CHAPTER I

INTRODUCTION

1.1 Statement of the Problem

The emissions of volatile organic compounds (VOCs) such as benzene, toluene, ethylbenzene, xylene, styrene, phenol, formaldehyde, methylene, chloride, ethylene glycol, texanol, and 1,3-butadiene are becoming a serious concern for global environmental conservation. VOCs refer to organic compounds which vapor pressure is at least 0.01 kPa at 20 °C with low water solubility (de Nevers, 2000; Pagans *et al.*, 2006). They are atmospheric pollutants and have adverse effects on human health, harmful to animals and environment (Kuroki *et al.,* 2007). The removal of them has become a major air pollution concern (Malhautier *et al.,* 2005).

Various treatment technologies, including chemical, physical, and biological means have been developed for removal of VOCs from waste gases. The current control process, based on vapor-phase adsorption followed by thermal oxidation, is costly to install and operate (Kim *et al.,* 2000). Among them, the biofiltration system has received much attention as a more ecologically cost-effective process than conventional technologies. The removal of VOCs from a polluted air stream using a biological process is highly efficient and has low installation operation and maintenance costs (Chan and Lin, 2006; Devinny *et al.,* 1999).

Xylene isomers have been listed as hazardous and toxic atmospheric contaminants. It is one of VOCs that is used as a solvent in products such as paints, paint thinners, shellacs, lacquers, permanent ink markers, and carpet adhesives. It is also found in cigarette smoke, gasoline and car exhaust. A large share of the total emissions of xylene into the atmosphere is considered to be from industrial facilities. It has chemical structure as dimethyl benzene ($CH_3C_6H_4CH_3$), with molecular weight of 106.16 and consists of isomeric forms including ortho, meta, and para. They are distributed widely in the environment; they have been detected in air, rainwater, soils, surface water, sediments, drinking water, and aquatic organisms (EPA, 2006). The worldwide markets for xylene in thousands of metric tons were in US, Canada, Japan, Europe, Asia Pacific, Middle East, and Latin America (Global Industry Analysts, 2006).

The exposure routes to xylene are via inhalation, ingestion, eye or skin contact, and, to a small extent, by absorption through the skin (OSHA, 2000). Sign and symptoms, the first signs of adverse effects on humans are irritation of the nose, throat and eyes. The irritation occurs at low levels after short exposures. The symptoms include fatigue, weakness, confusion, headache, nervousness, muscular fatigue, insomnia, dermatitis, tearing, and intolerance of light. Xylene exposure has been associated with effects in a number of organ systems including the lungs, skin and eyes; neurological system; heart and gastrointestinal system, kidney, and possibly the reproductive system. Pulmonary effects have been documented in occupational exposures to undetermined concentrations of mixed xylenes and other solvents and include laboured breathing and impaired pulmonary function (Air Toxics NEPM, 2003).

Conventional VOCs control techniques such as adsorption and absorption, scrubbing, condensation, thermal and catalytic incineration has been used to treat VOCs in polluted air stream (Rene *et al.,* 2004). Although conventional VOCs treatment technologies were useful for reducing emission pollutants, they can generate undesirable by -products and are less cost-effective when treating high flow air streams containing low concentrations of pollutants.

Biological treatment, especially biofiltration is an alternative air pollution control technology for VOCs because of its cost-effectiveness for certain waste gas streams when compared with other conventional VOCs control options. Biofilter is an inexpensive method for biodegradable gas-phase contaminants, capable of meeting stringent air quality requirements (Wright, 2005). Biofiltration uses microorganisms to degrade various pollutants. A waste gas stream is purified by passage through a biologically active medium under aerobic conditions. It involves microorganisms immobilized in the form of a biofilm on a porous carrier, such as, peat, soil, compost, synthetic substances or combinations of them. The system provides the microorganisms with a favorable environment in terms of pH, temperature, moisture, nutrients and oxygen supply (Sene *et al.,* 2002; Ramírez-López *et al.,* 2003). These microorganisms organize themselves into a biolayer on the surface of packing material. As contaminated air flows through the material, the air pollutants are transferred to the biolayer where they are transformed by the microbes residing it into water, carbon dioxide, mineral salts, and new microbial mass (Sene *et al.*, 2002). The packing media widely used in biofiltration are sugarcane bagasse, glass beads, activated carbon, polystyrene packaging, soil, broken brick, compost, wood mulch, pig manure, sawdust peanut shells, rice husk, coconut shells, and maize stubble (Sene *et al.,* 2002; Christen *et al.,* 2002; Elias *et al.,* 2002; Ramírez-López *et al.,* 2003; Kim, 2003; Khammar *et al.*, 2004; Savage and Tyrrel, 2005). The diversity of biofiltration mechanisms and their interaction with the microflora means that biofilter is defined as a complex and structured ecosystem (Malhautier *et al*., 2005).

The advantages of biofiltration are lower capita costs; lower operating costs, low chemical usage, and no combustion. It can be designed to physically fit into most industrial settings. It can be designed as any shape, size or as an open field with the piping and delivery system underground. The treatment efficiencies for VOCs can be above 90% for low concentrations of contaminants. Different media, microbes and operating conditions can be used. Unlike conventional control technologies, biofilters do not produce hazardous by- products. Disadvantages of biofiltration are that it cannot successfully treat some organic compounds, which have low adsorption or microbial degradation rates. This is especially true for chlorinated VOCs. Contaminant sources with high chemical emissions would require large biofilter units or open areas to install biofiltration systems. Biofiltration requires constant and consistent loading condition and the removal efficiency degrades substantially after shutdown periods lasting longer than a few weeks. They were not considered capable of treating extreme fluctuations in VOCs loading concentration or highly concentrated loading. Biofilters previously have been limited to be used with contaminated air streams with relatively low and consistent concentrations of pollutants.

In addition, acclimation periods for the microbial population may take weeks or even months, especially for VOC treatment (Stewart and Kamarthi, 1997; Anit and Artuz, n.d). Biofilter's performance is dependent on many factors, including, the microbial community, contaminants to be degraded, and reactor operating conditions such as moisture content, pH, temperature, pressure, residence time, and nutrient availability. Microbial degradation kinetics play a vital role in the design and scale up of a biofilter and therefore, it is imperative that these be well understood and defined if biofiltration is to be used successfully in industrial applications (Dirk-Faitakis and Allen, 2000).

The mixed culture is commonly used in biofilter to remove pollutants. Mixed cultures were used for removal of BTX and other VOCs (du Plessis *et al.,* 2001; Veiga *et al.,* 1999). Activated sludge from wastewater treatment plant was taken as a popular initial microorganisms source (Singh *et al.,* 2006). Bacteria such as Bacillus and Pseudomonas were shown as a dominant species (Veiga *et al.,* 1999; Andreoni *et al.,* 1996). Pure culture of the fungus *Cladosporium sphaerospermum*, was also used for VOC mixture treatment. (Qi *et al.,* 2005) *Exophiala oligosperma or Paecilomyces variotii* were also used to remove toluene (Estévez *et al.,* 2005) and *Aspergillus niger* was successfully applied to remove hexane from contaminated air streams in biofilter (Spigno *et al.*, 2003).

Biofiltration is based on the natural ability of a specific microbial species to degrade the target pollutant. Fungi, bacteria and actinomycetes are main microorganisms in biofilter process. However, the species of microorganisms specific for xylene degradation in biofiltration process are still unknown. In this research, the dominant microorganisms species for xylene degradation will be identified and the performance of dominance species on biofiltration will be investigated.

1.2 Objectives of the Study

1.2.1 To select and identify microorganisms' specific for xylene degradation in biofilter system.

1.2.2 To investigate the xylene removal efficiency by selected microorganisms in biofilter system.

1.3 Scope of this Study

This research study aimed to investigate the application of biofiltration for the treatment of xylene vapor. The performance of biofiltration system inoculated with selected species of microorganisms will be evaluated.

Type of microorganisms in this study are M1: *Aspergillus flavus,* M2: *Aspergillus terreus and* M3: *Penicillium glabrum.* Biofilter Media consisted of coconut husk and manure at ratio 70: 30 (v/v) with initial moisture content 50 % of dry weight.

Research study period was June 2005-March 2007.

1.4 Conceptual Framework

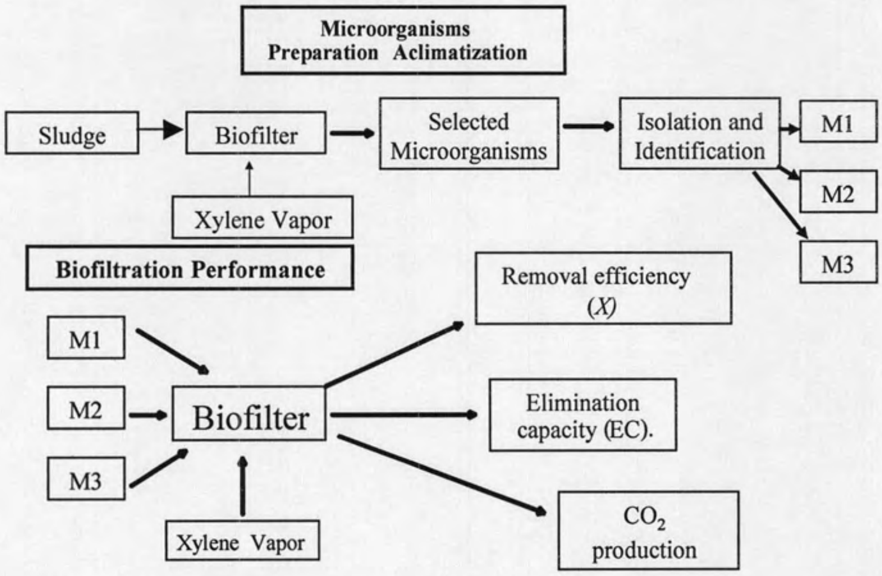

Figure 1 -1 Conceptual Framework

1.5 Benefits of this Study

The research will provide the information on the specific microbial species suitable for xylene vapor degradation in biofiltration process. The information on xylene degradation in biofiltration will be useful for treatment of xylene vapor in industry.