MATHEMATICAL MODELING OF WATER POLLUTION IN RIVER

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To my beloved mother and father

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ABSTRACT

This project proposed a steady one-dimensional advection-dispersion-reaction equation to calculate the chemical oxygen demand (COD) concentration in a river. (COD) refers to the amount of oxygen required to oxidize the organic compounds in a water sample to carbon dioxide and water[1]. It is used for monitoring and control of discharges, and for assessing water treatment performance[2]. The equation is converted to second order linear ordinary differential equation and solved by using finite difference method (FDM). The method involving finite differences for solving boundary-value problems replace each of the derivatives in the differential equation with an appropriate difference-quotient approximation. The derivatives are approximated by using forward difference, backward difference and central difference. The resulting system of equations is expressed in the tridiagonal N x N matrix form which can be solved by Thomas Algorithm. From the result, a total of 1.0161 mg/L COD concentrations is reduced with the least treatment cost of euro 663. In addition, 1 mg/L of COD concentration is reduced by using 35 pieces of EM mudballs within the 10000m^3 of polluted water in two days. The estimated cost is RM 22.75.

ABSTRAK

Projek ini mencadangkan persamaan stabil satu dimensi olahan-penyebaran-tindak balas untuk mengira daya penumpuan “chemical oxygen demand (COD)” di sungai. “Chemical oxygen demand (COD)” merujuk kepada kuantiti oksigen yang diperlukan untuk proses mengoksidakan bahan organik dalam air kepada karbon dioksida dan air. Ia juga boleh memerhati dan menilai keberkesanan process rawatan air. Persamaan tersebut akan ditukar kepada linear pembezaan biasa terbitan kedua dan boleh diselesaikan dengan Kaedah Beza Terhingga. Kaedah ini merangkumi penggunaan pembezaan terhingga untuk menyelesaikan syarat sempadan yang mengganti setiap terbitan di dalam persamaan pembezaan . Terbitan tersebut boleh dianggarkan dengan perbezaan formula hadapan, perbezaan formula belakang dan perbezaan formula pusat. Persamaan sistem yang didapati adalah dalam bentuk tiga-penjuru N x N matrik yang boleh diselesaikan dengan kaedah “Thomas Algorithm”. Keputusannya, anggaran sebanyak 1.0161 mg/L (COD) telah diturunkan dengan kos 663 euro. Tambahan pula, 1mg/L (COD) dapat diturunkan dengan 35 biji bebola (EM) dalam lingkungan 10000m^3 air tercemar dengan masa selama dua hari. Kos yang diperlukan ialah RM 22.75.

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EM	Effective Microorganism
EMAS	Effective Microorganism Activated Solution
FDM	Finite Difference Method
TSS	Total Suspended Solid

LIST OF SYMBOLS

$c(x)$	concentration of COD at the point $x \in [a,b](kg/m^3)$
u	flow velocity in the x-direction (m/s)
D_x	diffusion coefficient m^2/s
R	substance decay rate (s^{-1})
Q	rate of change if substance concentration due to source $kg/m^2 s$

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CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. Water pollution affects plants and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and populations, but also to the natural biological communities. An understanding of the behavior and fate of chemicals, which are discharged to the aquatic environment as a result of these activities, is essential to the control of water pollution. Figure 1.1 show types of river pollution on the earth.

In Malaysia, water pollution is a serious problem and impacts negatively on the sustainability of water resources. It reduces total water availability considerably as the cost of treating polluted waters is too high and in some instances, polluted waters are not treatable for consumption. The large majority of source of water pollution can be categorized into three categories of waste (Figure 1.2).

(a) Domestic wastes

(b) Industrial and

(c) Agricultural

Figure 1.1 : Sources of River Pollution

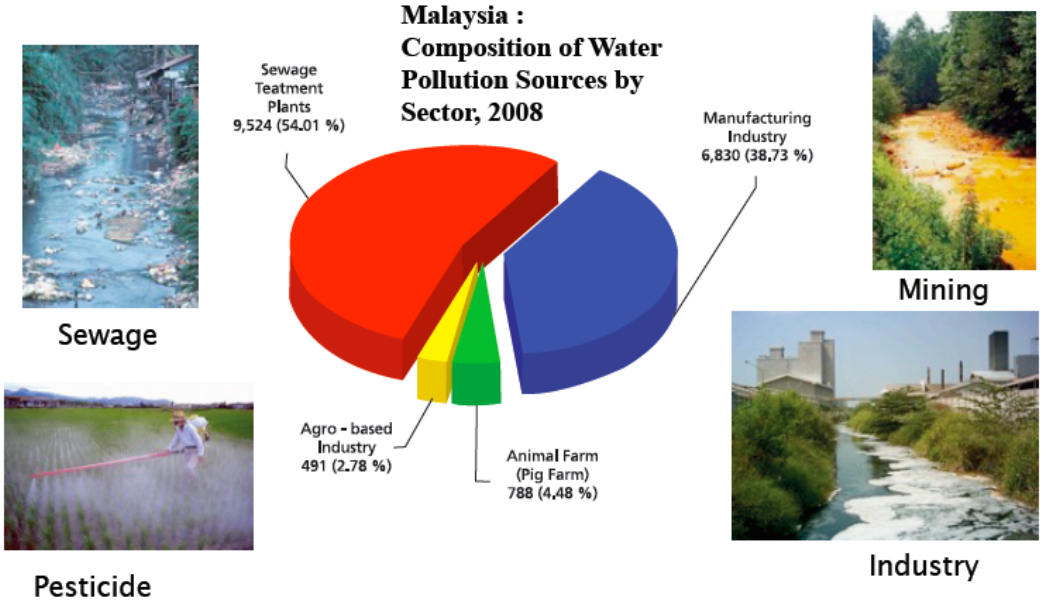

Figure 1.2 Source : Pollution Sources Inventory, 2008

Effective Microorganism (EM) Technology was proposed to be a solution way to reduce pollution problem in river with the lowest impact bring to the environment. The technology of Effective Microorganisms (EM) was first developed at the University of Ryukus, Japan by Dr. Teruo Higa during the 1970's. Developments EM Technology over the past 3 decades indicated that the beneficial effects of EM could be extended considerably beyond agriculture and the environment largely because of the antioxidant potential of EM cultures. Based on research and development activities in many countries, EM is now increasingly viewed as a means of providing solutions to many problems of food production, depletion of natural resources, environmental pollution, food safety and nutrition, and human and animal health. Further review about Effective Microorganism (EM) Technology will be mentioned in Chapter 2.

1.2 PROBLEM STATEMENT

Pollutant wastes that discharged into rivers utilizes dissolved oxygen (DO) of water in river. The depletion of oxygen in river water makes it difficult for the biota of the river to survive. The amount of dissolved oxygen in river is dependent on the water temperature, the quantity of sediment in the river, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, river flow, and aeration.

Since dissolved oxygen (DO) is indirectly proportional to chemical oxygen demand (COD). The problem now is how to calculate the COD in rivers in order to achieve an optimal control in treating river pollution using EM product. Efforts will also put in to study the amount of Effective Microorganism (EM) product to be used to become effectual in treating river pollution and increasing river water quality.

1.3 OBJECTIVES

The objectives of this research are :

(i) To calculate the amount of (COD) by using advection-diffusion-reaction equation with finite difference method.

(i) To determine the quantity of (EM) product to be used to reduce the level of COD concentration.

1.4 SCOPES OF STUDY

Based on the study in journal " An optimal Control of Water Pollution in a Stream Using a Finite Difference Method", the focus is to assess the chemical oxygen demand (COD) concentration in a river by using finite difference method. These are then subjected to the optimal control of the polluted river to achieve minimum cost. Study is also conducted to determine the amount of EM product needed to increase river water quality.

1.5 SIGNIFICANCE OF STUDY

A report from Pollution Sources Inventory, 2008, the causes of river pollution mainly contributed by sewage treatment plant, manufacturing industry, animal farm and agro-based industry. One of the environmental friendly solution is the use of Effective Microorganism (EM) Technology to help to increase the river water quality. Effective Microorganism (EM) Technology is an environmental friendly method that can be used by communities to help minimize the river pollution with the lowest impact bring to our environment.

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