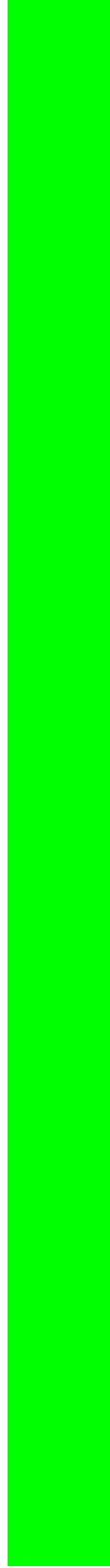


Chapter 1: Introduction



CHAPTER 1

INTRODUCTION

The freshwater resources in South Africa are a finite resource, which must be conserved for sustainable use and development. The country has an annual average rainfall of approximately 464 mm, which is half of the global average of 860 mm (Godden, 2005). The rainfall distribution is rather skewed with 85% of country receiving an annual rainfall of less than 500mm (Richard and Pocard, 1998) and 20% receiving less than 200mm (Godden, 2005). The water quality of some of the freshwater impoundments has continued to deteriorate over the years through pollution and nutrient enrichment (eutrophication) (Scott, 1991; Harding et al., 2001; Van Ginkel, 2002).

Eutrophication is a natural process or a human-induced activity that leads to the nutrient enrichment of water bodies with nitrates and phosphates, which in turn promote the excessive growth of aquatic weeds and cyanobacteria blooms (Codd, 2000). As a natural process the ageing of freshwater body may take thousands of years to occur. The natural process involves the following succession: from an oligotrophic (low in productivity and abundance in biodiversity of species) through to mesotrophic (moderate productivity and high species abundance) to eutrophic (high productivity and high species abundance but low in species diversity). The other extreme end of eutrophic conditions is known as hyper-eutrophic (Van Ginkel, 2002).

The Department of Water Affairs and Forestry (DWAF) as the legal custodian for the management of water resources in South Africa, as stipulated in the National Water Act, No. 36 of 1998 has established a National Eutrophication Monitoring Program (NEMP) to assess how spread is the problem of eutrophication in the country's freshwater resources (Figure 1.1). The Hartbeespoort dam is located in the North West Province of South Africa. It is one of the freshwater impoundments that are monitored as part of the NEMP. The dam has continued to receive large loads of urban runoffs and wastewater effluent from Johannesburg, Midrand and Krugersdorp. The effluents are rich in phosphates, ammonia and nitrates and have contributed to

eutrophication and are directly responsible for the proliferation of *Microcystis* algal blooms.

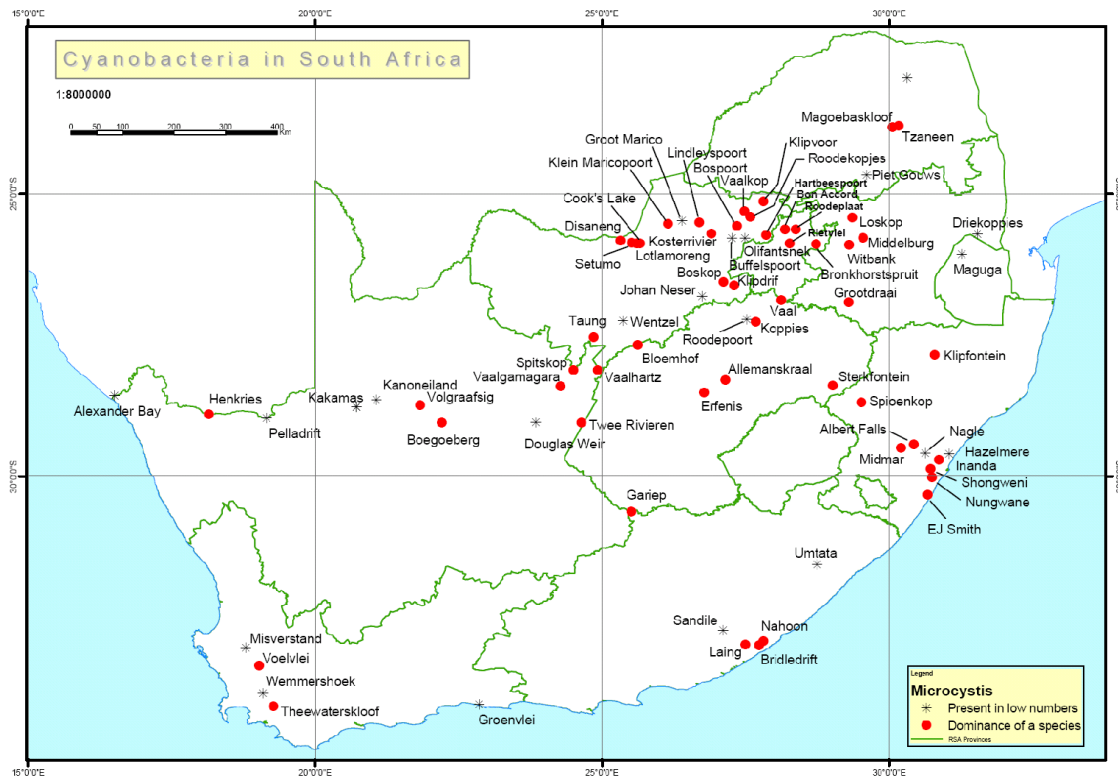


Figure 1.1: Distribution of *M. aeruginosa* algal blooms in South Africa (Van Ginkel, 2003).

The control measures such as mechanical harvesting (Harding et al., 2004) and use of chemical flocculants such as Phoslock™ (Greenop and Robb, 2001; Robb et al., 2003) have been attempted to manage the harmful algal blooms (HABs). These methods controlled the HABs through nutrient precipitation (depriving cyanobacteria of nutrients) and cell coagulation (removal of intact cells) but did not cause significant increase in microcystins (Lam et al., 1995). The major limitation for daily use has been their prohibitive cost.

The chemical use of copper algicides has been the first choice of managing *Microcystis* algal blooms that threaten raw water supplies that are intended for potable purposes (Lam et al., 1995; García-Villada et al., 2004). However, there are increasing demands to reduce the use of chemicals for environmental and safety

reasons (Mason, 1996). During the *Microcystis* lysis induced by copper there is release of microcystins into surrounding water. These microcystins presented health hazards to livestock and humans using the water for consumption (WHO, 1999). Thus the development of non-chemical control measures such as biological control is of great importance to the management of harmful algal blooms.

The biological control method is based on predatory bacteria, which are antagonistic towards *Microcystis*. These predatory bacteria have been isolated from the *Microcystis* algal blooms and are indigenous to the lake environment, thus providing an environmentally friendly solution. Other microbial agents such as fungi, virus and protozoa have been isolated from HABs (Shilo, 1970; Burnham et al., 1981; Ashton and Robarts, 1987; Yamamoto et al., 1998; Walker and Higginbotham, 2000; Bird and Rashidan, 2001; Nakamura et al., 2003a; Choi et al., 2005). In many cases these microbial agents are species- or genus-specific (Bird and Rashidan, 2001), while others attack a variety of cyanobacteria classes (Daft et al., 1975).

Other researchers have isolated and identified a *Sphingomonas* species and a strain of *Pseudomonas aeruginosa* that are capable of degrading microcystins. From the predatory bacteria, other studies have isolated and purified extracellular lysozyme that inhibited the growth of the cyanobacterium, *Oscillatoria williamsii* (Sallal, 1994).

Wright and Thompson (1985) isolated three *Bacillus* species from garden compost in Bath, Britain. Two of the strains were identified as *B. licheniformis* and *B. pumilis*. The *Bacillus* species produced volatile substances that inhibited the growth of the filamentous cyanobacterium, *Anabaena variabilis*. Nakamura et al. (2003a) isolated *Bacillus cereus* N14 from a eutrophic freshwater lake in Japan. *B. cereus* N14 released unidentified protease substance that inhibited the growth of *Microcystis* species. The bacterium *Saprospira albida* isolated from Hartbeespoort dam, a eutrophic freshwater reservoir, was observed lysing the cyanobacterium, *Microcystis aeruginosa* (Ashton and Robarts, 1987). However there was no further research carried out to evaluate its biological control potential.

In my doctoral studies, I hypothesized that there were predatory bacteria that are antagonistic to *Microcystis aeruginosa* that are naturally occurring in the Hartbeespoort dam. The major objectives of the research study were:

- To isolate and characterize the predatory bacteria that were antagonistic towards *Microcystis*;
- To determine the mechanism of lysis involved during the contact between the predator and prey and
- To assess the efficiency and efficacy of predatory bacteria against *Microcystis* under laboratory conditions.