CHAPTER 1 : INTRODUCTION

1.0 PREAMBLE

Waste can be characterised as material or energy, which in the eyes of the producer, arises at a rate and in a form such that it has no value. While it has no perceived value to the producer, it represents a loss of raw materials or energy that the producer has paid for, and more importantly, it has the potential to cause environmental harm, directly or indirectly. Treatment and disposal of waste has also become increasingly more regulated and expensive over the years.

To deal with the many issues and problems associated with industrialisation, industries are deluged with environmental, health and safety regulations. In the 1970's and 1980's some large companies in North America and Europe realised the impact of this regulations on their businesses and adopted a proactive stance rather than reacting to the regulatory requirements. They began to apply good management practises to environmental programmes and projects and subsequently integrated them into their daily business practices. This spawned the various Environmental Management Systems (EMSs) such as the BS 7750, "Environmental Management Systems", in the United Kingdom, the "Eco-Management and Audit Scheme" (EMAS) in Europe and the Chemical Manufacturing Associations "Responsible Care Programme" in the United States and Canada. In preparation for the United Nation Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, the International Organisation for Standardisation (ISO) formed the Strategic Action Group on Environment. This group through the ISO Technical Committee recommended the

development of an environmental management standard, and the result as we all know today, is the ISO 14000 environmental management series standards.

Environmental management essentially evolves a plan of action, based on a comprehensive assessment over the state of the environment vis-à-vis the stage of socio-economic development. It calls for the necessary legal and institutional arrangements, employs the most cost-effective technical measures, and operates with the most efficient economic or fiscal instruments. Its purpose is to control, abate and prevent pollution of the environment and to preserve and protect living resources from over exploitation. Above all, its purpose is to balance the socio-economic goals of development against the maintenance of sound environmental conditions, in order that the needs of the present are met without compromising the ability of future generations to meet their own needs.

As environmental issues become more complex, it is no longer sufficient for industries to conform to acceptable standards set by the regulatory agencies. Industries must realise the need to minimise adverse environmental impacts of production and the use of resources. Pollution prevention and waste minimisation practises must be emphasised to ensure efficient business operations and minimal wastage of resources. Waste minimisation is one of the major tools available to industries for the reduction of the environmental impacts of its operations. Waste minimisation involves techniques, processes or activities which either avoid, eliminate or reduce waste at source, usually within the confines of the production unit, or allows reuse or recycling

of the waste. **Figure 1.1** depicts a simplified diagram adapted from EPA, 1988 which outlines various options that can be undertaken to minimise waste.

Today, while many organisations may adopt waste minimisation measures in response to financial and regulatory compliance measures, implementation is increasingly seen as securing business advantages over competitors. Voluntary approaches adopted by organisations via implementation of environmental management systems such as the European Union Eco-management and Audit Regulation (EMAS) or International Standards Organisation's 14000 standard , and the development of products that satisfy Eco-labelling requirements are seen as measures to capture the consumer market that has become increasingly more environmentally conscious over recent years.

The development of waste minimisation practises in developed nations and its current state in Malaysia are reviewed briefly hereafter.

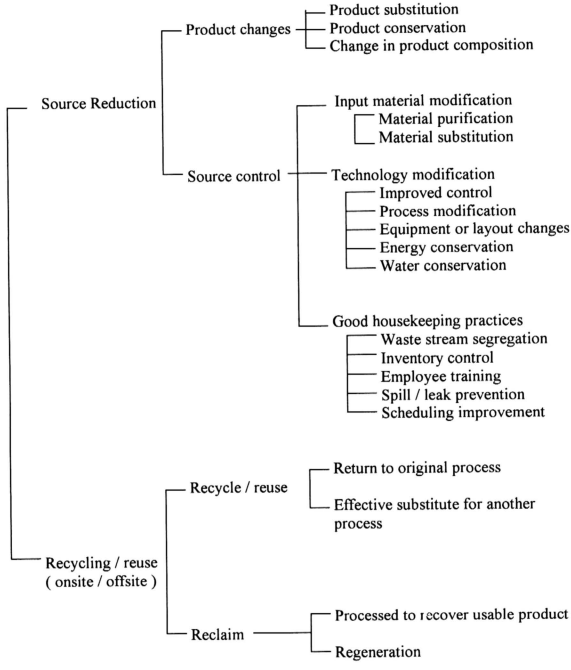

Figure 1.1 Waste Minimisation Alternatives (Adapted from EPA, 1988)

1.1 WASTE MINIMISATION PRACTICES IN VARIOUS COUNTRIES

1.1.1 Waste Minimisation in the United States

In the United States, waste minimisation has its origins in the Resource Conservation and Recovery Act (RCRA), signed in 1976 to provide control over solid and hazardous wastes from generation to disposal, reduction and / or elimination of hazardous waste, and minimisation of the threat to human health and the environment. The Hazardous and Solid Waste Amendments (HSWA) was passed by Congress in 1984. It further enforced the provisions set forth in the RCRA, providing deadlines within which the US EPA had to take regulatory action. It also required that untreated hazardous waste be banned from land disposal by 1989 except under certain circumstances.

In recent years, important changes have taken place in the US national strategy for protecting the environment. The US EPA noted that voluntary goals and commitments achieve real environmental results. Thus, in addition to legislative mechanisms, the EPA began building co-operative partnerships with small and large businesses, citizen groups, state and local governments, universities and trade associations. The results of these partnerships are impressive, with many partners making pollution prevention (P2) a control consideration in doing business. The US EPA claims that the partners are achieving measurable environmental results, often more quickly and with lower costs than would otherwise be the case with regulatory approaches. The collaborative efforts include projects known as 33/50, Waste Wise, Climate Wise, Green Lights, Energy Star, WAVE, Design for the Environment and Project XLS (Smith M., 1997).

Waste Wise was a programme implemented to conserve energy and natural resources and to prevent pollution via waste reduction at source, recycling and increasing the manufacture or purchase of recycled products. The 33/50 programme relies on the Toxic Releases Inventory (TRI), a national inventory of industrial toxic chemical releases and transfers reported to the government by businesses on an annual basis as required by law. The programme was implemented in the late 1980's to encourage businesses to reduce their TRI reported releases. Both programmes demonstrated that voluntary direct action on the part of the industry could outpace command and regulation in terms of environmental results.

The Waste Minimisation National Plan was eventually formulated and finalised in November, 1994. Based on the success of programmes such as 33/50 and Waste Wi$e, its objective was to promote long-term efforts to minimise the generation of hazardous constituents in the RCRA wastes by emphasising source reduction and environmentally sound recycling over waste management. The US EPA's Waste Minimisation Plan evolved from both the Hazardous and Solid Waste Amendments of 1984 and the Pollution Prevention Act of 1990, each of which emphasised a national policy to reduce or eliminate the generation of hazardous constituents in wastes, rather than managing them after they are generated. Currently, the issue of waste minimisation in the US has clearly shifted away from an activity related to reaching legislative standards towards a sensible business activity, where saving wastes saves money and benefits the environment.

1.1.2 Waste Minimisation in the United Kingdom

In the United Kingdom, the system of Integrated Pollution Control (IPC), proposed by the Royal Commission on Environmental Pollution (RCEP) and embodied in the Environmental Protection Act 1990 (EPA 90), marked a milestone in the development of the legislative philosophy and framework. The holistic approach adopted by the IPC system provided a mechanism and a legal basis for looking at the impacts which a process has on the environment as a whole and ensures that substances released unavoidably to the environment are released to the medium to which they will cause least damage. It embodies the precautionary principle: prevention is better than cure. Regulatory processes come under the purview of, initially, Her Majesty's Inspectorate of Pollution and currently the Environment Agency.

In 1992, The Institution of Chemical Engineers published the "Waste Minimisation Guide". The concept of waste minimisation was introduced through the Chief Inspectors Guidance Notes covering the chemical industry. Inspectors were advised to encourage applicants to carry out formal process assessment and leave in place a waste minimisation programme prior to submitting their application. This allowed the applicants to identify in a systematic manner, those areas in their processes where reduction in releases may be accomplished thus, providing the foundations for a programme for up-grading the plant.

The environmental and economic benefits of waste minimisation is clearly demonstrated by projects such as Aire and Calder (Smith, 1997). This project which centred on water treatment for a number of companies in the Yorkshire area, was a waste minimisation project sponsored by the NRA and Yorkshire Water Services in collaboration with the Environment Agency and the BOC foundation for the environment. The project clearly demonstrated environmental and economic benefits resulting from reduction in the use of inputs such as water, energy and raw materials. The project proved to all that to prevent, minimise and render harmless releases to the environment is a readily achievable objective.

1.1.3 Waste Minimisation in the European Union

A structured approach towards waste minimisation was adopted across the European Union with the introduction of the Integrated Pollution Prevention and Control (IPPC) system at the end of September 1996. Through the implementation of the IPPC system, the application of cleaner production technologies and identification of the best available control technology or best overall environmental protection options for processes that emit substances to the environment are encouraged.

1.1.4 Waste Minimisation in Malaysia

As a nation that achieved independence in the late fifties, Malaysia has made great strides in economic development. Endowed with abundant natural resources, and blessed with a stable socio-politico environment, the country has enjoyed consistent and impressive growth over the last three decades. However the rapid growth of business and industrial activities in the various sectors of the economy has brought

with it degradation and damage to the environment. With the shift in the nation's development strategy from that of agriculture towards manufacturing and heavy industries, there has been a rapid increase in the generation of industrial wastes accompanied by the deterioration of air and water quality. The government's vision of achieving a fully developed country status by the year 2020 and the associated industrial expansion would put further pressure on the environment. Unchecked, it would threaten the quality of life in Malaysia, lower its attraction as a choice location for investment and tourism, and waste the environmental capital, the resource base that underpins development. As stated in the National Development Policy of the Second Outline Perspective Plan (OPP 2) (1991-2000) "in the pursuit of economic development, adequate attention is given to the protection of the environment and ecology so as to maintain the long term sustainability of the country's development as well as the quality of life". The challenge is thus to ensure that economic expansion and environmental development go hand in hand. In other words, Malaysia should not be developed only in the economic sense. It must be a nation that is fully developed along all dimensions, particularly in terms of the quality of life.

Malaysia has depended very much on the existing legal and institutional arrangements for the implementation of its environmental policies, objectives and strategies. Realising that the development of the ISO 14000 standards could have serious implications to industries, the government, through SIRIM Berhad responded positively and participated actively in the activities of ISO/TC207, Technical Committee on Environmental Management. In December 1995, following the Malaysian Accreditation Council (MAC) approval for Malaysia to adopt ISO DIS

14001 as provisional Malaysian Standard (MS), SIRIM Berhad launched its pilot programme for ISO 14001 certification involving 32 companies from various industrial sectors including electronics, palm oil, petrochemical, and pulp and paper. As of March 1998, 96 companies had been certified to ISO 14001 in Malaysia (Abu Bakar J.,1999).

The Department of Environment (DOE) has also played its part in encouraging industries to adopt waste minimisation practises. In April 1996, the DOE launched project MAWAR, "Malaysian Agenda for Waste Reduction" to encourage waste reduction by industries. Phase I of Project MAWAR, involved the voluntary participation of industries and saw the setting up of an industrial committee to design a programme and long term plan for waste reduction. Following the success of Phase I, the DOE launched phase II of Project MAWAR, which involved the distribution of questionnaires to solicit information on possible waste minimisation approaches that could be adopted by the various industries.

In Malaysia the concept of waste minimisation is still at its infancy. Many companies are still reluctant to go beyond legislative requirements in terms of compliance to environmental standards. A number of multinational companies that have their own global environmental policies however, have adopted waste minimisation programmes for environmental and economic benefits. These have mainly been achieved through the voluntary implementation of the ISO 14001 Environmental Management System Standards.

To ensure sustainable development, developing nations like Malaysia must optimise or redesign their processes now and not go through the same evolution the developed nations had. Waste minimisation should be seen as a positive contributor to companies' bottom lines. The success of demonstration projects in developed nations should prove as incentives for local companies to adopt similar programmes in their operations.

1.2 RESEARCH OBJECTIVES

One of the major discharges of waste material from industrial facilities is waste water. Water, an essential raw material for many industries, gives rise to waste water which requires treatment and discharge under an "end of pipe" approach. This study focuses on the possibility of adopting waste minimisation through water recycling in a paint manufacturing plant.

There is no major stream of waste water associated with the manufacturing process of paints. All constituents entering the mixers and reactors end up as finished products. Waste water streams originate from paint wash-up water from reactors, mixers and from spillage. One of the raw materials used in the manufacture of paints is hydroxy ethyl cellulose (HEC), which gives the thickening effect to paints As this substance is cellulose based, it is very susceptible to bacterial attack, which can cause degradation of paints and loss of viscosity. One of the primary concerns associated with the quality of recycled water is that it is must be free from bacterial contamination.

The objectives of the study were two fold. Initially, the performance of water-soluble organic polymers in combination with alum were determined as pre-treatment for

waste water emanating from a paint manufacturing facility prior to membrane treatment. The second objective was to evaluate the use of cross-flow microfiltration employing cellulose acetate membrane as the polishing treatment to produce recycled water that is of sufficient quality for reuse within the plant.

The scope of work of this study included the following :

1) Characterisation of influent and effluent waste water streams.

2) Examination of the possibility of waste water recycling by employing chemical coagulation as pre-treatment prior to membrane filtration processes. This involved determining the optimum pH and chemical coagulant dosage for pre-treatment of the effluent.

3) Examination of the performance of a bench scale cross-flow microfiltration unit employing cellulose acetate membranes as the polishing treatment in producing water for reuse in the various production processes.

4) Characterisation of the permeate and the effluent stream after pre-treatment.

5) Adopting a water balance approach to help identify the major areas for waste water reuse.