# Chapter 1

# INTRODUCTION

There is an increasing demand for water in South Africa for both domestic and commercial uses, due to the escalation in the population and increased industrialisation (van Leeuwen *et al.*, 1990). South Africa's average rainfall is approximately 497mm per year, in comparison to the world average of 860mm. In addition, severe droughts occur periodically, resulting in further demands on already limited water resources (Anon., 1986). Consequently, industrial installations in South Africa are forced to recycle and reutilise water, particularly during drought periods (Baecker *et al.*, 1988; Bondonno *et al.*, 1989). Thus, the quality of not only cooling water, but also of natural water bodies is rapidly deteriorating due to salination, eutrophication and pollution (Anon., 1986; Nell and Aspden, 1990). This decrease in water quality has increased problems associated with uncontrolled microbiological growth in open recirculating cooling water systems (Honneysett *et al.*, 1985; Poulton and Nixon, 1990).

The types of microbiologically related problems commonly found in open recirculating cooling water systems are generally attributable to sessile microorganisms and include microbiologically influenced corrosion (MIC) and biofouling (Colturi and Kozelski, 1984; Soracco *et al.*, 1988; Cloete *et al.*, 1992). MIC has resulted in severe metal loss in many power utility cooling water systems (Breske, 1990) while biofouling and biofilm formation cause decreases in heat transfer and flow rates (Blenkinsopp and Costerton, 1991).

Many of Eskom's power stations are operated on the principle of zero effluent discharge, thus reducing specific water consumption from 3.2 $l.KWh^{-1}$ to approximately 2.2 $l.KWh^{-1}$ (Nell and Aspden, 1990). In order to be able to achieve this reduction, cooling water systems are operated at high cycles of concentration and water is reused where possible. Due to the resulting poor water quality, the majority of Eskom's power stations experience microbiological problems and associated financial losses (Poulton and Nixon, 1990). It has been estimated that the direct cost of MIC in South Africa is approximately R400 million per annum (von Holy and Cloete, 1988).

To date, the control of sessile microorganisms in cooling water systems has been by means of both oxidising (Connell and Jones, 1991) and non-oxidising biocides (McCoy, 1980). However, it has been reported that bacteria may become resistant to the action of biocides (Russell, 1990), thus prompting investigation into alternate means of controlling microbiological growth. Biodispersants are widely used in industry to disperse sessile bacteria. There is, however, little published information on their mechanisms of action or case studies on their efficacy in cooling water systems.

The monitoring of biofouling and MIC in South Africa has generally been by means of quantification of the planktonic microorganisms (Cloete *et al.*, 1989) and on occasion by means of the Robbins Device (von Holy and Cloete, 1988). However, the accurate determination of microbiological conditions in cooling water systems remains problematic. To date, no in-depth scientific study has been carried out to determine the most effective techniques for the monitoring of sessile microorganisms in cooling water systems. A need therefore exists for a study of this nature.

The aims of the work outlined in this thesis were therefore as follows:

- to establish the sources and extent of microbiologically related problems in Eskom's open recirculating cooling water systems.

- to investigate the use of biocides and biodispersants as a means of controlling microbiological growth in Eskom's open recirculating cooling water systems.

- to evaluate monitoring techniques for the determination of biofouling and biocorrosion occurring in cooling water systems, as well as for the evaluation of the efficacy of microbiological treatment programmes.