CHAPTER ONE : INTRODUCTION

1.1 Introduction

The British first introduced rubber trees *Hevea brasiliensis* during its colonisation of the then Malaya in the nineteenth century. Since then, rubber has progressed into one of the major agro-based industries that contributed to the development of our country. In fact, Malaysia is one of the leading producers of natural rubber in the world. In 1999, Malaysia was the third main producing country in natural rubber, after Thailand and Indonesia (Statistics on Commodities, 2000). The total production was 768,900 tonnes. The Association of Natural Rubber Producing Countries, which consists of Malaysia, Indonesia, Thailand, Sri Lanka, Papua New Guinea, reported that Malaysia contributed approximately 11.7% of the world grand total production of 6.59 million tonnes of natural rubber (Statistics on Commodities 2000). However, the production declined to 611,800 tonnes in 2000 or 20.4% less than the production in 1999 (Malaysian Rubber Review, 2001).

According to the Monthly Rubber Statistic Malaysia, Jan - Dec. 2000, export of natural rubber for 1998 was 435,500 tonnes. United States of America was our biggest importer amounting to 111,000 tonnes, followed Germany, Korea, China and United Kingdom with amounts of 100,300 tonnes, 84,100 tonnes, 66,300 tonnes and 50,900 tonnes, respectively.

Besides exporting the natural rubber, this valuable product is also being consumed in Malaysia as well. Our domestic consumption of natural rubber for 1999 amounted to

343,094 tonnes (Statistic on Commodities 2000). The major industries which consumed natural rubber were latex goods (270,943 tonnes or 68.3%), general rubber goods (55,131 tonnes or 13.9 %) and tyre (50,690 tonnes or 12.8%). These three industries accounted for more than 90% of the total domestic consumption of natural rubber.

The rubber industries can be categorised into two main groups i.e. the rubber processing industries and rubber product manufacturing industries. The former involves the production of latex concentrate and SMR.

While rubber processing industry has long been established in the market, rubber products manufacturing industry in Malaysia has grown at a tremendous rate in the 90's. In 2000, the export earning from rubber products was RM5.7 billion, an increase of thrice the amount for 1991 of RM2.1 billion (Liew, 2001). Latex-based products, which included gloves, catheters, and rubber threads remained the major contributors to exports, accounting for 79.1% or RM4.5 billion of the total export of rubber products (Ministry of International Trade & Industry, 2001).

The rubber glove manufacturing industry in Malaysia itself has expanded tremendously in the past few years due to the increase demand. In 2000, it was reported that the exports earning for rubber glove was RM3.4 billion, a slight decline of 5% from RM3.6 billion from the previous year. Catheters contributed approximately RM444.1 million of export earnings in the year 2000 (Ministry of International Trade & Industry, 2001).

The importance of the rubber industry is further felt with its contribution in the employment opportunities it has created. The rubber industry employed 63,120 workers, who constituted 6% of the total manufacturing sector employment. About 85.8% of the employment was concentrated in the sub-sector producing other rubber products, inclusive of latex-based products, industrial rubber goods and general rubber products (Ministry of International Trade & Industry, 2001).

1.2 Generation of Rubber Effluent during the Processes

While most modern civilisation owes much to the development of agriculture and agro-based industries, most of these industries also created potential threat to our environment. The natural rubber industry, with a wide variety of products, is no exception. While rubber industry is recognised as one of the main contributor to the development of Malaysia, it is also undeniably one of the major sources of organic pollution in this country. It was estimated approximately 31 million litres of effluent from latex-based industry are being discharged into the Malaysian watercourses daily (Zaid, 1992a).

The rubber effluent can be classified according to the type of processing procedure. There are two major types of rubber industries based on the processes involved, namely rubber processing and rubber product manufacturing. Both the industries discharge large volumes of effluent into the water stream daily. During the processing of rubber, water is always required in varying amounts for washing, creaming and dilutions. For example, field latex contains about 30% dry rubber, while the balance

is in the form of water, and will eventually constitute the final wastewater produced. The effluent consists mainly of process water, uncoagulated latex and non-latex components including sugars, proteins, lipids and others.

Generally, the characteristics of effluent from rubber processing industry are different from the effluent from rubber product manufacturing industry. The raw effluent from the former generally exhibits higher values for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Solids (TS), Suspended Solids (SS), Total Nitrogen and pH, as compared to the latter.

In rubber products manufacturing industry, there are at least four main stages in the process that will eventually lead to the generation of effluent. The stages are former cleaning, latex compounding, latex dipping line and tumbling (see Figure 1.1).

There are four main sources of effluent from glove manufacturing industry:

1. Former cleaning tank
   - Normally acidified water is used to clean the formers. Therefore the effluent from this stage contains residual acid or detergent.

2. Latex Dipping tank
   - Two types of effluent are generated from the latex-dipping tank. The first type is the washing water used to clean the tank, while the second type is the sludge from the tank itself. The sludge will be discharged during the cleaning of tank, which is usually carried out once every fortnightly or every three weeks.

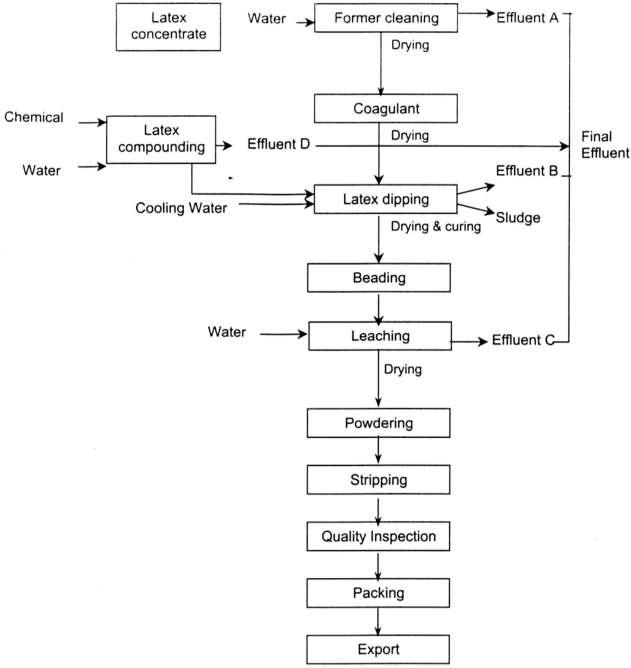

Figure 1.1: Generation of effluent from the examination glove manufacturing industry at different location of the process. (Zaid, 1993b)

3. Leaching tank

- At this stage, pollutants will be leached out from the gloves when they are washed with water. The effluent discharged is the main source of effluent from examination glove manufacturing plant.

4. Latex compounding

- Effluent from this stage contains mainly washing water from ball mill, latex containers, uncoagulated latex and sludge.

1.3 Regulatory Standards

The rubber product manufacturing industry is required by the Environmental Quality Regulations (Sewage and Industrial Effluents) 1979 to treat its effluent in order to comply with the regulatory standards for sewage and industrial waste (see Appendix A). These standards were formulated by the Department of Environment (DOE) for the control of watercourse discharge of sewage and industrial effluents (DOE, 1979). There are two sets of standards depending of the location of discharge point of the wastewater. Standard A is applicable to factories located at the upstream of water supply intake, while Standard B applies to factories located at the downstream of water supply intake. As it is critical to control and minimise the pollution of the water supply intake at the upstream, the requirement for Standard A is more stringent as compared to Standard B.

1.4 Treatment of Effluent

Often the raw effluent discharge from the production line contains high levels of COD, BOD and other parameters which well exceeded the limit of the discharge standard under the Malaysian Third Schedule of the Environmental Quality Regulations (Sewage and Industrial Effluents) 1979. As such it is critical that the effluent needs to be treated to bring down the level of these parameters to within the standard before being discharged into the public drain, river or receiving water.

When discharged into rivers the effluent from rubber glove manufacturing factories will normally undergo natural decomposition during which oxygen naturally present in the rivers is rapidly depleted. A clean river should have a BOD level of 2 ppm, while a value of 5 ppm is for a moderately clean river. Effluent from rubber glove manufacturing industries is known to contain BOD level ranging from 20 to approximately 2000 ppm (Zaid, 2001). As such any discharging effort of this effluent into the river will inevitably pollute the river.

Being one of the top exporters of latex products, and with long-standing history in this field, a considerable amount of work has been carried out on the treatment of wastewater generated from these industries in Malaysia. In fact, most of the rubber products manufacturing industries in our country are equipped with proper treatment system to treat the effluent prior to discharge to outlets. In line with the stringent regulations enforced by Malaysian government, the factories' owners will be prosecuted and they will be fined or jailed or both should they fail to install treatment plants to treat the wastewater. This measure, as part of Malaysian government's

serious commitment to safeguard the environment, is taken to ensure the environment is well protected and to prevent further degradation to our environment.

There are numerous treatment systems used by the latex-based industries. However, these treatment systems generally involve at least two stages i.e. the primary treatment and secondary treatment as shown in Figure 1.2.

In the primary treatment, large solids are removed by screening. The effluents, which were generated from various sources in the production lines at different times, will then be equalised in the equalisation basin. The objective of the equalisation basin is to minimise or control the fluctuations in wastewater characteristics in order to provide optimum conditions for subsequent treatment processes.

Neutralisation step takes place after equalisation. Either acid or alkaline will be added to neutralise the effluent that may contain acidic or alkaline materials. It is important to neutralise these materials prior to discharge into the receiving water or to the next stage of chemical treatment or biological treatment. Coagulants such as alum, lime or ferric chloride are dosed into the effluent during the coagulation process. These coagulants will help to coagulate the suspended or colloidal materials found in the wastewater that often do not settle out on the standing and cannot be removed by conventional physical treatment processes. Colloids are particles over a size range of 0.1nm to 1nm.

Besides coagulants, flocculants are added into the effluent in order to flocculate the finely divided particles existing in the effluents, to form bigger particles. Both

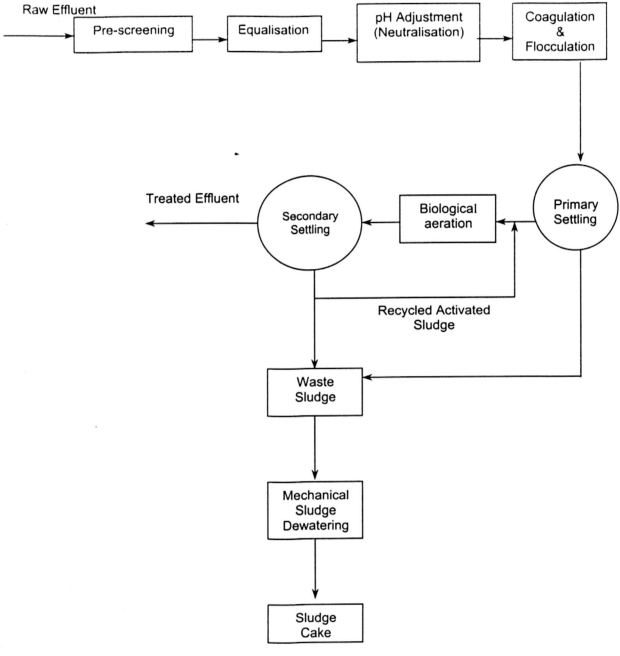

Figure 1.2 : Typical Process Diagram for Rubber Industry Effluent Treatment System

coagulation and flocculation processes will increase the removal of the suspended solids (SS) and BOD in the primary settling facilities and subsequently improve the performance of secondary settling tanks following the biological process. Since chemicals are used in the processes of treating the effluent, this stage is also known chemical process or treatment.

The primary treatment has proven to be an effective step for the treatment of effluent from latex-based industries. It helps to remove the settleable solid and floating material through primary sedimentation and thus reduced the suspended solid content and BOD level in the effluent. Primary sedimentation tanks varies from conventional circular clarifier, conventional rectangular sedimentation tank to the more sophisticated and efficient technologies such as dissolve air flotation (DAF), rotary screen, cavitation air flotation (CAF), etc.

The partially treated effluent will subsequently undergo biological treatment. Often known as secondary treatment, biological processes are used to convert the finely divided organic matter in the wastewater into flocculant settleable biological and inorganic solids that can be removed in the secondary settling tank.

Sludge generated from the primary and secondary settling tank will then be subjected through a series of treatment steps involving thickening, dewatering and final disposal. Meanwhile, the clarified effluent, which must adhere to the requirements of the Department of Environment (DOE), will be discharged into the receiving water. Filtrate generated from the dewatering stage will be recycled back to the equalisation basin.

1.5 Performance Studies on Rubber Glove Manufacturing Plants

A comparative study on the performance of effluent treatment plant from on three gloves manufacturing factories was carried out. However, as these plants are commercial-based and in order to safeguard their business interest, the names of these plants could not be revealed. These manufacturing plants could only be identified as Factory A, B and C. Factory A with the generation of approximately 166 m^3 daily is located in Kuala Pilah, Negeri Sembilan while Factory B with the effluent capacity of 1000 m^3/d is located in Kuantan, Pahang. Factory C, located in Setiawan, Perak, is designed to cater approximately 1200 m^3/d of effluent generated from its production lines.

The design systems adopted for these treatment plants are alike. The treatment systems for all these plants A, B and C involved chemical-flocculation with DAF as the primary treatment, followed by activated sludge process (extended aeration).

This study emphasised the effectiveness of the effluent treatment plants in reducing the pollutant parameters in the wastewater. This will help to determine whether the design of these three wastewater treatment plants (WWTPs) are suitable to treat the effluent from rubber gloves manufacturing, and thus enable to establish the most appropriate design for this kind of effluent. Three main parameters were selected for this study, namely Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Suspended Solids (SS). A reduction in BOD, COD and SS means reduction of organic pollutants, and subsequently less polluted water down stream. Besides determining the efficiency of the treatment plants, this study will also

investigate the efficiency of various stages of the wastewater treatment plants (WWTPs), on the removal of BOD, COD and SS in the effluent.

This will help to create a better understanding of the wastewater characteristics and its susceptibility to different kinds of treatment. As rubber gloves manufacturing effluent contains both organic and inorganic solids which are potentially oxygen-absorbing materials, both chemical-physical and biological treatments are necessary to reduce its BOD level.

1.6 Objectives of this study

To investigate the overall performance of the existing wastewater treatment plants (WWTPs) from three rubber glove manufacturing plants based on the following analyses or determinations:

a) To characterise the effluent from rubber gloves manufacturing factories.

b) To study the efficiency of the different stages of the WWTPs on removal of BOD, COD and suspended solids (SS) in the effluent.

c) To study the impact of the size of the WWTP on the performance to remove polluted parameters, and

d) To determine if the design of these three WWTPs is appropriate to handle the effluent from rubber gloves manufacturing industries.