CHAPTER I
INTRODUCTION

1.1 Introduction

Carbofuran (2,3-dihydro-2,2-dimethylbenzofuran-7-yl-methylcarbamate) is a broad spectrum carbamate insecticide widely used to control insects and nematodes on contact or after ingestion (EPA, 2003). It is widely used in paddy field by spraying directly onto paddy soil and water (EPA, 2003). Carbofuran is an environmental importance because of its high toxicity through cholinesterase inhibition. For example, LD_{50} in mice is 2 mg/kg (EPA, 2003). The half-life of carbofuran in bulk soil is 30-120 days depending on moisture content, temperature, pH, and number of microorganisms (DeVries and Evans, 1999). Its low adsorption coefficient (K_{oc}= 22 at 25°C) and high water solubility (320 mg/L at 25°C) resulting in the contamination of carbofuran in the environment (Extonet, 1996). Carbofuran was reported to moderately mobile in soil and surface runoff (Cohen.1996). It was detected 0.2 mg/kg soil in rice field, North-Eastern, Thailand (Aiumsupasit, 2005). The widespread use of carbofuran in liquid and solid forms to kill insects in agricultural areas contributes to a possible contamination of carbofuran in the environment. Runoff of pesticide from agricultural areas, accident between transportation as well as rinsate from cleaning pesticides containers and application equipments are also the possibilities sources of carbofuran in the environment (Ferrell, 2003).

Two types of the contaminants polluted the soil environment are characterized (i) recently-contaminated soil; and (ii) aged-contaminated soil (Trindade et al., 2005). In this present work we paid attention to both types of contaminations. Aged-contaminated soil received an attention because aging process made the contaminants become increasingly resistant with the time to extraction and difficult to remove (Moorman et al., 2001). The approach of this study to remove carbofuran from soil was to use biostimulation technique.

Biostimulation refers to the addition of nutrients, air or oxygen into the contaminated systems with an attempt to stimulate the indigenous microbial population to degrade the contaminants of concern (Vidali, 2001). Advantages of this method are simple to maintain, applicable over large areas, cost-effective, and leads to the complete destruction of the contaminant (Vidali, 2001). Biostimulation has been

reported to successfully remediate various types of contaminant such as petroleum hydrocarbon (Perez et al., 2004, Barahona et al., 2004, Gallego et al., 2001, Dibyendu et al., 2005) and pesticides (Wong et al., 2005; Maria et al., 2006; Moorman et al., 2001; Atagana, 2006). Agricultural residues were used to stimulate the degradation of contaminants. For example, farm manure, straw and nitrogen fertilizer were used to biostimulate the degradation of atrazine in soil (Hance, 1973). Addition of fertilizer reduced the PAHs concentration from 210 mg/kg soil to 21 mg/kg soil (Atagana et al., 2006). Zhang and Frankenberger (2002) reported that the addition of rice straw accelerated the selenate removal from 1000 μg/L to 70 μg/L in agricultural drainage water. Addition of compost, corn stalks, corn fermentation by product, peat, manure, and sawdust at the rates of 0.5% and 5% enhanced the degradation of atrazine, metholachlor, and trifluralin from 175, 182, and 165 mg/kg soil to 122.5, 122, and 92.4 mg/kg soil, respectively (Moorman et al., 2001). Venkateswarlu and Sethunathan (1979) reported that a rapid removal of carbofuran (80%) was obtained when rice straw was added into the carbofuran contaminated rice soils compared to un-amended soils (34%). These data indicated a promise of using agricultural residues to stimulate the microorganisms to degrade contaminants. However, there is a very limited information on using agricultural residues to biostimulate carbofuran degradation in soil and aged soil.

In order to discover the responses of microbial to the environment such as substrate concentration, temperature, and dissolved oxygen concentration, etc. the kinetic characterization is needed. Though, to the best knowledge, there is no report on kinetics of cell growth and biodegradation of carbofuran by mixed cultures.

Therefore, in this study two different types of soil amendments i.e., various kinds of organic amendment from agricultural residues and synthetic inorganic amendment were used to investigate biostimulation effect on carbofuran degradation in soil and aged soil. Laboratory microcosms with carbofuran-spiked soils were incubated to estimate: (1) the efficiency of adopted amendments in degrading carbofuran; (2) the soil microbial activity based on total CO_2 release and enzymatic activity i.e., dehydrogenase activity; and (3) the responses of carbofuran degradation isolated from successful biostimulated microcosm to various concentrations of carbofuran. Information from this study would provide necessary information for the possible *in situ* bioremediation of carbofuran in soil and aged soil.

1.2 Objectives

1.2.1 Main objective

To enhance the removal of carbofuran from soil and aged soil by biostimulation technique.

1.2.2 Sub-objectives

1.2.2.1 To study the effect of organic amendments on carbofuran degradation in soil.

1.2.2.2 To study the effect of inorganic amendments on carbofuran degradation in soil.

1.2.2.3 To examine the efficiency of biostimulation technique in carbofuran removal from aged soil.

1.2.2.4 To examine the responses of microbial obtained from successful biostimulated soil to various concentrations of carbofuran.

1.3 Hypothesis

Organic and inorganic amendments can enhance the efficiency of carbofuran removal from soils and aged soil.

1.4 Scope of the study

This study covered the investigations on the effect of organic and inorganic amendments on biostimulation of carbofuran degradation in soil and aged soil. Kinetic characterization of mixed culture in the most successful biostimulated microcosm compared to non-biostimulated microcosm were conducted in order to obtain the helpful information on the responses of microbials to the various concentrations of carbofuran.