INTRODUCTION

Cutler and Davis (1972) stated that detergent is a term used to describe a substance or formulation which aids cleaning processes. The word detergent itself is a general term, derived from the Latin word "detergere" meaning to wipe off or cleanse (Sperry 1951). Both soap and soapless detergents are surfactants, in that, both groups of compounds show surface active properties. The difference between the two compounds refer more towards the source of their raw materials (Moore 1967, Cain 1981). It is called soap, if it is derived from oils and fats of plants and animals. It is called soapless if it is not derived from plants or animal origin. Soap, being the first commercial cleaning agent, is at present being successfully replaced by soapless detergents, essentially due to the fact that the cleansing action of soap in hard or acid water is greatly reduced compared to soapless detergents.

The branched alkylbenzene sulphonates were the most popular surfactants in use in the 1950s and in the early 1960s. They were mostly tetrapropylenebenzene sulphonates which were later replaced by linear alkybenzene sulphonates in response to environmental and

experimental evidence that they were recalcitrant.

The presence of recalcitrant detergents in wastewaters are known to cause problems in rivers as well as in sewage treatment plants. These include toxicity to microorganisms and fishes (Janicke 1973, Abel 1974), reduction of oxygen transfer into water (Mancy and Okun 1960, Koide et al 1976), eutrophication (Jenkins et al 1972), foaming which could result in transmission of pathogenic microorganisms from sewage treatment systems and removal of active biomass into the foam layer. The foams produced are also aesthetically undesirable and they can cause reduction in visibility (McKinney 1957, ERL 1978). This had resulted in the complete banning and changeover to biodegradable detergents in the developed countries.

However, the use of branched alkylbenzene sulphonates in detergent formulations has yet to be banned in some countries of which Malaysia is an example. This is because if the changeover to linear alkylbenzene sulphonates were to be adopted, it would result in corrosion problems to the existing plants, lower viscosity of the pastes and slurries produced which created problems when it was sold as a liquid or paste detergent, the powders manufactured became sticky and

lost their free flowing characteristics and also resulted in a higher cost of production (Davidsohn and Milwidsky 1978, Khanpara 1982). It has also been argued that the regular high rainfall in countries like Malaysia would minimize the environmental problems since the dilution effect could take care of the surfactant effluent discharged into the waterways.

Biological treatment methods as reported in literature for wastewaters containing detergents are scarce and usually include the trickling filter and activated sludge processes (Eden and Truesdale 1961, Simko et al 1965, Kumke and Renn 1966). Even then the detergent content of the wastewaters has always been low, in the order of 20 mg/l methylene blue active substances (MBAS) or less since they have always been treated in combination with sewage. The use of biological treatment methods for wastewaters containing high concentrations of surfactants, especially branched alkylbenzene sulphonates, from detergent plants are not known. However, laboratory scale studies have been conducted (McGauhey and Klein 1959, Jenkins et al 1967, WPRL 1968) but were found to be inefficient for the biodegradation of branched alkylbenzene sulphonates.

Branched alkylbenzene sulphonates being xenobiotic compounds of complex chemical structures afford some problems in biodegradation. The chemical structures which make the compound resistant to biological oxidation include methyl branching (Pirnik 1977), terminal branching (Schaeffer et al 1979) and terminal quaternary groupings (Ryckman and Sawyer 1957). In addition, the benzene ring itself is not easily oxidised and the sulphonate group which is known to be thermodynamically stable also resists biological oxidation.

The wastewater used in the present investigation contained a high concentration of branched alkylbenzene sulphonates, as tridecylbenzene sulphonates in the range of 100 mg/l to 240 mg/l MBAS. It was obtained from a local detergent plant and it is a by-product of the manufacture of a wide range of household washing detergents. The wastewater obtained had already undergone physical-chemical treatment at the plant with the use of slaked lime and alum for the purpose of coagulation and flocculation. This process basically resulted in the reduction of MBAS in the range of 90 to 95%, biochemical oxygen demand (BOD) in the range of 55 to 60%,

chemical oxygen demand (COD) in the range of 70 to 80% and phosphates in the range of 99 to 100%. However, the wastewater still contained a high amount of MBAS, BOD and COD which did not satisfy the requirements of the Environmental Quality Act Of Malaysia (Department of environment 1974).

Therefore, a programme of research encompassing the activated sludge process and related studies were initiated to determine the biodegradability of the recalcitrant detergent wastewater. Although, it is inevitable that such a wastewater would contain a variety of other chemicals used in the detergent formulations, the present study will concentrate on the branched alkylbenzene sulphonate which would be considered as the main causative agent of any environmental problem.

The programme of research includes the determination of a suitable inoculum to be used to obtain an acclimatized culture of microorganisms for the detergent wastewater. Consequently, experiments were conducted to isolate and identify the microorganisms present in an acclimatized microbial culture of an activated sludge tank with sludge recycle operating

at steady state, treating detergent wastewater. Furthermore, the degradative capabilities of each of the microorganisms isolated to the branched alkylbenzene sulphonates were determined and compared with the mixed culture in the tank. Following this, the optimal concentration of the MBAS required for their effective biodegradation by the mixed cultures was investigated. In addition, the treatment efficiencies of a completely stirred tank without sludge recycle, completely stirred tanks in series and a completely stirred activated sludge tank with sludge recycle were compared, and the biokinetic coefficients for the latter were determined. The oxygen transfer coefficients using atmospheric air and pure oxygen for the detergent wastewater were also examined.