CHAPTER ONE

INTRODUCTION

1.1 DENGUE

Dengue is currently the most important and rapidly increasing arbovirus infection in the world. It causes a spectrum of illness ranging from mild, nonspecific viral syndrome to severe hemorrhage disease and death. It is spread by the day-biting *Aedes aegypti* and *Aedes albopictus* mosquito, the main vectors of the disease, that flourish in the urban and suburban environment and have helped maintain the prevalence of the disease in the Asian regions. According to the statistics provided by the Division of Control of Tropical Diseases, WHO, an estimated two-fifth of the world's population are at risk and there are tens of millions of cases per year of which 95% are children. Also, there has been about 500 000 hospitalized cases and thousands of deaths per year. The average mortality rate of dengue haemorrhagic fever (DHF) is 5%. DHF and DF occurs in multiple epidemics every year. More than 100 tropical and sub-tropical countries have experienced dengue fever (DF) or DHF outbreaks. In 1997, thousands of cases were reported in India, Bangladesh and Singapore (WHO World Health Statistics Quarterly) . Cases occur regularly in Puerto Rico and throughout Central and South America (Brazil and Cuba). The geographic expansion of DHF is associated with the increased movement of dengue virus via airplane travelers and the development of hyperendemnity in the Pacific and the Americas(WHO Weekly Epidemiological Record, 1997). These epidemics have serious socio-economic consequences and are both difficult and costly to control.

In Malaysia, the distribution of dengue outbreaks is associated with the distribution of *A. aegypti* mosquitoes. Table 1.1 below shows the number of deaths and case fatality rate of dengue fever for the year 1990-1995 in Malaysia.

Table 1.1 : The Number of Deaths and Case Fatality Rate for Dengue in Malaysia (1991 - 1995) (Ministry of Health, Malaysia)

Year	No. Of Deaths	Case Fatality Rate (%)
1990	21	0.43
1991	39	0.59
1992	24	0.44
1993	23	0.41
1994	13	0.41
1995	26	0.43

Based on the Annual Report (1997) produced by WHO Collaborating Centre for Arbovirus Reference and Research in Kuala Lumpur, Malaysia recorded 19,544 dengue cases in 1997, 37% higher than the number reported in 1996 and the highest recorded since the disease was made notifiable in 1973. Included in this study for 1997 were 806 cases of DHF with 50 deaths. Cases were reported throughout the year but peaked in July. Although all states were affected, most cases were reported in urban areas with high population density. Of the cases reported in 1996, 66% of them were from the Federal Territory and Selangor, while 20% were from the states of Johor, Perak and Pahang. As observed by Knudsen and Slooff (1992), owing to population growth, poor levels of hygiene and increasing urban poverty causing the urban environments in developing countries to deteriorate. Densely packed housing in shanty towns or slums and inadequate drinking water supplies, poor garbage collection services and surface water drainage systems combine to create favourable habitats for the proliferation of vectors and reservoirs of this disease. As a result, dengue has become a major health problem associated with rapid urbanization in tropical countries. DHF prevention and control can only be accomplished at the present time through mosquito control. Insecticides are available for control of both adult and immature mosquitoes but these are expensive. There has been a near complete reliance on insecticides directed at adult mosquitoes, especially ultra-low volume (ULV) application of Malathion for the past 20 years. This method has been effective in preventing epidemic disease transmission. The most cost-effective approach to prevent and control DHF is larval source reduction. Thus, a precise picture of current vector bionomics and their relation to human ecology and other prevailing environmental factors is essential.

1.2 Aedes aegypti

A. aegypti is the most important vector of dengue. The spread of dengue throughout the world can be directly attributed to the proliferation and adaptation of this mosquito. This vector has been found to breed in water collected in anthropogenic containers of almost any kind inside and outside houses. They include containers for water collection or storage (cisterns, water jugs, animal watering trough), flower pots, discarded containers (pots, cans, bottles), masonry defects and neglected containers (gutters, drain traps, unused toilets). *A. aegypti* larvae has also most frequently been found in tyres that are improperly stored or illegally dumped. The adult mosquito usually stays within a few 100m of their larval sites, therefore the long-range dispersal of the species depend primarily on humans. It moves along human travel and trade routes and is particularly prevalent along coastal areas and harbours.

The rapid growth and proliferation of the *A. aegypti* can be attributed to man's intervention in the urban environment. Monchet and Carnevale (1997) noticed that current environmental conditions favour vector breeding . Streams and rivers have been managed for power production and irrigation. The use of dams and the culture of rice in paddy fields produce large expanses of water which are suitable breeding grounds (Monchet and Carnevale, 1997). The world has experienced unprecedented population growth for the past 50 years and most of it concentrated around developing tropical countries. This has resulted in deteriorating housing and in inadequate water, sewage and waste management systems. In the absence of safe and reliable water supplies, poorly developed facilities for water storage and wastewater disposal offer multiple opportunities for vector breeding. The lack of basic installations and services or when available, their defective design and construction or their improper use and maintenance can result in increased population of mosquitoes living in intimate association with crowded human populations. Second, changing lifestyles have contributed to expanding geographic distribution and increased population densities of *A. aegypti*. For example, most consumer goods are packaged in nonbiodegradable plastic or cellophane that is discarded in the environment making ideal *A. aegypti* larval habitats. Also, there has been a dramatic increase in automobiles and thus used automobiles' tyres that are discarded in the environment make ideal mosquito larval habitats.

Although the hemisphere-wide eradication of *A. aegypti* is desirable, their elimination is difficult for many reasons including the costs associated with its extermination. The attempted eradication of *A. aegypti*, despite the latest equipment to spray insecticides and millions of dollars annually has not been successful. Through the years it is found that source reduction is a preferred avenue of control. These services rely heavily on health education, source reduction and in some instances legal recourse to limit breeding *of A. aegypti*. The contributions of community and individuals toward the control of *A. aegypti* probably are greater in non-insecticide methods. Of great importance is the creation of adequate public services, such as dependable piped water, frequent trash collections and effective sanitary education.

1.3 Prevention of Dengue and Control of *A. aegypti* Breeding

Most diseases transmitted through the bite of *A. aegypti* are more urban than rural. *A. aegypti* is found breeding primarily in man-made containers such as water storage receptacles, tyres, discarded tin cans and bottles and occasional breeding in highly organic water such as soakway pits. Vector control approaches include source reduction and environmental management, larviciding with the use of chemicals (synthetic insecticides, insect growth regulators and microbial insecticides) and diminishing the population of adult mosquitoes using personal protection measures (household insecticide products and repellents) for long-term control and space spray (both thermal fogging and Ultra-Low-Volume sprays) as short-term epidemic measures (Yap *et al.*, 1994) A variety of methods have been previously used in an attempt to control *A. aegypti*. DDT application characterized the post-war era. Thailand and other Asian countries attempted eradication using larvicide (Abate) and malathion fogging. ULV(Ultra-Low Volume) malathion spraying by aircraft was also employed. These methods worked well in the short-term but mosquito populations inevitably increased after a period of 2-3 weeks. According to a study conducted by Rawlins and Wan (1995), it was found that most *A. aegypti* in Caribbean strains show marked resistance to insecticides such as temephos, fenthion, malathion, fenitrothion and chlorpyrifos. Gratz and Jany (1994) noted that due to the development of insecticide resistance and environmental considerations, and the cost of development and of registration, the number of compounds available for use has declined while the number of new insecticides submitted for laboratory and field trials to the World Health Organization has dwindled even more.

Large scale field trials of the ULV application of insecticide concentrates in Southeast Asia, South America and Africa, using aerial, ground, vehicle - mounted and hand-carried equipment resulted in satisfactory levels of control of adult population. Gratz (1991) concluded that while ULV applications can provide rapid and effective emergency control of vectors at the time of outbreaks of disease in urban and periurban areas, they should not be used as a routine mosquito control measure due to its adverse impact on the environment.

Bio-control efforts include the use of predatory fish (*Clarias fuscus*) and the use of *Bacillus thuringiensis* on the *A. aegypti* larvae.. Both

B.thuringiensis (Bti) and *Bacillus sphaericus* are common bacteria found in soil and aquatic habitats. These strains produce a protein crystal, called parasporal body beside the spore during sporulation and it is toxic if eaten by mosquito larvae. Wilmot *et al* (1993) studied the efficiency of two Bti formulations for the control of *A. aegypti* - the Vectobac and Bactimos - and found that both provided greater than 90% control at application rates as low as 100mg/m^2 (0.89 lb/acre). Mesocyclops have also been used successfully for eradication in Vietnamese rural areas.

Environmental management for vector control was defined by the WHO (WHO Technical Report Series No. 561, 1975)as the planning, organization, carrying out and monitoring of activities for the modification and/or manipulation of environmental factors or their interaction with man with a view to prevent or minimize vector propagation and reducing man-vector-pathogen contact . Environmental modification and manipulation for the control of mosquito vectors of disease was not employed due to the development of chemical insecticides. After the Second World War, the use of insecticides especially as residual house sprays, was so efficacious in controlling mosquito and mosquito-borne diseases that little or no use was made of biological and physical methods of mosquito control. However, the development of insecticide resistance in the mosquitoes of economic and public health importance as exemplified by the *Culex molestus* in Italy and *Anopheles sacharovi* in Greece (WHO Technical Report Series No. 649, 1980) have shown that chemical control alone is ineffective. Furthermore, environmental concern over repeated applications of insecticides for pest or vector control has contributed to a decrease in the use of insecticides. At the same time the development and extended availability of skilled manpower and efficient earth-moving equipment increased the feasibility of applying large-scale environmental measures for mosquito control. The need to develop integrated strategies incorporating both old and new methods of mosquito control is now widely accepted. Environmental management measures constitute an effective component of such strategies. The objective of environmental management for vector control is the reduction of the abundance of dangerous species through the manipulation of environmental factors. Chen *et al.*, (1994) in Taiwan, concluded that integrated pest control is the best and most effective method for Dengue Fever control and this includes solid waste and drinking water management. In Singapore, the strategy for *Aedes* control is an integrated approach incorporating case detection, source reduction, health education and law enforcement. This had reduced the *Aedes* population to a house index of 1% (Wang ,1994). Knudsen and Slooff (1992) discussed that vector borne diseases can best be controlled through sound environmental management practices and community education and participation with minimal reliance on routine pesticidal spraying.Yadava *et al.*, (1991) concluded that for the control of vectors of disease, the adoption of environmental management is imperative. Physical methods like drainage of excess and waste water, making water unsuitable for vector breeding and community based activities are identified as the basic approaches to achieve this goal. Yadava *et al.*, (1991) stressed that minimizing the potentiality of vector breeding through source reduction and water management is thought to be the simplest, cheapest and most permanent method. Environmental management measures are not intended to replace other methods and techniques applied to control vector-borne diseases but rather to complement these and provide for the development of "integrated control". The disadvantages of environmental management operations are mainly their high capital cost for the purchase of equipment and propaganda, the length of time required for completion of each project and the complexity of each environmental management project. However, small scale operations are feasible, and can be incorporated into integrated control strategies for vector and disease control.

The application of environmental management measures should always be preceded by thorough ecological studies to take maximum advantage of natural processes and to avoid damaging environmental consequences. Environmental management measures thus depend on the understanding of mosquito biology and ecology (such as population dynamics as well as epidemiology of mosquito-borne disease). Studies on vector habitats must therefore be intensified in order that vector control may be made on a sound basis. To aid in vector control, vector breeding sites should be characterized and analysed. As freshwater is a potential habitat for juvenile *A. aegypti*, it may be beneficial to investigate if there are any particular water quality parameters that could inhibit or enhance the proliferation of this vector.

1.4 RESEARCH OBJECTIVES

The main purpose for carrying out this study is summarized in the research objectives below.

I To determine the water quality parameters of rainwater, river water and stagnated water where *A. aegypti* is suspected to breed and proliferate. These water quality parameters include pH, suspended solids, rate of filtration and concentrations of the heavy and trace metals namely arsenic, lead, iron, zinc, cobalt, chromium, manganese, magnesium, cadmium, copper and tin.

II To determine if there is any relationship between the above water quality parameters and the growth and survival of juvenile *A. aegypti*.