UNIVERSITI TEKNOLOGI MARA

TECHNICAL REPORT

NUMERICAL SOLUTION OF LINEAR REACTION-DIFFUSION PROCESSES ON FIXED DOMAIN: CRITERIA FOR COLONIZATION

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IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

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ABSTRACT

The macroscopic pattern exhibited by bacterial colony depends on certain environmental parameters and it gives some clues about the coordinated colonization strategy followed by the community of cell. Mathematical models of such colonization pattern usually take the form of a reaction-diffusion partial differential equation (PDE) on fixed domain. This research presents a numerical solution of linear reaction-diffusion PDE on fixed domain. The solution is for a general class of one-dimensional linear reaction-diffusion process with interval of domain fixed on $x = [0, 1]$. The linear reaction-diffusion problem model is solved numerically via finite difference method implicitly which are Crank-Nicholson (C-N) and Backward time Central space (BTCS) approach and is verified with pdepe solver in MATLAB. Crank-Nicholson and Backward time Central space approach are chosen because the methods are unconditionally stable. Furthermore, this research paper also illustrates a delicate interplay between the diffusivity associated with the spreading density profile and the grow rate of the bacteria species. Alternating the balance between this two features leads to different outcomes in term of colonizes the entire length of fixed domain and the condense rate of cell concentration at a particular nodes of the domain.

1 INTRODUCTION

1.1 Research Background

Partial differential equation that consist of diffusion (spreading out) term and reaction of one or several chemical species are called reaction-diffusion equation. Reaction term is refers to an interaction between two or more object. In case of one-dimensional reaction, the reaction part determine either the system is expanding or decaying. In more specific way, reaction term is describe as the change in concentration of species depending on its local value (Kimura, 2014). It is interested to study the reaction-diffusion models since it is widely used in various fields, including chemical, physics and biology. Such model are often implemented in real life to study the system itself. Its can also be analyzed how the system work based on mathematical model used that mimic the real life situation. It can be said that reaction-diffusion is always occurs at surroundings.

Cell colonization is defined as the formation of compact population groups of the same type of microorganism. Cell colonization is an essential in biological fields and applications such as vascularization, healing process, tissue development and biosensors. Lawrence & Madihall (2008), Simpson (2015) proposed a reaction diffusion model on colonization of cell. The mathematical model of reaction diffusion on colonization that proposed by Simpson (2015) include the cell diffusivity and growth rate of cell which play important role on colonization. Diffusivity is refer to a measure of the capability of a substance to be diffused. According to Gaur et al. (2014), the diffusion transport goes from region of high concentration to regions of low concentration. Diffusion is also a result of the random walk of the particles. When the cell diffusive from the left end to the right end of the domain, the movement of cell from one end to another is called as the migration of cell. Cell migration is fundamental to establishing and maintaining the proper organization of multicellular organisms and formation of colonies (Trepat et al., 2012).