol Adulyadej Rama IX” (Figure 14) proved to be more than just a symbolic figurehead or a head of the state. He was also a key factor in development in the country. He proposed the idea of “Sufficiency Economy” which means “enough to live on” to promote sustainable development and to diminish poverty for all Thais. Moreover, sufficiency means to lead to a reasonably comfortable life without excess or overindulgence, whilst having enough. This would be an appropriate principle to develop the country and achieve self-reliance (Technical services and planning division, Department of local administration, 2001).

During the 70 years of King Bhumibol’s reign, he had more than 4,000 royal projects for the well-being of his people throughout the country. The royal projects could be classified into eight categories which are development of water sources, agriculture, environment, occupational promotion, public health, transportations/communications, public welfares, and other projects (Office of the Royal Development Projects Board, 2017). One of his royal projects called “the King royally initiated Leam Phak Bia environmental research and development project” involved wastewater management and is considered in the next chapter (Chapter Six: Wastewater management).

Figure 14 Picture of “King Bhumibol Adulyadej Rama IX” (source: Photoontour, 2017)

5.1.2 Branches of sovereign power

Sovereign power is divided into three branches: legislative, the executive, and the judicial (Technical services and planning division, Department of local administration, 2001).

The legislative branch consists of the National Assembly, which comprises the House of Representatives (500 members of whom 100 are elected by the whole country through party-lists system and 400 members on a constituency basis) and the Senate (200 members elected by the people in the country) (Technical services and planning division, Department of local administration, 2001).

The executive branch comprises the Prime Minister as the head of the government and ministers responsible for the various ministries within the cabinet. The Cabinet Committees consist of relevant ministries (Technical services and planning division, Department of local administration, 2001). The 20 ministries are: the Office of the Prime Minister (OPM), Ministry of Defence (MOD), Ministry of Finance (MOF), Ministry of Foreign Affairs (MFA), Ministry of Tourism and Sports of the Kingdom of Thailand (MOTS), Ministry of Social Development and Human Security (M-SOCIETY), Ministry of Agriculture and Cooperatives of the Kingdom of Thailand (MOAC), Ministry of Transport (MOT), Ministry of Natural Resources and Environment (MNRE), Ministry of Digital Economy and Society (MDES), Ministry of Energy (MOE), Ministry of Commerce (MOC), Ministry of Interior (MOI), Ministry of Justice (MOJ), Ministry of Labour (MOL), Ministry of Culture (m-culture), Ministry of Higher Education, Science, Research and Innovation (MHESI), Ministry of Education (MOE), Ministry of Public Health (MOPH), and Ministry of Industry (M-Industry) (Royal Thai Government Gazette, 2004).

The judicial branch is responsible for the enforcement of all laws. There are four main courts which are the constitutional, the supreme, the appeal, and the trial courts, respectively (Technical Services and Planning Division, Department of Local Administration, 2001).

5.1.3 Thai public administration

The National Public Administration Act, B.E. 2534 (1991) designated three levels of public administration in Thailand: central, provincial, and local administration (Technical services and planning division, Department of local administration, 2001).

Central administration (under the Government): National administration is organised around the 20 cabinet-level ministries listed above. The main offices of each ministry are in Bangkok but some have local offices in each part or province in Thailand. For example, the Ministry of Natural Resources and Environment (MNRE) has local offices in many provinces around the country. MNRE defined local offices in 16 regions of the county and each regional office has many provinces to take care of, within which it has responsibility for the environment (MNRE, 2011).

Provincial administration (under Ministry of Interior): Thailand has 76 provinces (excluding Bangkok), 878 districts, 7,255 subdistricts, and 75,032 villages (Department of Provincial Administration, 2015). Provinces are the highest type of the sub-national administration and are headed by a Governor. The Governor is a government official and is assigned by the Ministry of Interior. Each district has a District Chief Officer, who is assigned by the Department of Local Administration and the Ministry of Interior, as a head. For Minor districts, the Department of Local Administration assigns an Assistant District Chief Officer as head. The number of sub-districts within a district depends on location, transportation, communication, and other public facilities. There is a sub-district head who is elected by villagers for a five-year term of office. Villages are the lowest type of the provincial administration and have a Village Headman or Village Leader as a head. The Village Headman is elected by villagers with five-year term (Technical services and planning division, Department of local administration, 2001).

Local administration (under Ministry of Interior): there are two types of local administrative organisations which are the general and the special type (Technical services and planning division, Department of local administration, 2001). The general type consists of the Provincial Administration Organisation (PAO) which has a Provincial Governor who is assigned by the Ministry of Interior to be a Chief Administrator in each province, Municipality has 2,441 municipalities (Department of Local Administration, 2017; Department of Provincial Administration, 2018) and there is a Mayor as a head of each municipality. Municipalities are divided into three categories depending on revenue and population. These divisions are the city, the town, and the sub-district municipality. Finally, the last one of the general type is Sub-district Administration Organisation (SAO) which has 5,334 SAOs throughout Thailand (Department of Local Administration, 2017; Department of Provincial Administration, 2018). SAO is composed of the council which is two persons elected from each village and the executive board who are elected by the council.

The special type of local administration consists of Bangkok Metropolitan Administration and the city of Pattaya. The Bangkok Metropolitan Administration (BMA) comprises legislative and executive bodies similarly to the local administration. The legislative body has 60 elected members who serve four years of term. The executive body consists of the elected Governor and four Deputy Governors for a four-year term. The city of Pattaya consists of the Pattaya City council which is the legislative body and a Mayor who is the executive body. The legislative body comprises of 24 elected members to serve a four-year term. The Mayor is elected by the people serving the four-year term.

5.1.4 Decentralisation process in environmental management in Thailand

There has been increasing local involvement in environmental management over the past decade which was found in the national constitution (1997). Moreover, the national constitution (1997) also requires public participation in environmental management (Missingham, 2000). Besides, administration has been addressed on the potential role of Sub-district Administrative Organisations in environmental management (Puntasen, 1997).

5.2 Environmental governance or environmental good governance

Having reviewed the structure of government and administration in Thailand, I will now approach how the environment fits into the government structure, and also the operation of environmental governance (i.e., the involvement of non-governmental stakeholders).

Thailand has a particular form of environmental governance to support environmental management, which is analysed in this section. Whereas ultimately political decisions are taken, implemented and enforced by governments and governmental bodies, 'governance' implies that other stakeholders have an input in decisions (UNESCAP, 2009). The expression of environmental governance, as opposed to government, came from the Earth Summit or UN Conference on Environment and Development (UNCED) at Rio de Janeiro, Brazil in 1992. One of the key outputs was the **'**Rio Declaration on Environment and Development**'** of which Principle 10 indicated that 'Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided' (Unesco, 1992: 3). This emphasizes the need for governments to provide information to the public necessary for them to make informed contributions to environmental decision making and to be able to understand the reasoning behind, and the implications of a decision local to them. Environmental governance as seen in this was part of the broader drive for sustainable development, i.e., not just protecting the environment, but also respecting social concerns.

The concept of environmental governance was expanded by UNEP (2008), who defines environmental governance as the 'multi-level interactions (i.e. local, national, international/ global) among, but not limited to, three main actors, i.e. state, market and civil society, which interact with one another, whether in formal and informal ways, in formulating and implementing policies in response to environmental-related demands from the society, bounded by rules, processes, and widely accepted behaviours, for the purpose of attaining environmentally sustainable development'.

Thailand applies the concept of environmental governance as understood by the UNEP and IUCN definitions. Thailand Environment Institute (2007:3) defined environmental governance as 'natural resources and environmental management, with public access to information and participation in policy plans, projects, and activities which affect natural resources and the environment with transparency, accountability, rule of law, predictability, and social justice'. However, in Thailand the expression environmental good governance is also used. The

Ministry of Industry (2010: 1-1) and the Industrial technology Review (2009) defines environmental good governance for factories as a document in which factories declare methods used to manage pollution followed by the laws and regulations which the public can access. Besides, the public can suggest methods of energy conservation and resource management and the factory has to listen and respond to their opinion. Ministry of Industry adopted UNEP approach to environmental governance including cooperation between industry, government, and public sectors to promote the sustainable development of the industry and also to protect the environment in 2008. Moreover, the Ministry of Industry specifies guidelines for government officials assessing the quality of environmental governance in industry (Ministry of Industry, 2010). These guidelines are voluntary for companies. By 2015, the Ministry had certified 92 % of premises who had undertaken to meet the guidelines as having passed the criterion of good environmental governance, including complying public participation requirements (Ministry of Industry, 2010).

Following these principles, the Ministry of Industry (2010) classified environmental governance for all stakeholders involved with industry into seven categories: accessibility, participation, transparency, accountability, rule of law, social justice, and sustainability.

1) Accessibility (access to information): The factory has to report types, methods or processes of pollution management including water, air, noise, odour, chemicals, sewage, or any wastes. Besides, the factory must disclose their pollution management where the public can gain access to that information such as at the factory, at government offices, on a website etc. (Ministry of Industry, 2010). With respect to wastewater, the two case studies companies have BOD and COD online systems (see Chapter Six: Wastewater management) which link continuously to the government's system and also have laboratories to test water quality every month. Moreover, they report their water quality to the government at least every three months as a requirement (more detail on 5.3 Regulatory context of industrial wastewater). However, the public hardly has access to waste management information because there is no information on either website.

2) Participation: People can report to the government agency or the factory about environmental problems that may happen under laws and regulations for encouraging the factory to solve problems. Moreover, the public can co-operate with the factory to inspect

and give opinions to solve that problem. However, the effected community has to approve any methods that will be used to solve the problems (Ministry of Industry, 2010). This study found that both factories have methods to listen to public opinion such as questionnaires, a comment box etc. (see Chapter Seven: Public participation). Besides, both factories try to participate with the public in many ways and also try to improve their systems in waste management (see Chapter Six: Wastewater management).

3) Transparency: Factories have to disclose the results of pollution quality or methods to deal with pollution in a way that the public can easily access the information (Ministry of Industry, 2010). Laws and regulations specify that the factory has to report production, wastewater quality and technologies in wastewater management to the government at least every three months (more detail on 5.3 Regulatory context of industrial wastewater). However, it is still difficult for the public to access the waste management information because there is no information on website.

4) Accountability: The factory must respond and solve any mistakes and also report the effectiveness of problem solving. The factory must have methods to listen to public opinion and record that opinion at least annually. Moreover, the factory must find a process or method to avoid that problem recurring and must inform the public (Ministry of Industry, 2010). My case studies listen to opinions from the community and consider the methods or processes used to deal with any comments.

5) Rule of law: The factory must manage their pollution following laws and regulations including monitoring and measurement of the emission of substances that could affect public health and safety. The factory must have safety inspections in every process that affect the environment and community (Ministry of Industry, 2010). Both factories claim to have the best technologies available to manage their wastewater. The factory in Khon Kaen uses the zero discharge idea (see Chapter Six: Wastewater management). Although, the factory in Ayutthaya does not use zero discharge idea, their treated wastewater quality meets water quality standards.

6) Social justice: Factories should have a method to reduce energy and resource consumption especially electricity, water, and fuel. The factory should manage resources

properly so as not to interfere with the community's needs. The factory participates with the public by using corporate social responsibility (CSR) addressing the community around the factory (Ministry of Industry, 2010). Both factories use the 3Rs principle which is reduce, reuse, and recycle in wastewater management (see Chapter Six: Wastewater management). Besides, Khon Kaen's factory uses zero discharge idea to cut water consumption both in the factory and their golf course (see Chapter Six: Wastewater management). The two factories are concerned about the public, not only in their area but also throughout Thailand. So, they have many activities that participate with public such as donating water, supporting education and religion etc. (see Chapter Seven: Public participation).

7) Sustainability: Factories should operate their business conscientiously, not affect the community or the environment. The factory should respond to concerns from the public, and those concerns should decrease over time. Besides, the factory and the community should co-exist contentedly (Ministry of Industry, 2010). Both factories try to do their best in operating and wastewater management (see Chapter Six: Wastewater management). Both Khon Kaen's and Ayuttaya's factory listen to public opinion and support the community in many ways (see Chapter Seven: Public participation). For example, Khon Kaen's factory donates their solid wastes to the community as a fertilizer or animal's food.

The fieldwork for this study interrogated the attitude of companies to these requirements. Managing director of Khon Kaen's factory and the representatives of both factories had similar views on environment governance. Both factories adopted this policy to use in environmental management and have been certified as complying by the Government. Besides, the managing director of the factory from Khon Kaen commented 'The factory also has my own policies to improve the environment and participate with locals for sustainable coexistence. So, this theory or policy is just only one part to drive the factory' (Interview with Managing director, June/2015). This suggests that the need to follow the principles of environmental governance is not only understood by the factory, but is taken seriously.

5.3 Regulatory context of industrial wastewater

There are many laws and regulations relating to industrial wastewater. Table 6 summaries regulations and government bodies in regards to industrial wastewater. This section analyses all the regulations relating to the management of industrial wastewater in Thailand. The next section reviews the regulations, which relates to the establishment and operation of factories, including the brewing industry. As will be discussed below, there is some overlap between different regulations and the authority of different government departments.

Table 6 Relevant regulations and organisations in industrial wastewater

Regulation	Organisation	Function
Factory Act, B.E. 2535 (1992)	- Department of Industrial Works (Ministry of Industry)	- Inspect wastewater quality and method to manage wastewater from factory - Responsibility to the factory
National Environmental Quality Act, B.E. 2535 (1992)	- Office of Natural Resources and Environmental Policy and Planning - Pollution Control Department - Department of Environmental Quality Promotion (Ministry of Natural Resources and Environment)	- Specify water quality standard - Inspect wastewater quality in waterways - Responsibility to all waterways in Thailand
Public health Act, B.E. 2535 (1993)	- Department of Health (Ministry of Public Health)	- Inspect effect of wastewater on human health
Royal Irrigation Act, B.E. 2485 (1942)	- Royal Irrigation Department (Ministry of Agriculture and Cooperatives)	- Inspect wastewater that affect to irrigation
Industrial Estate Authority of Thailand Act, B.E. 2522 (1979)	- Industrial Estate Authority of Thailand	- Provide wastewater treatment plant - Inspect wastewater quality in industrial estate - Responsibility to the factory in industrial estate

5.3.1 Factory Act, B.E. 2535 (1992)

The Factory Act, B.E. 2535 (1992) is the latest Act, it is used to inspect and control all factories of every size. The Act mentions wastewater as follows (Department of Industrial Works, 2005);

Promoting and supporting to reduce point source pollution by using pollution prevention or cleaner technology:

However, it does not specify the types of technology used, and does not appear to have been updated since 1992. This was confirmed by government officials from the Water technology and industrial pollution management bureau, Department of Industrial Works that factories can choose the technology, providing that the wastewater emitted meets the regulatory limits for controlled substances. According to interviewees from the Department of Industrial Works, the government official from that department has the responsibility of checking the specifications of the proposed technologies before factories become operational and also inspecting the equipment installed as it is used. Moreover, this bureau has further responsibilities to give any comments or suggestions on technology to improve performance in treating wastewater. The brewing industry in general, however, is considered to be effectively complying with regulations and using appropriate technology (Interview with a government official no.1 from Water technology and industrial pollution management bureau, Department of Industrial Works, May/2015).

Using Polluter Pays Principle (PPP):

Thailand has applied the Polluter Pays Principle (PPP) for many years; it can be found in many regulations such as the Factory Act, B.E. 2535 (1992) and National Environmental Quality Act, B.E. 2535 (1992) etc. The PPP is used in the sense of setting emission standards for water treatment plants (PCD, 2012). However, government official no.1 from the Water Technology and Industrial Pollution Management Bureau, Department of Industrial Works argued that 'Although there is a PPP included in the Factory Act, B.E.2535 (1992), there is no practical environmental tax enforcement' which is also the opinion of Kadganglai (2010) and Kaewsa-ard (2014) said that there is no serious enforcement in environmental tax. Besides, Fiscal Policy Office, Ministry of Finance is studying the pattern of environmental tax from wastewater and still being in the process of becoming a new Act. (Fiscal policy office, 2016) Despite the seemingly problematic enforcement, there are Ministerial regulations and Notifications under the Factory Act, B.E. 2535 (1992) (Table 7) for supporting the government officials in inspecting wastewater management once factories are in operation. Factories must not discharge wastewater until it meets the required standards. Factories have to report power consumption (via a power meter) and also record everything used in wastewater treatment. Factories must set up a flow meter for wastewater, and a system transmitting all data online to the Department of Industrial Works. Any factory draining wastewater more than 10,000 m^3 per day, any factory drain wastewater between 3,000 and 10,000 m^3 per day or influent BOD (Biochemical Oxygen Demand) load more than 4,000 kg per day, and factories that drain wastewater between 1,000 and 3,000 m^3 per day, and factory that drain wastewater between 500 -1,000 m^3 per day have to set up flow and power consumption meter, and BOD (Biochemical Oxygen Demand) meter and/or COD (Chemical Oxygen Demand) meter that can transmit signal continuously and send data to the system used by the factory to recheck all recorded data and set up a system to change signal for transmitting all data online to the Department of Industrial Works (Department of Industrial Works, 2011b).

The Managing Director and factory representatives from both factories (June and July/2015) asserted that they responded to all policies or regulations and also set up special online devices (see Chapter Six: Wastewater management) and reported all data online to the Department of Industrial Works' system. Both factories check their water quality daily in their factory's laboratory. The director from Khon Kaen (June, 2015) guaranteed that 'My factory uses the best technology in treating wastewater and my water quality parameters from the wastewater treatment plant are better than the standard for sure. Although, there were some higher water quality parameters in rainy season than other seasons, water quality parameters were still not exceeding the standards'. Moreover, factory representatives from Ayutthaya also said that water quality after treatment exceeded the standards.

Although, this was a new law to the factories at that time, the factories had adapted and accepted it. However, government official no.3 from Industrial cluster 1 bureau, Department of Industrial Works indicated that the online system was required by the Department of Industrial Works. However, other organisations such as the Control Pollution Department, which require the same information, did not have access to the online system. 'Some factories used to complain about special online devices because they were very expensive (about 3 million baht [approximately £60,000] per set) and there was the only one government organisation which was the Department of Industrial Works which could use this device at that time, but now every factory has accepted this law' (Interview with government official no.3 from Industrial cluster 1 bureau, Department of Industrial Works, May/2015).

Table 7 Ministerial regulations and Notifications under the Factory Act, B.E. 2535 (1992) for supporting the government officials in inspecting wastewater management

Policy	Detail
Ministerial regulation No.2, B.E. 2535 (1992) (Department of Industrial Works, 2011a)	- Do not drain wastewater outside the factory unless the factory treated that wastewater until it reached the standards not using dilution method. - In a factory which has a wastewater treatment plant, the owner has to set up power consumption meter for the wastewater treatment plant and has to record all power consumption each day. - Factories must record all chemical or physical substances and devices used in wastewater treatment and must provide evidence for these.
Ministerial regulation No.11, B.E. 2539 (1996) (Department of Industrial Works, 2011b)	- Set up an online flow meter of wastewater which drains from the factory to continuously calculate and analyse all data by computer. - Set up system to change signal for transmitting all data online from power consumption meter and flow meter at wastewater treatment plant through other communication devices such as mobile phone, radio, or satellite etc. to the Department of Industrial Works. - Set up communication devices to transmit all data online to the Department of Industrial Works.
Notification of the Ministry of Industry, B.E. 2547 (2004) (Department of Industrial Works, 2011c)	- Specify types of factory that drain wastewater outside the factory into two types that must set up special devices to report wastewater to the Department of Industrial Works; any factory drain wastewater more than 10,000 m^3 per day, and any factory drain wastewater between 3,000 and 10,000 m^3 per day or influent BOD (Biochemical Oxygen Demand) load more than 4,000 kg per day. - Special devices have two types which are flow and power consumption meter, and BOD (Biochemical Oxygen Demand) meter and/or COD (Chemical Oxygen Demand) meter. - Set up system to change signal for transmitting all data online from power consumption and flow meter, and BOD and/or COD meter at wastewater treatment plant to the Department of Industrial Works. Moreover, this system must have qualifications as follow; has signal to alarm when BOD or COD exceed the standards, can transmit signal to transmitter for recording to the control system of the Department of Industrial Works, and could control the system from a long distance.
Notification of the Ministry of Industry (No.2), B.E. 2548 (2005) (Department of Industrial Works, 2011d)	- Add two types of factory that must set up special devices; factories that drain wastewater between 1,000 and 3,000 m^3 per day, and factories that drain wastewater between 500 -1,000 m^3 per day. - Set up BOD and COD devices that can transmit signal continuously and send data to the factory system to record data and that can recheck all recorded data.

Although, these regulations on special online devices are useful to inspect wastewater quality online all the time, the government official no.3 from Industrial cluster 1 bureau, Department of Industrial Works (May/2015) also said that a disadvantage of these devices is that the factory can configure data or fake data before sending online to the Department of Industrial Works' system.

Another regulation (Notification of the Ministry of Industry, B.E. 2545 (2002) under the Factory Act, B.E. 2535 (1992), see Table 8) concerns the specification of types and sizes of the factory, methods to control wastes, qualifications of controllers and also regulates to register to be a controller. This notification indicated that the factory has to have an environmental manager and also a wastewater treatment plant controller (Department of Industrial Works, 2011e).

Government officials no.1 and 2 from Water technology and industrial pollution management bureau and government officials no.3 and 4 from Industrial cluster 1 bureau, Department of Industrial Works mentioned that the company environmental manager or controller must pass training and be registered by the Department of Industrial Works. However, the factory can hire a third party who has passed and is registered with the Department of Industrial Works to be a controller for inspecting wastewater treatment systems. Directing managers and factory representatives from both brewing industries claimed that their factories have an environmental manager, a controller, and engineers who inspect and control the wastewater treatment plant system.

Notification of the Ministry of Industry, B.E. 2550 (2007) under the Factory Act, B.E. 2535 (1992) on report types and quantity of pollution released outside the factory. The factory must collect wastewater before and after treat by wastewater treatment plant every month and test basic parameters which are BOD, COD, pH, and SS (Suspended Solids) (Department of Industrial Works, 2011f).

Notification of the Ministry of Industry, B.E. 2558 (2015) under the Factory Act, B.E. 2535 (1992) on report types and quantity of pollution released outside the factory. This notification adapted some points from Notification of the Ministry of Industry, B.E. 2550 (2007) which collected wastewater before and after treat by wastewater treatment plant at least every 3 months. While wastewater which is drained to outside factory has to be collected every month online reports have to be sent to the Department of Industrial Works' system twice a year (Department of Industrial Works, 2016).

Table 8 Notification of the Ministry of Industry, B.E. 2545 (2002) under the Factory Act, B.E. 2535 (1992) on specification of qualifications of an environmental manager about wastewater and wastewater treatment plant controller

Policy	Detail
Notification of the Ministry of Industry, B.E. 2545 (2002) (Department of Industrial Works, 2011e)	Specification of qualifications of an environmental manager about wastewater: - Certify a report that a wastewater treatment plant controller submitted, do an emergency plan to protect any wastes spread out to the environment. - In the case of an emergency, the environmental manager has to report to the Department of Industrial Works immediately and try to solve the problems as soon as possible. - Report problem, sources of problem, methods to solve, and overall result to the Department of Industrial Works. Specification of qualifications of a wastewater treatment plant controller: - Consider types of fuels and also raw materials used in the factory. - Evaluate and inspect pollution and capability of wastewater treatment plant. - The factory has to have action plans in an emergency and also environmental management to follow strictly. The controller has responsibility to control, regulate, take care, and follow environmental plan, handout of environmental management, and also emergency plan in factory efficiency. Protect and prevent any wastes or pollution through out to the environment without any treatment. - Do the report in processing of wastewater treatment plant and send it to an environmental manager. - Do the result report in quantity of pollution by using laboratory where the Department of Industrial Works approved. The factory can hire a third party or use their laboratory which is approved by the Department of Industrial Works to test water quality.

Government officials no.1, 2 from Water technology and industrial pollution management bureau and government officials no.3, 4 from Industrial cluster 1 bureau, Department of Industrial Works all stated that every factory has to follow by laws and regulations in collecting wastewater samples and send the report every 6 months. Moreover, representatives from both brewing companies confirmed the same as summarised that their factories have to follow the laws and regulations that the Department of Industrial Works regulated and they also send a report about their pollution online on time.

5.3.2 National Environmental Quality Act, B.E. 2535 (1992)

The National Environmental Quality Act, B.E. 2535 (1992) is an environmental law designed to control, preserve, and promote the environment in Thailand. So, wastewater is relevant to this Act and there are many points and Notifications involving wastewater, for example the owner of the source of water pollution must set a wastewater treatment plant or have a controller who inspects the wastewater treatment plant. If some areas have a government provided wastewater treatment plant, the owner of wastewater has to pay a service charge to use it (Department of Industrial Works, 2005).

Moreover, the National Environmental Quality Act, B.E. 2535 (1992) has Notifications about wastewater including Notification No. 3, B.E. 2539 (1996) of the Ministry of Science, Technology and Environment on defining characteristics of water discharge from point source industry and industrial estate. And Notification No. 4, B.E. 2539 (1996) of the Ministry of Science, Technology and Environment on defining types of industry and industrial estate where there is a point source of pollution and so have to control wastewater drainage to the environment.

Characteristics of water discharge will be clarified in section 5.4 specifying Industrial effluent standards.

5.3.3 Public health Act, B.E. 2535 (1993)

The Public health Act, B.E. 2535 (1993) clarified that local administration organisations have the responsibility to eliminate any wastes including wastewater in their area or to authorise other organisations to eliminate the waste. The government officials have the responsibility to control and/or cancel any factory where accidents from wastes happened, and command any factory to fix or edit any waste treatment plant (Water Resource System Research Unit, 2017a; Department of Industrial Works, 2005).

5.3.4 Royal Irrigation Act, B.E. 2485 (1942)

The Royal Irrigation Act, B.E. 2485 (1942) mentions that wastewater must not drain any waste or chemical components into irrigation waterways (Royal Irrigation Department, 2017).

5.3.5 Industrial Estate Authority of Thailand Act, B.E. 2522 (1979)

The Industrial Estate Authority of Thailand Act, B.E. 2522 (1979) indicated that an industrial estate has to provide a central wastewater treatment plant for any factories in the industrial estate area (Water Resource System Research Unit, 2017b).

Both factories and the government officials of the Department of Industrial Works mentioned the 'zero discharge idea' (see Chapter Six: Wastewater management). The government officials pointed out that this idea is quite good when controlling and protecting wastewater drainage outside the factory. A director from Khon Kaen confirmed and guaranteed that 'My factory adopted zero discharge idea by reusing treated wastewater in my golf course. Moreover, my factory has tried to adopt zero waste in the factory also' (Interview with Managing director, June/2015). Factory representatives from Ayutthaya said that 'Although, the factory has tried to adopt zero discharge, the factory is still not completely zero discharge' (Interview with factory representative, July/2015). However, NGO from Ecological Alert and Recovery-Thailand (EARTH) disagreed with this idea because they are concerned about accumulated chemical or physical components that are left after treated wastewater in groundwater and the effect on agriculture, people and the environment.

In addition, the factory representative from Ayutthaya complained about laws and regulations from the government that 'Although, all laws and regulations are useful to control and protect pollution from the factory, some new laws and regulations are not easy to follow by the old factory which was established and operated for a long time. It may take time and also some budget to adopt and follow that law and regulation' (Interview with factory representative, July/2015).

All the laws and regulations above indicate processes or methods to manage and/or control wastewater from the factory to the waterways. However, the Factory Act, B.E.2535 (1992) regulates functions of government officials from Industrial cluster 1 bureau, Department of

Industrial Works to inspect and control every factory to follow the laws. Besides, the Factory Act, B.E.2535 (1992) enforces the factory to follow and respond to the command of the government officials from the Industrial cluster 1 bureau, Department of Industrial Works in solving the wastewater problem by changing, fixing technology to treat wastewater and/or closing the factory.

Therefore, the laws require a range of testing and reporting activities and matching standards, though not specifying technology except for the reporting device. Installing appropriate treatment and reporting devices places an expense on companies. The companies interviewed appear to be very familiar with the regulations, with which they claim to be compliant. Government officials also attested to a generally good level of compliance from the brewing industry. They reported that initial resistance to the cost of the reporting devices has been overcome, but also noted that the devices were vulnerable to tampering.

5.4 Industrial effluent standards

The industrial effluent standards were declared in Notification No. 2, B.E. 2539 (1996) of the Ministry of Industry under the Factory Act, B.E. 2535 (1992) on defining characteristics of water discharge from the plant (Department of Industrial Works, 2011g) and Notification No. 3, B.E. 2539 (1996) of the Ministry of Science, Technology and Environment under the National Environmental Quality Act, B.E. 2535 (1992) on defining characteristics of water discharge from point source industry and industrial estate. However, there are Ministerial Notification, B.E. 2559 (2016) of the Ministry of Natural Resources and Environment (PCD, 2017) and Ministerial Notification, B.E. 2559 (2016) of Ministry of Industry (Department of Industrial Works, 2016c) on defining characteristics of water discharge from point source industry, industrial estate, and industrial land which is up to date data.

Government official no.1 from Water technology and industrial pollution management bureau, the Department of Industrial Works could confirm the origin of the standards but he assumed that they came from or had been adapted from international standards. However, he commented that Thailand adjusted the parameters to make them appropriate for the country. ‘Nowadays, it is still a discussion on some parameters that it should still be in the laws and regulation or not. If it has to change, the Department of Industrial Works has to discuss with Pollution Control Department, Ministry of Natural Resources and Environment and find some references or results of the research' (Interview with government official no.1 from Water Technology and Industrial Pollution Management Bureau, the Department of Industrial Works, May 2015).

Government officials no.1 and 2 from Water Technology and Industrial Pollution Management Bureau and government officials no.3 and 4 from Industrial Cluster 1 Bureau, the Department of Industrial Works came to the same conclusion about the Act, that the Department of Industrial Works has tried to improve it for some time. But the improvements require the support of the government of the day. All officials volunteered that when the government changes, the progress of improving the Act becomes uncertain.

However, the NGO representative (from Ecological Alert and Recovery-Thailand (EARTH)) disagreed with ability of the existing regulations to control wastewater and also the idea of zero discharge. Besides, the NGO points out that the regulations concern effluent emissions from the factory. All factories have to meet the same standards, regardless of the water bodies into which they discharge effluents and the density of other factories also discharging into the same water body. Thai regulations do not consider the quality of water bodies into which effluent may be discharged. This is in contrast to the practice within the European Union (EU), where individual company emissions limits are set with a view to achieving prescribed standards for water bodies (see Driessen and Vereijken (2003) for discussion of brewery effluent treatments in the EU context).

In response to the Government promoting the idea of zero waste, the NGO is attempting to promote a new regulation which is Pollutant Release and Transfer Register (PRTR). Pollution Control Department, Thailand (2012) defined PRTR as 'PRTR is a database that shows types and quantity of pollution released to air, soil and water including information of quantity of wastewater or waste transferred from point sources for treatment or disposal', which accords with the OECD definition (2016). This regulation would require consideration of the quality of water bodies, amongst other innovations.

The NGO, which was the first organisation promoting PRTR, arranged a meeting about PRTR, inviting the government organisations and other stakeholders to listen and comment on a draft of PRTR regulation. The interviewee from the NGO (August/2015) said that the Pollution Control Department agreed with them, so the Pollution Control Department adopted their draft of PRTR and tried to promulgate this as a new law and regulation in the future. However, according to the NGO, the government supported the concept of PRTR but tried to adapt existing regulations to include this approach to environmental management.

One of the characteristics of PRTR is the promotion public participation in wastewater management, which includes the release of important information, including regarding wastewater management, to the public. The Pollution Control Department (2012) indicated objectives of PRTR in Thailand are: to distribute information about pollution management from point sources to the public; to reduce and solve any problems of pollution released from factories; to follow international standards for chemical and pollution management; and to follow and evaluate progress in reducing or eliminating pollution from point sources and to also inspect pollution from each point source. Any information of PRTR would be distributed to the public via internet, publications, and CD-ROMs. This is because some information on types and quantity of pollution is still unavailable to the public or the source of that information is still not easy to access via internet. PRTR would also be used to follow and check chemical components or pollution from point sources to the environment. In the case of an emergency PRTR is useful as it requires the exact quantity of chemical released to the environment to find the best treatment for the doctors or emergency teams. Thus, all stakeholders will know and be able to assess the pollution that affects communities and the environment. The advantages of PRTR for different stakeholders are shown in Table 9.

The table below (Table 10) shows industrial effluent standards in Thailand compared with requirements for discharge for EU and also the composition of brewery effluent based on an international analysis (International Finance Corporation, 2007). EU water quality indicators for water bodies deemed to have 'good' quality according to the Water Framework Directive are also shown. Some Thai standards are more ambitious than the actual average levels reported by the brewing industry. BOD and COD levels permitted in effluent in Thailand are lower than allowed in 'good' water bodies in the EU, implying that effluent discharged must have a quality at least comparable to that of the water into which it is flowing. This in accordance with an interview of government official no.1 from Water Technology and

Industrial Pollution Management Bureau, the Department of Industrial Works. He asserted that Thai water quality standards are internationally competitive.

Table 9 Summary of advantages drawn from PRTR (Pollution Control Department, 2012)

Group	Advantage
Government	- To know trend of releasing to the environment including transferring specific pollution and/or specific area. - To be a basic way to regulate environmental policy and define process to prevent and solve pollution. - To inspect an enforcement/progress of environmental policy. - To follow international law or agreement - To plan a policy to support an emergency event
Industry	- To improve chemical management in factories, promote using chemical efficiency, reduce loss of raw material in production, and decrease releasing pollution. - To reinforce knowledge about chemical use/management. - To reuse any wastes. - To present a good image to the public.
People	- To encourage public participation with the government and private factories to solve pollution problem. - To be a method to access and acknowledge information about pollution, chemical, and environmental management of the factory. - To be an instrument to protect themselves from pollution released from industry and other sources. - To be information for fire fighters, hospitals, police, emergency units in the case of an emergency. - To be information to study and adapt technology about pollution management and effect on health.

Both industry and government interviewees asserted that the brewing industry is on a large scale and the wastewater management is good and uses the best water treatment technology. Moreover, government official no.1 from Water Technology and Industrial Pollution Management Bureau said that ‘There is no wastewater problem or water pollution from the brewing industry’. For example, the government official no.3 from Industrial cluster 1 bureau said that ‘Brewing industry has the best technology in wastewater management, so no need to worry about wastewater’. Moreover, the government officials from Water technology and industrial pollution management bureau and Industrial cluster 1 bureau, the Department of Industrial Works guaranteed the same that both factories, which were the case study in this thesis, are the best examples in wastewater management.

Table 10 Ministerial Notification, B.E. 2559 (2016) of the Ministry of Natural Resources and Environment (PCD, 2018) and Ministerial Notification, B.E. 2559 (2016) of Ministry of Industry (DIW, 2017) on defining characteristics of water discharge from point source industry, industrial estate, and industrial land with international comparisons.

Parameters	**Industrial Standard values (Thailand)** (PCD, 2018)	**Breweries effluent values** (IFC, 2007)	**Requirements for discharge (EU)** (European Commission, 1991)
pH	5.5-9.0	6-9	
Temperature	not more than 40°C		
Colour	300 ADMI		
Total Dissolved Solids (TDS)	- not more than 3,000 mg/l, if drain to receiving water - if exceed 3,000 mg/l but not more than 5,000 mg/l in receiving water		
Total Suspended solids (TSS)	not more than 50 mg/l	50 mg/l	35 mg/l
Biochemical Oxygen Demand (BOD)	not more than 20 mg/l	25 mg/l	25 mg/l
Chemical Oxygen Demand (COD)	not more than 120 mg/l	125 mg/l	125 mg/l
Sulphide as H2S	not more than 1.0 mg/l		
Cyanide as HCN	not more than 0.2 mg/l		
Fat, Oil & Grease (FOG)	not more than 5.0 mg/l	10 mg/l	
Formaldehyde	not more than 1.0 mg/l		
Phenols	not more than 1.0 mg/l		
Free Chlorine	not more than 1.0 mg/l		
Pesticides	not detectable		
Total Kjedahl Nitrogen (TKN)	not more than 100 mg/l		
Zinc (Zn)	not more than 5.0 mg/l		
Chromium (Hexavalent)	not more than 0.25 mg/l		
Chromium (Trivalent)	not more than 0.75 mg/l		
Arsenic (As)	not more than 0.25 mg/l		
Copper (Cu)	not more than 2.0 mg/l		
Mercury (Hg)	not more than 0.005 mg/l		
Cadmium (Cd)	not more than 0.03 mg/l		
Barium (Ba)	not more than 1.0 mg/l		
Selenium (Se)	not more than 0.02 mg/l		
Lead (Pb)	not more than 0.2 mg/l		
Nickel (Ni)	not more than 1.0 mg/l		
Manganese (Mn)	not more than 5.0 mg/l		

5.5 Regulatory context of brewing industry

Besides wastewater management, there are three main policies involved in operating or expanding a factory (Table 11). These are Factory Act, B.E. 2535 (1992), Town Planning Act, B.E. 2518 (1975), and National Environmental Quality Act, B.E. 2535 (1992). These relate to the brewing industry along with other cabinet resolutions and other policies.

Table 11 Main regulations and organisations in operating or expanding brewing industry

Regulation	Organisation	Function
Factory Act, B.E. 2535 (1992)	- Department of Industrial Works (Ministry of Industry)	- Responsibility to all factories include with brewery.
Town Planning Act, B.E. 2518 (1975)	- Department of Public Works and Town & Country Planning (Ministry of Interior)	- Responsibility to approve whether the brewery locate outside area specified in Town Planning Act.
National Environmental Quality Act, B.E. 2535 (1992)	- Office of Natural Resources and Environmental Policy and Planning - Pollution Control Department - Department of Environmental Quality Promotion (Ministry of Natural Resources and Environment)	- Responsibility to any brewery that have to do EIA.

5.5.1 Factory Act, B.E. 2535 (Appendix 6)

Factory Act, B.E. 2535 (1992) is not only used to control and regulate the wastewater management but this Act is also used to control and regulate the establishment and operating of any premises for manufacturing purposes. The purposes of the Act are to conserve environment, and promote safety of the population and country (Department of Industrial Works, 2005).

The first Factory Act was announced in 1939 which was Factory Act, B.E. 2482 (1939) (Table 12) for controlling factories to promote economy, safety, and sanitation. The Factory Act, B.E. 2482 (1939) had 23 sections which were used to regulate factories initially in just 29 provinces. However, the brewing industry was added to be regulated under this Act in 1950 (Legislative Institutional Repository of Thailand, 2017).

After that, the Factory Act (2nd), B.E. 2503 (1960) was enacted to edit and improve the first one (Factory Act, B.E. 2482 (1939)). The main points of this Act were to control and collect all productivity data and other statistics from the factories. Moreover, to protect some industry and also increase fines and decrease imprisonment (Legislative Institutional Repository of Thailand, 2017).

The Factory Act, B.E. 2512 (1969) (Table 12) was enacted to revoke the Factory Act, B.E. 2482 (1939) and 2503 (1960). This Act consisted of 55 sections with four categories; establishing, controlling, cancelling the permission, and enforcement (Legislative Institutional Repository of Thailand, 2017). Next, the Factory Act (2nd), B.E. 2518 (1975) was enacted to edit and improve the Factory Act, B.E. 2512 (1969). The main additions or improvements for this Act concerned environmental problems, health problems, well-being, and natural resources. Under the 1975 Act, a factory was required to stop operation in the event of being found at fault for safety, pollution management, drainage, and ventilation. If they were unable to rectify the situation themselves, they would have to pay a third party to manage the situation for them. Moreover, this Act increased fines and also instituted imprisonment for factory directors whose companies did not follow the Act (Legislative Institutional Repository of Thailand, 2017).

Next, the Factory Act (3rd), B.E. 2522 (1979) was enacted to amend and improve the Factory Act (2nd), B.E. 2518 (1975). This Act was enacted because there were many factories being established or expanding illegally. The attempted enforcement of the Factory Act (2nd), B.E. 2518 (1975) could not cope with the illegal factories. Thus, the 1979 Act increased fines, imprisonment and gave the court the right to close the factory if it did not follow the Act. Besides, this Act did not only punish the Director and manager of the factory, but this Act also punished any person involved with the problem (Legislative Institutional Repository of Thailand, 2017).

Finally, the Factory Act, B.E. 2535 (1992) (Table 12), is still in use. However, many laws and regulations under this Act have been rectified over time. The Factory Act, B.E. 2535 (1992) was enacted because the old Act did not match with the present economy and society and also did not distinguish between different scales of factory in terms of the requirements placed upon them. The 1992 Act introduced three different types of factory (Table 12); setting more stringent requirements for the larger types. In addition, the 1992 Act promotes cooperation between government officials with different responsibilities to reduce permitting process for establishing a factory. Moreover, the Act specifies the role of government officials to enforce the factory to follow the Act. In addition, it increases fines, prison sentences, and specifies penalty to any person who works in the factory. This Act has only two categories which are engagement of the factory, and controlling and inspection the factory (Department of Industrial Works, 2011h).

Table 12 Details of the Factory Act

Factory Act, B.E. 2482 (1939)
- Factory meant places for business and was specified by types of factory - This Act was used to regulate for only private factories - Prohibit anyone from establishing or expanding any factories before receiving permission form Ministry - Anyone who wanted to establish or expand factories, had to complete two forms and send to officials with or without factory and/or machinery plans as officials requested. - Ministry allowed or denied permission within 30 days from the first day that the forms were sent. - Any factories ready to operate had to report to the government officials for inspecting before operating. Government officials had to allow or deny the operation within 30 days. If any factories wanted to appeal government officials command to the Ministry, had to do within seven days and Ministry's command was a final. - Manager had to take care and keep clean factories and area around the factories followed by sanitation. - Any factories which used machines had to have a good condition and had to find methods to protect an accident. - Factory owners had to provide sufficient exits for emergencies. - Any factories stopped operating no longer than 30 days or started operating again after being stopped more than 30 days, had to report in paper to the government officials within fifteen days. If there is a changing owner or manager of the factory, new owner or manager had to report to the government officials within 15 days. - If an accident causes a worker to be unable to work for 72 hours or more, or the factory to cease production for seven days, the manager had to report to the government officials as soon as possible. - Government officials had a responsibility to inspect the factory followed by this Act. - If anyone set up or operated the factory without any permission, they had to pay fines of up to 1,000 baht or face imprison of up to six months, and courts could order the factory to stop operation. - Any Factories which used water had to provide gutters to waterways or ponds for sewage and must not cause any harm the environment or communities. - Any factories discharging sewage or wastewater, had to provide clarifiers for sanitation.

Table 12 Details of the Factory Act (continued)

Factory Act, B.E. 2512 (1969)
- Factory meant buildings, places, and any vehicles which used machines of more than two horse power or used manpower of more than seven people with or without machines to produce, prepare, fix, test, improve, transform, or destroy anything. - Ministry have the power to announce in Government Gazette to expect any factories by the following list to follow this Act: factory which had an objective to developing industry, factory of any school which had objective to educate students, factory where proceed just an essential tool for other objective not for factory business, and factory which operate in household and not harm to anybody. - Establishing the factory had to give permission from the Permanent Secretary and had to specify the date for operation. - When the factory finished, the person who had permission to establish had to get permission to operate to the Permanent Secretary within 30 days after establishing finished. The government officials would go to the factory to inspect before giving permission to operate. - Permission to operate the factory would be valid for three years. - Have to show the permission to operate, on site, where everyone can see. - For the benefit of the country's economics, The Minister has the power to announce in Government Gazette by the following topics; specify types of factory which allow or deny to establish and/or expand the factory, specify types, qualities, ratio, and sources of raw materials which will be used in the factory, specify types or quality of products in the factory, specify types of products to use in other factories or export to other countries. - Clarifying authority and function of the government officials as follows; to come in the factory where it is suspected that a factory does not have a permit, come in to the factory to inspect buildings, machines for protecting any dangers, order in paper to an owner of the factory to fix the factory or machines which can cause any danger on time, order in paper to an owner of the factory to stop operation until the factory is fixed. In the case that the factory can cause harm to public, bring some of the suspected products to inspect the quality included with document, seize any products or containers which may cause harm to public, seal any machines to avoid using that machine if the owner does not follow the order of the government officials.
Factory Act, B.E. 2535 (1992)
- Factory means buildings, places, and any vehicles which uses machines with power of more than five horse power or used manpower more than seven people with or without machines to produce, prepare, fix, test, improve, transform, or destroy anything. - The Minister has the power to announce ministerial regulations to specify types of the factory into three types depending on controlling, protecting, safety and level of effect on public or the environment; type 1 is the factory which can operate immediately, type 2 is the factory which can operate after informing to the Permanent Secretary, and type 3 is the factory which can operate after having permission. - In the case of an inspection the factory or any machines, may be assigned private instead of the government officials to inspect and report as a result of the inspection by Ministry of Industry Regulation, B.E. 2557 (2014) under the Factory Act, B.E. 2535 (1992) on assignation private to inspect and report the result of the inspection to specify qualification and function of private inspection (Department of industrial Works, 2011i). - A permission to operate the factory would be valid for five years. - Clarifying authority and function of the government official as follows; gain entry to a factory suspected of flouting the Act, bring some of the suspected products with their documents in order to inspect the quality, inspect, find, seize any products, containers, account books, other documents in the case that the suspected factory can cause harm to public, has permission to call relevant people and provide documents for considering. - When someone avoids the Act, the government official can arrest and send that person to inquiry official. - The government official has to show a directive to cancel operation of the factory at least three places in that factory where easy to everyone to see.

Moreover, under the Factory Act, B.E. 2535 (1992), there is a requirement from the Ministry of Industry Regulation for a public hearing to consult the public before giving permission to operate or expand a factory No. 1, B.E. 2555 (2012) and No. 2, B.E. 2557 (2014) (Uthaithani Provincial Office for Local Administration, 2017; Department of Industrial Works, 2011j). A hearing may take different forms, which might include a public meeting. However, it could be a notification that something has been applied for, and the public are given a specific time period within which to comment. The main points of this regulation are as follows:

- The aim of a public hearing is to make people understand the factory properly and to collect all opinion in order to consider giving permission (Uthaithani Provincial Office for Local Administration, 2017).

- Applicants have to provide the public with documents and information as follows; information on the factory, copy of operating letter, raw materials/products /wastes/pollution which can affect the environment, notice of methods to control any potentially harmful effects of the factory for the people around it and methods to control wastes and pollution from the factory (Uthaithani Provincial Office for Local Administration, 2017; Department of Industrial Works, 2011j).

- A public hearing has to be announced by a notice posted publicly in the following places; Provincial Industry Office or Department of Industrial Works, District Office, Office of the Local Administration or District Office, and at the factory (Uthaithani Provincial Office for Local Administration, 2017).

- Durations to post a notice are 7 and 15 days for the factory type 2 and 3, respectively. After 7 and 15 days, the government has to collect the input from the public and make it available to the public within a further 15 days. Following the announcement of the input from the public hearing, the government body has 45 days to consider the application in the light of that input and to decide its verdict on the establishment or expansion of a factory (Department of Industrial Works, 2011j).

- Decisions concerning the establishment or expansion of a factory have to include the result of the public hearing as follows: if there are no comments from the public, the government officials decide under the law. If the public expressed opinions, the government officials have to consider whether there are any valid reasons under the laws to support the public objections. The factory may have to meet conditions set by the government officials to solve the indicated problems (Uthaithani Provincial Office for Local Administration, 2017).

- In the case of there being people who refused but the government officials consider to give permission to establish or expand the factory, the government officials have to announce the result of the consideration and the reason they have given permission immediately at the same place used to announce the public hearing (Uthaithani Provincial Office for Local Administration, 2017).

The first Factory Act (Factory Act, B.E. 2482 (1939)) showed that the government was concerned about environment but specified only simple methods to control wastewater. After that, there were no regulations or policies addressing environmental management until the Factory Act (2nd), B.E. 2518 (1975), which concerned environmental problems and natural resources by enforcing the factory to stop operation or pay charges to a third party who would undertake the environmental management. And the present Act (1992) shows that the government is concerned about environmental management and also wastewater management more than the previous Act by supporting cleaner technology and PPP etc. Moreover, each Act since the first Act until the present Act have adapted and improved methods to establish, expand, and operate the factory and also improved or increased fines and/or imprisonments not only for the owner but also director, manager, and/or other person involved with the factory. The public hearing has become one of methods to consider in the establishment and operation of any factory. This showed that the government has tried to listen to public's opinion more than in the past. However, the regulations about public hearing in the establishment and operation of the factory are used for the new factory after the regulations were promulgated.

5.5.2 Town Planning Act, B.E. 2518 (1975)

When establishing and expanding it needs to be ascertained whether the area of the brewing industry comes under the Town Planning Act. If the brewing industry is in the area under

Town Planning Act, that brewing industry would be refused permission to establish (Department of Industrial Works, 2009).

5.5.3 National Environmental Quality Act, B.E. 2535 (1992)

The location proposed for the establishment of a brewing factory must not be contrary to laws and regulations under National Environmental Quality Act, B.E. 2535 (1992) (Department of Industrial Works, 2009).

Moreover, there is a Notification of the Ministry of Natural Resources and Environment, B.E. 2552 (2009) under National Environmental Quality Act, B.E. 2535 (1992) on specification of types and sizes of projects or premises that have to report Environmental Impact Assessment (EIA), and also rules, methods, and regulations in reporting EIA. The brewing industry is one of many premises which must to do EIA (for premises producing more than 600,000 litre of effluent per month) and have to report EIA in the process of asking for permission to establish or operate (Department of Industrial Works, 2011k).

5.5.4 Constitution, B.E. 2550 (2007)

The Constitution, B.E. 2550 (2007) was the first Constitution that mentioned public participation and also public hearing in giving permission to any projects or premises which may affect the environment, health, life-being, and also any advantages and disadvantages to the public (Department of Industrial Works, 2009). The Constitution indicated that the government must consider many points when asking for permission to establish and expand the brewing industry as follow (Office of the Higher Education Commission, 2017);

- People have the right to know all information from the government unless information would affect the security of the country.
- People have the right to know information, any explanation, and the reason from the government before giving permission to establish or proceed any projects which affect to the environment, health, life-being, advantages and disadvantages of people or community. Moreover, people have the right to express their opinion to the government for considering any projects.

- People have the right to participate in the consideration of the government official who may affect their rights and freedom.

- People who gather as a community have the right to conserve or revive their tradition, indigenous knowledge, culture and have the right to participate in sustainable management, maintenance, and the taking advantage of natural resources, environment, and also biodiversity.

- Any projects or activities which may seriously affect the community in environmental, natural resources, and health could not be done unless there is a study to evaluate the effect on the environment, and the health of people in the community. Moreover, have to arrange a public participation and public hearing from people and also other stakeholders to express their opinion.

Thus, public participation and also public hearing were included and related to the laws and regulations after the Constitution, B.E. 2550 (2007) was promulgated. The public has been involved in the process of considering many projects and new laws. Moreover, the public's opinion or comments affected the considerations of the government. For example, the government commanded palm oil mill in Nakhon Si Thammarat province to stop the operation for 45 days to fix and improve the factory because locals informed that pollutions (dust, noise, and odour) from this factory had effect on locals on 1 September 2017 (EARTH, 2017). Besides, the public has the right to know any information and can inspect any projects or regulations which may affect their lives.

The Department of Industrial Works has the Bureau of Public Participatory Promotion which has the responsibility to inform, consult, involve, collaborate, and empower the public. Moreover, this bureau also has responsibilities to educate and train local organisations, factories, and local people in environmental management, safety, and relevant laws. This bureau involves educating and informing locals with fact and information in an attempt to reconcile factories and people in the establishment and operating of the factory. Furthermore, the government official from this bureau said that this bureau also hires a third party such as universities to educate locals about the environment (Department of Industrial Works, 2011l). However, the company has a responsibility to learn and understand any laws and regulations involved with the company (Interview with government official no.5 from Bureau of Public Participatory Promotion, May/2015).

The Department of Industrial Works has many channels to listen to opinion of the public such as website, telephone, or contact directly to the Department etc. However, the process to respond to locals' opinion depends on the consideration of the Department on problems, urgency, priorities. The Department may ask local organisations to take an action and investigate that problem at the beginning. However, if the problem is prolonged, the Department may send the government officials from the Department to cooperate with local organisations and solve that problem (Interview with government official no.5 from Bureau of Public Participatory Promotion, May/2015).

Moreover, all of the governmental websites in Thailand have lots of data and information which the public can access and study. The governmental websites also have a channel to receive any complaint from the public. Furthermore, every government organisation has a hot line number which the public can call to complain or comment about their problems. Thus, the public can contact the government organisations directly and easily.

However, methods of listening to public opinion are somewhat exclusive as not everyone would be able to attend a conference or access the internet. Furthermore, notice boards are not necessarily in places that the public would be visiting, unless they had some reason to expect an announcement. Pamphlets may be issued over only a restricted area. So, for the local people it may be hard to access to or find the information and to express their opinion.

5.6 Conclusions

Thailand is a constitutional monarchy of which "King Bhumibol Adulyadej Rama IX" the late King of Thailand was a key factor in the development the country in many ways. In this study, as can be seen in Chapter Six: Wastewater management, the late King was involved in the development of wastewater management. Thailand has 20 ministries and found that Ministry of Interior (MOI) and Ministry of Industry (M-Industry) are involved with the case study breweries in Khon Kaen and Ayutthaya provinces.

There are many laws, and regulations in industrial wastewater management. The Factory Act, B.E. 2535 (1992), National Environmental Quality Act, B.E. 2535 (1992), Public health Act, B.E. 2535 (1993), Royal Irrigation Act, B.E. 2485 (1942), and Industrial Estate Authority of Thailand Act, B.E. 2522 (1979) are compulsory laws. Both of the factories in this study have adopted standards of environmental governance which exceed the requirements and have received awards from the government.

The Factory Act, B.E. 2535 (1992) is used to inspect wastewater quality and methods of managing wastewater but the government does not specify types or methods used to treat wastewater. The factory can choose any technologies or other methods to treat their wastewater to meet the standards and found that water quality from both breweries meet the standards. Besides, the government specified that both factories have to have BOD and COD online systems to continuously transfer data to the government system, which both factories have already set up. The government officials confirmed that both breweries follow and accept all laws and regulations. However, Polluter Pays Principle (PPP) is still in the process to promulgate as an Act on environmental tax.

The National Environmental Quality Act, B.E. 2535 (1992) defines types of industry and also characteristics of water discharge from point source industry and industrial estate. The government officials mentioned that the standards are appropriate but some parameters should cut off while NGO disagreed. NGO needs to push PRTR to be a new law to control wastewater from the factory and the government agreed with this. However, the PRTR is still in the process to promulgate.

The environmental governance is adapted to apply to the industry to promote public participation. Although this principle is still limited in some factories, both case studies adopted this policy to use in their factories. Thus, both factories in Khon Kaen and Ayutthaya are not only concerned with themselves but also the public and the environment.

Besides, there are many laws and regulation in operating or expanding a brewery. The main laws and regulations are Factory Act, B.E. 2535 (1992), Town Planning Act, B.E. 2518 (1975), and National Environmental Quality Act, B.E. 2535 (1992). Moreover, Constitution, B.E. 2550 (2007) specified that people have to right to know all information from the government and also have right to express their opinion to the government when considering any projects before giving permission to establish or proceed any projects which affect the environment and community. The government allows the public to access information and comment on or complain about their problems in many methods such as governmental websites, hot lines etc. which are easy ways to communicate with the government. Regulations on public hearing in giving permission to operate and expand the factory were promulgated in 2012. So, the public hearing regulations have been involved with the brewery since 2012. However, both breweries concern with the public and communities before the regulations were promulgated as can be seen in Chapter Seven: Public Participation.

Chapter Six: Wastewater management

This chapter analyses the technologies used in industrial wastewater treatment at the case study breweries. It will answer research question three: What are the similarities and differences of the technologies to international comparators? Section 6.1 examines industrial wastewater treatment technologies used in a brewery in the Khon Kaen province. Section 6.2 shows technologies in treating industrial wastewater in brewery in the Ayutthaya province. And the last section (section 6.3) provides conclusions. All data came from interviews with company representatives, websites, and secondary information.

6.1 How Khon Kaen's brewery treated their industrial wastewater

The company faced wastewater problems for some years following their launch in 1994, partly owing to the factory's location on sloping ground adjacent to a waterway. The company Manager Director commented:

'Water from rain, from agriculture around the area, and also from our treated ponds mixed up and caused a problem in rainy season. After that, we had tried to find any methods to solve that problem such as building dams etc. until we found a zero discharge idea is the best idea. So, we had planned to make canals to protect our water to drain to outside and also build a golf course to reuse our water'. (Interview with Managing Director, June/2015).

This indicates an interest in the environment beyond simply preventing harm, or avoiding non-compliance with regulation. As can be seen from Khon Kaen's website, the company is interested in environmental management including wastewater management. So, as will be discussed below, the company has adopted 3Rs principle (reduce, reuse, and recycle) to help with wastewater management. Reduce is reducing amount of water used in all processes. Treated wastewater is indeed re-used in a golf course or gardens in the company following in-house processing.

6.1.1 Technologies used in treating industrial wastewater

The company's managing director stated that they use the best international technologies in treating our wastewater and they also confirmed that their treated wastewater qualities meet or are better than standards (Interview with Managing Director, June/2015). The technologies used in the company are divided into two main systems which are Up-flow Anaerobic Sludge Blanket (UASB) combined with Activated Sludge (AS), and Internal Circulation (IC) combined with AS. These two systems could treat wastewater up to a maximum quantity of 12,440m^3/day and could also produce biogas as a by-product with the maximum quantity of 15,498 m^3/day. The biogas from wastewater treatment systems is used instead of fuel for boiler in the company (Interview with factory representatives, June/2015). More details on technology itself can be found in Chapter Three: Industrial wastewater.

Upflow anaerobic sludge blanket (UASB) and Activated sludge (AS)

UASB + AS is the first wastewater treatment plant in the company and it cost an estimated 70 million baht (approximately 1.4 million pound) according to the Director. In addition, the company claimed that they measure water quality of the treated wastewater from these systems every month by third party laboratory and found an average of COD ≈ 80 mg/l, BOD ≈ 9 mg/l, and SS ≈ 28 mg/l which were within the standards (Interview with factory representatives, June/2015).

From the figure below (Figure 15), wastewater passes through a rotary screen for removing coarse solid waste from wastewater and then through the equalisation tank to adjust wastewater quality before draining to UASB. After wastewater is treated by UASB, biogas is a by-product at this stage with the maximum quantity at 6,048 m^3/day (This is supported by laboratory reports made available to the author). Wastewater passes through AS and meets relevant standards. Moreover, some of the sludge from AS is reused, the rest is disposed of, because there is more than needed. Treated wastewater from this stage is ultimately used for the golf course and garden, after treated by natural treatment as follows (Interview with factory representatives, June/2015).

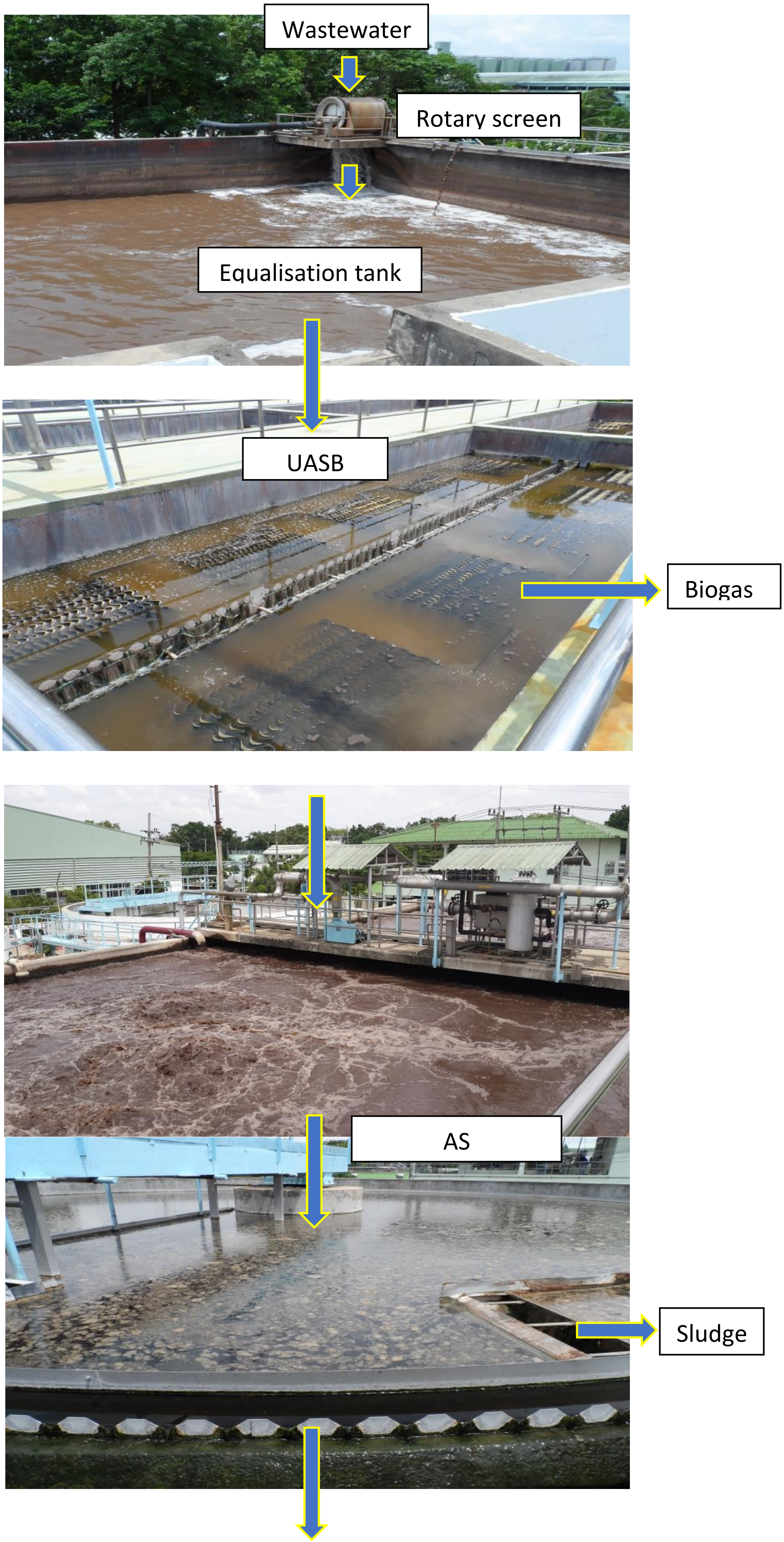
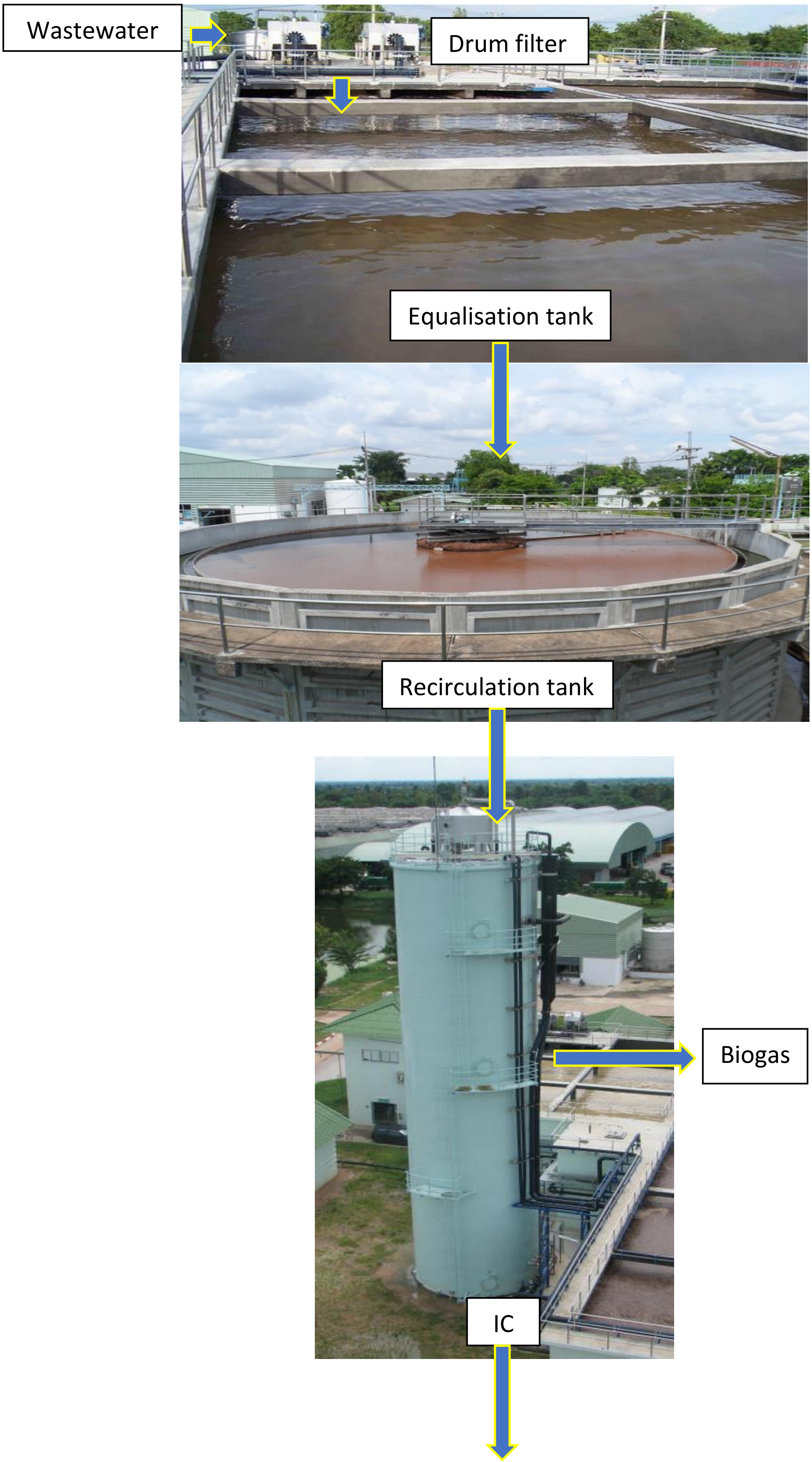

Wastewater
Rotary screen
Equalisation tank
UASB
Biogas
AS
Sludge

Figure 15 Author’s photographs of UASB, AS, and biological treatment for treatment wastewater from brewery processes and reusing in the golf course or garden of the company

Internal circulation (IC) and Activated sludge (AS)

The IC + AS system was built in 2007 because the company wanted to enhance the efficiency of their old wastewater treatment system and also to increase biogas as a by-product. This system cost 107 million baht (estimated £2.14 million) and could produce the maximum quantity of biogas at 9,450 m^3/day which is more than the previous system (Interview with factory representatives, June/2015). Besides, the company asserted that their wastewater quality after treated by IC+AS system is better than the standards by the measurement of third party every month (COD ≈ 29 mg/l, BOD ≈ 1 mg/l, and SS ≈ 10 mg/l). These data are supported by laboratory reports made available to the author.

Wastewater from the company passes through the drum filter to filter coarse solid waste from the wastewater before passing through to the equalisation tank and also the recirculation tank for adjusting wastewater quality. Afterwards the wastewater passes through IC and biogas is produced at this stage. Treated water from IC passes through AS. Sludge is separated from this stage, as a by-product. Treated wastewater from these systems meets international standards (Interview with factory representatives, June/2015) and is sent for purification by Reverse Osmosis (RO), before being reused in the company for cleaning purposes. This water is not reused in beer production (Figure 16).


Wastewater
Drum filter
Equalisation tank
Recirculation tank
Biogas
IC

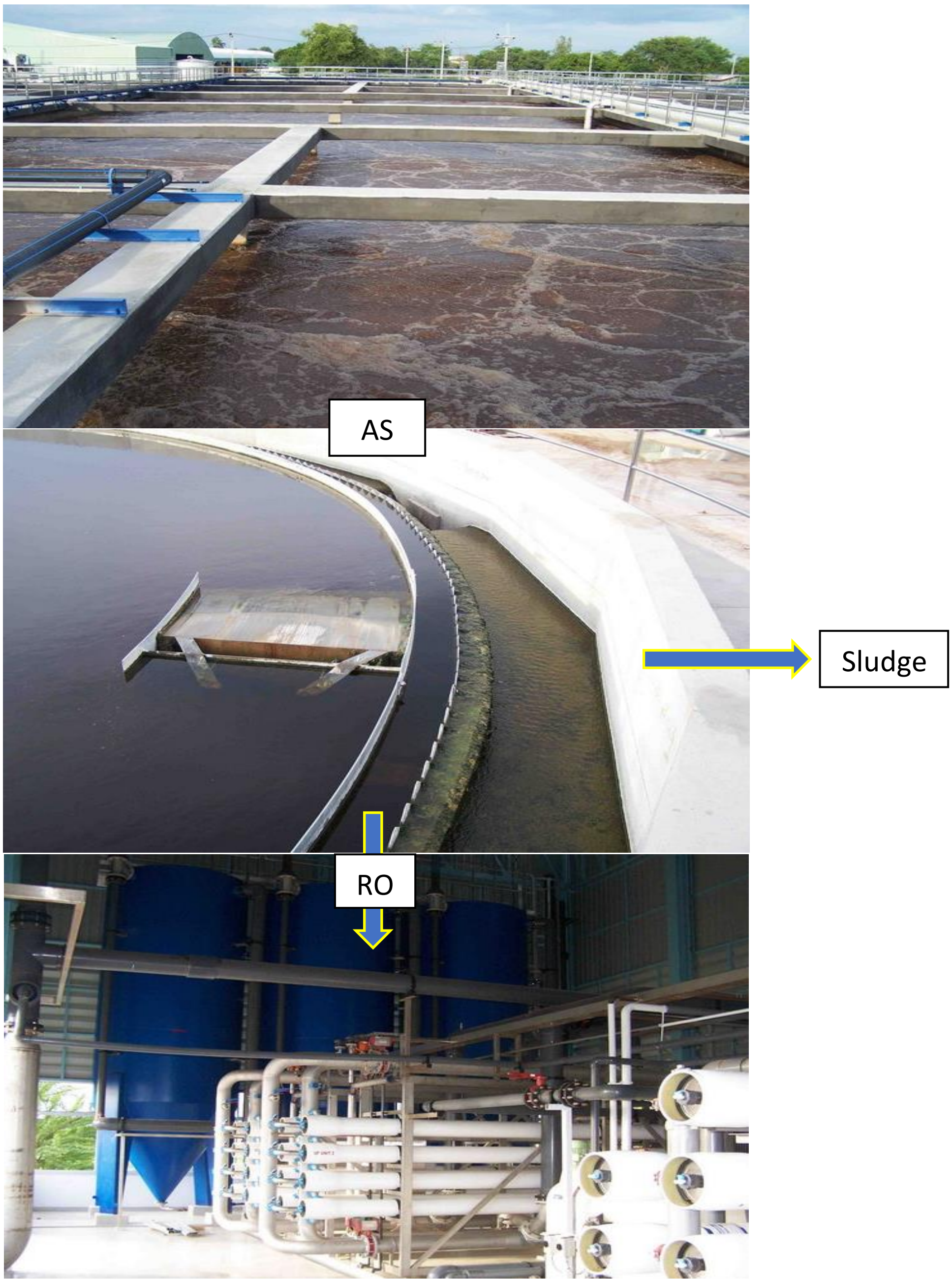


Figure 16 Author's photographs illustrating IC + AS + RO for treatment wastewater and reuse in the factory

6.1.2 Constructed wetland and algae based-system used in treating industrial wastewater

The company uses plant and algae-based systems in treating waste water, which it refers to as a 'natural treatment'. This treatment comprises a series of ponds and makes use of vegetation and microbes to purify the water (Interview with factory representatives, June/2015). 'This is because nitrate and phosphate from the brewery affect the growth of plants, so we decided to adapt natural treatment from the King Bhumibol Adulyadej Rama IX's project to use in the company'. (Interview with Managing director, June/2015). The King Bhumibol Adulyadej Rama IX's project is called 'the King's Royally Initiated Laem Phak Bia Environmental Research and Development Project' which addressed environmental management including both litter and wastewater (See Chapter Three: Industrial wastewater).

The constructed wetland (Figure 17) is located on 100 rai (160,000 m^2 = 40 acre) area and is divided into 11 areas which is sediment pond, floating plant-algae bloom pond 1, floating plant-algae bloom pond 2, main canal, farming canal, rice farming, constructed wetland, grass filtration, floating plant pond 1, floating plant pond 2, and polishing pond (Interview with factory representatives, June/2015).

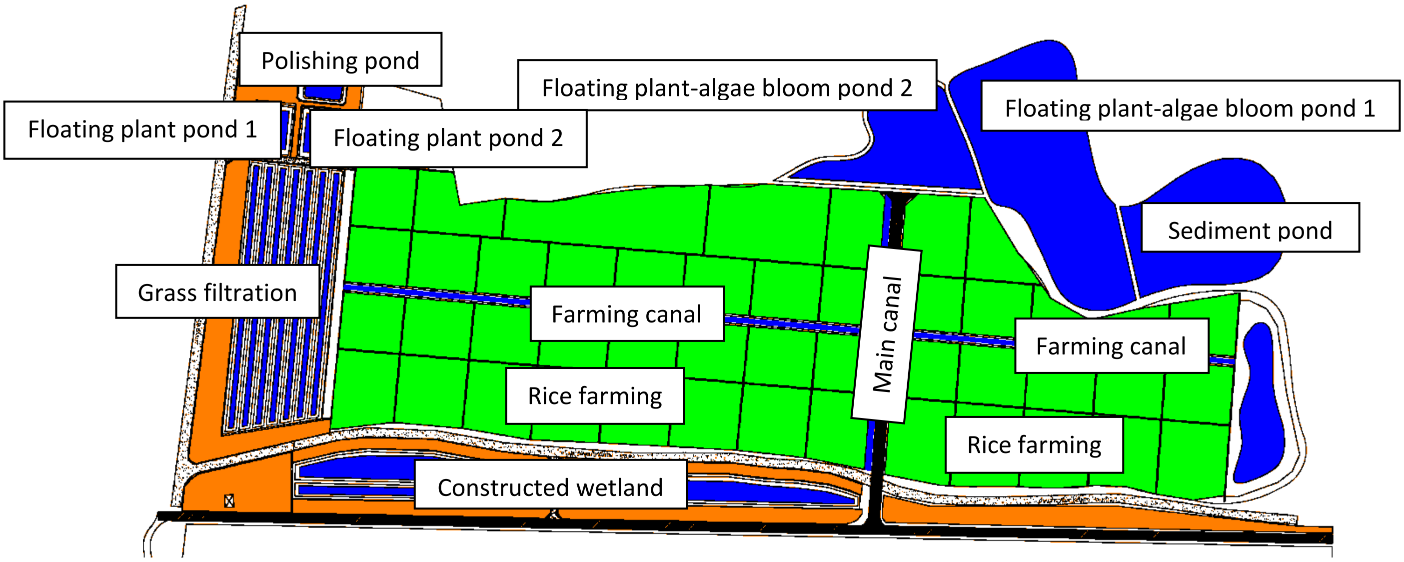


Figure 17 Arrangement of the constructed wetland and associated features (Adapted by the author from the factory's records)

Sediment pond

Sediment pond (Figure 18) is located on 4 rai (6,400 m^2 = 1.6 acre) area with depth 3 m and hydraulic detention-time is 4-5 days. This pond uses microorganisms to decrease 40 % of Total suspended solids (TSS) and also Biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period (BOD5) (Interview with factory representatives, June/2015). This pond is used for separate settlings from water same as rotary screen and equalisation tank in UASB+AS.

Figure 18 Photograph within the sediment pond supplied by the factory. Presence of fish indicates a good quality of water after initial treatment

Floating plant-algae bloom pond 1

Floating plant-algae bloom pond 1 (Figure 19) is located on 6 rai (9600 m^2 = 2.4 acre) area with depth 3 m and hydraulic detention- time is 17 days. This pond uses water hyacinth, microorganisms, and algae to reduce 60% of TSS, BOD5, Total Kjeldahl Nitrogen (TKN), and Total Phosphorus (TP) (Interview with factory representatives, June/2015).

Figure 19 Floating plant-algae bloom pond 1

Floating plant-algae bloom pond 2 (Figure 20)

This pond is the same as Floating plant-algae bloom pond 1 but the area is smaller at 2.5 rai (4,000 m2 = 1 acre) with the depth 2.5 m and hydraulic detention-time is 2-3 days. This pond could reduce TSS, BOD5, TKN, TP at 30% (Interview with factory representatives, June/2015).

These ponds (Floating plant-algae bloom pond 1 and 2) are used to purify wastewater and eliminate nitrogen and phosphorus that still remain after treated by UASB+AS technology.

Figure 20 Floating plant-algae bloom pond 2

Main canal

Main canal (Figure 21) has width 2.2 m, length 160 m, and depth 0.7 m. This canal is used to pass water to constructed wetland and also rice farming for reducing or eliminating algae as a fertilizer for wetland plants and rice (Interview with factory representatives, June/2015).

Figure 21 Main canal (Source: author)

Farming canal

Farming canal (Figure 22) has width 2.2 m, length 500 m, and depth 0.7 m. This canal is used as a waterway to send water from the main canal to rice farming land (Interview with factory representatives, June/2015). During the process of moving along the canal algae is eliminated from the water by decomposing on the floor (Abdel-Raouf *et al*., 2012).

Figure 22 Farming canal (Source: author)

Rice farming

Rice farming (Figure 23) is located on 49 rai (78,400 m^2 = 19.6 acre) area and is used as a research and development area to demonstrate using treated wastewater from the company to plant rice (Interview with factory representatives, June/2015). Moreover, this rice farming is used as a wastewater management area for the zero discharge idea. Although, this company is a zero discharge company, rice farming is the best example that treated wastewater from the company can use for agriculture.

Figure 23 Rice farming (Source: author)

Constructed wetland

Constructed wetland (Figure 24) is located on 4.5 rai (7,200 m^2 = 1.8 acre) and is divided to 3 ponds. Each pond has depth 1 m, length 320 m, and water height 0.2-0.5 m and hydraulic detention- time is 2-3 days. This wetland uses rush (or reed) and also microorganisms to reduce TSS, TKN, BOD5, and TP at 80, 80, 45, and 30%, respectively (Interview with factory representatives, June/2015).

Figure 24 Constructed wetland (Source: author)

Grass filtration

Grass filtration (Figure 25) is located on 5.5 rai (8,800 m2 = 2.2 acre) and is divided to 7 ponds. Each pond has depth 1 m, length 160 m, and water height 0.2-0.5 m and hydraulic detention-time is 1-2 days. These ponds use 2 types of grass and also microorganisms to reduce TSS, BOD5, TKN, and TP at 85, 80, 80, and 30%, respectively (Interview with factory representatives, June/2015).

Figure 25 Grass filtration (Source: author)

Floating plant pond 1

Floating plant pond 1 (Figure 26) is located on 0.4 rai (640 m^2 = 0.16 acre) area with width 12 m, length 18 m, depth 2.5 m, and capacity 1,185 m^3. This pond uses water hyacinth, microorganisms, and algae to reduce TSS, BOD5, TKN, and TP at 30% and hydraulic detention-time is 11 hours (Interview with factory representatives, June/2015).

Figure 26 Floating plant pond 1 (Source: author)

Floating plant pond 2

Floating plant pond 2 (Figure 27) is located on 0.5 rai (800 m^2 = 0.2 acre) with width 16 m, length 22 m, depth 2.5 m, and capacity 1,769 m^3. This pond uses water hyacinth, microorganisms, and algae as in floating plant pond 1 to reduce TSS, BOD5, TKN, and TP at 30% with hydraulic detention- time is 16 hours (Interview with factory representatives, June/2015).

Figure 27 Floating plant pond 2 (Source: author)

Polishing pond

Polishing pond (Figure 28) is located on 400 m^2 (0.1 acre) with width 10 m, length 15 m, depth 1.2 m, and capacity 180 m^3 (Interview with factory representatives, June/2015). This pond is used to store treated wastewater that has been through the treatment processes outlined above and also to check water quality before releasing for use in the golf course.

Figure 28 Polishing pond (Source: author)

Golf course

The golf course of the company (Figure 29) is located on an area more than 500 rai (800,000 m^2 = 200 acre) and relies on water from the natural treatment system (Interview with factory representatives, June/2015). Numerous golfing websites in Thailand refer to this golf course as an example of good practice for its use of company wastewater following a vegetation-based treatment (references withheld for anonymity). The community around the company does not suffer from water deficiency because the golf course only uses water from the company.

Figure 29 Golf course (Source: author and the company provided to the author)

The company exercises concern over their wastewater, partly in response to the regulations, and partly out of concern for the environment and to give confidence to the local community that the river (into which treated wastewater may run-off by surface or sub-surface flow) is safe for community agricultural use. In accordance with regulation the company checks their water quality after treatment every week. In addition to testing for BOD and COD they set up an online system (Figure 30) to continuously monitor the quality of the last pond before treated wastewater is drained to the golf course. As noted above, the wastewater meets the required standards. Besides, the company can be confident in their reports to locals and community that their treated wastewater and also zero discharge idea are safe and can be used in agriculture.

Figure 30 Online system for monitoring COD and BOD (Source: author)

6.1.3 Solid waste (or non-liquid)

Brewery production has many wastes in addition to wastewater, such as sludge, spent grains, yeast, and Kieselguhr slurry. 'After we had met zero discharge idea, which only concerns wastewater already, so we have tried to meet zero waste idea further' (Interview with Managing director, June/2015).

Sludge

Sludge (Figure 31) comes from wastewater treatment process which is AS at an average quantity of 1,000 kg/day. This is supported by laboratory reports made available to the author. The company has a sludge belt press to separate sludge and water. Sludge is used as a fertilizer for agriculture. The company donates the sludge to the community. They helped the community establish a cooperative in 2010 to make and sell fertilizer, in order to provide a source of revenue for the locals (Interview with factory representatives, June/2015).

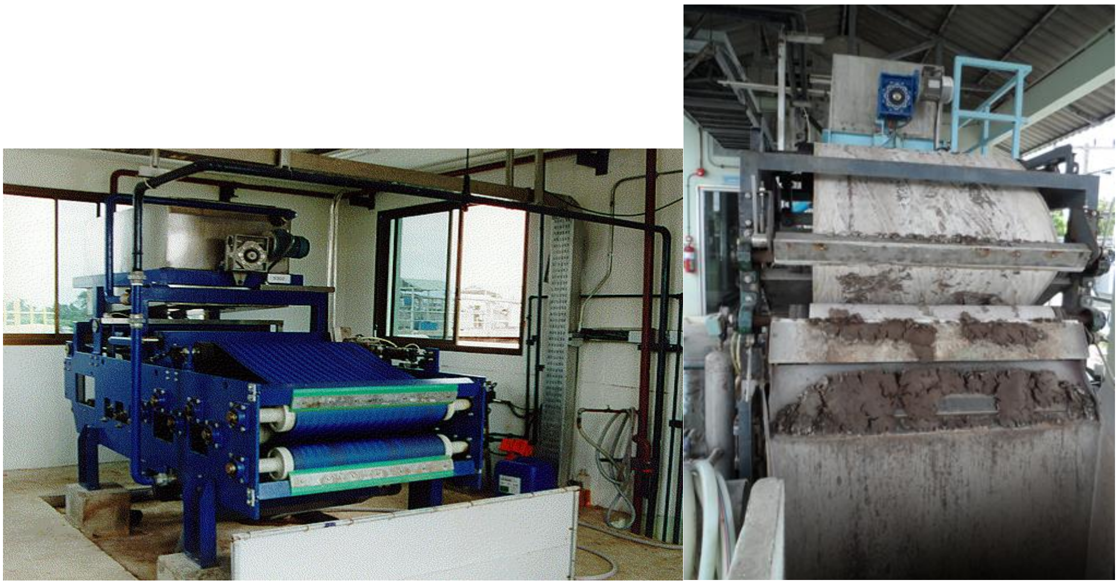


Figure 31 Sludge belt press removing liquid from the sludge. The liquid goes back into the water treatment system (Source: author)

Spent grains

Spent grains (rice, wheat, or malt etc.) (Figure 32) come from the filtration of boiled water in the brewery process. On average spent grains are produced at 220,000 kg/day. This is supported by laboratory reports made available to the author. The spent grains after filtration could be used as an animal feed directly or could be used as an ingredient of animal feed. So, the company sells spent grains for commercial use (Interview with factory representatives, June/2015).

Figure 32 Spent grains in the filtration process (Source: author)

Yeast

On average 70,000 kg of yeast per day is left over from the fermentation process. This is supported by laboratory reports made available to the author. The company manages yeast in four ways. One is supplying 10,000 kg of yeast to a dairy group in the community for feeding dairy cows (Figure 33). The company claimed that dairy cows fed yeast instead of other food produce 25 % more milk. Moreover, the dairy farm in this project received an award for best producer in 2010 and became a role model to other dairy farms. Secondly, 20,000 kg/day of yeast cake 20,000 kg/day is dried and sold as a fertilizer. Third, 10,000 kg/day of dried yeast is sold as a fertilizer and fourth 30,000 kg/day of yeast is used as a soil improver[1] in the community (Interview with factory representatives, June/2015).

Figure 33 Dairy cow feeding trough with yeast (Source: the company provided to the author)

Kieselguhr slurry

Kieselguhr slurry (Figure 34) has an average production rate of 7,000 kg/day and can be put to several uses. This is supported by laboratory reports made available to the author. The company set up filter press machines to press yeast in preparation for re-use. There are currently three uses for this slurry. Firstly, 380 kg/day of Kieselguhr slurry is used as a fertilizer at the cooperative. Secondly, 2,120 kg/day is donated to the community as a soil improver[1]. The last part of Kieselguhr slurry (4,500 kg/day) is used as an ingredient to produce glass bottles since 2011[2] and could be reused as bottles in packaging process (Interview with factory representatives, June/2015). The bottle factory is owned by the parent company of the brewery and supplies bottles for use in several different product lines. The slurry comprises a relatively small component of the inputs to the glass making process, and according to the Director its use would not be economically viable if the factories were not adjacent.

Thus, the company takes a concern in all wastes from brewing process and tries to re-use or reduce wastes in many ways. The locals and community around the company can take advantage of solid wastes from the company, and the company can reduce cost in eliminating solid wastes.

Figure 34 Kieselguhr slurry (Source: the company provided to the author)

[1] Soil improver is used to enhance quality of soil.
[2] The slurry are typically contain 88 – 91% of silica (Reed, 1986).

6.2 How Ayutthaya's brewery treated their industrial wastewater

Based on an interview with engineering manager of Ayutthaya company in July/2015, the company initially adopted its wastewater technologies from Danbrew., ltd A/S, a Danish company with worldwide experience in brewery construction. The technologies were updated following the expiration of the contract with Danbrew in 1995. The engineer manager also asserted that the company headquarters is concerned for the environment and natural resources. Its policy is to find good methods to manage the environment including water and/or wastewater. As mentioned on their website, they claimed that they will increase the rate of water reuse by 11% by 2020 compared to 2017 levels. In addition, the website claims that the company complies with government policy by enabling the public and other stakeholders to participate in sustainable water management. This company has also adopted 3Rs to use in water management as seen in Khon Kaen's company. They aspire to reduce water use by increasing efficiency in every sector of production line for reducing water uses. They reuse wastewater as discussed below.

6.2.1 Technologies used in treating industrial wastewater

The technologies used in treating wastewater are UASB and IC, and after being treated by these 2 systems, the wastewater is finally treated by AS. The wastewater treatment systems cost 400 million baht (estimated 8 million pound). Biogas is a by-product from UASB and IC systems which reduce fuel consumption at 10%. The company is confident in the quality of its wastewater treatment: 'We have the best and also suitable technologies in treating our wastewater. Moreover, our wastewater qualities after treated have to meet the standards' Interview with factory representatives (July/2015).

All wastewater (3,500-7,000 m^3/day) of the company passes through a rotating drum screen (Figure 35) for screening coarse solid from wastewater and then is then sent to an equalising tank to adjust basic water quality before treat. Water qualities at the equalizing tank are pH ≈ 6.0-8.2, COD ≈ 3,000-7,500 mg/l, and SS ≈ 1,500-3,000 mg/l. This is supported by laboratory reports made available to the author.

Figure 35 Drum screen (Source: the company provided to the author)

Upflow anaerobic sludge blanket (UASB)

The UASB tank has a volume of 1,700 m^3 (see Figure 36) and treats at the maximum capacity of 23,000 kg COD/day. This system produces biogas at an average rate of 50 m^3/hr, as supported by laboratory reports made available to the author.

Figure 36 UASB (Source: author)

Internal circulation (IC) (Figure 37)

This system can treat wastewater at the maximum capacity of 30,000 kg COD/day and has volume at 1,200 m^3 as supported by laboratory reports made available to the author. Moreover, this system produces biogas at an average rate of 300 m^3/hr which is higher than UASB and is used with the boiler (Interview with factory representatives, July/2015).

Figure 37 IC *(Source: author)*

Activated Sludge (AS)

The input for the AS comprises the treated wastewater from both UASB and IC systems. The AS system has 2 components which are aeration tanks (Figure 38) and sediment tanks (Figure 39). First the wastewater passes through the pre-aeration tank and the four oxidation tanks. Volume of each aeration tank is 2,400 m^3 and treatment capacity is 20,000 kgCOD/day. This is supported by laboratory reports made available to the author. Then the wastewater passes to the sediment tanks. There are two sediment tanks which have shark catfishes in them as an indicator of water quality (Interview with factory representatives, July/2015).

The polishing tank (Figure 40) receives treated wastewater from sediment tanks for settling sediment again. There are Koi Carp in the polishing tank for monitoring water quality. This is because Koi Carp are sensitive to water quality (Koi fish care info, 2017). A holding pond is used to store treated wastewater before reuse, recycle, or discharge. COD and BOD are monitored and reported electronically to the Department of Industrial Works (Figure 41), in compliance with the government requirement to report water quality continuously at the holding pond (Interview with factory representatives, July/2015). Treated water qualities after treated by all tanks are pH = 8, TSS = 7, COD = 27, and BOD = 2 which are better than the standards. This is supported by laboratory reports made available to the author.

Figure 38 Oxidation tank (Source: author)

Figure 39 Sediment tank and Shark catfish that they farm in the tank (Source: author and the factory provided to the author)

Figure 40 Polishing tank and Koi Carp (Source: author)

Figure 41 COD and BOD monitoring and reporting equipment (Source: author)

All processes for treating wastewater at the company indicated their concern for environmental compliance. Besides, fish in tanks appeared healthy, indicating that treated wastewater could be put to re-use such as for agriculture without a detrimental effect to the environment.

6.2.2 Management of solid wastes

Solid wastes from the brewery comprises of spent grains (approximately 10^9 kg/year) are sold to other companies to use as animal feed, dried yeast (approximately 4^8 kg/year) is sold as supplementary animal food, and Kieselguhr slurry is sold as a fertilizer and also an ingredient of foamed concrete blocks. ‘So, the company could reduce cost of waste disposal and also increase income from selling any wastes’ (Interview with factory representatives, July/2015).

This company manages solid wastes from the brewing process by selling to other companies which can make a profit to the company and can reduce cost in eliminating solids. However, this company is different from the previous company in Khon Kaen, from which most solid wastes are donated to the locals.

6.3 Conclusions

Both companies use the best and well-known technologies in treating their wastewater. However, the company in Khon Kaen uses a constructed wetland and algae-based system to treat their wastewater before using it for the golf course. The company in Khon Kaen adapted the system from the late King’s idea which is similar to the international concept. Solid wastes from both companies are re-used in many ways but the company in Ayutthaya sells all solids to third-party companies, whereas the company in Khon Kaen donates most solids to locals for re-use as fertilizers and animal feed etc. Besides, the company in Khon Kaen has already adopted zero discharge idea to use in the company, while Ayutthaya is still trying to implement it. However, the water quality standards of both companies exceed the standards. Thus, on the basis of the available evidence relating to waste water treatment, both companies appear to be justified in their claims to be concerned with the environment and for communities around their area.

Chapter Seven: Public participation

This chapter will examine and clarify public participation with industrial wastewater management. It addresses five aspects: 7.1 public engagement in Khon Kaen province; 7.2 public engagement in Ayutthaya province; 7.3 comparison of public engagement between Khon Kaen and Ayutthaya provinces; 7.4 public engagement of NGOs, and ends with a conclusion (7.5). Most results came from a questionnaire survey of the public, interviews with factory representatives and an NGO (Chapter Four: Research design and methodology), supported by analysis of secondary data sources such as websites, documents etc.

7.1 Public engagement in Khon Kaen province

This section will examine public engagement with the case study factory regarding industrial wastewater and also environmental management in Khon Kaen province.

7.1.1 Company engagement with the public

In addition to statements on the company website states that they are concerned about the public, the managing director of the Khon Kaen company also asserted that 'We are concerned about people around our factory and we have many activities and projects to deal with the public' (Interview with Managing director, June 2015). The managing director and also CSR officer showed some journals and leaflets that are distributed to the public regularly. There are many activities which the company pushes forward which support livelihoods and income for local people. The managing director gave some examples like 'We provide rushes from the wetland to the people to use as raw material of mats and other products. As we have many wastes from the factory, so we tried to find methods to reduce wastes and also be effective the most. For example, sludge and yeast can be used as a fertilizer'. Besides, CSR officer said that the company also provides knowledge and specialist advice to the locals.

These are numerous activities and projects that the company provides and supports the locals. Materials can be divided into six groups. The following information came from the interviews and also websites (factory's and other websites) state the same as follows;

Wastes from the brewing process (See Chapter Six: Wastewater management) comprise of sludge, spent grains, yeast, and Kieselguhr. Sludge is used as a fertilizer for local farmers. The company supports the sludge to sugar cane farms around the company. Moreover, the company set up a co-operative to support the locals in fertilization production. Spent grain is bought by locals to feed their animals such as chickens, ducks, and fish etc. Yeast is divided into three groups: liquid is used in milk cow farm for reducing budget of cattle food and also increasing the yield of milk; wet yeast is used as a fertilizer; and dried yeast is used as livestock feed. Kieselguhr is used as glass bottles' ingredients. This is because kieselguhr has silica or sand as main ingredient.

By-products from the company are rush and fish. Rush from wetland is a raw material to make mats or other products. The company supports rush to the locals around their area because the locals make mats and other products to earn money. Locals are allowed to catch fish from the ponds for eating.

Regulations for environmental governance (See Chapter Five: Regulatory context and policies in industrial wastewater) require the company to educate and give information to the public. The company distributes journals and/or leaflets (Figure 42) every three months or every other month. There are many sections in the journals and/or leaflets, for examples their activities, CSR, news, important laws and regulations, and health tips etc. For examples, laws and regulations on what happened as if employees make company in trouble, safety in working in factory, and how to cope with back pain from office syndrome.

As an example of transparency, the company allows locals, communities, government organisations, or other organisations to come to see the environmental management of the company. For example, Water Resource Regional Office 4 sent their officers to study about wastewater management of the company in 2011 (there are many examples on locals, communities, government organisations, or other organisations, not named here to preserve the anonymity of the company).

Figure 42 Example of content of the journal the company issues to the public

The company supports religious ceremonies and temples around their area every year by setting up activities to collect money to give to temples. Moreover, the company also supports other organisations relating to religious ceremony. For example, the company donated money to Khon Kaen hospital to support their religious ceremony in 2016 (there are many examples, not named here to preserve the anonymity of the company). The company realises that the brewery produces a product contrary to the rules of Buddhism. They encourage their officers who are Buddhists to make merit every Buddhist holy day. For example, they offer food and beverages to monks or donate some money to temples.

The company cooperates in academic and technical matters with researchers and also universities such as Rajamankala University of Technology ISAN Khon Kaen campus etc. Moreover, the company also supports the researchers and universities by allowing the researchers to use the company as a case study. For example, graduate student from Khon Kaen university used the company as a case study in 2016.The company gives scholarships to researchers or universities such as King Mongkut's University of Technology Thonburi in 2005 and Faculty of Medicine Ramathibodi Hospital in 2016 etc. (There are many examples of collaboration with universities, not named here to preserve the anonymity of the company)

The company sends their officers to support people and also donates any items or products of the company when needed such as flooding, drought, natural disaster etc. For examples, there was a huge flood in Thailand in 2011 and drinking water was widely impacted. So, the company produced drinking water to donate to the public instead of selling it. The company also supported drinking water and set up tanks in schools or communities that suffered from drought in 2016. Besides, the company donated coats to locals in winter season in 2017. The company hired locals to produce EM balls (Effective Microorganism Ball) for treating wastewater from flooding in 2011 (there are many other examples, not named here to preserve the anonymity of the company). The company support specialists and/or knowledge to the locals in order to improve their well-being and also their careers.

In summary, all these activities of the company confirm that it tries to engage with the public around their company and also in the whole country which is according with their slogan of 'Sustainable co-habitation of the factory, communities, and environment'. The public can take advantage from wastes and by-products of the company in enhancing qualities of their products and the public can thereby increase their income. The company does not profit from their wastes, but they effectively reduce their wastes and also support locals at the same time. The company emphasises education as well. Besides, the company was sufficiently confident in its performance to allow its named to be used in a study. The journals and/or leaflets of the company can use to introduce any activities of the company and also educate the locals in many ways involving basic laws and regulations, safety, and healthcare etc. So, the public can know and understand what happen in their community and the public can learn and adapt some knowledge to use in their daily-lives. Moreover, it is the best way of the company to promote itself to the public. The company has a transparency in environmental management and also has ability to manage with their wastes efficiently. Moreover, their name of the company is well-known in environmental management and other organisations trust in the company. The company is aware that temples are important places of the locals because most people in Thailand are Buddhists, reflecting the national religion, so the company shows that they respect and support religious ceremonies. This may also be the best way to communicate and engage with the locals. The company is not only concerned about their own business and the locals, but the company is also concerned about the effect of disasters which affect to people in the whole country. In addition, the company can make their image from these activities and also promote their products as the same time. Thus, the company uses all activities to make their image to the public and also make the people trust in the company. However, the author did not study about employees' lives and also benefits from employer, and so cannot judge how good an employer it is.

7.1.2 Public engagement with the environment

This section will show how the public around the company are concerned and involved in the environment and also environmental management by using data and information from the questionnaires.

Public opinion on environmental issues in Thailand

Table 13 summarises questionnaire responses concerned with the opinions of Khon Kaen local residents about environmental issues in Thailand. Most of the respondents to the survey in Khon Kaen (95%) considered that the environment in Thailand has problems and 38% of respondents identified litter as the main environmental issue (Table 13). However, nearly all of them (98%) thought that rivers in Thailand have a water pollution problem and half of respondents (54 %) considered that factories were the main source of water pollution. Respondents overwhelmingly thought that it is very important to protect the environment (87 %); only 2 % of them thought that it is of low importance and there is no one who thought that it is not important to protect the environment. However, 27% of people thought that the Ministry of Natural Resources and Environment in is effective in enforcing the environmental regulations and only 26 % thought that the effectiveness of companies to implement environmental regulations is better than neutral. When asked to write in comments to open questions (Is there anything else you wish to say relating to environmental management?), some residents (11 of 27 people) commented that a government agency should inspect and look after community for better environment. This should be happening, but the residents may feel that the agency is not as effective as it should be, or may be questioning whether inspections are actually occurring. And a government agency should have a 'serious manner' and be backed up by strong law enforcement for environmental management. Only one resident commented that a government agency should have a wastewater treatment plant or other processes to treat wastewater before it drains to the rivers.

These comments suggest that people in Khon Kaen think that there is water pollution or wastewater issue in their area and they think that factories are the main source of that water pollution or wastewater. So, they are aware of water pollution or wastewater and they think that government agencies should be stricter in enforcing laws and regulations than at the present time. Although factories are seen as a main source of water pollution or wastewater, the Mayor of Tambon Tha Phra (location of the case study factory) said to the author to that water pollution or wastewater in the area does not come from the case study brewery, which is respected for its environmental management (interview with Mayor, June/2015). The company appears to be managing to differentiate itself from other factories locally, at least in the eyes of an elected official. There is a strong implication of a lack of trust of the companies and government on the part of the public.

Table 13 Residents of Khon Kaen's opinions on environmental issues in Thailand

Do you think the environment in Thailand has any problems?	Khon Kaen (%)
Yes	95
No	5
N	100
What is your main concern in environmental issue?	**Khon Kaen (%)**
Air	19
Water	22
Litter	38
Land and soil	6
Forest	14
Other	1
N	100
Do you think rivers in Thailand have a problem with pollution?	**Khon Kaen (%)**
Yes	98
No	2
N	99
If you think there is a problem what are the main sources of water pollution?	**Khon Kaen (%)**
Agriculture	11
Household	22
Factory	54
Transportation	7
Other	5
N	95
Companies have responsibilities under environmental regulations. How effective do you think they are at implementing those regulations?	**Khon Kaen (%)**
1=Ineffective	22
2	11
3	41
4	19
5=Very effective	7
N	97

Table 13 Residents of Khon Kaen's opinions on environmental issues in Thailand (continued)

The Ministry of Natural Resources and Environment is responsible for enforcing environmental regulations. How effective do you think the ministry is?	Khon Kaen (%)
1=Ineffective	17
2	12
3	44
4	20
5=Very effective	7
N	97
How important do you think it is to protect the environment?	**Khon Kaen (%)**
Not important	-
Low	2
Neutral	6
Somewhat	5
Very important	87
N	96

Public awareness of the environment around the area

Most respondents (96%) were aware that there are environmental problems near their home and almost 50% of respondents thought that the effectiveness of companies in managing the disposal of their wastewater to the environment is neutral (Table 14). As I described above (Chapter Four), there are many rivers in Khon Kaen province. So, the vast majority of respondents (98%) in Khon Kaen have ready and frequent access to a river and half of them (53%) go to the river once a week; more than half of respondents (56%) live nearby the river and 29% of respondents use the river for leisure. 91% of respondents have seen signs of water pollution in the river and 45% have seen the signs of water pollution once a week, whilst a few of them said that they have seen signs of water pollution every day. Next, half of respondents (51%) think that the factory is the main source of wastewater because 76% of them have seen where the pollution came from themselves. A few respondents thought that dumping litter in the river could be a main source of water pollution. Most of respondents said that wastewater has an odour and also dark to black colour. Most of them think that water pollution could affect them and their family by bad odour, could not consume water which was affecting to their health, and felt that water pollution affected aquaculture in the rivers. Most of them also worry about that wastewater because they are afraid that it could cause disease and/or affect to their well-being, and wastewater may affect aquaculture or the environment and also could not consume water in the rivers because of a contamination. Moreover, more than half of respondents told someone about that wastewater and they usually told village leader because they thought that water pollution would be solved but a few said that they did not know who they should tell.

Thus it can be concluded that the public believe in the village leaders in consulting and solving their problems in the community. Besides, they told the village leaders or someone about that water pollution some of respondents knew that there was a government agency to cope with that problem while some said there was no anyone to solve the problems. 11 of the 27 residents who responded to an open question (Is there anything else you wish to say relating to environmental management?) commented that everyone should be aware of environmental management.

In summary, the respondents have seen wastewater or water pollution nearby their area in one or more of the many rivers in the district. They also think that factories are main source of wastewater or water pollution same as the first part on public opinion on environmental issues in Thailand. Besides, the respondents believe and trust in the village leaders. This may be because the village leaders are close and easy to access to the locals. Moreover, the village leaders also are middleman between locals and government. Table 19 pointed out that people who had seen any signs of water pollution are more likely to see sources of that water pollution by themselves and to find information on wastewater or pollution prevention by themselves than other. People who have seen any signs of pollution once a week are more likely to find information on wastewater or pollution prevention by themselves than others. People who think that water pollution affects them and their family are more likely to worry about effect of water pollution than other. People who worry about effect of water pollution are more likely to find information on wastewater or pollution prevention by themselves than other.

Table 14 Residents of Khon Kaen's opinions on wastewater and/or industrial wastewater

Do you think there are problems with the environment near your home?	**Khon Kaen (%)**
Yes	96
No	4
n	97
Do you ever go to the river near your home?	**Khon Kaen (%)**
Yes	98
No	2
n	97
How far do you live from the river?	**Khon Kaen (%)**
Next to my home	11
Nearby	56
Quite far away	23
So far away	11
n	95
Why do you come to the river?	**Khon Kaen (%)**
I live nearby	27
I work nearby	2
The river is on my way somewhere	28
For leisure	29
For fishing	10
Other	4
n	94
How often are you close enough to the river to see the water?	**Khon Kaen (%)**
Once a week	53
Once a month	26
Once a year	7
Other	14
n	94
Have you ever seen any signs of water pollution around the area where you live?	**Khon Kaen (%)**
Yes	91
No	9
n	97

Table 14 Residents of Khon Kaen's opinions on wastewater and/or industrial wastewater (continued)

How often?	Khon Kaen (%)
Once a week	45
Once a month	20
Once a year	25
Other	10
n	89
Where do think the pollution came from?	**Khon Kaen (%)**
Sewer	39
Agriculture	7
Factory	51
Other	3
n	89
Why did you think the pollution come from that source?	**Khon Kaen (%)**
Saw by myself	76
Someone told me	19
Other	5
n	88
Did that water pollution affect you and your family?	**Khon Kaen (%)**
Yes	88
No	12
n	92
Did you worry about effect of water pollution and how?	**Khon Kaen (%)**
Yes	93
No	7
n	89
Did you tell anyone about the water pollution?	**Khon Kaen (%)**
Yes	67
No	33
n	94
Who did you tell?	**Khon Kaen (%)**
Leader	66
Neighbour	13
Government	4
Media	7
Other	11
n	86

Table 14 Residents of Khon Kaen's opinions on wastewater and/or industrial wastewater (continued)

How effective to you think companies in your area are in disposing their wastewater in an environmentally sound manner?	Khon Kaen (%)
1=Ineffective	16
2	10
3	44
4	18
5=Very effective	11
n	88

Public opinion on information about wastewater and/or industrial wastewater management

This section will show how the public received and responded to any information about wastewater and/or wastewater management from a government agency and/or a company.

More than three quarters of the respondents (76%) had received some information on industrial wastewater, water pollution, or pollution prevention from a government agency or company and more than half of the respondents (60%) had received that information in the meeting/forum (Table 15). Although, the government agency and the company occasionally had provided the information about pollution or wastewater to the public, nearly three quarters of the public (73%) had also tried to find any information about wastewater or pollution by themselves occasionally. A main source to find the information came from the village leaders which addressed that the village leaders are influencers of the public. So, some residents (3 of 27 persons) commented on open question (Is there anything else you wish to say relating to environmental management?) that everyone should learn about environmental management.

The data indicates that the government agencies and companies reach out to the public and the public are interested in wastewater and/or wastewater management. In addition, the village leaders influence the locals in the area in both ways of communication. People who were provided with any information on industrial wastewater, water pollution, or pollution prevention by government agency and/or company are more likely to find information on wastewater or pollution prevention by themselves and more likely to attend to public meetings relating to environmental management than other people (Table 19).

Table 15 Residents of Khon Kaen's opinions on information about wastewater and/or industrial wastewater management

Has a government agency or a company provided you with any information on industrial wastewater, water pollution, or pollution prevention?	**Khon Kaen (%)**
Yes	76
No	24
n	92
How did you get that information?	**Khon Kaen (%)**
In the meeting/forum	60
Governmental document	33
Factory document	2
Other	5
n	84
How often?	**Khon Kaen (%)**
Regularly	24
Occasionally	53
Very rarely	21
Other	1
n	70
Have you ever tried to find information on wastewater or pollution prevention for yourself?	**Khon Kaen (%)**
Yes	73
No	28
n	91

Table 15 Residents of Khon Kaen's opinions on information about wastewater and/or industrial wastewater management (continued)

Where did you find that information?	Khon Kaen (%)
Leader	38
Neighbour	21
TV	14
Radio	5
Newspaper	9
Library	1
Website/social	9
Leaflet	3
Other	1
n	68
How often?	**Khon Kaen (%)**
Regularly	25
Occasionally	66
Very rarely	10
Other	-
n	64

Public participation in environmental management

This section will consider how the public are involved in the environmental management.

Table 16 shows that more than half of the respondents (62%) have been invited to at least one public meeting about environmental management and almost all of those respondents (91%) decided to attend that public meeting because they wanted to know sources and how to manage pollutions. The purposes of several meetings were wastewater, industrial wastewater, dust, wastes and hazardous wastes, and air pollution. All of those respondents who had attended the meeting thought that the public meeting was useful and 80% of those respondents said that they had an opportunity to express their opinion at the meeting. The respondents who had attended the meeting said that there were some responses to their opinions by solving their problems while other respondents said that some opinions were ignored. Almost half of the meetings (49%) were set up by the village leaders and the respondents also knew about the public meeting from the village leaders. Most respondents expressed the opinion that they will attend future meeting and they thought that a public meeting about industrial wastewater would be useful in the future. Thus, the residents think that public participation may help in environmental management. Besides, every stakeholder should participate in environmental management.

The data shows that locals in Khon Kaen have an interest in the environment and want to be a part of public meetings relating to environmental management and also industrial wastewater. Besides, village leaders play a main role same as previous parts by setting up the meeting. Table 19 shows that people who were invited to any public meetings relating to environmental management are more likely to have opportunities to express their opinion at the meeting than other.

Table 16 Residents of Khon Kaen's opinions on public meeting in environmental management

Have you been invited to any public meetings relating to environmental management?	**Khon Kaen (%)**
Yes	62
No	38
n	95
Who set up that meeting?	**Khon Kaen (%)**
Government	27
NGOs	1
Leader	49
Factory	17
Other	5
n	63
How did you know about that meeting?	**Khon Kaen (%)**
Leader	29
Neighbour	17
TV	13
Radio	2
Newspaper	7
Library	-
Website/social	2
Leaflet	7
Governmental document	15
Factory document	6
Other	2
n	65

Table 16 Residents of Khon Kaen's opinions on public meeting in environmental management (continued)

Did you decide to attend that meeting?	Khon Kaen (%)
Yes	91
No	9
n	65
Did you think that the public meeting was useful?	**Khon Kaen (%)**
Yes	100
No	-
n	67
Did you have an opportunity express your opinion at the meeting?	**Khon Kaen (%)**
Yes	80
No	20
n	61
If you have not attended a meeting, do you think it might be of interest in the future?	**Khon Kaen (%)**
Yes	97
No	3
n	93
If you have not heard of such a meeting, do you think a public meeting on industrial wastewater would be useful?	**Khon Kaen (%)**
Yes	81
No	19
n	93

7.1.3 Relationships between demographic groups and public perception/awareness/ participation in wastewater and/or industrial wastewater management

This section will clarify how demographic categories relate to public perception/public awareness/public participation on wastewater and/or industrial wastewater management. The chi-square test was used to test relationship between variables.

More than half of all respondents (56%) were female (Table 17) which was consistent with census survey in 2015 that there were more females than males in the area (Department of

Provincial Administration, 2018). Table 18 shows that although there is no difference between males and females in frequency of going close to the river, males are significantly more likely to see pollution than females. This is maybe because of males have more observant habits than females or maybe females are busy keeping an eye on children. Table 20 shows that females are more likely to have children than males. However, females think that water pollution affects them and their family more than males. Females are more likely to show interest in attending a future meeting than males, which may reflect the greater likelihood of being concerned about the potential effects of pollution. This is because females are more likely to have less education and to live in the area more than 10 years than males (Table 20). There is no statistical association between having been to a meeting and interest in a future meeting for either females or males. This suggests that females are more aware of the effects of water pollution than males.

The largest age group of respondents in Khon Kaen was 51-60 years old at 28% (Table 17). However, there is no statistical association between age and public perception/awareness/ participation in wastewater and/or industrial wastewater management. This can conclude that there is no relationship between age and awareness/participation in wastewater and/or industrial wastewater management. Table 20 shows that people who are 41-60 years old are more likely to married, have children, have less education, work as farm owner, farmer worker, casual worker or labourer, and live in the area more than 10 years than people who are younger and older.

Table 17 shows that most of the respondents were married (68%). Table 18 shows that married people see more signs of water pollution than single, divorced or widowed people and married people are also more likely than others to think that a public meeting on industrial wastewater would be useful. However, people who are single, divorced or widowed were more likely to say that they had opportunities to express their opinions at a meeting if they actually attended one. Table 20 indicated that married people are more likely to have children, work as farm owner, farmer worker, casual worker or labourer, and live in the area more than 10 years than others.

More than three-quarter of respondents (80%) had children (1-7 children per family) (Table 17). Table below (Table 18) shows people who have children are more likely to see signs of pollution than those who have no children. People who have children have more opportunities to express their opinion at the meeting than those who have no children. This is maybe because people who have children are aware and concerned about how water pollution may harm their children. So, they feel that they have to express their opinion in the meeting to cope with the effect of environmental problems. People who have children are more likely think that companies have high effectiveness in disposing their wastewater to an environment than have no children. However, people who have children are more likely than other to have less education and live in the area more than 10 years (Table 20).

The highest education level was secondary school (39%; see Table 17). People with less than secondary school-level education are more likely than others with more education to see sources of the pollution themselves (Table 18) and are also more likely to have been told by someone what the source of pollution was. People who have less education were more likely to feel that they had opportunities to express their opinion at the meeting than those with higher education. Table 20 indicated that people who have less education are more likely than other to work as farm owner, farmer worker, casual worker or labourer and have income less than 15,000 baht per month. Occupation

Respondents worked as casual worker or labourer at 32%, others (merchant and housewife) at 30%, government officials and officers at 19%, and farm owners and farmers at 16% (Table 17). Table 18 shows that people who work as government officers and office workers felt that they have more opportunities to express their opinion at the meeting than others. This is maybe because government officers and also office workers have more practice speaking in meetings than other occupations. Table 20 shows that people who have less education are more likely to work as farm owner, farmer worker, casual worker or labourer than people who have a degree.

Table 17 shows that the modal respondents' income is 5,001-10,000 baht per month (approximately £100-200 per month) at 40%. Table 18 shows that people who have lower income are more likely to go to the river and they are also more likely than higher income respondents to think that companies are disposing of their wastewater to the environment in a problematic manner. Lower income people are also more likely than others to think that the companies are the main source of water pollution. Higher income people are more likely to receive information on industrial wastewater, water pollution, or pollution prevention from a government agency and/or a company than lower income groups. People who have higher income are more likely to try to find information on wastewater or pollution prevention than lower income as well.

Table 17 shows that most of the respondents (84%) had lived in Khon Kaen more than 10 years. Table below (Table 18) shows that people who have lived in the area for between 0 - 10 years are more likely than those who have been there longer to think that manner in which companies dispose of their wastewater to the environment may be problematic. This suggests that people who have lived in the area more than 10 years are familiar with their environment and do not think that are problems. There is no relationship between period of living with income and education (Table 20).

Table 17 Aggregate demographic information of respondents in Khon Kaen

Gender	**Khon Kaen (%)**
Male	39
Female	56
Prefer not to answer	5
n	95
Age	**Khon Kaen (%)**
18-21	-
22-30	7
31-40	17
41-50	21
51-60	28
60 up	27
n	92
Marital status	**Khon Kaen (%)**
Single	16
Married	68
Divorce	6
Widowed	11
n	90
Children	**Khon Kaen (%)**
Yes	80
No	20
n	94

Table 17 Aggregate demographic information of respondents in Khon Kaen (continued)

Education	**Khon Kaen (%)**
Primary school	29
Secondary school	39
Bachelor degree	25
Master degree	4
PhD degree	-
Other	3
n	94
Occupation	**Khon Kaen (%)**
Government officer	8
Office worker	11
Farm owner	8
Farmer worker	8
Casual worker or labourer	32
Student	-
Retired	3
Other	30
n	90
Income (units)	**Khon Kaen (%)**
Less than 5,000	16
5,001-10,000	40
10,001-15,000	15
15,001-20,000	14
20,001-25,000	6
25,001-30,000	1
30,001-35,000	4
More than 35,001	1
Other	3
n	80
Lived in the area	**Khon Kaen (%)**
Less than a year	-
1-5 years	2
6-10 years	14
More than 10 years	84
n	93

Table 18 Relationship between demography and awareness factor for responses from Khon Kaen residents.
'No' indicates that there is no statistically significant relationship between the demographic factor and responses to a given question. 'Weak' indicates a relationship significant at the 0.10-0.05 level, and moderate a relationship significant at the 0.05-0.01 level

Question	Gender	Age	Marital status	Having children	Highest education	Occupation	Income per month	Period of living
There are environmental problems near their home	No	No	No	No	No	No	No	No
Ever go to the river near their home	No	No	No	No	No	No	No	No
How far they live from the river	No	No	No	No	No	No	No	No
Frequency of they close enough to the river to see the water	No	No	No	No	No	No	Weak	No
Seen signs of water pollution	No	No	Moderate	No	No	No	No	No
Frequency of seeing signs of pollution	Weak	No	No	Moderate	No	No	No	No
Opinion on where water pollution came from	No	No	No	No	Weak	No	No	No
Opinion on water pollution affects them and their family	Moderate	No	No	No	No	No	No	No
Worrying about effect of water pollution	No	No	No	No	No	No	No	No
Telling anyone about that water pollution	No	No	No	No	No	No	No	No
Effective of companies in disposing their wastewater to an environment	No	No	No	Moderate	No	No	Moderate	Moderate
Government agency and/or company provided any information on industrial wastewater, water pollution, or pollution prevention	No	No	No	No	No	No	No	No
Frequency that they get that information	No	No	No	No	No	No	Moderate	No
Trying to find information on wastewater or pollution prevention by themselves	No	No	No	No	No	No	No	No
Frequency that they ever tried to find information on wastewater or pollution prevention	No	No	No	No	No	No	Weak	No
Inviting to any public meetings relating to environmental management	No	No	No	No	No	No	No	No
Deciding to attend that meeting	No	No	No	No	No	No	No	No
Opportunities to express their opinion at the meeting	No	No	Weak	Weak	Weak	Moderate	No	No
Opinion that they might be interesting to attend the meeting in the future	Weak	No	No	No	No	No	No	No
Opinion about a public meeting on industrial wastewater would be useful	No	No	Moderate	No	No	No	No	No

Table 19 Relationships between public perception/awareness/participation responses and industrial wastewater management responses from Khon Kaen residents

Question	Question	Relationship
Ever go to the river near their home	Seen signs of water pollution	No
	Opinion on where water pollution came from	No
	Opinion on water pollution affects them and their family	No
	Worrying about effect of water pollution	No
	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Seen signs of water pollution	Opinion on where water pollution came from	Strong
	Opinion on water pollution affects them and their family	No
	Worrying about effect of water pollution	No
	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	Moderate
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Frequency of seeing signs of pollution	Opinion on where water pollution came from	No
	Opinion on water pollution affects them and their family	No
	Worrying about effect of water pollution	No
	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	Weak
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
In their opinion on water pollution affects them and their family	Worrying about effect of water pollution	Moderate
	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Worrying about effect of water pollution	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	Weak
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Effectiveness of companies in disposing their wastewater to an environment	Government agency and/or company provided any information on industrial wastewater, water pollution, or pollution prevention	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Government agency and/or company provided any information on industrial wastewater, water pollution, or pollution prevention	Trying to find information on wastewater or pollution prevention by themselves	Strong
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Inviting to any public meetings relating to environmental management	Strong
	Opportunities to express their opinion at the meeting	No
	Opinion that they might be interesting to attend the meeting in the future	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Trying to find information on wastewater or pollution prevention by themselves	Inviting to any public meetings relating to environmental management	Strong
	Opportunities to express their opinion at the meeting	No
	Opinion that they might be interesting to attend the meeting in the future	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Inviting to any public meetings relating to environmental management	Opinion that they might be interesting to attend the meeting in the future	Strong
	Opinion about a public meeting on industrial wastewater would be useful	No

Table 20 Relationships between demography from Khon Kaen residents

Demography	Demography	Relationship
Gender	Age	No
	Marital status	No
	Children	Moderate
	Education	Moderate
	Occupation	No
	Income	No
	Period of living	Strong
Age	Marital status	Strong
	Children	Moderate
	Education	Weak
	Occupation	Strong
	Income	No
	Period of living	Strong
Marital status	Children	Strong
	Education	No
	Occupation	Moderate
	Income	No
	Period of living	Moderate
Children	Education	Moderate
	Occupation	No
	Income	No
	Period of living	Strong
Education	Occupation	Strong
	Income	Strong
	Period of living	No
Occupation	Income	Strong
	Period of living	No
Income	Period of living	No

7.2 Public engagement in Ayutthaya province

This section will examine engagement between the public and the factory regarding industrial wastewater and also environmental management in Ayutthaya province.

7.2.1 Company engagement with the public

Ayutthaya's brewery company and also its parent company undertake various actions to engage to the public. 'My company interests in public's comment by setting up comment box in the villages around the company and also have notice boards to educate people about the environment' (Interview with company representative, July/2015). The CSR officer added some information about public participation that the company also set a group of officers to listen to public's opinion by using the website to host a questionnaire to solicit public opinion twice a year.

However, the company did not have a regular plan for public participation because it has to ask for a budget from the parent company. The company has open house activities for government organisations or other companies to educate and learn from the company. For example, Japanese reporters and also Japanese investors came to visit and learn production and also management of the company in 2017 (there are many examples of government organisations or other companies, not named here to preserve the anonymity of the company). The company also said that they set up an exhibition on World Environment Day every year, and planted trees on important days in Thailand to educate people and also conserve the environment. The company has a plan to provide a collection point for local's community in the near future for buying and collecting recyclable household waste. In addition, the company used to donate money to the '5 provinces forest' foundation to help in forest conservation in 2013 (there are many examples, not named here to preserve the anonymity of the company). Besides, the company also supports researchers or universities by allowing students or staff to use them as a study for many different types of research (there are many examples on University sites, not named here to preserve the anonymity of the company).

The parent company's website shows many activities to support and help people in the country. For example, the parent company helps and supports the public by donating water, boats, disaster relief packages, and mobile health units. The parent company donated drinking water to locals Southern Thailand who suffered from flooding and also donated blankets to locals in winter season in 2017. Moreover, the parent company also supports religious ceremonies and other activities of the public or the community. In addition, sometimes the parent company supports the community where is in trouble such as helping with bridge construction or repairs. Besides, the parent company also helps and supports public and community via social activities, education, public health, art, and sport etc. For example, the parent company sets up football matches, builds medical centres, gives scholarships, and supports locals' products etc.

In summary, many activities of the Ayutthaya's company and their parent company indicate that they try to engage with the locals and people in the country. They also try to engage with other organisations in many ways to make their company transparent and build the image of their company indirectly. Thus, they try to do a lot to reach their mission of 'Making a relationship in every way between the company and stakeholders'.

7.2.2 Public engagement with the environment

This section will investigate how the public around the company in Ayutthaya province feel about the environment and are involved in environmental management by using data and information from the questionnaires.

Ayutthaya residents' opinion on environmental issues in Thailand

Most of the respondents in Ayutthaya (95%) were aware that there are environmental problems in Thailand with just under a third (32%) of the respondents identifying water as a main environmental Issue (Table 21). Nearly all of them (97%) thought that Thailand faces a water pollution problem in the rivers and half of respondents (51%) considered that factories are the main source of water pollution. More than three quarters of them (87%) agreed that it is very important to protect the environment. Almost half of respondents (49%) thought that the effectiveness of the Ministry of Natural Resources and Environment in enforcing the regulations were neutral and 57% of the respondents also thought that the effectiveness of company to implement environmental regulations is neutral. Almost half of the residents in Ayutthaya (7 of 15 persons) who commented in the open question (Is there anything else you wish to say relating to environmental management?) said that a government agency should cope with the environmental issues by themselves or someone reported, and that a government agency should be strict in enforcing laws and regulations in environmental management. This suggests that the locals in Ayutthaya are aware about environmental issues and they also think that there is water pollution in Thailand. They think that the effectiveness of the government and companies in environmental management should be better.

Table 21 Ayutthaya residents' opinion on environmental issues in Thailand

Do you think the environment in Thailand has any problems?	**Ayutthaya (%)**
Yes	95
No	5
n	100
What is your main concern in environmental issue?	**Ayutthaya (%)**
Air	24
Water	32
Litter	20
Land and soil	8
Forest	15
Other	0
n	100
Do you think rivers in Thailand have a problem with pollution?	**Ayutthaya (%)**
Yes	97
No	3
n	99
If you think there is a problem what are the main sources of water pollution?	**Ayutthaya (%)**
Agriculture	15
Household	21
Factory	51
Transportation	12
Other	1
n	95

Table 21 Ayutthaya residents' opinion on environmental issues in Thailand (continued)

Companies have responsibilities under environmental regulations. How effective do you think they are at implementing those regulations?	**Ayutthaya (%)**
1=Ineffective	13
2	10
3	49
4	19
5=Very effective	9
n	90
n	89
How important do you think it is to protect the environment?	**Ayutthaya (%)**
Not important	1
Low	6
Neutral	5
Somewhat	1
Very important	87
n	98

Ayutthaya residents' awareness of the environment around the area

Most of respondents (80 %) in Ayutthaya said that there are environmental problems near their home and half of them (53%) were neutral about the effectiveness of companies in disposing their wastewater to the environment (Table 22). Most of them (98%) had gone to the river near their home and 46% of them usually go to the river once a week; 48% said that the river is nearby and 23% of respondents also had come to the river because it was on the way to somewhere. This result is quite similar to Khon Kaen province because Ayutthaya also has many rivers. Most people regularly seeing a river had seen signs of water pollution (91%). Nearly a third (32%) had seen a water pollution once a month, but a few said that they saw water pollution every day. Almost half respondents (42%) thought that factory is the main source of water pollution while a few thoughts that the general public was one of causes of wastewater because they had seen this source of pollution themselves. They said that the water pollution they saw had a bad odour and black colour; they also observed dead fish in the polluted water. Most of respondents (80%) thought that water pollution affects them and their family because of the odour and also worried that a pathogen infection may affect their health. Consequently, they could not consume the water. More than three quarters of respondents (83%) worried that wastewater might affect their heath and aquaculture, and they were afraid that they would not have enough water to consume in the future. So, half of them (56%) had told someone about that wastewater in the river. 32 % chose to tell leaders and/or neighbours about wastewater they had seen. Some respondents were satisfied that the problems that they had complained about had been resolved; others considered that there was still a problem. Some residents of Ayutthaya (5 of 15 persons) commented in response to the open question (Is there anything else you wish to say relating to environmental management?) that no-one should dump any wastes in the rivers and a government agency should deepen the water by removing mud or sludge.

The survey indicates that locals in Ayutthaya are aware in the environmental problems and they are afraid that water pollution may affect them and their families. Table 27 shows that people who have seen any signs of water pollution are more likely to think the effectiveness of companies in disposing their wastewater to an environment is adequate than people who never seen any signs of water pollution. People who had seen any signs of pollution once a week are more likely to worry about effect of water pollution than others. People who had seen any signs of pollution once a week are more likely to think that effectiveness of companies in disposing their wastewater to an environment is adequate than others. People who think that water pollution affects them and their family are more likely to worry about effect of water pollution than others. People who think that water pollution affects them and their family are more likely to try to find information on wastewater or pollution prevention occasionally than others. People who think effectiveness of companies in disposing their wastewater to an environment is adequate are more likely to try to find information on wastewater or pollution prevention occasionally than others.

Table 22 Ayutthaya residents' awareness of the environment around the area

Do you think there are problems with the environment near your home?	Ayutthaya (%)
Yes	80
No	20
n	97
Do you ever go to the river near your home?	**Ayutthaya (%)**
Yes	98
No	2
n	97
How far do you live from the river?	**Ayutthaya (%)**
Next to my home	31
Nearby	47
Quite far away	18
So far away	4
n	95
Why do you come to the river?	**Ayutthaya (%)**
I live nearby	38
I work nearby	5
The river is on my way somewhere	23
For leisure	17
For fishing	12
Other	5
n	94
How often are you close enough to the river to see the water?	**Ayutthaya (%)**
Once a week	46
Once a month	22
Once a year	6
Other	26
n	94
Have you ever seen any signs of water pollution around the area where you live?	**Ayutthaya (%)**
Yes	91
No	9
n	98

Table 22 Ayutthaya residents' awareness of the environment around the area (continued)

How often?	**Ayutthaya (%)**
Once a week	27
Once a month	32
Once a year	18
Other	23
n	84
Where do think the pollution came from?	**Ayutthaya (%)**
Sewer	38
Agriculture	16
Factory	42
Other	4
n	90
Why did you think the pollution come from that source?	**Ayutthaya (%)**
Saw by myself	84
Someone told me	11
Other	5
n	88
Did that water pollution affect you and your family and how?	**Ayutthaya (%)**
Yes	80
No	20
n	86
Did you worry about effect of water pollution and how?	**Ayutthaya (%)**
Yes	83
No	17
n	83
Did you tell anyone about the water pollution?	**Ayutthaya (%)**
Yes	56
No	44
n	86
Who did you tell?	**Ayutthaya (%)**
Leader	32
Neighbour	32
Government	10
Media	15
Other	10
n	59

Table 22 Ayutthaya residents' awareness of the environment around the area (continued)

How effective to you think companies in your area are in disposing their wastewater in an environmentally sound manner?	**Ayutthaya (%)**
1=Ineffective	7
2	15
3	53
4	18
5=Very effective	8
n	76

Ayutthaya residents' opinion on any information about wastewater and/or industrial wastewater management from a government agency and/or a company

Nearly three quarters of the respondents in Ayutthaya (74 %) indicated that a government agency and/or a company had occasionally provided information on industrial wastewater, water pollution, or pollution prevention from the meeting and/or forum at 38% (Table 23). More than half of them (63 %) had found information on wastewater or pollution prevention for themselves. 27 % said they occasionally find information from websites and/or social media. The residents think that a government agency should encourage people to be aware about environmental management and that government agencies should provide the public with important information.

The data shows that people in Ayutthaya are interested in industrial wastewater, water pollution, and/or pollution prevention. They think that government agencies should give more information. People who were provided any information on industrial wastewater, water pollution, or pollution prevention by government agency and/or company are more likely to try to find information on wastewater or pollution prevention by themselves than others. People who are provided any information on industrial wastewater, water pollution, or pollution prevention by a government agency and/or company are more likely to invite to any public meetings relating to environmental management than others. Those who were provided with any information on industrial wastewater, water pollution, or pollution prevention by a government agency and/or company are more likely to think that a public meeting on industrial wastewater would be useful. People who have ever tried to find information on wastewater or pollution prevention by themselves are more likely to invite to any public meetings relating to environmental management than others. Respondents who ever try to find information on wastewater or pollution prevention by themselves are more likely to think that a public meeting on industrial wastewater would be useful than others (Table 27).

Table 23 Ayutthaya residents' opinion on any information about wastewater and/or industrial wastewater management from a government agency and/or a company

Has a government agency or a company provided you with any information on industrial wastewater, water pollution, or pollution prevention?	**Ayutthaya (%)**
Yes	74
No	26
n	84
How did you get that information?	**Ayutthaya (%)**
In the meeting/forum	38
Governmental document	27
Factory document	19
Other	17
n	64
How often?	**Ayutthaya (%)**
Regularly	10
Occasionally	59
Very rarely	31
Other	-
n	61
Have you ever tried to find information on wastewater or pollution prevention for yourself?	**Ayutthaya (%)**
Yes	62
No	38
n	84

Table 23 Ayutthaya residents' opinion on any information about wastewater and/or industrial wastewater management from a government agency and/or a company (continued)

Where did you find that information?	Ayutthaya (%)
Leader	18
Neighbour	15
TV	24
Radio	1
Newspaper	11
Library	-
Website/social	27
Leaflet	4
Other	-
n	74
How often?	**Ayutthaya (%)**
Regularly	12
Occasionally	63
Very rarely	26
Other	-
n	51

Ayutthaya residents' participation in environmental management

This section considers whether respondents in Ayutthaya have ever taken part in a public event relating to environmental management organised by a company or government agency.

Half of respondents (52%) had been invited to a public meeting relating to environmental management, of which 42% of them said that the meetings were set up by leaders and 20% of them knew about that meeting from both leaders and TV (Table 24). The subjects of the meeting were litter and water hyacinth (which sometimes clogs the river), water pollution, and wastes etc. Nearly three quarters of respondents (70%) decided to attend a meeting because they wanted to know the causes and how to solve the problems. Most of them (88%) thought that the meeting was useful because they could use knowledge to adapt in their daily-lives such as how to manage household wastewater etc. (e.g., based on observations, when using the river to dispose of water from the kitchen or for laundering clothes) and they had more awareness of the environment. Half of the respondents (51%) had an opportunity to express their opinion at the meeting and a few thoughts there was some response. Almost all respondents (89%) thought it might be of interest to attend a meeting in the future and 86% of them thought a public meeting on industrial wastewater would be useful. The residents think that a government agency should have more meetings to educate people about environmental management every year.

This suggests that the respondents are interested in environmental management and village leaders have the main role in setting up the meeting as in Khon Kaen. The respondents seem to regard public meetings as a useful tool in public information and more specifically environmental management. Table 27 pointed out that people who were invited to any public meetings relating to environmental management are more likely to think that a public meeting on industrial wastewater would be useful than others.

Table 24 Ayutthaya residents' participation in environmental management

Have you been invited to any public meetings relating to environmental management?	**Ayutthaya (%)**
Yes	52
No	48
n	86
Who set up that meeting?	**Ayutthaya (%)**
Government	28
NGOs	5
Leader	42
Factory	19
Other	7
n	43
How did you know about that meeting?	**Ayutthaya (%)**
Leader	20
Neighbour	16
TV	20
Radio	3
Newspaper	12
Library	-
Website/social	10
Leaflet	4
Governmental document	7
Factory document	4
Other	3
n	69

Table 24 Ayutthaya residents' participation in environmental management (continued)

Did you decide to attend that meeting?	Ayutthaya (%)
Yes	70
No	30
n	43
Did you think that the public meeting was useful?	**Ayutthaya (%)**
Yes	88
No	12
n	43
Did you have an opportunity express your opinion at the meeting?	**Ayutthaya (%)**
Yes	51
No	49
n	37
If you have not attended a meeting, do you think it might be of interest in the future?	**Ayutthaya (%)**
Yes	80
No	11
n	72
If you have not heard of such a meeting, do you think a public meeting on industrial wastewater would be useful?	**Ayutthaya (%)**
Yes	86
No	14
n	72

7.2.3 Relationships between demographic groups and public perception/ awareness/participation in wastewater and/or industrial wastewater management

This section will clarify how demography relates to public perception/public awareness/public participation on wastewater and/or industrial wastewater management in Ayutthaya province.

Table 25 shows that half of respondents are male (54%), notwithstanding that the census survey in 2017 indicated that the province has more females than males (almost 30,000 more, 3.67% of the population) (Department of Provincial Administration, 2018). Although male respondents are more likely to say that they live near the river than female, the female respondents go to the river more than the male ones. Possibly as a consequence, females saw more sign of pollution than males and also were more likely to see the source of water pollution themselves, which is the opposite of findings from Khon Kaen. Females are more likely to think that a public meeting on industrial wastewater would be useful than males. This suggests that females in Ayutthaya are the more observant (in contrast to the other case study area) and also think the meeting will help them to understand and learn about industrial wastewater more than males. However, males are more likely to try to find information on wastewater or pollution prevention by themselves and are also more likely to say that they were invited to public meetings relating to environmental management than females (Table 26). This may be because men are usually the family member to attend a meeting; the invites are not specifically addressed to one person. Table 28 shows that males are more likely to have children, to have less education, and to be a government official and office worker than females.

The modal age group of the respondents was 31-40 years old at 28% (Table 25). There is no statistically significant association between age and other variables. Therefore, there was no apparent relationship between age and awareness/participation in wastewater and/or industrial wastewater management (Table 26). However, people who are 22-40 years old are more likely to be single than others. People who are 41-60 years old are more likely to have children than other. People who are 22-40 years old are more likely to have a degree than other. People who are 22-40 years old are more likely to have income less than 15,000 baht per month than other. People who are 22-40 years old are more likely to live in the area more than 10 years than other (Table 28).

Marital status: table 25 shows that almost half of respondents (49%) were single. Table below (Table 25) shows that married people are more likely to live near the river than others while divorced and widowed people are more likely to worry about the effect of water pollution than others. Singles are more likely to think that the public meeting was useful and singles also think that a public meeting on industrial wastewater would be useful more than others. This may be because singles have more interest to attend a meeting or to say that they will attend a meeting on industrial wastewater in the future. However, single people made up nearly half the respondents, and likely worked for the company; the company encourages its employees to attend the meetings. Table 28 indicated that people who are married are more likely to have children than others while singles are more likely to have no children. Married people are more likely to work as government official and office worker and to live in the area more than 10 years than others.

Table 25 shows that 57% of respondents have children (1-3 children per family) but there is no statistically significant association between having children or not and other variables. This suggests that there is no relationship between having children and awareness/participation in wastewater and/or industrial wastewater, despite the fact that married people were responding differently to some questions than single people (the questionnaire indicates that single people are likely to have children). Besides, people who have children are more likely to have less education and to be a government official and office worker than others. People who have children are more likely to live in the area more than 10 years than other (Table 28).

The highest education level of the respondents was Bachelor degree at 39% (Table 25). Table 26 shows that people who do not have degrees are more likely to live next to the river than people who have degrees but people who have a degree have seen where source of water pollution came from by themselves more often than those with a lower level of education. Although people who have less education are more likely to have received information on industrial wastewater, water pollution, or pollution prevention from government agency and/or company than people with degrees, the latter are more likely to try to find information on wastewater or pollution prevention themselves. People who do not have degrees were more likely to have noticed an invitation to public meetings relating to environmental management, while people who have higher education are more likely to think that a public meeting on industrial wastewater would be useful. This suggests that a government agency and/or a company focuses on educating people in lower education level, whilst higher education level can easily access and also know where to find sources of information than lower education level. Table 28 pointed out that people who have less education are more likely to have income less than 15,000 baht per month than other. People who have less education are more likely to have lived in the area for more than 10 years than other people.

Nearly three quarters of respondents (71%) work in an office (Table 25). Table 26 shows that office workers and government employees think that water pollution affects them and their family and also worry about effect of water pollution more than others. However, farmers and/or factory workers are more likely to think that companies are disposing of their wastewater in an environmentally sound way. Office workers and government employees are aware of and concerned about water pollution and think that companies have to dispose of their wastewater in more environmentally sound manner.

Average incomes per month in this area are 10,001-15,000 baht (approximately £200-300) (Table 25). Table 26 shows that people who have lower income are more likely to live near the river than higher income people, while higher income people are more likely to visit the water than lower income. This can assume that lower income who have lived near the river, they may feel familiar with the river and less likely to pay close attention. People who have higher incomes feel that they have more opportunities to express their opinion at meetings than those with lower incomes. Higher income people are more likely to say that they might attend a meeting in the future and are also more likely to think that a public meeting on industrial wastewater would be useful.

More than half of respondents in Ayutthaya (69%) have lived in the area for more than 10 years (Table 25). Table 26 shows that people who have lived in the area for more than 10 years are more likely to go to the river near their home than people who have lived between 0 – 10 years. People who have lived in the area more than 10 years had received more information on industrial wastewater, water pollution, or pollution prevention from a government agency and/or a company and were also more likely to have been invited to any public meetings relating to environmental management than those who have lived there between 0 – 10 years. However, people who have lived there between 0 – 10 years are more likely think that a public meeting on industrial wastewater would be useful than people who have lived more than 10 years. This can assume that people who have lived in the area more than 10 years may be familiar with a government agency and/or a company. So, they had received information and been invited to public meetings from a government agency and/or a company.

Table 25 Demography of respondents in Ayutthaya

Gender	Ayutthaya (%)
Male	54
Female	42
Prefer not to answer	4
n	81
Age	**Ayutthaya (%)**
18-21	10
22-30	26
31-40	28
41-50	26
51-60	10
60 up	-
n	81
Marital status	**Ayutthaya (%)**
Single	49
Married	38
Divorce	6
Widowed	8
n	80
Children	**Ayutthaya (%)**
Yes	57
No	43
n	65
Education	**Ayutthaya (%)**
Primary school	5
Secondary school	35
Bachelor degree	39
Master degree	7
PhD degree	-
Other	14
n	74
Occupation	**Ayutthaya (%)**
Government officer	3
Office worker	71
Farm owner	1
Farmer worker	-
Casual worker or labourer	15
Student	6
Retired	-
Other	4
n	79

Table 25 Demography of respondents in Ayutthaya (continued)

Income	**Ayutthaya (%)**
Less than 5,000	7
5,001-10,000	18
10,001-15,000	42
15,001-20,000	18
20,001-25,000	8
25,001-30,000	1
30,001-35,000	4
More than 35,001	-
Other	3
n	77
Lived in the area	**Ayutthaya (%)**
Less than a year	3
1-5 years	16
6-10 years	13
More than 10 years	69
n	77

Table 26 Relationship between demography and awareness factor for responses from Ayutthaya residents.

'No' indicates that there is no statistically significant relationship between the demographic factor and responses to a given question. 'Weak' indicates a relationship significant at the 0.10-0.05 level, and moderate a relationship significant at the 0.05-0.01 level

Question	Gender	Age	Marital status	Having children	Highest education	Occupation	Income per month	Period of living
There are environmental problems near their home	No	No	No	No	No	No	No	No
Ever go to the river near their home	No	No	No	No	No	No	No	Weak
How far they live from the river	Weak	No	Moderate	No	Moderate	No	Moderate	No
Frequency of they close enough to the river to see the water	Moderate	No	No	No	No	No	Weak	No
Seen signs of water pollution	No	No	No	No	No	No	No	No
Frequency of seeing signs of pollution	Strong	No	No	No	No	No	No	No
Opinion on where water pollution came from	Moderate	No	No	No	Moderate	No	No	No
Opinion on water pollution affects them and their family	No	No	No	No	No	Moderate	No	No
Worrying about effect of water pollution	No	No	Weak	No	No	Moderate	No	No
Telling anyone about that water pollution	No	No	No	No	No	No	No	No
Effective of companies in disposing their wastewater to an environment	No	No	No	No	No	Moderate	No	No
Government agency and/or company provided any information on industrial wastewater, water pollution, or pollution prevention	No	No	No	No	Strong	No	No	Moderate
Frequency that they get that information	No	No	No	No	No	No	No	No
Trying to find information on wastewater or pollution prevention by themselves	Weak	No	No	No	No	No	No	No
Frequency that they ever tried to find information on wastewater or pollution prevention	No	No	No	No	Weak	No	No	No
Inviting to any public meetings relating to environmental management	Strong	No	No	No	Moderate	No	No	Strong
Deciding to attend that meeting	No	No	No	No	No	No	No	No
Opinion that the public meeting was useful	No	No	Weak	No	No	No	No	No
Opportunities to express their opinion at the meeting	No	No	No	No	No	No	Strong	No
Opinion that they might be interesting to attend the meeting in the future	No	No	No	No	No	No	Moderate	No
Opinion about a public meeting on industrial wastewater would be useful	Weak	No	Moderate	No	Strong	No	Moderate	Weak

Table 27 Relationships between each public perception/awareness/participation in wastewater and/or industrial wastewater management from Ayutthaya residents

Question	Question	Relationship
Ever go to the river near their home	Seen signs of water pollution	No
	Opinion on where water pollution came from	No
	Opinion on water pollution affects them and their family	No
	Worrying about effect of water pollution	No
	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Seen signs of water pollution	Opinion on water pollution affects them and their family	No
	Worrying about effect of water pollution	No
	Effective of companies in disposing their wastewater to an environment	Strong
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Frequency of seeing signs of pollution	Opinion on where water pollution came from	No
	Opinion on water pollution affects them and their family	No
	Worrying about effect of water pollution	Moderate
	Effective of companies in disposing their wastewater to an environment	Strong
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Opinion on water pollution affects them and their family	Worrying about effect of water pollution	Strong
	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	Strong
	Opinion about a public meeting on industrial wastewater would be useful	No
In their about effect of water pollution	Effective of companies in disposing their wastewater to an environment	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Opinion about a public meeting on industrial wastewater would be useful	No
Effectiveness of companies in disposing their wastewater to an environment	Government agency and/or company provided any information on industrial wastewater, water pollution, or pollution prevention	No
	Trying to find information on wastewater or pollution prevention by themselves	No
	Frequency that they ever tried to find information on wastewater or pollution prevention	Weak
	Opinion about a public meeting on industrial wastewater would be useful	No
Government agency and/or company provided any information on industrial wastewater, water pollution, or pollution prevention	Trying to find information on wastewater or pollution prevention by themselves	Strong
	Frequency that they ever tried to find information on wastewater or pollution prevention	No
	Inviting to any public meetings relating to environmental management	Strong
	Opportunities to express their opinion at the meeting	No
	Opinion that they might be interesting to attend the meeting in the future	No
	Opinion about a public meeting on industrial wastewater would be useful	Weak
Trying to find information on wastewater or pollution prevention by themselves	Inviting to any public meetings relating to environmental management	Strong
	Opportunities to express their opinion at the meeting	No
	Opinion that they might be interesting to attend the meeting in the future	No
	Opinion about a public meeting on industrial wastewater would be useful	Moderate
Inviting to any public meetings relating to environmental management	Opinion that they might be interesting to attend the meeting in the future	No
	Opinion about a public meeting on industrial wastewater would be useful	Strong

Table 28 Relationships between demography from Ayutthaya residents

Demography	Demography	Relationship
Gender	Age	No
	Marital status	No
	Children	Moderate
	Education	Strong
	Occupation	Moderate
	Income	No
	Period of living	No
Age	Marital status	Strong
	Children	Strong
	Education	Moderate
	Occupation	No
	Income	Weak
	Period of living	Weak
Marital status	Children	Strong
	Education	No
	Occupation	Moderate
	Income	No
	Period of living	Moderate
Children	Education	Moderate
	Occupation	Strong
	Income	No
	Period of living	Strong
Education	Occupation	No
	Income	Strong
	Period of living	Moderate
Occupation	Income	No
	Period of living	No
Income	Period of living	No

7.3 Comparison of public engagement between Khon Kaen and Ayutthaya provinces

This section discusses similarities and differences between respondents in Khon Kaen and Ayutthaya provinces in terms of public engagement with environmental management and industrial wastewater management.

There are statistically significantly differences between Khon Kaen and Ayutthaya in demographic variables and in the frequency that respondents see any signs of water pollution around the area where they live (Table 29). There are significant differences in the frequency that they ever tried to find information on wastewater or pollution prevention for themselves, age, marital status, highest level of education, income per month, and periods of living in the area.

The average age of respondents in Ayutthaya is lower than Khon Kaen. Most of respondents in Ayutthaya are single while those in Khon Kaen are mostly married. The highest education level and typical income of respondents in Ayutthaya is higher than Khon Kaen. This is probably because (more) of the respondents in Ayutthaya are office workers at the company. The respondents in Khon Kaen have typically lived in the area longer than those in Ayutthaya. The respondents in Khon Kaen have more likely to have seen any signs of water pollution than those from Ayutthaya. This is because of most of respondents in Khon Kaen are casual workers or labourers who are more likely to use water from the rivers. The respondents in Khon Kaen have tried to find information on wastewater or pollution prevention for themselves more than Ayutthaya, which may reflect the fact that they are more likely to have personally seen pollution. Respondents in both areas are sceptical about the ability of companies to control pollution; both sets of respondents see roles for government and industry in this regard. But neither group is entirely trusted by the public to carry out their responsibilities effectively.

Table 29 Comparison between local population views in Khon Kaen and Ayutthaya

Question	Test[1]/test statistic	p[2]	Significant difference?
Do you think the environment in Thailand has any problems?	F	1.000	No
Do you think rivers in Thailand have a problem with pollution?	F	1.000	No
How effective are companies at implementing environmental regulations?	M, 3952.500	0.239	No
How effective is the Ministry NRE at enforcing environmental regulations?	M, 3966.500	0.304	No
How important do you think it is to protect the environment?	M, 4674.000	0.897	No
Do you think there are problems with the environment near your home?	F	0.579	No
Have you ever seen any signs of water pollution around the area where you live?	F	0.563	No
How often have you seen signs of water pollution around the area where you live? (higher in Khon Kaen than Ayutthaya)	M, 2974.500	0.040*	Yes
Why did you think the pollution come from that source?	2x3 X^2, 2.481	0.648	No
Did that water pollution affect you and your family?	F	1.000	No
Did you worry about effect of water pollution?	F	1.000	No
Did you tell anyone about the water pollution?	1x1 X^2, 0.029	0.864	No
How effective are local companies at disposing of their wastewater safely?	M, 3271.500	0.799	No
Have you had information from a government agency or a company…?	F	0.540	No
How often did you get such information?	M, 1772.500	0.062	No
Have you ever tried to find information…?	2x2 X^2, 0.040	0.842	No
How often have you tried to find information…? (higher in Khon Kaen than Ayutthaya)	M, 1239.000	0.009**	Yes
Have you been invited to any public meetings…?	2x2 X^2, 0.545	0.461	No
Did you decide to attend that meeting?	F	1.000	No
Did you have an opportunity express your opinion at the meeting?	F	0.635	No
If you have not attended a meeting, do you think it might be of interest in the future?	F	0.326	No
If you have not heard of such a meeting, do you think a public meeting on industrial wastewater would be useful?	F	0.585	No
Demographics of respondents			
Gender	2x3 X^2, 3.617	0.460	No
How old are you? (average age higher in Khon Kaen than Ayutthaya)	M, 1478.500	0.000***	Yes
Marital status (residents more likely to be married in Khon Kaen than Ayutthaya)	2x4 X^2, 20.262	0.016*	Yes
Do you have any children?	F	0.489	No
Highest level of education (higher in Ayutthaya than Khon Kaen)	M, 2134.500	0.000***	Yes
Occupation	2x8 X^2, 24.962	0.727	No
Income per month (higher in Ayutthaya than Khon Kaen)	M, 2333.500	0.007**	Yes
How long have you lived in this area? (higher in in Khon Kaen than Ayutthaya)	M, 2959.000	0.008**	Yes

[1] F = Fisher's exact test, M = Mann-Whitney, X^2 = chi-squared test [2] (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

7.4 NGO engagement with a government agency and also the public in environmental management

This section will describe the roles of an NGO and how that NGO engages with both a government agency and also the public in environmental management. Although there are a lot of NGOs in Thailand, one NGO contacted during this research responded that most of them are not interested in industrial wastewater anymore. Therefore, I chose to interview a representative from one of the few which does still have an interest, Ecological Alert and Recovery-Thailand (EARTH).

7.4.1 Interests of EARTH

EARTH has roles concerned with addressing academic research, with supporting and helping any communities affected by pollution and hazardous substances, and with supporting social and environmental sustainability. EARTH's work is based on the public's right to know, public participation, public's access to justice, transparency and good governance, corporate accountability, and the polluter pays' principle. According to their website, EARTH collaborates with organisations at three levels: national, regional, and international. National organisations consist of LearnPRTR.net, Greenpeace Thailand, BIOTHAI, Thai-PAN, Thai Climate Justice Working Group, Child Safety Promotion and Injury Prevention Research Center (CSIP), ENLAWTHAI foundation, The Council of Work and Environment Related Patent's Network of Thailand (WEPT), Consumer Thai foundation, Ashoka: Innovators for the Public Foundation (Thailand), and Dawei Watch Thailand. Regional organisation consists of The Open Research Center for Minamata Studies, Greenpeace Southeast Asia, Mekong Watch, Dawei Development Association (DDA), SIPCOT Area Community Environmental Monitors (SACEM), International Campaign for Justice in Bhopal (ICJB), and Waste Not Asia. International organisation consists of International POPs Elimination Network (IPEN), Arnika, Oil Watch, The Climate Action Network (CAN), Global Community Monitor (GCM), Toxics Link, Global Alliance for Incinerator Alternatives/Global Anti-Incinerator Alliance (GAIA), International Campaign for Justice in Bhopal (ICJB), and The Open Research Center for Minamata Studies (Ecological Alert and Recovery – Thailand, 2017).

The Director of EARTH said that EARTH was first set up as a committee because of an explosion of chemicals at Khlong Toei pier in 1991, when it emerged that there was no organization in the country to cope with the resulting problems. Thailand was a developing country and trying to expand its industrial sector to developed country scale. Therefore, many chemical components were used in production and natural gas extracted from the Gulf of Thailand. The explosion at Khlong Toei pier indicated that Thailand did not have adequate policies for handling chemicals or dealing with emergencies; the authorities did not know types and quantities of the chemicals to which the public had been exposed. The committee was given permission by the government to gather information from stakeholders and followed a process to solve that problem. After that, EARTH changed from a committee and set up as an independent non-governmental organization in 2009 to deal with industrial pollution in Thailand. There were many activities that EARTH has taken up; public access to any information relating on toxic release, empowerment of public in environmental and health monitoring, educating on impacts of pollution on health, hazardous wastes problems, and climate justice. EARTH has many emphatic projects such as Khlong Dan wastewater treatment plant project, industrial pollution at Map Ta Phut industrial estate project, and Pollutant Release and Transfer Register (PRTR) etc.

7.4.2 EARTH engagement with the public in environmental management

EARTH has two procedures in environmental management which are first to define for themselves issues of concern and second to respond to the public's complaints and information supplied to EARTH. Moreover, there are many different groups that contact EARTH including Greenpeace, reporters, scholars, and also local people. EARTH has educated the public by distributing documents relating to EARTH's projects and EARTH also helped the public by being a specialist witness in a court. Director of EARTH said that 'EARTH is a small organization, so the public may not know about us. Moreover, EARTH has limited manpower, and also budget while there are many environmental problems which EARTH could not solve or help' (Interview with Director of EARTH, August/2015).

EARTH's website (Ecological Alert and Recovery – Thailand, 2017) also has documents and/or information in Thai and English to educate the public on environmental management and make them aware of the organisation's projects. Examples include The Battery Report: Result of a Preliminary survey on Managing Expired Cell Phone Batteries in Thailand, Industrial Pollution Impact and the PRTR Development in Thailand, Experiences & Understandings of the Human-Ecological Issues: Tasik Chini and Kiriwong Sites, Lead in New Enamel Household Paints in Thailand, Map Ta Phut Industrial Development: National Economic Success on Environmental Disaster and Health Damages, and Increasing Transparency Industrial Pollution Management through Citizen Science: A Report on Thailand's Waste Situation and Management. In some projects, EARTH also published leaflets or books distributing to the public and the government depended on their funding such as Lead in New Enamel Household Paints in Thailand and Increasing Transparency Industrial Pollution Management through Citizen Science: A Report on Thailand's Waste Situation and Management etc. Moreover, their website also has news and activities relating to the environment such as 'Fast-tracked EEC poses 'risks environment, social unrest'', 'Thai Environmentalists Seek Easing of Protest Restrictions', and 'Govt failing on environment, efforts to curb pollution: report' etc.

The Director of EARTH indicated that public participation is supported by law and/or regulation but that it is not easy to put it into practice. The Director of EARTH thought that public participation should include public awareness, public hearings, and consulting the public. In some cases, the public also wanted to be a part of an EIA study. However, Director of EARTH believes in public participation in environmental management because protestors could help a government to inspect and improve the environment. Some projects had to be cancelled because they impacted to communities and also the environment, and others had to rethink about the environment and also well-being of the locals. Thus, the Director of EARTH thought that the public or locals have power in environmental management and can make the government have awareness in doing any projects of how they could affect any communities or the environment.

In addition, Director of EARTH indicated that main issue in Thailand is there is not enough information for public access. For instance, there is no publically accessible information on how many factories there are, what they produce, where they are located, what chemicals are stored onsite, and what wastes are released to the environment etc. According to the interview with

EARTH, most of the public in Thailand are only interested in things that they see as significant to their own future. The interviewee thought that if there were more interest, then some of the current pollution problems could be addressed.

EARTH is also concerned about wastewater or water pollution. Although, EARTH has basic instruments to test water quality such as pH, and Electric Conductivity etc., for other parameters such as metals EARTH has to send samples to be tested at laboratories in Thailand. Director of EARTH pointed out that the petrochemical industry, gas separation plant, oil refinery, paper industry, and small and medium-sized enterprises (SMEs) are main source of wastewater or water pollution because wastewater treatment plants cannot remove metals. 'Corruption in Thailand also is a severe problem in wastewater management and found that there is only 10% of wastewater treatment plants in Thailand that can be used to treat wastewater' said by Director of EARTH (interview with Director, August/2015). Although Thailand has laws and regulations about public participation, they are still not used in practice, and corruption is still a problem. Construction of many treatment plants have been started but not finished to an adequate standard,

The Director of EARTH mentioned that they used to receive complaints from locals in the past about wastewater from some breweries. The locals suffered from the wastewater which affected their farmlands. However, EARTH suggested that the locals complain to Department of Industrial Works instead because EARTH did not have enough manpower and also instruments to inspect that problem. After that the brewery has improved their wastewater treatment technology and found that they don't have complaints anymore.

She also commented on the corporate social responsibility (CSR) of the company. She said that CSR could not help in industrial wastewater and wastes because CSR is only a method to change the image of the company. She thought that company CSR is not relevant to waste management and/or clean technology. The Director of EARTH indicated that a good relationship between company and public may affect to environmental management because public would take side with the company.

This shows that EARTH takes action on the environment especially in chemicals, toxins or wastes, and also believes in the public's power in environmental management. They thought that protests or public movements should make a government or a company aware in environmental management and also could delay or cancel any projects that impact on the environment and public well-being. However, EARTH did not trust the company in CSR campaigns because they thought that it was just a method to shape their image and also improve the relationship between the company and the public. EARTH thinks that public participation in Thailand still remains limited. Even though the government tries to push public participation in many ways, it is still not entirely public participation.

7.4.3 EARTH engagement with a government agency in environmental management

EARTH sees itself as opposing government agencies but when they have set up a public meeting, they have invited all stakeholders including government agencies. Conversely, when a government agency set up a public meeting, they have not invited NGOs. 'That is a government agency did not want us to involve with but locals want us to be a counselor' (Interview with Director of EARTH, August/2015).

The Director of EARTH stated that other countries, for example USA, Japan, and EU, specify water, air, and wastes limits parameters for more than 800, 300, and 70 parameters, respectively. According to the Director of EARTH's interview (August/2015) Laws and regulations in Thailand still do not control or manage the environment and main point of laws and regulations is only a management at the end of pipe. Moreover, laws and regulations specified water quality parameters for less than 25 characteristics (confirmed by analysis of the policy), while industrial waste water can contain more than 100 different metals and chemicals. The Toxic Release Inventory (TRI) regulation in the USA requires that every factory has to report types and quantity of chemicals released from the factory, while Thailand has no equivalent law. Moreover, countries in Europe which are member of OECD also have laws and/or regulations in each country to control wastes from the factory.

Thai laws and regulation specified only mean of concentration of each parameter that the factory released but did not mention quantity of each chemical per year. While in USA, Japan, or Europe who could declare how many types and how much quantities of chemicals in their wastewater. So, international governments could plan environmental management or find a better technology to treat their wastes and also warn the factory to reduce toxins or chemicals. 'In my opinion, I have worked about the environment for many years, I confirmed that Thai laws and regulations could not manage or control the environment' (Interview with Director of EARTH, August/2015). In addition, Thailand is still in the process of drafting a Polluter release and transfer register (PRTR) Act to follow types and quantities of toxins and chemicals in the rivers to help develop better environmental management plans rather than planning without enough data and quality of information. There is cooperation between EARTH and a government agency which is a main organization in promulgating an Act. Although, EARTH wanted PRTR to be an ACT, a government agency wanted it just to be a ministerial regulation in an old Act. EARTH thought that a ministerial regulation could not control and enforce factory behaviour, so EARTH tried to push PRTR to be an Act. In addition, EARTH is still trying to reform some old laws and/or regulation about Environmental Impact Assessment (EIA) and Environmental Health Impact Assessment (EHIA). Polluter pays principle (PPP) in Thailand is still not enforced by laws and/or regulations (as indicated in Chapter Five).

The Director of EARTH disagreed with a zero-discharge idea proposed by the government and think that it will be a cause of wastewater or water pollution indirectly. She said that 'A zero discharge idea has both pros and cons depending on an efficiency of wastewater treatment system to treat their wastewater. This is because treated wastewater could accumulate with groundwater and affect to agricultural areas nearby, if the factory used that water within their area. At this point, there is no one can inspect and control about this problem'.

A government agency has tried to cooperate with people in environmental management more than in the past by grouping locals to be volunteers in inspecting their communities. 'If a government is serious in solving environmental problems, the environmental problems would be reduced and the public would believe in a government's manner' (Interview with Director of EARTH, August/2015) said by Director of EARTH.

Although, EARTH and the government see themselves has occupying opposite sides in the overview of the environment, they have to cooperate and exchange their ideas in some cases. As can be seen from PRTR principle that the government agreed with EARTH but it is still in an argument to promulgate as a ministerial regulation in an old Act or to be a new Act. Moreover, EARTH or other NGOs may be a voice of the public to oppose or make the government to rethink about any projects that effect to the environment and also the public.

7.5 Conclusions

The respondents in both provinces are aware about environmental problems in Thailand and they also think that Thailand faces water pollution. Factories are the main source of water pollution in their opinion, while both companies state that their factories have the best technologies in wastewater management and their water qualities meet the standards. In addition, from the interviews with government officials, I found that both companies are the best companies in wastewater management. However, the respondents in both provinces have neutral views of the role of a government agency in enforcing laws and regulations and the behaviour of the company in implementing laws and regulations. The residents commented that a government agency should be strict in enforcing laws and regulations and the company also has to follow laws and regulations strictly. Although village leaders in Khon Kaen seem to have more influence than in Ayutthaya, village leaders take a main role in participation and awareness of the public in both areas.

The respondents in both areas are interested and want to participate in the meetings relating to environmental management. They also think that public meetings on industrial wastewater would be useful. The respondents in both areas had received and had tried to find information on industrial wastewater, water pollution, or pollution prevention. Both companies have open houses which locals or people can attend to learn how they manage their wastewater. Moreover, the companies also have many activities to interact with the public. In addition, Khon Kaen's company has distributed leaflets and/or journals to educate locals in many topics. A government agency also communicates with locals through the village leaders in the areas. The government agency's website also has much information relating to laws and regulations, and locals can inform the government agency about their troubles in their website. The NGO interviewed disagrees with CSR of the companies and thinks that public participation in Thailand is limited for mega projects or new projects. However, the NGO believes that public participation can have an effect on a government agency in environmental management.

Chapter Eight: Discussion

This chapter analyses the main themes to emerge from the research. Relating to policy, ecological modernisation approach, technology, industrial symbiosis, and relationships between different stakeholders in industrial wastewater management in Thailand. The following headings will show how Thailand manages the industrial wastewater and how ecological modernisation appears in Thailand with respect to industrial wastewater management.

8.1 Technology used industrial wastewater management

The study showed that large companies in Thailand use international and up to date technologies in wastewater management to meet the required national (and international) standards (Chapter Three: Industrial wastewater and Chapter Six: Wastewater management). Their main objectives are to treat their wastewater, to meet the standards, and to protect the environment. There are some similarities but also differences between the ways to treat their wastewater. Wastewater treatment in Khon Kaen company includes treatments drawing on biological processes. They utilise wetland and algae-based systems to treat their wastewater after initial processing by machines. They are able to adopt the biological treatments because they have land available. On the other hand, Ayutthaya company uses only machines to treat their wastewater, but the company said that their machines are a newer technology which give a better water quality than those at Khon Kaen. So, there has indeed been a role for technology, driven by, or at least reflecting the standards.

The breweries have tried to use clean technology and also adapted other methods such as wetland etc. to treat their wastewater. Moreover, their technologies also give biogas which is used instead of fuel and reduce costs for the company. In addition, recycling and reuse of water in the company reduce cost of water usage. So, 3Rs policy and also water quality regulations force and push company to find the best technology to protect the environment and also cost saving. As a basic principle of ecological modernisation that supporting financial advantage from business and responding to environmental problems through ideas of profitable enterprise (Harvey, 1996; Weale, 1992). The payback period of the technologies adopted is not known.

That is, whilst the cost savings/income might be appreciated, they may not have been a significant element of the decision to adopt the technologies.

Both case studies (i.e., the companies in Khon Kaen and Ayutthaya) adopt international technologies to treat their wastes to meet the standards. Ayutthaya company differs from Khon Kaen company because Ayutthaya had adopted all technologies from Denmark since the beginning of establishment of the factory and has adapted some technologies to meet the standards after the expiration of the contract from Danish company. The adoption of state-of-the-art technologies (whether high or low tech) may be seen as the large companies 'leap-frogging' intermediate options (Zhang *et al*., 2007). However, as discussed above the smaller companies have been left behind in technology and compliance so the picture is not so much one of successful environmental protection in an industrialising country as the environmental pressures of international markets.

As two case studies are located in two provinces (Khon Kaen and Ayutthaya) which are in different region in Thailand. Khon Kaen province is in the North East while Ayutthaya province is in the central of Thailand. Khon Kaen is in a rural area While Ayutthaya is nearby the capital city (Bangkok). Thus, Khon Kaen has more land available which they could adopted plant-based system to treat their wastewater. Moreover, Khon Kaen used to face with the water problem in rainy season. Khon Kaen have tried to find many methods to deal with that problem. While Ayutthaya company has limited land, so they could not expand their area. Thus, Ayutthaya uses only machine to treat their wastewater.

8.2 Assessment of industrial wastewater policy in Thailand as ecological modernisation

Industrial wastewater regulations in Thailand can be characterised as ecological modernisation, but there are noteworthy deviations from theory-driven expectations. New laws and regulations mean that the companies have to treat or manage their wastes in order to meet the standards before discharging wastewater to the environment. So, the company has to find new and proper technology to treat their wastes in order to comply with the policies. This result confirms that policies can create a market for new technology (Roediger-Schluga, 2004). In this regard, Bakker *et al*. (2012) and Quitzao *et al*. (2012) stated that public policy can incentivize, or more directly promote technological innovation. However, as in the case of Brazil (Milanez and Bührs, 2008), the technology has been purchased from abroad, rather than developed in Thailand. Of course, it is a different proposition for a brewing company to develop pollution abatement technology rather than brewing technology. Further governmental support may be required to promote the research and development needed to produce pollution abatement technology and, furthermore, to link those needing the equipment with those developing the ability to produce it.

8.2.1 Regulatory enforcement

Although the case study companies have complied with the regulations, it is difficult to some old or small companies to meet the costs of finding and replacing new technology. There are still significant issues of water pollution in Thailand (Wongburi and Park, 2018). This study indicates that the public associate that pollution at least in part of industrial wastewater, and a government interviewee expressed the opinion that smaller companies are not compliant. The limited manpower of the government to inspect wastewater from the companies means some companies or factories manage to emit wastewater that does not meet standards without penalty. The problems of implementation support the idea that ecological modernisation needs certain standards of institutional capacity to be effective (Milanez and Bührs, 2008). The interviewee from the Department of Industrial Works pointed out that small companies have problems to deal with their wastewater. This is because the small companies have a limited budget to adopt the best technology. Seemingly the government lacks the capacity to enforce regulations, which may in part be due to the resourcing of the local officials of the regulatory body. The local officials who respond to the problems have limited capabilities due to less education and also limited budgets compared to national bodies (Thappom, 2003, Wattanapinyo and Mol, 2013). The national body takes more direct responsibility for more polluting factories, which may partially account for the greater compliance of the larger companies.

The smaller companies have either not been able to access, or not been induced to try to access the grants/loans that are said to be available from an Environmental Fund (according to the

Enhancement and Conservation of the Environmental Quality Act (1992)) for governmental organizations and private sector bodies to enhance and conserve environmental quality (Rammont and Amin, 2010). Such financial incentives have had a role in environmental management in Thailand since 1992 (Sujaritpong and Nitivattanonon,2009), but do not appear to have been sufficiently helpful or appropriately directed for the smaller companies, and were not necessary to the larger ones in this study. However, it is also highly likely that the larger, international, companies are responding to signals from above the national scale. Thus, if EM is at work, it may more be a side-effect of European or other foreign policy rather than the national scale prioritised in the EM literature. Whilst this is presumably better for nature and the population in Thailand environmentally than no effective regulation, the full benefits of the policies are not being shared beyond their jurisdiction of origin.

8.2.2 Style of regulations

Thai regulations are still taking a command and control approach, which Jänicke (1985); Mol (2001); Spaargaren and Mol (1992); and Weale (1992) seen as a less effective at solving the environmental problems. One limitation of command and control regulations is that there is no incentive for continuous improvement. Whilst companies should not be polluting above allowed levels, they are allowed to pollute up to those levels. Nonetheless, these regulations meet the EM expectations in terms of flexibility. The government and the policies do not specify technologies used to meet the limits (Chapter Five: Regulatory context and policies in industrial wastewater). There is a benefit to this regulation because a company can choose suitable technologies to treat each waste from the company in accordance with the quantity and quality of waste as well as their budget. Each technology has both pros and cons depending on a quality of waste. However, government officers from the Department of Industrial Works must check the specification of technologies used in treating wastewater or other wastes before they can be installed. In addition, the company has to set up online system and report the water quality automatically to the Department of Industrial Works. This is similar to the EU regulations on Best Available Techniques for the Waste Treatment Industries which lists all approved technologies used to treat each waste for the factory (European Commission, 2006). The Thai equivalent, not having any preferred technologies, offers more flexibility to trial new technologies without the need to go through the process of approval for BAT (compared for example to the restrictions on resource recovery technologies in the EU: Deutz *et al*., 2017). However, for the benefits of flexibility to be realised, emissions would need to be closely monitored and limits strictly enforced.

8.2.3 Public participation

The Thai government's policy about public participation shows the government has to listen to the public's opinion before promulgating any policies. The Thai laws and regulations state that the public has the right to know important data and information from the company and also the government. The public also has a right to comment and inspect the company and the government. This appears to be in line with Hajer (1993), who indicated that ecological modernisation theory is not only about changes to production and consumption changes, but does so through greater democratisation, redistribution and social justice. However, the cautionary note of Gibbs (2000), that the public is often overlooked in EM, also applies to the situation in Thailand.

This study indicates that the Thai government has tried to listen to the public's opinion as the laws and regulations enforce and also tried to solve problems that affect the public. However, although the government has many channels to listen to the public's opinion, the method to participate or comment on some laws and regulations is not available for every regulation or for every person in Thailand. Only certain important laws such as a constitution etc. come with the opportunity that all Thais can participate, while others have a limited channel to participate. In addition, the NGO interviewer indicated that policies in Thailand have lack of an important information and data for the public to inspect the quality of control of wastewater.

8.3 Industrial symbiosis in Thailand

Both breweries have solid wastes or residues which are used as a material for other products such as fertilizer, animal feed etc. Although, methods to manage residues of both breweries are different, benefit or usage of residues are quite the same. The research results in this regard provide an example of industrial symbiosis in practice, i.e., the use of residues (energy, water, material) from one entity as an input to another (Chertow; 2000; Deutz, 2014).

Cooperation with nearby companies is a critical part of industrial exchanges (Boons *et al*., 2011). Khon Kaen company is fortunate to have their own glass bottle company next to the company. So, the glass bottle company uses silica (by product) from brewery to produce glass bottles and return to Khon Kaen company. Moreover, the Khon Kaen company also donates their by-products such as sludge, spent grains etc. to the locals or the co-operative. Although, this approach comes from the company's idea to eliminate their wastes and also reduce cost to eliminate wastes. I.e., is not planned, or facilitated IS (e.g., Wang *et al*., 2017) but organised by the company on its own initiative. The arrangements resemble the process-oriented form of IS identified in the European context by (Boons *et al*., 2015), indicating a wider applicability of at least one of the three forms identified.

Although the company is not part of an eco-industrial park, the local network it has built for itself shares some features with the eco-industrial parks in the literature on Thailand. These include community engagement, which signifies of a high standard of operation (Pilouk and Koottatep, 2017), as well as contributing to environmental protection. There appears to be less involvement of governmental and university stakeholders than in the eco-industrial parks (Panyathanakun *et al*., 2013), but these are industry led symbioses, achieved without the need for facilitation. Furthermore, the IS network centring on the company shows a willingness to engage with the community beyond the extent mandated by Thai regulations – and also represents a practical contribution rather than just providing information and listening to opinions. The residue flows constitute waste minimisation and also offers an economic resource to the community which would technically comprise 'wealth generation' (Panyathanakun *et al*., 2013), albeit on a modest scale. However, the relationship could also be seen as creating a dependency between the company and the community, which might make residents more reluctant to risk offending the company by expressing a critical opinion. In this way the residents in the community are no longer purely external stakeholders, but to a certain extent are internal to the operation of the company.

8.4 Relationships between stakeholders

The stakeholder relationships uncovered by this study are quite noteworthy. As with the adoption of technology and public participation, there is some signs of EM but relationships are not functioning according to the ideal of the concept. A more participatory approach for factory representatives in implementing policy formulation can lead to a better environmental performance, as shown in Europe, U.S.A., and East Asia (Taiwan, Malaysia, and Singapore) (Revell and Rutherford, 2003; Holiday *et al*., 2002; Marcus *et al*., 2002; Angel and Rock, 2003). In this case the companies and the government appear to be close in their opinions – and both companies are doing well according to observations and analyses presented.

The government confirmed that two case study companies follow the direction of the government and comply with regulations (interviewed with government official). The two companies likewise assert that they have to respond to the government and also the regulations (Managing director of Khon Kaen and factory representatives from Ayutthaya) (Chapter Five). Some interviewees from Ayutthaya company (interviewed with factory representatives from Ayutthaya), however, reported that some policy or regulation was not easy to follow in the short time allowed to achieve new standards. Conversely, the government said that most of big companies do not have any problems with the government and also the regulations. The big companies can manage their wastes promptly and better than the standards (Managing director of Khon Kaen and factory representatives from Ayutthaya). The companies and the government appear therefore to have a positive view of each other. Whether that is to the benefit of the public or the environment, is a further question.

Thailand the government sees NGOs as an antagonist and the government also thinks that NGOs always oppose to every projects of the government (interviewed with the government official). Conversely, the NGO studied claims to have tried to cooperate with all sectors in environmental protection. For examples, NGO invited all sectors to comment and suggest about new law and regulation (Chapter Seven); NGO help locals to be a consultant in environmental problems etc (Chapter Seven). This suggests that there is more willingness on the part of NGOs in Thailand to engage with policy makers than vice versa. The government's application of ecological modernisation is therefore limited at least in this regard. That is, they may be aware of the potential of economic and environmental co-benefits, and hopeful of technological innovation to drive environmental improvements, but much less open to debate on the setting of environmental standards. This, however, may not be so different to the situation in developed countries, where government is more open to the views of industry than those of NGOs.

Mol (2000) suggested that if NGOs are going to cooperate with the company and the government on ecological modernisation, this implies accepting a reformist strategy in place of potentially more radical approaches. However, the NGO interviewed in this research has opposed or disagreed with some sectors such as companies, the government etc. in some issues that may affect to the environment or the public. For example, the NGO did not think that the company's (companies') CSR policies were adequate (see interview analysis in Chapter Seven) because they think that actions are addressing the image of the company but not solving environmental problems. The justification of these views is difficult to judge, but potentially the exclusion of the NGO from discussion is enabling them to hold on to more strident views, as opposed to their views causing their exclusion. In addition, NGO disagreed with the government's approach as NGO wants to promulgate PRTR as a new Act but the government wanted it to be a ministerial regulation in an old Act (Factory Act, B.E. 2535 (1992)). EM can be characterised by a constructive relationship between different stakeholders such as environmental NGOs, companies and government and the community. This requires that the stakeholders in such relationships have acknowledged each other has being a legitimate part of the debate (eg. entitled to have concerns, or a relevant source of expertise/information) (Bowen *et al*., 2010; Cooper and Owen, 2007; Grunig and Hunt, 1984; Herremans *et al*., 2016; Hess, 2008; Morsing and Schultz, 2006; Schnackenberg and Tomlinson, 2016). However, although the companies contend that they have a good relationship with NGOs based in their area, this interviewed NGO does not appear to be accepted as a legitimate voice in debate.

The company have consulted with the public for many reasons: to promote their company; to show how the company manage their wastes; to listen to locals' opinion; to follow by Environmental Governance; to be a candidate and to certify as complying by the Government.

However, locals' opinion in the present day is more critical than the past. So, the company has to listen and respond to their opinion. Both companies listen and respond to the public's comments but Khon Kaen company has a closer relationship to the public than Ayutthaya company. This is because Khon Kaen company is located in the rural area and relationship between Khon Kaen company and the locals are interdependent. Khon Kaen company participates with many local activities around their area. Moreover, Khon Kaen company helps and supports locals in many ways such as educating locals how to make mats or donating solids wastes as by-products. On the other hand, the locals will support and take side with the Khon Kaen company when faces any problems. Both companies see the public as an important factor to support their images' companies. On the other hand, the public also thinks that the companies listen to their opinions and try to solve their problems. Moreover, the public can take some advantages from the companies such as fishes and other by products etc. As van Marrewijk (2003: 102), clarified socially responsible management as 'company activities – voluntary by definition – demonstrating the inclusion of social and environmental concerns in business operations and in interactions with stakeholders.' While Ayutthaya company is located nearby Bangkok, the capital city. Though, relationship between Ayutthaya company and the public is more formally than Khon Kaen. However, Ayutthaya has tried to participate with the public by listening to the public's opinion and donating their fishes to the locals. Besides, the parent company of Ayutthaya has tried to support the public in Thailand in many ways such as donating drinking water to the public in dry season etc. This study showed that both companies use CSR as tools to promote their business and they also use public's voice to help or protect the companies. In addition, the company promotes and makes image of their products and also their company are environmentally friendly by concerning with the environment and the locals as can be seen in their websites. Besides, the company has open houses to allow other organisations to inspect their waste management. Dryzek (1997) confirmed that selling environmentally-friendly products and services are one of many types of ecological modernisation.

8.5 Relationships between ecological modernisation, environmental governance and trust

Thailand has adopted ecological modernisation and also environmental governance theory to use in environmental management. Environmental governance is used to support environmental management (Harashima, 2000). Both case study companies received the environmental governance awards from the governance which claim that they follow the environmental governance. The environmental governance principle in Thailand involves with three main stakeholders which are the government, the company, and the public. As Harashima (2000) argues, the government, sovereignty and the public are main actors in environmental governance in Thailand. The environmental governance for the factory in Thailand consists of accessibility, participation, transparency, accountability, rule of law, social justice, and sustainability (Ministry of Industry, 2010). The public has right to access information from the company or the government which is related to the environmental governance in Thailand (Ministry of Industry, 2010). If the public receive important information from the company and the government, the public will trust them. Yang (2005) indicated that an authority's trust in public is evenly significant as the public trust in the participatory process itself. The two companies have many channels that the public can access the information. As Gilson (2003: 1454) defined trust is 'a relational notion: it generally lies between people, people and organizations and people and events'. Besides, public participation has been applied in environmental governance (Zhong and Mol, 2008).

The two companies also listen and respond to the local's opinion by distributing questionnaires and comment boxes etc. Besides, the case study companies have to report water quality online to the government which the government could check the parameters but it is not easy for the public. Public participation is an important process in every projects or regulations which effect to the public or the environment in Thailand (Ministry of Industry, 2010). In addition, the two case studies also find the best method to treat their wastewater and they also to find the best technology to protect the community and the environment. Thus, the companies express their ability to deal with the environment and make the public trust with management of the companies. Klijin et al. (2010) pointed out that trust is an important role in the interaction of knowledge exchange and intensive interaction and Tyler (2003) also stated that trust is an important factor in the governance. Moreover, the public and/or company has to trust between each other to exchange or buying the residues or by-products followed by industrial ecology or industrial symbiosis theories such as Khon Kaen company donated their residues to the cooperative while Ayutthaya company selling residues to other companies. These activities of two companies shows building trust between the company and other stakeholders which Sztompka (1999) stated that trust comprises of two main parts which is beliefs and commitment. Moreover, Gibbs (2003) stated that trust and cooperation are key factors that affect to networking and interchange activity in industrial ecology.

Trust between the government and the public in this thesis is unclear because the case study companies were established before the laws and regulations about public hearing promulgated. The laws and regulations enforce the company to report their treated water quality and also their ability to deal with their wastewater to the government every three month. The public could inspect and check the companies' ability from the government's or the companies' websites. Moreover, the public could inform the government to inspect the company in case of any problems which effect to the public or the environment.

8.6 Conclusions

There are elements of EM in Thailand's approach to the management of industrial wastewater and associated residues in the brewing industry. The government sets the water quality standards to limit and control wastewater from the company. Besides, the Department of Industrial Works has provincial industry offices to inspect and solve some problems of the factory in each province under the national laws and regulations. Moreover, the laws and regulations give an important to public participation in many aspects and the government has many channels to listen to the public's opinion. The public's opinion is one of the methods to force any factory to concern about the environment. As Thai laws and regulations are command and control approaches which many scholars in ecological modernization think it effects to environmental reform. Moreover, financial incentives in Thailand also are the role in environmental management. Besides, participatory approach effects to implement the laws and regulations.

In term of technology, the government does not specify technology to manage factory's wastewater. The company has a responsibility to select the best and proper technology to treat their wastewater but the government has to approve the technology before an operation. Technology used in industrial wastewater in Thailand shows the new technology increases efficiency and reduce environmental problem. Moreover, new technology also reduces cost in production and consumption which is one of ecological modernization theory. Besides. Industrial ecology is one of theories that the company used for reducing cost to manage their wastes. There is a close relationship between company and public; the company donates residues to support the locals. In this regard, the company saves cost to manage and eliminate their wastes. The locals are satisfied by this and support the company's image.

The NGO is more critical of the companies and the government than they are of each other. The government sees NGOs as an antagonist, whilst the NGOs claim to have tried to cooperate with all stakeholders to manage the environment. The relative exclusion of the NGO from debate may have left them more critical, or perhaps able to be more critical, whereas the public critique may have been neutralised by the close involved with one of the companies. However, these do appear to be high performing companies environmentally (less being known of their employment practices). More particularly, the relatively poor environmental performance of smaller companies, admitted by the government, and reflected in the public's concerns, indicates that EM is not functioning well. The large companies may be responding to international pressures as much or as more as to the national regulation.

Chapter Nine: Conclusion and recommendation

This chapter critiques how Thailand has managed industrial wastewater including with regulatory context, and technology. Besides, to evaluate how public has participated in wastewater management. Finally, this chapter provides recommendations for further research into wastewater management in Thailand.

9.1 Conclusions

9.1.1 Regulatory context and policies in industrial wastewater

Thailand is a constitutional monarchy and has the King to approve or disapprove any bills affirmed by the Parliament. Sovereign power is divided into three branches: legislative, the executive, and the judicial. The National Public Administration Act, B.E. 2534 (1991) designated three levels of public administration in Thailand: central, provincial, and local administration. Besides, local involvement in environmental management has increased which was found in the national constitution (1997).

There are many regulations and policies in industrial wastewater management in Thailand. There are both compulsory and voluntary policies. However, water quality standards are compulsory law which every factory has to treat their wastewater to meet the standards.

Thailand has a particular form of environmental governance to support environmental management. Thailand applies the concept of environmental governance as understood by the UNEP and IUCN definitions. Environmental governance is "natural resources and environmental management, with public access to information and participation in policy plans, projects, and activities which affect natural resources and the environment with transparency, accountability, rule of law, predictability, and social justice" (Thailand Environment Institute, 2007:3). The environmental governance for a company includes a document which declares methods used to manage pollution followed by the laws and regulations which the public can access. In addition, the public can suggest methods of energy conservation and resource management; the factory has to listen and to respond. The result found that both factories had similar views on and approaches to environmental governance and also adopted this policy to use in environmental management. Moreover, both companies have been certified as complying with the Government.

The main regulation and policy in industrial wastewater is the Factory Act, B.E. 2535 (1992) which is used to inspect all process of the factory including with establishment, operation, and waste management. The Act does not specify the types of technology used in wastewater management but the government officials from the Department of Industrial Works have responsibility to approve the technology used before establishment. Although, there are Polluter Pays Principle (PPP) in the Act, there is no serious enforcement in environmental tax. Besides, Fiscal Policy Office, Ministry of Finance is studying the pattern of environmental tax from wastewater and still being in the process of becoming a new Act. There are Ministerial regulations and Notifications under the Factory Act, B.E. 2535 (1992) which specify methods and procedures to the factory to follow. However, the factory has a responsibility to report flow and power consumption meter, and BOD (Biochemical Oxygen Demand) meter and/or COD (Chemical Oxygen Demand) meter that can transmit signal continuously and send data to the system of the Department of Industrial Works. Government officials from Department of Industrial Works all stated that every factory has to follow by laws and regulations in collecting wastewater samples and send the report every 6 months. Both Factories confirmed that the factories respond to all laws and regulations and use the best technology to treat wastewater to meet the standards.

The National Environmental Quality Act, B.E. 2535 (1992) is an environmental law designed to control, preserve, and promote the environment in Thailand which includes with wastewater. Besides, this Act was promulgated the Industrial effluent standards. The case studies confirmed that the factories meet the standards with better performance. In addition, there is zero discharge idea which the government and both factories have adopted to use in their factories. But Ayutthaya company is still in the process to adopt the zero-discharge idea completely.

The industrial effluent standards were declared in Notification No. 2, B.E. 2539 (1996) of the Ministry of Industry under the Factory Act, B.E. 2535 (1992) which were adapted from the international standards. Moreover, the government official from the Department of Industrial

Works stated that some parameters of Thai standards have to change or adjust but it has to discuss with other governmental organisations to specify new standards.

However, the NGO representative (from Ecological Alert and Recovery-Thailand (EARTH)) disagreed with ability of the existing regulations to control wastewater and also the idea of zero discharge. This is because NGO thought that the regulations are not up to date and also missed some important standards. Moreover, the zero-discharge idea may cause an environmental problem if the company manages it unproperly. In response to the Government promoting the idea of zero waste, the NGO is attempting to promote a new regulation which is Pollutant Release and Transfer Register (PRTR).

Besides wastewater management, there are three main policies involved in operating or expanding a factory. These are Factory Act, B.E. 2535 (1992), Town Planning Act, B.E. 2518 (1975), and National Environmental Quality Act, B.E. 2535 (1992). These relate to the brewing industry along with other cabinet resolutions and other policies.

Public participation and also public hearing were included and related to the laws and regulations after the Constitution, B.E. 2550 (2007) was promulgated. The government also has many channels to listen to the public's opinion such as governmental organisations' websites, telephone etc. The public can access to many information from the governmental organisation's' websites. Besides, The Department of Industrial Works has the Bureau of Public Participatory Promotion which has the responsibility to inform, consult, involve, collaborate, and empower the public. Moreover, this bureau also has responsibilities to educate and train local organisations, factories, and local people in environmental management, safety, and relevant laws. However, methods of listening to public opinion are somewhat exclusive as not everyone would be able to attend a conference or access the internet. Furthermore, notice boards are not necessarily in places that the public would be visiting, unless they had some reason to expect an announcement.

9.1.2 Wastewater management

As can be seen from Khon Kaen's website, the company is interested in environmental management including wastewater management. Khon Kaen's brewery has adopted and developed their techniques and also technologies to deal with their wastewater and other wastes. Moreover, they have adopted the 3Rs principle, reduce, reuse, and recycle, and also zero discharge idea to help with wastewater management. The technologies used in the company are divided into two main systems which are Up-flow Anaerobic Sludge Blanket (UASB) combined with Activated Sludge (AS), and Internal Circulation (IC) combined with AS. In addition, the company uses plant and algae-based systems in treating wastewater as they have adopted from the King Bhumibol Adulyadej Rama IX's project. Treated wastewater after pass the plant and algae-based systems will be reused in golf course in the company's area. While other treated wastewater will be treated by reverse osmosis to reuse in the company. The company confirmed with the report that their water quality after treated meet or batter than the standards.

In addition, solid wastes from the Khon Kaen's brewery will be conforming to the zero-waste idea in the future. The company donates the sludge to the community as a fertilizer and the locals sell the fertilizer to provide a source of revenue. Spent grains have a commercial use as an animal feed. Yeast is donated by the company to a dairy group in the community; it is sold as a fertilizer, and is used as a soil improver in the community. Kieselguhr slurry is donated as a fertilizer to the cooperative, is donated to the community as a soil improver, and is used as an ingredient to produce glass bottles. Thus, the company can save cost for the disposal of solid wastes and also can support the locals, which is CSR policy.

Ayutthaya's brewery initially adopted its wastewater technologies from a Danish company with worldwide experience in brewery construction. After the expiration of the contract, the company has adopted the best technology to use in wastewater management. In addition, the website claims that the company complies with government policy by enabling the public and other stakeholders to participate in sustainable water management. This company has also adopted 3Rs to use in water management same as Khon Kaen company. The technologies used in treating wastewater are UASB and IC, and after being treated by these two systems, the wastewater is finally treated by AS. The report from the company showed that treated wastewater of the company meets or better than the standards same as Khon Kaen.

All solid wastes from the Ayutthaya company are sold to the third-party companies. Spent grains are used as animal feed, dried yeast is used as supplementary animal food, and Kieselguhr slurry is used as a fertilizer and also an ingredient of foamed concrete blocks. So, the company have a profit and also save cost to eliminate the wastes.

Both case studies have shown that they have tried to find the best technology and also other methods to deal with their wastewater until their water quality parameters better than the national standards. Moreover, these two companies display good practice in choosing technology, and plant-based system to manage their wastewater. Besides, industrial ecology and industrial symbiosis theories were adapted to manage their residues from the companies by exchange or selling their residues to other companies or the communities. Last but not least, they are still finding the best method to manage their wastes to improve their communities and the environment. However, this combination of ability and willingness to exceed national requirements does not necessarily extend to smaller companies, given that water pollution remains an issue in Thailand. There is a distinction between performance based on company size which exceeds that in western countries. In the latter, larger companies are frequently cited as having more capacity for sustainability issues, but the smaller ones have to meet at national standards.

9.1.3 Public participation

Khon Kaen’s company is actively engaged in public participation and also the environment as is indicated by their slogan on their website. The company engages with the public in many ways; solids wastes from the brewing process are donated to the locals, donating by products which are rush and fish to the public, distributing journals and/or leaflets for educating or giving information the public, allowing other organisations to come and see their environmental management, supporting religious ceremonies and temples around their area, cooperating in academic and technical matters with researchers and also universities and also supporting the researchers and universities by allowing the researchers to use the company as a case study, sending their officers to support people and also donating any products of the company when needed. These activities of the company showed that the company gives an importance to the public. Conversely, the company also take some advantage from the public when needed.

Summarising of the questionnaires indicated that most of respondents in Khon Kaen concerns with the environmental problems and they also think that rivers in Thailand have a water pollution problem. Although half of respondents consider that factories were the main source of that pollution, the Mayor of Tambon Tha Phra confirms that the wastewater in the area does not come from the case study brewery. Moreover, most respondents were aware that there are environmental problems near their home and half of them think that the effectiveness of companies to deal with their wastewater to the environment is neutral. Half of respondents also confirm that factories are main source of wastewater because they have seen by themselves. In addition, most of them think that water pollution could affect them and their family and they also worry about it. So, they usually told the village leader to solve that wastewater problem and they found that wastewater problem was solved by the government agency sometimes. More than three quarters of the respondents had received some information on industrial wastewater, water pollution, or pollution prevention from a government agency or company. Nearly three quarters of the public had also tried to find any information about wastewater or pollution by themselves occasionally. More than half of the respondents have been invited to at least one public meeting about environmental management and almost all of those respondents decided to attend that public meeting. Most respondents said that they had an opportunity to express their opinion at the meeting. There were some responses to their opinions by solving their problems while other respondents said that some opinions were ignored. The residents think that public participation may help in environmental management.

The Ayutthaya company is not only concerned about stakeholders, but also concerned about the environment. Their parent website and also the interviews show their ability to engage with the public in many ways. The company has open house activities for other companies to educate and learn from the company. They set up an exhibition on special and important days in Thailand to educate people and also conserve the environment. The company has a plan to provide a collection point for local's community in the near future for buying and collecting recyclable household waste. The company used to donate money to some projects to conserve the forest. Besides, the company also supports researchers or universities by allowing students or staff to use them as a study for many different types of research.

From the questionnaires I found that most of the respondents in Ayutthaya were aware that there are environmental problems in Thailand with just under a third of the respondents identifying water as a main environmental issue. Most of them thought that Thailand has wastewater in the rivers and half of respondents considered that factories are the main source of wastewater. More than three quarters of them agreed that it is very important to protect the environment. Most of respondents said that there are environmental problems near their home and half of them thought that the effectiveness of companies in disposing their wastewater to the environment were neutral. Most people regularly seeing a river had seen signs of water pollution. Almost half respondents thought that factory is the main source of water pollution because they had seen this source of pollution themselves. Most of respondents thought that water pollution affects them and their family and they also worried about wastewater which affect to their health and aquaculture. Some of them have told someone, which may be a village leader, about the water pollution and found that some problems had been resolved but there was still a problem. Nearly three quarters of the respondents indicated that a government agency and/or a company had occasionally provided any information on industrial wastewater, water pollution, or pollution prevention. More than half of them had found information on wastewater or pollution prevention for themselves. Half of respondents had been invited to any public meetings relating to environmental management which were set up by leaders. Nearly three quarters of respondents decided to attend a meeting because they wanted to know the causes and how to solve the problems.

There are statistically significantly differences between Khon Kaen and Ayutthaya in demographic variables and in the frequency that respondents see any signs of water pollution around the area where they live. There are significant differences in the frequency that they ever tried to find information on wastewater or pollution prevention for themselves, age, marital status, highest level of education, income per month, and periods of living in the area. The range age of respondents in Ayutthaya is lower than Khon Kaen. Most of respondents in Ayutthaya are single while those in Khon Kaen are mostly married. The highest education level and typical income of respondents in Ayutthaya is higher than Khon Kaen. The respondents in Khon Kaen have typically lived in the area longer than those in Ayutthaya. The respondents in Khon Kaen have more likely to have seen any signs of water pollution than those from Ayutthaya. The respondents in Khon Kaen have tried to find information on wastewater or pollution prevention for themselves more than Ayutthaya, which may reflect the fact that they are more likely to have personally seen pollution.

NGO (Ecological Alert and Recovery-Thailand (EARTH)) has two procedures in environmental management which are first to define for themselves issues of concern and second to respond to the public's complaints and information supplied to EARTH. EARTH has educated the public by distributing documents relating to EARTH's projects and EARTH also helped the public by being a specialist witness in a court. EARTH's website (Ecological Alert and Recovery – Thailand, 2017) also has documents and/or information in Thai and English to educate the public on environmental management and make them aware of the organisation's projects. EARTH also commented that public participation should include public awareness, public hearings, and consulting the public and thought that public participation has power in environmental management. However, EARTH indicated that main issue in Thailand is there is not enough information for public access. EARTH pointed out that CSR could not help in industrial wastewater and wastes because CSR is only a method to change the image of the company. A good relationship between company and public may affect to environmental management because public would take side with the company. EARTH sees itself as opposing government agencies but when they have set up a public meeting, they have invited all stakeholders including government agencies. In addition, EARTH tried to push PRTR to be a new Act. EARTH is still trying to reform some old laws and/or regulation about Environmental Impact Assessment (EIA) and Environmental Health Impact Assessment (EHIA). EARTH disagreed with a zero-discharge idea proposed by the government and think that it will be a cause of wastewater or water pollution indirectly.

9.2 Recommendations

Although the government and other stakeholders have tried to manage and control industrial wastewater in Thailand, it is still a significant environmental problem. Regulation and technology used to be main roles in wastewater management but public participation has become one of main role to manage wastewater. To deal with the wastewater problems or environmental problems more generally, effective combinations of laws, technology, and public participation is essential.

9.2.1 Regulatory context and policies in industrial wastewater

To achieve the sustainable industrial wastewater management, the following recommendations are proposed:

- The government should update laws and regulations on industrial wastewater and also the water quality standards by comparison with the international countries.

- To enhance companies' awareness of wastewater, the government should strictly enforce the laws and regulations. Government officials should inspect the company regularly to ensure that relevant laws and regulations are followed.

- To enhance awareness to public on wastewater, the government should educate and distribute important information on laws and regulations to the public. Besides, channels for the public to access should be easy and throughout the whole country.

- To enhance capacity of government officials, the government should increase budget to local organisations to recruit more government officials to inspect the company. Moreover, the government should educate the government officials on relevant laws and regulations and also methods to inspect the company.

- The government should give more priority to small and medium enterprises which is the most effect to wastewater in Thailand.

- The government may specify or list all up to date technology from which each company has to select in managing their wastewater.

9.2.2 Wastewater management

Not only laws and regulations are main role in industrial wastewater management, but technology is also an important role in sustainable development in industrial wastewater management. Thus, the new technology plays a role in higher productivity, increasing efficiency and decreasing pollution. The following recommendations are proposed;

- To meet the water quality standards, the government should approve and inspect technology used to treat wastewater regularly. Moreover, the government maybe specify minimum standards of technology used in treating wastewater for each company.

- The company should show concern for their technology used in industrial wastewater management and inspect their treated wastewater quality regularly. Besides, the company should study and adopt new international technology used in their company

- The government should find optional techniques (such as wetlands, and algae-based systems etc.) used to treat wastewater and also promote new techniques to the company.

- The large companies can show good practice in managing their wastewater and other wastes.

9.2.3 Public participation

Public has an important role in wastewater management as can be found in many studies and also many countries. The following recommendations are made on public participation in industrial wastewater management in Thailand:

- The government should give more importance on the public's opinion on wastewater and should also try to solve any problems. Moreover, channels to listen to the public's opinion should easy to access and throughout the area.
- The government should educate the public to be aware industrial wastewater and methods to inform the government agency about that industrial wastewater.
- The public should be aware and interested in the environment around their area which affect directly or indirectly to them.

9.3 Recommendations for further research

As can be found in literature on public participation in Thailand, there have only been studies on mega projects which effect much more people and the environment. Therefore, the information on public participation on industrial wastewater in Thailand has been limited. It is recommended that a further study should focus on public participation on all projects that may affect to the public and the environment including with wastewater not only on mega projects. This may help the public are aware with the industrial wastewater and also the environment.

In addition, the government should give an importance to public participation and also public hearing on wastewater and the environment. The government should not only listen or respond the public's opinion after there are protest and cannot stop the project. Thus, the researcher should study on methods used in public participation and public hearing in environmental management. Result from the study will make the government find the best method to listen and participate to the public before start any project.

Moreover, as laws and regulations on industrial wastewater in Thailand are not quite up to date. Therefore, researcher should study and compare Thai laws with international laws. In this regard, the government can use information of the study to adapt or promulgate the new law on industrial wastewater in Thailand. Moreover, the government should be aware and consider the environmental problems as an important issue. In this regard, the government will focus on effect of the environmental issues before other issues and push the government agency to manage this situation.

Finally, research should focus on various sizes of company to investigate and compare water quality and also industrial wastewater management. In this regard, the government should know the source of the main problem in industrial wastewater and manage wastewater properly. Furthermore, the researcher should compare technology used in treating wastewater for each company and find the best technology. The government may specify the best technology for each company as a guideline further. Moreover, optional techniques (such as wetlands, and algae-based systems etc.) may be considered to treat industrial wastewater but have to find a suitable technique for the company.

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Appendixes

Appendix 1: Letter Government officials, Factories, and NGO

To

RE: Miss Tiraprapa Ratanachoti

Miss Tiraprapa Ratanachoti is a postgraduate student in the Department of Geography, Environment and Earth Sciences, University of Hull. She is studying for a PhD in Human Geography, her topic is "The influence of public participation on the implementation of policy and technology in industrial wastewater management in Thailand" especially in brewing industry. This research is funded by the Government of Thailand. I have the pressure to be supervising Tiraprapa's studies.

At present Tiraprapa is looking forward to undertake the data collection about role and function of government officers, policies, technology and public participation in industrial wastewater management in May 2015. It may involve with Industrial cluster 1 bureau, Water technology and industrial pollution management bureau, and Bureau of public participatory promotion (an example of questions as attached). She and I would be very grateful to you for any assistance you can provide potential interviewees and information.

Do not hesitate to get in touch if you have any questions or would like further information. Thank you for any assistance you can provide.

Yours faithfully,

To

RE: Miss Tiraprapa Ratanachoti

Miss Tiraprapa Ratanachoti is a postgraduate student in the Department of Geography, Environment and Earth Sciences, University of Hull. She is studying for a PhD in Human Geography, her topic is “The influence of public participation on the implementation of policy and technology in industrial wastewater management in Thailand” especially in brewing industry. This research is funded by the Government of Thailand. I have the pressure to be supervising Tiraprapa’s studies.

At present Tiraprapa is looking forward to undertake the data collection about role and function of company, policies, technology, wastewater and public participation in industrial wastewater management in June 2015 (an example of questions as attached). She and I would be very grateful to you for any assistance you can provide potential interviewees and information.

Do not hesitate to get in touch if you have any questions or would like further information. Thank you for any assistance you can provide.

Yours faithfully,

To

RE: Miss Tiraprapa Ratanachoti

Miss Tiraprapa Ratanachoti is a postgraduate student in the Department of Geography, Environment and Earth Sciences, University of Hull. She is studying for a PhD in Human Geography, her topic is “The influence of public participation on the implementation of policy and technology in industrial wastewater management in Thailand” especially in brewing industry. This research is funded by the Government of Thailand. I have the pressure to be supervising Tiraprapa’s studies.

At present Tiraprapa is looking forward to undertake the data collection about role and function of NGOs, policies, government officers and public participation in industrial wastewater management in August 2015 (an example of questions as attached). She and I would be very grateful to you for any assistance you can provide potential interviewees and information.

Do not hesitate to get in touch if you have any questions or would like further information. Thank you for any assistance you can provide.

Yours faithfully,

Appendix 2: Examples of question

Government organisation

1. Government officers
    - Role and function of government officers in national and local?
2. Policies
    - How many policies involved in industrial wastewater?
    - Originate from?
    - When policies legislated?
    - How many government organisations involved?/overlap?
    - How policies enforce?
    - Any pros and cons?/efficiency?problems?
3. Inspectors or third parties
    - Role and function of inspectors/third parties?
    - How often?
    - How to inspect?
    - How inspectors force?
4. Company
    - How companies respond with policies?
    - Report?/how?/how often?
    - Methods to measure chemical components?
    - Environmental manager?/controller?
5. Technology
    - Which technologies give the best result?
    - Where from?/how?/why?
6. Public participation
    - How to educate people about policies?
    - How many channels to report wastewater?
    - How governments respond to people?

Company

1. Policy
    - How to know and learn about policy?
    - How to respond the policies?
    - How to set up?/EIA?
    - Extension contract?/how?
    - Report?/how often?
    - Environmental managers?/controllers?
    - Efficiency?
    - Problems?
2. Sources of water pollution

- Volume of water input?/output?
- Chemical components before and after?

3. Technologies
   - Where from?
   - Why choose these technologies?
   - How these technologies work?
   - Costs of operation?/costs of maintenance?
   - Sustainability?
4. Public participation
   - Any programmes?/how?/how often?/why?
   - Any feedback?/Any channels to complain?
   - Funding?/to whom?/how much?
   - Public relation staffs?role?function?

NGOs

1. NGOs
   - Role and function of NGOs in international, national, and local?
   - Register with the government?/how?
   - How to inspect?/why?/how often?
   - How to measure chemical components?
2. Policy
   - How to know and learn about policy?
   - Any problems?
   - Efficiency?
3. Government officers
   - How to cooperate?
   - Any problems?
4. Public participation
   - How to participate?
   - Any channels to complain or report?
   - How to respond?

Appendix 3: Questionnaire

This survey relates to awareness, perception, and participation of people in wastewater management in your neighborhood.

You have received this questionnaire because you live near a water course.

…………………………………………………………….

Please tick the relevant box or write your answer on the dotted line. You can leave blank any question that you are not comfortable answering.

1. **Overview**

This section is to clarify your interest in environmental issues.

1.1 Do you think the environment in Thailand has any problems?

☐ Yes ☐ No

1.2 What is your main concern in environmental issue?

☐ Air ☐ Water ☐ Litter ☐ Land and soil ☐ Forest

☐ Other……

1.3 Do you think rivers in Thailand have a problem with pollution? (If yes, please answer 1.4)

☐ Yes ☐ No

1.4 If you think there is a problem what are the main sources of water pollution? (You can choose more than one choice)

☐ Agriculture ☐ Household ☐ Factory ☐ Transportation

☐ Other……

1.5 Companies have responsibilities under environmental regulations. How effective do you think they are at implementing those regulations? (Ranking from 1=ineffective to 5=very effective)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.6 The Ministry of Natural Resources and environment is responsible for enforcing environmental regulations. How effective do you think the ministry is? (Ranking from 1=Ineffective to 5=Very effective)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.7 How important do you think it is to protect the environment?

☐ Not important ☐ Low ☐ Neutral ☐ Somewhat ☐ Very important

2. Public awareness of wastewater and/or industrial wastewater

This section is examining your view of the environment near your home.

2.1 Do you think there are problems with the environment near your home?

☐ Yes ☐ No

2.2 Do you ever go to the river near your home? (If yes, please answer 2.3-2.5)

☐ Yes ☐ No

2.3 How far do you live from the river?

☐ Next to my home ☐ Nearby ☐ Quite far away ☐ So far away

2.4 Why do you come to the river?

☐ I live nearby ☐ I work nearby ☐ The river is on my way somewhere

☐ For leisure ☐ For fishing ☐ Other…………………………………………………………………

2.5 How often are you close enough to the river to see the water?

☐ Once a week ☐ Once a month ☐ Once a year Other………………………………………

2.6 ☐ Have you ever seen any signs of water pollution around the area where you live? (If yes, please answer 2.7-2.13)

☐ Yes ☐ No

2.7 How often?

☐ Once a week ☐ Once a month ☐ Once a year ☐ Other…………………………………….

2.8 Where do think the pollution came from?

☐ Sewer ☐ Agriculture ☐ Factory ☐ Other…………………………………………………….

2.9 Why did you think the pollution come from that source?

☐ Saw by myself ☐ Someone told me ☐ Other…………………………………………………

2.10 What did the pollution look like? (Please be as specific as you can)

Colour………..

Odour………

Taste………

Other……….

2.11 Did that water pollution affect you and your family and how?

☐ Yes ☐ No

How? ………

2.12 Did you worry about effect of water pollution and how?

☐ Yes…………………………………………………………………………………………………… ☐ No

2.13 Did you tell anyone about the water pollution? (If yes, please answer 2.14-2.17)

☐ Yes ☐ No

2.14 Why or why not?

…….

2.15 Who did you tell?

☐ Leader ☐ Neighbour ☐ Government ☐ Media

☐ Other……

2.16 What happened after you told someone?

…….

2.17 Who and how managed with that water pollution?

…….

2.18 Companies are legally obliged to manage their waste water in a way that protects the environment. How effective to you think companies in your area are in disposing their wastewater in an environmentally sound manner? (Ranking from 1=ineffective to 5=very effective)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. **Public awareness on wastewater and/or industrial wastewater management**

This section is investigating the information available to you on wastewater.

3.1 Has a government agency or a company provided you with any information on industrial wastewater, water pollution, or pollution prevention? (If yes, please answer 3.2-3.3)

☐ Yes ☐ No

3.2 How did you get that information?

☐ In the meeting/forum ☐ Governmental document ☐ Factory document

☐ Other………

3.3 How often?

☐ Regularly ☐ Occasionally ☐ Very rarely ☐ Other…………………………………

3.4 Have you ever tried to find information on wastewater or pollution prevention for yourself? (If yes, please answer 3.5-3.6)

☐ Yes ☐ No

3.5 Where did you find that information?

☐ Leader ☐ Neighbour ☐ TV ☐ Radio ☐ Newspaper

☐ Library ☐ Website/social ☐ Leaflet ☐ Other……………………………………………

3.6 How often?

☐ Regularly ☐ Occasionally ☐ Very rarely ☐ Other…………………………………

4. Public participation in environmental management

This is section is interested in whether you have ever taken part in a public event relating to environmental management organised by a company or government agency.

4.1 Have you been invited to any public meetings relating to environmental management? (If yes, please answer 4.2-4.10)

☐ Yes ☐ No

4.2 What was the purpose of the meeting? Eg. Wastewater, waste, atmospheric pollution etc.

……

4.3 Who set up that meeting?

☐ Government ☐ NGOs ☐ Leader ☐ Factory ☐ Other………………………

4.4 How did you know about that meeting?

☐ Leader ☐ Neighbour ☐ TV ☐ Radio ☐ Newspaper

☐ Library ☐ Website/social ☐ Leaflet ☐ Governmental document

☐ Factory document ☐ Other……………………………………………………………………

4.5 Did you decide to attend that meeting?

☐ Yes ☐ No

4.6 Why or why not?

………

4.7 Did you think that the public meeting was useful?

☐ Yes ☐ No

4.8 Why?

………

4.9 Did you have an opportunity express your opinion at the meeting?

☐ Yes ☐ No

4.10 What was the response to your opinion and comments?

………

4.11 If you have not attended a meeting, do you think it might be of interest in the future?

☐ Yes ☐ No

4.2 If you have not heard of such a meeting, do you think a public meeting on industrial wastewater would be useful?

☐ Yes ☐ No

5. Basic information

This section is asking for some information about you, to be sure that we have included a good cross section of different people.

5.1 Please tick the relevant box to indicate your gender:

☐ Male ☐ Female ☐ Prefer not to answer

5.2 Please indicate your age: How old are you?

☐ 18-21 ☐ 22-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 60 up

5.3 Please indicate your marital status

☐ Single ☐ Married ☐ Divorce ☐ Widowed

5.4 Do you have any children and how many?

☐ Yes…………………………………………………………………………………………………… ☐ No

5.5 Please choose your highest level of education

☐ Primary school ☐ Secondary school ☐ Bachelor degree ☐ Master degree

☐ PhD degree ☐ Other ………………………………………………

5.6 Please indicate your occupation

☐ Government officer ☐ Office worker ☐ Farm owner ☐ Farmer worker

☐ Casual worker or labourer ☐ Student ☐ Retired

☐ Other………

5.7 Please indicate your income per month (Baht)

☐ Less than 5,000 ☐ 5,001-10,000 ☐ 10,001-15,000 ☐ 15,001-20,000

☐ 20,001-25,000 ☐ 25,001-30,000 ☐ 30,001-35,000 ☐ More than 35,001

☐ Other………

5.8 How long have you lived in this area?

☐ Less than a year ☐ 1-5 years ☐ 6-10 years ☐ more than 10 years

6. Is there anything else you wish to say relating to environmental management?

……

Thank you for your participation.

All comments are anonymous and will be treated as confidential.

Contact Detail: Tiraprapa Ratanachoti, PhD student

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Dusit, Bangkok
10300

Appendix 4: Information letter

Information letter

Research title: ***The influence of public participation on the implementation of policy and technology in industrial wastewater management in Thailand***

Letter of interview information

You are invited to participate in research conducted by Tiraprapa Ratanachoti, PhD student in Human Geography, University of Hull. Under the supervision of Dr. Pauline Deutz. The main aim of this research is to analyze the influences on industrial waste water management in Thailand in the field of policies and also technologies. Besides, to what extent are companies incentivized by public and public policy in decisions to adopt more sustainable behavior? The research questions of this study as follow:

1. How are the relevant policies established by the government and enforced by the regulatory agencies?
2. How do companies engage with industrial effluent policies, standards and the regulatory agencies?
3. What are similarities and differences of the technologies to international comparators?
4. How have the public attempted to engage with industrial wastewater management and how effective has this been?
5. How do companies engage with the public with respect to industrial wastewater?
6. Have non-government organisations (NGOs) engaged with the public in industrial wastewater management, and if so how?

Participation requires a tape-recorded interview be conducted. I would appreciate the opportunity to conduct a tape-recorded interview with you at your convenience. There are no identified risks to participating in this research/interview. The information that you will provide will only be used for the purpose of writing my thesis and associated academic purposes and will only be accessed by my supervisor and me during the period of storage. Interview transcripts, however, will only be accessible to the researcher and supervisor. If you ask the researcher can further insure anonymity by removal of any identifying features from transcript.

Yours faithfully,

Tiraprapa Ratanachoti

Appendix 5: Consent Forms

DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF HULL

CONSENT FORM: SURVEYS, QUESTIONNAIRES

I, of

Hereby agree to participate in this study to be undertaken

By Tiraprapa Ratanachoti, PhD student

and I understand that the purpose of the research is to analyze the influences on industrial waste water management in Thailand. Primarily, the study concerns the extent to which companies are incentivized by public and public policy in decisions to adopt more sustainable behaviour.

I understand that

1. Upon receipt, my questionnaire will be coded and my name and address kept separately from it.
2. Any information that I provide will not be made public in any form that could reveal my identity to an outside party ie. that I will remain fully anonymous.
3. Aggregated results will be used for research purposes and may be reported in scientific and academic journals.
4. Individual results **will not** be released to any person.
5. That I am free to withdraw my consent at any time during the study, in which event my participation in the research study will immediately cease and any information obtained from me will not be used.

Signature: Date:

The contact details of the researcher are:
Tiraprapa Ratanachoti, PhD student
University of Hull
Cottingham Road, Hull, HU6 7RX.
Tel.
Email: tiraprapa.ratanachoti@2013.hull.ac.uk

Supervised by Dr. Pauline Deutz
University of Hull
Cottingham Road, Hull, HU6 7RX.
Email: P.Deutz@hull.ac.uk

The contact details of the Geography Ethics Officer are: Department of Geography, University of Hull, Cottingham Road, Hull, HU6 7RX, tel. 01482-465320.

DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF HULL

CONSENT FORM – For Institutions/Organisations

I, ... of ....

Agree to be involved in a research study being undertaken by
Tiraprapa Ratanachoti, PhD student

and I understand that the purpose of the research is is the influences on industrial waste water management in Thailand. Primarily, the study concerns the extent to which companies are incentivized by public and public policy in decisions to adopt more sustainable behaviour.

I understand that

1. The aims, methods, and anticipated benefits, and possible risks/hazards of the research study, have been explained to me.
2. I am free to withdraw my consent at any time during the study, in which event participation in the research study will immediately cease and any information obtained through this institution/organisation will not be used if I so request.
3. I understand that aggregated results will be used for research purposes and may be reported in scientific and academic journals. Comments may be paraphrased or used as a brief quote in your PhD thesis and/or academic publications.

I agree that

4. The institution/organisation MAY / MAY NOT be named in research publications or other publicity without prior agreement.
5. ***I / We DO / DO NOT require an opportunity to check the factual accuracy of the research findings related to the institution/organisation.***
6. ***I / We EXPECT / DO NOT EXPECT to receive a copy of the research findings or publications.***

Signature: Date:

The contact details of the researcher are:
Tiraprapa Ratanachoti, PhD student
University of Hull
Cottingham Road, Hull, HU6 7RX.
Tel.
Email: tiraprapa.ratanachoti@2013.hull.ac.uk

Supervised by Dr. Pauline Deutz
University of Hull
Cottingham Road, Hull, HU6 7RX.
Email: P.Deutz@hull.ac.uk

The contact details of Geography Ethics Officer are: Department of Geography, University of Hull, Cottingham Road, Hull, HU6 7RX, tel. 01482-465320.

Appendix 6: Factory Act, B.E. 2535 (1992)

Unofficial Translation

FACTORY ACT,
B.E.2535 (1992)[1]

BHUMIBOL ADULYADEJ REX.
Given on the 2nd Day of April, B.E. 2535 (1992)
Being the 47th Year of the Present Reign

His Majesty King Bhumibol Adulyadej is graciously pleased to proclaim that:

Whereas it is expedient to revise the law on factory;

Be it therefore enacted by the King, by and with the advice and consent of the National Legislative Assembly acting as the Parliament, as follows:

Section 1. This Act is called the "Factory Act, B.E. 2535 (1992)".

Section 2. This Act shall come into force after the expiration of ninety days from the date of its publication in the Government Gazette.[2]

Section 3. The following shall be repealed:

(1) The Factory Act, B.E. 2512 (1969);

(2) The Factory Act (No.2), B.E. 2518 (1975);

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[1] Translated by Center for Translation and Language Services, Research Institute for Languages and Cultures of Asia, Mahidol University under contract for the Office of the Council of State of Thailand's Law for ASEAN project.- Initial version- pending review and approval.

[2] Published in the Government Gazette, Vol. 119, Part 44, Page 62, dated 9th April B.E. 2535 (1992).

(3) The Factory Act (No.3), B.E. 2522 (1979).

Section 4. This Act shall not apply to Government factories run by the Government for the purpose of national security and safety, however, the operation of such factories shall be guided by the criteria and procedure relating to the factory operation under this Act.

Section 5. In this Act:

"factory" means building, premises, or vehicle using machine or machines with total power or an equivalent of five horsepower or more, or which employs seven workers or more with or without machinery to manufacture, produce, assemble, pack, repair, maintain, test, improve, process, convey, keep, or destroy anything in accordance with the type or kind of factory as prescribed in the Ministerial Regulations;

"factory setting up" means construction of buildings for the installation of machinery to engage in factory operation or installation of machinery for engaging in factory operation in the buildings, premises, or vehicles to engage in such operation;

"factory operation" means manufacturing, producing, assembling, packing, repairing, maintaining, testing, improving, processing, conveying, storing, or destroying anything in accordance with the nature of the factory operation but not including machinery test-run;

"machinery" means contrivances consisting of several parts for the generation of energy, change or transformation of energy, or transmission of energy, by the power of water, steam, wind, gas, electricity, or any other energy or a combination of energies, and includes accessories, fly-wheels, pulleys, belts, axles, gears or other things working reciprocally;

"worker" means a person who works in a factory but excluding a person working in the administrative division;

"license grantor" means the Permanent Secretary or the person appropriately entrusted by the Permanent Secretary;

"license" means a license for factory operation;

"competent official" means the person appointed by the Minister for the execution of this Act;

"Permanent Secretary" means the Permanent Secretary of the Ministry of Industry;

"Minister" means the Minister who has charge and control of the execution of this Act.

Section 6. The Minister of Industry shall have charge and control of the execution of this Act and shall have the power to appoint the competent officials and to issue Ministerial Regulations prescribing the fees not exceeding the rates attached hereto, exempting fees and prescribing other activities for the execution of this Act.

The Ministerial Regulations and Notifications issued under this Act shall come into force upon their publication in the Government Gazette.

Chapter 1
Factory Operation

Section 7. The Minister shall have the power to prescribe in Ministerial Regulations categorizing factory of any type, kind, or size to be as Category 1 factory, Category 2 factory, or Category 3 factory, as the case may be, by taking into account the necessity for control and supervision, prevention of nuisance, prevention of damage, and prevention of danger in accordance with the severity of impact on the people or environment, by the following categorization:

(1) Category 1 factory is a factory of the type, kind, and size, capable of factory operation immediately as desired by the factory operator;

(2) Category 2 factory is a factory of the type, kind, and size, which requires a notice to be made to the license grantor prior to its operation;

(3) Category 3 factory is a factory of the type, kind, and size, the setting up of

which requires a license.

The factory prescribed in the Notifications of the Minister under section 32 (1), when published, shall be Category 3 factory.

Section 8. For the purpose of control on factory operation, the Minister shall have the power to issue Ministerial Regulations requiring factories under any or all categories under section 7 to comply with the following:

(1) to prescribe criteria relating to factory location, its environment, the nature of its buildings or its interior;

(2) to prescribe the nature, type, or kind of machinery, equipment or such other things to be used in factory operation;

(3) to prescribe requirements for specialized workers based on the type, kind, or size of factory for the performance of a duty in the factory;

(4) to prescribe criteria to comply with, production process, and acquisition of any equipment or tools to prevent or stop or mitigate the dangers, injuries, or distress that may happen to people or property in the factory or its vicinity;

(5) to prescribe standards and methods of controlling the discharge of waste, pollutants or anything affecting the environment as a result of the factory operation;

(6) to prescribe the requirements for documents necessary to have available at the factory for the purpose of controlling and inspecting the compliance with the law;

(7) to prescribe the requirements for necessary information relating to the factory operation which the factory operator shall have to furnish from time to time or at a specified period of time;

(8) to prescribe any other requirements for the protection of safety in the factory operation in order to prevent or stop or mitigate the dangers or injuries that may result from the factory operation.

The Ministerial Regulations under paragraph one may exempt the factory of any type, kind, or size from complying with any matter and such Ministerial Regulations may expediently prescribe, by publication in the Government Gazette, any detailed technical matters or any matters rapidly changing under social conditions to be in conformity with the criteria prescribed by the Minister.

Section 9. In the case where an inspection of a factory or machinery is required for the execution of this Act, private entity may be designated to carry out the same and to prepare a report of the result of the inspection instead of performance of duties by competent official provided that this shall follow the Rules prescribed by the Minister, by publication in the Government Gazette.

Section 10. The operator of Category 1 factory shall comply with the criteria prescribed in the Ministerial Regulations issued under section 8 and the Notifications of the Minister issued under such Ministerial Regulations.

Section 11. The operator of Category 2 factory shall comply with the criteria prescribed in the Ministerial Regulations issued under section 8 and the Notifications of the Minister issued under such Ministerial Regulations and shall notify the competent official in advance before commencing the factory operation.

The forms and particulars for the notification and the notification receipt forms shall be as prescribed in the Ministerial Regulations.

Upon receipt of the notification under paragraph one, the competent official shall issue a notification receipt to the notifying operator as evidence of such notification on the date of receipt of the notification, and the notifying operator shall engage in factory operation as from the date of receipt of such notification receipt.

In the case where the competent official finds out later that the notification under paragraph one is incorrect or incomplete, the competent official shall have the power to order the notifying operator to make corrections to or to complete the same within seven days as from the date of receipt of such order.

Dissolution of the operation, assignment, lease out or hire-purchase out of Category 2 factory requires notification by the factory operator in writing to be made to the competent official within thirty days from the action date.

Section 12. The operator of Category 3 factory shall have to obtain a license from the license grantor and shall comply with the criteria prescribed in the Ministerial Regulations issued under section 8, the Notifications of the Minister issued under the said Ministerial Regulations, and the Notifications of the Minister issued under section 32.

No person shall set up a factory before a license is obtained.

The application for a license and the procedure and time required for consideration for granting of a license shall be as prescribed in the Ministerial Regulations.

In the case where the license applicant requests for a certificate before a license is granted, if a preliminary consideration suffices the grant in principle, the license grantor shall issue a certificate upon making reservation on the part the consideration of which has not been finalized, in accordance with the criteria prescribed by the Minister as published in the Government Gazette.

In granting a license, the person having the power to grant a license shall consider in accordance with the criteria prescribed in the Ministerial Regulations issued under section 8, the Notifications of the Minister issued under the said Ministerial Regulations, and the Notifications of the Minister issued under section 32. In the case where no criteria are prescribed, it shall be considered by taking into account the safety of the people or property in the factory or its vicinity, or it shall be complied with the Notifications of the Minister issued under section 32. In this regard, conditions may be prescribed in the license to be followed specially by the factory operator.

Section 13. If a licensee under section 12 wishes to commence the operation in any part of the factory, he or she shall notify the competent official not less than fifteen days prior to the date of factory operation.

If there shall be a test run of the machinery prior to the factory operation under paragraph one, the licensee shall also notify the competent official of the date, time, and the duration of the test run of the machinery, for not less than fifteen days.

The criteria and period of time which may be used for the test run of the machinery shall be as prescribed in the Ministerial Regulations.

Section 14. A license shall be valid until the last day of the fifth calendar year from the year in which the factory operation has begun except in the case of moving of the factory under section 27 or dissolution of the factory operation, such license shall be deemed to expire on the date of issuance of a new license or on the date of dissolution of the factory operation.

If it is justifiable to discontinue an operation in a near future, the license grantor, with approval of the Minister, may grant a license with a shorter validity period than provided for in paragraph one. The license granted in this manner shall not be renewed.

Section 15. In renewing a license, a licensee shall file an application prior to its expiration. Upon filing of such application, the applicant shall be deemed to hold the status of a licensee until a final order denying the license renewal is given.

If the result of inspection indicates that the factory and the machinery are in compliance with section 8, the Notifications of the Minister issued under the said Ministerial Regulations, and the Notifications of the Minister issued under section 32, and with conditions set forth in the license, the license grantor shall renew the license. In case of non-compliance, the competent official shall order the rectification be carried out within a specified period of time. Upon such rectification having been done, a renewal shall be granted. Failure to make rectification within the specified period of time, the order refusing such license renewal shall be given.

The application for license renewal and granting of license renewal shall be in accordance with the criteria and procedure prescribed in the Ministerial Regulations.

If a person who fails to file an application for license renewal within the period of time under paragraph one, wishes to continue the factory operation and has already filed an application for license renewal within the period of sixty days as from the date of expiration of the license, it shall be deemed that the application has been filed within the specified period of time and the factory operation during such period shall be deemed as that of the licensee. However, upon the grant of the license renewal, such person shall have to pay an additional fine at twenty percent of the license renewal fee. If the sixty-day period has lapsed, the matter shall be treated as a new application.

Section 16. The applicant for license or license renewal may appeal to the Minister against the order refusing the granting of license or license renewal within thirty days from the date the order has been known. The decision of the Minister shall be final.

Section 17. Any factory of which the operator has been granted a license, if it appears thereafter that the machinery used by such factory is lower than five horsepower or the number of workers employed is less than seven, such factory shall be deemed to be the factory under this Act until a notification of dissolution of the factory operation is given or the license expires.

Section 18. The licensee may not expand the factory unless permitted by the license grantor.

Section 12, section 13, and section 16 shall apply to an application for factory expansion and the granting thereof as well as an appeal against an order refusing factory expansion, *mutatis mutandis.*

A factory expansion is:

(1) an increase in number, a replacement or modification of machinery to increase their total power by fifty percent or more in the case where the original machinery has a total power of not more than one hundred horsepower or an equivalent of not more than one hundred horsepower, or an increase of fifty horsepower or more in the case where the original machinery has a total power of more than one hundred horsepower or an equivalent of more than one hundred horsepower;

(2) an addition or remodeling of any part of the factory buildings rendering any of their original foundations to carry an additional weight of five hundred kilograms or more;

The validity period of the license for the expansion part shall be for the same period as the license under section 14.

Section 19. When the licensee increases the number of, replaces or modifies the machines used for production, machines used for generation of power, or energy of the machines to other forms but not tantamount to factory expansion, or increases the area of the factory building, or constructs additional building directly benefiting the factory operation resulting in an increase of the area of the factory to fifty percent or more in the case where the area of the factory is not more than two hundred square metres, or an increase of the area of the factory to one hundred square metres or more in the case where the area of the factory is more than two hundred square meters, the licensee shall notify the competent official within seven days from the date the machines have been increased in number or replaced or modified, or the factory area has been increased, or the additional factory building has been built, as the case may be. The licensee shall comply with the criteria and procedure concerning the increase, replacement, and modification of the machines, or the increase of factory area, or the building of additional factory building as prescribed in the Ministerial Regulations.

Section 20. For the conditions set forth in a license under section 12 paragraph five, if the license grantor deems it reasonable to cancel or change or add any appropriate conditions to be complied with by the licensee in the factory operation, the license grantor may issue such an order in writing.

Any licensee who wishes to cancel or change the conditions required to comply with in the factory operation, shall file an application with the license grantor stating the reasons. The license grantor shall consider the matter and issue an order in writing without delay.

If the licensee does not agree with opinion of the license grantor, he or she may appeal to the Minister within thirty days from the date of receipt of the written order. The decision of the Minister shall be final.

Section 21. In the case where the licensee assigns the factory operation, leases out, or hire-purchases the factory out, or sells the factory, such licensee shall be deemed to have discontinued the factory operation as from the date of assignment of the factory operation, lease out, or hire-purchase the factory out, or sale of the factory.

The assignee of the factory operation, the lessee or the hire-purchaser of the factory or the purchaser of such factory shall apply for license within seven days as from the date the factory operation is deemed to have discontinued under paragraph one without paying the license fee. Upon submission of such application, the factory operation shall continue pending the granting of a license as if such applicant is the licensee.

The criteria, procedure, conditions for acceptance of assignment and granting of license shall be as prescribed in the Ministerial Regulations.

Section 22. In case of death of a licensee, the heir or the administrator shall file an application with the license grantor for the acceptance of the assignment of the license within ninety days as from the date the licensee deceased or within a period as extended by the license grantor as necessary. Failure to file an application within the specified period, the license shall be deemed to expire. If the factory operation is to continue, an application for a new license must be filed.

During the period under paragraph one, the heir or the administrator who is engaging in the factory operation shall be deemed to be the licensee.

In the case where the licensee is adjudged incompetent, the provisions of the two preceding paragraphs shall apply to the guardian *mutatis mutandis*.

The criteria, procedure, conditions for acceptance of assignment and granting of license shall be as prescribed in the Ministerial Regulations.

Section 23. The licensee shall display the license in an open and conspicuous place at the factory of the licensee.

Section 24. Upon change of name of the factory or name of the licensee, the licensee shall notify the competent official in writing within fifteen days as from the date of such change.

Section 25. In case of loss or destruction of a license, the licensee shall apply for a substitute with the competent official within fifteen days as from the date the loss or destruction has been known.

Section 26. The licensee wishing to move parts of the machinery installed in the factory to another place for a temporary factory operation shall file an application for permission with the license grantor together with a layout drawing and other details stating the reasons for consideration.

If the license grantor deems it reasonable, the license grantor shall permit the moving of the machinery for the operation as requested to be done within a specified period of time but not exceeding one year as from the date such order has been given. In this respect, the conditions relating to safety measures may be prescribed to be complied with.

If the licensee needs to engage in such operation longer than the period permitted under paragraph two, an application for extension of such period of time shall be filed with the license grantor prior to the expiration of such period. If the license grantor deems it reasonable, the license grantor shall grant a time extension for not more than one year.

Section 27. Licensees wishing to move the factory to another place shall deal with the matter in the same manner as setting up a new factory.

Section 28. Any licensee who discontinues the factory operation shall notify the license grantor in writing within fifteen days as from the date of the discontinuation of factory operation.

If a licensee wishes to transform a Category 3 factory to a Category 1 or Category 2 factory, as the case may be, the licensee shall provide a notification of discontinuation of factory operation under paragraph one. When the factory operation is to be continued, the actions prescribed in this Act for the operation of such category of factory as prescribed in this Act shall be taken.

Section 29. In the case where there are Ministerial Regulations under section 7 or Notifications of the Minister under section 32(1) rendering Category 1 or Category 2 factory into Category 3 factory, if a factory operator applies for a license under section 12 within thirty days of the Ministerial Regulations having come into force, such person shall continue the factory operation as if he or she is the licensee and the license grantor shall issue a license without delay.

Section 30. The Minister shall have the power to designate any area as an industrial zone by publication in the Government Gazette.

The operation of Category 2 or Category 3 factory within the industrial zone under paragraph one or the industrial estate zone established under the law on industrial estate, (the operator of which) shall be exempted from having to notify the competent official under section 11 or as is licensed under section 12, as the case may be. However, such factory operation shall be in compliance with the criteria prescribed in the Ministerial Regulations issued under section 8, the Notifications of the Minister issued under the said Ministerial Regulations, the Notifications of the Minister issued under section 32 (1), and other provisions related to the control of factory operation under this Act, (the operator of which) shall be deemed the person making the notification or the licensee as the case may be.

Upon the designation of an area as an industrial zone or the establishment of an industrial estate under the law on industrial estate, the Minister may issue Ministerial Regulations prescribing areas within a specified distance surrounding the industrial zone or the industrial estate as non-factory operation areas or only certain type, kind, and size of factory can be operated in such areas.

Section 31. For the purpose of efficient public administration and facilitation to the public, if any factory operation involves a matter which also requires permission from competent official under other law, the competent official under this Act and the competent official under such other law may set up an administrative procedure to undertake joint consideration.

The undertaking under paragraph one may be required to be carried out by joint application or by exemption of required documents, particulars or information, the place of submission of the application and documents, or repetitive or similar documents and procedure for consideration or which may create unnecessary obstacles to joint consideration. In the case where appropriate, any additional criteria or procedure may be prescribed for compliance but the permission shall be in the format prescribed in the law on such matter.

In making joint consideration, the competent official who has the power to make inspection, the power to consider any part of the permission, or the power to grant permission, may deligate his or her power to other concerned competent official in the consideration for permission to act on his or her behalf as deemed fit.

The additional prescription and the delegation of power under paragraph two and paragraph three shall come into force after publication in the Government Gazette.

Chapter 2
Factory Supervision

Section 32. For the purposes of the economy, conservation of the environment, the security and safety of the country or the public, the Minister, with approval of the Council of Ministers, shall have the power to prescribe by publication in the Government Gazette, the following:

(1) to prescribe the number and size of each type or kind of factory allowed to be set up or expanded or the setting up or expansion of which shall be denied in any area;

(2) to prescribe the kind, quality, ratio of raw materials, sources of raw materials and/or factors or kind of energy to use or produce in the factory;

(3) to prescribe the kind or quality of products manufactured in the factory

allowed to be set up or expanded;

(4) to prescribe the use of products from the factory allowed to be set up or expanded for certain types of industry, or that all or part of the products shall be exported.

Section 33. If a Category 2 or Category 3 factory discontinues its operation consecutively for more than one year, the Category 2 factory operator or the Category 3 licensee, as the case may be, shall notify the competent official in writing within seven days from the date the one year period expires.

If the person under paragraph one wishes to continue the factory operation, such person shall notify the competent official in writing before commencing the factory operation. In the case of Category 3 factory, a written permission shall first be obtained from the competent official before commencing the factory operation.

In granting permission for the continuation of Category 3 factory operation, section 15 paragraph two and section 16 shall apply *mutatis mutandis*.

Section 34. In the case of an accident in a factory caused by the factory or a machine of the factory regardless of factory category, if such accident

(1) causes death, illness or injury to a person who after seventy two hours is unable perform his or her original duties, the factory operators shall notify the competent official in writing within three days as from the date of death or the expiration of seventy two hours, as the case may be;

(2) causes the factory operation to stop for more than seven days, the factory operator shall notify the competent official in writing within ten days as from the date of the accident.

Upon an occurrence of an accident in any factory under paragraph one, the competent official shall inspect the factory and the machinery and consider taking action under section 37 or section 39, as the case may be.

Section 35. For the execution of this Act, the competent official shall have the following powers:

(1) to enter a factory or building, premises or vehicle, with reasonable suspicion that a factory operation is going on, between sunrise and sunset, or during the working hours of such place to inspect the conditions of the factory, building, premises or vehicle, the conditions of the machinery or any act that may violate the provisions of this Act;

(2) to take the specimens of products suspicious of their quality in a reasonable quantity for inspection of their quality together with relevant documents;

(3) to inspect, search, detain, seize or attach the products, containers, books of account, documents or any relevant articles in a case where there is a suspicion that the factory may cause harm to the people or property in the factory or its vicinity or that there is a commission of an offence under this Act;

(4) to summon in writing any person to testify or to submit any document or object for consideration.

Section 36. When it appears that any person has committed an offence under this Act or there is a reasonable ground to so suspect, the competent official who is appointed from government official not lower than level 4 of position classification shall have the power to arrest such person in order to hand over the arrestee to an inquiry official for further legal action.

Section 37. In the case where the competent official finds out that any factory operator violates or declines to comply with this Act or engages in factory operation in such a manner as to cause harm, injuries or distress to people or property in the factory or its vicinity, the competent official shall have the power to order such person to stop such violating act or to rectify or improve the same or comply accordingly or appropriately within a specified period of time.

If the competent official deems it reasonable, upon approval of the

Permanent Secretary or the person entrusted by the Permanent Secretary, the competent official shall have the power to bind and seal the machines to prevent them from being operated during the compliance with the order of the competent official under paragraph one.

Section 38. For the service of an order under this Act, the competent official shall serve the same at the domicile or factory of the person specified in the order between sunrise and sunset or during the working hours of such person or may send the same by a registered mail with acknowledgement of receipt.

In the case where the order has been served by the competent official but the person specified in the order refuses to receive it, the competent official shall ask an administrative official or police to accompany him or her as witness for the depositing of the order at such place. If, however, the person specified in the order is not found at the domicile or the place of business of such person, the service may be made to any person of *sui juris* who is or works at such place, and if no person is found or someone is found but they refuse to accept it on behalf of the specified person, the order shall be posted at a conspicuous location at such domicile or factory in the presence of the accompanying administrative official or police as witness.

Upon execution by the competent official under paragraph one or paragraph two, the person specified in the order shall be deemed to have received such order. If, however, the order is sent by a registered mail with acknowledgement of receipt or by posting, such order shall be deemed to have been received upon the expiration of fifteen working days as from the date of delivery by a postman or of posting of such order, as the case may be.

Section 39. In the case where any factory operator intentionally declines to comply with the order of the competent official under section 37 without reasonable ground or in the case where it appears that the factory operator may cause serious harm, injuries or distress to the people or property in the factory or its vicinity, the Permanent Secretary or a person entrusted by the Permanent Secretary shall have the power to order such person to temporarily cease all or part of the factory operation and to rectify or improve the factory or comply accordingly within a specified period of time.

If the factory operator has modified the factory or complied accordingly within the specified period of time, the Permanent Secretary or a person entrusted by the Permanent Secretary shall order the factory operation to continue.

If the factory operator fails to rectify or improve the factory or comply accordingly within the specified period of time, the Permanent Secretary or a person entrusted by the Permanent Secretary shall have the power to order a closure of the factory and in case of a Category 3 factory, the closure order shall also have the license revoking effect.

Section 40. The order to cease factory operation or to close the factory shall be posted by the competent official at least at three conspicuous locations at such factory. The order shall contain statements prohibiting people who perform their duties in the factory, workers, or all people concerned from working in the factory to keep the factory functioning after the issuance of the order to cease factory operation or to close the factory.

Section 41. The order of the competent official under section 37 or the order of the Permanent Secretary or the person entrusted by the Permanent Secretary, to cease the factory operation under section 39 paragraph one or the order to close the factory under section 39 paragraph three, may be appealed to the Minister within thirty days from the date the order has been known. The decision of the Minister shall be final.

The appeal under paragraph one shall not stay the compliance with the order of the competent official or the order to cease the factory operation or the order to close the factory unless otherwise ordered by the Minister.

Section 42. In the case where the factory operator fails to comply with the order of the competent official under section 37, if there is ground for the Government to take over the operation, the Permanent Secretary or the person entrusted by the

Permanent Secretary shall have the power to order the competent official or to entrust any person to carry out the rectification in order to conform to such order. Such being the case, the factory operator shall bear the expenses for such takeover in the amount actually paid together with a penalty at the rate of thirty percent per annum of the said amount.

If the Government has undertaken to resolve the pollution problems or the impacts on the environment caused by the factory, it shall request a subsidy from the Environmental Fund under the law on the Enhancement and Conservation of the Environmental Quality Act for the costs of its operation and upon receipt of the money under paragraph one from the factory operator, the Government shall repay the Environment Fund for the subsidy so received.

Section 43. The factory operators of Category 2 and 3 factories shall pay the annual fee in accordance with the criteria, procedure, and at the rate as prescribed in the Ministerial Regulations throughout the period of factory operation. Failure to pay the fees within the specified period shall result in a monthly five percent surcharge. Denial of fee payments without justification shall empower the competent official to order such operator to cease factory operation until the fees and the surcharges have been paid in full, and section 39, section 40, and section 41 shall apply *mutatis mutandis.*

Section 44. In performing the duties, the competent official shall present his or her identify card upon request by person concerned.

The identity card of the competent official shall be in accordance with the form prescribed by the Minister upon publication in the Government Gazette.

Chapter 3
Penalties

Section 45. Any person violating or failing to comply with the Ministerial

Regulations issued pursuant to section 8 (1) (2) (3) (4) (5) or (8) or the Notifications of the Minister issued under the said Ministerial Regulations shall be liable to a fine not exceeding two hundred thousand baht.

Section 46. Any person violating or failing to comply with the Ministerial Regulations issued under section 8 (6) or (7) or the Notifications of the Minister issued under the said Ministerial Regulations shall be liable to a fine not exceeding twenty thousand baht.

Section 47. Any person producing a false inspection result under section 9 shall be liable to imprisonment for a term of not exceeding two years or to a fine not exceeding two hundred thousand baht, or to both.

Section 48. Any person operating Category 2 factory without notifying the competent official under section 11 paragraph one shall be liable to imprisonment for a term of not exceeding six months or to a fine not exceeding fifty thousand baht, or to both.

Section 49. Any person operating Category 2 factory by notifying incorrect or incomplete operation as prescribed in the Ministerial Regulations under section 11 paragraph two or failing to comply with section 11 paragraph five or section 33 shall be liable to a fine not exceeding twenty thousand baht.

Section 50. Any person operating Category 3 factory without license under section 12 paragraph one or setting up a factory without a license under section 12 paragraph two shall be liable to imprisonment for a term of not exceeding two years or to a fine not exceeding two hundred thousand baht, or to both.

In the case where the factory under paragraph one is of the type or kind of which its number or size is prescribed for granting or denying of setting up in any area in accordance with the Notifications issued under section 32 (1), the offender shall be liable to imprisonment for a term of not exceeding four years or to a fine not exceeding four hundred thousand baht, or to both.

Section 51. Any licensee failing to comply with section 13 paragraph one or paragraph two, section 19, section 28 or section 33 shall be liable to a fine not exceeding twenty thousand baht.

Section 52. Any licensee expanding a factory without license for factory expansion under section 18 shall be liable to imprisonment for a term of not exceeding two years or to a fine not exceeding two hundred thousand baht, or to both.

In the case where the factory under paragraph one is of the type or kind of which its number or size is prescribed for granting or denying of expansion in any area in accordance with the Notifications issued under section 32 (1), the offender shall be liable to imprisonment for a term of not exceeding four years or to a fine not exceeding four hundred thousand baht, or to both

Section 53. Any licensee failing to comply with section 23, section 24 or section 25 shall be liable to a fine not exceeding five thousand baht.

Section 54. Any factory operator failing to comply with section 34 paragraph one shall be liable to a fine not exceeding twenty thousand baht.

Section 55. Any person operating a factory during an order to cease factory operation or after the order to close the factory shall be liable to imprisonment for a term of not exceeding two years or to a fine not exceeding two hundred thousand baht, or to both, and to additional fine at a daily rate of five thousand baht until the cessation of the operation.

Any architect or engineer who keeps working in the particular part of the factory against which an order has been issued to cease operation or keeps working in the factory against which a closure order has been issued in order to continue the factory operation, shall be liable to the same punishment as the factory operator under paragraph one.

Any person working in the factory or worker who keeps working in the particular part of the factory against which an order has been issued to cease operation or is still working in the factory against which a closure order has been issued shall be presumed to be an accomplice or an abettor to the commission of offence under paragraph one, as the case may be, however, the Court may inflict less punishment than that provided by law taking into consideration of the status, family responsibility, intent to violate the law, and substantiality of participation in the commission.

Section 56. Any person who obstructs or fails to provide convenience to the competent official who performs the duties under section 35 shall be liable to imprisonment for a term of not exceeding one month or to a fine not exceeding twenty thousand baht, or to both.

Section 57. Any person who fails to comply with the order of the competent official given under section 37 paragraph one shall be liable to imprisonment for a term of not exceeding one year or to a fine not exceeding one hundred thousand baht, or to both, and to additional fine at a daily rate of five thousand baht throughout the period of violation or non-compliance.

Section 58. Any person doing any act to reactivate the machinery bound and sealed by the competent official under section 37 paragraph two, shall be liable to imprisonment for a term of not exceeding one year or to a fine not exceeding one hundred thousand baht, or to both.

Section 59. Any person obstructing or failing to provide convenience to a person entrusted by the Permanent Secretary or by a person entrusted by the Permanent Secretary to carry out an undertaking in conformity with the order under section 42, shall be liable to imprisonment for a term of not exceeding one year or to a fine not exceeding one hundred thousand baht, or to both.

Section 60. Any person doing any act causing defect or damage to the order to factory operation or to close the factory shall be liable to imprisonment for a term of not exceeding six months or to a fine not exceeding fifty thousand baht, or to both.

Section 61. In the case where the factory operator commits an offence under this Act, it shall be deemed that the architect or the engineer who works in the factory and is responsible for the part of the work in which such offence has been committed is participating or conniving in the commission of the offence with the factory operator and shall be liable to the same punishment as the factory operator except where the architect or the engineer can prove that he or she did not connive with nor consent to the commission of the offence.

In addition to the punishment inflicted under paragraph one, the Permanent Secretary shall notify the name and the act of such person to the Architectural Profession Control Commission or the Engineering Profession Control Commission to consider taking proper legal action in accordance with the architectural profession law or the engineering profession law.

Section 62. Any person who was ever punished for the commission of an offence under this Act, if again committed the same offence for which he or she was punished, the court shall consider increasing the punishment for such person at least an additional one-third of the imprisonment penalty or increasing the punishment for an additional one-half of the fine penalty of such offence.

Section 63. In the case where a partnership, company or other juristic person commits an offence under this Act, the director, manager or any person responsible for the commission of such offense shall also be liable to the penalties provided for such offence except it can be proved that such offence has been committed without his or her connivance or consent.

Section 64. In the case where an offence under this Act is committed, the people residing near or adjacent to the factory at which the offence is committed or the people whose livelihood is affected as a result of commission of the offence shall be deemed to be the injured persons under the Criminal Procedure Code.

Section 65. There shall be committees for settlement of cases in Bangkok Metropolis area and regional areas as are appropriate.

Each case settlement committee shall be appointed by the Minister from three qualified persons in the legal field whose term of office shall be for two years but upon retiring from office may be reappointed.

The vacation of office before the expiration of the term, the meetings, and the procedure of the case settlement committee shall be in accordance with the Rules as prescribed by the Minister and published in the Government Gazette.

All offences under this Act except for those under section 50 paragraph two or section 52 paragraph two may be settled by the committee if it is of an opinion that the alleged offender should not be prosecuted or penalized by imprisonment. Upon payment by the alleged offender of the settled amount of the fine within thirty days from the date the settlement has been initiated, the case shall be deemed settled under the Criminal Procedure Code.

In the case where the inquiry official finds out that a person has committed the offence under paragraph four and such person agrees to the settlement by payment of a fine, the inquiry official shall submit the docket to the case settlement committee within seven days as from the date on which such person has agreed to settle the case by payment of a fine.

Transitory Provisions

Section 66. Any applications filed and permissions granted or pending the consideration of the license grantor or pending the performance of the applicant as granted, as the case may be, shall be deemed the applications or permissions under this Act *mutatis mutandis*. In the case where such applications or permissions are different from the applications or permissions under this Act, the license grantor shall have the power to order amendment be made as is necessary in order to be in conformity with this Act.

Section 67. Licenses for factory operation issued to any person pursuant to the law on factory prior to the coming into force of this Act shall remain valid until the expiration of the period specified.

Licenses for setting up of factory under the law on factory prior to the coming into force of this Act shall be deemed licenses for factory operation under this Act and the licensee shall have the duty to carry on under this Act.

Section 68. All Ministerial Regulations and Notifications issued under the law on factory shall remain in force insofar as they are not contrary to or inconsistent with the provisions of this Act.

Countersigned by
Anand Panyarachun
Prime Minister

Rates of Fees

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(1) Application	100 baht each
(2) License or license for factory expansion	100,000 baht each
(3) Substitute for a license	1,000 baht each
(4) Renewal of a license shall be in accordance with the rate in (2)	
(5) Fee for factory operation	30,000 baht each

In issuing Ministerial Regulations prescribing the fees, different fee rates may be fixed by taking into account the size and the business of the factory concerned.