# CHAPTER 1

# INTRODUCTION

## 1.1 SEQUENCING BATCH REACTOR (SBR)

Sequencing batch reactor (SBR) is a fill-and-draw activated sludge system. The unit processes involved in SBR and conventional activated sludge (CAS) systems are identical. Aeration and sedimentation/clarification are carried out in both systems. However, there is one important difference. In conventional activated sludge plants, the processes are carried out simultaneously in separate tanks, whereas in the SBR, the processes are carried out sequentially in the same tank (Tchobanoglous and Burton, 1991). Improvements in aeration devices and control systems have allowed the development of fill-and-draw systems to achieve their present level of efficiencies, which enables SBR technology to compete successfully with conventional systems.

SBR process is an activated sludge process, and bears no similarity to the extended aeration (EA), another type of activated sludge process. In fact, unlike an EA process the SBR is designed to operate under non-steady state conditions. An SBR operates in a batch mode. As such, it provides for inherent flow equalization and flow blending, and also greatly reduces operator skill and attention requirements. Controls range from a simplified float and timer based system with a Programmable Logic Controller (PLC) to a Personal Computer (PC) based system with colour graphics using either flow proportional aeration or Dissolved Oxygen (DO), removal and control of filaments. A properly designed SBR process is a unique combination of equipment and software comprising a complete secondary wastewater treatment facility (Norcross, 1992).

While it is often suggested that periodic processes (like SBR) are a recent development, in fact most early activated sludge plants were designed to operate in a batch treatment mode. Continuous flow processes were developed, for the most part, to reduce operation and maintenance requirements of the early batch plants. Improvements in microprocessor control systems, automatic valves and aeration equipment have made batch or periodic processes not only practical, but for many applications, far preferable.

SBR can accomplish the tasks of primary clarification, bio-oxidation and secondary clarification within the confines of a single reactor (Irvine and Ketchum, 1989). As SBRs are time-oriented and not space oriented, fill/reactor ratios, aeration periods and mixing cycles may be altered to accommodate for specific operating conditions and to yield the desired results (Chiesa and Irvine, 1985; USEPA 1987; Ying *et al.*, 1979). Therefore SBRs are uniquely suited for wastewater treatment applications which are characterized by low flow or intermittent flow conditions (Silverstein and Schroeder, 1983; Goronszy, 1979). Advances have been made in recent years in sludge bulking control technologies using selector mechanisms. As SBRs have the flexibility of incorporating many of these selector mechanisms in their operations, they are also well suited for applications under high organic/low nutrient concentration conditions (Shekar *et al.*, 1993).

Conventional activated sludge treatment was initially developed to remove carbonaceous and nitrogenous BOD from sewage. Activated sludge systems have been modified to enhance biological nutrient removal (nitrogen and phosphorus) by providing aerated and non-aerated reactors in series, along with various internal recycle systems (USEPA, 1986a). One of these modified activated sludge systems is the SBR.

The SBR process involves a single, complete-mix reactor in which all steps of treatment occur. Discrete cycles are used during prescribed time intervals. Mixed liquor suspended solids (MLSS) remain in the reactor during all cycles, thereby eliminating the need for a separate clarifier (USEPA, 1986a). The specific treatment cycles shown in **Figure 1.1** are:

- Fill (raw or settled wastewater fed to the reactor)
- React (aeration/mixing of the rector contents)
- Settle (quiescent settling and separation of activated sludge from the treated wastewater)
- Draw (withdrawal of treated wastewater from the reactor)
- Idle (removal of waste sludge from the reactor bottom)

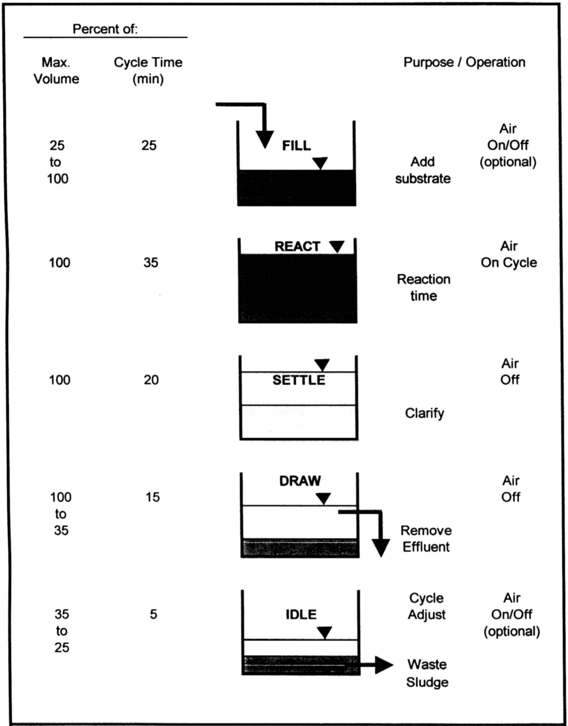


Figure 1.1: Typical SBR Operation for One Cycle

Source: USEPA, 1986a

The idle cycle may be omitted by wasting sludge near the end of the react or draw cycle. As a result of the batch nature of the process, flow equalization or multiple reactors must be provided to accommodate continuous inflow of wastewater to the facility (WEF, 1992).

SBR processes are favoured by some engineers because they do not require separate clarifiers. Nonetheless, proper provisions are needed to ensure a clear, high-quality supernatant when aeration and mixing are terminated. Most SBR designs involve interrupting the inflow to a basin while it is in the settling and decanting modes (WEF, 1992). Where inflow to the basin is continuous, this modification is called the Intermittent Cycle Extended Aeration System (ICEAS).

## 1.2 IMPORTANCE OF THE STUDY

Indah Water Konsortium Sdn Bhd, a privatised sewerage contractor, has undertaken the planning and functional design of all priority sewerage projects within urban local authority operational areas. In the long term, it is the objective of IWK to serve the urban areas with regional, central sewage treatment plants. However, in the short term new developments would still require small and medium scale sewage treatment plants.

Generally, a smaller area is required for the SBR plant compared to the conventional activated sludge or extended aeration plant. Thus the SBR plant is a cost effective alternative for small and medium housing schemes with severe space constraints. This research project will help to provide information as to the effectiveness of the SBR plant. It is anticipated that the data gathered for this project will prove that SBR plant will be able to comply with stringent regulations and requirements set by the Department of Sewerage Services.

The data collected in this study will be useful in optimizing the design of SBR systems for treatment of sewage at small and medium scale. The usefulness of SBR in removal of nutrients will be evaluated. Data obtained will be useful in the selection of the optimal cycling times in SBR. The efficiency of SBR with respect to the removal/reduction of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (SS), ammoniacal nitrogen, nitrate nitrogen and phosphate from sewage will be evaluated.

## 1.3 THE RESEARCH PROJECT

Not much work has been done in tropical countries like Malaysia on the characteristics and performance of SBRs in the treatment of sewage on small and medium scale, in comparison with conventional activated sludge and extended aeration systems.

It is known that the SBR can be operated to achieve any combination of carbon oxidation, nitrogen reduction and phosphorus removal (WEF, 1992; Tchobanoglous and Burton, 1991; Irvine *et al.*, 1997). Reduction of these constituents, can be accomplished with or without chemical addition by changing the operation of the reactor. Anaerobic conditions are required for biological nutrient removal.

In this research project a newly commissioned SBR plant at Kuala Lumpur International Airport, Sepang, serving the airport development including commercial and residential components was tested for performance under different conditions.

The Biological Nutrient Removal (BNR), namely nitrogen and phosphorus, with anaerobic and aerobic operations using SBR was studied. Also studied was the influence of cycle time (8 hours per cycle versus 6 hours per cycle) on the performance of the SBR.

## 1.4 Study Objectives

The objectives of the study are:

- To characterize the influent wastewater,
- To investigate the efficiency of removal of BOD, COD and SS from the wastewater,
- To evaluate the effectiveness of the SBR in biological nutrient removal,
- To compare the effect of changing cycle-times on the performance of the SBR, especially in terms of biological nutrient removal, and
- To evaluate the overall performance of the SBR in treating domestic wastewater under tropical climate conditions.