CHAPTER 1

INTRODUCTION

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Rapid industrialization in Malaysia has led to pollution of the environment. The Environmental Quality Act of 1974 and its regulations were enacted to protect the environment by enforcing pollution control on the industries (DOE, 1993).

Pollution of the aquatic system is of special concern because of the possible hazards to the human population. Water pollution can lead to toxification of drinking waters, waterborne diseases and eutrophication of water bodies with consequent hydrological cycle imbalance.

Traditional waste treatment involves physical and chemical systems aiming to dilute or cleanse the water before disposal. With biological treatment the abundant nutrients are utilized by microorganisms. Waste treatment is the largest and one of the most important controlled applications of microorganisms. In the United States of America, a total of US$40,000 million is spent per year on pollution control. It is estimated that environmental impact and toxicity testing can account for 10 to 20 percent of the production cost of raw products. Costs may probably increase due to increased public demand for better environment (Wheat, 1987). In terms of health, environment and economy, the fight against pollution has become a major issue.

In Malaysia the number of polluted rivers have increased from seven in 1992 to eleven in 1993 (DOE 1993). Three parameters of concern are suspended solids (SS), ammoniacal-nitrogen (NH_3-N) and biochemical oxygen demand (BOD_5). All three parameters have shown deterioration with an increase in values of 2.72% , 1.10% and 0.41% respectively. In 1993 soil erosion and organic loading were cited as the main causes of river pollution (DOE, 1993).

In Malaysia there are currently 354 industries dealing with rubber based products. Of these 33.9% have failed to comply with the Discharge Standards (Sewage and Industrial Effluents Regulations, 1979) for raw natural rubber (Table 1.1). Lack of adequate maintenance of treatment systems was the principal reason for the noncompliance cases. Rubber efluent (RE) has high Chemical Oxygen Demand (COD), ammoniacal nitrogen (NH_3-N) and orthophosphate (PO_4-P) contents. Currently rubber factories are using anaerobic facultative ponding, oxidation ditch, activated sludge and land application systems for waste treatment.

The 1978 Environment Quality (Prescribed Premises - Raw Natural Rubber) Regulation, states that the effluent has to be treated to comply with regulatory standards set by the Department of Environment before discharge into the watercourse (Zaid Isa, 1993).(Table 1.1)

TABLE 1.1: Regulatory Standards of Water Course Discharge of Effluent from Rubber Processing Factories

PARAMETER	LATEX CONCENTRATE
pH	6 to 9
BOD	50 (100) *
COD	400
SS	100 (150) *
TN	300 (60) #
NH3-N	300 (40) #
Pb	0.5
Cu	1.0
Mn	1.0
Zn	1.0
Fe	5.0

All values except pH in mgL^{-1}

* No single value to exceed the limit in hte parentheses

Target limit to be achieved as soon possible in accordance with RRIM'S (Rubber Research Institute of Malaysia's) recomendation

With the present switch in concept from waste treatment to waste utilization, wastes like rubber effluent can now be viewed as a source of raw materials. Therefore integration of algal cultivation with rubber effluent treatment offers an economical and cost-effective system. The products are algal biomass, suitable for use as animal feed as it contains 40 - 70 % protein (Goldman, 1979)) and `clean' water. The cost of the system is thus shared by its waste treatment capability and the value of the algal biomass and algal products obtained.

The Algal Research Group at the Institute of Advanced Studies, University of Malaya has successfully cultivated a species of *Chlorella* in RE using the high-rate algal pond (HRAP) (Geetha *et al.*, 1994). The HRAP system proved to be an efficient waste treatment system achieving 98% COD removal with a retention time of 6-8 days. The *Chlorella* biomass, with 37 to 55% protein, 3.9 to 22% carbohydrate and 5 to 12.5% lipid contents is suitable for use as animal feed. During this study, suitable operating conditions in terms of biomass production and significant reduction in the polluting parameters, for the HRAP, was found to be at 0.1 m blade immersion-depth and a paddle-wheel speed of 20 rpm (flowrate of 17 cm/s). The preliminary studies showed carbon to be a limiting factor for algal growth in the HRAP (Geetha, 1992). The *Chlorella* was also found to possess heterotrophic ability.

Chui (1994) found that *Chorella* growth improved in the HRAP with addition of molasses as an organic carbon source. Molasses suplementation not only helped enhance algal yield but also improved nutrient removal especially NH_3-N and PO_4-P from the RE. Introduction of molasses under dim light conditions in the evenings was found to be more effective for heterotrophic utilization of the molasses by the *Chlorella*.

1.1 Objectives of this research

In this present study the main objective is to optimize the productivity of *Chlorella vulgaris* and treatment efficiency of the HRAP through:-

i) improving RE as a substrate for algal growth

ii) improving the carbon:nitrogen ratio of the rubber effluent (RE) by supplementation with inorganic carbon (CO_2) during autotrophic growth (daytime).

iii) supplementation with an organic carbon source, that is molasses, to further enhance heterotrophic growth of *Chlorella* in RE in the evening.