Chapter 1

Introduction

1.1 Problem Identification

Growing expansion of population, industrialization, agricultural activities and urbanization have led to increase in huge amount of waste which require proper disposal. Nowadays, solid waste management and wastewater treatment are the most important problems facing. Municipal solid wastes are major sources of air, water and soil contamination. It has been a major environmental problem in Thailand. Recent estimate indicates that annual generation of municipal solid waste in USA is projected to increase to 253 million tons in 2010 (USEPA, 2007). In Thailand, more than 14.3 million tons/year or 39,200 tons/day of municipal solid waste is produced in urban areas all over the country with an annual increasing rate of about three percent (Pollution Control Department, 2002). Since the production of solid waste is increasing much more rapidly than it degrades, land space for disposal has become more difficult and expensive to attain. Municipal solid waste disposal in the landfill is the most common, cheap and easiest municipal solid waste management practice followed throughout the world.

Landfill is mainly used for the disposal of solid waste which is unavoidable worldwide including Thailand. Currently, majority of wastes (about 65%) are being disposed in open dump whereas remaining is being managed by sanitary landfill (35%). Most of sanitary landfills in Thailand employed stabilization pond as the only main treatment including Nonthaburi solid waste disposal site (Figure 1.1). Nonthaburi solid waste disposal site, with a total area about 0.194 km^2, receives more than 900 tons/day of municipal solid wastes from Nonthaburi province, Thailand (as of 2007). The site has been in operation since 1982 and at present the total accumulated dumped waste is more than one million cubic meters. Each cell is about 0.0384 km^2 and is normally filled up in one year. The incoming municipal solid waste composition in Nonthaburi solid waste disposal site (as of 2005) contains about 41.5% of plastic. The other main component was soil fraction (about 30.9%) (Prechthai et al., 2006). About 10% of waste is biodegradable in nature and the wastes are divided into combustible and non-combustible. Additionally, this kind of waste has high moisture content in the range of 55-65%. The selected site is very typical for the region. It features a design of bottom liner and final cover both of compacted clay of reasonable low permeability, and an efficient leachate drainage system as well as a simple gas drainage system. Intensive gas recovery is feasible. There are three leachate ponds. The leachate is pumped to the pond which behaves like an anaerobic pond and help in stabilization of leachate.

Landfill leachate is one of the biggest problems as it is high strength wastewater which contains high concentration of organic matter and ammonia nitrogen. Presence of organic, inorganic, heavy metal components and concentrated toxic contaminant in the leachate make it more difficult to deal with. Under tropical climatic condition, heavy rainfall during monsoon season yield huge amount of leachate to be treated whereas the capacity of the existing treatment system is usually limited. Inadequately treated water is then discharged into the nearby water body, causing severe pollution problem (Chiemchaisri and Srisukphun, 2003). The improper handling of this landfill leachate especially from some of the landfills located in the water resource preservation areas might result serious environmental consequences such as soil and groundwater contamination. When the leachate containing high strength of organic matter, suspended solids as well as heavy metals is discharged without treatment, it can stimulate the algal growth through nutrient enrichment, deplete dissolved oxygen and cause the formation of toxic carcinogenic breakdown products in the surrounding water environment. Large quantities of intensely colored and toxic effluents are released, causing an aesthetic problem in receiving water body and serious environmental pollution.

As the treatability of landfill leachate depends on its composition and characteristics, the nature of the organic matter present as well as the age and structure of the landfill, different technologies including biological treatments, physico-chemical treatments, advanced oxidation process as well as natural systems such as constructed wetlands have been developed in recent years in order to comply with the increasingly stringent discharge standards imposed by Thai government. However, the method of selection of leachate treatment methods should be simple, cost-effective and highly adaptable to accommodate in developing countries like Thailand.

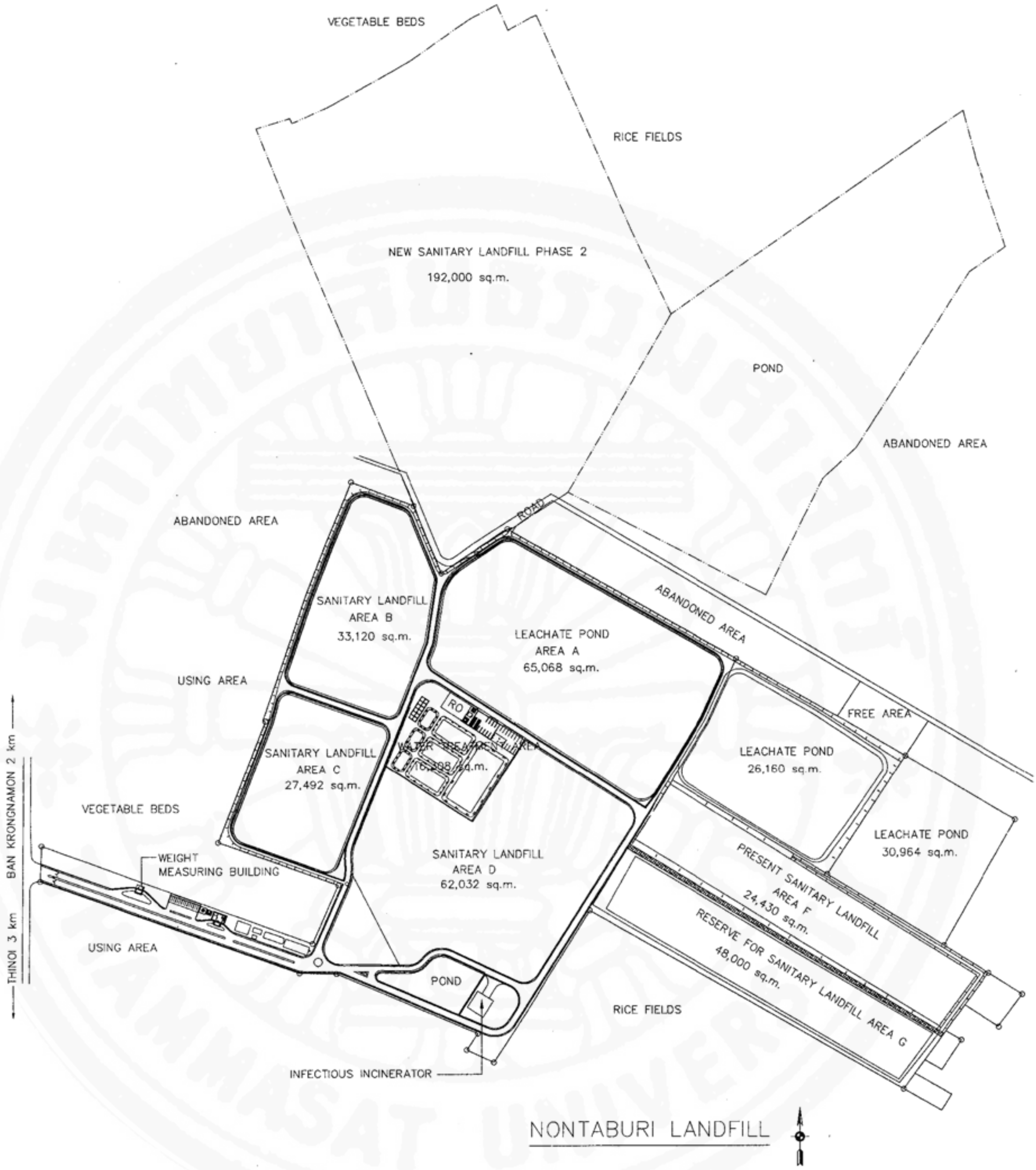

Figure 1.1 Profile of Nonthaburi solid waste disposal site (Nonthaburi Provincial Adminstration Office, 2007)

1.2 Rational of Study

Physico-chemical methods used for landfill leachate treatment include activated carbon adsorption, filtration, evaporation, etc. these processes are generally effective for the removal of high strength organic and inorganic materials but the high cost per unit volume is the major draw back. The chemical methods include coagulation and precipitation and oxidation of the organics. The disadvantage of the coagulation and precipitation is the large amount of sludge produced which is difficult to manage.

Biological treatment has been used to reduce the COD of the effluents while many pollutants from wastewater may be only removed by chemical and physical methods like adsorption, coagulation–flocculation, oxidation, filtration and electrochemical treatments. All these methods have different color removal capabilities, capital costs and operating speed. Among these methods coagulation and adsorption are the commonly used; however these create huge amounts of sludge which become a pollutant on its own creating disposal problems. There is a great need to develop an economic and effective way of dealing with the landfill leachate wastewater in the face of the ever increasing production activities.

The major colored component in the leachate is the humic substances which are fractionated into humic acid and fulvic acid. These humic compounds are a complex mixture of organic compounds resulting from the decomposition of organic matter through enzymatic and auto-oxidative reactions. Fungi are the most efficient humic substance degraders. White rot fungi has been growing attention for use in bioremediation processes since these organisms have the ability to degrade a wide range of environmental pollutions (Fu and Viraraghavan, 2001; Paszczynski and Crawford, 1995; Pointing, 2001). White rot fungi are versatile and robust organisms having enormous potential for oxidative bioremediation of a variety of toxic chemical pollutants due to high tolerance to toxic substances in the environment. The white rot fungi have been extensively studied for their ability to degrade the complex plant polymer, lignin, and a broad spectrum of xenobiotic pollutants. Due to their large size of macromolecules such as color, they are not likely to be taken up by microbial cells; they are therefore initially degraded by extracellular enzymes, such as lignin-peroxidase (LiP), manganese peroxidase (MnP) and the laccases (Kastner and Hofrichter, 2001). Several factors make the white rot fungi particularly suitable for bioremediation applications. The non-specificity of the ligninolytic enzymes allows for the degradation of a range of pollutants, without extensive acclimation. The decolorization can be achieved either by adsorption or oxidative degradation by the enzymes (Fu and Viraraghavan, 2001). The pathway followed by each enzymatic product (degradation) is probably dependent not only on the enzymes and substrates involved, but also on reaction conditions, such as pH, humidity, percent oxygen and electrical conductivity, as well as on the presence of other compounds. Previous studies have shown a need for a carbon source for fungi (Swamy and Ramsay, 1999b). This association has been found in many other studies of both lignin and humic acid degradation. However, they do not require preconditioning to particular pollutants and owing to their extracellular nonspecific free radical-based enzymatic system, they cannot only decolorize but also biodegrade toxic chemicals as well. Due to the unique ability of nonspecific oxidizing enzymes to react with a variety of aromatic substrates, white rot fungi have been found to be the most efficient degraders of humic substances (Hofrichter and Fritsche, 1996; Gramss et al., 1999). The utilization of biodegradative abilities of some white rot fungi seems to be promising. Considering for both economic and ecological reasons; the fungi can be grown on a number of inexpensive agricultural or forest wastes such as cassava, bagasse and sawdust, biological degradation has become an increasingly popular alternative for the treatment of leachate.

While many studies have been carried out on biodecolorization for example; decolorization of textile dyes and their effluents using white rot fungi (Sathiya et al., 2007), biological treatment of a pulp and paper industry effluent by *Fomes lividus* and Trametes versicolor (Selvam et al., 2002), degradation of lignin in pulp mill wastewaters by white rot fungi on biofilm (Wu et al., 2005), no attention has been paid to the treatment of leachate by white rot fungi. *Trametes versicolor* was chosen in this study because of the previously shown potential for decolorization ad organic treatment (Benito et al., 1997, Raghukumar et al., 2001; Jimenez et al. 1997).

1.3 Objective of Study

Batch and continuous experiments were conducted to investigate the technical feasibility of using immobilized white rot fungus, *Trametes versicolor* BCC 8725 and *Flavodon flavus* BCC 17421 on polyurethane foam (PUF) to treat landfill leachate.

The specific objectives of the study are as follows:

- To investigate treatment of landfill leachate using white rot fungi in batch and continuous experiment.
- To find out the optimum conditions required to achieve maximum removal of color, BOD and COD with different types and doses of co-substrate in batch experiments.
- To investigate the effect of organic loading, degree of immobilization and reuse of fungi in continuous experiments.
- To compare the removal efficiency of batch and continuous experiment.

1.4 Scope of Study

1) Leachate was collected from Nonthaburi solid waste disposal site and garbage truck.
2) The white rot fungi namely *Trametes versicolor* BCC 8725 *and Flavodon flavus* BCC 17421 were used for the landfill leachate treatment in this study and were obtained from the Biotech Central Research Unit, Pathumthani, Thailand.
3) *T.versicolor* BCC 8725 and *F.flavus* BCC 17421 were immobilized on PUF and biomass growth was observed with and without co-substrate.
4) Glucose, cassava and corn starch were used as co-substrates and varied at different concentration to find maximum color removal efficiency.
5) In batch experiment, pH, co-substrates (glucose, cassava, and corn starch) and contact time were varied to find optimum color removal.
6) In batch experiment, reuse of immobilized *T.versicolor* BCC 8725 was studied for the leachate collected from garbage truck in Nonthaburi district for 4 cycles (1 cycle = 7 days)
7) Color, BOD and COD were measured both before treatment and after treatment at optimal conditions.
8) In continuous experiment, the effect of organic loading was studied by diluting the leachate 5-time and 10-time.
9) In continuous experiment, the effect of degree of immobilization was investigated by immobilized the fungi initially for 4 and 15 days in PDB.
10) In continuous experiment, the effect of reuse of fungi was carried out for 4 cycles of 5 days each.